2nd Two Day National Conference
on
Water, Environment & Society
(NCWES - 2015)
30th-31st July, 2015

Hyderabad, India

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Centre for Water Resources

Institute of Science and Technology

Jawaharlal Nehru Technological University Hyderabad

Kukatpally, Hyderabad - 500 085

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Published by

BS Publications
A unit of **BSP Books Pvt. Ltd.**
4-4-309/316, Giriraj Lane, Sultan Bazar,
Hyderabad - 500 095
Phone : 040 - 23445605, 23445688
e-mail : info@bspbooks.net
www.bspbooks.net

ISBN: 978-93-83635-87-0

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

Smt. Shailaja Ramaiyer, I.A.S.,
Incharge Vice- Chancellor

Foreword

Water is the basic resource essential for the survival of mankind on earth and is the greatest gift of nature. It is fortunate that India is endowed with vast natural resources. But unplanned plundering, thoughtless Pillage, ravenous devastating destruction and ruinous selfish exploitation of natural resources degraded the lands, dwindled the availability of water resources and erased the greenery. The gloomy status coupled with drought conditions has their interactive influence on environment. Advancements in Science and Technology, consequent industrial development and alarming growth of human population have all contributed to deterioration of environment which calls for urgent action.

Climate change is altering the world's water resources, as evidenced through changing precipitation patterns, severe drought and floods, snow pack amount, stream flow, and rising sea levels. It is critical that local bodies responsibly manage water resources in all local communities in order to minimize the adverse effects of climate change.

Emphasizing water & environment management as a means to an end rather than an end itself, the proceedings of the conference seeks to explore global water as resource for economic, social & environmental development. In an attempt to address diversities of this complex world, this initiative focuses to balance rural- urban dichotomy, agricultural- industrial needs in wake of technological advances. It recognizes need for inclusive & environmentally sustained growth for shared prosperity and directed accordingly.

There is thus an urgent need to promote Research and Development, educational and training activities in the areas of water and environment by way of organizing seminars, workshops, conferences and training programs to bring about and development more awareness. The 2nd two day National Conference on "Water, Environment and Society (NCWES-2015)" is an appropriate step in this direction. Keeping this in view, the subject matter of the conference is planned to cover a wide range of topics spreading over eight technical sessions.

I appreciate efforts of the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad for taking up such a stupendous task. I congratulate the editor and publisher for bringing out the pre-conference proceedings in time.

Smt. Shailaja Ramaiyer, IAS
Vice- Chancellor of JNTUH &
Chief Patron, NCWES-2015

Preface

While water is elixir of life, environment is the sole harbinger of human existence. But skeweddistribution and dwindling water and environmental resources are gradually unfolding a situation of crisis that has turned more acute in urban habitats. Human growth patterns have still left hundreds of millions of people behind. Hence efforts aiming inclusiveness & sustainability is the felt need.

Agriculture and industry, the major users of water are at the same time the ones that contribute to its contamination. The demands for water and clean environment are compounded by growing population expecting better standards of life also necessitating societal management strategies.

At this critical juncture, harmonizing efficient water use and ensuring safe environments with climate resilience have become need of the hour. The present conference offers broad contribution towards achieving goals of diversification & sustainable development.

It is in this context and backdrop that the Centre for Water Resources, Institute of Science and Technology, JNTUH felt the need to organise 2nd two day national conference on Water, Environment and Society (NCWES-2015) to take stock of the current status of applications in water resources development and management.

Researchers, engineers, site managers, regulatory agents, policy makers, Consultants, NGO's, academicians and vendors will all benefit from the opportunity to exchange information on recent research trends and to examine ongoing research programs in the areas of water and environment. Keeping in view the importance and need of the hour, this issue of proceedings is brought out to coincide with the conduct of the national conference. The high value contributions by eminent speakers, Research scholars and participants have been overwhelming and encouraging.

The two day national conference on NCWES will focus its attention on various themes in the form of technical sessions such as

1. Hydrologic parameter estimation & modeling
2. Climate change and environment
3. Hydropower, bio-diversity, catchments treatment and EIA
4. Groundwater exploration, development, recharge and Modeling
5. Water quality, water treatment, pollution and society
6. Water conservation and irrigation management
7. Farm management and rainwater harvesting
8. Geospatial applications in water resources

More than 150 delegates and 110 technical papers are being presented in these eight technical sessions. I hope the present conference would serve as a link between technology, policy, practice and decision making in the quest for synergetic solutions for sustainable development of water resources and environment.

It is with this great pleasure; I extend a warm welcome to all the delegates, speakers and participants to NCWES – 2015.

Dr. M.V.S.S Giridhar

- *Editor*

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

Smt. Shailaja Ramaiyer, I.A.S.,
Incharge Vice- Chancellor

Message

The organizing secretary and the faculty of the "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad are to be appreciated for organizing 2nd Two Day National Conference on ***"Water, Environment and Society NCWES 2015"***, a topic of great importance to the field engineers, NGO's, academicians, researchers and students.

When a major fresh water crisis is gradually unfolding in India, it is quite appropriate to have chosen this topic. I am sure that this National Conference will be of immense use to all those, who move with high aspirations. This new reality from which there is no escape must be recognized and managed. In this regard education serves to foster innovation & capacity in transferring social ideal to reality.

On this occasion, let us impress upon everyone the preciousness of water and need to protect the water resources of our country.

In this context, I hope the conference will bring out important policy decisions and strategies to be adopted to meet pressing demands of this ever changing society.

I congratulate the organizing secretary and committee members of this conference for taking up this topic and wish them all success.

Shailaja

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MESSAGE

The organizing secretary and the faculty of the "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad are to be appreciated for organizing 2nd Two Day National Conference on **"Water, Environment and Society NCWES"**, a topic of great importance to the field engineers, NGO's, academicians, researchers and students.

As water is elixir of life and vital for survival of living beings and environment, harmonizing efficient use of water is need of the hour in a scenario of ever increasing demand for precious water resources and clean environment. Efforts towards sustainability is the most crucial challenge of present age.

This being a significant area in the field of Engineering, I am hopeful that the participants will avail this opportunity by enriching themselves greatly and augment their technical knowledge and skills. A conference on such topic is appropriate to spread the message across all the sections of the society.

I congratulate the organizers, sponsors and other sponsors for their excellent work in conducting such conference and I wish the conference a grand success.

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SMIEEE, FIE, FIETE, MSSI, MISTE
Professor of EEE &
REGISTRAR

MESSAGE

It gives me immense pleasure to note that the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a 2nd two day National Conference on *"**Water, Environment and Society - NCWES 2015**"* during 30-31 July, 2015.

Water is indispensable for life and more so for man and society. The demand for water for irrigational and industrial uses also increased correspondingly to meet the requirements of the growing population. The world's water supply is a finite resource and the practice of water reuse helps to conserve it. The societal responsibility to curtail environmental degradation has also heightened.

This provides a platform for the researchers, engineers, managers, policy makers and the academicians to discuss about the advancements in the field of water resources and environment. The final resolutions of the conference can be sent to the perusal of the government for implementation in the field.

I hope this platform brings out new ideas among academic sections and educate every individual in facing this challenge effectively. On this occasion I wish the program a grand success.

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Dr. A. Damodaram
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Professor of Comp. Sc. & Engg., &
Director,
Academic & Planning

MESSAGE

I am glad to learn that the "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing 2nd two day National Conference on *"**Water, Environment and Society — NCWES 2015**"* during 30th -31st July 2015.

The topics covered and sessions are contemporary and experts across the India are likely to bring about interesting discussions during the course of the conference, which will be of great interest to academics, researchers and students of water resources and environment.

This being a thrust area in the field of Civil Engineering, I am confident that the participants will avail this opportunity to enhance their technical knowledge greatly and contribute to the wider utilization of Watershed Management and Impact of Environmental Changes on Water Resources.

I wish the program a grand success.

22/7

(Dr.A. Damodaram)

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B.E. (Civil) M.E., Ph.D., F.I.E., MISTE, MIAH, MIWRS, MISRS, MJOSH
Professor of Civil Engineering &
Officer on Special Duty to VC

MESSAGE

I am very delighted to note that Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a 2^{nd} two day National Conference on "Water, Environment and Society — NCWES 2015" during 30-31, July 2015 with a mission to improve science and art of natural resource conservation.

India is crisscrossed by a large number of small and big rivers, some of them figuring amongst the mighty rivers of the world. Also it is home to rich biodiversity and diverse physiography. However, misconduct of man and seldom mischief of nature are putting enormous pressure on water and environmental wealth.

In wake of increasing awareness on vulnerability of water and environment fostering their protection and conservation gained paramount importance.

This conference offers dialogues to showcase diverse interests on environment, ecosystem and hydrology and strives to explore alternatives and innovations that can lead to greater water use efficiency and environment conservation.

I hope the conference will provide a forum to celebrate past conservation accomplishments as well as share and promote science-based knowledge on critical, current issues to pave way for sustainable future. In this regard I congratulate the organizers and wish the program will be grand success.

Dr. G. K. Viswanadh

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Professor of Chemistry
DIRECTOR

Message

I am pleased to note that the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing 2^{nd} Two Day National Conference on "Water, Environment and Society — NCWES 2015" during 30^{th}-31^{st} July 2015.

The human species which buffers against environmental changes by culture & technology is dependent on flow of ecological services. Globally, environment and water are in peril with increasing pressure from pollution, degradation & overexploitation. This new reality from which there is no escape must be recognized and managed. In this regard education serves to foster innovation & capacity in transferring social ideal to reality.

In this pretext this conference recognizes need for inclusive & environmentally sustained growth for shared prosperity and directed accordingly.

I hope that the outcome of the conference will be very much useful not only to the academic community but also to the field engineers and all others working in the area of water resources engineering and environmental engineering.

I extend my best wishes for the success of the conference.

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Dr. A. Jaya Shree.

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HEAD

Message

I am delighted to inform that the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing 2^{nd} Two Day National Conference on "***Water, Environment and Society — NCWES 2015***" during 30^{th} -31^{st}July 2015.

Water is the vital and essential components for survival of all living beings on the earth. The development of water resources plays a key role in the economic growth of the country. The deficit rains and dwindling water resources and degradation of agricultural lands lead to environmental insecurity impacting on food production and the prices of essential commodities. All these factors ultimately affect the society and livelihood of the people.

It is very appropriate topic in the current scenario of water crises and environmental pollution. I hope the participants will take advantage of this great opportunity to get exposed to recent trends and technical issues in this emerging area of water and environment.

Centre for Water Resources welcomes Environment and Water academicians, practitioners & interested colleagues regardless of discipline and states.

I hope the two day conference program shall be a great success.

Dr. M.V.S.S Giridhar

Acknowledgements

The 2^{nd} two day national conference on Water, Environment and Society NCWES-2015 has been made possible with the support of many technical experts, individuals and organizations both in man power and finance. This support is gratefully acknowledged.

I owe a deep sense of gratitude to Smt. Shailaja Ramaiyer, IAS , Vice-Chancellor, Jawaharlal Nehru Technological University Hyderabad and Chief patron of the conference for her constant encouragement valuable guidance in organizing the conference in most efficient way.

I am very thankful to Prof. T. Kishen Kumar Reddy, Rector, Jawaharlal Nehru Technological University Hyderabad for his precious support as Patron of this 2^{nd} two day conference.

My sincere and special thanks to Dr. N. Yadaiah, Registrar, Jawaharlal Nehru Technological University Hyderabad for his cordial, time to time permissions and support.

I am deeply indebted to Dr. A. Jaya Shree, Director, IST, JNTUH and Chairman of this conference for her constant support and having taken every responsibility for completing this task through various stages.

My grateful thanks are due to Prof. B. Venkateswar Rao, Prof K. Rammohan Reddy and Prof. C. Sarala, Professors of water resources for their valuable support throughout the conference.

My sincere thanks to the officials of Technical Education Quality Improvement Program, Phase-II, IST, ISRO, SINSIL International, SWAN Environmental Pvt. Ltd., State Bank of Hyderabad and JNTUH University for sponsoring this event. Without their help organization of this conference would not have been possible.

The financial assistance received from Research and Development Fund of National Bank for Agriculture and Rural development (NABARD) towards publication of proceedings of the conference is gratefully acknowledged.

We have been very fortunate enough to be backed by a team of very motivated and dedicated experts of various committees in guiding us throughout the conference very meticulously. My sincere thanks to all the members of the Scientific and Advisory Committee, Technical Committee and Organizing Committee for their sincere advice and help from time to time.

I profusely thank all the Key note speakers, Chair persons and Co-chair persons of various technical sessions of conference have readily responded to our invitation to conduct the proceedings and to address the gathering and for their kind gesture in the conference.

I thank all the students of M.Tech (WET) and research scholars who have assisted in every event of conference.

My thanks are also due to various other Teaching and Non-teaching staff of IST and Engineering Staff of JNTUH who have cooperated on several occasions in organizing this Conference.

I sincerely thank M/s BS Publications for bringing out the souvenir and pre-conference proceedings well in advance.

My sincere thanks to all my students Smt. P. Sowmya, Senior Research Fellow, UGC Project, Ms. P.B.Rakhee Sheel, M.Tech students Sri. R. Anirudh, Ms.G. Jalaja, and Ms. K. Divya for their continuous day and night support for this conference.

Finally, I thank all the people and organizations who are directly and indirectly involved in organizing the conference, but I could not mention their names due to paucity of space.

I thank one and all

M.V.S.S. Giridhar
Convener

Contents

THEME - I

Hydrologic Parameter Estimation and Modeling

THEME - I

Hydrologic Parameter Estimation and Modeling

Regional Flood Frequency Analysis using Parametric Estimation Methods

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ABSTRACT

Extreme floods are often associated with loss of life and cause severe impact to agricultural production and infrastructures. In this study, regional frequency analyses of annual maximum series of flood events from Godavari and Krishna rivers were conducted. This includes data screening, outlier analysis, identification of homogenous regions, development of regional growth curves and regression models to estimate the quantile floods for ungauged catchments. The study area comprises of 32 gauging stations in the Lower Godavari basin with 30 years of daily stream flow data and 39 gauging stations in the Upper Krishna basin with 30 years of daily stream flow data. The choice of an appropriate regional flood frequency distribution was performed based on L-Moment approach together with the index flood procedures and Goodness of fit (GOF) tests. The Generalized Extreme value distribution (GEV) was found to be the suitable distribution for annual maximum series of flood in Godavari and Krishna river basins. Regional growth curves were plotted using L-Rap software and the regional homogeneity was checked by using L-moment ratio plot. L-moment parameters such as L-Mean, L-Coefficient of variation, L-Skewnessand L-Kurtosis were computed. However efficient estimations of the magnitude of such extreme events with their non-exceedance probabilities either for design or for risk management planning purposes are often limited by the data availability i.e. both in quality and quantity.

Keywords: Floods, L-moments, outlier analysis, Goodness of fit, Generalized extreme value distribution, L-Moment ratio plot, and Regional growth curves.

INTRODUCTION

Floods can be estimated using several methods, dependent upon the structure being designed or analysed, and the size of the watershed. Approaches to flood hydrology include deterministic, probabilistic, conceptual or parametric analysis. The estimation of accurate magnitude of flood has remained one of the problematic issues where hydrological data and information are either limited or not available. For sites where data are not available, the analysis is based on the regionally available data. For sites with available data, the joint use of at-site data and regional data from number of other stations of that region provides sufficient information to enable a probability distribution to be used with greater reliability. This type of analysis represents a substitution of space for time where data from different locations in a region are used to compensate for short records at a single site.

The study area is Godavari and Krishna regions. The Godavari basin lies between 16º 16’ and 23º 43’ North latitudes and 73º 26’ and 83º 07’ East Longitudes. Krishnabasin lies between 13º 07’ and 19º 20’ North longitudes and 73º 22’ and 81º 10’ East latitudes. The study consists of determining outliers from the data and choose a distribution using chi square goodness of fit test for the data. Hosking and Wallis and Jenkinson Showed that the General Extreme Value distribution was found to give better results especially in Regional flood frequency analysis.

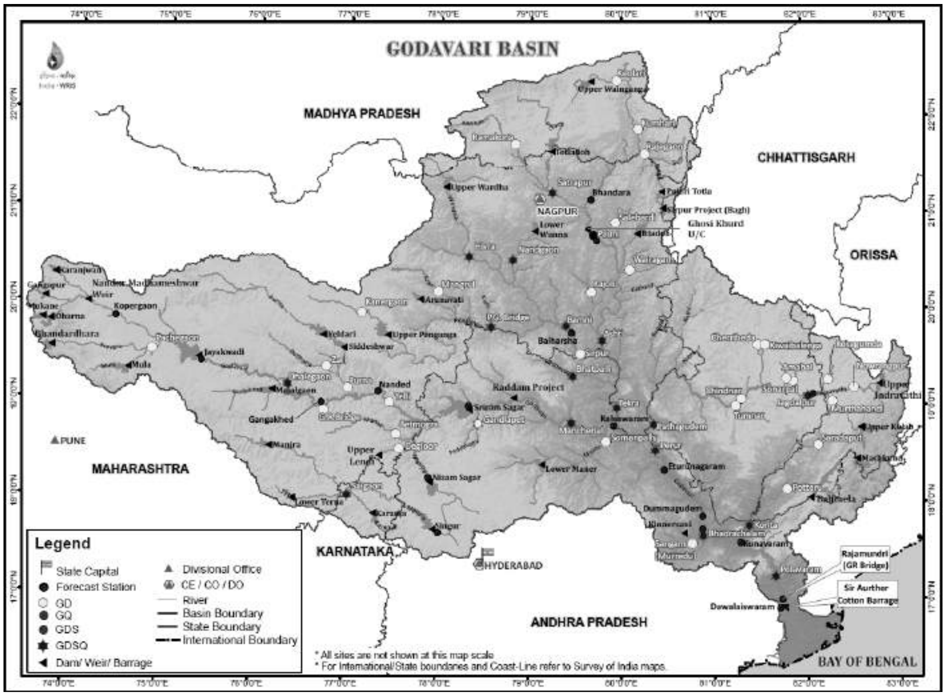

Figure 1. Godavari basin

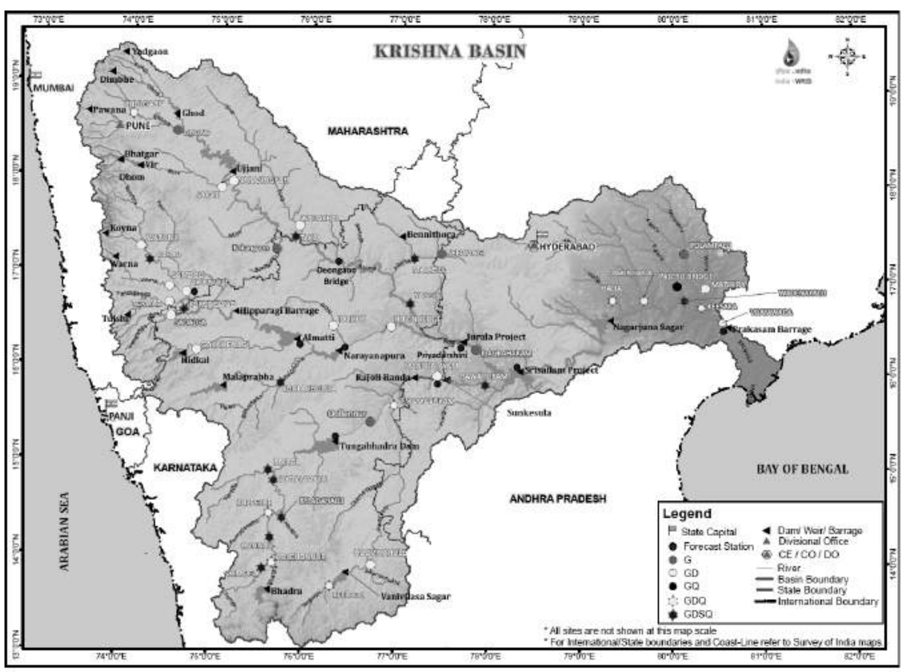

Figure 2. Krishna basin

PARAMETRICESTIMATION METHODS

After selecting General Extreme Value distribution its parameters such as location parameter, Scale parameter and Shape parameter are estimated by Method of Moments, Method of likelihood, Probability Weighted moments and L-Moments.The Method of Moments (MOM) is a natural and relatively easy parameter estimation method. However, MOM estimates are usually inferior in quality and generally are not as efficient as the ML estimates, especially for distributions with large number of parameters (three or more), because higher order moments are more likely to be highly biased in relatively small samples.

The Maximum Likelihood Method (MLM) is considered the most efficient method since it provides the smallest sampling variance of the estimated parameters, and hence of the estimated quantiles, compared to other methods. Also, the ML method has the disadvantage of frequently giving biased estimates, but these biases can be corrected. Furthermore, it may not be possible to get Estimates with small samples, especially if the number of parameters is large. The Probability-Weighted Moments (PWM) method, which has been investigated by many researchers, was originally proposed by Greenwood et al. Since then it has been used widely in practice and for research purposes. Hosking et al investigated the properties of parameters estimated by the PWM method for the Generalized Extreme Value (GEV) distribution using fairly long observed series, and they gave a good summary of the PWM method. Hosking et al. showed that the PWMmethod is superior to the Maximum-Likelihood (ML) method in parameter estimations when the Extreme Value Distribution is used for longer return periods.

The method of probability weighted moments (PWM) is widely used in practice and research. This method makes use of the analytical relationships among the parameters and the so-called Probability-Weighted Moments of a probability distribution in calculating magnitudes for the parameters. For a 3-parameter distribution, the zeroth, first, and second Probability-Weighted Moments of the distribution (population) are estimated out of the available sample series by approximating either the probability of exceedance or the probability of non-exceedance of each element in the sample series by a suitable plotting position formula. Next, the magnitudes of the parameters are computed as the roots of the equations formed by equating the analytical expressions for the population Probability Weighted Moments to their numerical estimates calculated from the recorded sample series. If the number of parameters is more than three, as with the Wakeby distribution. For example, it is continued to calculate higher order Probability-Weighted Moments until the number of equations is equal to the number of parameters.(Rao and Hamed, 1997)

Where i is the rank and X_i is the flow corresponding to that site i and N is the sample size. The formula used was Hosking plotting position formula. Solving these for α, μ and k is very difficult. Hosking gave an approximation as Equation (1).

$$C = \frac{2M110 - M100}{3M120 - M100} - \frac{\log 2}{\log 3} \tag{1}$$

The shape, scale and location parameter of the GEV distribution are calculated using Equations 2, 3 and 4.

$$k = 7.8590\, C + 2.9554 C^2 \tag{2}$$

$$\mu = \frac{(2M110 - M100)K}{r(1+K) * \left(1 - \left(2^{-K}\right)\right)} \tag{3}$$

$$\alpha = \mu + \frac{\alpha}{k}\left(\left(1+K\right) - 1\right) \tag{4}$$

The magnitude of flood using GEV distribution is calculated by Equation 5.

$$X_T = \mu + \frac{\alpha}{k} 1 - \left(-\log\left(1 - \frac{1}{T}\right)\right) K \tag{5}$$

L-moments method can be considered similar as L-moments statistics can be obtained by simpler linear expressions. It uses only GEV distribution to develop Regional flood frequency relationships for T year flood and does not require the determination of frequency ratios. First L-moments is the measure of location, second moment is the measure of dispersion of data values about their mean. By dividing the higher order L-moments by the dispersion measure we obtain the L-moments ratios which are dimensionless quantities. L-CV is the measure of dispersion, L-CS is the measure of Skewness and L-CK is the measure of Kurtosis which refers to the weight of the tail of the distribution.

L-moments obtain their name from their construction as linear combinations of order statistics. They are a dramatic improvement over conventional product moment statistics for characterising the shape of a probability distribution and estimating the distribution parameters particularly for environmental data where sample sizes are very small. (Hosking and Wallis, 1997). L-moments are defined to be the expected values of these linear combination multiplied for numerical convenience by scalar constants. The "L" in L-moments emphasizes the construction of L-moments from linear combination so for derstatistics. L-CV and the L-moments ratios t_3 and t_4 are the most useful quantities for summarizing probability distributions. Their most important properties are

If the mean of the distribution exists then all of the L-moments exist. If the mean of the distribution exists then the L-moments uniquely define the distribution, i.e. no two distributions have same L-moments. These are an alternative system of describing the shapes of probability distributions. Historically they arose as modifications of the probability weighted moments.

In terms of probability weighted moments L-moments are given by Equations 6-9.

$$L_1 = b_0 \quad (6)$$

$$L_2 = 2b_1 - b_0 \quad (7)$$

$$L_3 = 6b_2 - 6b_1 + b_0 \quad (8)$$

$$L_4 = 20b_3 - 30b_2 + 12b_1 - b_0 \quad (9)$$

The probability weighted moments are given by Equations 10-13.

$$b_0 = \frac{1}{n}\sum_{j=1}^{n} x_j \quad (10)$$

$$b_1 = \frac{1}{n}\sum_{j=2}^{n} x_j \left(\frac{J-1}{n-1}\right) \quad (11)$$

$$b_2 = \frac{1}{n}\sum_{j=3}^{n} \frac{x_j (j-1)*(j-2)}{(n-1)*(n-2)} \quad (12)$$

$$b_3 = \frac{1}{n}\sum_{j=4}^{n} x_j * \frac{(j-1)*(j-2)*(j-3)}{(n-1)*(n-2)*(n-3)} \quad (13)$$

The L-Moment parameters such as L-Mean, L-CV are given by Equations 14-17.

L-Mean = L_1 (14)
L-CV (t_2) = L_2/L (15)
L-Skewness (t_3) = L_3/L_1 (16)
L-kurtosis (t_4) = L_4/L_2 (17)

L-Moment Ratio Diagram

To test the regional homogeneity of the study area L-Moment ratio diagram was plotted for various stations between L-Skewness and L-Kurtosis which shows all the stations in the study with in it. The aim of L-Moment diagram was to choose the distribution that gives the best fit to the data. The stations can be recommended for regional flood frequency analysis. These stations belong to one homogeneous region shown in figures 3for the study.

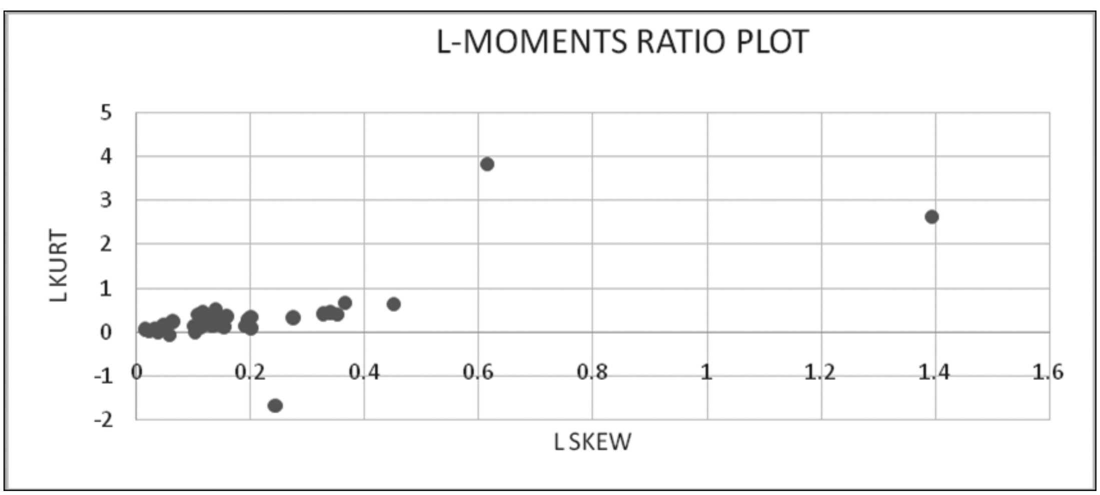

Figure 3. Godavari basin

REGIONAL GROWTH CURVES

In large regions that are homogeneous with respect to flood producing characteristics, individual streams, whose drainage areas vastly differ in size have frequency curves of approximately equal slope if the discharge is expressed as a ratio of the mean. The flood peaks at each gauging station are divided by an index flood which is often taken as the mean annual flood at the station and are thus reduced to dimensionless ratios. The individual curves plotted using the flood ratios can be superimposed and will nearly coincide. (Singh, 1988).

Flood frequency curves describe the relationship between the magnitude of river peak flows and the recurrence interval or return period. They can be derived from data at flow monitoring stations and regionalized for use at any location along the basin’s river network, by relating the spatial differences to geographical regions and to variations in upstream sub basin characteristics inside each region. This availability is important for flood risk management.

RESULTS AND CONCLUSIONS

The basic conclusions that are drawn from the present study can be summarized as follows:

- Using the Goodness of Fit test for all the stations the probability distribution selected was the Generalized Extreme Value (GEV) distribution.
- Parameters of the distribution were analysed by L-moments were found to be less biased.
- Regionalisation provides valuable information even in possibly heterogeneous regions and regional analysis is more accurate and flexible than single site analysis particularly at higher extreme quantiles.
- Regression analysis shows that the relationship between mean annual peak discharge and catchment area is very strong in Godavari region.
- Flood quantiles for various return periods were computed by probability weighted moments
- The homogeneity of the study area was tested by L-moment ratio diagram.
- Regional growth curves were plotted from which flood can be predicted at ungauged station.
- L-RAP was used to estimate various regional growth curves for several distributions not only for Generalized Extreme Value distribution.

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Rainfall-Runoff Modeling With HEC-HMS

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ABSTRACT

Hydrological modeling is a commonly used tool to estimate the basin's hydrological response to precipitation. HEC-HMS model is used to simulate rainfall-runoff modelling for catchment of Wan reservoir, Akola, Maharashtra. To compute runoff, Peak runoff rate, base flow and flow routing methods SCS curve number, Clark unit hydrograph, Recession and Muskingum-Cunge routing methods were chosen, respectively. Rainfall runoff simulation is conducted using 33 rain event data. Out of these, 12 events were selected for model calibration, 09 for model validation and remaining 12 for prediction. To judge the performance of model, statistical tests of error functions like Root mean square error (RMSE), Nash Sutcliffe coefficient $\left(R^2 NS\right)$ and coefficient of residual mass (CRM) were selected. Curve number (CN), Initial abstraction (I_a), Time of concentration (T_c), Initial base flow (Q_o), Recession constant (R_c), and Threshold flow (Q_t) were the model parameters which were fixed as 61.47, 32.20, 10.50, 5.07, 6.38, 1.0 and 0.25, respectively, for catchment of Wan reservoir. The model performed well in terms of RMSE, $\left(R^2 NS\right)$, CRM (1.40 mm day^{-1}, 0.89 and - 0.11). Considering the performance of model in simulating the runoff, it is suggested that the calibrated HEC-HMS model could be used to predict runoff for the rainfall events over catchment of Wan reservoir.

Keywords: DEM, HEC-GeoHMS, HEC-HMS, Event based, Hydrologic Modeling, catchment of Wan reservoir.

INTRODUCTION

"Water is the elixir of life. Without it life is not possible" (Fetter, 2000). An increasing urbanization and per-capita demand, the water demands of domestic, industrial and other sectors are expected to increase and the country will face water scarcity if adequate and sustainable water management initiatives are not implemented. One of the most widely used techniques for estimating direct runoff depths from storm rainfall is the United States Department of Agriculture (USDA) Soil Conservation Service's (SCS) curve number (CN) method. However, it requires a detailed knowledge of several important properties of the watershed which may not be readily available. HEC-HMS is designed to simulate the precipitation runoff processes of watershed systems in a wide range of geographic areas such as large river basins and small urban or natural watersheds. HEC-HMS uses separate models to represent each component of the runoff process including models that compute runoff volume, direct runoff, and base flow.

Several studies [Yusop *et al.* (2007), Yenar *et al*. (2008), Chu and Stenman (2009); Arekhi (2012), Majidi and Shahedi (2012), Sardoii *et al*. (2012), Halwatura and Najim (2013), Majidi and Vagharfard (2013)] proved the capability of HEC-HMS model in accurately simulating rainfall runoff process in different regions under different soil and climatic conditions. Wan reservoir project is located at village Wan, Taluka Telhara, Distt. Akola on river Wan, a tributary of Purna river. It is multipurpose major project with objective of irrigation, hydroelectricity and drinking water supply. The total length of dam, including spillway is 500 m and height of dam above lowest foundation is 67.65 m. Catchment area of Wan Reservoir is spread over 278.94 km^2. Maximum/Gross storage capacity of Wan Reservoir is 83.465 MCM, while live storage capacity is 81.955 MCM. Region to region climate, geography and physical properties of watershed changes and because of it, basin response to the rainfall event accordingly changes. Thus, it has become inevitable to determine rainfall-runoff model and the model parameters for a particular watershed (Halwatura and Najim, 2013).

MATERIAL AND METHODS

Wan river, a tributary of Purnariver, forms the part of northwest boundary of Akola district of Maharashtra State of India, after entering from Amravati district. The basin of wan river is spread over 173.65 km^2 in Melghat Tiger Reserve Project in Satpura ranges, Amravati district of Maharashtra State.

2.1 DATA COLLECTION

2.1.1 R-R model using HEC HMS

The data required to build a HEC-HMS model are elevation, land cover, percent impervious area, soil and hydrography information. These datasets were used to determine stream/subbasin characteristics and hydrologic parameter estimations.

2.1.2 R-R data for basin

Rainfall is observed at four stations in the basin viz. Wari Bhairavgarh, Wan Road Station, Kelpani and Khatkali.

2.1.3 Topography of basin

The DEM obtained have a resolution of 1/3 arc-second (approximately 10 m). The DEM clears that there is 544 m elevation difference between the highest and lowest point of basin.

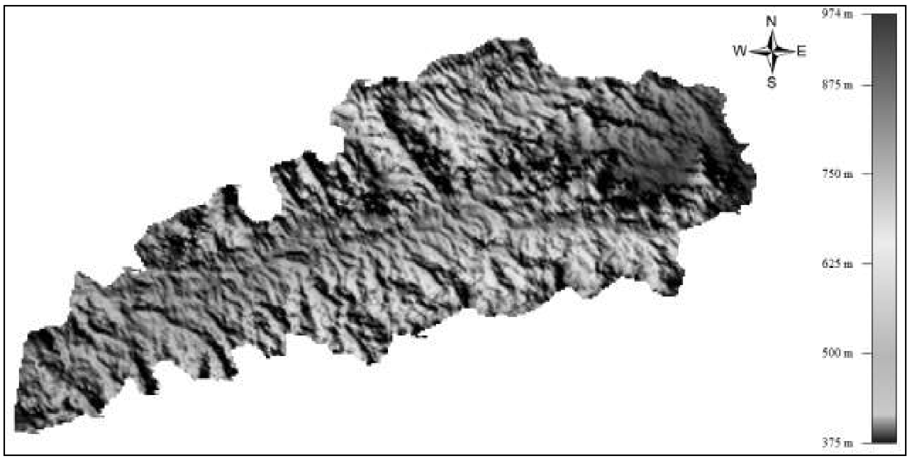

Figure 1 Topography (DEM) of catchment of Wan reservoir.

2.1.4 Soils of basin

Spatial soil map (shape file) for basin was obtained from MRSAC, Nagpur.

2.1.5 Land use land cover pattern of basin

The detail spatial ‘land use land cover (LULC)’ map for basin was also obtained from MRSAC, Nagpur. LULC map divides the area of basin as Dense forest, agriculture, water bodies, built up, wastelands and forest.

2.2 PREPROCESSING OF DATA

‘Terrain Processing’ menu in HEC-GeoHMS was used to process raw DEM. The steps or processes in terrain processing and watershed delineation are described briefly in following sections.

2.2.1 DEM Reconditioning

To ensure that the true channel is represented and flow is conveyed along the channel, the elevations of cells in the raw DEM that coincide with flow lines contained in the hydrography shapefile were artificially lowered. This was done using the ‘DEM Reconditioning tool’.

2.2.2 Fill Sink

‘Fill Sink’ tool was used to fill any potential sinks contained with the raw DEM or created during the reconditioning process. The resulting DEM (Fig. 2) is hereafter referred as hydro DEM.

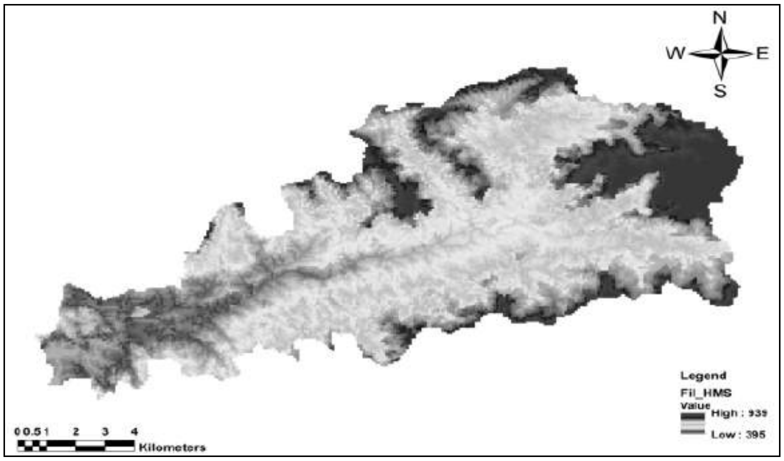

Figure 2 Hydro DEM for catchment of Wan reservoir.

2.2.3 Flow Direction

The hydro DEM was used to determine the flow direction within each cell using ‘Flow Direction’ tool. This tool determines the steepest descent within each cell within the hydro DEM and create a new raster which assigns a flow direction ID for each cell as 1 (east), 2 (southeast), 4 (south), 8 (southwest), 16 (west), 32 (northwest), 64 (north) and 128 (northeast).

2.2.4 Flow Accumulation

A flow accumulation grid was created using ‘Flow Accumulation’ tool and flow direction grid. The number associated with a cell in the flow accumulation grid represents the total number of cells draining to that specific cell.

2.2.5 Stream Definition

A stream network grid was defined using flow accumulation grid and a user-specified threshold. The threshold defines the flow accumulation needed before a stream is initiated. The 1% default for threshold was used in the ‘Stream Definition’ tool to create the stream network grid.

2.2.6 Stream Segmentation

A segmented version of the stream network grid was created using the ‘Stream Segmentation’ tool. This segmented stream network grid creates the initial reaches for the HEC-HMS hydrologic model.

2.2.7 Catchment Grid Delineation

A subbasin (catchment) grid was created from the flow accumulation grid and segmented stream network grid using ‘Catchment Grid Delineation’ tool. This creates an initial gridded form of subbasins for HEC-HMS hydrologic model. Fifty-three subbasins were created within basin of Wan river basin.

2.2.8 Catchment Polygon Processing

The subbasin grid was converted to a polygon shapefile through the Catchment Polygon Processing tool.

2.2.9 Drainage Line Processing

The drainage line shapefile was created within a geodatabase to comply with ArcGIS structuring and avoid errors.

2.2.10 Watershed Aggregation

The last step before creating a HEC-HMS project within ArcGIS was to combine the upstream subbasins at every stream confluence using the ‘Watershed Aggregation’ tool

2.3 HEC-HMS PROJECT SETUP IN HEC-GEOHMS

2.3.1 Basin Processing

This created 53 subbasins within the Wan river basin for use in the final HEC-HMS hydrologic model. The area for all subbasins was recalculated and stored in the subbasin attribute table.

2.3.2 Stream and Watershed Characteristics

(i) The length of each reach was determined by the 'River Length' tool. The units are taken to be the units of the DEM, which is a meter for this study.

(ii) 'River Slope' tool calculated river slope by using the upstream and downstream elevation and length of each reach.

(iii) The 'Slope' tool finds the slope at each cell, while the 'Basin Slope' tool finds the average slope across a subbasin. The basin slope was used to determine the CN lag time parameter if used in the hydrologic model.

(iv) the longest flow paths were created using the 'Interactive Longest Flow Path' tool. Using interactive tool, the approximate upstream location of the longest flow path was selected.

2.3.3 Hydrologic Parameter Estimation

This program assisted in estimating a number of parameters for the loss methods, Muskingun-Cunge and kinematic wave routing parameters, subbasin time of concentration, and subbasin lag time.

2.4 HEC-HMS MODEL SETUP

HEC-GeoHMS has the ability to set up the model files needed for HEC-HMS.

2.4.1 Basin Model

A basin model in HEC-HMS describes the physical representation of watersheds and river channels (Fig. 3).

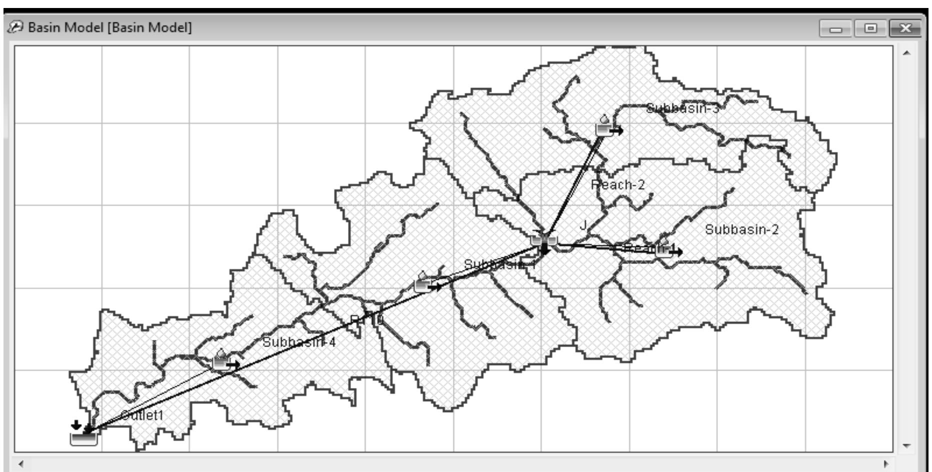

Figure 3 HEC-HMS schematic of Wan river basin

3.6 MODEL CALIBRATION AND VALIDATION

Runoff depths for events *i.e,*. 29th June 2013 to 10th July 2013 were used for calibration of HEC-HMS model for entire catchment of Wan reservoir. During calibration the following parameters were adjusted.

(i) Curve number (CN),

(ii) Initial abstraction (I_a),

(iii) Time of concentration (T_c),

(iv) Initial base flow (Q_o),

(v) Recession constant (R_c), and

(vi) Threshold flow (Q_t)

The calibrated model was finally validated using data of two years *i.e.*, 02th August 2013 to 10th August 2013. Here also, the model performance was evaluated by comparing observed and simulated runoff depths.

3.6.1. Performance criteria

To evaluate the performance of model, the simulated data was compared with observed ones. As suggested by ASCE Task Committee (ASCE, 1993a) on hydrological modeling, Root Mean Square Error (RMSE), Nash-Sutcliffe coefficient and Coefficient of Residual Mass (CRM).

3.6.2 Prediction of runoff

Using validated HEC-HMS model, runoff for catchment of Wan reservoir was predicted for the event 28th August 2013 to 04st September 2013.

3. RESULT AND DISCUSSION

3.1 CALIBRATION AND VALIDATION OF HEC-HMS MODEL FOR CATCHMENT OF WAN RESERVOIR

3.1.1 Calibration of HEC- HMS model

To judge the performance of model, observed runoff was compared with simulated output. Comparison of observed and simulated runoff is presented in Figure 4 depicts model generated runoff hydrograph.

The observed and simulated runoff varied between 00.00 to 81.34 m over calibration period. Value of RMSE, Nash Sutcliffe coefficient (R^2NS) and coefficient of residual mass (CRM) were observed as 1.40 mm day^{-1}, 0.89 and - 0.11, respectively. Model overall slightly overestimated the runoff, as indicated by negative value of CRM. Value of R^2NS close to 1 indicates that the model simulated runoff accurately.

Temporal variation of observed and simulated runoff is depicted in Fig. 4, while Fig. 5 depicts ccomparison of observed and simulated runoff over calibration period.

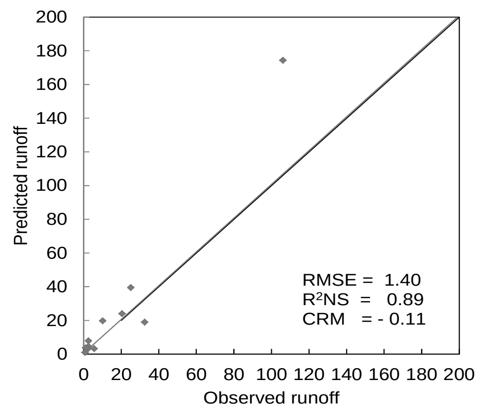

Figure 4 Temporal variation of observed and simulated runoff over calibration period.

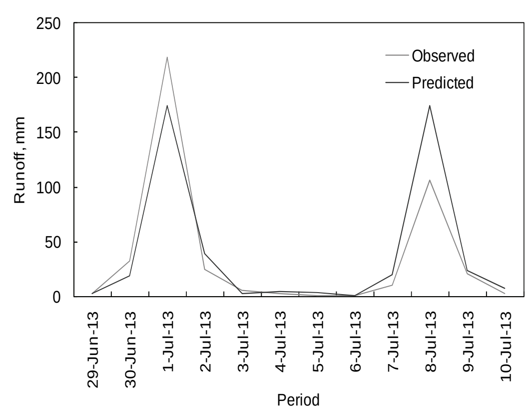

Figure 5 Comparison of observed and simulated runoff over calibration period.

Fig. 4 clears that the observed and simulated runoff over calibration period are in close match at outlet of the command. It is seen from scattered plot *i.e.* Fig. 5, that the runoff lie on both sides of 1:1 line, which shows that there is no consistent over or under estimation.

Above results confirmed that the observed and simulated runoff matched well. RMSE, R^2NS and CRM statistics were also acceptable. Hence, the model setup was considered as calibrated. Thus, the model parameters for sub-basin 1, sub-basin 2, sub-basin 3 and sub-basin 4 are presented in Table 1.

Table 1. Calibrated model parameters for Sub-basin 1, 2, 3 and 4

Description	sub-basin 1	Sub-basin 2	sub-basin 3	sub-basin 4
(i) Curve number (CN),	53.78	60.80	62.06	61.47
(ii) Initial abstraction (Ia),	19.80	37.00	40.70	32.20
(iii) Time of concentration (Tc),	10.54	13.74	18.94	10.50
(iv) Storage coefficient	05.28	07.54	08.12	05.07
(v) Initial base flow (Qo),	06.88	04.97	10.81	06.38
(vi) Recession constant (Rc),	01.00	01.00	01.00	01.00
(vii) Threshold flow (Qt)	00.23	00.25	00.20	00.25

3.1.2 Validation of HEC-HMS model

The observed and simulated runoff varied between 00.00 to 81.34 m over validation period. Value of RMSE, R^2NS and CRM were found as 0.64 mm day^{-1}, 0.91 and -0.44, respectively. As value of CRM are negative, indicating that the simulated runoff was overestimated by the model.

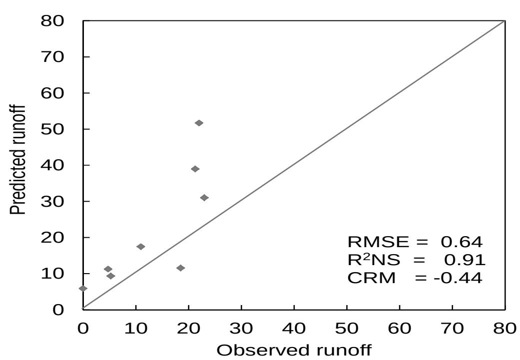

Figure 6 Temporal variation of observed and simulated runoff over validation period

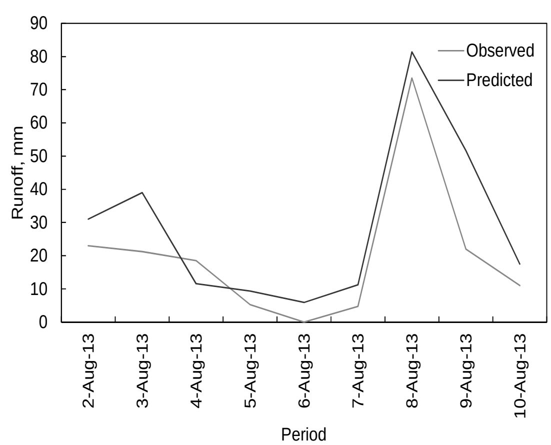

Figure 7 Comparison of observed and simulated runoff over validation period

Fig. 6 clears that the observed and simulated runoff for validation period are in close match. It is seen from Fig. 7 that the runoff lie on both sides of 1:1 line, which shows that there is no consistent over or under estimation over validation period. As RMSE, R^2_{NS} and CRM statistics were acceptable, the HEC-HMS model, as such, was accepted as validated.

3.1.3 Prediction of runoff using validated HEC-HMS model

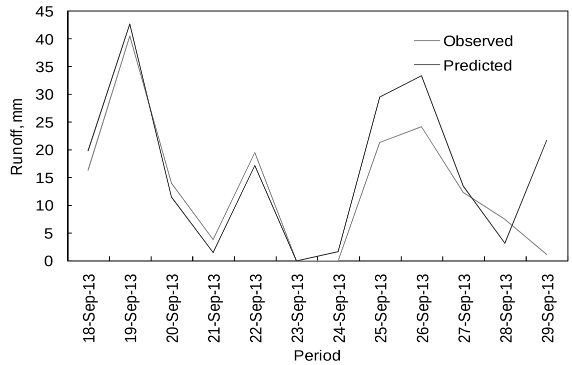

Figure 8 Temporal variation of observed and simulated runoff over prediction period

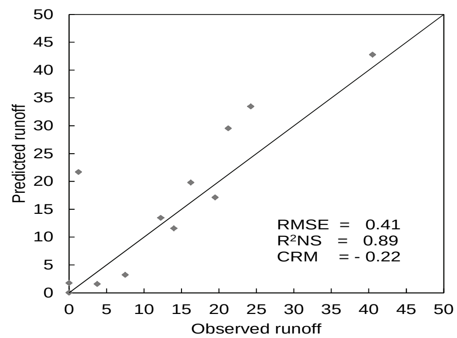

Figure 9 Comparison of observed and simulated runoff over prediction period

Fig. 8 clears that the observed and simulated runoff are in close match over prediction period. It is supported by statistical parameters *i.e.* RMSE, R^2NS and CRM in acceptable limit.

CONCLUSIONS

HEC-HMS model proved its capability in simulating runoff for catchment of Wan reservoir. The calibrated model parameters i.e. Curve number (CN), Initial abstraction (Ia), Time of concentration (Tc), Initial base flow (Qo), Recession constant (Rc), and Threshold flow (Qt) were observed as 61.47, 32.20, 10.50, 05.07, 06.38, 01.00 and 00.25, respectively, for catchment of Wan reservoir. Considering the performance of model in simulating the runoff, it is suggested that calibrated HEC-HMS model could be used to predict runoff for the rainfall events over catchment of Wan reservoir.

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Estimation of Reference Evapotranspiration using various Methods

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ABSTRACT

The temporal and spatial variation in evapotranspiration values could have been influenced by location specific measurement conditions or by bias in weather data collection. The reference evapotranspiration (ETo) was estimated using four ETo estimation methods *i.e.,* Pan evaporation model (Epan), Hargreaves-Samani Model (H-S), Blaney-Criddle (B-C) and Penman-Monteith (PM-56) for Akola (Maharashtra) and then compared using statistical indices. Based on good correlation and lower RMSE value, Penman Montieth FAO-56 and Pan model (Epan) is recommended to estimate ETo for Akola station.

INTRODUCTION

The concept of the reference evapotranspiration (ETo) was introduced to study the evaporative demand of the atmosphere independently of crop type, crop development and management practices. It reflects the impact of weather conditions on evaporation and transpiration. The evapotranspiration rate from a reference surface of 12 cm tall green crop with fixed surface resistance of 70 s/m, and albedo of 0.23, completely shading the ground and not short of water is called reference crop evapotranspiration (FAO-56).

Evapotranspiration plays an important role in establishing of appropriate irrigation scheduling. Evapotranspiration (ETo) is a complex and non-linear process. ETo is commonly estimated by indirect methods, either physically-based equations (Penman, Penman-Monteith, *etc*.) or empirical relationships between meteorological variables (*e.g.* Hargreaves, Hargreaves-Samani, Blaney-Criddle, *etc*.). Empirical and semi-empirical models reported in literature are based on relationships between evapotranspiration and a limited number of meteorological variables. A large number of empirical formulae relating ETo to standard climatological data have been developed. The FAO group of scientist on crop water requirement screened 31 empirical formulae for prediction of ETo and recommended only five ETo estimation methods *i.e.* Pan evaporation model (Epan), Hargreaves-Samani Model (H-S), Blaney-Criddle (B-C), Priestley Teylor and Penman-Monteith (PM-56). Numerous researchers analyzed the performance of the different methods/models of predicting ETo for different locations. The results of such analysis cleared that the temporal and spatial variation in ETo values could have been influenced by location specific measurement conditions or by bias in weather data collection. It became evident that the existing methods do not behave the same way at different locations around the world. Therefore, there is a need to develop area based relationship for determination of reference evapotranspiration. Hence a study is undertaken with an objective to estimate reference evapotranspiration using different available models for Akola (Maharashtra).

MATERIAL AND METHODS

Study Area

Akola is situated in subtropical zone (Agro-climatic zone VII) at $20^0$41’N latitude and $77^0$02’E longitude. The average annual rainfall at Akola is 750 mm.

Data collection

The climatic data *i.e.* temperature (maximum and minimum), relative humidity (maximum and minimum), wind speed, solar radiation, actual sunshine hours and pan evaporation that influences reference evapotranspiration was collected from Agricultural Meteorological Observatory, Dr. P.D.K.V., Akola for the period of 10 years *i.e.* 1997-2007 except 2004.

Models used for estimation of evapotranspiration

The details of models used in the study to estimate reference evapotranspiration are as

1) Pan evaporation model (Epan)

This method is also known as FAO 24 Pan Evaporation (24-PAN) method. The data from 'USDA- class A' pan was used for analysis.

$$ET_0 = E_{pan} \times K_p \quad (1)$$

where,

ET_0 = Reference evapotranspiration, mm/day,

K_p = Pan coefficient, (0.7) and

E_{pan} = Pan evaporation, mm/day.

2) Hargreaves-Samani (H-S) model

The Hargreaves-Samani model was adopted for use by FAO for areas where air temperature is the only available variable. The form of Hargreaves-Samani model presented in FAO-56 by Allen *et al.* (1998) is as:

$$ET_o = 0.0023\,(T_{mean}+17.8)\,(T_{max} - T_{min})^{0.5}\,R_a \quad (2)$$

where,

ET_o = Reference evapotranspiration, (mm/day),

T_{mean} = Mean air temperature, (°C),

T_{max} = Daily maximum temperature, (°C),

T_{min} = Daily minimum temperature, (°C) and

R_a = Daily extraterrestrial radiation (MJ/m^2/day).

3) Blaney-Criddle model (B-C)

Blaney and Criddle developed model for estimation of reference evapotranspiration for arid farmlands of Western U.S.A. For daily calculation of the reference evapotranspiration, the Blaney-Criddle model was revised by Jensen *et al.*, (1990) and is as follows.

$$ET_0 = a + b*f \quad (3)$$

where,

f = p(0.46 T + 8.l3),

a = 0.00430 .RH_{min} - n/N-1.41,

b = [0.908-0.00483 RH_{min}+0.7949* n /N + 0.786* (In (U_d+1))] – [0.0038 RH_{min} n/N – 0.0004430 RH_{min} *U_d + 0.28*(In (n /N + 1))] – [0.0975 (In (U_d+ 1)*(In(RH_{min}+l))^2]* [In (n/N+1)].

ET_0 = Reference evapotranspiration, (mm/day),

P = Mean percentage of annual daytime, (hours),

T = Mean air temperature, (°C),

RH_{mm} = Minimum relative humidity, (%),

n / N = Ratio of possible to actual sunshine, (hours) and

U_d = Daytime wind speed at 2 m height, (m/s).

4) Penman-Monteith model (FAO - 56)

Penman-Monteith (FAO-56) model will be used as standard reference at United Nations, Food and Agriculture Organization (FAO). The Penman family of models is generally considered among the most accurate ET models in virtually any climate. The Penman Monteith (FAO - 56) equation is given as:

$$ETO = \frac{0.408\Delta\left(R_n - G\right) + \gamma \frac{900}{T + 273}\left(e_s - e_a\right)}{\Delta + \gamma\left(1 + 0.34u_2\right)} \quad (4)$$

where,

ET_0 = Reference evapotranspiration, (mm/day),

R_n = Net radiation at the crop surface, (MJ/m^2/day),

G = Soil heat flux density, (MJ/m^{2}day),

T = Mean daily air temperature at 2 m height, (^{o}C),

Δ = Slope of vapour pressure curve, (k Pa/^{o}C),

e_s = Saturation vapour pressure, (k Pa)

e_a = Actual vapour pressure, (k Pa)

$e_s - e_a$ = Saturation vapour pressure deficit, (k Pa)

γ = Psychometric constant, (k Pa/^{o}C)

U_2 = Wind speed at 2 m height, (m/s)

Statistical indices used:

To compare the performance of different models used for estimation of evapotranspiration following statistical indices were used

a) Root mean square error (RMSE)

Root mean square error (RMSE) between standard method and rest four methods was used as indicator of accuracy and reliability of both equations. RMSE could reflect the estimated sensitivity and extreme effect of samples. RMSE is determined as follows:

$$RMSE = \sqrt{\frac{\Sigma\left(P_i - O_i\right)^2}{N}} \quad (5)$$

where,

N = Number of observations,

P_i = Estimation of reference evapotranspiration by different methods and

O_i = Reference evapotranspiration estimated by (FAO-56) equation.

b) Coefficient of correlation (r)

Correlation coefficient was used to check the correlation of different methods with Penman Montieth method

$$r = \frac{\left[\Sigma\left(X_i - X\right)\left(Y_i - Y\right)\right]^2}{\sqrt{\left[\Sigma\left(X_i - X\right)^2 \Sigma\left(Y_i - Y\right)^2\right]}} \quad (6)$$

where,

X_i and Y_i = ith actual and estimated data,

X and Y = Average of the data arrays of Xi and Yi.

RESULTS AND DISCUSSION

Daily reference evapotranspiration (ET_O) using daily climatic data for last 10 years *i.e.,* 1997-2007 except 2004 collected from Agricultural Meteorological Observatory, Dr. P.D.K.V., Akola is estimated and discussed below.

Daily reference evapotranspiration (ETo)

The average annual daily estimated value of reference evapotranspiration (ETo) with different models are presented in table 1 and depicted in figure 1. From Fig. 1, it is cleared that average annual daily ET_o values are over estimated by Blanney-Criddle models. The daily ETo values estimated with Hargreaves – samani model varies significantly from that estimated with penman montieth and pan evaporation model (Fig. 2); while the average annual daily ET_o values estimated with penman montieth, pan evaporation and Hargreaves – Samani model are at par.

Table 1. Average value of ETo for year 1997-2007 except 2004

Year	Evapotranspiration values estimated with different models, mm day^{-1}			
	ETopm	**ETopan**	**ETohs**	**ETobc**
1997	5.20	4.90	5.14	6.46
1998	5.05	4.80	5.11	6.65
1999	4.91	4.40	5.11	6.77
2000	5.22	5.00	5.27	7.05
2001	5.05	4.88	5.18	6.94
2002	5.28	5.17	5.29	7.15
2003	5.13	4.99	5.03	6.97
2005	4.08	5.23	5.12	6.41
2006	4.05	4.69	4.96	6.25
2007	4.30	4.88	5.16	6.20

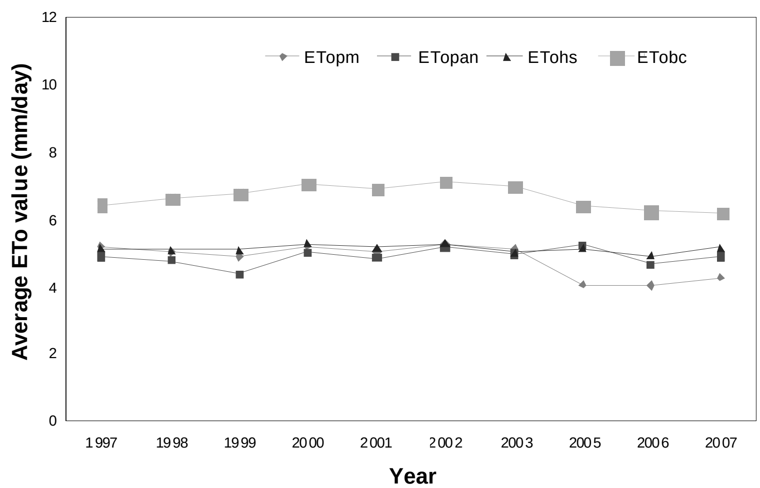

Figure 1. Average annual estimated daily evapotranspiration at Akola by using PM, Pan, H-S and B-C models

Statistical analysis

Values of root mean square error (RMSE) and coefficient of correlation (R) are presented in table 2. The value of correlation coefficient between the Pan and Penman-Monteith model was maximum (0.92). The high value of correlation coefficient indicates good correlation between these two models. The value of RMSE was observed less for pan method as compared to other methods. Smaller value of RMSE means more accuracy.

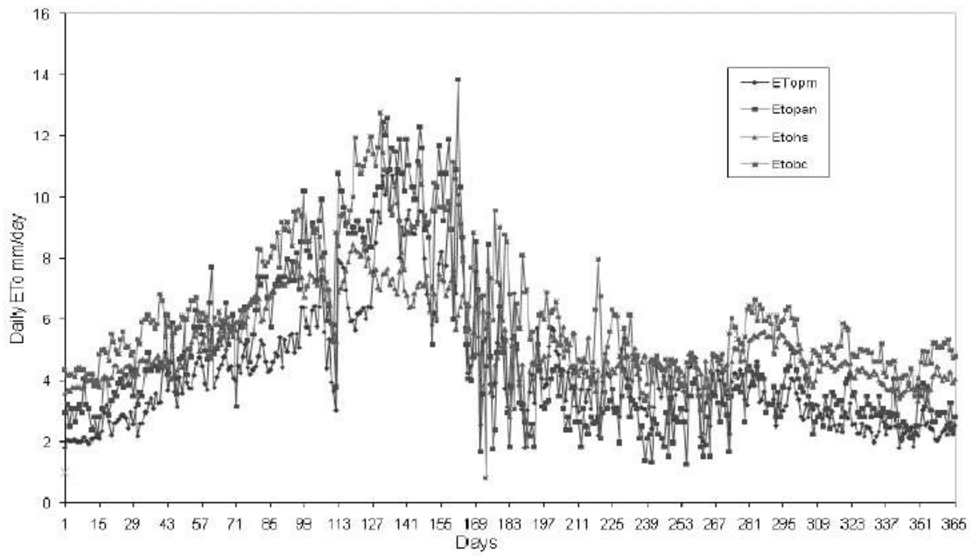

Figure 2. Estimated daily evapotranspiration at Akola by using PM, Pan, H-S, B-C models for the year 2007

Table 2. Comparative performances of different models as compared to Penman-Montieth method

Model	RMSE	R
Pan	1.33	0.92
H-S	1.55	0.81
B-C	2.40	0.82

CONCLUSION

Having good correlation and lower RMSE value, the Penman-Montieth FAO–56 and Pan model (Epan), should be used to estimate reference evapotranspiration for Akola.

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Soil Water Balance Study using CROPWAT

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ABSTRACT

Precipitation deficit of wan river basin was assessed using CROPWAT. It also cleared that more or less the effective rainfall was constant around 600 mm over entire basin. Soil moisture deficit decreased from Wari Bhairavgarh to Khatkali *i.e.* from low to high altitude. There was no precipitation deficit in case of soybean crop whereas it was observed maximum for pigeon pea followed by cotton. Daily soil moisture deficit analysis confirmed that readily soil moisture is available though less than field capacity, to satisfy ETc need of plants up to last decade of September. Thus, two protective irrigations should required during the month of October-November for maintaining optimal growing conditions in the basin.

Keywords: Cropwat, Precipitation deficit, Pigeaon pea, cotton, wan river basin.

1. INTRODUCTION

Shortage of water for domestic, industry and agriculture use is a cause of concern throughout the world, specially in developing and under developed countries. India has been well endowed with large freshwater reserves, but the increasing population and over exploitation of surface and groundwater over the past few decades has resulted in water scarcity in some regions. However, increasing urbanization and per-capita demand, the water demands of domestic, industrial and other sectors are expected to increase and become highly competitive with the agricultural sector. Agriculture, being the major water user, its share in the total freshwater demand is bound to decrease from the present 83% to 68% due to more pressing and competing demands from other sectors by 2050 AD (GOI, 2013), and the country will face water scarcity if adequate and sustainable water management initiatives are not implemented on substantial scale. India is a country of diverse agro-ecosystems and cropping preferences. Indian agriculture dominated by rainfed agriculture that accounts 68 per cent of the total net sown area (136.8 million hectare) spread over 177 districts. Rainfed crops account for 48 per cent of the total area under food crops and 68 per cent under non-food crops (Musuku, 2014). There is a need to double annual foodgrain production from about 246 million tonnes (2013) to 420 million tonnes by 2050. Since land is a shrinking resource for agriculture, the pathway for achieving this goal has to be higher productivity per unit of arable land and water (Swaminathan, 2006; GOI, 2006). Water stress at a particular crop growth stage results adversely in yield (Allen *et al.* 1988, Doorenbos and Kassam 1979). Thus there is a need to use decision support system for determination of precipitation deficit and thereby protective irrigation planning.

CROPWAT is a decision support system developed by Land and Water Development Division of FAO for planning and management of irrigation. CROPWAT is meant as a practical tool to carry out standard calculations for reference evapotranspiration, crop water requirements and crop irrigation requirements. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rainfed conditions or deficit irrigation (Marica, 2002; Diro and Tilahun, 2009; Abdalla *et al.*, 2010; Adeniran *et al.*, 2010; Arku *et al.*, 2012; Admasu *et al.*, 2014). Wan river forms the part of northwest boundary of Akola district of Maharashtra State of India, after entering from Amravati district. It rises in the Gawilgarh hills of eastern Satpura Range in Amravati District of Maharashtra state, and flows southward, draining Amravati, Akola and Buldhana region before emptying into the Purna River in Buldhana District of Maharashta. But basin of wan river experienced water scarcity every year and the crop yield also get affected. Considering this fact the study aimed to assess the precipitation deficit of wan river basin using CROPWAT.

2. MATERIAL AND METHODS

The basin of wan river is spread over 173.65 km^2 in Melghat Tiger Reserve Project in Satpura ranges, Amravati district of Maharashtra State.

2.1 Data collection

2.1.1 Meteorological Data

Rainfall, evaporation, minimum and maximum temperature data observed at four stations viz. Wari Bhairavgarh, Wan Road Station, Kelpani and Khatkali, in basin area was obtained for the period from 2000 to 2013. The average annual rainfall of basin is 1013 mm. Average daily maximum temperature varies between 28.3 and 44.7^{o}C. It was found maximum during the month of May, while lowest during the month of January.

2.1.2 Land use land cover pattern

The detail spatial 'land use land cover (LULC)' map for command was obtained from MRSAC, Nagpur. Area under different land use pattern is presented in Table 1. The data indicates that, the major area is under forest (91.50%) followed by agriculture (6.56%). Cropping pattern details were obtained from Department of Agriculture, Maharashtra State. Table 2 presents area under different crops in basin.

Table 1 Area under different land use pattern in command

Sr. No.	Land use pattern	Area, km^2	Percentage
1.	Agriculture	11.39	6.56
2.	Forest	158.88	91.50
3.	Built up area	0.36	0.21
4.	Wastelands	0.49	0.28
5.	Water bodies	2.53	1.45
Total		**173.65**	**100.00**

Table 2 Area under different crops in command

Sr. No.	Crops	Total sown area, km^2	Percent of sown area
1	Cotton	5.01	43.99
2	Soybean	3.98	34.94
3	Pigeonpea	2.40	21.07

The data regarding crop coefficients and rooting depth of various crops in command was referred from available numerous literature.

2.2 CROPWAT model set up

CROPWAT is a powerful simulation tool which analyzes complex relationships of on farm parameters such as the crop, climate, and soil, for assisting in irrigation management and planning. CROPWAT is one of the models extensively used in the field of water management throughout the world. CROPWAT model is comprised of eight modules viz. Climate/ETo, Rain, Crop, Soil, CWR, Schedule, Crop Pattern and Scheme (FAO Water, 2015).

(i) *Climate/ETo module*

This module calculates evapotranspiration using Penman-Monteith method (Allen *et al.* 1988). The module estimate evapotranspiration based only on temperature data. CROPWAT 8.0 estimate the values for the other climatic data (humidity, wind speed, sunshine hours) based on the temperature and altitude/latitude data, as required by Penman-Monteith method.

(ii) *Rain module*

Rain module is primary for data input of precipitation values on a monthly, decade or daily basis. This module also calculates 'Effective Rainfall' using USDA Soil Conservation Service Formula developed by USCS, using following formulae.

Monthly step:

Peff = Pmonth * (125 - 0.2 * Pmonth) / 125 for Pmonth <= 250 mm

Peff = 125 + 0.1 * Pmonth for Pmonth > 250 mm

Decade step:

Peff(dec) = Pdec * (125 - 0.6 * Pdec)) / 125 for Pdec <= (250/3) mm

Peff(dec) = (125 / 3) + 0.1 * Pdec for Pdec > (250 / 3) mm

(iii) *Crop module*

Crop module is essentially for crop data input over different stages of crop development. This Crop module essentially requires parameters as planting date, crop coefficient (Kc), crop stages, rooting depth, critical depletion fraction (p), maximum Crop height and yield response factor (Ky).

(iv) *Soil module*

Soil (non-rice crop) module essentially requires the parameters viz. total available water (TAW), maximum infiltration rate, maximum rooting depth and initial soil moisture depletion. This module also includes calculations, providing the Initial available soil moisture.

(v) *CWR (Crop Water Requirement) module*

Crop water requirement module estimates precipitation deficit or irrigation water requirement of the crop on a decade basis and over the total growing season, as the difference between the crop evapotranspiration under standard conditions (ETc) and the effective rainfall. Precipitation deficit or irrigation requirement indicatively represents the fraction of crop water requirements that needs to be satisfied through irrigation contributions in order to guarantee to the crop optimal growing conditions.

(vi) *Schedule module*

Schedule module estimates soil water balance on a daily step. This allows to develop indicative irrigation schedules to improve water management; evaluate the current irrigation practices and their associated crop water productivity; evaluate crop production under rainfed conditions and assess feasibility of supplementary irrigation; and develop alternative water delivery schedules under restricted water supply conditions.

(vii) *Crop pattern module*

The cropping pattern module is primary data input, requiring information on the crops being part of the scheme. With reference to each crop, the required data is crop file, planting date and area.

(viii) *Scheme module*

The Scheme module calculates irrigation requirement for each crop of the scheme, net scheme irrigation requirement, irrigated area as a percentage of the total area and irrigation requirement for the actual area.

3. RESULTS AND DISCUSSION

3.1 Rainfall pattern of the basin

Based on rainfall data, CROPWAT estimated effective rainfall, presented in Table 3, while Fig. 1 depicts month wise rainfall and effective rainfall over entire basin area.

Table 3 Rainfall and effective rainfall of basin of wan river

Month	Wari Bhairavgarh Mm		Wan Road Station, mm		Kelpani, mm		Khatkali, mm	
	Rainfall	Effective Rainfall	Rainfall	Effective Rainfall	Rainfall	Effective Rainfall	Rainfall	Effective Rainfall
May	0	0	0	0	0	0	0	0
June	329	157.9	173	125.1	175	126	199	135.6
July	471	172.1	309	155.9	520	177	549	179.9
August	189	131.8	264	151.4	297	154.7	354	160.4
September	345	159.5	279	152.9	395	164.5	286	153.6
October	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0
Total	**1334**	**621.3**	**1025**	**585.3**	**1387**	**622.2**	**1388**	**629.5**

Table 3 cleared that maximum rainfall occurs at Khatkali followed by Kelpani, Wari Bhairavgarh and Wan Road Station. It also cleared that more or less the effective rainfall was constant around 600 mm over entire basin. Fig. 1 cleared that maximum rainfall occurs in the month of July at all observation stations, whereas minimum rainfall occurred in the month of June.

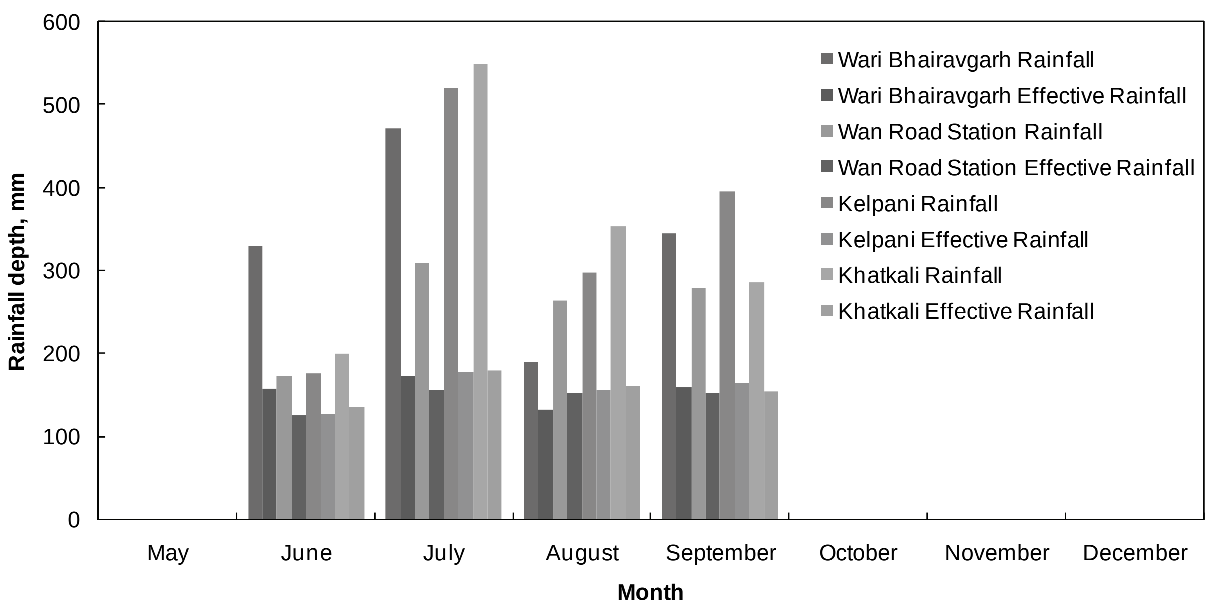

Figure 1 Month wise rainfall and effective rainfall variation in the wan river basin

3.2 Crop evapotranspiration

Variation in crop evapotranspiration over the year in the basin as calculated by CROPWAT model is depicted in Fig. 2.

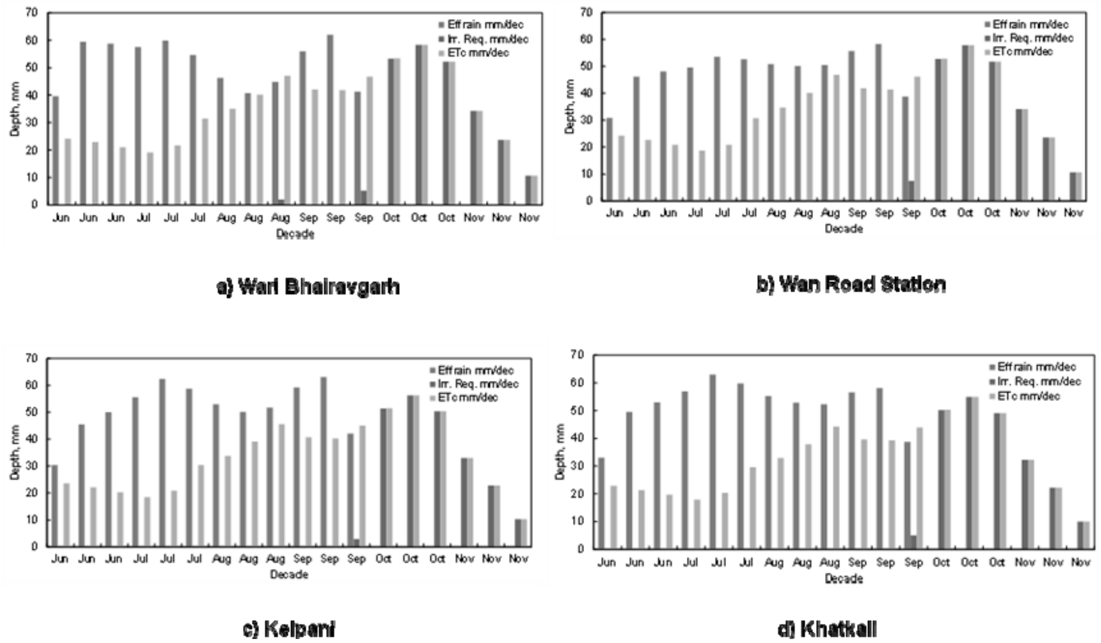

Figure 2 Variation of ETc over wan river basin

Fig. 2 clears that crop evapotranspiration (ETc) is less than effective rainfall for all four stations over monsoon months *i.e.* June to second decade of September. Therefore there is no need of irrigation during this period. However, from last decade of September, ETc started increasing due to full vegetative growth of crops. There is almost no rainfall after September, crops survived only on available soil moisture. At the same time due high temperatures of October, ETc further increased. ETc followed similar pattern over entire basin area, as evidenced in the Fig. 2. Therefore, protective irrigation become essential during the month of October and November, otherwise crop yield will be adversely affected.

3.3 Soil water balance for the basin

Daily soil water balance as given by model in reference to rainfall is depicted in Fig. 3.

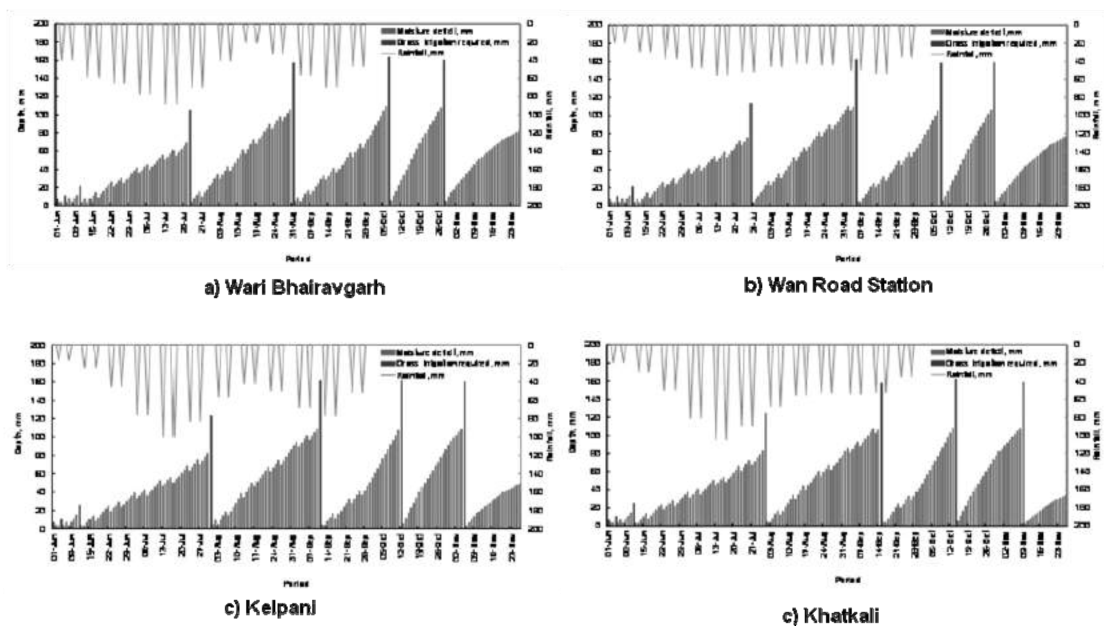

Figure 3 Station wise variation of soil moisture deficit

Fig. 3 cleared that soil moisture deficit decreased from Wari Bhairavgarh to Khatkali *i.e.* from low to high altitude. It also cleared that in all seven protective irrigations are required in the basin over the crop period. On the contrary, Fig. 2 clears that in all six irrigations are required during September to November, when decadal effective rainfall and ETc were taken into consideration. However, Fig. 3, clears that during monsoon months *i.e.* June to September soil moisture is in readily available zone though less than field capacity. Thus, two protective irrigations become essential during the month of October-November for maintaining optimal growing conditions.

3.4 Precipitation for the basin

Precipitation deficit in respect to crops of basin is depicted in Fig. 4.

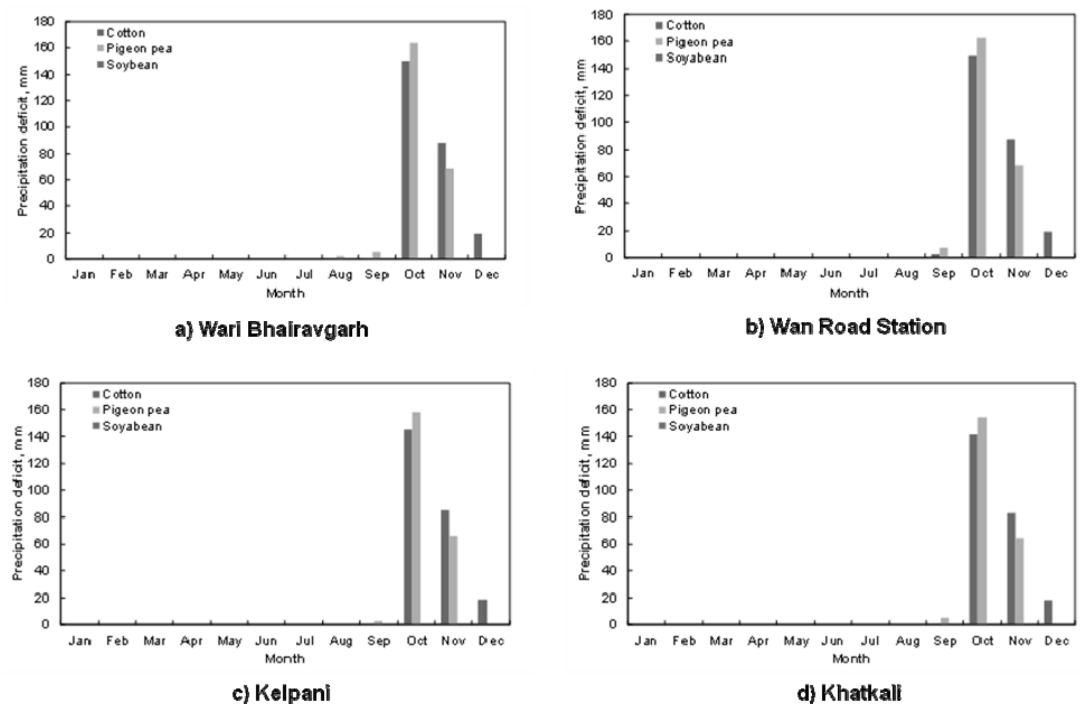

Figure 4 Crop wise soil moisture deficit in the basin

It is cleared from Fig. 4 that there was no precipitation deficit in case of soybean crop whereas it was observed maximum for pigeon pea followed by cotton. The precipitation deficit was more or less same over the entire basin as evidenced from Fig. 4.

4. CONCLUSION

Based on daily soil moisture balance study and precipitation deficit estimates, it is suggested to provide at least two irrigations, during the month of October-November, to guarantee crop optimal growing conditions.

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Reuse of PET Waste from Coastal Area in High Performance Concrete – Case Study on Goa Coast

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ABSTRACT

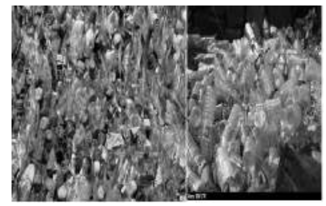
The Poly-Ethylene Terephthalate (PET) materials from the accumulated plastic waste in the coastal areas are adversely affecting wildlife and humans. The entanglement of marine organisms such as fish, seals, turtles and birds in plastic debris leads to their death. It is estimated that global production of plastics is approximately 225MTyr-1. Though part of it is recycled, the remaining ends up in landfills, as litter on land or in waterways and the ocean. TheCPCB estimated the quantity of plastic floating in the ocean nearly 0.27MTyr-1. In India plastic products are produced approximately 15 MTyr-1. According to the Goa Tourism Department report nearly 4.1Million tourists visited the Goa coasts in the year 2014.Annually more than 236T PET water bottles were used by Goa tourists and that waste is spoiling the ambience of Goa beaches. The collection and safe disposal of this PET waste has become a serious problem to the environmentalists. Hence, a detailed study is carried out to disposethis PET waste into concrete as fibres. The BIS samples are casted by considering the 1% of PET waste and 15% of silica fume into the fiber reinforced high performance concrete. The micro-structural analysis of this concrete samples made with PET fibres is investigated by using X-ray diffractionand SEM images. Among the generated PET waste in Goa coast in a year considerable quantity can be used for laying concrete roads. It is also recommended to use in the massive constructions like flyovers, dams etc., as this PET fiber reinforced high performance concrete satisfied all the requirements of BIS.

Keywords: PET, Fiber Reinforced Concrete, Silica Fume, XRD analysis, SEM images.

1.0 INTRODUCTION

According to the Goa Tourism Department report nearly 4.1 Million tourists visited the Goa coasts in the year 2014. Annually more than 236 tonnes PET water bottles were used by Goa tourists and the waste generated by PET bottles alone is spoiling the ambience of Goa beaches. The collection and safe disposal of this PET plastic waste has become a seriousproblem to the environmentalists (Goa Tourism Dept., 2015).The use of silica fume, reduces the required quantity of admixture in blended cements to achieve specified performance, with the additional advantage of the formation of a highly densified structure and refined pournet work, contributing to potential improvements in durability (Erich. D, 2012).Approximately 15.1Tonnes of non-putrescible solid wastage are generated annually on Kayangel Island (0.42 kg percapita per day) with 57% being marine litter derived from the ocean and 43% derived from household activities. The most significant wastagecategories (by mass) include mixed material and non-recyclable plastic wastages from both household sources and ocean derived marine litter (Emily. L. Owens, 2011).Ultra high performance concrete (UPHC) and ultra-high performance fiber reinforced concrete (UHPFRC) were introduced in the middle of 1990s. Special treatment, such as heat curing, pressure and/or extensive vibration, is often required in order to achieve compressive strengths in excess of 150MPa (Kay Wille, 2011). It was found that the fibers tended to align perpendicular to the direction of flow. As a result,panels poured from the center were significantly stronger than panels poured by other methods because the lignment of fibres led to more fibres bridging the radial cracks formed during mechanical testing (Stephanie, 2009).Results showed that ilmenite concrete mixed with 15% silica fume had the highest density; compressive, tensile, flexural and bond strengths; modulus of elasticity andattenuation coefficient values (Sakr K., 2006). The results showed that mineral admixtures improved the properties of highperformance concretes, but at different rates depending on the binder type (Hassan. K. E, 2000). Fiber reinforcement can effectively improve the toughness, shrinkage and durability characteristics of concrete. The use of recycled fibers from industrial or costconsumer waste offers additional advantages of waste reduction and resources conservation (Youjiang Wang, 2000). Resins based on recycled polyethylene terephthalate were chosen because it can be used in the production of very good quality polymer concrete at a relatively low cost (Karim S. Rebeiz, 1995). This knowledge is obtained by X-ray diffraction (XRD), which in a few minutes gives a spectrum by which the crystalline phases can be identified by its peaks, as well as some information concerning non-crystalline constituents, from the position and form of the diffuse band. Active additions can modify properties of cement, increasing or decreasing its durability (Rafael Talero, 1990). Fiber treatment alone was found to be extremely effective, leading to 50% or more toughness retention after 5 to 9 months of accelerated aging. The effects of the silica fume treatments can be investigated in terms of the microstructural and chemical aging mechanisms (ArnonBentur, 1989).

2.0 MATERIALS FOR PET FIBER REINFORCED HIGH PERFORMANCE CONCRETE



2.1 PET bottle fibers

The Poly-Ethylene Terephthalate(PET)is mainly used for filling soft drink, juice, water, beer, mouth wash, peanut butter, salad dressing, detergent and cleaner containers and its density is1.38 g/cm^3. The minimum aspectratio of PETfibers will be 50 to 80 and the maximum is 150. The minimum volume of PET fibers will be0.5% of volume of concrete. The collected PET bottles should be washed and cleaned from all other particles. “Figure 1. PET bottle The PET fibres are made from bottles shown in Figure 1. samples”.

Property	Portland Cement	Silica Fume
SiO2 content (%)	21	85-97
Al2O3 content (%)	5	-
Fe2O3 content (%)	3	-
CaO content (%)	62	< 1
Specific surface(m2/kg)	370	15000-30000
Specific gravity	3.15	2.22
General use in concrete	Primary binder	Property enhancer

2.2 *Silica Fume:* Inorganic materials that have pozzolanic or latent hydraulic properties, these very fine-grained materials are added to the concrete mix to improve the properties of concrete i.e., mineral admixtures or as a replacement for portland cement. A by-product ofthe production of silicon and ferrosilicon alloys. Silica fume is similar to fly ash but has a particle size100 times smaller. This results in a higher “Table 1. Properties of cement & silica fume” surface-to-volume ratio and a much faster pozzolanic reaction. Silica fume is used to increase strength and durabilityof concrete, but requires the use of superplasticizers for workability.

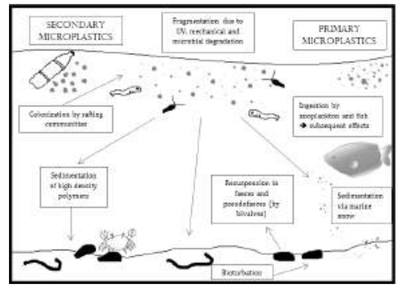
2.3 Conventional concrete ingredients

The major ingredients which are generally used in conventional concrete are 20 mm and 12 mm metals as coarse aggregates, river sand as fine aggregate, OPC53 as binding material and good quality water.

Goa Coast

Entanglement in plastic debris has been responsible for the deaths of many marine organisms, such as fish, seals, turtles, and birds. These animals get caught in the debris and end up suffocating or drowning. Because they are unable to untangle themselves, they also die from starvation or from their inability to escape predators. Being entangled also often results in severe lacerations and ulcers. Plastic pollution does not only affect animals that live solely in oceans. Seabirds are also greatly affected as the toxic chemicals i.e., “Figure 2. Goa beach” polychlorinated biphenyls (PCBs) concentrated on the surface of plastics at sea are in to their food. These chemicals can accumulate in body tissues and have serious lethal effects on a bird's reproductive ability, immune system, and hormone balance. Floating plastic debris can produce ulcers, infections and lead to death.It is estimated that global production of plastics is approximately 225

Million Tonnes per year. Though part of it is recycled, the remaining ends up in landfills, as litter on land or in waterways and the ocean. The CPCB estimated the quantity of plastic floatingin the ocean nearly



0.27 Million Tonnes per year. In India plastic products are produced approximately 15Million Tonnes per year. Goa's beaches cover about 125 kilometers (78 mi) of its coastline shown in Figure 4 & 5.According to the Goa Tourism “Figure 3. Plastic waste Department report nearly 4.1 Million tourists visited the impact on biological

Goa coasts in the year 2014. Annually more than 236 Tonnes community” PET water bottles were usedby Goa tourists and that waste is spoiling the ambience of Goa beaches. The collection and safe disposal of this PET waste has become a serious problem to the environmentalists.

(a) (b) (c)

Figure 1 (a) Coastal line of Goa, India (b) Baga Beach in North Goa and (c) Fishing nets onthe beach

3.0 Manufacture of PET fiber reinforced high performance concrete:

Design Mix Proportion: IS code method is used to design mix for fibre reinforced high performance concrete. The constituents of above concrete are detailed in Table 2.

Weight of 1% of PET fibres:

The cube samples are made with 1% of PET fibers. The PET bottle fibers at 1% of volume of concrete is 13.81kg/cum. The physical properties of PET are shown in Table 3.

Table 2 Weight of ingredients in kgs for PET fiber reinforced high performance concrete”

Cement	Fine Aggregates	Coarse Aggregates	Water	Silica Fume (15%)	1% of PET fibers
07.87	12.04	24.24	03.54	1.18	0.134

Table 3 Properties of PET

S No	Test	Test Method	Result	Unit
1	Tensile Load	ASTMD638 (CIPET)	71.45	Kg
2	Elongation at break		53.44	%
3	Density ASTM792	ASTMD 92 (CIPET)	1.38	g/cc
4	Identification	CIPET Method	Polyethylene terephthalate (PET)	
	Property			
5	Linear expansion co-efficient (X)		$7x10^{-5}$	/k
6	Modules of elasticity (E)		2800-3100	N/mm^2
7	Water absorption		0.16	
8	Thermal conductivity		0.24	W/mk
9	Melting point		260	^0C

3.1 PET fiber reinforced high performance concrete samples:

The BIS samples i.e., cubes of size 150mm are casted with fiber reinforced high performance concrete by adding PET fibers at 1% to the volume of theconcrete. When 1% of PET fibers are added to the conventional concrete the compressive strength of cubes are increased compare to the conventional concrete samples. The fiber reinforced concrete and fiber reinforced high performance concrete cube compressive strength results are shown in Table 4.

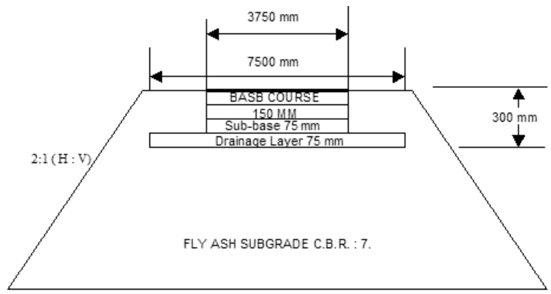


Figure 5. Cross Section of a CC Road

4.0 CEMENT CONCRETE (CC) ROAD

Cross Section of CC Road: The cement concrete Road cross section is shown in Figure 5. The 1 m^3 concrete quantity required for laying the 1.778 m of road length. For laying 1 km length of road required 562.5m^3 of concrete. The PET fibers quantity at 1% of volume of concrete required is 7.768 Tonnes.

5.0 RESULTS AND DISCUSSIONS

Compressive Strength:

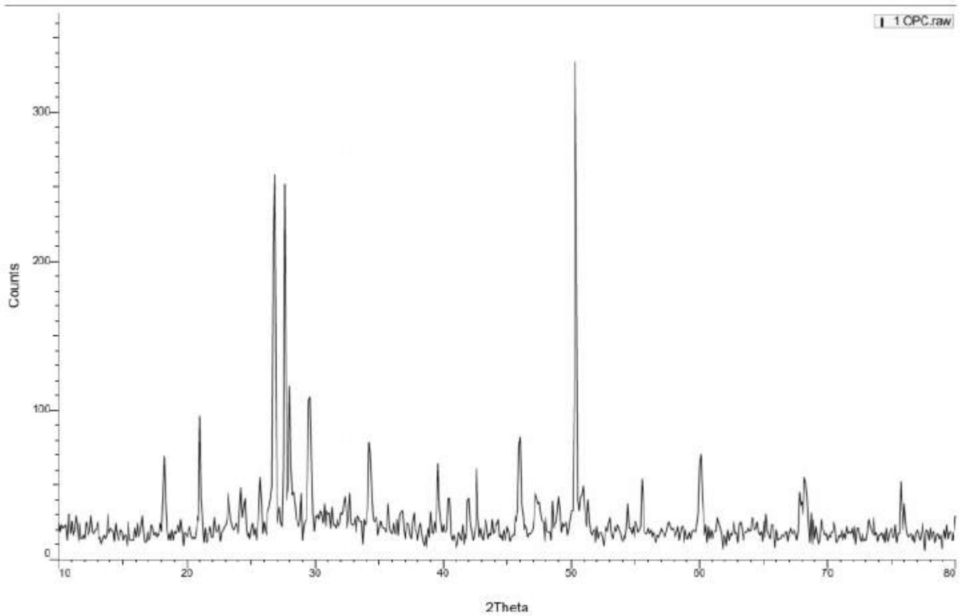
Cube size: 150 × 150 × 150 mm and Rate of Loading = 5.0 kN/sec.

Table 4 7 days compressive strength of PET fiber reinforced high performance concrete (M30)

S No	% of Fibers	% of SilicaFume	Load InkN	Average Load in kN	Average Compressive Strength in N/mm^2	% of Improvement
1)Conventional Concrete	0.00	0.00	976.5	922.67	41.01	0.0
			881.5			
			910.0			
2)PET fiber Reinforced Concrete	1.00	0.00	1095.2	1078.57	47.94	16.9
			1078.5			
			1062.0			
3)High Performance Concrete	0.00	15.00	1095.1	1102.33	48.99	19.5
			1101.5			
			1110.4			
4)PET fiber Reinforced High Performance Concrete	1.00	15.00	1355.2	1347.47	59.89	46.0
			1348.3			
			1338.9			

5.1 X-Ray Diffraction Results:

(a)



(b)

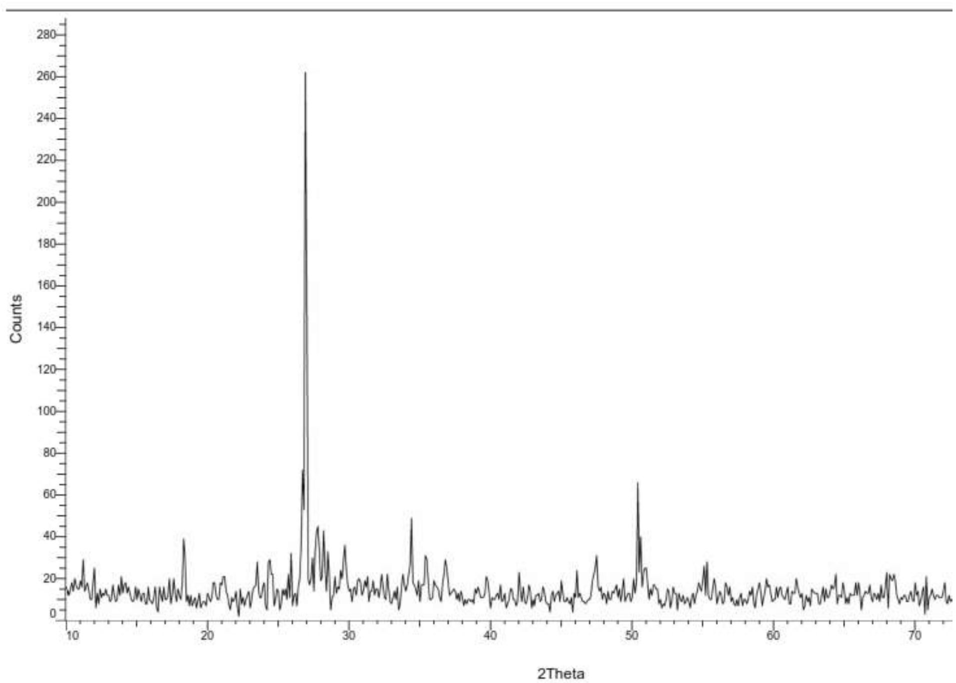
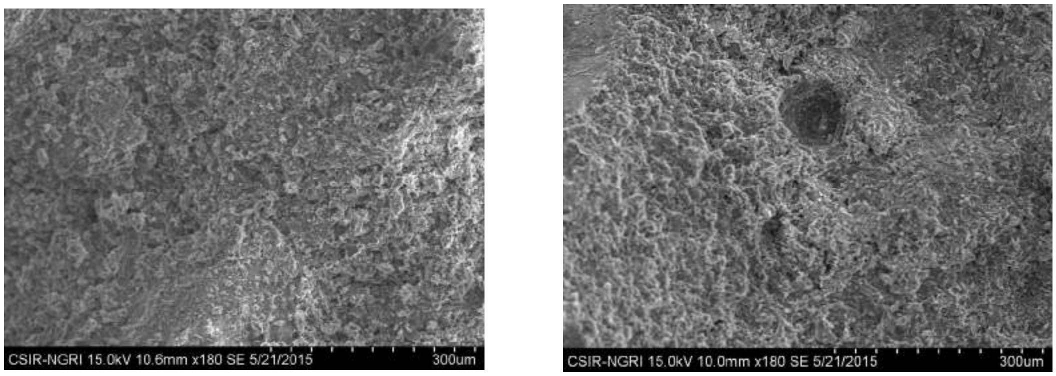


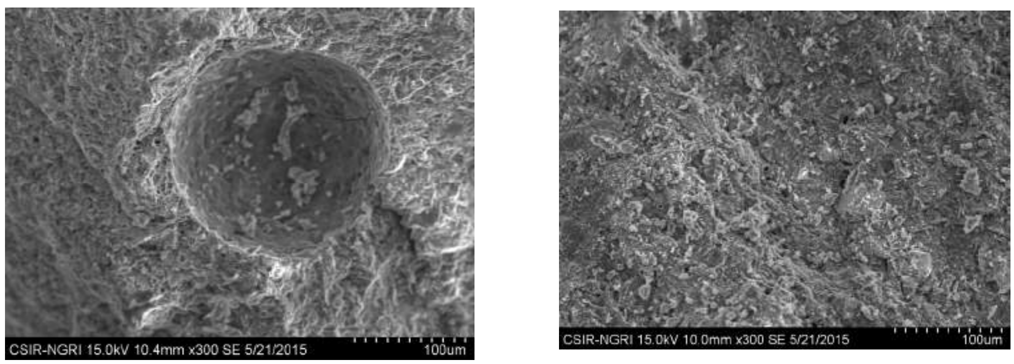
Figure 6 X-Ray Diffraction patterns of (a) conventional concrete and (n) Fiberreinforced concrete

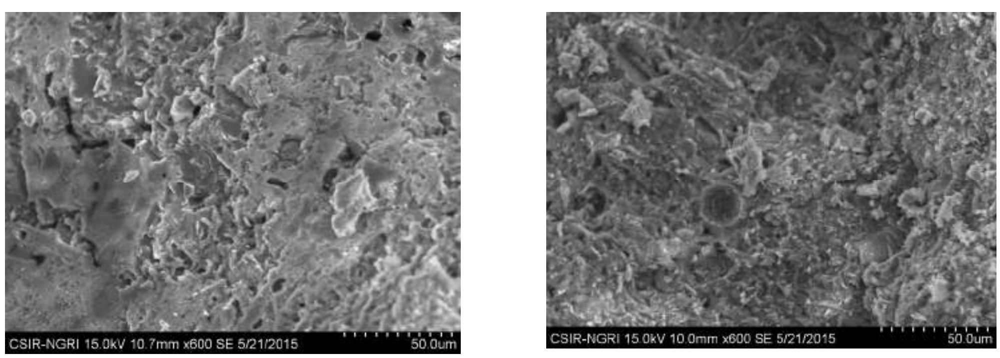
5.2 Scanning Electron Microscope (SEM) images:



(a)

(b)





(c)

Figure 7. Microstructure of (a) conventional concrete, (b) fiberreinforced concrete and (c) fiberreinforced high performance concrete

From Table 4 the cube results for fiber reinforced concrete and fiber reinforced high performance concrete are compared with conventional concrete results. When the PET fibers added to conventional concrete the compressive strength increased by16.90%. When the silica fume and PET fibers are added to conventional concrete then it acts as high performance concrete. The cube compressive strength of PET fiber reinforced high performance concrete is improved by 22.25% compare to high performance concrete.

5.3 XRD Analysis

The X-Ray Diffraction results shown in Figure 6 are for conventional concrete and PET fiber reinforced concrete samples. The 2θ value on X-axis is 0 to 80^0 and the count value on Y-axis is 0 to 350. The peak counts are observed for conventional concrete at 2θ values of 28^0 and 50^0 as 250 and 340 respectively. For PET fiber reinforced concrete the peak counts are observed at 2θ values of 28^0 and 50^0 as 260 and 70 respectively. The peak count for PET fiber reinforced concrete at 2θ value of50^0 is 20% of conventional concrete only. The XRD patterns of conventional concrete and fiber reinforced concrete are compared for crystalline presence in Figure 6. Fiberreinforced concrete is having single peak and conventional concrete has numerous. Fiber reinforced concrete is free from crystals apart from fibers and the particle packing is done properly that improves the natural characteristics of concretewhen reinforced with fibers.

5.4 SEM Analysis:

The microstructure images of conventional concrete, PET fiber reinforced concrete and PET fiber reinforced high performance concrete are shown in Figure 7.From the SEM images it is observed that the voids are formed in conventional concrete samples, whereas they are found less in fiber reinforced high performance concrete. There is a small depression found in conventional concrete sample and expected it is formed due to non-bonding between the aggregates and matrix, such type of depressions are not found in fiber reinforced high performance concrete. The mineral admixture silica fume reacted with cement matrix and fills all voids in fiber reinforced high performance concrete to get more compressive strength. The fibers are well mixed with matrix and form a solid concrete to improve the strength of concrete.PET fiber reinforced high performance concrete is also recommended to use in the massive constructions like flyovers, dams, etc.

CONCLUSIONS

1. The adding of mineral admixture silica fume at 15% and 1% PET fibers to the conventional concrete are improved the compressive strength by 46%.
2. The X-Ray diffraction of high performance concrete and fiber reinforced concrete shows fiber reinforced concrete is free from crystals leading to proper particle packing for durability.
3. The SEM images are showing less % of voids in fiber reinforced concrete due to the addition of silica fume to the cement matrix.
4. Nearly 13.8kg of PET bottle waste can be used in one cubic meter of concrete in order to clean the coasts when the plastic waste is converted to building material.
5. A massive 7.768 tonnes PET waste can be cleaned by laying 1km coastal road. Hence, Goa coast will be free from PET bottle accumulation by laying 30km concrete road.

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Determination of Aquifer Characteristics in Jalagaon (Ja) Region

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ABSTRACT

The field experiment was conducted on the farm of Krishi Vighyan Kendra, near the College of Agricultural Engineering and Technology Jalgoan (Ja) for "Measurement of Infiltration on Different Land Covers". The measure of infiltration of water into the soil is an important indication concerning: the efficiency of irrigation and drainage optimizing the availability of the water for plant improving the yield of the crop and minimizing the erosion. Infiltration is an important parameter in irrigation planning. Study was undertaken to measure the infiltration on different land covers. Infiltration was measured by double ring infiltrometer and developed the infiltration equations, also determined the different properties of soil on cultivated land cover and bared land covers. It was found that for cultivated land cover, the average infiltration rate was 6.06 cm/hr and 4.34 cm/hr for bared land cover. The average moisture content, bulk density and field capacity was found to be 16.49%, 1.71 gm/cc and 26.23% respectively for cultivated land cover. Also the average moisture content, bulk density and field capacity was found to be 11.7%, 1.59 gm/cc and 29.55% respectively for bared land cover.

Keywords: Infiltrometer, moisture content, bulk density, field capacity.

1. INTRODUCTION

India has a naturally available abundant water resource. Infiltration is one of the most important component in irrigation. Water infiltration is driving force influencing crop growth, soil erosion and chemical leaching process. The water is driven into the porous soil by force of gravity and capillary attraction. The rate at which a given soil can absorb water at given time is called infiltration rate and it depends on soil characteristics such as soil texture, hydraulic conductivity, soil structure, vegetation cover etc. the infiltration plays an important role in generation of runoff volume, if infiltration rate of given soil is less than intensity of rainfall then it results in either accumulation of water on soil surface or in runoff. There are two general approaches to determine capacity of soil infiltration rate. That is first analysis of hydrograph of runoff from natural rainfall in plots and watersheds. Secondly, use of infiltrometer with artificial application of water to enclosed sample areas, concerning hydrograph analysis (*Baxla et. al 2010*). The major factor affect infiltration of water in to soil are initial moisture content condition of soil surface, hydraulic conductivity of soil profile, texture, porosity, organic matter, vegetative cover, duration of irrigation or rainfall and viscosity of water. Infiltration rates are generally lower than soil of light texture.

2. MATERIALS AND METHOD

2.1 Materials

Double ring infiltrometer, bucket, oven, electrical weight balance, mechanical shaker, scale, stop watch, wooden hammer, screw auger etc

2.2 Experimental Site

The site for conducting the experiment was selected at Krishi Vigyan Kendra, Jalgaon (Ja) near the College of Agricultural Engineering and Technology, Jalgoan (Ja). Which is affiliated to Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S Two land covers were selected for study viz.

1. Cultivated land
2. Bared land

2.3 Location

The study was confined in the Jalgaon (Ja), District Buldana, which is situated in Vidarbha region of Maharashtra. The Buldana district is situated in between latitude 210 3.1164 N-S and altitude 760 32.0784 E-W and altitude 309 m above the sea level.

2.4 Climate

The climate of area hot and dry sub tropical. The summer is two dry and hot. The winter is to cold and rainy season start from the first week of June and continues up to September with maximum rainfall in July. The average annual rainfall is about 750 mm. The average minimum and maximum temperature varies between 70c to 170c and 400cand 460c respectively. May is driest and January is coolest month.

2.5 Experimental Setup

The experimental was conducted on the form of Krishi Vigyan Kendra, Jalgaon (Ja) near the College of Agricultural Engineering and Technology, Jalgoan (Ja), district Buldana. Double ring infiltrometer was used for measurement infiltration because of its reliability and accuracy. The complete setup consist of two cylinders outer cylinder with diameter 60 cm and 25 cm height, inner cylinder with diameter 30 cm. One hook gauge for measurement of water level, stop watch and water container. One of the two cylinder, one was used to form buffer pond in order to avoid the lateral movement of water. The cylinder were installed 10 cm deep in soil care was taken to maintain the same instruction depth in all the experiments. The cylinder were installed in the field by means of a mild steel plate and hammer. Gentle hammering was done to avoid the soil in getting distributed from their natural condition. The depth of water in all the experiment was kept equal, (Michael 1978). Water level in cylinder was recorded with help of point gauge and stop watch. The point gauge was used to record the water level at the cylinder. The water level in cylinder was brought to initial level often a regular interval of one hour.

2.6 Determination of moisture content of soil

Soil auger was used to collect the samples for measurement of moisture content. The soil samples were taken always from 20 cm depth in all the observations. The soil auger was driven in to soil up to the depth of 20 cm and sample were collected in moisture box was weight was already known. Now the sample along with moisture box was weighed on a balance and kept in an electric oven at 105^0C for 24 hour. The dried samples were again weighed and the moisture content on dry weight basic was calculated (Punmia 2004).

2.7 Determination of bulk density of soil

Bulk density of soil was out by core cutter. The were cutter was used to take undisturbed soil sample. The cylinder of core sampler has cutting edged was driven into soil and an un compacted core obtained within tube. The samples were carefully trimmed at both ends of core cylinders. They were dried in an oven at 105^0C for 24 hour until all the moisture was given off and the sample weight again. The volume of soil core cylinder was measure, (Punmia 2004).

2.8 Determination of field capacity

Field capacity was determine by ponding water on the soil surface in an area of about 1 sq. m and permitted it to drain for one day with surface evaporation prevented. Evaporation was prevented by spreading a polythene sheet on the ground surface. After one day soil samples were collected with an auger from 20 cm depth. The moisture content was determined by oven dry method (Michael 1978).

3. RESULTS AND DISCUSSION

3.1 Infiltration under cultivated land cover and curve fitting

The infiltration depth at the selected time interval was measured. Infiltration rate was calculated using the actual infiltration depth and time period. Average infiltration rate and accumulated are given in Table 1.

Table 1. Measured cumulative infiltration, measured infiltration rate and predicted cumulative infiltration in cultivated land by double ring infiltrometer

SN	Time (min)	Infiltration depth cm	Average rate infiltration cm/hr	Accumulated infiltration cm.	Predicted infiltration
1	5	1.7	20.4	1.7	1.6
2	10	0.4	12.6	2.1	2.11
3	15	0.3	9.6	2.4	2.53
4	20	0.6	9	3	1.9
5	25	0.2	7.68	3.2	3.2
6	30	0.3	7	3.5	3.5
7	35	0.5	6.85	4	3.8
8	40	0.2	6.3	4.2	4.1
9	45	0.2	5.8	4.4	4.4
10	50	0.2	5.52	4.6	4.6
11	55	0.3	5.34	4.9	4.9
12	60	0.3	5.2	5.2	5.1
13	65	0.2	4.98	5.4	5.3
14	70	0.1	4.71	5.5	5.6
15	75	0.1	4.48	5.6	5.8
16	80	0.2	4.35	5.8	6
17	85	0.2	4.23	6	6.21
18	90	0.1	4.23	6.2	6.4
19	95	0.1	4.133	6.3	6.7
20	100	0.1	3.97	6.4	6.9
21	105	0.1	3.84	6.5	7.1
22	110	0.1	3.71	6.6	7.3
23	115	0.1	3.6	6.7	7.4
24	120	0.1	3.49	6.8	7.6
25	125	0.1	3.4	6.9	7.8
26	130	0.1	3.31	7	8
Total			157.72		

Average infiltration rate = 6.60 cm/hr.

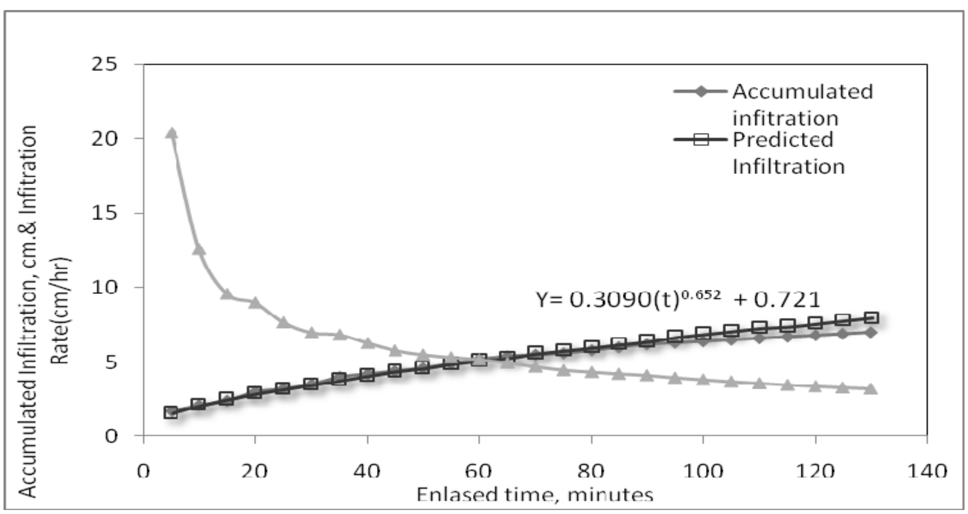

Figure 1. Plots of Accumulated infiltration and average infiltration rate against elapsed time of the cultivated land.

3.2 Infiltration under bared land cover and curve fitting

The infiltration depth at the selected time interval was measured. Infiltration rate was calculated using the actual infiltration depth and time period. The average infiltration rate and accumulated infiltration rate is shown graphically in Fig. 1. From the graph it is seen that the infiltration rate decreased during the experiment.

Infiltration was measured at suitable interval of 5 minutes up to 130 minutes and plotted the graph of accumulated infiltration verses elapsed time, then developed equation which was suggested by Davis (1943). The following equation was developed for cultivated land cover.

$$Y = 0.62(t)^{0.380} + 0.50$$

Table 2. Measured cumulative infiltration, measured infiltration rate and predicted cumulative infiltration in bared land by double ring infiltrometer.

Sr. No.	Time (min)	Infiltration depth cm	Average rate infiltration cm/hr	Accumulated infiltration cm.	Predicted infiltration
1	5	1.5	18	1.5	1.68
2	10	0.4	11.4	1.9	1.98
3	15	0.3	8.8	2.2	2.23
4	20	0.2	7.2	2.4	2.43
5	25	0.2	6.24	2.6	2.6
6	30	0.2	5.6	2.8	2.75
7	35	0.2	4.97	2.9	2.89
8	40	0.1	4.5	3	3.01
9	45	0.1	4.1	3.1	3.13
10	50	0.1	3.84	3.2	3.2
11	55	0.1	3.6	3.3	3.34
12	60	0.1	3.3	3.3	3.4
13	65	0.1	3.1	3.4	3.5
14	70	0.1	3	3.5	3.6
15	75	0.1	2.88	3.6	3.69
16	80	0.1	2.77	3.7	3.77
17	85	0.1	2.68	3.8	3.85
18	90	0.1	2.6	3.9	3.92
19	95	0.1	2.52	4	3.99
20	100	0.1	2.46	4.1	3.06
21	105	0.1	2.4	4.2	4.13
22	110	0.1	2.45	4.3	4.26
23	115	0.1	2.29	4.4	4.32
24	120	0.1	2.25	4.5	3.38
25	125	0.0	0.0	4.5	4.38
26	130	0.0	0.0	4.5	4.44
Total			112.95		

Average infiltration rate = 4.34 cm/hr.

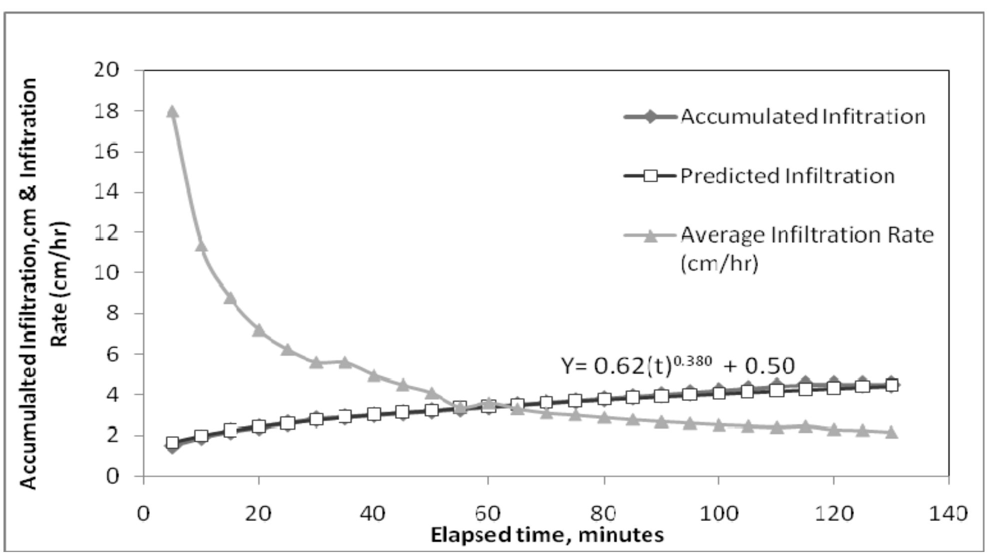

Figure 2. Plots of Accumulated infiltration and average infiltration rate against elapsed time of the Bared land.

3.3 Determination of soil properties

Soil properties i.e. moisture content, bulk density, and field capacity etc. was found out by standard procedure. It is given in Table 3.

Table 3. Properties of soil

Sr.No.	Properties of soil					
	Moisture content, %		Bulk density gm/cc		Field capacity,%	
1	16.16	13.33	1.72	1.54	25	30.43
2	13.33	10.11	1.67	1.6	26.05	27.65
3	20	11.66	1.74	1.63	27.65	31
Avg.	16.49	11.7	1.71	1.59	26.23	29.55

4. CONCLUSIONS

1. The average infiltration rate for cultivated land cover was 6.06 cm/hr and 4.34 cm/hr for bared land cover.
2. Measured and predicted values were nearly same and curved were nearly fitted with each other.
3. The average moisture content, bulk density and field capacity was found out to be 16.49%, 1.71 gm/cc, 26.23 % respectively, for cultivated land cover. The average moisture content, bulk density, and field capacity was found out to be 11.7%, 1.59 gm/cc, 29.55% respectively, for bared land cover.

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A Sustainable Concrete made with Recycled Concrete Aggregates in Self-Compacting Concrete: Environmental Aspects

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ABSTRACT

The construction industry has become one of the main contributors to the environmental pollution as the emission of carbon monoxide and other pollutants are the bi-products of many construction materials, operation of equipments and other construction processes. This paper describes about the Environmental pollution , Impact Human Life and its origin, the role of using of recycled aggregate with SCC in the Construction to the possible sustainable process that can be implemented in construction of buildings and infrastructure in India towards economy and development process in the world market scenario. Sustainability in general terms is to create an economic system with enhanced performance with long term safety. Sustainability is the one which mainly focuses on the climate change, energy conservation, protection of natural resources and environmental enhancement. Pollution is anything that damages and destroys the surrounding atmosphere causing health hazards to human beings and animals. The presence of unnatural elements such as gas emissions, solids, liquids, waste disposal, and high sounds turns atmosphere polluted. Moreover, extensive use of chemicals and fertilizers on crops has disturbed whole eco systems of earth. Together we must participate in combating with increasing pollution and makes our environment safe and healthy.

These sustainable concepts should be incorporated at the design time itself by the structural engineers and it can be understood that the construction professionals play a key role for implementing the Use of Recycled Concrete aggregate in concrete and It also enforces the necessity of use of Recycled Coarse Aggregates (RCA) in concrete so as to reduce the emission of CO_2 gas towards sustainability of Construction Industry, and utilizing EIA's in project planning is to prevent avoidable losses of environmental resources & values through the development of a judicious and appropriate Environmental Management Plan (EMP).

Keywords: Self-Compacting Concrete (SCC), Recycled concrete aggregate (RCA), Sustainability, Environmental Pollution, Environment, Sustainable design.

LITERATURE REVIEW

Self-Compacting Concrete (SCC) which has been now a hot topic has its roots a long back ago in the 1980's which is not as much as popular as it is now. SCC which yields an excellent deformability and resistance to segregation easily moulds with even a heavy reinforcement formwork without use of any vibrators. SCC was developed by making use of simple concrete along with the addition of the super plasticizer and viscosity modifying agent. The main intention of developing this type of concrete is in regarding the homogeneity and compacting of cast in place concrete within intricate structures and improvement of overall durability quality of concrete due to lack of skilled labour. In the 1983 at Japan there has been a serious social problem faced on durability of concrete structure that were build at that time as gradual reduction in number of skilled labours which in turn lead to reduction in quality of construction works. This SCC has proved to be better solution as it could be compacted into every corner of a formwork, purely by means of its own weight and there is no need of a skilled labour at the time of pouring concrete. Many researchers since decades have tried different proportions of SCC by adding different admixture so as to attain strength to the concrete by replacing cement content. By far many have researchers from their understanding suggests that use of admixtures like GGBS and Fly ash in proportions to the SCC will be giving strength, workability to the SCC.

The proper utilization of Recycled Concrete aggregates(RCA) can reduce the over-development of the environment & Ecology Protection of earth and slow the huge consumption of natural resources for concrete use. Self Compacting Concrete (SCC) appears to have significant potential for its use in the precast/pre stressed concrete industry. As with any new material, there are material properties differences and production process differences that must be understood and appropriately addressed in both design and production activities. Self compacting concrete (SCC) has more significant environmental advantages in comparison to the vibrated concrete: absence of noise pollution and vibrations during construction & installing provides a healthier working environment. In the Place of Natural aggregate some percentage is usage of coarse recycled aggregate obtained from crushed concrete for making of self-compacting concrete to be done based on the innovative technologies implementing new techniques in to Construction. And additionally emphasizing its ecological value. On the other hand the issue of the waste disposal sites created by the demolition of old structures is solved. The recycled coarse aggregate can successfully be used for making of self-compacting concrete. Many more researches were still going on the SCC by adding different admixtures, since last decade as environmental impact is much considered the researches have focussed on the use of Recycled Coarse Aggregate (RCA) in concrete so as to reduce the CO_2. By using of this Recycled concrete aggregate(RCA) in SCC there can be a maximum chance to reduce the global CO_2 emission as the construction industry is one the main contributor to environmental damage and CO_2 emission. In the recent years many researchers in construction industry are trying to implicit the use of RCA in the mix designs of SCC so that it can be more environmental friendly mixes which could reduce the CO_2 emission to maximum extent. In this paper various physical and mechanical properties of SCC and RCA are discussed in detail.

CONSTRUCTION AND DEMOLITION WASTES

According to (DEFRA, 2008) C&D (Construction and Demolition) wastes is a major kind of municipal solid waste sent to landfill, which accounts for about 22% of the entire solid waste by weight. In many of developed countries Kartam *et al*. (2004) has performed his empirical work and determined that in actuality the amount of building and construction waste literally being generated is about 500-1000 Kg/capita per annum. The root cause for the generation of the C&D waste is inherently due to the never ending process of using lands for carrying out newly proposed constructions, re-construction, stretching of the road for transportation network, refurbishments. This is made a source path to make use of these recycled materials on large basis for many tall buildings construction, According to Kartam *et al*. (2004), some of the ways in which these C&D wastes can be reutilized are as follows:-

- ❖ Concrete aggregate with lesser requirements (pure concrete chips, brick chips) , Road construction, Paved or tiled areas, Planting medium, Water bound layers, Drainage material and backfill material & Production of cement blocks (using powdered concrete)

USE OF RECYCLED CONCRETE AGGREGATE

Concrete is indisputably the inherent construction material, that is used in different construction works and the facts reflect that around 800 factories are producing about 36 million tonnes of precast concrete products every year and which is the main contributor for pollution. The use of RCA would be must better solution mainly making use of this RCA in construction of Tall buildings would be a positive approach in reducing the carbon foot prints in these buildings. According to Noriega (2011), it can be confirmed that the conventional concrete aggregate can be confidently replaced by recycled concrete aggregate as it exhibited similar compressive strength and bearing. According to Fulton (2009), a new research is being carried out by the University of Liverpool to create a ‘geopolymer’ concrete, which means concrete without cement. This new variety in concrete is being developed by utilising waste materials like Incinerator ash, Ash released from burnt coal thermal power plants and Basic oxygen steel slag.

RECYCLED COARSE AGGREGATE (RCA)

Recycled aggregates composed of original aggregates and adhered mortar. To obtain good quality concrete using recycled aggregate it is necessary to follow the minimum requirements defined by the respective Building Standards. Acceptable properties of aggregates are an elemental base for concrete quality, however adequate mix proportions and concrete production methods are highly important in concrete quality too. The physical properties of recycled aggregates depend on both adhered mortar quality and the amount of adhered mortar. The adhered mortar is a porous material; its porosity depends upon the w/c ratio of the recycled concrete employed. Crushing concrete to produce coarse aggregate for the production of new concrete is one common means for achieving a more environment-friendly concrete. This reduces the consumption of the natural resources as well as the consumption of the landfills required for waste concrete. The crushing procedure and the dimension of the recycled aggregate have an influence on the amount of adhered mortar. The density and absorption capacity of recycled aggregates are affected by adhered mortar and they must be known prior to the utilization of recycled aggregates in concrete production in order to control properties of fresh and hardened concrete.

USE OF METAL

Use of 'Metal' as it is environmental friendly because these are recyclable and long lasting building material which also offers excellent solar reflective benefits. It is energy efficient choice for roofing and wall panels when constructing a building envelope. The energy generation systems are the most expensive materials of green building. The initial cost of construction of green building is high but it is worth able and justified when these attain the energy savings for the building on long term basis. A building can be termed as sustainable building if the building design is in such a way that it incorporates a balance between social, economic and environmental issues in all the stages of a building such as in design, construction, operational and till the end of the life of building. A sustainable tall buildings is also defined as the on which reduces the emission of CO2 and a buildings which has less impact to pollution of land, air and water thought its life span and is an economical to the social community.

So the main challenge is to make sure that in the future, the construction industry should focus on construction of sustainable tall buildings with zero emission of CO_2 and every country having their own building regulations must look into these aspects as well into regulations. Generally these tall buildings are less sustainable when compared to low rise buildings as these tall buildings have more consumption of natural resources besides having some advantages as lesser land is made use for accommodating large no: of people in it. So, balancing of both advantages and disadvantages must be taken care which is only achieved if the construction of these high rise buildings is developed with sustainability concept. The applications of SCC are limited to special case where it is impossible to use ordinary concrete., SCC was used in India at Rajasthan Atomic Power Project Unit-5 & 6 for Beams, Columns and walls in the Power plant and also at Kaiga Atomic Power Project Unit-3 & 4 for Pump house, Turbine Building, Control building and tunnels.

BENEFITS OF SCC: There are many advantages by using this SCC, below are some the possible advantages, they are:

- With this SCC, the ease of placement results in cost saving thereby reducing equipment and labor requirement.
- Reduction Noise levels, Absence of Vibration Safer working environment
- Improving the quality, durability and reliability of concrete structures
- Easier placing, Faster construction, Reduction in site manpower& Improved durability
- Easily placed in thin-walled elements & Better surface finishes.

SUSTAINABLE BUILDINGS MATERIALS AND APLLICATIONS:

By constructing sustainable buildings the use of natural resources in limited means like using water saving faucets and plumbing elements, energy efficient lighting units and passive solar design and by using environment friendly materials in the construction of walls, floors, ceilings, etc. All these materials keep the building sustainable for all types of weather and by constructing such buildings we can reduce the carbon monoxide footprint of the building on environment and even it provides the direct cost savings to the building owners. There are many materials that were used in construction of green buildings; some of them are explained below:

IMPACT ON ENVIRONMENT AND HEALTH AND SAFETY:

The SCC has a positive impact on the environment and is it best in terms of health n safety issues, as by this SCC the personal noise of loading the workers will be lowered by as much as one tenth of the noise levels produced when traditional vibrated concreted is used. Using SCC leads to an improved environment both for concrete workers and for the people in the neighborhood due to less noise.

Measures to Prevent Pollution in the construction industry

Major/Good construction site practice can help to control and prevent pollution. The first step is to prepare Environmental risk assessments for all construction& infrastructure activities and materials likely to cause pollution. Specific measures can then be taken to mitigate these risks:

- To prevent erosion and run-off, minimise land disturbance and leave maximum vegetation cover.
- Control dust through fine water sprays used to dampen down the site.
- Screen the whole site to stop dust spreading, or alternatively, place fine mesh screening close to the dust source.
- Cover skips and trucks loaded with construction materials and continually damp down with low levels of water.
- Cover piles of building materials like cement, sand and other powders, regularly inspect for spillages, and locate them where they will not be washed into waterways or drainage areas.
- Use non-toxic paints, solvents and other hazardous materials wherever possible
- Segregate, tightly cover and monitor toxic substances to prevent spills and possible site contamination.
- Cover up and protect all drains on site .
- Collect any wastewater generated from site activities in settlement tanks, screen, discharge the clean water, and dispose of remaining sludge according to environmental regulations.
- Use low sulphur diesel oil in all vehicle and equipment engines, and incorporate the latest specifications of particulate filters and catalytic converters.
- No burning of materials on site.
- Reduce noise pollution through careful handling of materials; modern, quiet power tools, equipment and generators; low impact technologies; and wall structures as sound shields

The construction industry is a major source of pollution, responsible for around 4% of particulate emissions, more water pollution incidents than any other industry, and thousands of noise complaints every year. Although construction activities also pollute the soil, the main areas of concern are: air, water and noise pollution.

INDIAN ENVIRONMENTAL PROTECTION:

CONSTITUTIONAL PROVISIONS: The Constitution 42nd Amendment Act, 1976 made the express provision for the protection and promotion of the environment, by the introduction of Article 48-A and 51-A (g) which form the part of Directive Principles of State Policy and the Fundamental Duties respectively.

***Thus the Indian Constitution makes two fold provisions*:** "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

a) On the one hand, it gives directive to the State for the protection and improvement of environment.

b) On the other hand the citizens owe a constitutional duty to protect and improve natural environment.

The Parliament of India has legislated various acts for meeting the International obligations in the direction of protection of Environment. The Laws have to be enforced by the State Pollution Control Boards, Central Pollution Control Board and Ministry of Environment and Forests. There are three principal Acts to be enforced by the regulators.

- Those are The Water (prevention and control of pollution) Act, of 1974,
- The Air (prevention and control of pollution) Act, 1981; and
- The Environment (protection) Act, 1986.

The Ministry of Environment and Forests issues certain guidelines pertaining to the Environment (Protection) Act, 1986 which have to be followed by Central Pollution Control Board and State Pollution Control Boards.

Types and Effects of Pollution: **The major forms of pollution are explained under:**

1. **Air Pollution:** Air Pollution is formed due to the release of chemicals and poisonous gases through industrial chimneys into the atmosphere. Some of the gaseous air pollutant elements are carbon monoxide, sulphur dioxide, nitrogen oxides, and chlorofluorocarbons (CFCs). Air Pollution damages lungs as it goes through respiration activity in the human body.

2. **Water Pollution:** it is another major problem to the environment as the nature is not in its purest form as it was years back. The main reason behind this is being the advancements and development of Science & Technology. Water Pollution is caused due to dumping of waste garbage, sewage and contaminants disposal into rivers and ponds. These wastes come from human being and industries.
3. **Noise Pollution:** Noise Pollution is caused due to unnecessary noises in the environment that disrupts whole society. The main source of Noise Pollution is automobiles, construction industry, aircraft noise, rail noise, loud music systems noise, etc. Noise Pollution damages the physical and psychological health of human being resulting into high stress, headache, hearing problems, sleep disturbances and many other harmful effects.
4. **Environment Pollution:** it is includes the mixture of pollutions caused due to various reasons in the environment damaging whole eco systems. Various environment pollutions are soil pollution, Light pollution, Visual pollution, smoke pollutions, etc.

Objective of Environmental Management Plan (EMP):-

The major objective and benefit of utilizing EIA'S in project planning is to prevent avoidable losses of environmental resources & values through the development of a judicious and appropriate Environmental Management Plan (EMP). Environmental Management Plan includes protection / MITIGATION / enhancement measures as well as monitoring.

In the process of planning , it is essential for every project to formulate an EMP to ensure that resources are used with maximum efficiency and that each of the adverse impacts , identified and evaluated as significant be prevented , attenuated or where required compensated. Possible mitigation measures generally include:

- Changing project sites, routes, production technology, raw materials, disposal methods, engineering designs, safety requirements.
- Introducing pollution controls measures, recycling and conservation of resources, waste treatment, monitoring, phased implementation, personnel training, special social services or community awareness and education.
- Devising compensatory measures for restoration of damaged resources, monetary compensations for project affected persons, off-site programs to enhance some other aspects of the environment or quality of site for the community.

Monitoring is required to evaluate the success or failure (and consequent benefits and losses) of environmental management measures and subsequently to reorient the EMP. Regardless of the quality of an EIA and consequent environmental management measures, they are of limited value unless implemented. As experience has increased in using EIA process for environmental planning the need and justification for periodic monitoring in order to establish meaningful data bases has become obvious.

For the Construction Industry & development of infrastructure for environmental management has to be formulated and continuously implemented after the Development becomes operational. This plan will have to include the following:

A. During Construction Phase:

Measures to mitigate the adverse impacts due to the following during construction phase.

1. Site preparation
2. Sanitation
3. Noise
4. Construction equipment & waste
5. Storage of hazardous material/ dumping materials
6. Site security and Safety
7. Displacement of Population

B. During Operation Phase

1. Collection and disposal facilities for emission, wastewater and solid waste.
2. Routine monitoring of selected parameters.
3. Laboratory facilities.
4. Data handling, reporting, storage and retrieval facilities, feedback to facilitate future planning.
5. Emergency action procedures and disaster management procedures.
6. Manpower for Environmental Management.

EMP During Construction Phase

The mitigation measures to control adverse impacts during construction phase are discussed below.

Site Preparation: The development of site will involve the movement of top soil, removal of trees, shrubs, soils, rocks, debris etc.., the site grading operation will also involve stock piling of backfill material. All the distorted slopes shall have to be stabilized suitably. During dry weather, control of the dust nuisance created by excavation, levelling and transportation activities need to be carried out by water sprinkling. It should be ensured that both petrol and diesel powered construction vehicles are properly maintained to minimize smoke in the exhaust emission.

Sanitation: The construction work force shall have to be provided with sufficient sanitation facilities in order to maintain adequate hygienic conditions. Low cost sanitation system like septic tanks/soak pits are to be provided. This may be done by provisions in contracts with the contractors.

Noise: There will be intense movement of trucks, passenger cars, earth movers etc, in and around the project site. These will create noise and air pollution. Poor visibility, accidents, damages to health of local people etc, are foreseeable consequences. Workers working with heavy equipment generating high noise levels shall have to be provided with ear plugs/ muffs. The maintenance of construction equipment has to be done properly. This may be done by provision in the various contracts with the contractors. Vehicular movement towards the construction sites should be properly regulated to minimize the consequences. Movement of cargo trucks should be minimum during night. Since the project site is surrounded by villages, it is very necessary to restrict the operation of noise generation equipment during night time.

Construction Equipment and Waste: The project would involve lot of construction activities for infrastructural facilities/ structures likely to come up on the proposed site and would thus involve the use of construction equipment/ instruments. These at times would require onsite maintenance and repairing. It should be ensured that both petrol and diesel powered construction vehicles are properly maintained by the contractors to minimize pollutant emission from exhaust. The vehicle maintenance area will be so located that contamination of surface water bodies by accidental spillage is avoided. Unauthorized dumping of waste oil will be prohibited.

Storage of Hazardous Material/ Dumping Material: Petrol, diesel, lubricating oil etc. will be required to be stored at site. These materials will be stored as per stipulated safety standards. Also a lot of material may be generated for disposal during construction activity. These if disposed off haphazardly can pollute the nearby water bodies adversely. They would increase the accident incidences also. Utmost care needs to be taken to store these materials at a suitable incidence also. Utmost care needs to be taken to store these materials at a suitable place and then disposed them off at a place in consultation with PCB.

Site Security and Safety: A construction site forms a potentially hazardous environment. To ensure that the surrounding population is not exposed to these hazards, the site will be properly secured by fencing or by construction of a boundary wall and also guards will be posted at entry points.

1. First aid facilities should be created at different locations for immediate assistance in case of emergencies and accidents.
2. Important information about nearby hospitals, fire stations, police station etc. Should be kept available in the first aid centers for speedy action at the time of emergency.
3. In case inflammable materials are to be kept at the site, they should be stored and handled in accordance with guidelines of inspectorate of safety and health of state and central governments.

4. Fire hydrants and extinguishers should be located at all vulnerable sites.

Displacements of Population: The project will cause displacement of the people. Their rehabilitation will have to be done with utmost care so that their cultural and other aspects would not suffer and they would easily be able to blend with the social setup where they will be accommodated.

EMP During Operational Phase: *Operation of various plants and facilities*

It may be pertinent to mention that adherence to recycling of emission and / or waste materials to the following dictum would go a long way to mitigate the pollution hazard due to any industry.

- Formulation of In-Plant Waste minimization programmes can save energy and raw materials. Recycling of emission and/or waste materials at source i.e. linked to the production process can be treated, recycled and reused for some secondary utilities.
- Research and development programs on clean technologies have underlined that clean technology implementation is an effective mechanism to abate pollution, which works in addition to and independent of the regulatory process.

Socio- economic environment

- It is imperative that a concrete and feasible plan be made to promote employment to the local people with equal opportunities to people.
- Training should be provided to the local people to acquire skill in various fields
- The proposed project will cause population displacement of people. Proper means is to be employed to facilities suitable rehabilitation measures for these displaced people.

Environmental Monitoring : Routine monitoring

After the park is in operation, routine monitoring of certain parameters will have to be done to ensure environmental quality control. It may be mentioned that the project proponents would make arrangements for the necessary monitoring programme. The parameters to be monitored, the specific sites selected and frequency of Project site monitoring .

Manpower for Environmental Management

(a) For proper environmental management of the proposed park including operation & maintenance of all facilities outlined earlier, a regular ‘Environment Cell’ will be set up with trained staff. The cell will have core staff of following type of personnel.

(b) To monitor the implementation of the proposed EMP a core Committee involving project management proponents, representatives from nearby villages, citizen’s committee and NGO’s would be formed.

Scope of Further Study

Since many years this SCC has been a focal point for many researchers. Now along with this SCC, RCA has grabbed the attention of many researchers as it has been an environmental friendly material which considerably reduces the CO_2 emissions.

- In the recent years many researchers are trying to make use of this RCA in the mix designs of SCC and checking the workability, strength, etc., by adding various admixtures in different proportions.
- Further Investigation needs to be carried out on usage of Recycled Concrete Aggregate(RCA) in Low, Medium and High Strength Self Compacting Concrete (SCC).

CONCLUSION

The major work is being done on researches on various parameters of the Environment but a little attention is being given on enforcement of the Environment Laws. One of the construction sector's major contributions to the preservation of the Environment and sustainable development is the reuse and recycling of the waste materials it generates (reducing, reusing, recycling and regenerating the residues that originate the constructive activity). The Use of Recycled Concrete Aggregates (RCA) for concrete production is not simply applied because the properties of Recycled Concrete Aggregates (RCA) are different from natural aggregates. Furthermore, the quality of Recycled Concrete Aggregates (RCA) fluctuates when collected from different sources. In physical terms, distinctive differences are observed between the properties of RCA since it not only consist of original aggregates, but also comprise of the remains of mortar (cement paste) adhering to the aggregate surfaces. The presence of mortars remain in the RCA is a main reason for deteriorated Recycled Concrete Aggregates (RCA) quality as compared to Natural Aggregates.

The Self-consolidating concrete is an exciting technology that has found many successful applications. Although the concept has been around for a few decades, new products are still emerging and better mix proportioning strategies are yet still in development. Many researchers are finding different aspects in which SCC can be used and how the properties of SCC can be changed by admixtures is also been observed. The used of RCA has been a now a research aspect to look into and many research scholars are looking forward to use this RCA in the SCC mixes which could be a research scope in the upcoming years so as to try to reduce the impact of CO_2 emissions and make more environmental friendly materials. SCC which has no set definition, for now the concrete construction industry generally follows certain methods of measuring mix properties to define an SCC. The absence of an established industrial standard for SCC allows more creativity in tailoring a mix to specific job requirements. At the same time, the lack of standards means devising a successful mix depends on the expertise of the producer and contractor. Therefore, it is clear that educating manufacturers and contractors is the crucial first step in expanding the use of SCC's extremely promising technology.

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Phosphorus Balance at a 30MLD STP in Hyderabad

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ABSTRACT

Sewage sludge is usually considered as treatment residue that needs expensive treatment forremoval. Sludge volumes will continue to grow worldwide with increasing population and country wealth. The Main objective of sludge treatment is to reduce its volume and moisture content. The cost of handling and treating sludge generated from a wastewatertreatment facility can range from 20 to 50 % of total operation and maintenance costs. In a sustainable society, sludge should rather be seen as asource of energy, phosphorus and other products. Wastewater treatment facilities are exploring technologies to utilize these values worldwide. Technologies on extracting minerals fromsludge would either help offset treatment facility's costs or even turn a profit. First step inturning sludge from a costly waste material into a profitable revenue stream should be amaterial balance.

The Wastewater treatment plant considered in this Study is located across picket nala, one of the influent stream and a pollution point source to HussainSagar Lake. The Plant is of 30MLDcapacityand is designed with Biological Nitrogen Removal (BNR) by A^2/O Process with an integrated phosphorous removal mechanism.Phosphorus balance in various treatment steps was studied and potential technologies forExtracting phosphorus was reviewed.

Keywords: Phosphorus removal, recovery and reuse; extraction, balance, sludge, struvite; wastewater.

1. INTRODUCTION

1.1 Phosphorus – a limited or abundant resource

Phosphorus (P) is an essential macronutrient for crop production. Agriculture accounts forabout 80% of the phosphate ore utilization worldwide, which is finite and non-renewableresource. Current phosphate deposits may last for only a hundred years at the presentdepletion rate (Steen, 1998). Phosphorus may become a limiting substance in the future and phosphorusleakage from existing sludge deposits may become a diffusive phosphorus source. The excesscontent of phosphorus in receiving waters leads to intensive algae and hydrophyte growth,known as eutrophication.

Biological phosphate removal in activated sludge processes was reported in seventies (Levin et al (1972), Barnard (1974), Fuhs et al (1975)),and currently it is a common phosphorus removal step in most modern treatment plants.However, as phosphorus concentrations in effluent water decrease, phosphorus concentrationsin waste activated sludge (WAS) increase. Increased phosphorus concentrations in WAS leadto two significant problems commonly faced by plant operators: undesirably high levels ofphosphorus in sludge intended for land application, and struvite clogging during anaerobictreatment (Balmer (1988), Danesh et al (2008)).

Sewage sludge is usually considered as treatment residues, which is expensive to get rid of.The treatment and handling of sludge can represent between 20 and 50 % of a wastewatertreatment facility's costs. Sludge production volumes will continue to grow worldwide withincreasing population and country wealth. In a sustainable society, sludge should rather beseen as a source of energy, phosphorus and other products. Water treatment facilities areexploring technologies to extract these values worldwide. Technologies on extractingminerals from sludge would either help offset treatment facilities costs or even turn a profit.

1.2 Extraction of P, review

There are currently several alternative ways to remove phosphorus from wastewater enablingits recovery and reuse as fertilizer (de-Bashan, 2004):

- improved sludge quality at treatment plants and use of the sludge for agricultural purposes,

- improved wastewater treatment systems using reactive filter media,
- processing of the sludge into separate fractions to obtain phosphorus containing productswith a high purity,
- processing of sludge incineration ashes to obtain phosphorus containing products,
- Phosphorouscrystallisation in the effluent process flow,
- combined precipitation of phosphorous and nitrogen in the wastewater,
- Phosphorous adsorption on activated clay,
- Ion exchange in the effluent process flow,
- Acid P-extraction and precipitation.

(a) *Direct application of sludge compost:* Biological removal of phosphorus generates large amounts of sludge, which is costly tomanage and does not always allow efficient phosphorus recovery. Sludge compost has beenpreferred instead of liquid application. Sludge drying, pelletizing or briquetting has beenpracticed to achieve more hygienic application, and slower release of nutrients.

(b) *Filter substrates:* There is a large variety of reactive porous filter substrates, rich in Ca, Fe or Al with a highaffinity for P (Cucarella et al (2007), Johansson (2006), Berg et al (2005)). The mechanisms of P retention involve sorption processes at the surfaceof the material. Once saturated with P the material could be recycled back to agriculture. P inthe material should be in a form capable of desorbing and being released to the soil P solution,thus becoming available to plants (Cucarella et al, 2007).

(c) *Formation of Struvite:* Phosphorus recovery through struvite ($MgNH_4PO_4 \times 6H_2O$) crystallization and the possiblereuse of struvite as a fertilizer is widely reported (Balmer (1988), Bhuiyan (2008), Battistoni et al (2005), Marti et al (2010), Paster et al (2010)). Safe and quick extraction of highpurity calcium phosphate, magnesium phosphate or Struvite pellets has been studied by manyauthors. The formation of magnesium phosphates such as $MgHPO_4 \times 3H_2O$ (newberyite), $Mg_3(PO_4)_2 \times 8H_2O$ (bobierrite) and $Mg_3(PO_4)_2 \times 22H_2O$ (cattiite), during struvite crystallizationor dissolution process, is reported already in early works (Taylor et al, 1963) as well as late ones (Michalowski, 2006).

A complete phosphorus removal and recovery from anaerobically digested sludge liquors asstruvite has been implemented in Japan, and the resulting product sold to fertiliser companies(Gaterell et al (2000), Ueno (2001)). Struvite can be used as slow release fertilizer at high application rates, without thedanger of damaging plant roots. Granular forms of struvite are one of the best, slow releasephosphorus fertilizers (Gaterell et al (2000), Bridger et al (1962)).

(d) *Microwave extraction:* Phosphorus in sludge can be released into solution by heating it to 50 to 70°C prior toanaerobic digestion with microwave irradiation (Danesh et al (2008)). Domestic and industrial microwave ovensgenerally operate at a frequency of 2.45 GHz corresponding to a wavelength of 12.2 cm andenergy of 1.02×10^{-5} eV (Jacob J, 1995). Unlike anaerobic processes, the phosphorus released consists ofa significant fraction of phosphorus that is not orthophosphate. Likely mechanisms for releaseinclude cell membrane disruption, causing the release of stored polyphosphate into solution,and the release of phosphorus trapped in extracellular polymeric material. Microwaveirradiation also causes the release of arsenic, molybdenum, nickel, and selenium into solution(Danesh et al (2008)), which is a problem in case they are present in wastewater.

(e) *Solvent extraction:* Inorganic phosphorus can be extracted and separated from municipal wastewater with primaryamine as a solvent in the presence of sodium molybdate.

(f) *Phosphorus recovery from sludge ash:* Phosphorus recovery from sludge ash has been studied. After the thermo-chemicaltreatment at 1000ºC, a mechanical finish transforms the clean phosphate semi-product tomarketable phosphate and complex fertilizers. Direct phosphorus recovery from sludgeincineration ash by leaching with acid or base has been shows, that acid leaching allows torecover phosphorus as iron phosphate, which, however, has low commercial value.

1.3 Phosphorus balance in treatment plant

First step in turning phosphorus-rich liquids or sludge from a costly material to treat into aprofitable revenue stream should be a material balance. In 30MLD Sewage Treatment Plant(STP) located on Picket nala of HussainSagar Lake, Phosphorus balance in various treatment steps was studied, aiming to find potentialtechnologies for extracting phosphorus.

2. MATERIAL AND METHODS

2.1 Study Area

With phenomenal urbanization, once peripheral HussainSagar Lake finds itself in the densely populated zone in the mega-city of Hyderabad. As a result of heavy anthropogenic pressures,Inlast three decades the entire Lake has deteriorated. The lake is fed by 4 feeder influent streams/ canals (now called nalas) and both of its outlets lead to Musi River. RapidUrbanisation of the surrounding areas of the lake from which nalas emerge out has resulted in a wide range of water pollution problems.

Located 17.4^{o}N 78.4^{o}E, the lake is 510 m above the mean sea level (MSL) and has about 240 Km^{2}of Combined catchment area which in turn hasabout 80 Lakesin it. The Direct Catchment area of HussainSagar stands at 67Km^2 and is divided into four sub basins viz. Kukatpally, Dullapally, Bowanpally and Yusufguda (Shivakumar et al, 2014).

Among the four influent nalas, Kukatpallynala discharges both Domestic and Industrial effluents whereas remaining 3 (Balkapur, Banjara& Picket Nalas) contribute only Domestic sewage. A survey of the ground water conducted by the central ground water board with Canadian assistance has revealed contamination of well water in the HussainSagar basin.

2.2 Picket Nala - Sewage Treatment Plant

The 30MLD WWTP is serving Picket nala with the capability of 30,000 m^3 d^{-1}since its establishment in 2008. According to the current process, the technologicalconcept of the WWTP is A/O process (which is Improvised Activated Sludge Treatment (ASP) by using an anaerobic selector to develop biomass)mixed with Biological Nitrogen Removal (BNR) according to theModified LudzackEttinger (MLE) concept, and integrating these 2 processes of A/O & MLE, biological phosphorous andnitrogen removal happens according to A2/O process. In addition to the biological phosphorousremoval, chemical phosphorous removal with Alum is integrated. The chemical precipitate is mixed into the organic excess sludge. Sludge is dewatered and made as a cake in Sludge Drying Yard. The working parameters are in *Table 1*.

Table 1. Influent & Effluent Parameters of 30MLD Picket nala STP(on 15/06/15)

Wastewater Quality Parameters	**Influent (mg/lit)**		**Effluent (mg/lit)**		
	Planned/ Designed	**Actual**	**Limit Value (Into Inland Waters) [25]**	**Planned/ Designed**	**Actual**
Biochemical Oxygen Demand (BOD_5)	150-300	150.49	30	<5	3.4871
Chemical Oxygen Demand (COD)	200-650	321.91	250	<70	25.863
Total Suspended Solids (TSS)	200-300	296.55	100	<5	3.1226
Total Phosphorous {P_{total}}	6-10	6.507	Dissolved phosphates (as p)=5	<0.5	0.4326
Total Nitrogen {N_{tot}=TKN (as NH_3) +[NO_2^{-2}-N]+[NO_3^--N]}	TKN(as NH_3)=35-70	TKN(as NH_3)=31.315	100+0+10	<10	4.27

2.3 Sampling

Eight sampling points were taken from the most characteristic locations of the STP, wherehigh values of dissolved phosphorus were expected. Samples are collected at alternate days for the first 2 weeks of June 2015 between 9 A.M to 10 A.M. The sampling points are numbered on alayout of the treatment plant, *see Figure 1*.

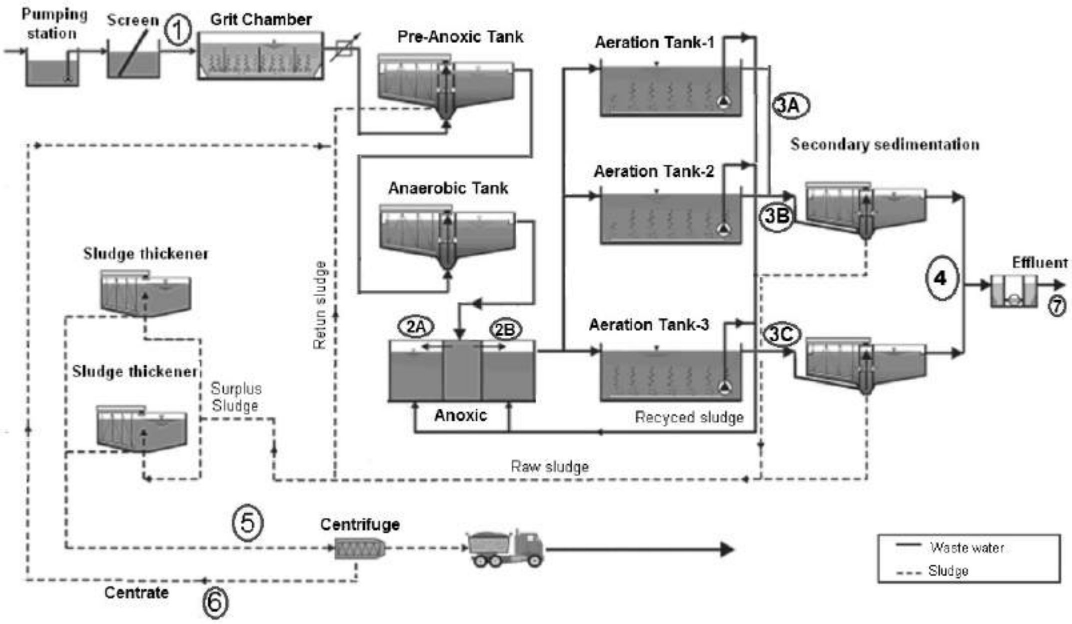

Figure 1. Schematic Layout and Location of sampling points in Picket nala STP

2.3 Forms of Phosphorus

Most phosphorus in surface water is present in the form of phosphates. There are four classifications of phosphates often referred to in environmental literature:

1. Orthophosphates are the inorganic forms of phosphate, such as PO_4^{3-}, HPO_4^{2-}, and $H_2PO_4^{-}$. These are the forms of phosphates used heavily in fertilizers and are often introduced to surface waters through runoff.
2. Organically bound phosphates are found in human and animal excrement wastes/feaces or in decaying organic matter.
3. Condensed phosphates (also called polyphosphates), such as $P_3O_{10}^{5-}$, are sometimes added to water supplies and industrial processes to prevent the formation of scaling and to inhibit corrosion. This is the form of phosphate that was commonly found in detergents in the past.
4. Total phosphates are the sum of all three of the forms described above. This is the most commonly reported form of phosphate concentration.

2.4 Experimentation &Laboratory procedures

Total phosphorus and phosphates, as well as pH, conductivity, and COD were analyzed at theaccredited laboratory of STP itself. All the analytical methods wererecommended by APHA 1998 and IS standards, all the samples are grab samples and were filtered. Orthophosphate is determined by adding ammonium molybdate which will from a colored complex with the phosphate. The polyphosphates and organic phosphates are converted to orthophosphates using an acid digestion step before they can be determined in a similar manner. COD is determined using Open Reflux method whereas pH and Conductivity are determined by using digital pH meter and Conductivity meter.

3. RESULTS AND DISCUSSION

The results show that sludge liquor contains about 100 mg $L^{-1}$of total phosphorus, most of this(around 87 – 95 %) as dissolved phosphates. Second largest concentration of phosphorus wasmeasured in surplus/waste activated sludge (WAS) – 41 mg L^{-1}. Concentrations of Total phosphorous in influent to the STPwere as large as concentrations from anoxic zone, designed as for P-removal – 5.68 and 5.35,respectively (*Table 2*).

The average hydraulic flow was 31,332m^3d^{-1} on the particular sampling days. The totalphosphorous load on these days was 210kgd^{-1} and the yearly average load is 300kgd^{-1}. Thetotal hydraulic load is 12,156,669m^3 y^{-1} on the year 2014 what makes phosphorous loadbetween 82–110 t y^{-1}. Effluent from WWTP is still consisting phosphorous

0.3–0.6 mg L^{-1}what makes 3.6–7.29 t y-1. It means that 78–100 t/y is possible range for phosphorous recoveryfrom 30MLD STP.

Table 2. Characteristics of the samples

Sl.No	Sampling location	P_{Total} mgL^{-1}		PO_4 mgL^{-1}	COD mgOL^{-1}	Conductivity µS cm^{-1}	pH pH units
1.	Raw influent sewage	5.58		4.24	214	1.26	7.77
2	Effluent from anoxic zone(s)	A	5.68	5.35	76	1.18	7.22
		B	5.62	5.27	82	1.20	7.25
3	Effluent from aerobic tank(s)	A	0.22	0.11	53	1.14	7.43
		B	0.28	0.17	62	1.13	7.42
		C	0.19	0.09	60	1.10	7.46
4	Effluent from secondary clarifier	0.73		0.55	34	1.14	7.31
5	Waste/surplus activated sludge	40.9		38.5	213	1.15	6.89
6	Sludge liquor(centrifuged centrate)	98.5		89.2	190	2.22	6.99
7	Effluent from WWTP	0.72		0.44	37	1.14	7.88

4. CONCLUSIONS

Recovery of phosphorus for recycling, rather than its transfer into dewatered sewage sludge,may offer economic and environmental rewards for the water industry. At Picket nala 30MLD STP,82–110 tons of phosphorus enters into the STP, and 78–100 tons is removed as part ofdewatered sludge. Large proportion of it could be removed from liquid phase in mostphosphorous abundant sources, e.g. sludge liquor. For the phosphate industry, extraction of nutrients holds out the promise of a significantsource of sustainable raw material – phosphorus, which is comparatively free from heavymetals. These benefits must be compared with the investment and running costs of phosphorus recovery installations.

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Standardized Precipitation Index – An Effective Tool for Assessment of Meteorological Drought in Amravati District

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ABSTRACT

Precipitation deficiency due to natural climatic variability in space and time is the primary cause of drought. Drought is a complex phenomenon that is difficult to accurately describe. There are large number of tools that have been developed to monitor moisture conditions. The most common tool is a drought index. A drought index can be used to quantify the moisture condition of a region, to detect the onset and measure the severity of a drought, to quantify the spatial extent of a drought event. Drought characterization is one of the important aspects in crop planning and resource development in rainfed farming areas. In this study, monthly rainfall at five tehasils in Amravati district of Maharashtra was analyzed to estimate and compare Decile index (DI), Effective drought index (EDI) and Standardized precipitation index (SPI) for identifying drought years in Amravati district using 22 years rainfall data (1991 - 2012). The Decile drought index identified maximum number of years in moderate drought category. Effective drought index identified maximum number of years in normal condition. SPI identified maximum number of years in mild wet and mild drought condition. From the correlation between soybean and sorghum *kharif* rainfed crops yield data and drought years severity obtained by different indices, it can be concluded that the performance of decile index and SPI can be considered as better in identification of drought over EDI. The three indices were then compared using seven assessment criterion adopted by Ntale and Gan (2003) and Dabare (2007. Since Standardized precipitation index (SPI) satisfies all the seven assessment criterion followed by Decile index which fulfills only four criteria, SPI can be considered as the most suitable index for drought assessment in Amravati district.

Keywords: SPI, DI, EDI, Meteorological drought, drought index, Amaravati.

INTRODUCTION

Drought affects very large areas for months and years and thus has a serious impact on regional food production, life expectancy for entire populations and economic performance of large regions or several countries. Precipitation deficiency, due to natural climatic variability in space and time, is the primary cause of drought. Drought is a complex phenomenon that is difficult to accurately describe. There are large number of tools that have been developed to monitor moisture conditions. Several users such as top level policy makers at the national and international organisations, researchers, middle level policy makers at the state, province and local levels consultants, relief agencies and local producers including farmers, suppliers, traders and water managers are interested in reliable and accurate drought information for effective management.

The most common tool for monitoring drought conditions is a drought index. A drought index can be used to quantify the moisture condition of a region, to detect the onset of drought, to measure the severity of a drought event, to quantify the spatial extent of a drought event, thereby allowing a comparison of moisture supply conditions between regions (Alley, 1984). Precipitation is the primary factor controlling the formation and persistence of drought conditions. Thus, index of meteorological drought is used to measure how much precipitation for a given period of time has deviated from historically established norms. Drought indices are also useful tools for providing information to decision-makers in agriculture sector, government and to public stakeholders. The drought indices can be used to provide an early drought warning system (Lohani and Loganathan, 1997; Lohani *et al*., 1998), to calculate the probability of drought termination (Karl *et al*., 1987), to determine drought assistance (Wilhite *et al*., 1986), to assess forest fire hazard and dust storm frequency (Cohen *et al*., 1992), to predict crop yield (Kumar and Panu, 1997), to examine the spatial and temporal characteristics of drought, the severity of drought, and to make comparisons between different regions (Alley 1984, Soule, 1992; Kumar and Panu 1997 and Quiring *et al*., 2007). Dabare and Satpute (2008) quatified and categorized agricultural droughts in Nagpur district by using decile drought index. They evaluated the widespread drought years by compairing average crop yield of different crops and found that decile drought index can also be used for agricultural drought charecterisation. For proper crop planning and management there is an urgent need of analysis of droughts occurred in this region by quantifying and categorizing them using suitable drought index. Standardized Precipitation Index (SPI), Decile Drought Index and Effective Drought Index (EDI) are some of the widely used meteorological drought indices for drought quantification. These indices are solely based on precipitation data. Kim *et al.* (2009) compared the performances of the Effective Drought Index (EDI) and 1, 3, 6, 9, 12, and 24 month Standardized Precipitation Indices (SPIs) for drought monitoring data accumulated over 200-year period from 1807 to 2006 for Seoul, Korea. McKee (1993) used 3, 6, 12, 24 and 48 months Standardized Precipitation Index (SPI) for 120 years of random monthly precipitation based on the annual cycle and expected variability of precipitation at Fort Collins, CO. Bordi *et al.* (2001) demonstrated that SPI can be used as a tool in the historical reconstruction of drought events in locations in Italy and analyzed the rainfall on Marche region. Oza *et al.* (2002) used standardized precipitation index (SPI) for drought detection, quantification and agricultural impact assessment at a homogeneous rainfall region level (North-West India) and at meteorological subdivision level (West Rajasthan and Saurashtra-Kutch) using monthly rainfall data (1951-1999). Morid *et al.* (2006) compared the performance of seven indices for drought monitoring in the Tehran province of Iran. The SPI and EDI was found to be able to detect the onset of drought, its spatial and temporal variation consistently, and it may be recommended for operational drought monitoring in the Province. The meteorological drought study has been carried out by different researchers by using three drought indices such as Decile index (DI), Effective drought index (EDI) and Standardized precipitation index (SPI) at different locations. The present study was undertaken for comparative assessment of meteorological drought indices i.e., Decile index (DI) (Table 1). Effective drought index (EDI) (Table 2) and Standardized precipitation index (SPI) (Table 3) for identifying drought years in five tehasils of Amravati district using 22 years rainfall data (1991 - 2012).

Table 1 Climatic condition during different years as identified by decile drought index during 1991 -2012

	Climatic Condition				
Taluka	**Above normal**	**Normal**	**Mild drought**	**Moderate drought**	**Severe drought**
Anjangaon	2006 2007	1994 1998 2012	1996 1997 1999 2002 2004 2005 2008 2010	1992 1993 1995 2000 2001 2003 2009 2011	1991
Per cent year	10	15	40	40	5
Amravati	——	1998 2007 2010 2011 2012	1992 1994 1996 1999 2001 2005 2006 2008	1991 1993 1997 2000 2002 2003 2009	1995 2004
Per cent year	0	25	40	35	10
Chandur Railway	2010	1999 2003 2005 2006 2007	1996 2011	1991 1992 1994 1995 1997 1998 2000 2001 2002 2004 2008 2009 2012	1993
Per cent year	5	25	10	65	5
Morshi	2007	2005 2006 2010 2012	1992 1994 1999 2003 2004 2011	1991 1993 1996 1997 1998 2001 2002 2008 2009	1995 2000
Per cent year	5	20	30	45	10
Warud	——	1993 1994 1995 2007 2010 2011 2012	1992 1999 2005 2006	1996 1997 1998 2001 2002 2003 2004 2008 2009	1991 2000
Per cent year	0	35	20	45	10

Table 2 Climatic condition during different years as identified by effective drought index during 1991 - 2012

Taluka		Extremely wet	Severe wet	Moderate wet	Mild wet	Normal condition	Mild drought	Moderate drought	Severe drought	Extremely dry
Anjangaon		2006 2007	2012	2001	2005 2010	1993 1994 1995 1997 1998 1999 2002 2003 2004 2008 2009 2011	1991 1992 1996 2000	____	____	____
	Per cent year	10	5	5	10	60	20	0	0	0
Amravati		2010	____	1998 2000 2001	2005 2007	1991 1992 1993 1994 1999 2003 2006 2011 2012	2008 2009	2002	1995 1997 2004	1996
	Per cent year	5	0	15	10	45	10	5	15	5
Chandur Railway		2010	1994	2006	2005	1999 2000 2003 2007 2011	1991 1992 1993 1997 1998 2001 2002 2004 2012	1995 1996 2008	2009	____
	Per cent year	5	5	5	5	25	45	15	5	0
Morshi		____	2001 2007 2010	____	____	1991 1992 1998 1999 2003 2004 2005 2006 2011 2012	1993 1994 1995 2002 2009	1997 2000 2008	1996	____
	Per cent year	0	15	0	0	50	25	15	5	0
Warud		____	____	1993 1994 1995 2007	____	1992 1999 2000 2001 2003 2004 2005 2006 2008 2009 2010 2011 2012	1991 1996 1997 1998	2002	____	____
	Per cent year	0	0	20	0	65	20	5	0	0

Table 3 Climatic condition during different years as identified by standardized precipitation index during 1991-2012

Taluka		Extremely wet	Severe wet	Moderate wet	Mild wet	Mild drought	Moderate drought	Severe drought	Extremely dry
Anjangaon		2006 2007	1998	____	1994 1997 1999 2005 2009 2010 2011 2012	1992 1993 1995 1996 2001 2002 2003 2004 2008	1991 2000	____	____
	Per cent year	10	5	0	40	45	10	0	0

Taluka		Extremely wet	Severe wet	Moderate wet	Mild wet	Mild drought	Moderate drought	Severe drought	Extremely dry
Amravati		____	2010	1994 2006 2007 2012	1992 1993 1998 1999 2000 2005 2008 2011	1991 1996 1997 2001 2003 2004 2009	____	2002	1995
	Per cent year	0	5	20	40	35	0	5	5
Chandur Railway		2010	1992 2006	1994 2005 2007	1996 1999 2003 2011 2012	1997 1998 2000 2004 2009	1991 1993 1995 2002	2001 2008	____
	Per cent year	5	10	15	25	25	20	10	0
Morshi		2010	2007	2012	1992 1994 1998 1999 2001 2003 2004 2005 2006 2011	1991 1996 1997 2008 2009	1993 1995	2000	2002
	Per cent year	5	5	5	50	25	10	5	5
Warud		1993	____	1992 2007	1994 2005 2006 2009 2010 2011 2012	1995 1996 1997 1998 1999 2003 2004 2008	2000 2001 2002	1991	____
	Per cent year	5	0	10	35	40	15	5	0

MATERIALS AND METHODS

Location of Study Area

The study was conducted for Anjangaon, Amravati, Chandur Railway, Morshi and Warud tehasils of Amravati district. The longitude (N) and latitude (E) of the five tehasils is 21.1600^0 and 77.3100^0, 20.9258^0 and 77.7647^0, 19.7300^0 and 79.1800^0, 21.3392^0 and 78.0131^0, $21.4667^0$and 78.2667^0 respectively. The average seasonal rainfall (1991 – 2012) of the selected tehasils is 624.3, 799.0, 699.4, 646.1 and 712.4 mm respectively.

Meteorological data and Yield data

The 22 years (1991-2012) rainfall data and yield data of *kharif* dry land crops viz., soybean and sorghum in selected taluka places in Amravati district was used. The yield data was obtained from the Office of Joint Director of Agriculture, Amravati.

Determination of Decile DroughtIindex

In the present analysis decile value for each monsoon month from June to September has been calculated and compared with actual rainfall of that month to identify the severity of drought in that month, according to the classification given by Gibbs and Maher (1967). After categorizing the months according to above classification, the drought years were computed by critically analyzing the growing period using the criteria given by George and Kalyansundaram (1969).

Determination of Effective Drought Index

Effective drought index (EDI) was developed by Byun and Wilhite (1999) and Monthly EDI values were estimated for the study period (1991-2012) by running 'EDI.exe' program. EDI values are standardized which allows drought severity at two or more locations to be compared with each other regardless of climatic differences between them. EDI roughly varies in the range from -2 to 2. It has thresholds indicating the range of wetness from extremely dry to extremely wet conditions.

Determination of Standardized Precipitation Index

SPI was developed by McKee *et al*. (1993) in Colorado State University is based on the probability distribution of precipitation. The standardized precipitation index (SPI) was estimated by running the 'SPI _SL_6.exe' program using monthly rainfall data. The 3-month time scale SPI for September values were used to represent SPI index for *kharif* season of the year according to Patel (2007), which uses the monthly rainfall data of July, August and September for estimating the 3-month SPI index. Drought classification by SPI value and corresponding event probabilities as given by McKee et al. (1993) is used to categorize the drought.

Comparison of Drought Indices

This study is planned to identify the most suitable index for characterizing drought in Amravati district, but realistically no one index can perfectly track the dimensional variation of the climatic system. Ntale and Gan (2003) discussed and used the criteria that can be used to gauge the suitability of drought indices. Dabare (2007) evaluated three different drought indices in identifying drought years in eastern Vidarbha by following the criteria suggested by Ntale and Gan (2003). The three drought indices were compared according to the procedure followed by Dabare (2007) by following assessment criteria to determine most appropriate drought index for monitoring meteorological drought in Amravati District.

Drought years identified by different indices

The drought years identified by different indices were analyzed according to their severity class. The index, which is having more consistency with historical drought events, was characterized as good indicator of drought for this region. The three indices were checked with the well-known historic drought event in 1991, 1995, 2000 and 2002 in Amravati district.

Spearman rank correlation coefficient

Due to the discrete variation of two variables (i.e. yield and drought year), Spearman rank correlation rank correlation was chosen as a measure of how well years ranked by drought index value are compared to years ranked by yield of the area. For all drought indices, a positive index value indicates wetter than normal condition and negative index value imply dryer than normal conditions. Correlation between the drought years and yield of the year can range between -1 and 1 (Chandel, 1965). A positive correlation indicates a direct relationship between two variables. In other words, when one variable shows a lower value than normal, the other variable will also show relatively lower values, and conversely, higher values of one variable will be associated with higher values of the other variable. A negative correlation indicates an inverse relationship. This means that a higher ranked value of one variable will be associated with a lower ranked value of the other variable (Hall and Brown, 2005).

RESULTS AND DISCUSSION

Drought years identified by different indices and Comparison of Drought Indices

The drought years identified by three drought indices i.e. Decile drought index, EDI and SPI at five tehasils in Amravati district during 1991–2012 are sorted out according to drought severity and presented in Table 1, 2, 3 respectively. The monthly decile classes for various drought severity ranges (DDI) during *kharif* season in different taluka places of Amravati district for the study period (1991-2012) (Table 4) was determined and presented in

Table 1. From Table 1, it is revealed that maximum number of years at most of the taluka places falls under mild to moderate drought category and very few years falls under severe drought and above normal conditions. Out of 22 years of study period, moderate and severe drought condition in different taluka places of Amravati district varied from 35 to 65 per cent and 5 to 10 per cent years respectively.

Table 4 Spearman rank correlation between various crop yield and drought severity by different drought indices for different talukas in Amravati district

Taluka	Decile		EDI		SPI	
	Soybean	Sorghum	Soybean	Sorghum	Soybean	Sorghum
Anjangaon	0.30	0.24	0.46	0.045	0.3	0.3
Amravati	0.71	-0.15	0.49	-0.13	0.58	-0.30
Chandur Railway	0.46	-0.08	0.36	-0.18	0.49	-0.16
Morshi	0.58	-0.15	0.05	-0.03	0.40	-0.18
Warud	0.47	-0.007	0.35	0.25	0.47	0.17

The monthly effective drought index (EDI) values were estimated for the study period and presented in Table 2. From Table 2, it is revealed that maximum number of years at most of the taluka places falls under normal climatic category (25 to 65 %) followed by mild drought (10 to 45 %) category and very few years falls under moderate drought (0 to 15 %), severe drought (0 to 15%) extreme dry (0 to 5%), mild wet (0 to 10 %), moderate wet (0 to 20 %), severe wet (0 to 15 %) and extreme wet condition (0 to 10%).

The seasonal climatic condition for different years was decided by considering the 3-months SPI for September and is summarized in Table 3. Out of 22 years of study period, most of the years fall under mild wet (25 to 50%) and mild drought condition (25 to 45%) in different taluka places of Amravati district. Moderate wet and moderate drought climatic condition in different taluka places in Amravati district varied from 0 to 20 per cent years. Extreme wet, severe wet and severe drought conditions varied from 0 to 10 per cent years. The extremely dry climatic condition was found to vary from nil to 5 per cent years (Table 3).

From Table 1 to 3, it is observed that SPI and decile index methods had identified most of the drought years which were not observed by EDI method. However, decile index method has identified extra large number of year in moderate and severe category at different taluka places compared to SPI and EDI methods. From the above results, it can be concluded that SPI method identifies all the drought years consistently and distinctly over decile index and EDI method which proves the superiority of SPI method over the latter two drought indices.

Analysis of major historical droughts

The three indices used for drought characterization in different taluka places of Amravati district have identified four major historical droughts in Amaravati district viz., 1991, 1995, 2000 and 2002. Decile index and SPI are showing more consistency with historical drought events indicating the superiority of these two indices over EDI in identifying proper severity of drought in the region.

Spearman rank correlation coefficient

From Table 4, it can be revealed that for Soybean crop, decile index gives highest positive correlation followed by SPI and EDI, for different taluka places in Amravati district. For Sorghum, SPI and EDI gives positive correlation at two taluka places followed by decile index (1 taluka places). At Amravati, Chandur Railway and Morshi all the three indices showed negative correlation for sorghum crop. At Warud, decile index and EDI gave negative correlation for sorghum crop. Also at Achalpur EDI showed negative correlation for sorghum crop.From the above results of correlation between different rainfed crops yield data and drought years severity obtained by different indices, it can be concluded that the performance of decile index and SPI can be considered as better in identification of drought over EDI.

The three indices were then compared using seven assessment criterion adopted by Ntale and Gan (2003) and Dabare (2007). The SPI was found to be superior over that of decile index and EDI because it describes all the major droughts occurred in Amravati district, more consistency with historical drought events, easily adapted to the local climate, can be computed at almost any time scale, has no theoretical upper or lower bounds and it fulfills the criteria of data requirement and availability for its assessment. Since Standardized precipitation index (SPI) satisfies all the assessment criterion followed by Decile index which fulfills only four criteria, SPI can be considered as the most suitable index for drought assessment in Amravati district.

CONCLUSION

The monthly rainfall at five taluka places in Amravati district of Maharashtra was analyzed to estimate and compare Decile index (DI), Effective drought index (EDI) and Standardized precipitation index (SPI) for identifying drought years in Amravati district using 22 years rainfall data (1991 - 2012). The Decile drought index identified maximum number of years in moderate drought category. Effective drought index identified maximum number of years in normal condition. SPI identified maximum number of years in mild wet and mild drought condition. From the correlation between soybean and sorghum *kharif* rainfed crops yield data and drought years severity obtained by different indices, it can be concluded that the performance of decile index and SPI can be considered as better in identification of drought over EDI. The three indices were then compared using seven assessment criterion adopted by Ntale and Gan (2003) and Dabare (2007. Since Standardized precipitation index (SPI) satisfies all the seven assessment criterion followed by Decile index which fulfills only four criteria, SPI can be considered as the most suitable index for drought assessment in Amravati district.

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Study and Characteristics of Concrete with Recycled Aggregate and Coconut Coir Fibre

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ABSTRACT

In the world of construction, concrete like other materials is playing an important role in development. concrete is a composite material which is a mixture of cement, fine aggregate , coarse aggregate and water .The major constituents of which is natural aggregate such as gravel, sand, Alternatively, artificial aggregates such manufactured sand furnace slag, fly ash, expanded clay, broken bricks and steel may be used where appropriate. It possesses many advantages including low cost, general availability of raw material, adaptability, low energy requirement and utilization under different environmental conditions. Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality. Coconut fibre is one of the natural fibres abundantly available in tropical regions, and is extracted from the husk of coconut fruit. Coconut fibre is extracted from the outer shell of a coconut. Not only the physical, chemical and mechanical properties of coconut fibres are shown; but also properties of composites (cement pastes, mortar and/or concrete etc). The fibres were added to the recycled aggregate in a proportion and cubes, prisms and cylinder were prepared and some of the tests were conducted and results were obtained. Based on the results the life of the concrete or building can be estimated.

1. INTRODUCTION

Concrete is preferred as it has longer life, low maintenance cost & better performance. For achieving GDP rate, smaller structures are demolished & new towers are constructed. Protection of environment is a basic factor which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development, play an important role in modern requirements of construction works. Concrete fails suddenly under tension and cracks excessively when unreinforced. Steel rebar is conventionally used to reinforce concrete. But, it is expensive to many people in most developing countries. In tropical regions, natural fibres are abundantly available which when utilized will reduce the cost of reinforced concrete and improve its performance. The use of natural fibre as reinforcing material is as old as man. Egyptians used straw in making mud bricks between 1200 and 1400 BC while in 2500 BC asbestos fibres were used in Finland to make clay pots. However, the usage was more of tradition than technical. In the recent past, there has been growing interest in studying the properties of coconut fibres and coconut fibre reinforced composite They reported that the tensile and specific tensile strength were 500 MPa and 0.43 MPa respectively while the density was 1150 kg/m^3. The divergent reported properties of coconut fibres suggested that they do not have standard properties.

On the use of CF as reinforcing material in concrete studied the strength characteristics of concrete containing between 0.5% and 2% coconut fibre (CF) of length 4 cm. They observed that strengths increased with increase in fibres volume fraction. The compressive strength, splitting tensile strength, modulus of rupture and shear strength were increased up to 13.7, 22.9, 28.0 and 32.7 % respectively. They concluded that natural fibres may be good alternatives to relatively more expensive steel, polyester or glass fibres.

The concrete specimens were subjected to static loading. Their results showed that treated CF performed better than the raw ones. But the compressive strength decreased as the volume of CF increased for all the mixes. They concluded that CF can be used to produce structural lightweight concrete in the case of low-cost constriction. But, dynamic properties of coconut fibre reinforced concrete (CFRC) showed that damping of CFRC beams increases and natural frequency decreases with increasing damage due to static loading for all cases. CFRC beam with 3 % fibre content has the highest damping and lowest natural frequency in the uncracked and cracked stage as compared to that of CFRC beams with fibre contents of 1 and 2 % [8].and cracked stage as compared to that of CFRC beams with fibre contents of 1 and 2 % [8].

2. MATERIALS AND METHODS

2.1 Materials

The cement used in the study was Ordinary Portland Cement (OPC). Table 1 summarizes the chemical and physical properties of the cement. River sand of maximum particle size of 3.18 mm and crushed granite (maximum size of 12.5 mm) were used as fine and coarse aggregates while potable water was used as mixing water. Coconut fibres (CF), brown type, were collected from a local coconut processing centre in Epe, Lagos State, Nigeria (Figure 1). Strands of the fibre were extracted from the compressed natural form and chopped into uniform sizes of 40 mm long.

2.2 Mixing and Preparation of Samples

The cement used in the study was Ordinary Portland Cement (OPC). were used as fine and coarse aggregates while potable water was used as mixing water. Strands of the fibre were extracted from the compressed natural form and chopped into uniform sizes of 40 mm long.

Figure 1 Pieces of Red Coconut Fibre

2.3 Methods

2.3.1 Sieve Analysis and Properties of Aggregates

In order to determine the suitability of the aggregates used in this study, the particle size distribution of both the fine and coarse aggregates were carried out in accordance with BS 1377 Part 1 and 2. The particle size distribution curves were plotted. The grading for the aggregates and their relative combinations were numerically expressed in terms of uniformity coefficients (Cu) and curvature (Cc). Also, the water

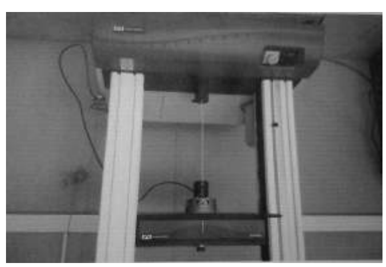

Figure 2 Testing of Tensile Strength of Coconut Fibre Using Instron Machin

Diameter and density of the CF were also determined. Average of 10 readings was recorded in each case.absorption and specific gravity of the aggregates were determined.

2.3.2 Properties of Coconut Fibre

The tensile strength of the CF was determined using Instron mechanical testing machine (Figure 2) at Centre for Energy and Research Development (CERD), Obafemi Awolowo University, Ile-Ife, Nigeria. The procedure specified in ASTM D638 – 10 was followed.

2.3.3 Slump, Compressive and Flexural Strengths of Coconut Fibre Reinforced Concrete

The slump for each of the concrete mix was determined in accordance with the provisions of BS 1881:Part102. In order to maintain the same consistency for all the mixes, the slump value was kept at 60 mm and the water-cement ratio to achieve that was measured. Compressive strength test at the end of each curing age was performed as described in BS 1881-107. The experimental set up for flexural strength is shown in Figure 3. The force that caused flexural failure was recorded and the flexural strength as expressed as modulus of rupture (MOR) was determined from the

3.0 RESULTS AND DISCUSSION

3.1 Particle Size Distribution and Physical Properties of Aggregates

The particle size distribution curves of the sieve analysis carried out on the aggregates (fine and coarse) are shown in Figure 4. These coefficients are within the values accepted for well graded aggregates [13]. The import of this is that the aggregates are fit for concrete production. The specific gravities were 2.56 and 2.62 respectively; their water absorption capacities were 18.3 and 17.10 for sand and crushed granite respectively.

3.2 Physical and Mechanical Properties of Coconut Fibre

In order to assess the characteristics of coconut fibre used in this study, the parameters that measure its physical and mechanical properties were determined. The average results as compared to those of other researchers are presented in the Table 3. It is observed that the average diameter, length and density of the coconut fibre are 0.32 mm, 82.23 mm and 720 kg/m3

These values are within the range proposed by other authors (Table 3). But for the mechanical parameters, tensile strength and tensile strain were 1.66 MPa and 0.31 respectively while the elongation was 31.8%.

The difference could be attributed to test conditions and variations in coconut fibres from different part of the world. Despite the relative low tensile strength, it is observed that the CF used has resistance to break easily as shown by the elongation value (31.8%) compared to values of other authors and as shown in the stress-strain deformation of the CF specimen (Figure 5). The elastic modulus could be determined by determining the slope of the linear portion of the curve. The Thus, it is necessary to test CF for its mechanical properties whenever it will be used.

Table 1 Properties of Coconut Fibre

Reference	Physical Properties			Mechanical Properties		
*Coconut Fibre (strand)	Diameter (mm)	Length (mm)	Density(Kg/m3)	Tensile Strength (MPa)	Tensile Strain	Elongation (%)
[3]	**0.32**	**82.23**	**720**	**1.66**	**0.31**	**31.8**
[13]	0.40- 0.10	60- 250	-	15- 327	-	-
[14]	0.11– 0.53	-	670- 1000	108- 252	-	13.7– 41
[4]	0.1- 0.4	-	870	174	-	10 - 25

*Average test results of this study

3.3 Effect of Coconut Fibre on Mixing Water Requirement

In order to ensure constant consistency for all the mixes, the workability of the concrete mix was fixed with a slump value of 60 mm. The value selected was to produce true slump of workable concrete. The water-cement ratio required to achieve the slump as the content of coconut fibre varied is presented in Table 4

It is observed that the w/c increased as the content of CF increases. At 1, 2, 3 and 4% content of CF, the w/c were 0.63, 0.66, 0.68 and 0.70 respectively while the normal concrete had w/c of 0.62. This indicated that CF absorbed moisture. Since concrete required moisture for its strength development, the use of CF could be an advantage in this regard and could cause biodegradation of the fibre at later age.

3.4 Compressive Strength of Coconut Fibre Reinforced Concrete

The compressive strengths of the concrete containing different proportions of CF are plotted against curing ages as shown in Figure 5. It is observed that, for all the mixes, the strength increased with age. It is also observed, with the exception of 1%, that the compressive strength decreased with increase in CF content. On monitoring strength development, it is seen that, at early age of 3 days, the compressive strength of concrete mixes containing 1 and 2%

CF were 9.45 and 9.01 respectively as against that of normal concrete (8.77) while the concrete mixes with 3and 4% CF were in the order of 7.76 and 6.83. Similar trend was observed in case of 7-day strength only that normal concrete had strength higher than that of concrete containing 2%.

But, at 28 days, when the strength of normal concrete was compared with that of CFRC of 1%, the compressive strength was 6.7% above strength of normal concrete, and is reduced up to 6.3, 18.6 and 26.7 % for CFRC with fibre content of 2, 3 and 4%. Similar pattern was observed in case of 56-day strength. It is interesting to note that, the 28-day strength for normal and up to 2% CFconcrete were above the minimum strength of 17 for use as structural concrete. The test results showed that coconut fibre had influence on the compressive strength development of concrete. At lower content of CF, up to 2%, the relative increase in strength observed could be due to the potential of CF to resist compressive stress. But higher fibre content in CFRC might have caused voids resulting in decreased compressive strength.

Table 2 Effect of Coconut Fibre on the Water-Cement ratio at Constant Slump

Content of CF (%)	Water/Cement Ratio	Slump(mm)
0.5	0.62	60
1	0.62	60
1.5	0.63	60
2	0.63	60

3.5 Flexural Strength of Coconut Fibre Reinforced Concrete

Flexural strength (or modulus of rupture) is one of the principal factors in concrete pavement design as it measures the resistance of the concrete to flexural force. Results of the flexural strength test for all the concrete mixes containing different volume fraction of CF are presented in Table 5. Increased flexural strength of CFRC is evident compared to normal concrete. It is observed that the flexural strength increased with increase in fibre fraction from 1 to 4% for all the ages. Quantitatively, at age 3 days, flexural strength increased from 1.52 for normal concrete to 2.51 for 4% CF concrete representing about 65% higher. Also, at 7, 28 and 56 days, the flexural strength of 4% CFRC were about 145, 118 and 118% of the normal concrete (0%) respectively.

It was observed that the relative increase in flexural strength reduced with age and became constant between 28 days. The implication of this was that, CF did not influence the relative flexural strength at later age. It could also be attributed to the fact that coconut fibre is biodegradable and possibly reduced bond strength between concrete ingredients which may result in early failure compared to when less volume of fibres are used. However, improved flexural strengths noticed at early ages could be due to increased denseness of the paste, improved paste-aggregate bond and occasioned by the presence of coconut fibre. Due to the possible negative effect of higher volume of CF in concrete, a maximum of 2% volume fraction could be recommended. The relationship between compressive and flexural strength could be assessed by the strength ratio (SR). Strength ratio, as used in this study, denotes the ratio of flexural strength to corresponding compressive strength. The SRs for all the concrete specimens at different ages are summarized in Table 5. It is noticed that SRs increased with increase in fibre content but reduced with increase in age but became relatively constant at 28 days and above. The reason for this may be credited to positive influence of age on compressive strength (Figure 5) and relative low flexural strength at 28 days and above.

This trend further confirmed that age did not appreciably influence flexural strength of CFRC especially at ages above 28 days due to possible degradation of CF in the alkaline concrete medium. However, this defect could be minimised by pre-treatment of the fibre which was not considered in this study.

Table 3 Flexural Strength and Strength Ratio of Concrete Fibre Reinforced Concrete

Coconut fibre (CF) content (%)	Flexural Strength(N/mm^2)			Strength Ratio (SR)		
	Curing Age (Days)			Curing Age (Days)		
0	**3**	**7**	**28**	**3**	**7**	**28**
1	1.52	1.96	2.54	0.173	0.136	0.132
2	2.1	2.44	2.73	0.222	0.149	0.133
3	2.31	2.72	2.79	0.256	0.206	0.154
4	2.41	2.84	2.88	0.311	0.239	0.183

3.6 Effect of Coconut Fibre on Flexural Crack of Concrete Beam

When concrete beams are subjected to flexural loading, there is tendency for flexural stress to develop which has the potential to initial cracks when the concrete carrying capacity is exceeded. The absence of crack is of considerable importance in maintaining the continuity of a concrete structure and in many cases in the prevention of corrosion of reinforcement.

During flexural loading of the CFRC beams, it is evident that coconut fibre reinforcement directly affected the flexural cracks developed. Figure 6 shows the crack patterns for normal concrete (NC) beam and CFRC beams at 28-day testing. On visual observation, cracks initiated from the tension zone (bottom of the beam) where the bending moment was suspected to have been higher and progressed inward towards compression zone (top of the beam), *zero bending moment.* But, the crack was more pronounced in the case of normal concrete (NC) in which no fibre was used when compared with those with different volume fraction of fibres. It could also be seen that the crack reduced as the fibre content increases. The interpretation of this behaviour could be attributed to the presence of CF which prevents progression of cracks due to crack-arresting, crack thinning and crack bridging effect of CF.

Generally, there appears to be at least three stages in the cracking process. In each stage, coconut fibre is suspected to play crucial role in arresting crack formation and progression. In Stage I: before loading, intrinsic volume changes in concrete due to shrinkage or thermal movements can cause strain concentrations at the aggregate–paste interface. Within this stage localized cracks are initiated at the microscopic level and at isolated points throughout the specimen where the tensile strain concentration is the largest. This shows that these cracks are stable and, at this load stage, do not propagate. Luisito et al. in [18] showed that CF has low thermal conductivity which makes it suitable for roofing material. This is also an advantage in arresting crack. Since, CF is likely to have low thermal conductivity compared to other ingredients of concrete, its presence in concrete could stem down the thermal movements caused by heat of hydration developed in concrete matrix. Thus, it hindered the early formation of cracks.

During Stage II, as the applied load increased beyond Stage I, the crack system multiplies and propagates but in a slow stable manner in the sense that, if loading is stopped and the stress level remains constant propagation ceases. The extent of the stable crack propagation stage will depend markedly upon the applied state of stress, being very short for ‘brittle’ fractures under predominantly tensile stress states and longer for more ‘plastic’ fractures under predominantly compressive states of stress. In this Stage, concrete is need of material to sustain it in resisting the bending stress. As earlier established, CF is a tough materials that could provide needed resistance to limit propagation of cracks when optimum volume fraction is used. At the last Stage, this occurs when, under load, the crack system has developed to such a stage that it becomes unstable and the release of strain energy is sufficient to make the cracks self-propagate until

NC(0.5%)

CFRC(1%)

CFRC(1.5%)

CFRC(2%)

Figure 3 Crack Progression in Coconut Fibre Reinforced Concrete Beam under Flexural Loading

CONCLUSION

As per the observation of test results. the percentage of recycled aggregates. Replacement gives the optimum value of the strength and various tests perfomed on the recycled aggregates. satisfactory results were obtained. as per IS 2386 from economic point of view. the use of recycled aggregates in construction.ennergy and cost of transportation saved. this inturn reduces the impact of waste material on environment. As per through observation of specimens casted.due to addition of coconut coire fibre.the shrinkage cracks. temparature stresses due to variation of temperatures.were significantly reduced.and the strength is no change as per addition of recycled aggregates for the % mentioned above construction.

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Assessment of Meteorological Drought for Crop Planning at Pandharpur in Scarcity Zone of Maharashtra

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ABSTRACT

Rainfall plays an important role in crop planning in scarcity zone. The common peculiarity of the scarcity zone is dry spell of the varying duration. Scarcity zone is one of the biggest and important zone of Maharashtra which occupies nearly about 1/3 rd area of the state comprising 114 tahsils of 18 districts. The rainfall has key position in success of dry framing. Generally, the rainfall of scarcity zone of Maharashtra is scanty, erratic and ill distributed. Sometimes quantity of rainfall may not be limiting factor but its distribution and uncertainty are other two qualities which make the rainfed farming very difficult. The daily rainfall data at Pandharpur for fifty three years (1961-2013) has been analyzed to study weekly, monthly and yearly meteorological drought. The average annual rainfall of Pandharpur is 648.57 mm. Rainfed *rabi* sorghum cultivation is mostly practiced in Pandharpur region. During the fifty three years period, occurrence of extreme severe drought was once and severe drought was twice while Moderate Drought, Mild Drought and No Drought experienced eleven years, thirteen years and twenty six years respectively. In case of monthly drought analysis, highest frequency of drought was observed in August month followed by September, June and October. The highest frequency of drought was observed in 30th meteorological week followed by 25th and 39th Meteorological week. Based on rainfall analysis, it was found that, the year, 1972 was experienced as extreme drought year. Critical dry spells expected to occur during 30th, 25th and 39th Meteorological week of the year. Hence for sustainable crop production, *in-situ* soil and water conservation measures viz., opening of ridges and furrows, compartment bunds, tied ridges, mulching, etc. should be adopted. Also, emphasis should be given on the contingency crop planning measures.

Keywords: Meteorological Drought, Rainfall Analysis, Scarcity Zone.

INTRODUCTION

Rainfall plays an important role in crop planning in scarcity zone. Yearly-seasonal and geographical crop yield variability depends on the space and time rainfall distribution. A reduction of precipitations due to climate changes has several and important impacts on human activities and the environment. Although many erroneously consider drought a rare and random event, it is a normal, recurrent feature of climate. It occurs in virtually all climatic zones, although its characteristics vary significantly from one region to another.

The common peculiarity of the scarcity zone is dry spell of the varying duration. The intra-seasonal vagaries of weather indicate the fragility of production systems sustainability. A sustainable production system needs management strategies by using advance weather forecasting tool leading to precision farming, timeliness in pest and disease management approaches so as to reduce the input cost and obtain higher profit. The availability of rainfall is not well assured at all the places and time. There is a large variation of rainfall distribution observed over space and time in India (Dhar et al., 1979). In our country, nearly 75% of the rainfall is occurring during June to September. Extreme situations are also observed in certain years. Deficiency of rainfall is the basic cause of drought. As such no general method is available which can be applied for the drought prediction (Salas, 1986).

Meteorological drought is the condition when a region receives less than half the amount of normal precipitation (IMD, 1971). The meteorological drought analysis is mostly done based on point rainfall data as reported by several researchers earlier. Sharma et al., (1979.a, 1987.b and 1987.c) analyzed the rainfall for crop planning to overcome drought like scenario. Based on 14 years rainfall data analysis for meteorological drought assessment Lala et al. (2010) opined that for growing rainfed rice in Tura, Meghalaya during monsoon, farmers of this region may depend on monsoon as there was hardly drought occurrence. Similar analysis has been done by various researchers for meteorological drought analysis at various places in India. An attempt has been made in this paper, to assess the meteorological drought occurrence at Pandharpur (Dist. Solapur, Maharashtra under scarcity zone), based on analysis of daily rainfall data. The major crops in this region are pigeonpea, pearlmillet, sunflower, greengram and blackgram in *kharif* season and *rabi* sorghum, cheackpea, safflower in *rabi* season. Pomegranate and custered apple are predominant horticultural plantation in this region.

MATERIALS AND METHOD

The study place, Pandharpur is located in Solapur district of Maharashtra state at 17°68' North Latitude and 75°33' East Longitude with an altitude of 465 m above mean sea level. The average annual rainfall of Pandharpur is 648.57 mm, coming under scarcity zone of Maharashtra. The behavioral pattern of rainfall with reference to the amount of rainfall were calculated using probabilistic approach from historic daily rainfall records (1961-2013). The weekly rainfall from 23rd to 42nd standard meteorological weeks (that coincides with the monsoon period of this region), monthly rainfall and yearly rainfall were analyzed. The average weekly, monthly and yearly rainfall values were worked out. The variation of rainfall for each week, month and year from the mean was determined. Total numbers of drought weeks, month and years were determined using the standard procedure (IMD, 1971). Drought week: the amount of rainfall is equal to the half of the normal rainfall or less (Ramdas and Mallik, 1948). Drought month: the actual rainfall is less than 50% of the average monthly rainfall (Sharma et al., 1979.a). Drought year: the annual rainfall is deficient by 20-60% of the average yearly rainfall and if the deficient is more than 60% of the average yearly rainfall it is known as scanty drought year (Dhar et al., 1979). The yearly intensity of drought was also determined using the criteria suggested by IMD (1971) which is based on the percentage deviation of rainfall from its long term mean and it is given by (Equation.1).

$$Di = \left(\frac{Pi - \mu}{\mu}\right) \times 100 \qquad (1)$$

where,

Di = the percentage deviation from the long-term mean,

Pi = the annual rainfall, mm and

μ = the long term mean of the annual rainfall, mm.

Drought codification based on percentage departure of rainfall from normal is presented in Table-1. The percentage of deviation (Di) is then used to categories the drought.

Table 1 Drought codification based on percentage departure of rainfall from normal value (IMD, 1971).

Percentage departure of rainfall from normal	Intensity of drought	Code
0.0 or above	No drought	M_o
0.0 to - 25.0	Mild drought	M_1
-25.0 to - 50.0	Moderate drought	M_2
-50.0 to - 75.0	Severe drought	M_3
-75.0 or less	less Extreme drought	M_4

RESULTS AND DISCUSSION

The weekly analysis of drought for 23rd to 42nd standard week is (that coincides with the monsoon period of this region), presented in Table 2. From the Table 2, it is found that the average rainfall of different weeks has a variation from 52.01 mm in the 38th meteorological week to 15.46 mm in the 28th meteorological week. The maximum number of drought was observed 29 times in 30th standard meteorological week while the minimum number of drought has recorded 13 times in 28th and 42nd meteorological week.

The weekly variation of rainfall from standard meteorological week 23rd to 42nd week, and the frequency of drought occurred during these weeks is shown in Fig-1. It is found that the maximum frequency of drought is 29 times in 30th meteorological week followed by 28 times in 25th meteorological week and 39th meteorological week. The droughts during crop growth period affects the productivity sometimes crop failure takes place. Hence for sustainable crop production, *in-situ* soil and water conservation measures viz., opening of ridges and furrows, compartment bunds, tied ridges, mulching, etc. should be adopted. Also, emphasis should be given on the contingency crop planning measures.

The monthly analysis for drought is presented in Table-3. The highest rainfall of 180.42 mm was observed in the month of September and the lowest average rainfall of 1.68 mm occurred in the month of February. The frequency of drought was observed to be the highest at a magnitude of 33 times in August and 32 times in September in fifty three years. The major *kharif* crops are in flowering and pod formation stage during September and October, so this indicates that there is need for protective irrigation in the above months.

The yearly intensity of drought for Pandharpur is presented in Table-4. The years are codified according to IMD specification as described in Table-1. It is found from the Table-4 that, there was extreme drought and severe drought during year 1972 and 1966 respectively. The monthly average rainfall during these two years (1966 and 1972) is presented in Fig-2. However, for the year 1967 and 2012, the percentage deviation is just below the severe drought. The years 1967, 1968, 1970, 1976, 1992, 1994, 1997, 1999, 2006, 2011 and 2012 were moderate years (11 years) and the years 1963, 1964, 1971, 1982, 1991, 1995, 2000, 2002, 2004, 2005, 2007, 2008 and 2013 were mild drought years (13 years).

The average annual rainfall of Pandharpur is 648.57 mm with a maximum rainfall of 1216.7 mm in year 1974 and a minimum of 156.8 mm in the year 1972.The annual rainfall variation over the years 1961-2013 is shown in fig-3. The average monthly rainfall for the months April, May, June, July, August, September and October is 8.18, 21.22, 102.78, 90.18, 106.00, 180.42 and 103.37 mm respectively. The maximum average rainfall is received during the month of September (180.42 mm) and the minimum average rainfall is received during the month of February (1.68 mm).

Table 2 weekly rainfall analysis for drought (1961-2013)

Standard Meteorological Week	Average Rainfall, mm	Half of the average Rainfall, mm	No. of drought weeks	Percentage of drought week
23(4th to 10th June)	28.79	14.40	25	5.62
24(11th to 17th June)	25.32	12.66	24	5.39
25(18th to 24th June)	22.62	11.31	28	6.29
26 (25th to 1st July)	18.43	9.22	25	5.62
27 (2nd to 8th July)	16.53	8.27	22	4.94
28(9th to 15th July)	**15.46**	7.73	13	2.92
29(16th to 22nd July)	18.54	9.27	23	5.17
30(23rd to 29th July)	32.00	16.00	**29**	6.52
31(30th to 5th August)	21.54	10.77	23	5.17
32(6th to12th August)	18.93	9.47	26	5.84
33(13th to 19th August)	22.61	11.31	21	4.72
34(20th to 26th August)	28.66	14.33	20	4.49
35(27th to 2nd September)	34.04	17.02	19	4.27
36(3rd to 9th September)	26.18	13.09	21	4.72
37(10th to 16th September)	44.29	22.15	19	4.27
38(17th to 23rd September)	**52.01**	26.01	24	5.39
39(24th to 30th September)	43.02	21.51	28	6.29
40 (1st to 7th October)	39.44	19.72	22	4.94
41 (8st to 14th October)	25.77	12.89	20	4.49
42 (15th to 21th October)	19.57	9.79	**13**	2.92

Table 3 Analysis of monthly rainfall for drought (1961-2013)

Month	Average rainfall, mm	Half of the average rainfall, mm	No. of drought month	Percentage of drought months
Jan	4.87	2.44	2	0.99
Feb	1.68	0.84	0	0.00
Mar	4.39	2.20	4	1.97
Apr	8.18	4.09	8	3.94
May	21.22	10.61	13	6.40
Jun	102.78	51.39	31	15.27
Jul	90.18	45.09	27	13.30
Aug	106	53.00	33	16.26
Sep	180.42	90.21	32	15.76
Oct	103.37	51.69	30	14.78
Nov	19.13	9.57	19	9.36
Dec	6.37	3.19	4	1.97

Table 4 Yearly Intensity of drought at Pandharpur (1961-2013)

Year	Total Rainfall, mm	% deviation	Intensity of drought	Code
1961	649.00	0.07	No Drought	M_o
1962	765.00	17.95	No Drought	M_o
1963	545.30	-15.92	Mild Drought	M_1
1964	593.00	-8.57	Mild Drought	M_1
1965	732.40	12.93	No Drought	M_o
1966	313.40	-51.68	Severe Drought	M_3
1967	329.40	-49.21	Moderate Drought	M_2
1968	478.20	-26.27	Moderate Drought	M_2
1969	791.30	22.01	No Drought	M_o
1970	429.00	-33.85	Moderate Drought	M_2
1971	557.00	-14.12	Mild Drought	M_1
1972	156.80	-75.82	Extreme Drought	M_4
1973	857.30	32.18	No Drought	M_o
1974	1216.70	87.60	No Drought	M_o
1975	1035.00	59.58	No Drought	M_o
1976	464.00	-28.46	Moderate Drought	M_2
1977	669.20	3.18	No Drought	M_o
1978	1016.00	56.65	No Drought	M_o
1979	651.10	0.39	No Drought	M_o
1980	683.00	5.31	No Drought	M_o
1981	1148.00	77.01	No Drought	M_o
1982	487.00	-24.91	Mild Drought	M_1
1983	1049.50	61.82	No Drought	M_o
1984	886.00	36.61	No Drought	M_o
1985	670.70	3.41	No Drought	M_o
1986	651.80	0.50	No Drought	M_o
1987	1154.90	78.07	No Drought	M_o
1988	1127.00	73.77	No Drought	M_o
1989	882.00	35.99	No Drought	M_o
1990	667.40	2.90	No Drought	M_o
1991	570.00	-12.11	Mild Drought	M_1
1992	484.40	-25.31	Moderate Drought	M_2
1993	675.30	4.12	No Drought	M_o
1994	355.90	-45.13	Moderate Drought	M_2
1995	487.70	-24.80	Mild Drought	M_1
1996	719.40	10.92	No Drought	M_o
1997	477.10	-26.44	Moderate Drought	M_2
1998	983.30	51.61	No Drought	M_o

Year	Total Rainfall, mm	% deviation	Intensity of drought	Code
1999	415.50	-35.94	Moderate Drought	M_2
2000	539.30	-16.85	Mild Drought	M_1
2001	675.30	4.12	No Drought	M_o
2002	538.90	-16.91	Mild Drought	M_1
2003	258.70	-60.11	Severe Drought	M_3
2004	528.70	-18.48	Mild Drought	M_1
2005	583.50	-10.03	Mild Drought	M_1
2006	464.90	-28.32	Moderate Drought	M_2
2007	553.30	-14.69	Mild Drought	M_1
2008	541.20	-16.55	Mild Drought	M_1
2009	745.80	14.99	No Drought	M_o
2010	767.00	18.26	No Drought	M_o
2011	413.30	-36.27	Moderate Drought	M_2
2012	329.80	-49.15	Moderate Drought	M_2
2013	609.4	-6.04	Mild Drought	M_1

Table 5 Drought years during 1961-2013 at Pandharpur

Intensity of drought	Years	Total no. of Years
No Drought Year	1961, 1962, 1965, 1969, 1973, 1974, 1975, 1977, 1978, 1979, 1980, 1981, 1983, 1984, 1985, 1986, 1987, 1988, 19989, 1990, 1993, 1996, 1998, 2001, 2009, 2010.	26
Mild Drought Year	1963, 1964, 1971, 1982, 1991, 1995, 2000, 2002, 2004, 2005, 2007, 2008, 2013.	13
Moderate Drought Year	1967, 1968, 1970, 1976, 1992, 1994, 1997, 1999, 2006, 2011, 2012.	11
Severe Drought Year	1966, 2003.	2
Extreme Drought	1972	1
Total		**53**

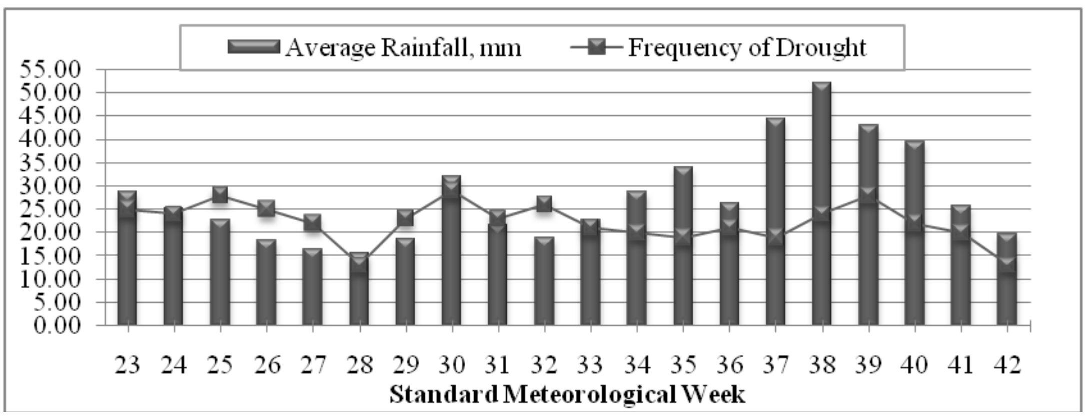

Figure 1 Variation in weekly rainfall and frequency of drought at Pandharpur station.

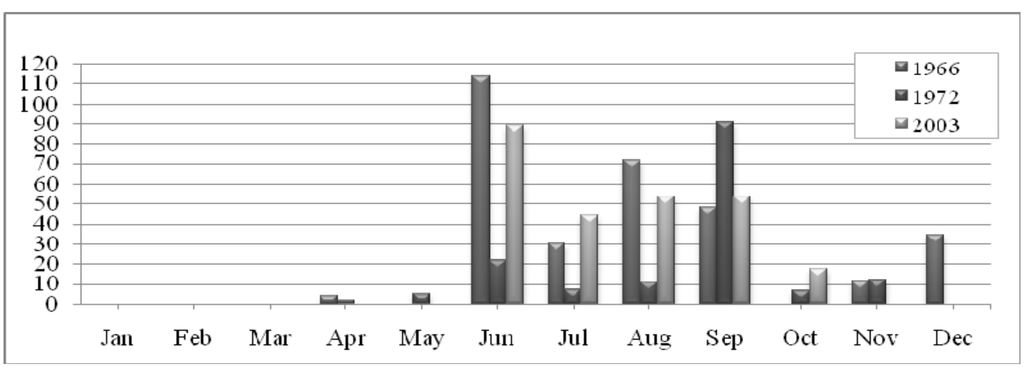

Figure 2 Monthly rainfall variation during the severe droughts years 1966, 1972 and 2003 at Pandharpur

CONCLUSION

Drought analysis based on 53 years daily rainfall record showed that 30th meteorological week had maximum frequency of drought, while in case of 28th and 42nd meteorological week the frequency is less. Month wise maximum frequency of drought is observed in August followed by September, June and October. During fifty three years of rainfall analysis, occurrence of extreme drought was once during the year 1972 while severe drought was experienced twice during 1966 and 2003 in Pandharpur. In the year 1967 and 2012 the drought was moderate but the percentage deviation just approaches the severe drought condition.

The 30th meteorological week, September, June and October months comes under *kharif* and *rabi* season period in which the frequency of drought is more. Hence for sustainable crop production, *in-situ* soil and water conservation measures viz., opening of ridges and furrows, compartment bunds, tied ridges, mulching, etc. should be adopted. Also, emphasis should be given on the contingency crop planning measures.

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A Detailed Investigation Report on Sri Ram Sagar Dam/Reservoir and Distributory Canal Efficiencies

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ABSTRACT

Water is a vital natural resource, a basic human need and a precious national asset. It is a key source for all activities right from agriculture to industry. In view of increasing water demand for various purposes namely irrigation, drinking, domestic, power (Thermal and Hydro), industrial and other uses, there is severe stress on water resources. Its scarcity is more pronounced with increasing population and needs. The performance of the existing irrigation systems (particularly, the major and medium irrigation schemes in the State) suffer from low water use efficiency, distribution losses, poor operational maintenance and management of soil salinity, water logging and tail end problems. Canal system performance has been below its potential and significant problem need to be addressed to maintain its past contribution. The gap between the planned cropping intensity and area actually irrigated has widened and the economic returns to project investment have been disappointing. There is weakness in most area of implementation and management. The water distribution is unreliable and often in equitable, maintenance is insufficient to sustain existing infrastructure

Keeping in view of the above scenario, the Central Water Commission, Ministry of Water Resources, Government of India, have initiated the study of water use efficiency of all the major and medium projects of India including Andhra Pradesh in a phased manner so as to enable to take necessary steps for improving the system. The study will focus on Dam/Reservoir efficiency, canal/ conveyance efficiency, on-farm application efficiency, Drainage efficiency, Irrigation potential created and utilized etc. The efficiency studies on 14 major and 6 medium Irrigation Projects of Andhra Pradesh have been taken up. Sri Ram Sagar Project in Nizamabad District is one of the above major irrigation projects for which water use efficiency studies are taken up.

Keywords: Dam, Reservoir, Kakatiya Canal, Saraswathi Canal, Laxmi Canal Drainage Systems, Efficiencies.

1. INTRODUCTION

Irrigation in India includes a network of major and minor canals from Indian rivers, groundwater well based systems, tanks, and other rainwater harvesting projects for agricultural activities. Of these groundwater system is the largest.[1] In 2010, only about 35% of total agricultural land in India was reliably irrigated.[2] About 2/3rd cultivated land in India is dependent on monsoons.[3] Irrigation in India helps improve food security, reduce dependence on monsoons, improve agricultural productivity and create rural job opportunities. Dams used for irrigation projects help produce electricity and transport facilities, as well as provide drinking water supplies to a growing population, control floods and prevent droughts.

The Sri Rama Sagar Project, also known as the Pochampadu Project is an Indian flood-flow project on the Godavari River. The Project is located in Nizamabad district, 3 km away from National Highway 44. It has been described by The Hindu as a "lifeline for a large part of Telangana". Sriramsagar is an irrigation project across river Godavari in Telangana to serve irrigational needs in Karimnagar, Warangal, Adilabad, Nalgonda and Khammam districts. It also provides drinking water to Warangal city. There is a hydroelectric plant working at the dam site, with 4 turbines each with 9 MW capacity generating 36 MW. The study will focus on Dam/Reservoir efficiency, canal/ conveyance efficiency, on-farm application efficiency, Drainage efficiency, Irrigation potential created and utilized etc. The efficiency studies on 14 major and 6 medium Irrigation Projects of Andhra Pradesh have been taken up. Sri Ram Sagar Project in Nizamabad District is one of the above major irrigation projects for which water use efficiency studies are taken up.

2. AIMS AND OBJECTIVES

The main objective of the study is to examine the status of the following efficiencies and to suggest necessary improvements in the system. The objectives of the water use efficiency studies.

- To show when and where improvement can be made in the system.
- More efficient irrigation.

3. SCOPE OF WATER USE EFFICIENCY STUDIES

The study will focus on the following aspects:-

1. Dam efficiency (inflows and release pattern)
2. Delivery system/Conveyance efficiency
3. On farm efficiency studies
4. Drainage efficiency and
5. Irrigation potential created and utilized.

The above efficiency studies of the project involve collection of primary as well as secondary data.

4. DAM/ RESERVOIR EFFICIENCIES

The project is intended to store a gross storage of 3171 M.cum or 112 TMC at its FRL + 332.537 m or +1091 ft for irrigating an ayacut of 9.69 Lakhs acres or 3.92 Lakh ha under the project including Lower Manair Dam of which the gross capacity is 24 TMC or 680.648 M.cum at its FRL + 280.416 m, through three canals as detailed below:

- Kakatiya canal from Km 0.00 to 146 (upto L.M.D) Km 146 to Km 234 and subsequently extended upto Km 284 9.11 Lakh acres
- Saraswathi Canal (Km 47.0) **0.35 Lakh acres**
- Laxmi Canal (Km 3.5) **0.23 Lakh acres**
- Total : **9.69 Lakh acres or 3.92 Lakh ha**

The catchment area at the dam site of SRSP is 91,751 Sq km out of which the free catchment area is 26,996 Sq kms and the balance 64,755 Sq km intercepted. The Catchment area of LMD is 6648 Sq.kms. The Sri Ram Sagar Project dam a Multipurpose Irrigation Project is located at a latitude of 18°-58' N and longitude of 78°-20' E. The Lower Minor Dam is located at a latitude of 18°-24' N and longitude of 79°-20' E. and is at kms 146 of Kakatiya canal. The dam acts as a balancing reservoir. The Sri Ram Sagar Project Dam is also meant for generating 36 M.W power, drinking water supply to Karimnagar and Warangal town and water supply to NTPC.

5. 75 % ANNUAL DEPENDABLE FLOWS

Dependable flow is the magnitude of river flow, which may be already expected at a given point on the river in a year and it is statistically determined. The 75% net dependable yield is assessed as 196.10 TMC or 5553.55 M.cums by C.W.C (after subtracting 98 TMC for future developments upstream) in addition to this yield of 13.40 TMC of water assessed at Lower Manair Dam at 75% dependable. A bilateral agreement was concluded in 1975 between the state of Maharashtra and Andhra Pradesh which became part of Godavari water dispute tribunal award and according to which a quantity of 200 TMC is available at Maharashtra border for flow into Sri Ram Sagar Reservoir and serves as the basis of SRSP utilization. In contrast to KWDT provisions, no expiry date was set for the GWDT award. The available water resources at project head and water allocation is as follows.

Sri Ram Sagar Project Dam

196.100 TMC (75% dependable yield based on the data for the period from 1950-51 to 1986-87 as per CWC U.O. Note No. G/171/86/PACS.214 dt.12-03-1992)

Stage – I 145.35 TMC

Stage – II 49.15 TMC

Total 194.50 TMC

At the time of project formulation, Irrigation was proposed under Sri Ram Sagar Project Dam was for 1/3rd wet and 2/3rd I.D.

6. INFLOW PATTER

Observed monthly inflows into river Godavari at Sri Ram Sagar Project site from the year 1995-96 to 2005-06 format-I (PART-A) are appended. Peak inflows were usually observed in the months of July to October every year except in year 1997-98 where in the more inflows are also received in the months of November and December. Further, the annual inflow varies over a wide range of values ranging from a maximum inflow of 16,042 M.cum during the year 1998-99 and minimum of about 736.42 M.cum in the year 2004-05, as seen from the inflow data of Sri Ram Sagar Project for the last 11 years. As far as monthly inflows are concerned, the maximum inflow of 6,654.90 M.cum was received during the month of October, 98 and minimum of 58.31 M.cum received during July 2001 (11.11 MM^3 during July, 2004 a drought year). It is seen that 75% dependable yield is received only in 6 years out of 11 years data observed and in the remaining years the actual inflows are less. The inflows are far less in the years 1997-98 (27 %), 2004-05 (13.26 %).

7. WATER SPILLAGE

The spillage of water from the Sri Ram Sagar Project from the year 1995-96 to 2005-06 are appended in format-I (part-A). As can be seen from the table that the project had spillover during 7 years of the 11 years observed. A maximum spillage of 11058.54 MM^3 was noticed during the year 1998-99 and a minimum of 789.46 MM^3 during the year 2001-02. There is no spillage during the years 1997-98, 2002-03, 2003-04 and 2004-05. **The histograph furnished below depicts the year wise inflows, outflows and spillover from the reservoir during the years 1995-96 to 2004-05.**

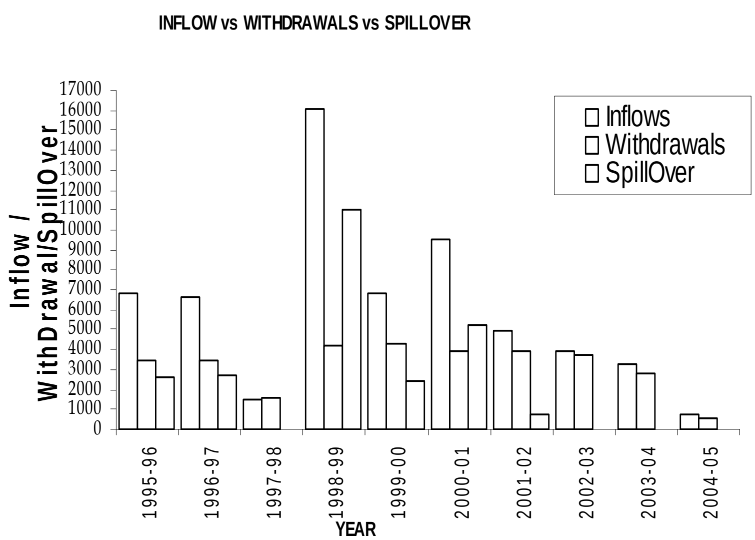

Figure: 1

8. EVAPORATION LOSSES IN THE RESERVOIR

Evaporation of water from storage reservoirs or barrages is a natural phenomenon. Evaporation is a direct function of water spread area and the rate of evaporation varies directly with temperature and wind velocity and inversely with humidity. Huge quantities of water lost through evaporation means loss of irrigation. The need for minimizing evaporation losses is greater in the reservoirs and barrages located in arid and semi-arid regions of A.P.

In case of Sri Ram Sagar Project, evaporation losses in the reservoir are considered in all working tables of the years from 1995 -96 to 2005-06 under study. A quantum of 25.00 TMC or 708 M.cum have been earmarked towards the evaporation losses at the time of formulation proposals of the project. Maximum of 395 M.cum were found to be evaporated from the reservoir during the year 1995-96 and the minimum evaporation of 169 M.cum observed during 1997-98 as seen from the working tables in Format-I (Part-A).

9. SEEPAGE LOSSES

The principal factor influencing seepage losses in reservoir are the permeability and thickness of the soil layers in the ponded area and the total head of water producing seepage. Seepage losses are generally more when the reservoir is underlain with porous strata having ample outlets beneath the surrounding hills or under the dam. In case of Sri Ram Sagar Project seepage losses were observed and indicated in working tables as per Format-I from 1995-96 to 2004-05 and the same are indicated in the table of dam efficiency under column no.7. The maximum seepage losses observed are 132 M.m3 during the year 1995-96 and the minimum losses are found to be 40 M.cum during the year 2004-05 which was found to be a drought year and there was MM^3 no irrigation during that year

10. CALCULATION AND PRESENTATION OF EFFICIENCIES IN TABULAR FORM

The efficiency of the dam / reservoir mainly depends on Hydrology of the project, inflow pattern, spillage (Maximum flood discharges), losses with reservoir such as seepage, evaporation etc and actually on the capacity to hold the water and regulating arrangement, condition of the reservoir which are discussed in this chapter.

The dam efficiency of the Sri Ram Sagar Project from 2003 to 2014 (i.e. 11 Years) is worked out and tabulated below, indicating the inflows during year, withdrawals, spill over, evaporation losses, seepage losses and the storage during the year

Table 1 Live Capacity : 2322 $M.m^3$ Gross capacity:112 TMC or 3171 $M.m^3$

No	Year	Inflows	With drawals	Spill over	Evaporation	Seepage	Actual Storage / month	Dam efficiency %
1	2	3	4	5	6	7	8	9
1	2003-04	6806	3417	2647	395	132	2811 (10 / 95)	84.5
2	2004-05	6632	3476	2751	369	122	2742 (10 / 96)	81.52
3	2005-06	1511	1549	-	169	42	571 (12 / 97)	-
4	2006-07	16,042	4217	11,059	309	103	2684 (11 / 98)	79.03
5	2007-08	6843	4334	2465	281	85	2491 (10 / 99)	70.71
6	2008-09	9488	3952	5187	259	83	2426 (10 / 00)	67.92
7	2009-10	4954	3894	789	235	59	2361 (10 / 01)	65.12
8	2010-11	3967	3698	-	210	52	2295 (9 / 02)	62.27
9	2011-12	3250	2832	-	315	105	1850 (8 / 03)	43.1
10	2012-13	736	523	-	180	40	617 (10 / 04)	-
11	2013-14	9380	4472	4404	266	79	3056 (9 / 05)	95.05

DAM EFFICIENCY

As seen, the dam has spilled over during (7) seven out of (11) eleven years of study and during (4) four years i.e. during the years 1997-98, 2002-03, 2003-04 and 2004-05, the spill over is nil. The maximum spill over is during 1998-99 and the minimum during 2003-04. The maximum storage efficiency is 84.50 % in the year 1995-96 and the minimum attained in the year 2003-04 (43.10 %).

The following observation are made with reference to dam efficiency.

The hydrographic surveys conducted during 1984 by the APERL when the reservoir attained its FRL + 1091 ft revealed that siltation problem exists in the reservoir and the rate of siltation was found to be abnormal. Again, the sedimentation surveys conducted in 1994 revealed that the gross capacity has come down to 2557.25 M.cum (90.31 TMC) against the original gross capacity of 3172 M.cum (112 TMC). The rate of siltation found to be 4.74 Ha. m / per 100 Sq. Kms / year. Again the hydrographic surveys conducted during 2006 reveal that the gross capacity of the reservoir at FRL has come down to 2264.21 M.cum (79.96 TMC) and the rate of siltation found to be 4.67 Ha. m / 100 Sq. Km / Year.

Certain measures have been taken up in construction of silt arresting tanks in the fore shore of SRSP catchment area so as to minimize the silt coming into the reservoir to some extent. Measures are required to be taken up for minimizing the rate of siltation into the Sri Ram Sagar Project,

The following observations with reference to safety of dam are made.

10.1 Earth Dam

- It is necessary to examine the capacity of the spill way to pass the designed flood at the specified MWL for which PMF is to be evaluated and the adequacy of spill way to pass the PMF and the adequacy of the free broad to be observed. Further the tail water level is to be maintained by erecting a gauge on the down stream so that a record would be available for any future purposes.
- The toe drains at a few places covered with vegetation need be cleared and the chute drains needs immediate replacement and brought to normal functioning as the same is in bad conditions. Also it is essential to install some more ‘V’ notches in addition to (4) four notches so that the areas of seepage could be classified into high, medium and low seepage zones.
- The vegetation growth on the downstream slopes of earth dam need be cleared.
- The black topped road on the top of earth dam needs repairs to ensure smooth movement.
- The Survey of India may be contacted for taking up dam deformation studies by establishing monitoring stations at various locations of the dam.

10.2 Spill Way

The bucket as well as the stilling basin have to be dewatered every year at the end of water year and the damages if any got be repaired including the repairs to solid apron, if any noticed after dewatering.

10.3 Gallery

The seepage from the drainage holes in the gallery has to be quantified so as to observe the functioning of drainage holes so also the porous drains functioning and the percentage of contribution from the drainage holes and the porous drains with reference to the total seepage. The performance of drainage holes have to be observed by measuring the depth of each hole and comparing it with the design depth so that need for new holes could be examined. The ventilation pipes ducts of gallery may be inspected and blocks cleared. The lighting in the galleries needs to be improved. The inside of the gallery may be white painted to enhance the lighting effect. Both the lifts providing access to the foundation gallery are not in working condition and they may be got repaired early.

10.4 Head Regulator

The scope for problems to the gates of Head regulators may be referred to the mechanical wing for getting them rectified on all fronts including seals and rollers.

10.5 River Sluices

The un attended river sluice (4 Nos) gates are of potential risk and hence need immediate attention.

10.6 Gates and Hoist Equipment

1. The seals of gates 1, 7,9,11 to 15 and 36 are said to be leaking. This may require rectification.
2. The turn buckles of radial gates getting jammed needs rectification.
3. An approach ladder may be erected for approaching the walk way bridge erected at trunnion level of the pier for maintenance staff to get down on the bridge.

The gates and the hoist equipment need painting and this may be got done. A full dress rehearsal of lowering the stop logs of one vent may be carried out to know any short comings and deficiencies either in the gantry crane or in the stop log elements. It is reported that action is being taken up in rectifying the system duly attending the above points.

11. CANAL CONVEYANCE EFFICIENCIES

Conveyance efficiency is the ratio of total water delivery at outlets to the block of fields and the water released at the project canal head work. It is expressed in percentage.

11.1 Canal Capacity

Sri Ram Sagar Project has three main canals namely

(1) Kakatiya Canal

(2) Saraswathi Canal

(3) Laxmi canal.

Sri Ram Sagar Project stage-I comprises the following net work of main canals and distributory net work system.

1. Kakatiya Main Canal from km 0.00 to km 284.00 with 147 distributaries minors and sub minors covering a total length of 3,350 Kms.
2. Saraswathi canal from km 0.00 to km 47.00 with 28 Nos distributaries, minors and sub minors covering total length of 300 Kms.
3. Laxmi canal from km 0.00 to km 3.50 with 4 Nos distributaries minors and sub minors to an extent of 50 Kms.

The Sri Ram Sagar Project stage-I, irrigates an ayacut of 3, 92,000 ha. in the districts of Adilabad, Nizamabad, Karimnagar and Warangal through the above main canals and distributory net work system. All the main canals followed the contours. The distributaries, Minors and Sub minors follow ridges except in some reaches where these follow contours also. The general bed fall of main canals distributaries, minors and sub minors are 1 in 10,000, 1 in 6000, 1 in 3000 to 2000 respectively. For field channels a bed fall of 1 in 500 is followed. The country slope of the area is a hilly one and highly undulated areas. The country slope of the area is very steeper compared to hydraulics of the canals. No lift irrigation scheme exist in the canal system except in Laxmi Canal (to cover the tail end command area of Nizam Sagar Project).

Table 2 The canal net work: The detail of the canal net work of Sri Ram Sagar Project is as follows

Canal	Name	CCA Ha	Discharge at Head in Cumecs	No. of direct out lets	Length of canal in kms	Lined unlined in Km	Remarks
A. Main	1. Kakatiya	3,69,000	274.7	147	284	284	(Lined) full length of Main canal is lined. Measuring devices/discharge measuring structures exist, on the canal
	2. Saraswathi	14,500	42.475	28	47	47	– do –
	3. Laxmi	8,850	14.13	4	3.5	3.5	– do –
Branch		Nil					

Table 3 Distributaries / Minors / Sub minors

S. No	Canal	Total length in Km	Portion lined	Unlined	Whether volumetric devises, discharge measuring structures exist
1	Under Kakatiya Canal Distributaries D_5 to D_{94} including minors and sub minor	About 2500 kms	100%	-	Available
2	Distributaries DBM 37 to DBM 53.	240 Kms	213 (88.75%)	27 Kms (4.25 %)	Yes
3	Minors of DBM 37 to DBM 53	301 Km	122 Km (40.53%)	179 Kms (59.47 %)	Yes
4	Sub minors	306 Km	-	306 Kms 100 %	
	Under Saraswathi Canal				
	Distributaries	117.505 km	-	117.505 (100%)	Nil
	Minors	181.105 km		181.105 (100 %)	Nil
	Sub minors	5.150 km		5.150 (100 %)	Nil
	Under Laxmi canal				
	Distributaries	50 Km		50 (100%)	Nil
	Minors				
	Sub minors				

Table 4 Cropping Pattern (Area / Percentage of CCA) in Ha

Crop Name	As envisaged in the Project				Present Cropping Pattern			
	Kharif	Rabi	Potential	Total	Kharif	Rabi	Potential	Total
1	2	3	4	5	6	7	8	9
Maize I	81453	30562						
Maize II	-	30562		142577	-			
Ground nut I	135735	50443						
Ground nut II		50443		236621	-	9391		9391
Chillies			31785	31785				
Cotton			39736	39736				
Pulses	54313	18330		72643				
Sorgum	54315	18329		72644				
Paddy					129683	45396		175079
Green gram					17811			17811
Jowar						1953		1953
Total	**325816**	**198669**	**71521**	**596006**	**195767**	**61373**		**257140**

11.2 DESIGNED CARRYING CAPACITY

The designed carrying capacities of three main canals of Sri Ram Sagar Project at their head reaches are as follows.

- Kakatiya canal at SRSP 274.70 cumecs
- Kakatiya canal at LMD (i.e. Km 146) 240.69 cumecs
- Laxmi canal at SRSP 14.13 cumecs
- Saraswathi canal 42.48 cumecs

11.3 ACTUAL CARRYING CAPACITY

A comparative statement showing the actual carrying capacities of Kakatiya main canal above Lower Manair dam from Km 7.22 to Km 45.725 and below Lower Manair dam from Km 148.463 to Km 193.594 and the designed carrying capcities is prepared and shown below.

Table 5

Sl. No	Designed discharge in Location	Designed discharge in cumecs at F.S.L.	Designed discharge in cumecs	Released discharge in cumecs	Actual discharge in cumecs
Kakatiya main canal above Lower Manair dam					
1	Km 7.27	274.7	191.74 (3.40 m.depth)	184.05	174.5
2	Km 23.48	274.7	191.74 (3.40 m.depth)	182.7	169.3
3	Km 45.725	266.94	179.58	175.06	158.33
Kakatiya main canal below Lower Manair Dam					
1	Km 148.463	240.69	125.5 (2.80 m.depth)	79.286	92.32
2	Km 168.45	232.2	106.1 (2.4 m.depth)	73.06	66.89
3	Km 193.594	205.36	87.25 (2.0 m.depth)	54.02	44.08

11.4 CONVEYANCE LOSSES IN VARIOUS REACHES IN VARIOUS CANALS

The method usually adopted is direct measurement of seepage losses form open channels by “inflow-outflow” method.

The method involves the measurement of water which flows into upstream end and the amount of water which flows out through down-stream end of the reach under study in a situation when no water is being diverted between the two upstream & downstream control points. The difference between the inflow and outflow is taken as seepage losses. Conveyance studies have been conducted on Kakatiya Canal both above LMD and below, Saraswathi Canal for the capacities above 150 cusecs and below using Current meter during Rabi season. The results are furnished below.

Table 6 Conveyance Losses in Main Canals

S. No	Name of Channel		Average wetted Perimeter (m)	Length of study reach (m)	Water lost in the reach (cumec)	Conveyance loss factor (Cumecs/ M sqm.)
1	Kakatiya canal(above L.M.D)	Km 7.27 to 23.48	50.245	16,210	3.837	4.711
		Km 23.48 to 45.725	54.125	22,245	3.332	2.76
2	Kakatiya Canal (below L.M.D)	Km 148.46 to 168.45	37.16	19,987	12.698	17.09
		Km 168.45 to 193.594	34.93	25,144	3.764	4.28
3	Saraswathi canal	Km 0.10 to 12.10	21.87	12,000	0.297	1.13
		Km 12.10 to 24.00	23.64	11,900	1.32	4.6

Table 7 Conveyance Losses in Distributaries

S. No	Name of Channel		Average wetted Perimeter (m)	Length of study reach (m)	Water lost in the reach (cumecs)	Conveyance loss factor (cumecs / M. sqm)
1	Distributory D_{29} of Kakatiya canal (above L.M.D)	Km 0.30 to 7.60	10.835	7,300	1.46	18.45
		Km 7.60 to 16.00	6.355	8,400	0.319	5.975
2	Distributory DBM 15 of Kakatiya canal (below L.M.D)	Km 0.30 to 7.00	8.998	6,700	0.48	7.96
		Km 7.00 to 14.00	4.7	7,000	0.416	12.64
3	Distributory D/16 of Saraswathi canal	Km 1.43 to 5.10	5.86	3,670	0.12	5.57
		Km 5.10 to 6.00	5.975	900	0.084	15.61

11.5 EVAPORATION LOSSES IN VARIOUS CANALS

These losses generally take place from the exposed water surface area which would vary with the temperatures, humidity and wind velocity etc. In hot and dry weather months (summer) these losses are maximum but they may seldom exceed 10% of the total water entering into the canal. The average may vary between 4 mm to 10 mm per day. During 2nd crop period specially for I.D crops where intermittent supplies are resorted, the evaporation losses will be on higher side.

CONCLUSIONS AND RECOMMENDATIONS

1. Water releases are to be made as per the water delivery schedcule prepared responding to the overall crop demands and agregate area duly taking into consideration the constraints in the Physical system related to soil status, stage of crop growth and climatic condition.

2. Over irrigation has to be discontinued in the areas where excess water utilisation is a habit throughout the year.
3. Lining is to be continued in the entire canal system including distributory system to minimize losses.
4. Suitable cross drainage works are to be constructed wherever inlets are existing to prevent silt entering the canal system.
5. To achieve equitable and reliable distribution of water suitable operation plan may be developed.
6. The existing distributory system has become old and needs re-sectioning, removal of weeds and proper regulating arrangements need be provided to minimize wastage of water.
7. Construction of distribution boxes for effective distribution system equally to all the ayacut with in the distributory.
8. Measuring devices like V notches, Broad crested weir, Parshal flumes and throat flumes gauges are required to be provided to increase operational efficiencies.

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Reservoir Capacity Evaluation using Different Techniques
A Case Study of Himayat Sagar Reservoir

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ABSTRACT

Reservoir volume evaluation is very important and it will give quantity of water to be utilized for various human needs. All most of all reservoirs in India has facing reductions of reservoir volume due to sedimentation, evaporation, infiltration. Latest technology in reservoir volume studies will be require and which will helpful in various aspects such as the efficient reservoir management, reservoir water allocation, predicting future water needs. The knowledge of evaluating the reservoir capacity using various methods and formulas are very important for present and future human needs. Considering all this in view, the present study is that, an attempt has been made to use RS(Remote sensing) and GIS(Geographical Information system) has used in estimate the reservoir capacity in Himayat sagar reservoir using different formula techniques. Himayat sagar reservoir is situated at 20km from Hyderabad, Telangana, India with a latitude of 17^0 19′ 30″ and longitude 78^0 25′ 0″ having a catchment area of 1292.8 Sq.km. Himayat sagar reservoir is catering drinking water needs of the twin cities of Hyderabad and Secundarabad. In the present study, remote sensing data, satellite imageries, different formulas and other collateral data were used apart from basic topo sheet to estimate the capacity of reservoir. water spread up areas of the satellite imageries of the 2006,2007, 2009, and 2013 years are calculate in M.sqm using GIS software are 3.270,5.325, 5.420,12.371, 12.355, 15.268. Water levels of reservoir has collected from the reservoir office. The volume of the Himayatsagar reservoir has estimated as 80.893M.cum and 70.129 M.cum using the prismoidal method and the average volume method respectively.

Keywords: reservoir volume, Himayatsagar reservoir, Remote sensing and GIS, prismoidal formulae, average volume method, water spread area.

INTRODUCTION

It is necessary to carry out the reservoir volume studies of the Himayat sagar as it is a Major drinking water supply sources for the Hyderabad and Secunderabad. The river Easa flows in the Deccan plateau is Musi river which against one of the principle tributaries of the Krishna river. During the year 1908. Musi river swelled up in to high floods and submerged a major portion of Hyderabad city and many of the villages on the banks had considerable damage. So, to major reservoirs i.e. Himayat sagar and Osman sagar were constructed on the two branches of river Easa and Musi. Himayatsagar reservoir was commenced in the year 1920 and completed in the year1927. Though the purpose of the reservoir at the time of the construction was for the flood absorption and it is now serving as a water supply project for the twin cities of the Hyderabad and secundrabad. Himayat sagar situated in the Hyderabad city at Latitude of $17^0$19′ 30″ and Longitude 78^0 25′0″ The reservoir was constructed across Easa tributary of Musi river which meet at Sangam 5.6 km upstream of the Hyderabad city .Original capacity of Himayatsagar was 120.39 M.cum.

Main objectives of study area: 1. Estimating the reservoir volume using the prismoidal and Average volume technique. 2. Comparing the capacity evaluation obtained by prismoidal and average volume technique. 3. comparing the evaluation of reservoir volume by different surveys.

Methodology: To meet the set objectives, it is proposed to carry out the investigation by using the Remote Sensing and GIS in additional to the conventional data from the toposheet. Collecting the reservoir levels from the field book .Browse the nrsc site for the availability satellite imageries. Noted the satellite pass dates of particular Himyatsagar imagery and noted the reservoir level from field book. Load the imagery in the GIS software and digitize the water spread area. Arrange the reservoir levels in the ascending order between MDDL(minimum draw down level) and FRL(full reservoir level). The depth between the contours are noted. The total volume of the reservoir is calculated using prismoidal and average volume method.Various satellite Imageries required to the study area has collected from the NRSA. And various water spread thematic maps are prepared. To know the factor affecting the reservoir capacity the slope map, drain map ,contour map, catchment area map are prepared. with the help of drain map, slope map it is possible to identify the soil erosion zones.

Prismoidal method: The capacity is worked out **V= H/3 (A1+ A2 +√A1xA2)**

where,

V = Capacity

H = Contour interval

A_1 = Area of lower contour

A_2 = Area of the upper contour

Table 1 Reservoir Capacity of Himayatsagar by two methods method

S.No.	Date of Imagery	Reservoir Elevation in(m)	Depth between successive contours in (m)	Water spread Area in M.sqm (sq.km)	Capacity as per Remote sensing& GIS data(2013) (M.cum) Average method	Cumulative Capacity between successive contours in (M.cum) Average method	Cumulative Capacity as per Remote sensing& GIS data(2013) (M.cum) Prismoidal method
1	LBL	525					
2	3/2/2007	529.219	4.215	3.27	6.89	6.89	4.594
3	14/2/2013	530.657	1.438	5.327	6.1812	13.9712	10.74
4	27/5/2009	531.102	0.445	5.42	2.3912	15.4624	13.105
5	2/1/2006	534.814	3.712	12.37	16.2445	31.7609	45.313
6	25/12/2009	534.939	0.125	12.35	1.545	33.2519	46.846
7	1/2/2011	537.362	2.547	15.268	35.171	68.4229	80.763
8	FRL	537.67		By Extrapolation		**70.12** 1	**80.893**

Mid area method (Average area method), which assumes the areas contained within successive contours represents cross sections, and the distance between the contours being the contour interval. Mid area rule;

$V = (A_1 + A_2)H/2$

V = Reservoir capacity(volume),

A_1 = Surface area at contour

A_2 = Surface area at the next contour level above contour level

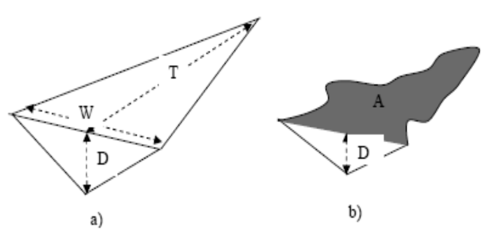

Figure.1 Shape of reservoir storage capacity (prismoidal)

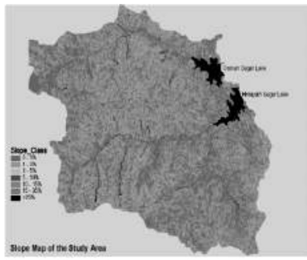

Figure 2a. Slope Map(catchmentarea)

Figure 2b. Drain Map

Water spread area extraction

Satellite image loading in the Arc Map(GIS) Digitizing water spread area

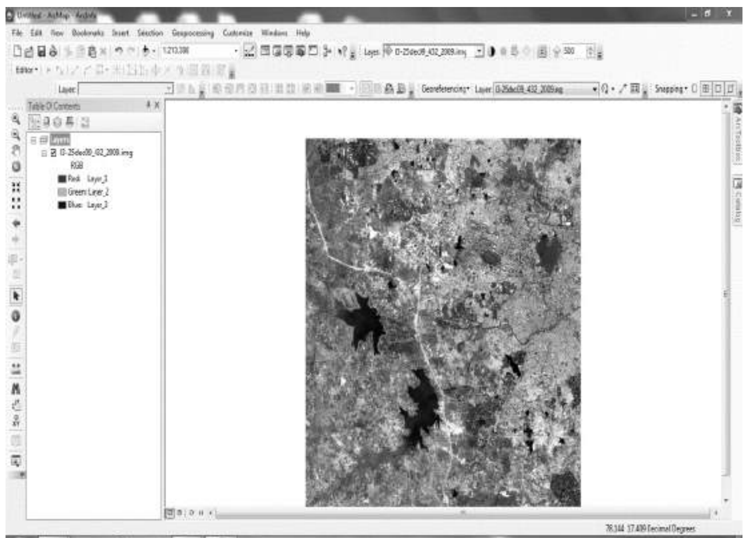

Figure 3 Satellite Imagery Dated

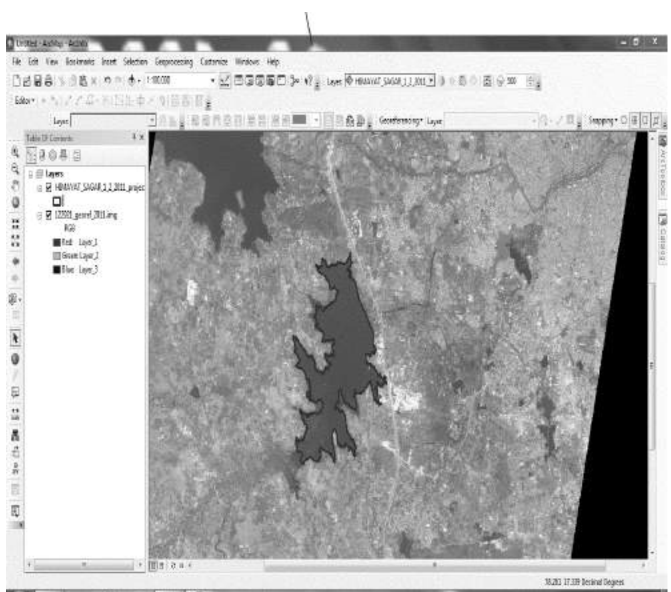

Figure 4 Digitizing satellite Imagery

Estimation of storage capacity of a reservoir

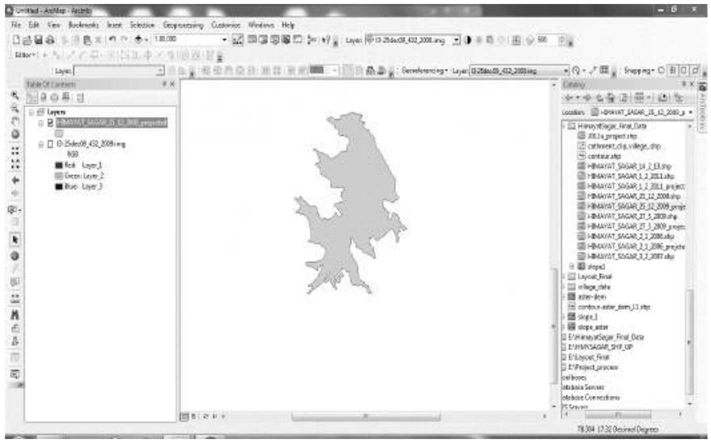

Figure 5 Extracting the water spread area

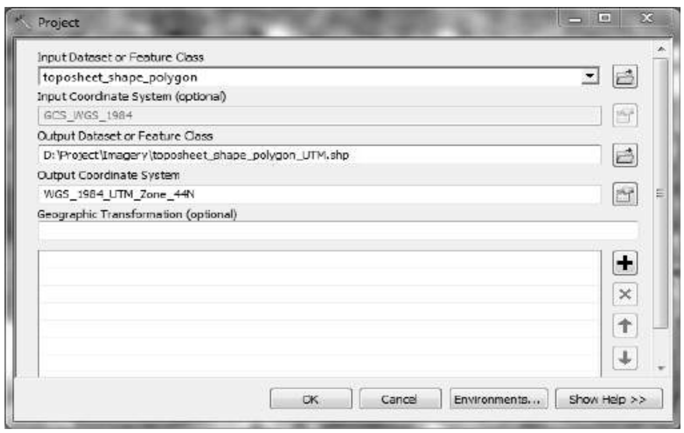

Figure 6 Projection to the polygon

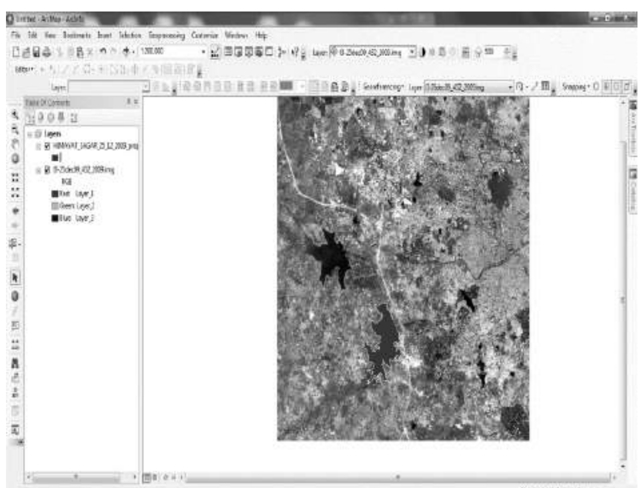

Figure 7 Water spread area showing

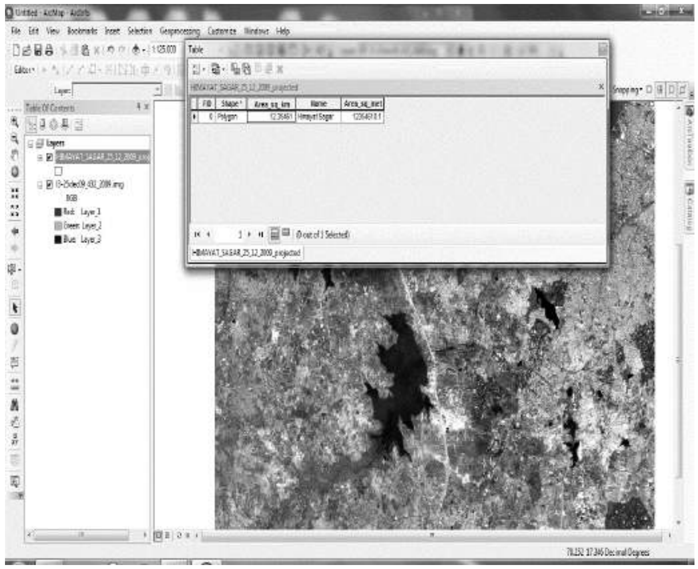

Figure 8 Calculating the water spread

List of satillite Imageries and with date mentioned

Figure 9 Date 3-2-2007

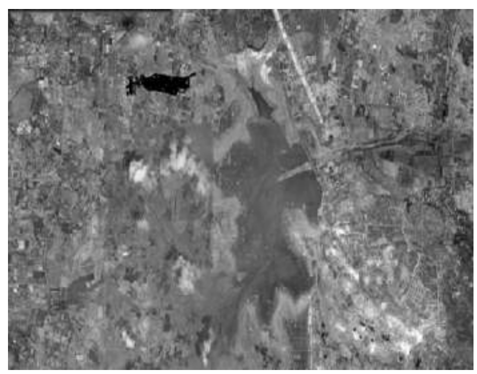

Figure 10 Date 14-2-2013

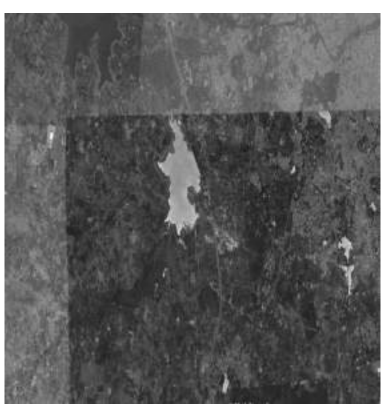

Figure 11 Toposheet 2006

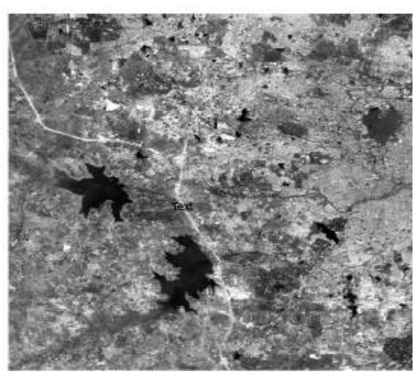

Figure 12 Dated 25-12-2009

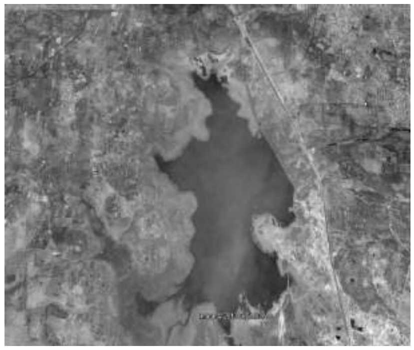

Figure 13 Dated 27-5- 2009

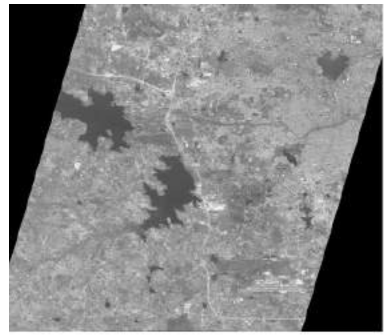

Figure 14 Dated 1-2-2011

Table 2 comparison of Reservoir capacities

S.No.	Type of survey	year of study	Reservoir Name	Gross Capacity (M.cum) as per prismoidal formulae	Gross Capacity (M.cum) as per Average Volume formulae	Gross Capacity (M.cum)difference between two formulae
1	**RS&GIS**	**2013**	**Himayat Sagar**	**80.893**	**70.129**	**10.764**
2	Hydrographic	2006	Himayat Sagar	83.575	72.42	11.155
3	RS	1989	Himayat Sagar	86.8	79.652	7.148

Table 3 Showing loss of Himayatsagar Reservoir volume

Description	Original capacity 1927	Hydrographic survey 1983	R.S 1989	Hydrographic survey 2006	R.S and GIS 2013
Total capacity (M.cum)	120.39	88.78	86.8	83.575	80.893
Loss of capacity	-	31.61	33.59	36.875	39.497
% Loss of capacity /year	-	0.4688	0.4500	0.3877	0.3814
No. years from original volume	-	56	62	79	86
Annual Loss in (M.cum)	-	0.5644	0.5693	0.4667	0.4592
Total Catchment Area in (sq.Km)	-	1292.8	1292.8	1292.8	1292.8
Rate of Sediment (Ham/100Sq.Km/year)	-	7.674	7.366	6.346	6.244
Rate of sedimentation (Mm^3/year)	-	0.5644	0.5417	0.466	0.4593
Free Catchment Area in (Sq.km)		735.5	735.5	735.5	735.5

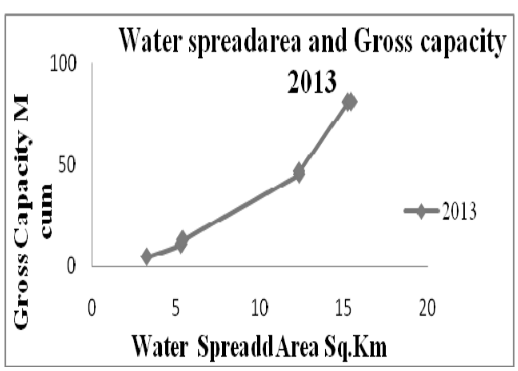

Figure 15a WS-E curve

Table 4 Capacity-Elevation

Gross Capacity as per R.S& GIS data 2013	Reservoir Elevation in 'm'
0	525
4.594	529.219
10.714	530.657
13.105	531.102
45.313	534.814
46.846	534.939
80.763	537.362
80.893	537.67

Table 5 Water spread-Elevation

Water spread Area in M.sqm(sq.km)	Reservoir Elevation in 'm'
0	525
3.27	529.219
5.325	530.657
5.42	531.102
12.37	534.814
12.355	534.939
15.268	537.362
15.468	537.67

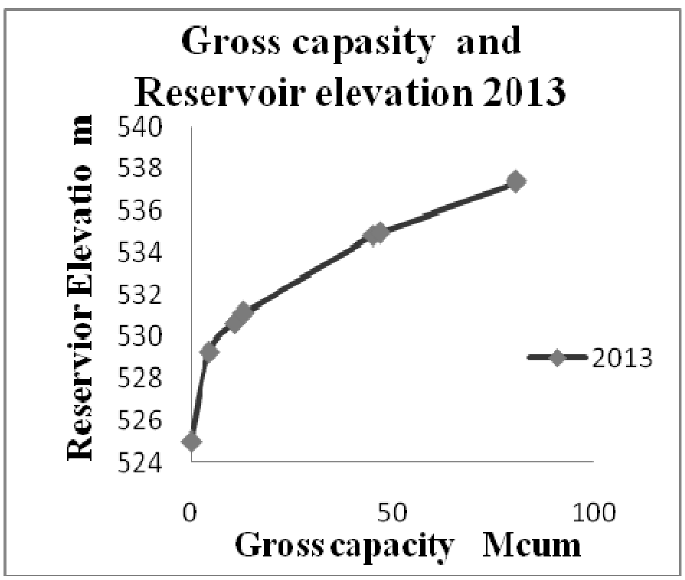

Figure 15b A-E curve

Table 6 Comparing the Reservoir Capacity of Himayatsagar 1989 it has shown in tabular column.

Date of Imagery	Reservoir Elevation m	Depth between contour m	Water spread Area in M.sqm or sq.km	Capacity between contours in M.cum	Gross Capacity as per Remote sensing & GIS data 2013 M.cum	Reservoir Elevation 2006 Hydro Graphic Survey	Gross Capacity as per remote sensing data 2006 M.cum	Reservoir Elevation (m) 1989	Gross Capacity as per remote sensing 1989 M.cum	Gross Capacity as per remote sensing 1983 Hydro Graphic Survey M.cum	Gross Capacity asper original 1927 M.cum
MDDL	525					525		523.271			
3/2/2007	529.219	4.215	3.27	4.594	4.594	529.742	7.546	529.712	10.48	10.21	19.11
14-2-2013	530.657	1.438	5.327	6.12	10.714	531.266	15.103	531.096	17.97	17.04	27.63
27-5-2009	531.102	0.445	5.42	2.39	13.105	533.095	29.168	533.827	38.42	38.7	53.03
2/1/2006	534.814	3.712	12.37	32.28	45.313	535.534	54.727	535.43	53.52	56.36	77.07
25/12/2009	534.939	0.125	12.35	1.533	46.846	536.448	66.153	536.424	66.92	69.74	95.46
1/2/2011	537.362	2.547	15.268	33.916	80.833	537.058	74.398	536.997	75.6	78.56	106.58
FRL	537.67		By Extrapolation		80.893	537.66	83.575	537.67	86.8	88.78	120.39

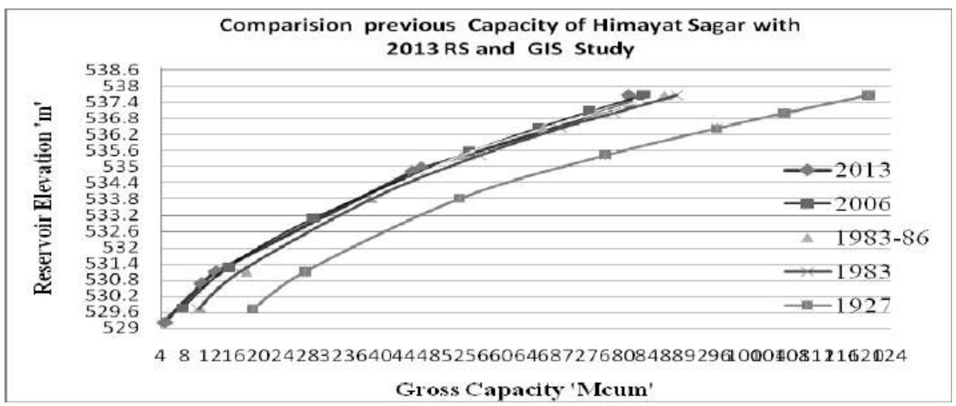

Figure 16 Comparison graph

CONCLUSIONS

Rate of edimentation has estimated as 0.4593Mm$^{3/}$year in 2013 studies and studies and It has noticed that the volume of the reservoir capacity is compared with prismoidal formulae with average volume formulae as 86.8 M.cum. 77.695 M.cum in volume of water calculated in Himayat sagar from the prismoidal fromaule is appropriate because for earlier surveys calculated values are matching with it. Hence prismoidal formulae are appropriate and used mostly in reservoir volume calculations. volume of Himayat sagar reservoir in 2013,2006,1989,1983, is 80.893,83575,86.5,88.78M.cum Respectively

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Stream Flow Generation using Temporal Disaggregation Model for Tungabhadra River

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ABSTRACT

The present study has been carried out to elaborate a model for generating the synthetic sequences of 10-daily stream flows for Tungabhadra River at Munirabad dam site. The goodness of fit of autoregressive model was tested by Akaike Information Criterion. The autoregressive model of order one was found best for generating annual stream flow data. Disaggregation model was selected to represents the 10-daily stream flows. Since, the disaggregation model for generating synthetic stream flows requires previously generated annual stream flow series, the annual stream flow series was modeled by using autoregressive model of order one. The annual stream flow discharges and 10-daily stream flow discharges of Tungabhadra River at Munirabad dam site for 33 years were used for elaborating mathematical model. The developed models were used to generate stream flow volumes. The suitability of disaggregation model was tested by comparing statistical properties i.e. mean, standard deviation, skewness, variance of historical and generated 10-daily stream flow volumes and those of the historical and generated annual stream flow series. The comparison of statistical characteristics of historical and generated stream flows suggests that disaggregation model can be used to generate 10-daily stream flow data which preserves the mean and skewness coefficient along with the mean of aggregated annual stream flow.

Keywords: Akanke Information Criterion; temporal disaggregation model; generation.

INTRODUCTION

The generation of synthetic series of stream flow data is generally needed for reservoir sizing, for determining the risk of failure of water supply for irrigation system, for determining the risk of failure of dependable capacities of hydroelectric systems, for planning studies of future reservoir operation and similar applications (Salas *et al.*, 1980). In the river basin studies the stochastic sequence of inflows and rainfall are used to determine how different system designs and operating policies might perform. Therefore, the study of reservoir operation system can employ various alternate stochastic hydrologic time series models to evaluate different scenario of water resources system operation. Since the rainfall and inflows are the important inputs to the water resources system, the development of good stochastic models is essential in order to determine an optimal system operation. The appropriate models that generate flow sequences are those, which manage to characterize the stream flows ideally representing the statistical and the correlation structure of the corresponding observed stream flows.

The stream flow data can be generated in two ways. In first type of generation, stream flows are generated directly. This is called direct generation and can be carried out where stationarity of stochastic process holds. The indirect generation has advantages as well as serious drawbacks. The length of available period is larger for rainfalls than for stream flows but the construction of rainfall stream flow transformation model itself is too complex. Hence in the present study, the sequential generation of stream flow is done by using the direct method. The direct generation model i.e. disaggregation model is used for stream flow generation. The present study was undertaken for the main objective of sequential generation of 10-daily stream flow of Tungabhadra River at Munirabad dam site using temporal disaggregation model.

METHODOLOGY

Site location and Data Acquisition

The Munirabad dam on Tungabhadra River situated at Mallapur village in Bellary district is near to heritage site Hampi. The dam site is located at 15°15′ N latitude and 76°21′ E longitude. The catchment of the dam is characterized by hilly terrain with high to medium rainfall. The average temperatures of the place vary from 10°C to 40°C. The average rainfall of the area is 639 mm. The reservoir level data were converted to volume data in thousand million cubic feet (TMC) using tables provided for this purpose and then it was converted to discharge in cumec.

Estimation for Annual Autoregressive (AR) Models

Consider an available sample of annual stream flow data denoted by X_1, X_2, …….., X_N, where N is the number of years of data. In general let the normal sequence be represented by Y_1, Y_2, ……., Y_N. Which can be obtained by transforming the observed data X_t t = 1,…..N. With this data sequence the parameters $\bar{X}, S^2, \phi_1, \ldots, \phi_P$ and σ_Σ^2 of the AR (p) model can be estimated. Determination of parameters of AR (p) model can be done by different methods like method of moment and maximum likelihood method.

Akaike Information Criterion (AIC)

A mathematical formulation which considers the principle of parsimony in model building is Akaike Information Criterion **(**AIC) proposed by Akaike (1974). AIC is used for checking whether the order of the fitted model is adequate compared with the other orders of the dependence model. The AIC for an AR (p) model is

$$\text{AIC (p)} = N \ln(\sigma_\varepsilon^2) + 2p \quad (1)$$

Where, σ_ε^2 is the maximum likelihood estimate of the variance. Therefore, a comparison can be made between the AIC (p) and the AIC (p-1) and AIC (p+1). If the AIC (p) is less than both the AIC (p-1) and AIC (p+1), then the AR (p) model is best.

Ten-Daily Stream flow Generation by Temporal Disaggregation

Lane (1979) has developed an approach, which essentially sets to zero several parameters of extended model which are not important. The model equation may be written as,

$$Y_\tau = A_\tau X + B_\tau \varepsilon + C_\tau Y_{\tau-1} \quad (2)$$

Where,

τ is the current 10-daily stream flow being generated

A_τ, B_τ, C_τ are parameters

Y is the column matrix of current 10-daily values being generated

X is column matrix of current annual values

The main advantage of this model is the reduction of the number of parameters.

Parameters Estimation for the model equation

The condensed model may be considered as a form of the extended model applied to 10-daily at a time. The parameters are estimated as,

$$\hat{A}_\tau = \left[S_{YX}(\tau,\tau) - S_{YY}(\tau,\tau-1)S_{YY}^{-1}(\tau-1,\tau-1)S_{YX}(\tau-1,\tau)\right]$$
$$\left[S_{XX}(\tau,\tau) - S_{XY}(\tau,\tau-1)S_{YY}^{-1}(\tau-1,\tau-1)S_{YX}(\tau-1,\tau)\right]^{-1} \quad (3)$$

$$\hat{C}_\tau = [S_{YY}(\tau,\tau-1) - \hat{A}_\tau S_{XY}(\tau,\tau-1)]S_{YY}^{-1}(\tau-1,\tau-1) \quad (4)$$

and

$$\hat{B}_\tau \hat{B}^T = S_{YY}(\tau,\tau) - \hat{A}_\tau S_{XY}(\tau,\tau) - \hat{C}_\tau S_{YY}(\tau-1,\tau) \quad (5)$$

Where, S_{YY} is the matrix of covariance among 10-daily series.

S_{YX} is the matrix of covariance between 10-daily series and annual series.

S_{XX} is the matrix of covariance among the annual series.

S_{XY} is the matrix of covariance between the annual value series associated with current 10-daily and these values associated with the previous to the current 10-daily.

The required moment estimates are $S_{YY}(\tau,\tau), S_{YX}(\tau,\tau), S_{XX}(\tau,\tau), S_{YY}(\tau,\tau-1), S_{YX}(\tau-1,\tau)$. In order to estimate these moments consider

$$X'_v = X_v - \overline{X} \tag{6}$$

Where,

X'_v is the reduced annual series for N years

X_v is the observed annual series for N years

$\overline{X}$ is the mean of annual series

$v = 1,2,3,\ldots\ldots\ldots N$

The seasonal reduced series is considered as

$$Y'_{v,\tau} = Y_{v,\tau} - \overline{Y}_{\tau} \tag{7}$$

Where,

$Y'_{v,\tau}$ is the reduced 10-daily series for N years

$\overline{Y}_{\tau}$ is the mean of 10-daily series

$v = 1,2,3,\ldots\ldots\ldots N$

$\tau = 1,2,3,\ldots\ldots\ldots \omega$

N is the number of 10-daily required for disaggregation in a year, for 10-daily data generation $\omega = 36$

RESULTS AND DISCUSSION

Modeling of 10-daily stream flow series

The modeling of 10-daily stream flow was performed by using Lane's condensed disaggregation model given Equation (2). To generate the 10-daily stream flows, disaggregation model requires a previously generated annual stream flow series. The annual stream flow series was modeled by autoregressive model. Historical annual and 10-daily stream flows were used to estimate the parameters of disaggregation model. The AR (1) model of method of moments was used to estimate the parameters of disaggregation model. Firstly, the sample covariances were computed. Then, the parameters were obtained by using Equations (3) to (5).

Generation of 10-daily stream flows

After selecting the form of model and estimating the parameters of the model, the synthetic 10-daily stream flows were generated by using the disaggregation model. The AR (1) model of the method of moment for generating the annual stream flow series was developed in the form of the equation

$$Z_t = 0.3512 Z_{t-1} + 1.05290 \varepsilon_t \tag{8}$$

$$X_t = Z_t + \overline{X} \tag{9}$$

Further, the generated annual stream flow series was obtained by using Equation (17) along with a series of normally distributed random numbers. The synthetic stream flows for different 10-daily were generated by using corresponding values of A_τ, B_τ and C_τ from the matrices.

Table 1 Statistical characteristics of Historical and Generated 10-daily stream flows

Statistical Characteristics		Mean (cumec)		Standard Deviation (cumec)		Skewness		Kurtosis	
Months	**10-daily**	**Historical**	**Generated**	**Historical**	**Generated**	**Historical**	**Generated**	**Historical**	**Generated**
Jan	**1**	5.71	5.92	12.30	23.13	2.5129	0.8210	9.1117	5.6230
	2	0.47	0.07	2.18	4.78	5.2034	1.1400	31.0366	3.0000
	3	0.78	0.41	3.52	39.98	5.3618	-1.8491	32.6484	7.8960
Feb	**4**	4.29	5.15	12.19	64.86	3.5330	-2.0133	15.8542	8.1671
	5	2.96	3.82	7.99	50.01	2.6605	-2.2950	8.8679	9.0492
	6	4.03	9.14	8.98	23.04	2.4597	-1.0678	8.6358	4.5899
Mar	**7**	1.08	1.24	3.78	64.82	4.3692	2.4018	23.6389	9.2536
	8	0.85	0.99	4.87	29.52	5.7446	-1.4794	36.0000	6.6112
	9	8.27	6.64	37.95	14.25	5.3762	0.0000	32.747	3.0000
April	**10**	12.10	18.94	24.19	14.50	2.4787	-0.6109	9.3765	3.6336
	11	9.81	9.88	22.22	32.58	3.6145	-2.2365	18.0529	8.0271
	12	14.40	9.59	19.57	3.69	1.7771	0.0000	5.5074	3.0000
May	**13**	28.42	27.02	43.30	46.42	3.2720	-2.1662	14.508	7.5390
	14	31.81	55.27	31.80	77.75	1.1078	2.2649	3.2898	8.5494
	15	46.53	39.09	50.19	32.51	2.1726	0.0414	7.3214	2.8869
Jun	**16**	66.51	81.10	74.71	31.78	2.4461	2.2223	9.8166	7.5753
	17	148.14	151.90	182.83	100.15	2.8820	-1.7843	14.1514	6.3844
	18	387.79	373.00	305.00	41.53	1.1251	1.9779	4.0925	8.3643
Jul	**19**	721.99	756.25	627.25	22.48	2.1665	-0.6204	9.6900	2.8463
	20	939.55	1046.22	818.73	71.96	1.6875	-2.1601	6.1709	7.0897
	21	1154.14	1137.77	739.64	49.06	0.9166	-1.2362	3.7066	4.0503
Aug	**22**	1267.09	1269.24	761.14	53.70	0.6134	-1.8267	2.4733	5.9829
	23	1429.48	1528.37	868.04	46.05	0.6669	0.0000	2.8243	3.0000
	24	965.47	1079.09	592.47	94.33	0.8505	0.8244	2.7428	8.8035
Sept	**25**	642.36	862.39	459.51	48.25	1.3719	-2.0514	4.9744	6.6182
	26	409.70	399.78	275.95	46.17	2.0535	-2.2068	8.6955	7.4100
	27	421.37	585.58	294.72	39.39	0.9049	-2.3899	3.2110	8.4925
Oct	**28**	466.05	486.94	365.82	34.43	2.6596	-1.1694	13.2468	5.3816
	29	296.06	307.87	266.22	41.36	2.1749	2.2366	8.8993	9.1849
	30	239.82	244.40	216.31	51.61	1.6626	-2.3923	6.2621	9.0155
Nov	**31**	164.01	158.26	152.77	4.09	1.7100	0.0000	6.2000	3.0000
	32	174.91	166.19	415.48	68.73	5.3861	-2.0187	33.1312	8.4771
	33	102.76	113.31	204.52	41.09	4.6255	-1.1003	26.514	3.8054
Dec	**34**	52.76	66.76	53.60	52.92	1.4225	1.5979	4.4888	7.1517
	35	31.23	47.23	39.74	60.73	1.0987	-1.5240	3.0553	6.8842
	36	10.00	14.01	15.94	4.72	1.6661	3.9031	4.9384	18.5080

CONCLUSIONS

The performance of disaggregation model was tested by comparing statistical characteristics, i.e., mean, standard deviation, skewness and kurtosis of historical and generated 10-daily data. Based on the results of study the author arrived at final conclusions are the disaggregation model conserved mean, skewness and kurtosis in some cases for 10-daily stream flows (given in table 4.). The mean and kurtosis of generated aggregative annual stream flow is nearly equal to historical data. This property is conserved in disaggregation model.

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Application of First Order of the Method of Moment of AR Model for Generation of Monthly Stream Flow for Tungabhadra River

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ABSTRACT

The present study carried out to develop a model for generating the synthetic sequences of monthly stream flows for Tungabhadra River at Munirabad dam Site. Lane's condensed disaggregation model was selected to represent the monthly stream flows. Since, the disaggregation model for generating synthetic stream flows requires previously generated annual stream flow series, the annual stream flow series was modeled by using autoregressive model of order one. The annual stream flow volumes and monthly stream flow volumes of Tungabhadra River at Munirabad dam site for 33 years (1977-2009) were used for developing mathematical model. The parameters of AR model and those of disaggregation model were estimated by the method of moments. The goodness of fit of autoregressive model was tested by Akaike Information Criterion. The AR (1) model was selected to represent the annual stream flow volumes. The parameter estimation of autoregressive (AR) models, tests of goodness of fit of selected model, synthetic generation of monthly stream flows and performance evaluation of the models are presented and discussed. The performance of method of moment model in generating the annual stream flow data was tested by comparing the statistical characteristics i.e., mean, standard deviation, kurtosis and skewness.

Keywords: Autoregressive; parameters; stream flow; variance.

INTRODUCTION

The science of hydrology is occupied primarily with the processes that make up the hydrologic cycle and the hydrologic implications of climate and anthropogenic changes. A variety of hydrologic models have been developed to facilitate this task, i.e., to simulate the hydrologic cycle (or a portion of it) for a region of interest. There are two aspects to the study of time series – analysis and modeling. Therefore, the study of reservoir operation system can employ various alternate stochastic hydrologic time series models to evaluate different scenario of water resources system operation. Since the rainfall and inflows are the important inputs to the water resources system, the development of good stochastic models is essential in order to determine an optimal system operation. In hydrology, the generation of sequence of probabilistic variables like rainfall, stream flows etc. is realized to be a necessity and the field of operational hydrology covers this aspect. Several types of model, such as autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) have been developed. Autoregressive moving average (ARMA) models have greater flexibility in fitting of time series than autoregressive (AR) models.

Autoregressive Markovian generation models have an important place in the theory of stochastic modelling of stream flow sequences, and they also are most commonly used in practical applications. This refers specially to modelling of seasonally varying processes occurring at several locations in the river basin. The length of available period is larger for rainfalls than for stream flows but the construction of rainfall stream flow transformation model itself is too complex. Hence in the present study, the application of method of moment of autoregressive model of annual stream flow was done by using the direct method for Tungabhadra river. The direct generation model i.e. autoregressive model used for stream flow generation.

METHODOLOGY

The Tungabhadra River is formed by the confluence of two rivers, the Tunga River and Bhadra River which flow down the eastern slope of the Western Ghats in the state of Karnataka. The Munirabad dam on Tungabhadra River situated at Mallapur village in Bellary district is near to heritage site Hampi. The dam site is located at 15°15′ N latitude and 76°21′ E longitude. The catchment of the dam is characterized by hilly terrain with high to medium rainfall and has an area of 28180 sq. km. The average maximum and minimum temperatures of the place vary from 30°C to 40°C and 10°C to 12°C respectively. The average rainfall of the area is 639 mm.

Statistical Properties of Historical Data

The historical stream flow data were used to compute seven different statistical properties, viz., mean, variance, standard deviation, skewness, serial correlation coefficient, autocorrelation function and partial autocorrelation function. Let, X_t, $t = 1, 2, \ldots\ldots\ldots, N$ be the historical (observed) time series of annual stream flow.

Parameter Estimation for Annual AR Models

Consider an available sample of annual stream flow data denoted by $X_1, X_2 \ldots, X_N$, where N is the number of years of data. In general let the normal sequence be represented by $Y_1, Y_2 \ldots, Y_N$,. Which can be obtained by transforming the observed data X_t t = 1,…..N. With this data sequence the parameters $\bar{X}, S^2, \varnothing_1 \ldots\ldots, \varnothing_P$ and σ_ε^2 of the AR (p) model can be estimated. Determination of parameters of AR (p) model can be done by method of moment.

Method of moment model parameters

The parameters $\varnothing_1, \ldots\ldots, \varnothing_p$ are estimated by solving the ‘p’ system of linear equations where the population correlation coefficients ρ_j replaced by the sample correlation coefficients r_j and the parameters $\varnothing_j$ replaced by the estimates. $\hat{\varnothing}_j$, Thus,

$$r_{k=\varnothing_1} r_{k-1} + \varnothing_2 r_{k-2} + \ldots + \varnothing_p r_{k-p}, k > 0 \quad (1)$$

In particular, for an AR (1) model or p = 1, Equation (1) gives

$$\hat{\varnothing}_1 = r_1 \quad (2)$$

Similarly, for an AR (2) model, p = 2

$$\hat{\varnothing}_1 = \frac{r_1(1 - r_2)}{(1 - r_1^2)} \quad (3)$$

and

$$\hat{\varnothing}_2 = \frac{(r_2 - r_1^2)}{(1 - r_1^2)} \quad (4)$$

Finally, the parameter σ^2 is estimated from equation $\hat{\sigma}^2 = \sigma^2\left(1 - \sum_{j=1}^{p} \varnothing_j \rho_j\right)$ by using the estimates, $\hat{\varnothing}_j$ and r_j instead of σ^2, $Ø_j$ and ρ_j respectively; and by multiplying it by factor N/(N-p) in order to obtain unbiased estimate of σ_ε^2. Thus,

$$\hat{\sigma}_\varepsilon^2 = \frac{N\hat{\sigma}^2}{(N - P)}\left(1 - \sum_{j=1}^{p} \hat{\varnothing}_j r_j\right) \quad (5)$$

In particular, for the AR (1) model, using Equations (10) and (13) give

$$\hat{\sigma}_\varepsilon^2 = \frac{N\hat{\sigma}^2}{(N - 1)}\left(1 - \hat{\varnothing}_1^2\right) \quad (6)$$

Similarly, for the AR (2) model,

$$\hat{\sigma}_\varepsilon^2 = \frac{N\hat{\sigma}^2(1 + \hat{\varnothing}_2)}{(N - 2)(1 - \hat{\varnothing}_2)}\left\{(1 - \hat{\varnothing}_2)^2 - \hat{\varnothing}_1^2\right\} \quad (7)$$

Generation of Synthetic Sequences of Annual Stream flow by Autoregressive Models

The AR models are of the following were used for the generation of synthetic annual stream flows.

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \cdots\cdots\cdots \phi_p Z_{t-p} + S^2 \varepsilon_t \quad (8)$$

Where,

$$Z_t = X_t - \overline{X} \quad (9)$$

Identification of AR model

Identification of AR model includes the determination of order p of AR process. The partial autocorrelation function was determined by using Equation (7). To determine the partial autocorrelation function $\phi_K(K)$ from a sample series, sample correlations r_k, was replaced by the ρ_s by r_s in the Equation (8). Then temporarily entertain the hypothesis that p = 1. The estimate of ϕ_1 is r_k, $r_1 = \phi_1$ is substantially different from zero, it is concluded that the process under consideration is of order 1. To see whether the process is of order 2 or greater, solve the equation for p=2, namely

$$\hat{\varnothing}_1 = \frac{r_1(1-r_2)}{\left(1-r_1^2\right)} \quad (10)$$

$$\hat{\varnothing}_2 = \frac{r_2 - r_1^2}{\left(1-r_1^2\right)} \quad (11)$$

If the resulting estimate ϕ_2 differs from zero considerably, the process is at least of order two. This procedure is repeated for successively larger values of p.

Model formulation

Based on the Akaike Information Criterion **(**AIC), the comparison can be made between the AIC (1) and the AIC (0) and AIC (2). The AIC (1) is less than both the AIC (0) and AIC (2), then the AR (1) model is best. Therefore following AR models of orders 1 and 2 viz., AR (1) and AR (2) were used for study as follows.

1^{st} Order

$$\left(X_t - \overline{X}\right) = \phi_{(1,1)}\left(X_{t-1} - \overline{X}\right) + S^2 \varepsilon_t \quad (12)$$

RESULTS AND DISCUSSION

The AR (1) first order model of method of moment which gives better estimates of annual stream flows of Tungabhadra River than the AR family. The annual stream flows series was modeled by using autoregressive (AR) models with the method of moment. In view of the simplicity and efficiency, autoregressive model was selected to describe annual stream flow series. Two main stages, i.e., model identification and parameter estimation were involved in the development of autoregressive model.

Table 1 Statistical characteristics of historical annual stream flows (33 Years database 1977-2009)

Mean (cumec)	10028.48
Standard Deviation (cumec)	3975.92
Skewness	0.53
Kurtosis	2.89

Parameters of Autoregressive (AR) model

The parameters the method of moment of autoregressive models up to two orders, i.e. one and two were determined to test the goodness of fit. The solution of system of equations, represented by Equations (8), (9) and Equation (10), yielded the parameters for AR (1) and AR (2) models. These parameters of AR (1) and AR (2) model for method of moment model was tabulated in Table 2.

Table 2 Statistical Characteristics of Autoregressive (AR) models for Annual Stream flow using Method of moment

Model	AR (1)	AR (2)
Autoregressive Parameters	Φ_1=0.351208	Φ_1= 0.248456
		Φ_2= 0.292566
Variance	0.951144	0.897786
Akaike Information Criterion, AIC (p)	0.347026	0.441839

Table 3 Statistical characteristics of Annual stream flow (Historical and Generated)

Statistical characteristics	Historical	Generated Aggregated
Mean (cumec)	10028.48	10094.32
Standard Deviation (cumec)	3975.92	1694.88
Skewness	0.53	0.28
Kurtosis	2.89	2.34

CONCLUSIONS

The annual stream flows were autoregressive modeled using AR (1) of method of moment model. It was found that the AR (1) model gives better estimates of annual stream flows of Tungabhadra River. On the basis of AIC test, the AR (1) of method of moment model was selected to represent the annual stream flow discharge. Autoregressive model of first order AR (1) best described for generating the annual stream flow data of Tungabhadra River than other models of AR family.

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THEME - II

Climate Change and Environment

Simulating Evaporation Losses using Artificial Neural Network for Ambikapur Station in Chhattisgarh

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ABSTRACT

Evaporation is one of the main components of the hydrologic cycle. This complex process is dependent on several climatic parameters. Accurate estimation of evaporation is required for irrigation scheduling, water availability in reservoir, etc`. In this study Artificial Neural Network (ANN) models have been developed to simulate evaporation losses for Ambikapur region in Chhattisgarh. Observation of maximum temperature (T_{max}), minimum temperature (T_{min}), relative humidity (RH), wind speed (WS), sunshine hour (SSH) & evaporation (E) for the past 18 years have been used for training and testing of the ANN models. Out of total number of 6576 patterns, 4600 has been used for training the network while remaining 1976 has been used for testing the model. The analysis was carried out in MATLAB software. A feed forward multiple layer network with a hidden layer and sigmoid function is used. Several input combination were tried and three different models such as M1 (T_{max}, SSH), M2 (T_{max}, WS), M3 (T_{max}) have been analysed. Performance evaluation of the models have been carried out by calculating statistical evaluation criteria viz. mean absolute deviation (MAD), root mean square error (RMSE), coefficient of correlation (CC), Nash - Sutcliffe coefficient efficiency (CE) and Index of Agreement (IOA). The network are selected based on maximized CC, CE and IOA value and minimized MAD and RMSE values both in training and testing. Upon comparison the model M1 was found performing better than other. It showed the highest CC value as 95.17, highest CE value as 90.58 and highest IOA value as 97.46 during training and maximized CC, CE, & IOA value is 97.22, 93.39, & 98.37 during testing. The model with combination of two input parameters (T_{max}, SSH) provided better estimate of evaporation than other combinations and individual parameters.

Keywords: Artificial Neural Networks; Back propagation ANN, Hidden Layers; Evaporation Models; Training; Testing; Performance Evaluation Criterion.

INTRODUCTION

Evaporation refers to water losses from the surface of a water body to the atmosphere. Evaporation occurs when the number of moving molecules that break from the water surface and escape into the air as vapour is larger than the number that re-enters the water surface from the air and become entrapped in the liquid. Evaporation increases with high wind speed, high temperatures and low humidity. A sizable quantity of water is lost every year by evaporation from storage reservoirs and evaporation of water from large water bodies influences the hydrological cycle. Among the hydrological cycle, evaporation is perhaps the most difficult toestimate due to complex interactions among the components of land-plant-atmosphere system. Evaporation is a very important phenomenon in the hydrologic cycle. It is only due to evaporation that the moisture can reach the atmosphere from the ocean and the land surface and finally results in rainfall which is the basic source of water for plants and all living things. At the same time, evaporation is responsible for loss of water from land surface, plant surface etc.

Evaporation losses should be considered in the design of various water resources and irrigation systems. In areas with little rainfall, evaporation losses can represent a significant part of the water budget for a lake or reservoir and may contribute significantly to the lowering of the water surface elevation. Therefore, accurate estimation of evaporation loss from the water body is of primary importance for monitoring and allocation of water resources at farm scales as well as at regional scales. The rate of evaporation depends on a number of meteorological factors such as solar radiation, air temperature, relative humidity, wind speed and to some extent atmospheric pressure. Other factors are related to the nature of the evaporating surface and the quality of water.

Various studies have been conducted to determine which of these factors have the dominant effect on evaporation. According to Linsely et al (1988) radiation is by far the most important single factor affecting evaporation and Chow et al (1988) reported that in addition to solar radiation, the mechanism of transporting the vapour from the water surface has also a great effect. Vapour pressure deficit, temperature, barometric pressure, humidity and wind speed were emphasized by Singh (1992) as the controlling factors. Gupta (1992) pointed out that relative humidity, wind velocity, temperature of water and atmosphere are the climatic factors on which evaporation awfully depends. In summary, it has been agreed that solar radiation, wind speed, relative humidity and air temperature have attained special consideration as the most influencing factors by most researchers.

In the hydrological practice, the evaporation can be estimated by conventional approaches like direct or indirect methods involving use of the empirical equations. In order to estimate the evaporation direct measurement methods or physical and empirical models can be used. Pan evaporation is one of the most popular instruments for direct measuring. The indirect methods use meteorological data to estimate evaporation by empirical based methods or statistical and stochastic approaches. The indirect methods are namely Temperature based formulae, Radiation method; Humidity based relation, Penman formulae, Energy balance approach etc. These methods of evaporation estimation have been applied by (Abtew (2001), Although there are empirical formulas available for Evaporation estimation, but their performances are not all satisfactory due to the complicated nature of the evaporation process and the data availability. Evaporation is an accurate formula to represent all the physical processes involved. For this purpose, artificial neural networks (ANN) models were developed.

Neural Network is a form of artificial intelligence that imitates some function of the human brain. Neural networks are general-purpose computing tools that can solve complex non-linear problems. The network comprises a large number of simple processing elements linked to each other by weighted connections according to a specified architecture. These networks learn from the training data by adjusting the connection weights. There is a range of artificial neuralnetwork architectures designed and used in various fields. In this study, a feed-forward neural network with back propagation learning algorithm is used. The model may require significantly less input data than a similar conventional mathematical model, since variables that remain fixed from one simulation to another do not need to be considered as inputs. The ANN is useful, requiring fewer input and computational effort and less real time control. An ANN can quickly present sensitive responses to tiny input changes in a dynamic environment. Many researchers have investigated the applicability of ANN in hydrology to estimate rainfall-runoff (Zealand, et al 1999), short-term stream flow (Luk, et al 2000), rainfall (Tokar, et al 1999, Sinha, J. 2013), reservoir inflow (Mohammadi, et al 2005) etc. The ANN models are also applied to estimate the Pan evaporation by Terzi, et al (2006), Eskin, et al 2006, Kokya, et al 2008.

MATERIALS AND METHODS

Study Area and Collection of Data

The study site is located in Bhagwanpur khurd Ambikapur, district Sarguja, Chhattisgarh at 23^{o}09’ N Latitude, 83^{o}08’ E Longitude and altitude of 611 m (above MSL). the Data (maximum temperature (T_{max}), minimum temperature (T_{min}), relative humidity (RH), and wind speed (WS), sunshine hour (SSH)) used of past 18 years (1 January 1996 to 31 December 2013) in the present study are taken from Department of Agro-meteorology, Rajmohini Devi College of Agricultiral and Research Station Ambikapur IGKV, Raipur (C.G.).

Evaporation was estimated using of different architectures of ANN. The data set are divided in training and testing periods.Out of total number of 6576 patterns, 4600 (1 January 1996 to 3 August 2008) has been used for training the network while remaining 1976 (4 August 2008 to 31 December, 2013) has been used for testing the model. A matrix was formed with these data. Evaporation was considered as output while combination of all the others were considered as input. In this study three different combinations of models have been tried and named M-1, M-2, and M-3. Details of these combinations are given in table 1.

Table 1 Combinations of input variables considered in developing ANN models.

Model	Input Vectors
Model 1	Temperature(max), Sunshine Hour, Evaporation
Model 2	Temperature(max), Wind Speed, Evaporation
Model 3	Temperature(max), Evaporation

DEVELOPMENT OF ARTIFICIAL NEURAL NETWORK MODELS

The architecture of an ANN is designed by weights between neurons, a transfer function that controls the generation of output in a neuron, and learning laws that define the relative importance of weights for input to a neuron. It will process the information in a way that is previously trained, to generate satisfactory results. The main control parameters of ANN model are interneuron connection strengths also known as weights and the biases.

In this study back propagation algorithm (Rumelhart and McClelland, 1986) is used to develop ANN models. It is used in layered feed-forward ANNs. The artificial neurons are arranged in layers, and send their signals “forward”, and then the errors are propagated backwards. The network receives inputs by neurons in the input layer, and the output of the network is given by the neurons on an output layer. There may be one or more intermediate hidden layers. The back propagation algorithm uses supervised learning. The idea of the back propagation algorithm is to reduce the error (difference between actual and expected results), until the ANN learns the training data.

In the present study the ANN was designed by using MATLAB codes. A programme was written, edited, debugged and run in MATLAB. The programme was suitably modified to accommodate different input patterns and models. The programme is flexible to accommodate different activation functions (tansig, logsig, and purelin), performance functions (mse, sse and msereg), training algorithm (trainbr, trainlm etc.) and a preset number of iterations. The programme takes input data file in the ‘delimited text files without header’ format with standard extension as ‘txt’ and gives output in the same format. The output file was then converted into ‘ms excel’ file with fixed width format.

In this study ‘logsig' activation function was used. The training algorithm chosen was Levenberg-Marquardt (trainlm) and the performance function chosen is sum squared error (sse).

PERFORMANCE EVALUATION OF MODELS

The statistical model evaluation criteria considered in this study are as follows:

Mean Absolute Deviation (MAD)

It is a measure of mean absolute deviation of the observed values from the estimated values. It has a unit and is not a normalized criterion. It is expressed as,

$$\text{MAD} = \frac{\sum_{j=1}^{n} \left| O_j - S_j \right|}{n} \tag{1}$$

Where, O_j = Observed Evaporation (mm), S_j = Simulated Evaporation (mm), n = Total number of observations.

Root Mean Square Error (RMSE)

It is an alternative to the criterion of residual error (Yu, 1994) and is expressed as the measure of mean of the residual variance summed over the period, that is,

$$\text{RMSE} = \sqrt{\frac{\text{residual variance}}{\text{n}}} = \left(\frac{\sum_{j=1}^{n} \left(O_j - S_j\right)^2}{n} \right)^{1/2} \tag{2}$$

Correlation Coefficient (CC)

The correlation between the observed and simulated values is described by the correlation statistic, called the correlation coefficient. It is estimated by the equation:

$$CC = \frac{\sum_{j=1}^{n}\left\{\left(O_j - \bar{O}\right)\left(S_j - \bar{S}\right)\right\}}{\left\{\sum_{j=1}^{n}\left(O_j - \bar{O}\right)^2 \sum_{j=1}^{n}\left(S_j - \bar{S}\right)^2\right\}^{\frac{1}{2}}} x100 \quad (3)$$

Where, $\bar{O}$ and $\bar{S}$ are mean of observed and simulated Evaporation (mm)values.

Coefficient of Efficiency (CE)

Nash and Sutcliffe (1970) proposed the criterion on the basis of standardization of the residual variance with initial variance and named it as the coefficient of efficiency.

$$\text{CE} = \left\{1 - \frac{residual\ \text{var}iance}{initial\ \text{var}iance}\right\} x\ 100 = \left\{1 - \frac{\sum_{j=1}^{n}\left(O_j - S_j\right)^2}{\sum_{j=1}^{n}\left(O_j - \overline{O}\right)^2}\right\} x\ 100 \quad (4)$$

Index of Agreement (IOA)

IOA= 1- ((sum((obs - pre)^2)) / sum((abs(pre - mean(obs)) + abs(obs - mean(obs)))^2)

$$\text{IOA} = 1 - \frac{\sum_{j=1}^{n}(\text{Sj} - \text{Oj})^2}{\sum_{j=1}^{n}((|\text{Sj} - \text{O}|) + (|\text{O} - \text{O}|)^2} \quad (5)$$

RESULTS AND DISSCUSSION

For the purpose of determination of the most suitable network based on defined function with different neurons in hidden layer, done train and test on 3 different model structure and selected best network. The ANNs have been successfully implemented to model evaporation in several studies. These studies indicated that the ANN models can be used as an alternative method to simulate evaporation. The performance of ANN models reported in these studies was superior to respective direct method of evaporation estimation. In this study Artificial Neural Network models have been trained with 70% of the patterns (4600) and tested with 30% (1975) of the patterns 6575. Values of different performance evaluation criteria *viz.* MAD, RMSE, CC, CE and IOA are analyzed both during training and testing. After detailed numerical experiment the best performance in each model has been selected. The network are selected based on maximized CC, CE and IOA value and minimized MAD and RMSE values both in training and testing. In Figure 1, for model M1 we have found maximized CC, CE, and IOA value is during training 95.17, 90.58, 97.46 maximized CC, CE, & IOA value is 97.22, 93.39, & 98.37 during testing. In Figure 2, for the model M2, value is 73.09, 33.42, and 82.11 during training, and during testing the value is 81.30, 33.00, and 85.43. And maximized CC, CE and IOA Values are 78.83, 64.72 and 88.51 during training and 82.70, 68.17 and 90.12 during testing for model M3. Upon comparison the model M1 was found performing better than other.

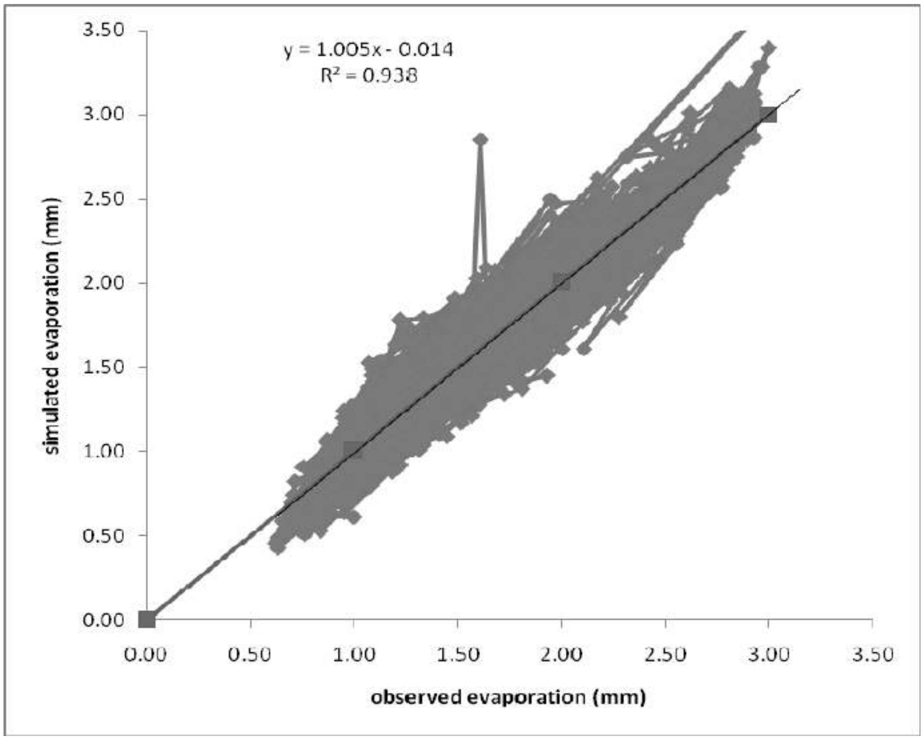

Figure 1. Relationship between observed and simulated evaporation for models M-1 during training.

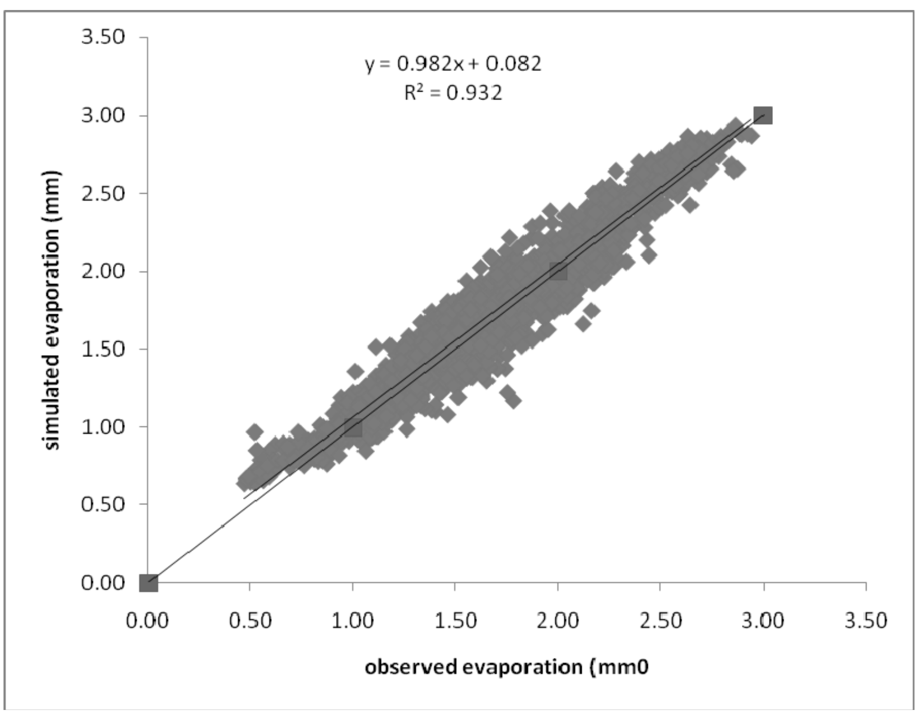

Figure 2. Relationship between observed and simulated evaporation for models M-2 during testing.

Table 2 Performance of Artificial Neural Network during Training and Testing.

Model Name/ Network Architecture (NOIN-NOHN-NOON)	Input combination	Training					Testing				
		MAD	RMSE	CC (%)	CE (%)	IOA	MAD	RMSE	CC (%)	CE (%)	IOA
2-6-1	**Tmax+SSH**	0.0942	0.1721	95.17	90.58	97.46	0.100	0.129	97.22	93.39	98.37

NOIN- Number of input nodes, NOHN- Number of hidden nodes, NOON- Number of output nodes

CONCLUSION

The artificial neural network (ANN) models show good capability to model hydrological process. They are useful and powerful tools to handle complex problems compared with the other traditional models. In general, ANN's learning process is affected by several factors such as number of input nodes, number of hidden layers, and number of nodes in hidden layer, learning algorithms, and learning cycles. And the climatic variable corresponding to the nodes. Artificial neural networking is one of the methods for estimate evaporation. In this method can use in any area that have only maximum and minimum data for estimate evaporation. Thus farmers can estimate needs of water for irrigation of farms. If there is more factors of climatic such as Maximum temperature and Sunshine estimation of evaporation will be more accuracy.

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A Multi-variable Statistical Downscaling Model for Monthly Precipitation and Temperature over Tung-Bhadra River

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ABSTRACT

Water resources is one of mankind's most crucial ecosystem services, and one of the natural processes most strongly affected by climate change. Global change in climate and consequent large impacts on regional hydrologic systems have, in recent years, motivated significant research efforts in water resources modeling under climate change. A study on surface water resources systems accounting for impacts due to climate change requires downscaled hydrological variables such as streamflow, rainfall, temperature, etc at a particular location. A multi-variable downscaling methodology needs to be applied for impact assessment studies involving multiple hydro-meteorological variables. To develop the projections of the multivariate predictands at-site an appropriate multivariable statistical downscaling technique must be adopted which can maintain the correlations between the downscaled predictand variables. In this context, a multivariable downscaling methodology based on Canonical Correlation Analysis (CCA) coupled with Principal Component Analysis (PCA) is developed. In the proposed methodology the relationships between climate variables and the surface hydrologic variables are simultaneously expressed, as occurs in nature by retaining the explained variance between the two sets. The statistical relationships in terms of canonical regression equations are obtained for each of the predictand based on National Center for Atmospheric Research (NCEP) data and surface observations using CCA. The developed regression equations are applied to the interpolated NCEP gridded General Circulation Model (GCM) output to model future projections of hydro-meteorological predictands. The present study downscales the future projections of precipitation and temperature over Tunga-Bhadra River basin.

1. INTRODUCTION

Global climate models (GCMs) are the primary tools designed for understanding physical processes of the earth surface-atmosphere system and how the global climate may change in the future. The Intergovernmental Panel on Climate Change (IPCC) has developed long-term emission scenarios to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties. For impact assessment, the simulations provided by GCMs for various IPCC scenarios are generally used. GCM outputs typically have a coarser scale (typically at a scale of 2.5^0 latitude x 2.5^0 longitude) and inadequate to represent hydrological variables at regional scales (which may be typically of the order of 0.5^0 latitude X 0.5^0 longitude). Further, accuracy of GCMs decreases from climate related variables, i.e., wind, temperature, humidity and air pressure to precipitation, evapotranspiration, runoff and soil moisture, while the latter variables are of key importance in hydrologic regimes. In this context, there is a need to convert the GCM outputs into hydrologic variables (e.g. precipitation and streamflow) at regional scale to study the climate change impacts on surface water resources system. Modeling of hydrologic variables at a smaller scale based on large scale GCM outputs is the most important step in hydrological impact assessment studies, known as downscaling. The approach involves the use of a transfer function downscaling based on regression methods, in which a quantitative relationship between the local hydrological variable (predictand) and the large scale atmospheric variables (predictors) is determined. The transfer function methods differ according to the choice of mathematical transfer function, number of predictand variables (i.e. single or multiple) or statistical fitting procedure. Artificial Neural Networks (ANNs) (Cannon, 2007), Support Vector Meachine (SVM) (Anandhi et al., 2008), Relevance Vector Machine (RVM) (Ghosh and Mujumdar, 2008), Conditional Random Fields (CRF) (Raje and Mujumdar, 2009), K-Nearest Neighbor (K-NN) (Gangopadhyay et al., 2005) have all been used to derive predictor-predictand relationships.

Most of the downscaling approaches in the literature deal mainly with downscaling of climatic simulations for a single site and single variable, but very few studies are concerned with the downscaling for multi-sites/variables because of the complexity in accurately describing the spatial dependence and inter-variable relationships.

Furthermore, a sustainable management of a surface water resources system accounting for impacts due to climate change on water availability, water demands and water quality requires various downscaled hydrological variables such as streamflow, rainfall, temperature, wind speed, relative humidity etc. at a particular location. A multi-variable downscaling method, where the transfer function itself can accommodate vector of predictands by maintaining the dependencies between variables is specifically important in hydrological impact studies. Transfer functions provide ease of use but only explain a fraction of observed variability. Efforts have not been made earlier towards multivariable downscaling at a single site with a transfer function approach. The present study aims to adopt a multivariable downscaling based on Canonical Correlation Analysis (CCA) (Rehana and Mujumdar, 2012) where the transfer function itself can accommodate vector of predictands by maintaining the realistic relationship between variables. The present study aims to show the advantage of using CCA as a multivariable downscaling methodology to predict the multivariable predictands at single site instead of downscaling each predictand variable separately. A detailed study is carried out to show the use of CCA downscaling in capturing the relationships between precipitation and temperature variables after downscaling. The proposed methodology is applied on Tunga-Bhadra River basin, situated in Karnataka, India.

2. MATERIALS AND METHODS

Tunga-Bhadra River is a perennial river formed by the confluence of Tunga and Bhadra, the two tributaries of river Krishna, located in Karnataka, India (Figure 1). The Tunga River is about 147 km long and the Bhadra River is about 178 km long. The two rivers rise in the Western Ghats, and join at a place called Kudli, which is about 14.5 km from Shimoga city, to form the Tunga-Bhadra River. The Tunga-Bhadra River flows for about 382 km through Karnataka and some parts of Andhra Pradesh before joining the Krishna River at Sangamaleshwaram. The total catchment area of the river is 69552 km^2 and it is influenced chiefly by the South-West monsoon.

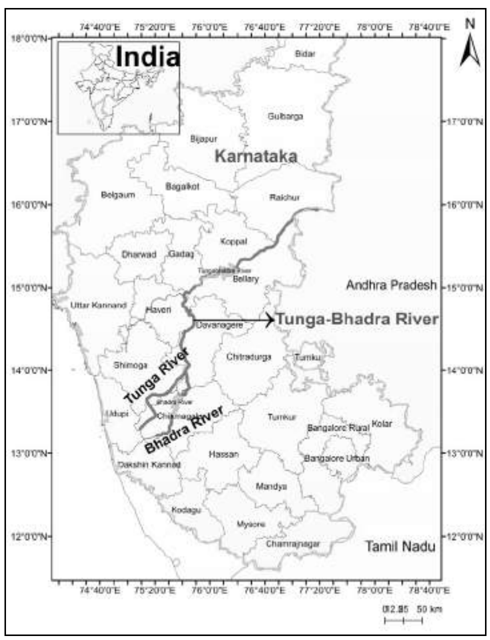

Figure 1. Location Map of Tunga-Bhadra River, India

Area from 10^0 - 20^0 N to 70^0 - 80^0 E over the target region where precipitation and temperatures are to be downscaled is chosen for the large-scale predictors data collection. These data of monthly values of the predictors are obtained from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis data (Kalnay et al., 1996) (available at http://www.cdc.noaa.gov/cdc /data.ncep.reanalysis.html) are used as observed data for training the model. Large-scale daily atmospheric variable outputs from the Model for Interdisciplinary Research on Climate, version 3.2 (MIROC 3.2) GCM for the A1B scenario are extracted from the multimodal data set of the World Climate Research Programme's Coupled Model Inter Comparison Project (WCRP/CMIP3) (available at https://esg.llnl.gov:8443/about/ftp.do). The simulations for A1B scenario of the Intergovernmental Panel on Climate Change (IPCC) AR4 (IPCC, 2007) provided by MIROC

3.2 GCM (medium-resolution of 1.125 x 1.125 deg, GCM from the Center for Climate System Research (CCSR), Japan) are used for impact assessment.

The overview of the proposed model is shown in Figure 2. A statistical relationship based on CCA regression for each of the predictand is developed between the reanalysis data extracted for predictors and observed predictands. The relationships developed by using the CCA model for each of the predictand are then used to model the future hydro-meteorological variables with the GCM projections of predictors. A separate regression equation can be derived for each hydro-meteorological predictand variable from the canonical variable coefficients or scores and correlations (ρ) computed from the observed data. The principal components extracted from the NCEP data are considered as predictor set to perform CCA to fit the regression relation between the climate variables and surface based observations. Here, U_q and V_q are defined as predictor and predictand canonical variables respectively; $\mathrm{a} = [\mathrm{a}_1, \mathrm{a}_2, \ldots \mathrm{a}_N]^T$ and $\mathrm{b} = [\mathrm{b}_1, \mathrm{b}_2, \ldots \mathrm{b}_M]^T$ as canonical loadings for U_q and V_q respectively. The objective of canonical correlation is to identify q sets of canonical variables along with the weights a and b such that the correlation, ρ_{cq}, between predictor canonical variable, U_q and predictand canonical variable, V_q, is maximum. The predictand canonical variable, $V_{predicted,q}$, can be evaluated from the predictor canonical variable, $U_{obs,q}$, as follows:

$$V_{predicted,q} = \rho_{Cq} \times U_{obs,q} \tag{1}$$

In above expression ρ_{Cq} is the canonical correlation coefficient and represents the percent of variance in the predictand canonical variable explained by the predictor canonical variable and it is a diagonal matrix. The downscaled scenario for each of the predictand can be derived according to:

$$Y_{predicted,q} = [b^{-1}] \times V_{predicted,q} \tag{2}$$

The regression equations developed for each of the predictand based on the observed data can be used with GCM outputs to obtain the future projections of precipitation and temperatures.

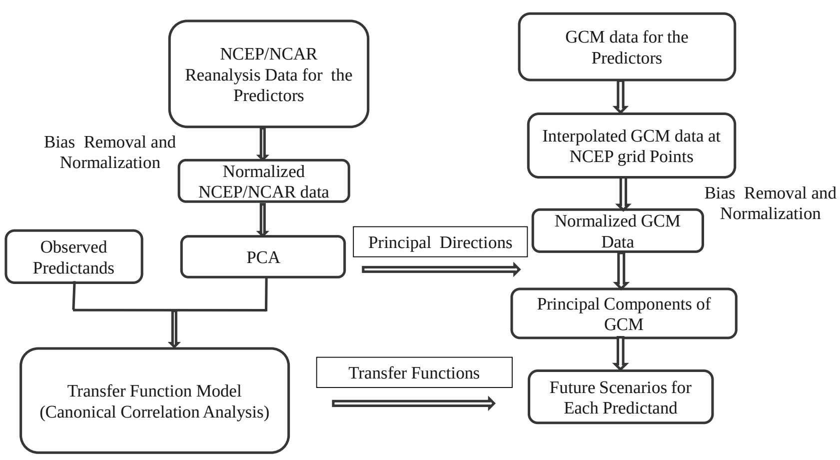

Figure 2. Overview of the Proposed Model

3. RESULTS AND DISCUSSION

The CCA downscaling model is trained using the past records of atmospheric and surface meteorological data of 25 years (1971 to 1995) to estimate the canonical scores, and the model is tested with the remaining data (period 1996 to 2004). Once the model performance is found satisfactory in the testing period, it can be applied for future predictions. The rainfall and temperatures are simulated with NCEP data and future projections are predicted from MIROC 3.2 GCM for the A1B scenario using CCA downscaling model. The CCA model is able to simulate reasonably well the observed data (Fig. 5.3(A)) for the training period of 1971 to 1995 with both NCEP and GCM.

The GCM predicted rainfall and temperatures are shown in Fig. 5.3 (B) for two time slices 2020-40 and 2040-60. The projected monthly rainfall shows an increasing trend over Tunga-Bhadra River basin. The expected rainfall increase is defined by the large scale atmospheric variables (air temperature, mean sea level pressure, geopotential height, humidity and wind variables) considered as predictors in the study region. Such an increase in rainfall is also observed in the study of Meenu et al. (2011) for the same case study of Bhadra command area with Statistical Downscaling Model (SDSM) and also with Support Vector Machine (SVM). GCM predicted temperature also resemble well with the observed data (figures (A) in Figs. 4.8 (i) to 4.8 (v)) with increasing trends in temperature variable (Fig) and along the Tunga-Bhadra river basin.

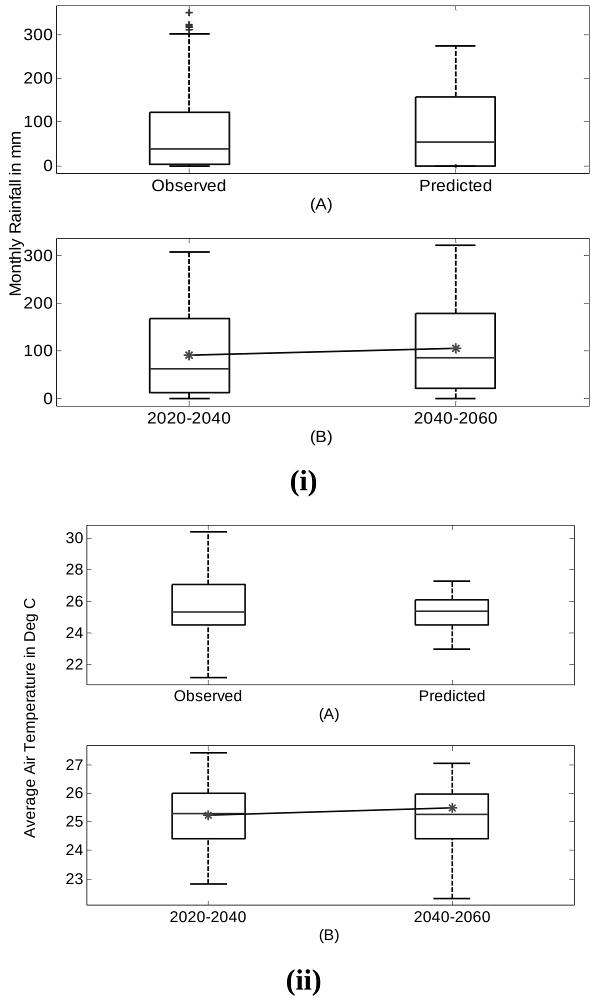

Figure 3. Results of observed and CCA predicted from MIROC 3.2 GCM (A1B).
(i) Rainfall, (ii) Temperature

4. CONCLUSIONS

Statistical downscaling with Canonical Correlation Analysis (CCA) is carried out to obtain the future projections of hydro-climate variables, starting with simulations provided by a GCM. The MIROC 3.2 GCM with A1B scenario, when applied to the case study of the Tunga-Bhadra River, projects a increasing trend in future rainfall and the air temperature shows an increasing trend. The major limitation of CCA model is it is a linear prediction model and therefore, relating the climate predictor variables and surface predictand variables as linear, which may not capture the non-linear relationship between two data sets. In addition to this the performance of this statistical downscaling method entirely dependent on the number of PCs retained, the number of CCA components used in the regression model and also on the training data sets. However, downscaled results can be substantially improved with longer training data sets as accuracy may be limited by representativeness of the training data for the current situation.

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ZnO/ZnS Nanostructured Material: Synthesis and Methylene Blue Photo Degradation

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ABSTRACT

Nanotechnology is the art of science which is manipulating matter at the Nanoscale. Nanoscale materials are having relatively larger surface area-to-volume ratio, hence they can become more chemically reactive and increases their strength. In connection of these nanomaterials ZnO/ZnS nanostructured materials are showing extraordinary properties. Due to this reason these are used in various applications such as energy conversion, energy storage, medical diagnostics and food packaging. The present paper focused on ZnO/ZnS nanostructured materials synthesis, characterization and application of photo degradation. In this present study the ZnO/ZnS nanostructured material was synthesized by Co-precipitation method.The initial precursor materials were taken as Zinc Sulphate, Thiourea and Ethylene glycol. Co-precipitation method is very simple and convenience method, high reproducibility and low cost method. The obtained ZnO/ZnS nanostructured material have been characterized by X-ray diffraction(XRD), Scanning Electron Microscope (SEM), Particle Size Analyser (PSA) and UV-Visible spectrometer (UV-Vis) for crystal structure, morphology, average particle size and optical properties respectively. Methylene blue photo degradation studies were observed by Colorimeter at 440nm wavelength.

Keywords: ZnO/ZnS nanostructured materials, Co-precipitation method, XRD, SEM.

INTRODUCTION

Recent investigations of some material designs to strengthen and toughen ceramics by using composite techniques to incorporate particulate, whisker platelet conversion systems, optical devices and reinforcement have shown that ceramic composites having nano sized metal particulate dispersions show excellent optical, electrical, and mechanical properties(Hayelom Dargo et al., 2014). Zinc oxide (ZnO) is a direct and wide band gap semiconductor with a band gap of 3.37eV that displays high optical transparency and luminescent properties in the near ultra violet and the visible regions (Kavita Ameta et al., 2014). The 21st century, Zinc sulphide (ZnS) is a commercially important II-VI semiconductor having a wide optical band gap, rendering it a very attractive material for optical application especially in nano crystalline form. ZnS can have two different crystal structures (zinc blende and wurtzite) both of which have the same band gap energy (3.68 eV) and the direct band structure. ZnS has been used for the cathode ray tube, the field emission display and the scintillator(Vendula Houskova et al., 2008).Optical and luminescent properties of nano crystalline ZnS reveal the energy structure and surface states of these particles [(Susheela Bai Gajbhiye, 2012). ZnO/ZnS Nano particles can be prepared in the forms of thin film, powder or colloid using different synthesis techniques such as sputtering, vapour phase condensation, thermal evaporation, sol-gel, sono-chemical synthesis, microwave irradiation, chemical co-precipitation method and ultrasonic irradiation(Tran Thi Quynh Hoa et al., 2009; Khalid et al., 2013). Most of these methods involve high temperature, sophisticated instruments, and large reaction time but chemical co-precipitation method is a very simple and cost effective method, as it does not require sophisticated instrumentation (Abbas Rahdar, 2013).

ZnO/ZnS nano particles exhibit many promising characteristics such as strength, thermal stability, electronic and magnetic properties, wider energy gap, surface effect and quantum confinement etc.., many of these unique properties of ZnO/ZnS nanomaterials are related to surface and volume effects (Nada K et al., 2013). Thus, preparation of size controlled, mono dispersed semiconductor nanoparticles in a stable host matrix to prevent occultation is of primary importance. The present paper concentrated on ZnO/ZnS nanostructured material synthesis, characterization and photo degradation application. Co-precipitation method is used to prepare ZnO/ZnS nanostructured material using Zinc Chloride, Sodium Sulphide and N-N Dimethylformamide are the initial precursor materials (Dasari Ayodhya et al., 2013).

EXPERIMENTAL DETAILS

Preparation of ZnO/ZnS Composite material: ZnO/ZnS nanocomposite materials were synthesized by a novel Chemical Co- Precipitation with starting materials Zinc chloride and Sodium Sulphide in the presence of organic solvent N, N-Dimethylformamide. 1M of $ZnCl_2$taken into a beaker and added 1M of Na_2S with vigorous stirring for 30 minutes. 1ml of N, N-DMF organic solvent added to the above solution. Suddenly the white colour precipitate solution was observed. The precipitate was further dried at 80°C for 60 minutes, which leads to the formation of ZnO/ZnS nanocomposite material.

RESULTS AND DISCUSSIONS

X -ray Diffractometer: XRD pattern of the ZnO/ZnS nano composite wasshown in figure. This figure conformed that the ZnO/ZnS nanocomposite was formed. The peak representations: @ and # for ZnO and ZnS respectively.

This result shows that the structure of the ZnO/ZnS nano composite was in the hexagonal phase. The extended peaks were representing the dimensions of the nano range particles. Peaks were observed at 28°, 33°, 45°, 47°, 66° and 77° with corresponding (h k l) values (102), (104), (105), (110), (207) and (212) respectively. The lattice parameters were good agreement with JCPDS card numbers of 36-1451 and 89-2739 for ZnO and ZnS respectively. The structure of the ZnO/ZnS nano composite was hexagonal phase. The extended peaks were representing the dimensions of the nano range particles (Anoop Chandran et al., 2010).

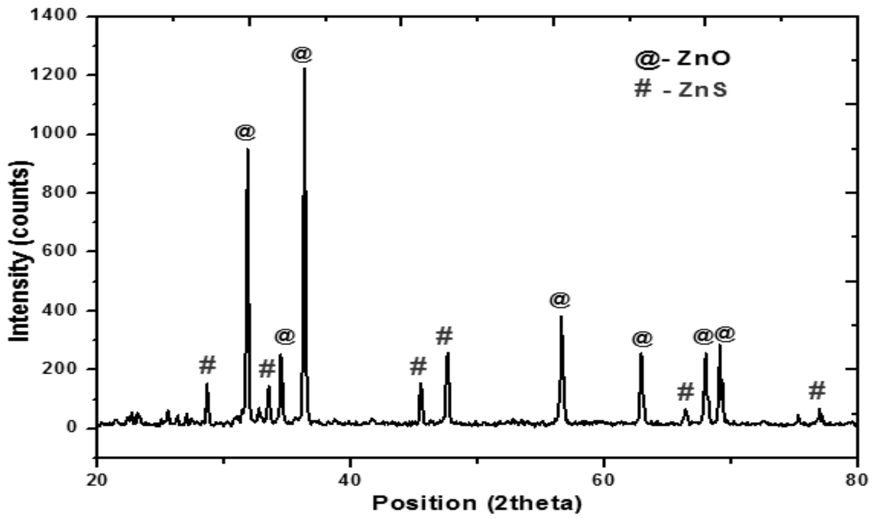

Figure 1. XRD Pattern of ZnO/ZnS nano composite

The crystallite size was calculated by Debye –Scherrer's equation

$$D = K\lambda/\beta.\ \cos(\theta)$$

Where D- is the average crystallite of the particles, λ-is the wavelength of the radiation, β –is the full width at half maximum (FWHM) of the peak, θ -is the Bragg's angle.

The average crystalline size was 34 nm.

Field Emission-Scanning Electron Microscope:

The grain size, shape and surface properties like morphology were observed using FESEM.

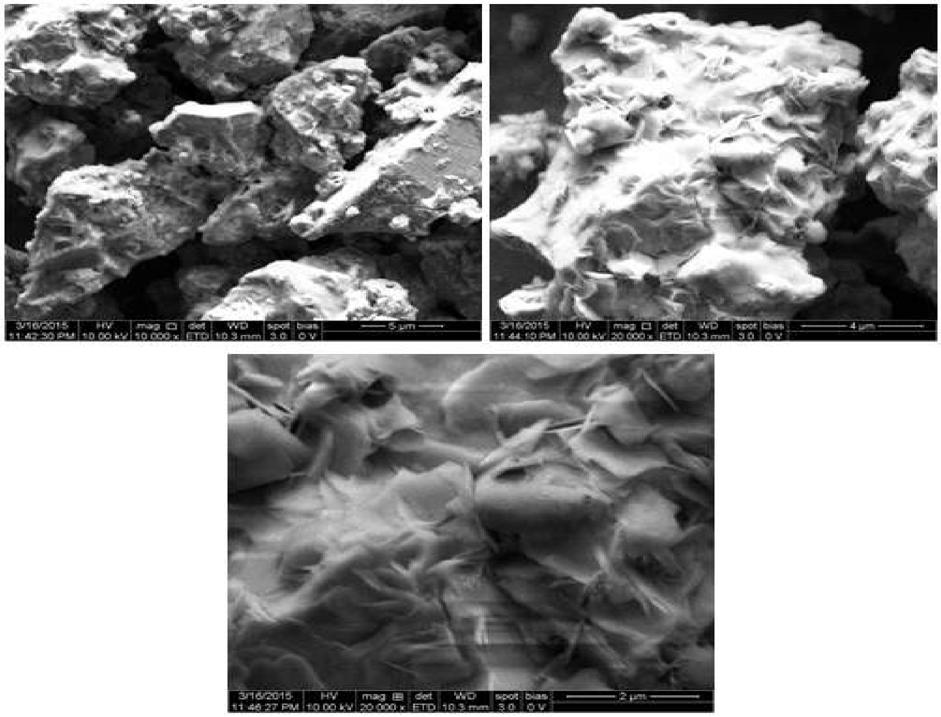

Figure 2. FESEM Images of ZnO/ZnS Nanocomposite

The ZnO/ZnS nanocomposite material was investigated with different magnifications like 5 µm, 4µm and 2µm.The FESEM images infer that the composite material having high porous nature. The shape of the nanocomposite material was flowers like structure with folded sheets. This folded sheet was formed due to the ZnS material (B S Rema Devi et al., 2007).

Particle Size Analyser:

The as-prepared ZnO/ZnS nanocomposite material was ultra-sonicated and using the ethanol solution. The size of the nano composite suspension was estimated using particle size analyser. The mean value of the histogram was taken as average particle size.

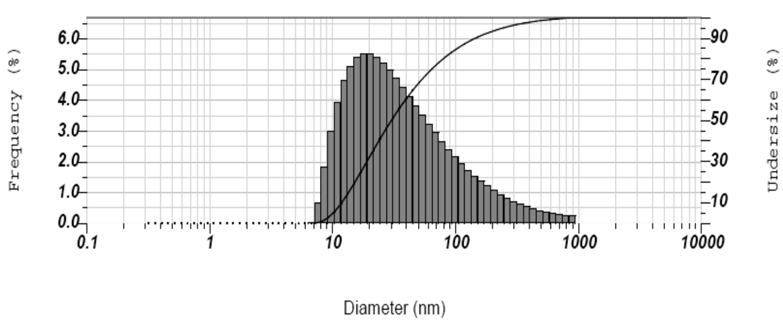

Figure 3. Particle distribution in the particle size analyser

From the particle size analyser the average particle size was obtained 62 nm. This average particle size value is greater than the average crystallite size (CH. Ashok et al., 2013).

UV-Visible Spectroscopy:

The absorption spectrum of ZnO/ZnS nanocomposite was as shown in figure. The optical study was observed from 200 nm to 1100 nm wavelength. The absorption peaks were observed in the ultra violet region i.e 250 nm, 320 nm and 400nm(Satyajit Saha et al., 2011).

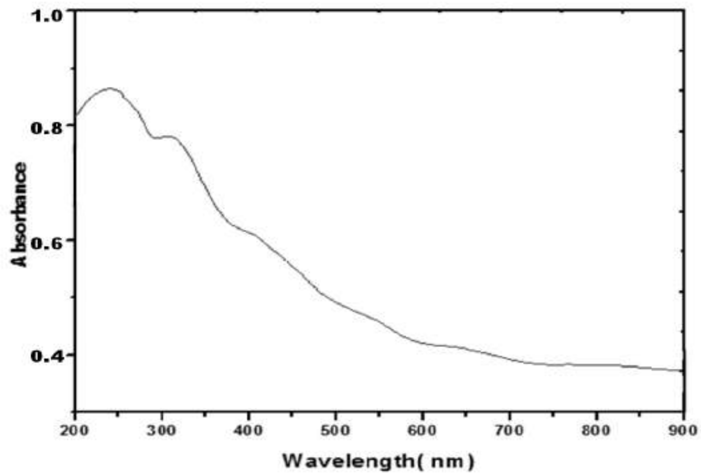

Figure 4. UV-Visible absorption spectrum of ZnO/ZnS nanocomposite

The fundamental absorption which corresponds to electron excitation from the valence band to conduction band can be used to determine the value of the optical band gap. The maximum absorption peak is noticed at 250 nm. The average energy band gap of the ZnO/ZnS nanocomposite was 3.54 eV.

APPLICATION

Water pollution is one the worldwide problem, which are directly affected living organisms. The Effluents of various industries discharged directly or indirectly into water sources without any prior treatment for removal of harmful or dangerous compounds, create water pollution. Researchers have developed some methods for wastewater treatment like adsorbents, electrolyte large scale due to high cost and therefore, some alternative methods are required, which are reliable as well decomposition, ion exchange method, biological methods etc. These treatment methods are not suitable at as green chemical in nature. Photo catalysis provides an eco-friendly pathway for degradation of many organic pollutants. This technique is considered as a promising technology for wastewater treatment. Degradation has emerged as an efficient process for degradation of organic pollutants, which are present in the effluents released by these industries.One of the high consuming materials in the dye industry is Methylene Blue (MB) which is used for cotton and silk painting. A great number of methods have been proposed in order to remove dyes from the industrial wastewater among which adsorption is the most acceptable due to its cost effectiveness and its capability to be used in large scales.

Methylene blue (MB) is a cationic dye, which is most commonly used for coloring paper, hair colorants, textile industry, dyeing cottons, wools etc. Through MB is not strongly hazardous, it can cause some harmful effects. MB will cause increased heart rate, vomiting, shock, cyanosis, jaundice, MB is generally used to test the adsorption capacity of various adsorbents and it also permits a quantitative comparison between the adsorption capacities of various adsorbents.

Methylene blue was diluted in 40 ml distilled water. The photo catalytic degradation of methylene blue dye was studied ataddition of:(1) diluted water with methylene blue, (2) methylene blue diluted with (1.5 g) of ZnO/ZnS nano composite and H_2O_2, (3) methylene blue diluted with (1 g) of ZnO/ZnS nano composite and H_2O_2, (4) (0.5 g) of ZnO/ZnS nano composite and H_2O_2, (5) is represents methylene blue diluted with (1 g) of ZnO/ZnS nano composite and H_2O. The beaker kept undersunlight. Colorimeter was used to measure the optical density of the dye solution at the regular time intervals, These experiments were carried out simultaneously for all the catalyst in sunlight between 10.00 a.m to 1.00 p.m ,The experiment were repeated for all the catalyst with H_2O_2 and without H_2O_2 Simultaneously in order to conform the consistency of result. The optical density of the solution was determined at 440 nm wavelength for methylene blue(Nayereh Soltani et al,. 2012).

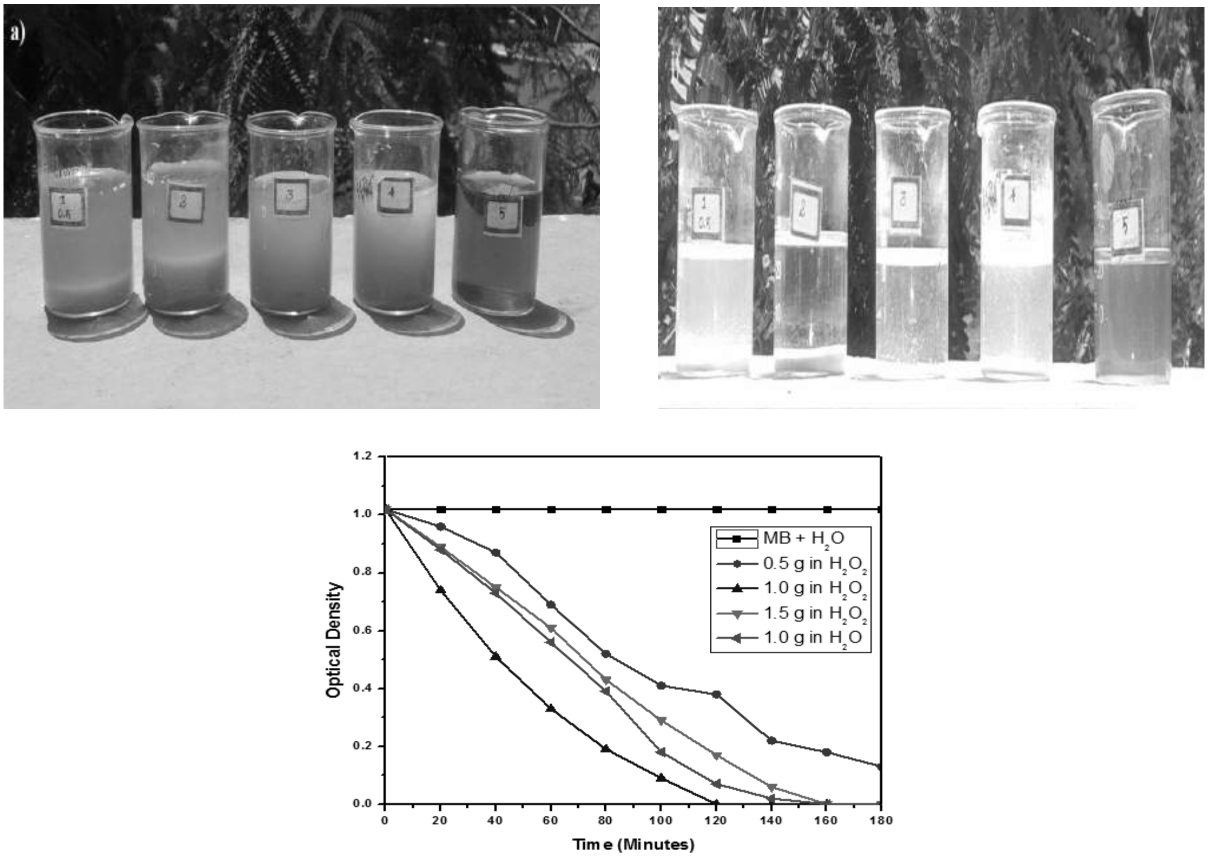

Figure 5. Photo catalytic degradation profile of the H_2O_2/MB/ZnO/ZnS composite

Degradation of methylene blue (MB) under sunlight with ZnO/ZnS composite was used as the catalyst for degradation. It may be used either alone or in combination with H_2O_2 to enhance their performance and control of bio growth. The H_2O_2 to activate the nano composite and may also be used to speed up catalysts reaction for complete degradation. Degradation of methylene blue under sunlight is fast within 20 min with a combination of ZnO/ZnS and H_2O_2 as a photo catalyst. By increasing the catalyst quantity degradation time less under sunlight. ZnO/ZnS shows efficient photo degradation for high concentrated MB dye under sunlight which is shown in the figure.

CONCLUSIONS

The ZnO/ZnS nanocomposite material had been successfully synthesized using the precursors Zinc Chloride, Sodium Sulfide and N-N Dimethylformamide by the Co-precipitation method. The XRD result indicates that the nano particles are shown hexagonal phase in a structure, the crystalline size is measured from the Debye-Scherrer's formula is 44 nm. Particle size histograms showed that the average particle size was 62 nm. The morphological structures of the samples were characterized by FESEM. The shape of the nanocomposite material is flowers like structure with folded sheets. This folded sheet was formed due to the ZnS material. The UV-Visible Spectroscopy analysis was used to study the optical absorption property of the ZnO/ZnS composite. Degradation of methylene blue (MB) under sunlight with ZnO/ZnS composite was used as the catalyst for degradation. By increasing the catalyst quantity degradation time less under sunlight. ZnO/ZnS shows efficient photo degradation for high concentrated MB dye under sunlight.

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Photo Degradation of Methylene Blue in Water: using Al_2O_3 Nanoparticles

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ABSTRACT

The rapid uses of methylene blue die in the textile industry causes a water pollution heavily which leads to death of aquatic animals. It can be controlled by hydrogen peroxide (H_2O_2) moderately but takes huge time. To improve the speed of the process Aluminium oxide nanoparticles were used in this experiment which have huge band gap, photo degradation property. In the Present paper focused on to synthesis of Aluminium oxide (Al_2O_3) nanoparticles and study of its applications in the field of water treatment under different concentration of material with H_2O_2 using sunlight. These nanoparticles were prepared by very easy & simple chemical method as Solution combustion. The synthesized metal oxide nanoparticles have been characterized by X-ray Diffractometer (XRD), Particle Size Analyser (PSA), Scanning Electron Microscopy (SEM) and UV-Visible Spectroscopy (UV-Vis) for average crystallite size, average particle size, morphology and optical properties respectively. The photo degradation was studied using colorimeter at 440nm wavelength.

Keywords: Al_2O_3 nanoparticles, Photo degradation, Methylene blue die, H_2O_2, Colorimeter.

1. INTRODUCTION

Water problem is one of the most serious issue in the present world, which is seriously affecting the living organisms. Effluents of various industries discharged directly or indirectly into water bodies without any prior treatment for removal of harmful compounds, create water pollution (Ankita Ameta et al., 2013).These pollutions are dependent on different ways, such as sludge from industrials and home waste and so on. Mostly Dyes and pigments are widely used in the textiles, paper, plastics, leather, food and cosmetic industry to color products.Textile industries generate 100-170 lit dye effluent per kg of cloth processed which could be characterized by strong odour, high COD & wide range of PH.The treatment of wastewater from textile dyeing is an environmentalproblem that has received considerable attention (Mohabansi et al., 2011).

Photo catalysis provides an eco-friendly pathway for degradation of manyorganic pollutants especially dyes. This technique is considered as a promising technology for wastewater treatment (Nayereh Soltani et al,. 2012).It was focused on the heterogeneous photo catalytic treatment of organic dyes present in air andwater. They have used TiO_2, ZnO, Al_2O_3, CdS, WO_3 and Fe_2O_3 for decolorizing and decomposing the organic dye to mineralized products (Susheela Bai Gajbhiye et al., 2012). Methylene blue is a cationic dye. It is most commonly used for coloring paper, temporary hair colorant, dyeing cotton wools and so on. MB although not considered to be a very toxic dye it can reveal very harmful effects on the living things. After inhale symptoms such as difficulties in breathing, vomiting, diarrhea and nausea can occur in humans (Olajire et al., 2014)

Al_2O_3 nanoparticles have large band gap and high absorbance; hence it can be used in photo catalytic reaction very effectively. These nano particles can be synthesised using Different methods like solution combustion (Hamed Sadabadi et al., 2013), sol–gel method (Fatemeh Mirjalili et al., 2011), Solvothermal (YanglongHou et al., 2003), hydrothermal (Hiromichi Hayashi et al., 2010), laserablation (Veeradate Piriyawong et al., 2012), co-precipitation (Rajaeiyan et al., 2013), microwave assisted synthesis (Prasant Sutradhar et al., 2013) methods. Solution combustion is one of the oldest, very simple and easy techniques to prepare nanoparticles. All the samples were synthesized under standard laboratory conditions and analysed using known analytical techniques such as XRD, PSA, SEM andUV-Vis.

The present study investigates the degradation of methylene blue using H_2O_2, Al_2O_3 in presence of UV light. Subsequent experiments were conducted to investigate the effects of various amounts of catalyst dosing on the process performance.

2. EXPERIMENTAL DETAILS

Materials: Aluminium nitrate nonahydrate {$Al(NO_3)_3.9H2O$,99.99%}, Glycine {H_2NCH_2COOH,99.7%} and Methylene Blue{$C_{16}H_{18}ClN_3S$}purchased from E. merck (India) limited Co.

Synthesis of Nanoparticles:

Calculated amount of Aluminium Nitrate and Glycine were dissolved in 100ml distilled water into breakers separately. They were stirred separately for half an hour using magnetic stirrer at constant stirring. Then, added two solutions at room temperaturewith vigorous stirring. Place the beaker on the hot plate at 300ºC, which will initiate the process of combustion. It requires very huge temperature, which can supply by fuel at end of the stage.During this process we observed boiling, frothing, smouldering, flaming and fuming. Finally the white colour powder was observed. Calcinations have done at 600ºC for 5 hours for removal of by products and carbon content in the materials.

The balanced chemical equation:

$$6Al(NO_3)_{3.}9H_2O + 10C_2H_5O_2N \xrightarrow{\Delta} 3Al_2O_3 + 14N_2 + 88H_2O + 20CO_2 + \frac{9}{2}O_2$$

Preparation of Methylene Blue Solution:

Dissolve 5mM of Methylene Blue solution into the 200 ml of general water, use magnetic stirrer for uniform mixing. Divide the solution into 4 separate beakers of 50ml each for the experiment. While adding the nanoparticles differentiate with/ without hydrogen peroxide medium and different ratios of materials.

3. RESULTS AND DISCUSSIONS

XRD

The XRD pattern of Al_2O_3 nanoparticles obtained from solution combustion synthesis was as shown in Fig 1. The result showed that the structure was in Rhombohedra and these results were good agreement with JCPDS card number 75-1865. Peaks were absorbed at 25°, 35°, 37°, 43°, 52°, 57°, 66°, 68° and 76° along with miller indices values (0 1 2), (1 0 4), (1 1 0), (1 1 3), (0 2 4), (1 1 6), (2 1 4), (3 0 0) and (1 0 10) respectively. As the width of the peak increases size of particle size decreases, which resembles that present material in nano range (Sudheer Kumar et al., 2013).

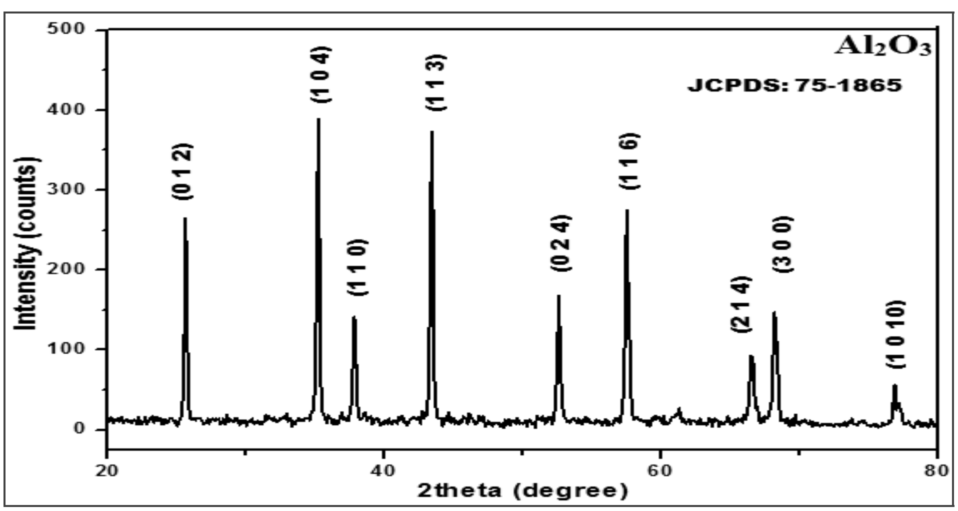

Figure 1. XRD Pattern of Alumina nanoparticles

The lattice parameters were obtained a=b=0.476 nm and c=1.3009 nm. The average crystallite size was measured by Debye-Schereer's equation as mentioned below.

$$D = \frac{K.\lambda}{\beta.\text{Cos}\theta}$$

where D is the average crystallite size of the particles, K is Debye scherrer's constant (=0.94), λ is the wavelength of the CuKα- radiation (=0.154 nm), β is the full width half maximum (FWHM) of the peak, θ is the Bragg's angle.

The average crystallite size was measured as 32 nm.

PSA

The average particle size was obtained by Particle Size Analyser. That material was dispersed in distilled water using ultra-sonicator. Figure 2. shows that the histograms of the dispersed nanoparticles.

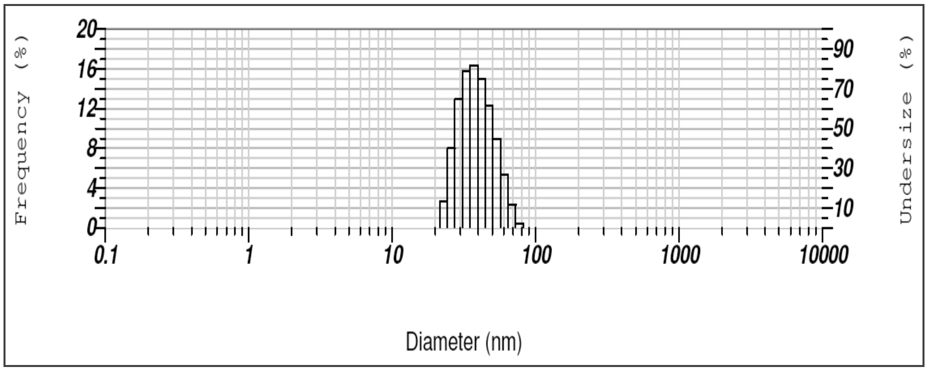

Figure 2. Particle distribution of Alumina nanoparticles

The mean value of the histogram was taken as average particle size. The average particle size was obtained 40 nm. These results were nearly equals to XRD average crystallite size (Ashok et al., 2014).

SEM

The grain size, shape and surface properties like morphology were investigated by the Scanning Electronic Microscopy shown in figure 3. This image was observed with in the magnification of 2 μm.

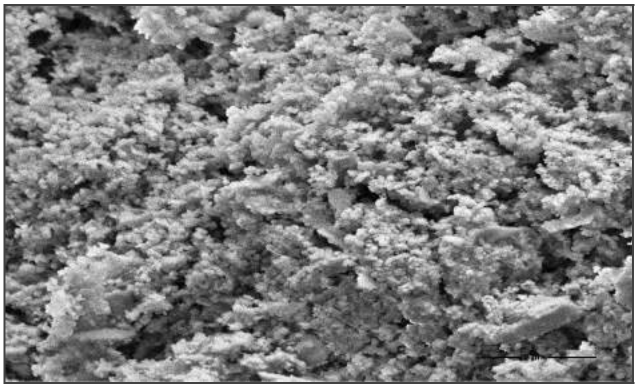

Figure 3. SEM image of Alumina nanoparticles

The alumina nanoparticles were showing agglomerated irregular nano particles. The size was ranging from 60 nm to 70 nm (Tun-Ping Teng et al., 2011).

UV-Vis

The Optical properties of the nanoparticles were studied using Systronics 2202 UV – Visible spectrometer using 200 nm to 1100 nm wavelength range. Figure 4 shows that the absorption spectrum of Al_2O_3 Nanoparticles.

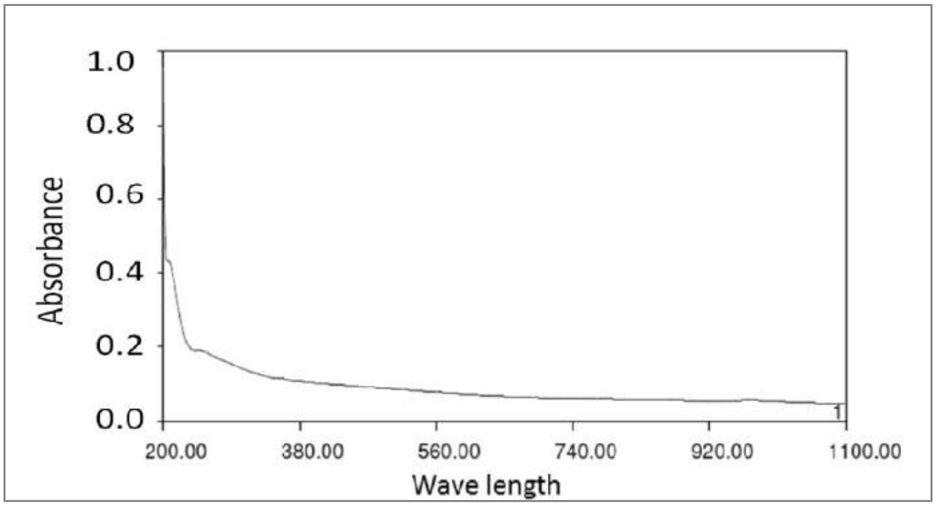

Figure 4. UV-Visible absorption spectrum of Alumina nanoparticles.

It has shown a peak around 200 nm wavelength with absorbance of 0.94 (<1), which means that it exhibits good absorbance in the UV region. The energy band gap of the materials was 6.2ev, which shows the material having higher band gap in the nano range. (Hamdan Hadi Kusuma et al., 2009).

Photo degradation of MB

The photo degradation of methylene blue was carried out under the sunlight for 180 minutes. It was measured using calorimeter in optical density values.

The optical density values were noted for every 15 minutes using calorimeter almost 13 values, which were plotted in the figure 5, shows that the resultant degradation values with respect to time.

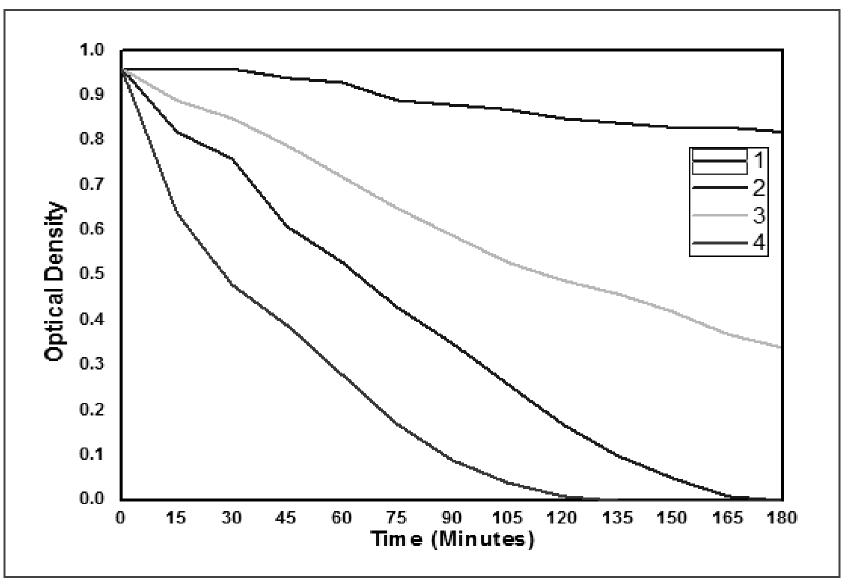

Figure 5. Optical density Vs Time

In this graph by observation the degradation of methylene blue occur in sunlight very little quantity even though using small quantities of hydrogen peroxide. The alumina nanoparticles shows the good results for degradation of methylene bluewith and without hydrogen peroxide compared to without nanopartiocles. But in the case of hydrogen peroxide solution with material shows good results comparing with water solution. In this process the colour change of the solution in the beaker can observe with digital camera which was shown in the figure 6 as complete colour changes of the solution for every 60 minutes (Madhu et al., 2007).

Table 1. Contents of the solution with sample reference

Sample No.	Contents in the solution
1	40 ml of MB + 10ml OF H_2O
2	40 ml of MB + 1 gm of Al_2O_3 nanopartices + 10ml OF H_2O
3	40 ml of MB + 10ml OF H_2O_2
4	40 ml of MB + 1 gm of Al_2O_3 nanopartices + 10ml OF H_2O_2

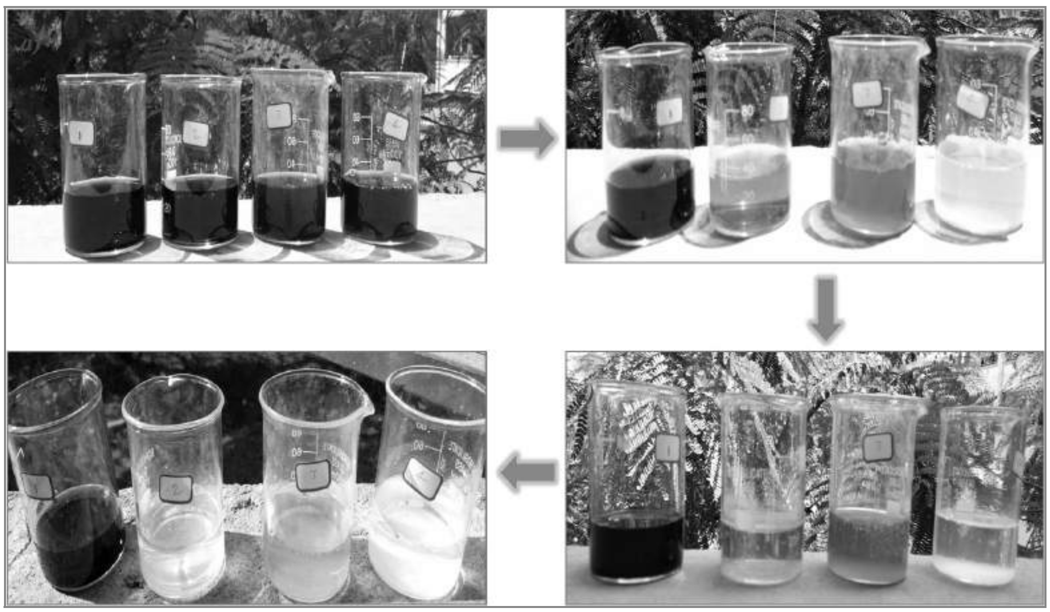

Figure 6. Colour Change in the MB Under sunlight
Increase some more words….

By observing the above results, the methylene blue degradation was very good in 1gm of alumina nanoparticles in the hydrogen peroxide medium comparatively all in presence of sunlight.

4. CONCLUSIONS

The Al_2O_3 nanoparticles were successfully synthesised using Solution combustion method. From XRD analysis average crystallite size of the sample was obtained 31.68 nm. It observed that Rhombohedra structure. The average particle size was estimated 40 nm from particle size analyser. The morphology of the particles was studied using SEM. The optical properties were studied by UV-Visible Spectroscopy. The photo degradation of Methylene Blue was successfully done using Alumina nanoparticles in hydrogen peroxide medium in the presence of sunlight.

ACKNOWLEDGEMENTS

My special thanks to All India Council for Technical Education (AICTE) for providing Graduate Aptitude Test in Engineering (GATE) scholarship.

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A Comprehensive approach to Evaluate the Climate Change Variability on Upper Watershed of River Subarnarekha using Hydrological Model Swat

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ABSTRACT

The effect of climate change on hydrological system of river basin is set to aggravate the current water stress. In today's arena, the changing land use and climate has threatened the sustainability of communities and ecosystems. In these circumstances, the analysis of the impact of climate changes on river hydrology has become very remarkable for various water conservation practices. To document the potential impact of climate change on the river basin, a hydrological model, SWAT (Soil and Water Assessment Tools) is applied on the upper watershed of river Subarnarekha of State, Jharkhand, India. This model helps in simulating the complex process of rainfall-runoff, soil erosion, under different situation. The SWAT model is set up using required hydrological and metrological indicators. The calibration, validation and simulation are performed on the monthly time step to evaluate its result. The performance efficiency of model is ascertained using statistical tools, Nash-Sutcliffe Coefficient value and PBIAS value. According to the study, the model performance is satisfactory. Modeling results also concludes that the model performs well in present study under different physical process within watershed. Based on preliminary output of the model, it can be ascertained that it is an useful tool and can yield a number of hydrological outputs scenario that allow for the estimation of the climate change impact on water resources.

1. INTRODUCTION

The aspect of climate change is one of the most debated issues in today's world. The effect of climate changes is being compounded by the anthropogenic activities, which is directly or indirectly threatening the ecological balance of nature. The impact related to the increase in the concentration of carbon dioxide and other harmful greenhouse gases in the atmosphere is affecting the weather pattern of world. The outcome as "global warming" is having a major implication on water resource. According to IPCC (2007), it states "warming of the climate system is unequivocal, as is now evident from observations of increases in global air and ocean temperatures, widespread melting of snow and ice, and rising global sea level". Many recent studies either in global level or regional level has concluded that there is a rise in global mean temperature of earth. These studies are also conducted with the help of various general circulation models (GCMs), which predicts that the increase in concentration of greenhouse gases will raise the surface temperature. Increase in atmospheric concentration of carbon dioxide is potentially harmful to human and plants (Pritchard et al., 1999). Similarly, research finding have suggested that the increase in carbon dioxide concentration will have an adverse affect on watershed hydrology especially the temperature and precipitation pattern of atmosphere (Chaplot, 2007). In present days, change scenarios are expressed in terms of annual river discharges (Kamga 2001, Legesse et al. 2003). The excess precipitation is the reflectance of increased surface runoff rate, which may lead to flood like situation. Apart from this, the higher evapotranspiration may reduce the stream flow and the frequency of drought may increase due the presence of inadequate moisture. (Nash, 1991). Climate variability would result in alteration of global and regional water resource systems.

Developing countries, like India, are susceptible to extreme weather events in present day climate variability, which may cause substantial economic damage (Monirul and Mirza, 2003). Hydrological model plays an important role in simulating the complex process of rainfall- runoff, soil erosion under different situation. They reproduce physical processes within watersheds and yield a number of hydrological outputs that allow for the estimation of the impact of natural and anthropogenic processes on water resources (Neitsch et al., 2001). In hydrological model various physical process are simulated using pre defined user condition and results are interpreted with respect to water yield and output scenario. The accuracy of model set up for any watershed depends upon data sufficiency and structural method of its scenario selection. In this study, the Soil and Water Assessment Tool (SWAT) is used. SWAT describes how precipitation, temperature, humidity, solar radiation affect surface run off, ET and other hydrological parameters (Arnold et al., 1998). In this study, more focus is given to SWAT model performance evaluation which is done statistically and only initial reference with respect to climate change variability on the study area have been made.

2. MATERIALS AND METHODS

21. Description of study area

The present study is conducted for river Subarnarekha that lies in the eastern part of India. The upper watershed of river Subarnarekha lies within 23° 10’ to 23° 40’ N and 85° 10’ to 85° 40’ E in the state of Jharkhand, India. The selected watershed covers an area of 12831 Km^2, in the state of Jharkhand, India (figure 1). The river originates near Nagri village, which is about 16 km west of Ranchi town. After originating and flowing through the Ranchi plateau, it descends down to the plain catchment towards south- east making a fall- the Hundru fall (243 feet).

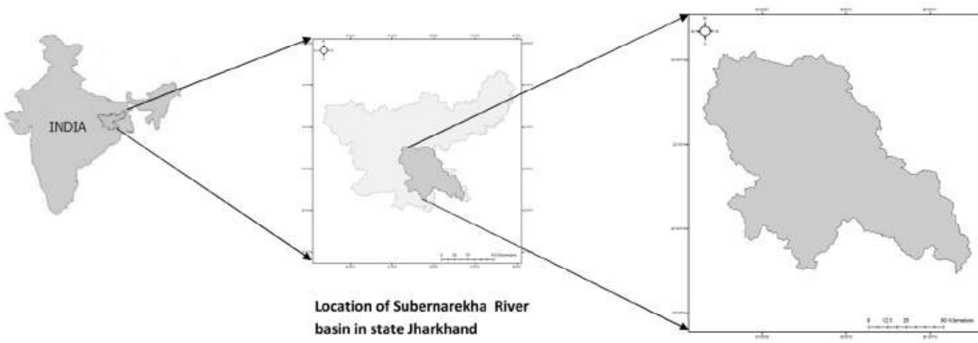


Figure 1. Location of Upper watershed of River Subarnarekha, in Jharkhand.

This region is predominately called as “Chhotanagpur” plateau, which is characterized by numerous small streams and isolated hillocks. The topography of Subarnarekha basin chiefly consists of steep undulating and flat plains with deposits of red and laterite soil. The river course consists of gorges and waterfalls with exposed rocks of granite, genesis, pegamatite (Gupta D.B, 2004). According to two types of aquifers, weathered aquifer, and fractured aquifers exist in the study area in which the thickness of weathered aquifers varies from 10 to 25 m in granite terrain and 30 to 60 m in the lateritic terrain. In weathered aquifers, groundwater occurs in unconfined condition, while in fractured aquifer groundwater occurs in semi-confined to confined conditions, (Krishna et al., 2014). This region is predominantly represented through continued erosion that can be observed as removal of superincumbent load of overlying rocks, (Rasool et. al., 2011). This river basin is totally rain-fed, and water availability depends on monsoon. During summer months, the river does not dry up but contain a stagnant pool of water. According to Köppen Climate Classification, this area is classified as “Humid Subtropical”. The summer is hot and starts from the month of March and end up to June, where as the winter is cold which starts from the month of November and end up to February. The average monthly temperature is 40.5° C in the month of May and 9.°C in December. Annual mean maximum and minimum temperatures vary from 32.4°C to 18.0°C respectively. This basin receives its rainfall from the South-West monsoon, which starts from July and ends in October. The average annual rainfall in the basin is around 1800 mm (Gupta D.B. et. al., 2004).

2.2 Hydrological model – SWAT

SWAT is a continuous-time, spatially distributed simulator of the hydrologic cycle and agricultural pollutant transport at a catchment. This model is developed by the United States Department of Agriculture–Agricultural Research Service (USDA–ARS) (Arnold et al., 1998; Srinivasan et al., 1998). SWAT model helps to predict the impact of agricultural or land management on water, sediment and agricultural chemical yields in ungauged basins. It runs on a daily and monthly time step. Weather, soil properties, elevation, flow of nutrients, pesticides, etc are some important components of this model. The basin unit of SWAT is hydrological response units (HRUs). These are the division of watershed into multiple watersheds having homogeneous land use, soil, slope and other hydrological properties (Flugel, 1995). Daily rainfall is used to predict the surface runoff phenomena using

CREAMS runoff model, whereas the runoff volume is estimated using the modified SCS curve number method. For estimation of ET, the Penman–Monteith method is used for climate change scenarios that account for changing atmospheric carbon dioxide levels. Similarly, various other mathematical methods are used to calculate climatic parameters; like, the kinematic storage model (Sloan et al., 1984) is used to simulate the percolation process to predict the flow through each soil layer. While the base flow is predicted by creating a shallow aquifer storage, stream flow routing uses either the variable storage coefficient method or the Muskingum method. Latin Hypercube Sampling (LHS) and One at Time (OAT) (Van Griensven et al., 2006a) is used in SWAT to perform sensitivity analysis.

2.3 Data collection and input file creation

The input data, which are required for SWAT model, are digital elevation model (DEM), soil texture, land use and land cover, drainage network and data related to meteorological observation and hydrological parameters. The elevation data at a resolution of 90 m acquired through the shuttle radar topography mission (SRTM) is available for the globe (Rabus et al., 2003). ARC GIS 10.1 is used to further the elevation data to obtain the digital elevation model (DEM) which defines the stream network (Fig. 2a). The elevation output, which shows the minimum and maximum elevation, is 48 m to 1043 m respectively is shown in (Fig. 2b). The satellite image is downloaded from http://www.landsat.org, dated: 02.11.2001 and is used for the preparation of land use/ land cover layer. The classified land use map of the watershed is given in Fig.2c. The land use classes of the study area are agricultural land (33.68%), forested area with deciduous trees (23.68%) and water bodies (10.45%). The urban settlement and scrub / waster land accounts for 14.44 % and 17.75 % respectively. Soil series map at 1:250,000 scales for Jharkhand state, published by National Bureau of Soil Survey & Land Use Planning (NBSS and LUP) is used as the source of soil database and soil grid. Detailed soil texture classification is given in fig 2d. Weather data as an input required for the SWAT model are precipitation, maximum and minimum temperature, solar radiation, relative humidity, and wind speed were collected from the weather station of Indian Meteorological Department (IMD), Pune. Similarly hydrological data is collected from CWC sites of Central Ground Water Board (CGWB).

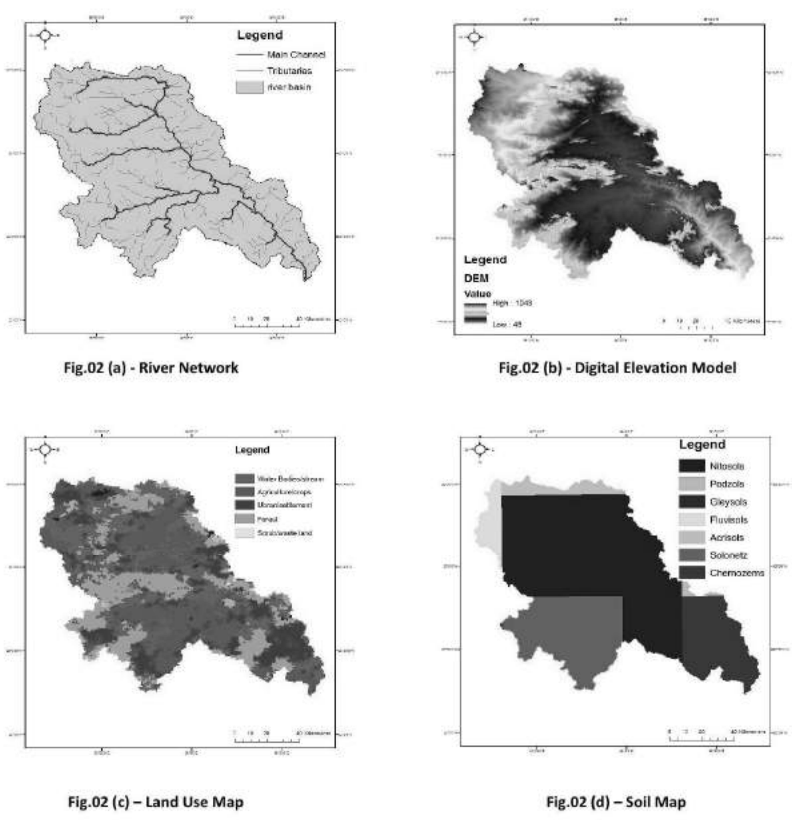


Figure 2 Input layer for upper watershed of river Subarnarekha in Jharkahnd (a) River basin area; (b) DEM; (c) land Use Map; (d) Soil Map

3. RESULT AND DISCUSSION

3.1 Model set up and delineation of watershed

The concept of hydrological modeling is applied to the river basin considering the discharge data of one CWC observatories, Adityapur. In this study, The ARC-GIS 10.1 is used as an interface for running SWAT. The first step in model set up is delineation of river basin watershed to obtain the exact area which is to be integrated in the model. DEM is used to produce the stream network. Watershed delineation tool of SWAT is used to delineate the watershed area, which generates the flow direction and accumulation.

3.2 Creation of Hydrologic Response Unit (HRU)

The total land area within a sub basin, which has a uniform land use and soil attributes is called as hydrologic response unit. The SWAT model calculates sediment runoff and transportation from each HRU separately and then summed together to determine the total loadings from the sub basin. This increases the accuracy as it adds to the prediction of loadings from the sub basin. Di Luzio et al., (2002) evaluated that smaller the area assigned to each sub-basin, more is the number of sub basins and more detailed is the drainage network. The study by Bingner et al., (1997) concluded that the sub-watershed size depends upon the SWAT erosion model and reported that the number and size of sub-watersheds do not appreciably affect runoff volume.

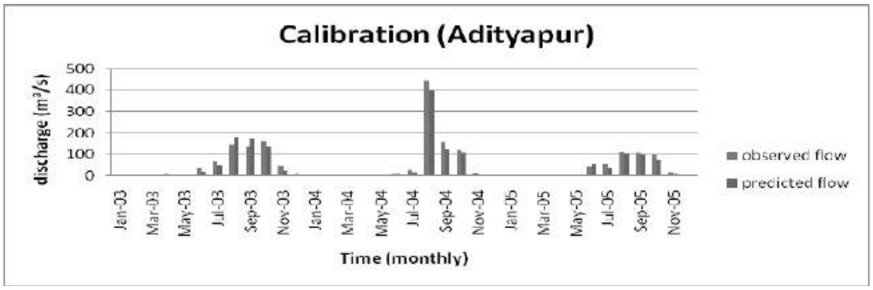
3.3 Sensitivity analysis

Table 1. Sensitivity analysis ranking

Parameters	Description	Sensitivity analysis rank	Range
ESCO	Soil evaporation compensation factor	3	0-1
GWQMN	water depth in the shallow aquifer required for return flow	4	0−5000 mm
GW_REVAP	Groundwater revap coefficient	5	0.02−0.20
RCHRG_DP	of percolation from the root zone that recharges the deep aquifer	8	0.0-1.0
ALPHA_BF	Base flow alpha factor (days)	7	0.1--1.0
SOL_AWC	Available water capacity of the soil layer (mm H2O /mm sol)	6	−10% to 10 %
CN 2	Initial SCS runoff curve number	1	−15% to 15%
SOL_Z	soil depth	2	-25 to 25 %

Sensitivity analysis is necessary to identify key parameters required for the calibration process (Ma et al., 2000). The LH-OAT (Latin Hypercube–One factor At a Time) method is selected for this purpose (Van Griensven et al. 2006). The different variable and value ranges chosen for the sensitivity analysis are listed in table 1. Every parameter which is used in the ranking has its own significance. The listed parameter are Initial SCS runoff curve number (CN2), water depth in the shallow aquifer required for return flow to occur (GWQMN), soil evaporation compensation factor (ESCO), soil depth (SOL_Z), the fraction of percolation from the root zone that recharges the deep aquifer (RCHRG_DP), and the groundwater “revap” coefficient (GW_REVAP). These parameters were then subjected to ranking and starting with the most sensitive parameters several calibrations were done. These adjustments are done in order to determine the most consistent outline of the model. Initial representation may be obtained from the sensitivity analysis that the increase in groundwater aquifer capacity interprets the soil horizon and subsurface parameters. Adjustment of parameters like ESCO resulted some mixed and consistent result over different selected time-period.

3.4 Model calibration and validation



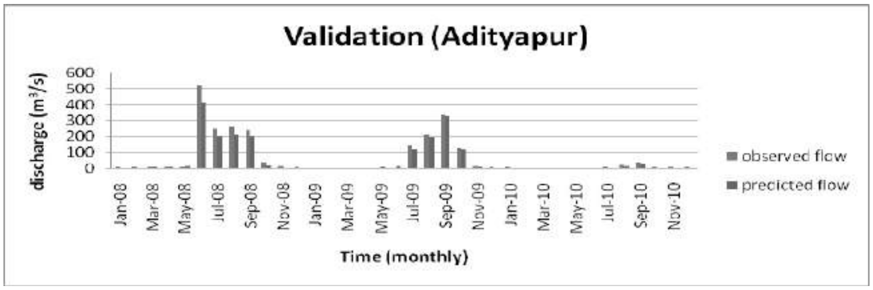


Figure 3. Calibration and validation result of the model

Calibration involves the adjustments of model parameter so that the performance and result of the model matches the observed rates in the field. It is applied to the model to reduce the forecast uncertainty for a given set of selected condition. In the calibration process, the discharge data taken over time from 2003-2007 from CWC hydrological observatory, Adityapur is used for calibration. The next and final step is validation. The time series of discharge data from 2008-2010 is used for validation process It involves running a model using parameters that were determined during the calibration process, and comparing the predictions to observed data not used in the calibration (Figure 3). This process demonstrates the model's capacity of making accurate simulations. A good model calibration and validation should involve multiple evaluation techniques as suggested by (Legates and McCabe, 1999).

3.5 Performance of model

The effectiveness of SWAT model simulation can be predicted on a daily time step, but in this study, the evaluation is done using monthly time series observation of discharge data from CWC observatory. Statistical tool is applied to evaluate the performance of model. As per the study, the Nash-Sutcliffe coefficient value for Adityapur is 0.81 for calibration and validation period, which suggest that the model set up and performance is satisfactory. Similarly, the value of PBIAS also lies within the limits, which suggest that the model perform well within the set of applied data. The limited and inadequate representation of rainfall or other meteorological input parameters may interfere with the efficiency but the weather generator tool can be effectively applied to overcome the anomaly. The model performance is satisfactory; this can be interpreted from the sensitivity analysis rank (Table 1). GW_delay represents the lag time, which is low according to the sensitivity analysis result. This time lag says about the inherent continuous capacity of surface water to move from bottom of the soil to deep aquifer. The ESCO coefficient indicates the relationship between soil evaporative demand (mm H_2O) and depth distributions (mm). The value obtained is 0.0412. The low value of ESCO suggests that the lower soil level plays an important role in extraction of most evaporative demands. This is an indicator of ground water recharge potential. The low value suggests that groundwater recharge is ample. GW_REVAP is the movement of water from the zone of deep aquifer to root zone. This coefficient is affected by the material overlying the aquifer and deep-rooted plants. As GW_REVAP approaches unity, the rate of transfer from the shallow aquifer to the root zone approaches the rate of potential evapotranspiration. The obtained value is 0.4, which suggest a fair balance between the movements of water from the shallow aquifer to the root zone. The value of RCHRG_DP is 0.78 indicates that a fair amount of percolation from the root zone to deep aquifer. SOL_AWC is the available water capacity, which is affected by plant available water content. The value of hydraulic conductivity (CH_K2) and roughness coefficient (CH_N) is high.

4. CONCLUSION

The successful set up of SWAT model on the river upper watershed of river Subarnarekha in Jharkhand, India, can be interpreted with statistical obtained for the calibration and validation period. With the outcome of model, the study can further be elevated to depict the possible land-use and climate changes on the hydrogeology of the basin. The Subarnarekha river basin is primarily consists of thick Sal (*Shore Robusta*) forest of deciduous type. The various meteorological parameters, which are used in the study, are not available with the concerned meteorological department, prior to 1980. If data gap can be minimized, then more simulation that is accurate could be performed for further study. The SWAT model efficiently simulates the physical process of any hydrological cycle if the availability of data for over long period is considered. Similarly, the inaccessible hilly terrain and thick forest cover hinders the empirical study of ground truth. The limited data availability is one of the constrain in the effective hydrological modeling of any watershed. This study can be the first step in the development of model for the entire river basin. The factor like presence of plateau region with uneven elevation together with mighty waterfalls (Johna, Hundru) along the subernarekha stream network has a high hydropower generation potential. The output data of this SWAT model can also be easily applied to identify the hydro power potential of the basin (B.C. Kusre, et al., 2013, Pandey et.al., 2014). The Hadley centre (HADCM3) projected climate change data and the output of SWAT can be used to analyses the climate change impact on the stream flow of river basins. The model can provide the increasing or decreasing future trend of annual precipitation, evapotranspiration. Thus, the study using SWAT model could provide an idea regarding water resource availability of the river basin, which can be used as a tool by environmentalist/ planner for decision-making.

5. ACKNOWLEDGEMENT

The author wish to express their sincere gratitute to the Dean, University School of Environment Management, and all organisations mentioned above who provided data for the present research work. The author also wishes thanks to G.G.S.I P University for providing reseach fellowship.

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Impact of Climate Change on Horticultural Crops

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ABSTRACT

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (Anon, 2007).Climate change is caused by factors that include oceanic processes, biotic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, and human-induced alterations of the natural world (Baumert et al., 2009). Global warming and climate change is now perceived to be the greatest threat to agriculture production and food security in the 21st century. The established commercial varieties of fruits, vegetables and flowers will perform poorly in an unpredictable manner due to aberration of climate. Commercial production of horticultural plants particularly grown under open field conditions will be severely affected. Due to high temperature physiological disorder of horticultural crops will be more pronounced eg. Spongy tissue of mango, fruit cracking of litchi, flower and fruit abscission in solanaceous fruit vegetables, etc. Hence there is a need to protect these valuable crops for sustainability against the climate change scenario. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation etc. To sustain the productivity, modification of present horticultural practices and greater use of greenhouse technology are some of the solutions to minimize the effect of climate change. Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi–tech horticulture and judicious management of natural resources will be the main strategies to meet this challenge.

Keyword: Climate, disorder, horticultural crop, India, yield.

INTRODUCTION

India with diverse soil and climate comprising several agro-ecological regions provides ample opportunity to grow a variety of horticultural crops which form a significant part of total agricultural produce in the country comprising of fruits, vegetables, root and tuber crops, flowers and other ornamentals, medicinal and aromatic plants, spices, condiments, plantation crops and mushrooms. It is estimated that all the horticulture crops put together cover nearly 11.6 million hectares area with an annual production of 91 million tonnes. Though, these crops occupy hardly 8% of the cropped area in India with approximately 30% contribution in agricultural GDP. Export of medicinal plants, fruits and approximately 30% contribution in agricultural GDP. Export of medicinal plants, fruits and vegetables have also exhibited rising trend. Horticultural crops play a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is labour intensive and as such they generate lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, carbohydrates etc. which are essential in human nutrition. Hence, these are referred to as protective foods and assumed great importance in nutritional security of the people. Thus, cultivation of horticultural crops plays a vital role in the prosperity of a nation and is directly linked with the health and happiness of the people. India with more than 28.2 million tonnes of fruits and 66 million tonnes of vegetables is the second largest producer of fruits and vegetables in the world next only to Brazil and China. However, per capita consumption of fruits and vegetables in India is only around 46kg and 130g against a minimum of about 92g and 300g respectively recommended by Indian Council of Medical Research and National Institute of Nutrition, Hyderabad. The knowledge about the impact of climate change on horticultural crops is limited. Addressing problems of climate change is more challenging in horticulture crops compared to annual food crops. The issues of climate change and solution to the problems arising out of it requires thorough analysis, advance planning and improved management. The crop productivity is subjected to number of stresses and potential yields are seldom achieved with stress. Climate change is predicted to cause an increase in average air temperature of between 1.40C and 5.80C, increases in atmospheric CO_2 concentration, and significant changes in rainfall pattern (Houghton et al. 2001). Impact of climate change on four sectors of the economy, namely Agriculture, Water, Natural Ecosystems and Biodiversity and Health in four climate sensitive regions of India, namely the Himalayan region, the Western Ghats, the Coastal Area and the North-East Region. The present challenges like global climate change, water and soil pollution, less water availability, urbanization etc adds up to the situation. In combination with elevated temperatures, decreased precipitation could cause reduction in availability of irrigation water and increase in evapotranspiration, leading to severe crop water-stress conditions. Vegetable production is threatened by increasing soil salinity particularly in irrigated croplands which provide 40% of the world's food. Fruits, vegetables, flowers, medicinal plants and tubers are grown from tropical to temperate, some horticultural crops like spices and plantation crops are location specific. In order to sustain our horticultural production with present day challenges we have to have packages to manage abiotic stresses. The nature and magnitudes of stress vary. Climate change poses serious challenges to human and places unprecedented pressure on the sustainability of horticulture industry. Therefore, the development of horticultural crops that can withstand stress will be the single most important step we may take to adapt the changes we have faced today and will face in the future.

Causes of climate change:

Natural Causes	Human Causes
1. Solar variability	1. Greenhouse gases
2. Volcanic eruptions	2. Aerosols
3. Internal variability	3. Ozone depletion
4. Geological changes	4. Land use change

HOW MIGHT THE CLIMATE CHANGE?

- **Temperature increases-** An increase in global mean annual temperatures of 1°C by 2025 and 3°C by the end of the next century
- **Sea Level Rises-** Global mean sea level is estimated to have risen 10-25cm over the last 100 years
- In the next 100 years the average sea level is projected to be about 50cm higher than today
- **Rainfall**
- **Increased Variability of Weather Events**
- **Carbon dioxide level increases-** concentrations of carbon dioxide, (the predominant greenhouse gas) have increased from 280 parts-per-million (ppm) to 383 ppm over the last 150 years

Projected climatic changes

- Warmer temperatures.
- Drier or wetter conditions.
- Increased frequency of extreme climatic events.
- Enhanced atmospheric co_2.
- Changing market conditions.

Positive impacts of climate change

- Increased productivity from warmer temperature.
- Possibility of growing new crops.
- Longer growing seasons.
- Increased productivity from enhanced $co_{2.}$
- Accelerated maturation rates.
- Decreased moisture stress.

Negative impacts of climate change

- Increased insect infestations.
- Crop damage from extreme heat.
- Planning problems due to less reliable forecasts.

- Increased soil erosion.
- Increased weed growth and disease outbreak.
- Decreased herbicide and pesticide efficacy
- Increased moisture stress and drought.

The climate change will have many impacts on horticulture and a few examples are given below.

1. Production timing will change due to rise in temperature. Due to rise in temperature, photoperiods may not show much variation. As a result, photosensitive crop will mature faster
2. The winter regime and chilling duration will reduce in temperate regions affecting the temperate crops.
3. Pollination will be affected adversely because of higher temperature. Floral abortions, flower and fruit drop will be occurred frequently.
4. The requirement of annual irrigation will increase and heat unit requirement will be achieved in much lesser time.
5. Higher temperatures will reduce tuber initiation process in potato, reduced quality in tomatoes and pollination in many crops. In case of crucifers, it may lead to bolting; anthocyanin production may be affected in apples and capsicum. Tip burn and blossom end rot will be the common phenomenon in tomatoes.
6. Coastal regions can expect much faster percolation of sea water in inland water tables causing more salinity.

Impact of climate change on fruits and vegetables

Parameters	Impact on fruits		Impact on vegetables	
	Physiological effect	**Yield**	**Physiological effect**	**Yield**
Drought	Drying of trees & vegetative growth is affected	Low yield	Moisture stress, poor vegetative growth	Low yield
Flood	Anaerobic condition in root zone and death of plants	Low to No Yield	Anaerobic conditions, rotting of roots and other storage organs like onion bulbs	Low to No Yield
Heat Wave	Bud break & fruit growth is affected eg. Mango, Citrus	Low to Medium Yield	Flowering, fruit set and fruit growth is affected	Low yield
Cold wave	Mango malformation, Banana shooting Low yield and finger filling is affected	Low yield	Poor fruit set/fruit development	Low to Medium Yield
Hail Storm	Physical damage to plants & fruit drop. Eg. Banana & Mango	Low to No Yield	Crops are destroyed	Low to No Yield

EFFECT ON FRUIT CROPS

India is the second largest producer of Fruits after China, with a production of 44.04 million tonnes of fruits from an area of 3.72 million hectares. A large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple and apple are the major ones. Due to rise in temperature, crops will develop more rapidly and mature earlier. For example, Citrus, grapes, melons etc. will mature earlier by about 15 days. Strawberries will produce more runners at the expense of fruits. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier. Delay in monsoon,dry spells of rains, and untimely rains during water stress period, supra-optimal temperatures during flowering and fruit growth, hailstorms are some of the most commonly encountered climatic conditions experienced by the citrus growers over the past decade or so.

The climate change increases the atmospheric temperature and change of rainfall pattern, as a result,banana cultivation may suffer from high temperature, soil moisture stress or flooding / water logging. high temperatures during panicle development cause quick growth and reduce the number of days when hermaphrodite flowers are available for effective pollination, which may lead to a satisfactory crop. Rising temperatures cause desiccation of pollen and poor pollinator activity resulting into low fruit set (Bhriguvanshi 2010). In mango rainfall during the flowering period adversely affects fruit setting. Fog, cloudy weather at the time of flowering from November to February results in poor fruit setting and favours pest and disease incidence. High temperature and moisture stress also increase sunburn and cracking in apples, apricot and cherries and increase in temperature at maturity will lead to fruit cracking and burning in litchi (Kumar and Kumar 2007). Air pollution also significantly reduced the yield of several horticultural crops and increase the intensity of certain physiological disorders like black tip of mango which is induced by coal fume gases, sulphur dioxide, ethylene, carbon monooxide and fluoride. Leaf production increases by one leaf per month for every 3.3 to 3.7oC rise in minimum or mean temperature from 10-20 oC or 13.5 to 25 oC respectively. Higher temperature (31-32oC), in general, increases the rate of plant maturity in annual species, thus shortening the growth stages, during which developing fruits and suckers absorb photosynthetic products. The temperature below 10oC leads to impedance of inflorescence and malformations of bunches. Chilling symptoms on leaves are not seen immediately but it may take 2 to 4 days to appear.

EFFECT ON VEGETABLE CROPS

India is the second largest producer of vegetables in the world (ranks next to China) and accounts for about 15% of the world's production of vegetables. The current production level is over 90 MT and the total area under vegetable cultivation is around 6.2 million hectares which is about 3% of the total area under cultivation in the country. Environmental stress is the primary cause of crop losses worldwide, reducing average yields for most major crops by more than 50% (Bray et al. 2000). Climatic changes will influence the severity of environmental stress imposed on vegetable crops. The response of plants to environmental stresses depends on the plant developmental stage and the length and severity of the stress (Bray, 2002). Plants may respond similarly to avoid one or more stresses through morphological or biochemical mechanisms (Capiati et al. 2006). Environmental interactions may make the stress response of plants more complex or influence the degree of impact of climate change. High temperatures can cause significant losses in tomato productivity due to reduced fruit set, and smaller and lower quality fruits. Pre-anthesis temperature stress is associated with developmental changes in the anthers, particularly irregularities in the epidermis and endothesium, lack of opening of the stromium, and poor pollen formation (Sato et al. 2002). Hazra et al. (2007) reported that symptoms causing fruit set failure at high temperatures in tomatos includes bud drop, abnormal flower development, poor pollen production, dehiscence, and viability, ovule abortion and poor viability, reduced carbohydrate availability, and other reproductive abnormalities. In pepper, hig h temperature exposure at the pre-anthesis stage did not affect pistil or stamen viability, but high post-pollination temperatures inhibited fruit set, suggesting that fertilization is sensitive to high temperature stress (Erickson and Markhart 2002). Plant sensitivity to salt stress is reflected in loss of turgor, growth reduction, wilting, leaf curling and epinasty, leaf abscission, decreased photosynthesis, respiratory changes, loss of cellular integrity, tissue necrosis, and potentially death of the plant.

Most of the vegetable crops are highly sensitive to flooding and genetic variation with respect to this character is limited. Flooded crops especially in tomato plants accumulate endogenous ethylene that causes damage to the plants (Drew 1979). The severity of flooding symptoms increases with rising temperatures; rapid wilting and death of tomato plants is usually observed following a short period of flooding at high temperatures (Kuo et al. 1982). During the last 40-50 years air pollution level increasing at an alarming rate in the developing countries and causing potential threat to the crop production. Sulphar dioxide, nitrogen oxide, hydrofluride, ozone and acid rain are the primary air pollutant. Ozone has adverse effect on vegetable production in terms of reducing growth, yield and quality. Risk of the air pollution is more when vegetable crops grown close to the densely populated areas. A recent study indicated that the ambient air pollution significantly decreased the yield upto more than 50 percent incase of Brassica oleracia, Lactuca sativa and Raphanus sativus. Many vegetable crops namely tomato, water melon, potato, squash, soyabeans, cantaloupe, peas, carrot, beet, turnip, etc are more susceptible to air pollution damage. Yield of vegetable can be reduced by 5-15 percent when daily ozone concentrations reach to greater than 50 ppb (Raj Narayan 2009).

EFFECT ON FLOWER CROPS

Melting of ice cap in the Himalayan regions will reduce the chilling requirement forthe flowering of many of the ornamental plants like Rhododendron, Orchid, Tulipa, Alstromerea, Magnolia, Saussurea, Impatiens, Narcissus etc. Some of them will fail to bloom or flower with less abundance while others will be threatened. Plant species requiring high humidity and water may find them under difficult conditions for survival. Plains of India will also have similar kind of problems and will be affected either by drought or excessive rains, floods and seasonal variations. Commercial production of flowers particularly grown under open field conditions will be severely affected leading to poor flowering, improper floral development and colour. chrysanthemum is a short day plant. So flowering round the year in open field condition is not possible. Low temperatures shut down flowering in Jasmine (<190C) and lead to reduction in flower size. Flowers do not open up fully in tropical orchids wherever temperatures below 150C. High temperature leads to flower bud drop and unmarketable spikes in tropical orchids when temperature remains > 350C.

EFFECT ON PLANTATION CROPS

Consecutive drought here reduced the coconut production by about three lakh nuts/year for four years. Productivity loss was to the tune of about 3500nuts/hectare/year in india. Apart from drought other natural calamities like cyclone etc have impacted the crop production and productivity. In coconut, arecanut and cocoa increased CO2 led to higher biomass production. But a slight decline in biomass production was apparent at elevated air temperature. All three crops responded differentially under elevated air temperature. In coconut, net photosynthesis rate has reduced but increased that of arecanut and cocoa.

However, TDM was slightly decreased in all three crops. Studies conducted on “Impact of climate change in cashew” at Directorate of Cashew Research, Puttur, India indicated that the rainfed cashew crop is highly sensitive to changes in climate and weather vagaries, particularly during reproductive phase. Cashew requires relatively dry atmosphere and mild winter (15-200C) coupled with moderate dew during night for profuse flowering. High temperature (>34.4 0C) and low relative humidity (<20%) during afternoon causes drying of flowers, resulting in yield reduction. Unseasonal rains and heavy dew during flowering and fruiting period aggravated the incidence of pests and diseases. All these situations resulted in reduction yield upto 50 to 65%.

EFFECT ON SPICE CROPS

In general due to increase in maximum and minimum day temperature and decreasing the annual rainfall the productivity showed decreasing trend in most of the black pepper growing areas of India. In black pepper, Accs 1380 (IC 316801), 1387(IC 316803), 1410(IC 316817),1423(IC 316825) and 1430(IC 316832) were identified as relatively tolerant to drought. In cardamom, RR1(IC 349591), CL-893 (IC 349537), Green Gold (IC 349550) were found relatively tolerant under Kerala, India conditions. Kashmir’s prized saffron crops have suffered a 40% drop in production, one of the three places in world - besides Iran and Spain - most famous for its saffron, water shortages are straining the crops. Some of the saffron farmers who traditionally relied on rainwater are now looking at irrigation measures to save their rare and labour intensive crop.

Seed Spices are winter season crops and commonly grown in arid and semi arid track of Rajasthan and Gujarat requiring certain period of low temperature for optimum vegetative growth. Heavy losses have been observed due to combined effect of chilling and frost injury. Cumin, coriander, nigella, ajowan are the crops which are very sensitive to frost. Incidence of frost causing serious loss in yield almost reaches up to zero. Fennel and fenugreek are also affected by frost but growth stage plays an important role. So far no efforts have been made to identify the source of resistance against low temperature injury in available germplasm of seed spices crops

STRATEGIES TO REDUCE CLIMATE CHANGE

Adaptation- mitigation strategies

It is important to distinguish adaptation from mitigation in terms of climate change.

- **Adaptation** refers to a response to the changing climate and implementation of policies and action taken to minimize the predicted impacts of climate change.
- An example of adaptation is the development of heat or drought resistant crop cultivars that will be able to grow in warmer climates with potentially less water (Parry et al., 2005).

- **Mitigation** is an intervention to reduce or prevent GHG emissions or any action that will enhance the removal of atmospheric GHGs through GHG sinks.
- An example of mitigation would be practicing zero till for agricultural soils, which would reduce the amount of CO_2 burned as fuel and prevent the disruption of soil that results in a release of CO_2 and N_2O.

STRATEGIES

- Integrated Horticultural Management systems.
- Genetic Approaches.
- Biotechnological interventions.

INTEGRATED HORTICULTURAL MANAGEMENT SYSTEMS

- Resistant/tolerant varieties
- Mulching
- Shelter belts
- Canopy management (cover / inter cropping)
- Use of organic manure
- High density planting
- Top working
- Shift in crop schedule

Pre and post-harvest management of produce

RESISTANT VARIETIES

Fruit Crop-varieties	Tolerant
Mango (13/1)	Salt
Citrus	
Rubidoux trifoliate (Rich16-6)	Cold
Swinglecitrumelo	Heat
v.Berlandieri x v.rupestris	Drought

Tolerant Root Stocks

Fruit crop	Characteristics	Root stock
Mango	Salinity and drought	Kurukkan ,neeleshwar dwarf
Citrus	Drought salinity	Cleopatra mandarin Rangapur lime
Grape	Salinity	Dogridge Salt creek
Sapota	Moisture stress	Khirni
Fig	Moisture stress	Gular

RESEARCH THRUSTS

- Development of new genotypes suitable to changing environment.
- Development of suitable agronomic adaptation measures for reducing the adverse climate related production losses.
- Development of crop simulation models for horticultural crops.
- Weather based forecasting systems.
- Quantification of carbon sequestration potential of perennial horticultural systems.

Capacity building

- There is an urgent need to train researchers, extension personnels and farmers on climate change issues.
- Infrastructural development also needs to be taken up to make the Indian horticulture resilient to climate change.

CONCLUSION

In view of these problems, horticulturists will have to play a significant role in the climate change scenario and proper strategies have to be envisaged for saving horticulture. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation etc. to sustain the productivity modification of present horticultural practices and greater use of green house technology are some of the solutions to minimize the effect of climate change. Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi –tech horticulture and judicious management of land use resources will be the main strategies to meet these challenge.

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Preserve, Conserve and Utilize

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ABSTRACT

The concept of rainwater harvesting involves 'tapping the rainwater where it falls'. A major portion of rainwater that falls on the earth's surface runs off into streams and rivers and finally into the sea. An average of 8-12 percent of the total rainfall recharge only is considered to recharge the aquifers. The technique of rainwater harvesting involves collecting the rain from localized catchment surfaces such as roofs, plain /sloping surfaces etc., either for direct use or to augment the ground water resources depending on local conditions. Water conservation is not a job of Engineers, technician, soil scientist, hydrologist and Government alone. There are many things that we can do to help the Governments to preserve water. Governments are striving by introducing new methodologies to preserve water by several ground water recharging methods. We must all recognize that water conservation really is our personal responsibility and not just leave it to other people or to the Government.

Keywords: Rain Water, Harvesting, Percolation Ponds, Case study, Responsibilities:

INTRODUCTION

Next to air, the other important requirement for human life to exist is water. It is the nature's free gift to human race which plays a vital role in day to day life. The use of water by man, plants and animals is universal. Water conservation is a great thing, and saving every little drop helps. Therefore every effort is needed to catch hold of every drop of water. A whole lot of people saving every little drop of water ads up to a large storage. A man can live without food for 60 days but can live without water only for about 3-4 days. We must all make changes in our lifestyles that will change the course of our water and its quality. Water conservation means using of water with utmost care only where it is needed without wasting a drop. If we all do our part in conserving water, we can make a huge difference to the environment.

Hence it is necessary to recharge the ground water in all the urban areas by conserving rain water. Land use in urban areas is different from that of the rural areas. Most of the urban areas would comprise of paved roads, built up areas, open grounds. The amount of deep percolation taking place in the rural areas predominantly with agricultural lands is high whereas in the urban areas, most of the land will not permit deep percolation (Rao….et.al 2003). Thus a predominant rain fall will flow as run off. The run off occurring within the residential premises can profitably be made to percolate within the premises itself by a simple structure. A Rain Water Storage Tank and the way it is connected to Ground Water Recharge are shown in Fig.1 below.

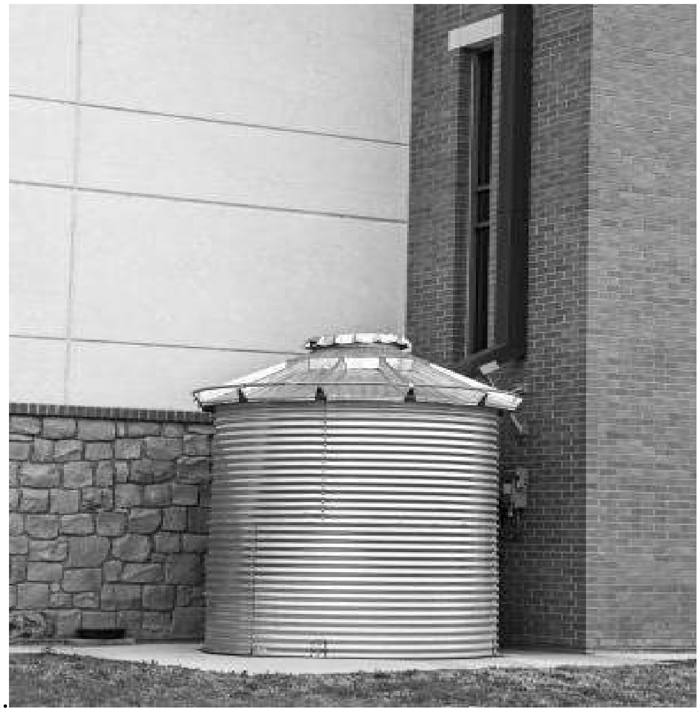

Figure 1 Rain Water Storage Tank is connected to Ground Water Recharge

METHODOLOGY

During normal rains, there should be no flow from the premises to the roads. The percolation device within the premises will have to be designed to store and facilitate percolation in to the ground. In case of high precipitation, the excess water would go out of the premises to the roads. The run off occurring on the roads as well as on open grounds can be collected at suitable valley points and a big size percolation pit can be provided there. In most of the premises, it is possible to provide a percolation trench within the set back provided for construction of the building. Even in the case of multi-storied flats, the set back areas are available and this area is a bit more.

The trench is filled up with graded filter material comprising of big size metal or stone in the bottom layer, covered by small size of metal and sand. This virtually behaves like a slow sand filter. Such filters have percolation rates ranging from 0.1 lit/second per square meter of area to 1.5 lit/second /square meter of area. If the inflow in to these pits or trenches is at higher rate (usually about 15 lit/second) most of the flow due to rain fall run off, would pass over the pit. Thus the graded filter material would not facilitate recharge of the entire inflow that occurs. If the sides of the trench are packed with R.R stone and provide the top with stone jelly, the water will be collected and gradually recharge the water table. It is little bit costlier.

However provide an economical structure as shown in Fig2. (Rao….et.al 2003)This can be about 1M away from the compound wall or the main building wall as shown in the drawing. Depth of the pit can be two meter and clear width of 0.80m.In order to retain the vertical sides of the trench, rough stone dry rubble packing of 0.225M thick may be provided for all the four sides of the trench as shown in the drawing. A small silt trap of 0.6mX0.6m and 0.3M depth may be provided for collecting the inflow and admitting the same in to the trench. This silt trap would arrest flow of silt into the trench and is therefore essential. Silt collected in the trap can be periodically removed and used for gardening. A trench of 2M length would be needed for every $100M^2$ of flat area, for the rainwater would be over flowing the trench, and as such a free passage from the trench to the road would be needed. The trench should not have any bed slope. If the ground has a slope and if a long trench is needed, it can be diverted into compartments keeping each at ban uniform level. The most important benefit of rainwater harvesting is that the water is totally free; the only cost is for collection and use (Giridhar.et.al...2014).

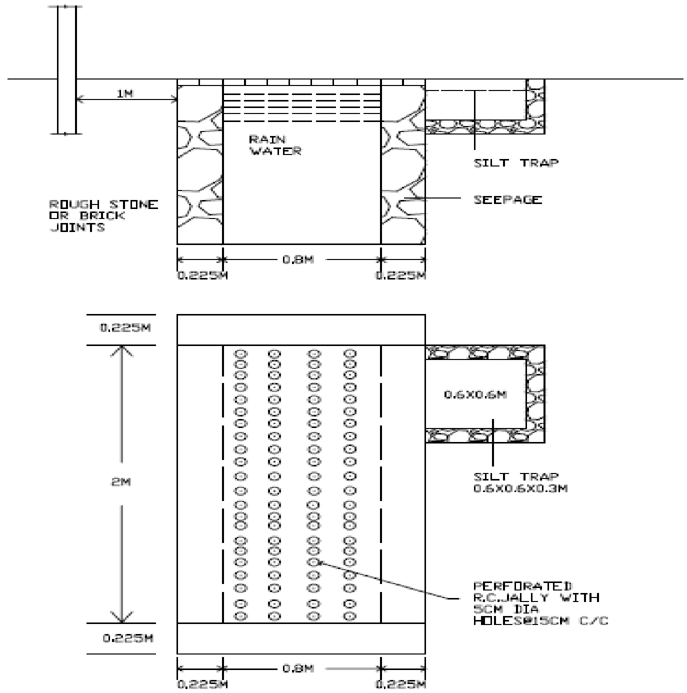

Figure 2 Percolation Trench (with silt trap)

The costs of the percolation trenches are worked out as under in Table.No.1 and which is most economical in executing at residential premises.

Table 1 Cost of Percolation Trench (WITH SILT TRAP)

S.No	Description of Item	Nos	Length(L) M	Breadth(B) M	Depth(D) M	Quantities Cum	Rate/Cum	Amount Rs:
1	EWE in Sand, loose soils,							
	Silt Trap	1	0.90	0.90	0..525	0.425		
	Sunken pit	1	2.0	1.50	1.0	3.0	94	325
	Total					3.425		
2	225 Th. rough dry stone packing							
	For silt trap(bottom)	1	0.90	0.90	0.225	0.182		
	Sides	3	0.6	0.225	0.30	0.122		
	Trench(LW)	2	2.0	0.225	1.0	0.90		
	Trench(SW)	2	0.8	0.225	1.0	0.36		
	Sub-Total					1.807		
	Deduct	2	0.225	0.225	0.225	0.02		
	Total					1.544	150	232
3	65 mm Metal	1	2.0	0.90	1.45	2.61	635	1660
	Total Cost							2217

Public Soak Pits

As discussed above there is a need to provide separate soak pits of bigger size to collect the rain fall run-off occurring on streets and open grounds. These pits will have to be located at suitable places where the flow can be gathered by gravity. The drawing and dimensions of the pit are shown in Fig3(Rao..et.al.2003). For every 10 hectares of urban area, a soak pit of size 22mx22mx6m depth would be needed to facilitate collection of runoff and to provide for deep percolation. These pits can be constructed in open areas, parks, play grounds, Government lands, public offices etc. If sufficient ground area is not available, smaller pits can be constructed at more number of places to facilitate recharge by increasing the recharge through soak trenches and common pits. It is possible to bring the water table level to 2 M below the ground level in urban areas. This would enable availability of adequate ground water for usage in urban areas. Another alternative Water Harvesting Structure suggested in Fig No.4.

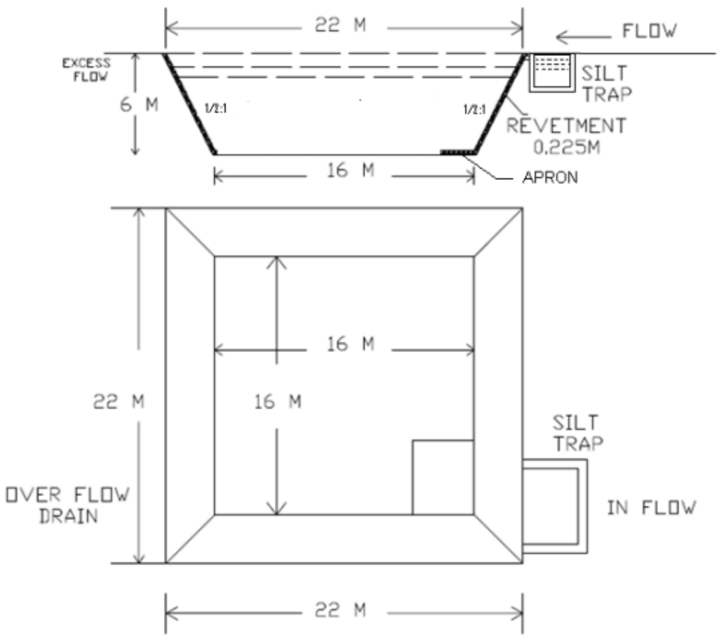

Figure 3 Public Soak Pit

Figure 4 Water Harvesting Structure

CASE STUDY

A case study is conducted for an open well existing as shown in the Fig.5 below in a thickly populated residential locality at Warangal surrounded by 5 bore wells within a distance of 16 M from both sides of the existing well. The open well is of 0.60 M diameter with a depth of 11.M. The unpaved area at the surrounding of the well is 10 M^2. It is observed since April 2015 to 10-06- 2015, the depth of water table in the well is 6M below the ground level. The Depth of water existing in the well is 5m. As per the Government data published in 12-06-2015 News

Papers that the water has gone 4 M below than last year's reserves i.e., the water table on publishing date is below 12 M from the Ground Level at Warangal.

Figure 5 Open Well for Case Study

It is amazing to note that, the water has risen 5M in the well during the rains at Warangal on 19th and 20th of June 2015. The water level at present in the well is below 1M from the Ground level. The owner of the House has made very good arrangements for recharge of ground water by rain water harvesting leaving 10 M^2 of unpaved area within the boundary of the well as shown in Fig.No.6. Even today this is only the house among 50 in the locality that does not have the bore well. The well is serving the purpose since last 50 years.

Figure 6 Unpaved Area adjacent to the Well

Competition for water is increasing rapidly. Water shortage is a worldwide problem for which the only solution is to make efficient use of water in agriculture. Therefore, a better understanding of water requirements and better management of irrigation water will result in large benefits (Viswanath….et. al. 2006).The water resources are certainly not infinite and a precious gift of nature. But to ensure their services for all the time to come, it becomes necessary to maintain, conserve and use these resources very carefully. By this case study, it is established that proper maintenance, conservation and use of water resources will avoid the chance of water famine. It is for this reasons that remedial measures will have to be found out in future to increase available water resources and to improve the quality of water.

De Silting of Village Tanks as Recharge Structure: In India, tanks/ponds and lakes have traditionally played an important role in conserving water for meeting various needs of the communities. As per 3rd Minor Irrigation Census 2000-2001, the tanks which are not in use are 16% for one or other reason. These existing village tanks which are normally silted and damaged can be modified to serve as recharge structure. In view of above the Government of Telangana has taken a programme of "Mission Kakatiya". Some of the percolation tanks constructed about decades back are silted abnormally, which has resulted in reduction of recharge. It is observed that the evaporation loses are more than percolated water. To facilitate quicker deep percolation, trenches are excavated in tank bed and there is no necessity to fill the trench with any material and this will facilitate for deep percolation. The de silted material can be used by the farmers for increasing fertility of their lands and otherwise it can also be deposited on the top of the bund. The soil will help good growth of grass over the bund, which prevents erosion of soils due to rains. De silting of tanks in villages can result in converting the tanks into recharge structures. Several such tanks are available which can be modified for enhancing ground water. One de silted tank is shown as below in Fig.7.

Figure 7 De Silted Tank

Gabion Structure: This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course .A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks. The height of such structures is around 0.5 M and is normally used in the streams with width of less than 10 M. The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water runoff for sufficient time after rains to recharge the ground water body. These structures shown in Fig.No.8 are common in the states of Telangana, Maharashtra, Madhya Pradesh, Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Jammu& Kashmir.

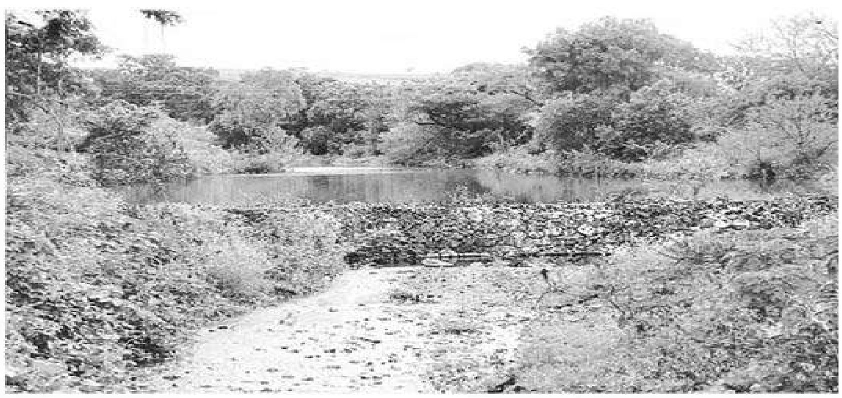

Figure 8 Gabion Weir

DISCUSSIONS

Turn the pages of ancient Indian history, the kings Cholas, Chalukyas and Kakatiyas were more concerned to preserve the water by constructing hundreds of tanks and reservoirs. In Warangal District, the existing four medium Irrigation Projects are irrigating to an extent of 39214 Acres of ayacut. Out of which 3 medium irrigation projects were constructed during Kakatiya dynasty 1000 years ago. It speaks volumes of their concern and the prominence given to preserving water besides maintaining the quality of construction. As per the statistics of 2008 A.D; under the aegis of irrigation department in Warangal district 759 minor irrigation tanks are irrigating 1 lakh 84 thousand acres of agriculture lands. At least more than 75% of them came into existence during the Kakatiya period alone and this is no small service by any yardstick. Added to this, there are 2737 tanks/ponds that help irrigate smaller units of less than 100 acres. Of these again a large chunk they owe their formation to Kakatiya period. The Bhadrakali tank constructed during Kakatiya Dynasty is being used as water storage reservoir and serving drinking water to the Town. Tank formation was considered a duty since times immemorial. Bhuvangiri (Bhongir) tank is a standing example for this. Ganapasamudram, Kesarisamudram, Prolasamudram, Naga samudram, Naamasamudram, Erakasamudram, Kata samudram, Balasamudram and such list of is unending. History reveals that the famous Yamuna Canals were constructed during Moghal period. In addition the British rulers gave utmost importance to water conservation and Constructed Krishna and Dowleswaram Barrages. After Independence, the Government of India constructed many Irrigation Projects in India. Writing about the Indian Kings in his "Wonders of the East", a foreign historian Foyer Jordan appreciates the Water Resources Systems, Water harvesting and Agricultural Development in India (Reddy..at.el.1962).

CONCLUSIONS

We can help keep our water pure to conserve and safe for generations to come. Since we all enjoy the benefits of having pure, clean water, we must help conserve water so that we may continue to enjoy these benefits. It is a job for the everyday person who just likes to have access to the life sustaining resource of water. We all enjoy the many ways that we use water, so why not do our part in caring for our water and ensure that the future generations have the same access to water both in quality and quantity.? Ninety - seven percent of all the water on the earth is salt water which is not suitable for drinking. Only three percent of all the water is fresh water, and only one percent is available for drinking water (Tromboni..et.al...2014).We must not pollute our water because it is the only water we will ever have. Some people do not realize the importance of water, and they are continually polluting it. Only about ten percent of waste water is disposed of properly. We must learn to save water now for the future. Saving water helps to preserve our environment and saves money.

The reliance on monsoon for the supply of water is also very important. The Indian philosophy has treated this subject from religious point of view and has led to the popular belief that there exists something like the "GOD OF WATER". Many other religions of the world also support this belief. Sometimes failure of monsoon leads to many disasters such as a famine, an epidemic etc. We must save water today so that it will be available to us in the future. We need to think of future generations, people who will not have a sufficient supply of water unless we become more concerned with how we use our water today. Water conservation is not a job of Engineers, technician, soil scientist, hydrologist and Government alone. There are many things that we can do help to the Governments to preserve water. Governments are striving by introducing new methodologies to preserve water by several ground water recharging methods. We must all recognize that water conservation really is our personal responsibility and not just leave it to other people or to the Government.

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Impact of Climate Change on Groundwater of the Part of Indus Basin

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ABSTRACT

Climate change will obviously impact the period and time of precipitation which will affect the availability of water resources. The climate change has many impacts on Indian climate like increasing monsoon rainfall (+10 to +12% per centaury) is occurring along the west coast, Andhra Pradesh & in northwest India, while decrease in rainfall (-6 to -8% per century) are being observed over east Madhya Pradesh & adjoining areas, north east India and parts of Gujarat & Kerala. Also recent studies show that a hint of ~ 10% increase in the variability of monsoon rainfall from the current levels in the future, possibility for stretching of monsoon season with a substantial increase in the rainfall during May & October.

The middle Indus basin is highly exploited to meet the agricultural demand. The distribution of rainfall in this region shows that there is increase in rainfall from 2071 to 2080 (an average rise of 19%), but there is a continuous decline from 2080 to 2100 at about 39.8%. The decline also gives the indication that between the periods of 2090-2100 and beyond, possibilities of drought conditions will occur in some parts of the basins, particularly in the western parts. Also the part of middle Indus Basin in Punjab area has an intensive network of canal system. With the system a large part in the canal command area has become water logged. Under the climate change scenario the evaporation from the water logged area will increase the concentration of salt and more & more area will likely to be water logged. Therefore, the food basket of India i.e. the middle Indus Basin will be adversely affected by the climate change which is discussed in detail in the paper.

INTRODUCTION

The Indus River is one of the most important water systems in Asia. Total drainage area of the basin is 11, 65,000 sq.km out of which 3,21,289 sq.km lies in India. The mountain area covers about 194074 sq.km and out of the Indus plain area Punjab covers about 50362 sq.km. Growing populations and increasing development, however, are placing mounting pressures on the Indus Basin's water supplies. The alluvial plains of Indus Basin are being intensively developed to meet the water requirements in India and Pakistan. In the current climate change scenario and the prevailing water crisis, there is an urgent need for a critical analysis of water management with a focus on both technical and policy implications. Water usage, especially in the agriculture sector, is almost 90% of the total freshwater available. Also the part of middle Indus Basin in Punjab area has an intensive network of canal system. The Punjab part of Indus basin has a large part in the canal command area, the seepage from the canal system has made a part of the area water logged and also inland salinity. Under the climate change scenario the evaporation from the water logged area will increase the concentration of salt and more & more area will likely to be water logged.

The recent report of IPCC (2008) has inferred that:

- By the middle of the 21st century, annual average river runoff & water availability are expected to increase by 10-40 % at high latitudes & in some wet tropical areas, & decrease by 10-30% over some dry regions at mid-latitudes & in the dry tropics.
- The frequency of heavy precipitation as well as the risk of rain-generated floods during the 21st century, over most areas will increase.

The implication under climate change will be:

1. Water related extremes are on rise in many areas. Drought affected areas are likely to increase & extreme precipitation events will increase in both frequency & intensity leading to augmentation of flood risks. Approx 20% of world's population live in river basins that are likely to be affected.

2. The population at risk of increasing water stress for the full range of SRES Scenarios is projected to be: 0.4-1.7 billion, 1-2 billion & 1.1-3.2 billion in 2020s, 2050s & 2080srespectively.
3. Semi arid & arid areas are particularly exposed to the impacts of Climate Change on the availability of freshwater resources. Efforts to offset declining surface water availability due to increasing precipitation variability will be hampered by the fact that groundwater recharge is likely to decrease considerably in some of the already water stressed regions, where vulnerability is exacerbated by the rapid increase of population & water demand.

Rainfall in Lower Indus Basin

The annual and seasonal rainfall is unevenly distributed in the basin. The normal annual rainfall increases from about 200 mm in the south western arid plain areas of Rajasthan and Haryana to more than 2400 mm in northeast hilly areas at Dharamsala. The study pertains to the Indus basin in Punjab area only. The southwest monsoon contributes to about 80% of the annual rainfall & the rest 20% of the rainfall is received due to western disturbances and thunder storms.

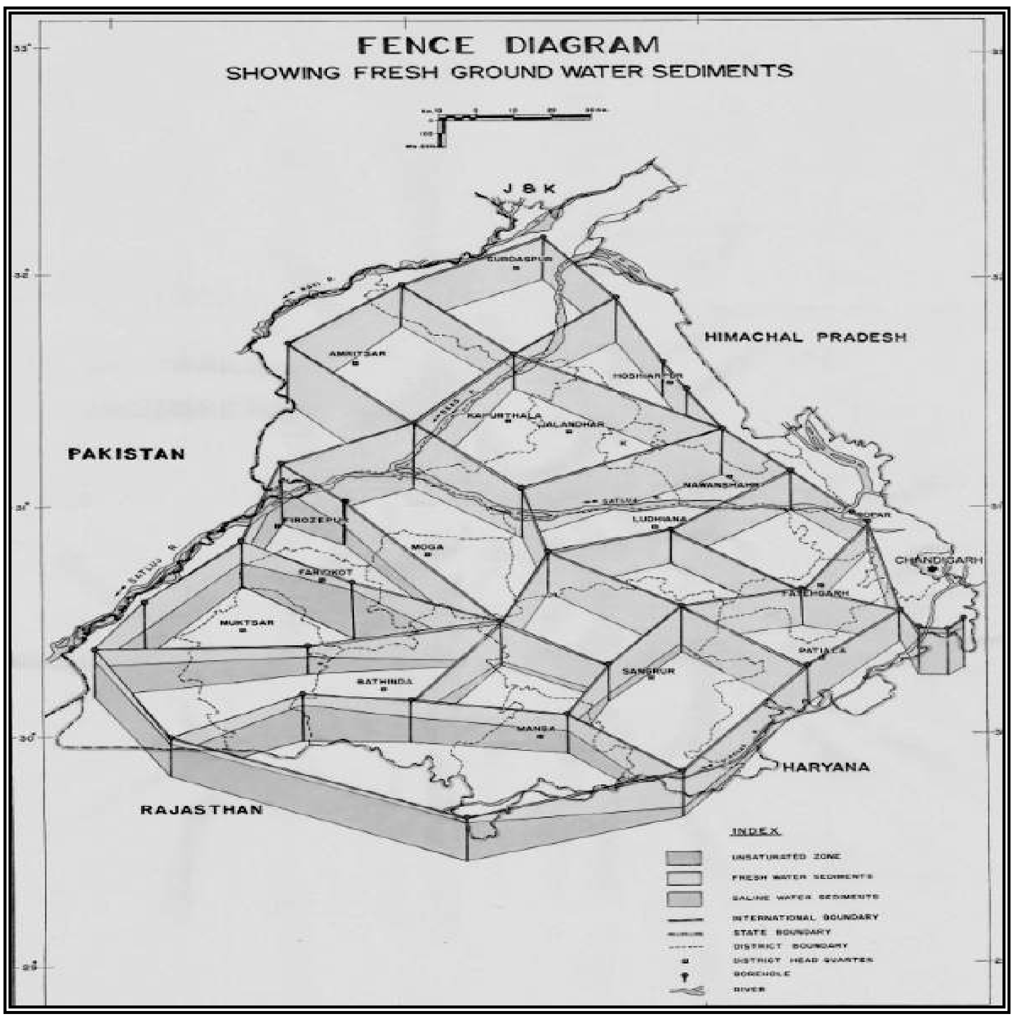

Figure 1 Fresh ground water sediments in Indus Basin

Geology and Aquifer System

The geology of the basin is complex being covered by Himalayan region with exposure of rocks belonging to pre-tertiary period & the contacts between the different formations are not normal. The lower Indus basin covers Punjab & part of Haryana & Rajasthan. The stratigraphy of geological formations for Indus basin is given in table 1.

Table 1 Stratigraphical sequence of Geological formations

System	Geological Age	Stratigraphic Unit	Lithological Characters
Quaternary	Recent	Eolian Sands	Medium to fine grained, buff colored dunes over the alluvium.
	Sub-recent	Newer Alluvium	Unconsolidated gravels, medium to coarse sand and silt along channels
	Upper to middle Pleistocene	Older alluvium	Unconsolidated poorly sorted fine to medium – grained sand, silt and clay occasionally mixed with kankar

Sub surface Lithology

The exploratory drillings & deep tube wells drilled in the lower Indus basin reveal that the aquifer system has number of aquifer zones of variable thickness and laterally extensive. The major litho unit is sandy strata which constitute more than 80 % of the lithological units. The general distribution of lithological units that is sand & clay in Punjab is given in figure 1. The sub-surface lithological section of Beas sub-basin is given in figure 2.

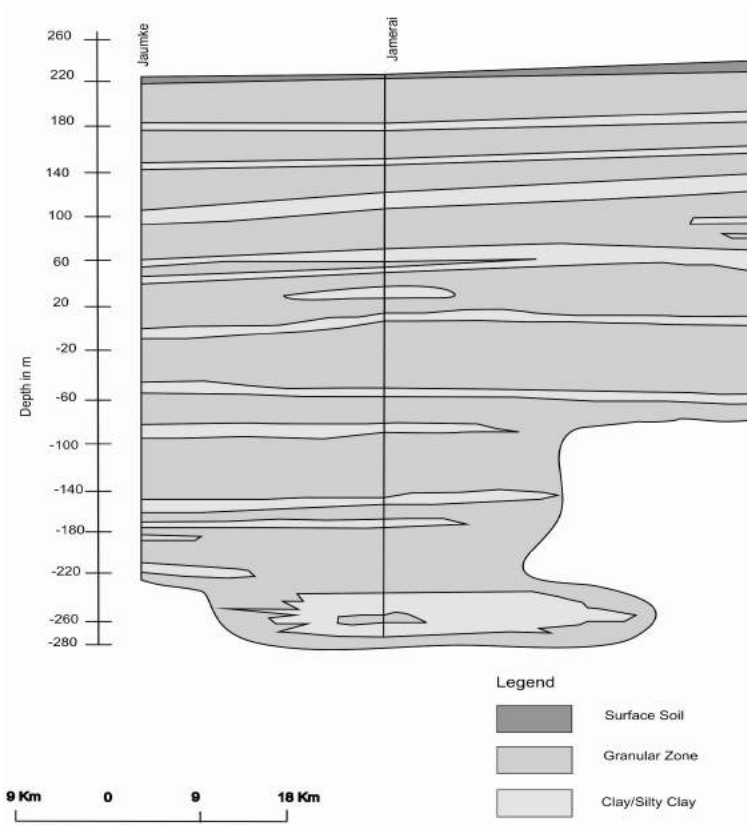

Figure 2 Sub surface lithological cross section of Beas sub-basin

Ground Water Balance

The ground water balance has been computed based on GEC-84 & 97 methodologies for the unconfined aquifer system. The lower Indus basin is also drained by a network of canal system, the seepage from which is also contributed to the ground water storage. The computation of the ground water balance is more complicated with number of variables than in case of the river basins which are not drained by canal system. The ground water balance is computed district wise so as to obtain more reliable information of the basin as a whole. Ground water balance of Indus basin in Punjab is given in table 2. The ground water resources assessment of Punjab for the year 2011 by Central Ground Water Board estimated the annual replenishable ground water resource to be 22.53 bcm, net annual ground water availability to be 20.32 bcm, annual ground water draft to be 34.88 bcm and stage of ground water development to be 172%.

The stage of ground water development (gwd) is more than 100 % implies that the ground water draft is more than the annual replenishment. It is observed from table 2 that the dynamic resource has been fully exploited in almost all the districts of Punjab, the maximum being in Jalandhar & Kapurthala recording more than 200 % of development. The high rate of ground water development vis a vis the annual recharge, the basin can be categorized as water stressed basin. It may also be pointed out that in view of the stipulated change in rainfall pattern, the decreased natural recharge & increase in ground water draft will highly impact the water resources of this basin.

Table 2 Ground water balance, Indus basin- Punjab area

S.No.	District	Recharge from Rainfall	Total Replenishable GW Resource	Total Annual Ground Water Draft	Stage of GWD (%)
1	Amritsar	40221	137072	222158	180
2	Barnala	14297	65488	120132	204
3	Bathinda	32081	111138	121452	119
4	Faridkot	14762	67846	97546	160
5	Fateh Garh Sahib	19894	59910	113256	210
6	Ferozepur	49469	210614	278951	147
7	Gurdaspur	72955	196232	226378	127
8	Hoshiarpur	60248	98525	91963	102
9	Jalandhar	44437	130529	271731	231
10	Kapurthala	27473	73355	154488	234
11	Ludhiana	58296	231265	348057	167
12	Mansa	21420	77386	144754	208
13	Moga	26153	133969	243949	202
14	Muktsar	24855	86571	54085	69
15	Nawan Shahr	25219	69718	72256	115
16	Patiala	53399	166056	292979	196
17	Ropar	23058	45623	46159	110
18	Mohali	23759	30538	28194	103
19	Sangrur	49170	145057	369427	283
20	Tarn Taran	34446	116002	190230	182
Total (ham)		715612	2252894	3488145	172
Total (bcm)		7.15612	22.53	34.88	172

Of the total recharge, the contribution from rainfall is 32%**.**

Computation of Projected Recharge

The Ground water aquifer system is prominent in the Indus plane area which constitutes very potential multi-aquifer system. The estimate of recharge potential is proximate as it is based on the limited explorated data & hydrogeological mapping. The recharge potential for Punjab has been computed using the monthly rainfall data of all the districts and multiplying with the rate of infiltration (Specific yield). The recharge potential for the Punjab area falling in lower Indus Basin for the projected years of 2071, 2080, 2090, 2100, is given in table 3. The summarized results of recharge potential are presented in table 4.

Table 3 District-wise Groundwater Assessment of Punjab in Indus Basin

S. No.	State/District	Area in Hectare			Projected Ground Water Recharge (HaM)				Recharge as on 2004 (CGWB)
		Consolidated	Un -Consolidated	Total	2071	2080	2090	2100	Recharge= Monsoon + Non Monsoon Rainfall
1	Gurdaspur	0	333000	333000	41964.3936	48409.9416	26114.6592	27360.2124	72491
2	Amritsar	0	508800	508800	57661.2864	59158.99008	33915.38688	33690.09024	78434
3	Hoshiarpur	0	276725	276725	43260.08718	49976.86707	35582.29671	35405.3034	60005
4	Kapurthala	0	163300	163300	22845.37606	29184.35546	18767.28516	15361.51669	27824
5	Jalandhar	0	264300	264300	31154.94396	37993.86504	32099.44644	25191.38448	45600
6	Nawanshahar	0	117700	117700	16983.4038	20693.35488	21093.91152	16700.35884	27132
7	Ropar	0	173900	173900	17322.5268	21397.83852	17570.64732	10322.3562	35231
8	Ludhiana	0	376200	376200	39124.95048	47500.06536	43530.77916	27737.37648	64939
9	Firozepur	0	522000	522000	40601.9952	45028.764	25052.868	18210.0744	50742
10	Faridkot	0	98360	98360	8849.213136	10900.2552	7428.461952	4734.85368	15125
11	Moga	0	23620	23620	2548.90506	3148.562534	2585.414494	1518.87229	26694
12	Muktsar	0	93410	93410	6821.246568	8940.45792	7581.454512	3923.107908	24949
13	Bhatinda	0	113520	113520	8289.775296	10865.22624	9213.646464	4767.703776	29124
14	Sangrur	0	416700	416700	33707.19636	40479.73812	41822.84556	23207.35644	66341
15	Fatehgarh	0	117700	117700	9520.84716	11433.80172	11813.17236	6555.08964	21065
16	Patiala	0	362700	362700	35987.8194	41501.00448	41528.27952	32733.96516	65586
17	Mansa	0	46190	46190	3675.43068	4504.245564	4363.125876	2141.571636	21841
	TOTAL	**0**	**4008125**	**4008125**	**420319.3971**	**491117.3338**	**380063.6811**	**289561.1937**	**733123**
			Total (BCM)		**4.203193971**	**4.911173338**	**3.800636811**	**2.895611937**	

Table 4 State-wise Recharge available in Indus basin for projected years

States	Projected rainfall Recharge (HaM)			
	2071	2080	2090	2100
Punjab	420319	491117	380064	289561
Haryana	110493	132801	115596	85239
Rajasthan	19075	18898	13488	8707
Total	**551959**	**644895**	**511238**	**385607**
Total (bcm)	**5.51959**	**6.44895**	**5.11238**	**3.85607**

Recharge from rainfall for the year 2011 for Punjab is 7.15 BCM. In computing the recharge from rain water, the specific yield value is taken as 12% and average annual rainfall for each of the district in Punjab is taken into consideration.

CONCLUSIONS AND SUGGESTIONS

The impact of climate change will amount to reduce the recharge but the surface excess water in the drain and canal will be available. The runoff from the rainfall will be planned for utilization for recharging the depleted aquifer. Under the climate change scenario the evaporation from the water logged area will increase the concentration of salt and more & more area will likely to be water logged. A detailed study will require to be carried out to study the impact on the water logged area. Alternatively, intensive study on conjunctive use should be done so that the water table reaches below 3.5 m depth. For this, a series of shallow tube well to dewater the water logged area would need to be installed. It is apparent from the present study that the recharge from rainfall in 2011 was 7.15 bcm which is projected to decrease to as low as 2.89 bcm in 2100.

ACKNOWLEDGMENT

We express our thanks to the research team of Global Hydrogeological Solutions especially to Ms. Deepika Mann and Ms. Nidhi Goyal, Research Fellow for their technical support in finalizing the paper.

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Studies on the Removal of Malachite Green using Sweet Orange Peels

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ABSTRACT

The present work was intended to explore removal of color from the wastewater obtained from textile dye, malachite green, in aqueous solution. The colour removal efficiency of the adsorption process, on removing colour of malachite green using orange peel has been studied. The effects of various experimental parameters like adsorbent dosage and contact time on the removal of Malachite green were evaluated using batch studies. The adsorption of dyes on adsorbent was a gradual process and equilibrium reached in 105 minutes. The degradation assays were performed in liquid medium with the Malachite green as single substrate. The experiments were carried out in natural ambient temperature. At initial pH 7, with 2.5 g/l of concentration and 100 mg/L of Malachite green concentration,74% removal efficiency was achieved. The adsorption isotherem were analyzed using Freundlich, Langmuir and Temkin isotherm.

Keywords: Malachite green; orange peel; Biosorption; Adsorption kinetics; Adsorption Isotherm.

INTRODUCTION

Generally textile industry consumes large quantities of water and produce large volumes of wastewater during dyeing and finishing process. Considering both volume-discharged and effluent, the wastewater from the textile industry is rated as one of the most polluting among all industrial sectors [1]. Their presence in watercourses is aesthetically unacceptable and may be visible at concentration of 1 ppm [2].Malachite Green is one of the important coloring agents used in textile and dye stuff industries and hence one of the important ingredients in these effluents. The concentration of the dye is different depending upon the source of effluent. Though Malachite Green is not strongly hazardous, it can cause some harmful effects [3,4, 5]. Orange peels are also reported to have been used for removal of dyes [3]. The authors used adsorbent dosage in the range of 10 to 60g which we believe is very high. The authors also performed experiments at fixed rpm. The authors also have not established the dynamics of the sorption mechanism which is looked into in the present study at 100 mg/l concentration of dye. The objective of the present research is to perform liquid phase batch adsorption experiments using coir pith as an adsorbent for removal of Malachite Green from aqueous medium and highlight the major differences and similarities between present work and the work reported in the literature.).Equilibrium data was analyzed using Freundlich, Langmuir and Tempkin models. Compared to other two models, Freundlich adsorption model was found to be in close agreement with experimental values.

2.0 MATERIALS AND METHODS

2.1 CHEMICALS

2.1.1 Adsorbate

The present study deals with the adsorption of malachite green (MG) on orange peel. An accurately weighed quantity of the dye was dissolved in double-distilled water to prepare stock solution (1000 mg/l). Experimental solutions of the desired concentrations were obtained by successive dilutions with distilled water. Concentrations of dyes were determined by finding out the absorbance at the characteristic wavelength using a double beam UV/Vis spectrophotometer

2.1.2 Preparation of adsorbent

Orange peel was dried in atmosphere. The dried material was grounded in the ball mill, and the obtained grounded material is sieved to obtain the desired size particle size such as 0.4-0.15mm (50-125 BSS mesh). Thereafter the desired size material is washed with distilled water and then dried in muffle furnace for 2hours at 600^0C.

The dried material obtained from the muffle furnace was treated with 0.1N HCL at room temperature for 24 h to oxidize the adhering organic matter. HCL treatment can improve the surface area of material to increase the Adsorption capacity, and HCL treatment will generally increase the adsorption of dyes. After acid treatment, the pH values of all samples are increased at varying extents. Finally the resulting material was thoroughly washed with distilled water and then subjected to the temperature of 100 ◦C for the moisture removal.

2.2 EXPERIMENTAL METHOD

2.2.1 Batch adsorption studies

To study the effect of important parameters like initial pH (pH_0), adsorbent dosage (m), initial concentration (C_0) and contact time (t) on the adsorptive removal of MG, batch experiments were conducted at ambient temperature. For each experimental run, 100 ml of MG solution of known concentration, pH_0 and a known amount of the adsorbent were taken in a 250 ml stoppered conical flask. Samples were withdrawn at appropriate time intervals. The samples were shaken in a thermostatic orbital shaker for the desired time periods, upto a maximum of 4 h at a constant temperature, pH and shaking speed (200 rpm). Some AOP particles remain suspended and do not settle down easily. The samples were separated from the adsorbent by centrifugation and filtered using Whatman No. 42 filter paper. The residual concentration of MG was determined using a UV-Vis spectrophotometer at the corresponding λ_{max}. All the measurements were carried out at room temperature. Adsorption isotherms were obtained by the orange peel concentration of 100 mg/L.

2.2.2 Analytical measurements

Concentrations of dyes were determined by finding out the absorbance at the characteristic wavelength using a double beam UV/Vis spectrophotometer. A standard solution of the dye was taken and the absorbance was determined at different wavelengths to obtain a plot of absorbance versus wavelength. The wavelength corresponding to maximum absorbance (λ max) as determined from this plot was 618 nm. This wavelength was used for preparing the calibration curves between absorbance and the concentration of the dye solution. The calibration plot of absorbance versus concentration for MG showed a linear variation up to 10 mg/l concentration. Therefore, the samples with higher concentrations of MG (>10 mg/l) were diluted with distilled water, whenever necessary, to make the concentration less than 10 mg/l, for the accurate determination of the MG concentration with the help of the linear portion of the calibration curve.

3.0 RESULTS AND DISCUSSIONS

3.1 Effect of Amount of Absorbent

The minimum amount of absorbent required for complete degradation of maximum amount of MG was examined by varying the amount of from 0.5 to 3.5 g/100 ml. The MG solution with 100mg/l concentration, showed 74% degradation. As the amount of absorbent increases, the degradation efficiency increases up to optimum loading of absorbent (2.5g/100ml) as shown in Fig.3.1. This may be due to the fact that as the quantity of absorbent increased, the number of MG molecules adsorbed was increased owing to an increased in the number of absorbent particles. Thus, the degradation efficiency was enhanced. Further increase in the amount of absorbent showed a negative effect. The decrease in degradation efficiency beyond 3g of absorbent may be attributed to screening effect of excess absorbent particles in the solution and scattering of light.

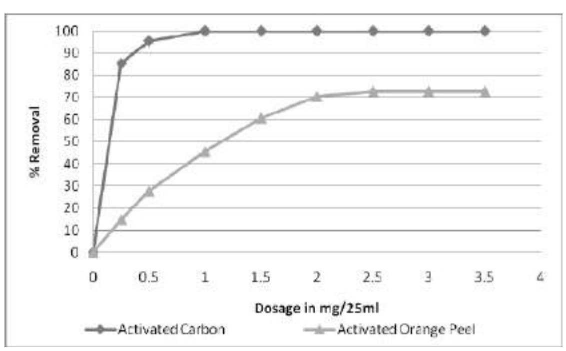

Figure 1 Effect of absorbent dosage amount on degradation efficiency (concentration = 10 mg/l, time = 120 min, pH=6.9±0.1)

3.2 Effect of Contact Time

The effect of contact time on degradation efficiency of MG was studied by keeping other parameters (dosage, pH) constant. The degradation of MG on absorbent was found to increase with increase in time and within 105 min there was 81% degradation for 100 mg/l initial concentration. Fig. 2 shows the graph plotted between % degradation vs. time 100 mg/l initial concentration.

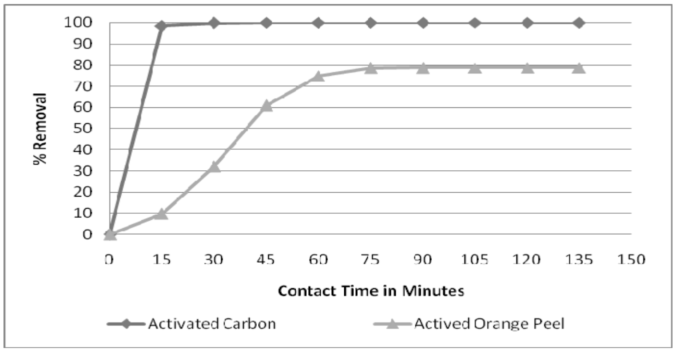

Figure 2 Effect of contact time on the removal of MG (initial Conc = 10 mg/l, Absorbent dose = 2.5 g/ 100 ml pH=6.9±0.1).

3.3 EQUILIBRIUM STUDY

3.3.1 Adsorption Equilibrium Study

To optimize the design of system for the adsorption of adsorbates, it was important to establish the most appropriate correlation for the equilibrium curves. Various isotherm equations like Freundlich, Langmuir, and Temkin were used to describe the equilibrium characteristics of adsorption. The Freundlich isotherm was derived by assuming a heterogeneous surface with a non-uniform distribution of heat of adsorption over the surface. Whereas in the Langmuir theory, the basic assumption was that the sorption takes place at specific homogeneous sites within the adsorbent.

3.3.1.1 Freundlich isotherm

The Freundlich isotherm is derived by assuming a heterogeneous surface with a non uniform distribution of heat of adsorption over the surface

$$q_e = K_F C_e^{1/n} \tag{1}$$

where C_e is the solute concentration in the liquid at equilibrium (mg/L),

q_e is the amount of dye sorbed at equilibrium (mg/g),

K_F (mg/g) and n are the Freundlich constants related to adsorption capacity and adsorption intensity. Fig 3 shows the Freundlich plot for100mg/l initial concentration.

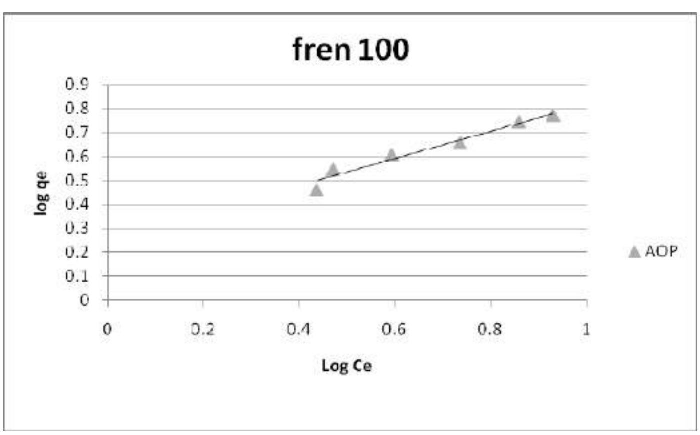

Figure 3 Freundlich adsorption isotherm for 10 mg/l initial concentration

3.3.1.2 Langmuir isotherm

The Langmuir theory, the basic assumption is that the sorption takes place at specific homogeneous sites within the adsorbent.

$$q_e = \frac{q_o K_L C_e}{1 + K_L C_e} \quad (2)$$

Where, C_e is the equilibrium concentration (mg/L), q_e the amount of dye sorbed (mg/g), q_o is qe for a complete monolayer (mg/g),

K_L is the adsorption equilibrium constant (L/mg).

Fig 4 shows the Langmiur plot for 10mg/l initial concentration.

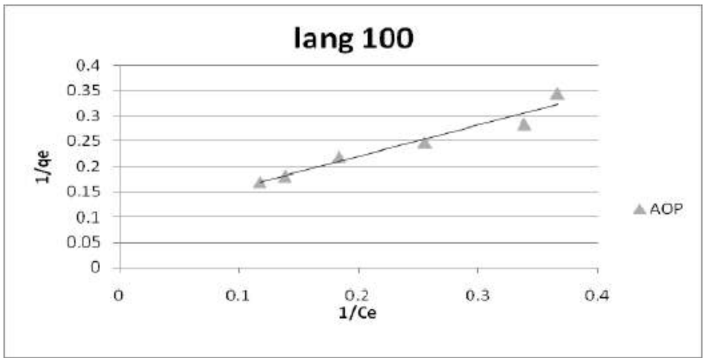

Figure 4 Langmuir adsorption isotherm for 10mg/l initial concentration

3.3.1.3 Temkin isotherm

The Temkin isotherm equation represented as:

$$q_e = \frac{RT}{b} \ln(K_T C_e) \quad (3)$$

Fig 5 shows the Temkin plot for 10mg/l initial concentration.

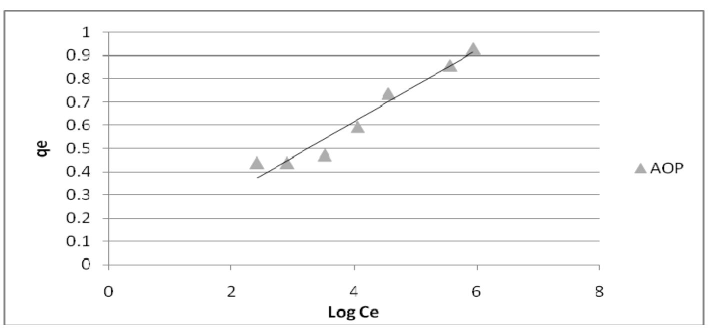

Figure 5 Temkin adsorption isotherm for 10mg/l initial concentration

4.0 CONCLUSIONS

1. The optimum contact time was found to be 105 min. The optimum dosage was found to be 2.5 g/L with the maximum efficiency of 81%.
2. From the isotherm study, the results show the Freundlich and Temkin isotherm plots fit well with the data than the Langmuir isotherm for 10 mg/l initial conc.
3. Adsorption tends to increase with contact time. At first the increase in adsorption is very rapid. Rate of adsorption is constant at equilibrium time at later stages. The optimum contact time for equilibrium was found to be 105minutes.

4. Some results acquired from batch studies did not get satisfactory results even though we conducted with activated carbon ,the reason behind it is improper weighing of sample and improper mixing i.e., some residue has been left during process of preparing methyl orange sample.

ACKNOWLEDGEMENT

The Authors thank the Principal Dr KVL Raju and Management for their constant support and suggestions throughout project work

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Study on Indirect Estimation of available Water Capacity of Soils for Shirla Nemane Watershed

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ABSTRACT

Assessment of soil water regimes is an important step in water management in agriculture. The most preferred way to acquire these data is indirect estimation pedotransfer function (PTFs) which has become a 'white-hot' topic in the area of soil science and environmental research. In this context; present study was carried out to develop Point Pedotranfer Function (PTF) to estimate available water capacity of soils of the ShirlaNemane watershed with geographical area of 22,400 ha in Buldhana district of Maharashtra state with different approaches viz. regression analysis, neural networks and a computer based program 'Rosetta'. Sixty sampling points were marked at a grid of 2 km × 2 km using Geographical Positioning System. Soil samples were collected from each sampling point at a depth range from 0-30 cm. Results revealed that nine different soil textural classes viz. were observed in ShirlaNemane watershed of 22,400 ha area indicating wide variation in textural composition of the study area. Measured available water capacities for Sandy, Loamy and Clay soils was ranging from 2.7 to 15.65%, 11.88 to 23.45% and 2.57 to 31.26% respectively. The results indicated that neural regression was a better tool for calibrating PTFs, as it has resulted in better predictions with minimum errors. However, in testing dataset the results were of mixed type implying the need of set more data for developing robust PTFs. The neural regression PTFs in general was found to be a better tool, compared to statistical regression PTFs and Rosetta tool. All the neural models (H1, H2, H3 and H4) were found superior for development data set. Applicability of generic PTF 'Rosetta' was ruled out for the soil types of given watershed due to high magnitude of errors in predictions. The calibrated neural PTFs can be used further for estimation of AWC (Available water capacity) of similar soils in other watersheds.

Keywords: Available water capacity, Pedotransfer functions, Rosetta.

1. INTRODUCTION

In an agrarian based economy, in India, management of natural resources like soil and water plays a critical role in food production. Current per capita land availability (2011) at 0.30 ha makes India one of the poorest in the world in terms of land resource. The soil hydraulic properties determine the behavior of soil water within the soil system under specified conditions. Under changing scenario, it is pertinent to study soil-water dynamics in detail for managing rainfed as well as irrigated agriculture. The study related to soil water dynamics needs an input of two important soil hydraulic properties – viz., saturated hydraulic conductivity and soil water retention characteristics of which the data are however rarely available. Soil-water retention characteristics are important in view of availability of soil-water to plants and to model movement of water and solutes in unsaturated soils.

Rosetta is a program that estimates unsaturated hydraulic properties, from surrogate soil data such as soil texture and bulk density. This kind of models can be named pedotransfer functions (PTFs) because they can transform soil basic data in hydraulic properties. The need for mathematical modeling of hydraulic properties arises from the fact that in-situ or laboratory measurements of hydraulic properties are time consuming, labour intensive and expensive. The most preferred way to acquire these data is indirect estimation.

The aim of present work is carried outdevelop function/models to estimate available water capacity of soils of the shirlanemane watershed located in Buldhana district, soil water retention characteristics, dependencies between soil properties and SWRC using different tools, evaluate and validate calibrated functions and compare their performance with generic model Rosetta.

2. MATERIALS AND METHOD

2.1 Location, topography and climate of the study areas

ShiralaNemane watershed is located between $76^0$19'23.72''E- $76^0$42'55.32''E longitude and $20^0$17'32.48'' N – $20^0$30'23.42'' N latitude with catchment area of about 224 km^2. The survey of India Topo-sheet number 55D/11 and 55D/7 contains the physiographical features of this watershed. Map of ShirlaNemane Watershed in Buldhana District Fig. 1. Also Grid Map of ShirlaNemane Watershed in Fig. 2.

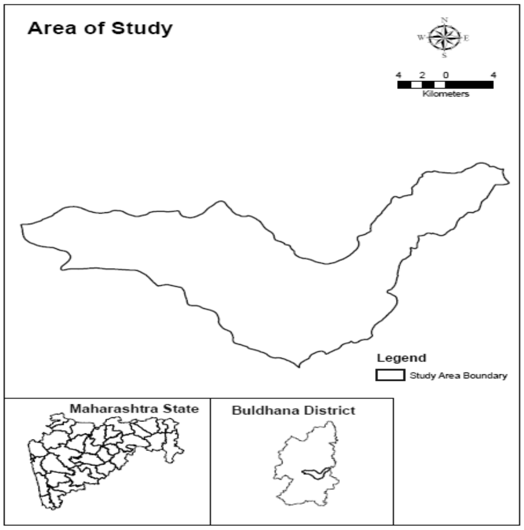

Figure 1 Map of ShirlaNemane Watershed

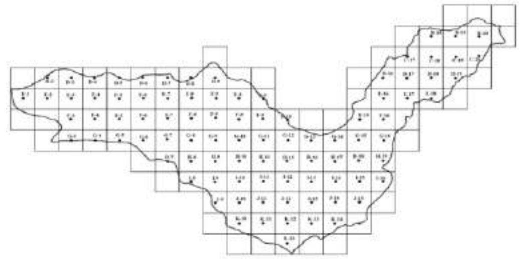

Figure 2 Grid map of shirlaNemane Watershed in Buldhanadistrict. In Buldhana district.

2.2 Collection of the soil samples

Seventy five sampling points were marked at a distance 2km x2km intervals using Geographical Positioning System (GPS). Soil samples were collected from each sampling point at a depth of 0-30 cm. Soil samples were air-dried and grounded to pass through a 2-mm sieve.

2.3 Soil analysis

Soil samples were then analysed for calculation of physical and chemical soil properties such as bulk density by clod method (1965), particle size distribution by Bouyoucos Hydrometer (1986), moisture retention parameter by pressure plate apparatus (1986) and organic carbon byWalkely and Black method (1967).

2.4 Development of Point PTFs

Pedotranfer (PTFs) are generally developed using one of the following methods:In a point-specific approach, water retention at a defined pressure (suction) head is estimated serving specific-point interest for application (Gupta and Larson, 1979; Hutson, 1987; Rawls and Brakensiek, 1982; Rawls *et al*., 1982; Campbell, 1990). Earlier researchers mostly used regression technique to develop prediction equations. General form of the equation is,

$$\theta(h) = C_1 sand + C_2 silt + C_3 clay + C_4 bd + ... + C_i x_i \quad (1)$$

where,

$\theta(h)$ = water retained at pressure h.

C_1, C_2, & C_i = regression coefficients.

X = variable represents predictor soil property that is readily available or easily measured.

2.5 Software Used

Rosetta

Rosetta is able to estimate the Van Genuchten water retention parameters (Van Genuchten, 1980) and saturated hydraulic conductivity (Ks), as well as unsaturated hydraulic conductivity parameters, based on Mualem's (1976) pore-size model (Schaap et al., 2001). The retention function is given by Equation (2)

$$\theta(h) = \theta_r + (\theta_s - \theta_r)\left[\frac{1}{(1+\alpha h)^n}\right]^{(1-1/n)} \quad (2)$$

Where,

θ (h) = volumetric water content (m^3/m^3).

θ_r = residual water content (m^3/m^3).

θ_S = saturated water contents (m^3/m^3).

α = inverse of the air entry suction (> 0, in cm^{-1}) and

n = pore-size distribution (> 1).

A hierarchical approach with limited or more extended sets of predictors was used to estimate the water retention parameters (θ_r,θ_S, a, n) and Ks (Schaap et al., 2001). The first model (H1) is a class PTF, consisting of a lookup table that provides parameter averages for each USDA textural class. The second model (H2) uses sand, silt, and clay as inputs (SSC). The third model (H3) includes bulk density as a predictor (SSCBD) in addition to the input variables of the second model.

2.6 Performance Evaluation Models

Performance of the pedotransfer (PTFs) will be evaluated based on one to one correspondence between measured and predicted values of Ks. Statistical indices. i.e. root mean square error (RMSE), mean absolute error (MAE), index of agreement (d), and maximum absolute error (ME) are based on squared difference between measured (M_i) and estimated (E_i) value, where 'i' indicates i^{th} value of dataset containing 'n' values.

3. RESULT AND DISCUSSION

The soil samples collected from ShirlaNemane watershed at a grid of 2 km x 2 km were analysed in laboratory and different pedotransfer functions were fitted and results are presented in following heads.

3.1 Determination of Basic Soil Properties

The textural classes of different soil samples were found to be varying in 9 different classes as sandy loam, sandy clay loam, loam, silt loam, silt clay loam, silt, clay loam and clay. The bulk density of different soil samples vary from 1.20 to 2.20 g/cc^3. Organic carbon was found to vary from 0.04 to 3.00 % in different soil samples of the study area.

The field capacity (FC) and permanent wilting point (PWP) of the clay soil was found in the range as 38.0 to 43.88 % and 29.0 to 31.0 % respectively with maximum available water capacity of 14.0 to 27.8 %. FC and PWP of course textured soils (sandy loam, sandy clay loam, loam and silt loam) was found to be in the ranges of 18.0 to 28.76 % and 8.0 to 18.5 % respectively with available water capacity in the range of 8.0 to 17.76 %. Similarly, FC and PWP of moderately textural soils (silt clay loam, silty clay and silt) was found to vary from 33.0 to 34.0 % and 16.0 to 17.0 % respectively with available water capacity in the range of 16.0 to 17.0 %.Descriptive statistics of measured soil properties in Table 1.

Table 1 Descriptive statistics of laboratory measured soil properties

Statistical parameters	Sand%	Silt %	Clay %	BD	OC	FC (%)	PWP (%)	AWC (%)
Mean	25.11	44.25	30.63	1.61	0.77	31.65	13.51	18.37
S.E.M.	2.08	2.09	1.97	0.03	0.1	0.96	0.46	0.82
S.D.	16.14	16.17	15.3	0.23	0.81	7.44	3.58	6.33
Variance	260.44	261.43	234.04	0.05	0.65	55.32	12.85	40.09
CV	0.64	0.37	0.5	0.14	1.04	0.24	0.27	0.34
Minimum	0.86	3.74	5.72	1.18	0.04	13.4	6.26	2.47
Maximum	69.59	80.01	62.24	2.2	3	51.56	21.7	31.26
Sum	1506.4	2655.2	1837.5	96.48	46.4	1898.7	810.89	1102.04
N	60	60	60	60	60	60	60	60

3.2 Prediction of PTFs Using Rosetta Model

Rosetta is able to estimate the Van Genuchten water retention parameters. The first model (H1) is a class PTF, consisting of a lookup table that provides parameter averages for each USDA textural class. The second model (H2) uses sand, silt and clay as inputs (SSC). The third model (H3) includes bulk density as a predictor in addition to the input variables of the second model (SSCBD).

The comparison of measured and estimated FC, PWP and AWC values was carried out using different statistical indices and results are shown in Table 2 and 3.

Table 2 Statistical indices of Rosetta in predicting FC and PWP of ShirlaNemane watershed soils

Statistical Index	SSC Model		SSCBD Model	
	FC	PWP	FC	PWP
RMSE	0.1059	0.0700	0.1033	0.0546
D	0.5359	0.5552	0.5144	0.6269
ME	0.2251	0.1793	0.2920	0.1359
MAE	0.0958	0.0603	0.0823	0.0453
R^2	0.51	0.34	0.06	0.23

Table 3 Statistical indices of AWC estimates using Rosetta

Statistical Index	AWC	
	SSC	SSCBD
RMSE	0.06432	0.08416
D	0.57	0.40
ME	0.149	0.2409
MAE	0.0497	0.0695
R^2	0.21	0.004

The graphical representation of measured and estimated available water capacity using SSC and SSCBD as an input in Rosetta is presented in Fig. 3 and Fig. 4 respectively. The graph of AWC in Fig. 3 shows higher spread on upper side of the 1:1 line indicative over prediction whereas the plot in Fig. 4 shows wide scattering of points above and below 1:1 line indicative under as well as over prediction

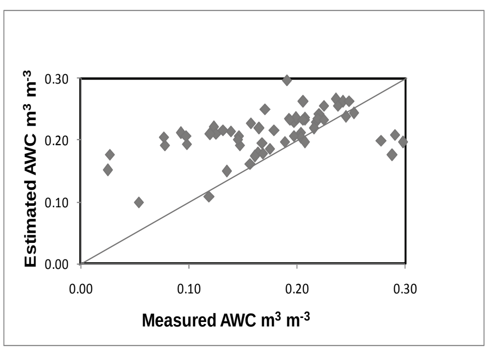

Figure 3 Measured Vs Estimated AWC using SSC as an as an input in Rosetta

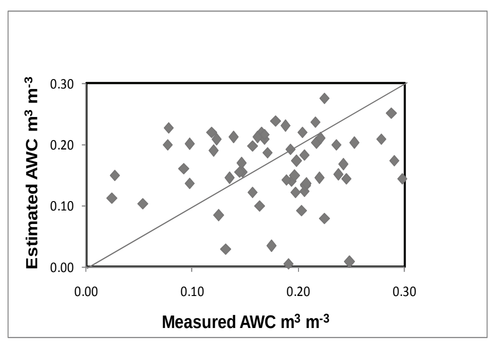

Figure 4 Measured Vs Estimated AWC using SSCBD as an input in Rosetta

The Rosetta model was found less applicable to soils of ShirlaNemane watershed for predicting PWP alone that too when no other tools or means of acquiring such data are available. Use of basic soil properties as input in 'Rosetta' to predict FC and PWP and consequently, AWC did not return desirable output.

3.3 Prediction of PTFs Using Different Tools

Pedotransfer Functions (PTFs) were calibrated and tested using statistical and neural regression. The total data points were 60, of which 45 were used for developing the PTFs and 15 points were used for testing the calibrated PTFs.

3.3.1 Prediction of FC and PWP using statistical regression PTFs

Following four hierarchical models were used for developing the statistical regression PTFs. The input data used in PTFs was as follows.

Model	Input
H1	sand, silt, clay (SSC)
H2	sand, silt, clay, bulk density (SSCBD)
H3	sand, silt, clay, organic carbon (SSCOC)
H4	sand, silt, clay, bulk density, organic carbon (SSCBDOC)

All the four PTFs were developed to estimate FC, PWP and consequently AWC. Developed models were evaluated by primary evaluators such as RMSE, and MAE as reported earlier.Regression equations developed to estimate FC are as follows:

Model	Equation for FC
H1	FC = (-0.71) +(0.81) Sand + (1.10) Silt +(1.09) Clay
H2	FC = (-54.63) +(0.65) Sand + (0.95) Silt + (0.93) Clay +(-0.77) Bulk density
H3	FC = (-67.78) + (0.77) Sand + (1.06) Silt +(1.05) Clay + (0.063) organic carbon
H4	FC = (-0.53) + (0.64) Sand + (0.93) Silt + (0.92) Clay + (-0.75) Bulk density + (0.027) Organic carbon

AWC was calculated as a difference between FC and PWP. These equations were evaluated using remaining 15 data points for PTF/model validation. Evaluation of indices (Table 4) suggest that the equations fitted well to the 45 point data used in developing equations (RMSE 0.0489 to 0.0497 m^3 m^{-3}). The coefficient of determination ranged from 0.46 to 0.47. The efficiency of calibrated equation did not improvewith inclusion of bulk density as an input parameter.

Table 4 Statistical indices of statistical regression PTFs to predict FC (Development dataset)

Development set					
FC	**RMSE**	**D**	**ME**	**MAE**	**R^2**
SSC	0.0497	0.796	0.126	0.13	0.47
SSCBD	0.0498	0.796	0.127	0.038	0.46
SSCOC	0.0496	0.796	0.126	0.039	0.47
SSCBDOC	0.0489	0.796	0.128	0.036	0.46
Mean	0.0495	0.796	0.12675	0.0608	0.465
Range-(Min to max)	0.0489 - 0.0498	0.796-0.796	0.126-0.128	0.036-0.13	0.46-0.47

3.3.2 Prediction of FC and PWP using neural regression PTFs

The four hierarchical models (H1, H2, H3 and H4) were used for developing the neural regression PTFs. The performance of developed neural regression PTFs presented in Table 5 shows significant reduction of neural network, in magnitude of error. The RMSE in developing PTFs to estimate FC ranged from 0.0212 to 0.0353 m^3 m^{-3} as against 0.0489 to 0.0498 m^3 m^{-3} in statistical regression. All other indices including coefficient of determination supports that neural regression was a better tool and all the models (H1, H2, H3 and H4) improved their performance in describing development data set.

Table 5 Statistical indices of neural regression PTFs to predict FC (Development dataset)

Development set					
FC	**RMSE**	**D**	**ME**	**MAE**	**R^2**
SSC	0.03536	0.86	0.1139	0.0282	0.62
SSCBD	0.02123	0.96	0.0787	0.0144	0.86
SSCOC	0.03243	0.93	0.1002	0.022	0.81
SSCBDOC	0.02637	0.94	0.0992	0.0172	0.80
Mean	0.028823	0.9225	0.098	0.0205	0.77
Range-(Min to max)	0.02123 to 0.03536	0.86 to 0.96	0.0787 to 0.1139	0.0144 to 0.0282	0.62 to 0.86

3.4 PREDICTION OF AWC

3.4.1 Prediction of AWC using statistical regression and neural regression PTFs

The measured and estimated AWC using SSC, SSCBD, SSCOC and SSCBDOC as input in PTF derived through statistical regression and neural regression PTFs

Statistical indices such as RMSE, ME, MAE and R^2 of developedstatistical regression PTFs for AWC ranged from 0.0424 to 0.0429 m^3m^{-3}; 0.74 to 0.79, 0.1101 to 0.1117m^3m^{-3}, 0.0324 to 0.0326m^3m^{-3} and 0.46 to 0.48, respectively. The RMSEwas remained within acceptable limit of 0.05 m^3 m^{-3} but the coefficient of determination (R^2) was moderate.Indicatively satisfaction performance of developed statistical regression PTFs for AWC.

Neural regression PTFs to estimate AWC ranged from 0.027 to 0.0409 m^3 m^{-3} as against 0.0424 to 0.0429 m^3 m^{-3} in statistical regression. Similarly other indices including coefficient of determination alsoshowes that neural regression is the better tool for improving model performance (H1, H2, H3 and H4) improve. The prediction performance of developed neural regression PTFs for AWC were found better compared to statistical regression PTFs.

The AWC estimates by all the hierarchical models (H1, H2, H3 and H4) of neural regression PTFs in development and testing dataset has RMSE values within acceptable range (0.05) except H1 Model (SSC) for testing dataset, it has higher value (0.0668 m^3 m^{-3}). Thus, neural PTF gives relatively better accuracy over that of statistical PTF based on lower RMSE within (0.05). Coefficient of determination (R^2) values suggested the neural PTFs were better with additional input of bulk density in model H2 (SSCBD) based and coefficient of determination (R^2). The RMSE improved considerably with use of organic carbon (OC) as input parameter. It has improved predictive performance of model H1 to H4 consistently. All indices suggested that neural PTFs performed better than statistical PTFsHence, it can be inferred that neural PTFs are the better predictors of AWC.

4. CONCLUSION

Based on the results obtained from the study, following conclusions are drawn.

1) Nine different soil textural classes were observed in ShirlaNemane watershed of 22400 ha area indicating wide variation in textural composition of the study area.
2) Measured available water capacities for Sandy, Loamy and Clay soils was found to range from 2.7 to 15.65%, 11.88 to 23.45% and 2.57 to 31.26% respectively.
3) The neural regression PTF was found to be a better tool than statistical regression PTF and Rosetta tool. The neural models (H1, H2, H3 and H4) were found to be superior for development data set.
4) Applicability of generic PTF 'Rosetta' was ruled out for soils of study watershed as high magnitude of errors in predictions were observed irrespective of the hierarchical models used.
5) The calibrated neural PTFs can be used to predict AWC.

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Restoration of Natural Resources and Renovation of Tanks – A Boon to Telangana Farmer

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ABSTRACT

Agriculture currently produces only 30% of total income in the Telangana region, but it remains the basis for survival of nearly 78% of the population. During the 53-year period, 1956-2009, Telangana lost 2.92 lakh hectares of tank irrigation. Meanwhile, despite the high cost of irrigation - both in capital and operating costs - over the same period the area irrigated by tube wells has grown up. The latter is entirely dependent on the recharge of groundwater and the availability and cost of power. Whatever the future irrigation policy and its implementation, it will need a close ground level, local district and regional governmental efforts in Telangana. Over the years the process of desertification has been taking place in large tracts of the Telangana because of soil erosion and sand casting on the one hand, and monocropping, chemicalisation, deforestation, excess use of ground water on the other. The total forest cover in the State is less than 12% of the total area. The landscape is undulating and has large arid, treeless expanses of poor soils. Due to the impoverished soil conditions, the scanty rainfall, indiscriminate grazing and poor protection, many of the forests have almost disappeared. Most parts of the state are desolate and barren. It is not to be repeated again and again that with the scantiest rainfall. Apart from building new tanks, encroaching the tanks and extraction of sand from tanks has become a common practice. Renovation of all types of storage tanks is the need of the hour. Even if they are constructed according to professional practice with the best materials and are maintained systematically, renovation is automatically required after several decades. This is necessary for economical as well as ecological reasons. Tank bottoms, shells that are constantly subjected to the influence the stored product or external corrosion, need to be replaced preventatively to avoid leakage and strengthening the bunds. Renovation of tanks, modernization, beautification and maintenance should be done quickly and accurately, so the period when the tank is out of service is kept to a minimum.

INTRODUCTION

Minor irrigation deals with the sources having ayacut of less than 5000 acres. In minor irrigation, construction of new M.I Schemes, Anicuts. Check Dams & percolation tanks, normal maintenance works repairs to the existing schemes and flood damage works are being taken up. New MI tanks, Anicuts, Check Dams and Percolations tanks are being taken up under normal state plan funds, AIBP, NABARD, APILIP, SCSP & TSP Programmes. Restoration works are taken up under APCBTMP, RRR, NABARD, Normal State Plan, SCSP, TSP and MGNREGS Convergence Programme.

Sl.No	District	Minor Irrigation Tanks		Panchayat Raj Tanks		Total Tanks	
		No.	Ayacut	No.	Ayacut	No.	Ayacut
1	Mahabubnagar	680	151024	5374	103077	6054	254101
2	Rangareddy	283	81368	1912	47528	2195	128896
3	Nalgonda	556	138855	4077	79750	4633	218605
4	Medak	582	136129	5174	101387	5756	237516
5	Warangal	793	190537	3920	74724	4713	265261
6	Khammam	400	141205	2097	54126	2497	195331
7	Nizamabad	324	81625	2772	61944	3096	143569
8	Karimnagar	632	165857	4495	105180	5127	271037
9	Adilabad	495	130685	1375	40424	1870	171109
Sub-total		4745	1217285	31196	668140	35941	1885425
Anicuts & others		363	123696			363	123696
Grand total		5108	1340981	31196	668140	36304	2009121

Category Wise Sources

Sl.No	Category	No. of Sources	Ayacut in Acres
1	M.I Sources ayacut > 100 Ac. • M.I Tanks • Anicuts, Open Channels and Others	4,745 • 363 • 31,196	12,17,285 • 1,23,696 • 6,68,140
2	M.I Tanks of ayacut < 100 Ac.	778	4,77,094
3	Lift Irrigation Schemes of APSIDC		
Total		37,082	24,86,215

Mission Kakatiya

- It is proposed to revive all the chain of tanks in Telangana under TRIAD Project
- Restoration of Minor Irrigation Tanks in Phased manner.
- Initiating 'Mana Vuru - Mana Cheruvu' Programme.
- All works will be taken up by traditional Tender system only through e-procurement.
- Implementing of Works Tracking system

Telangana State has been recorded as the drought prone state in the country. It is of great regret to place on record that though thousands of crores of amounts are being allocated to this region, either because of the negligence of the rulers or because of the sufficient awareness of the people, they are not being put to proper use. The Supreme Court has also ruled that providing the basic amenities to the people forms the fundamental right of the government. It is mater of great frustration that the people of Telangana are suffering from lack of drinking water and other basic irrigational facilities and driving thousands of farmers to suicidal deaths, and migration to other places. What would become of the this region if the same continues. This has been a million dollar question to be answered by the authorities and the public representatives. This issue was taken up by various civil organizations and NGO's, conducted series of workshops and interactive sessions with the irrigation experts, poets, writers, Farmers, self help groups, vanamitra, rythu mitra and Horticultural societies and all those groups which are being put to untold suffering and pain . As a result of all these seminars and workshops and interactive sessions, the common answer to the question was the immediate and urgent renovation of the existing water irrigation tanks of Telangana district. It has been estimated that if all the available tanks in the region are renovated they have the capacity to hold nearly 250TMC of water through rainfall if there is sufficient rainfall and avert drought for one to two years. It is a known fact that Telangana district has been facing drought for every five years and subjecting the farming community to untold suffering. No developmental activities what so ever to change the drought prone face of the state have taken place till now. With the supreme court judgment to go in for sharing of river water, apart from any other place it is the Telangana which would benefit a lot from it. Whatever the socio-political reasons may be, but the ultimate sufferer is the citizen of Telangana. It is a known fact that nearly 68 major and medium irrigation tanks of Telangana can be fed with the water thus released to replenish the ground water, provide fodder for the live stock and water humidity in and around the tanks for the sustenance of basic agricultural needs. It is highly regrettable that because of the following observations tanks have been neglected a lot resulting in a great loss to the society at large. It gives observation on the need, history, importance and usability and various norms to be practiced for the sustenance of the tanks and their usefulness.

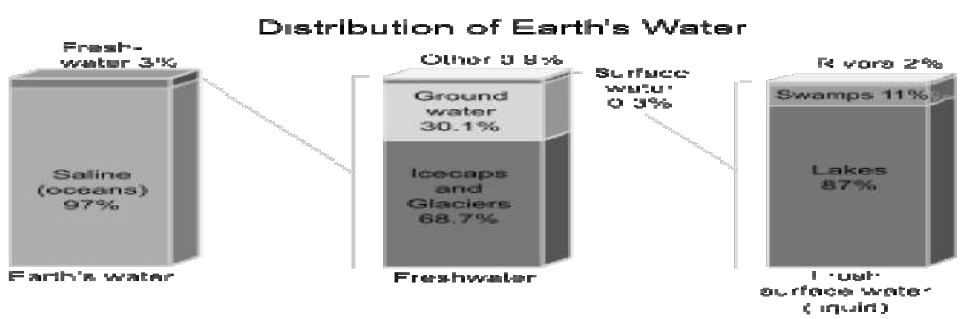





Water Resources of India

For survival human life, water is the second requirement next to air. Water resources of a country constitute one of its vital assets. Water is required for domestic, agricultural, hydro-power, thermal power, navigation, recreation, etc. Utilisation in all these diverse uses of water should be optimized and an awareness of water as a scarce resource should be fostered. According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO) estimates, the total volume of water on earth is about 1.4 billion km3 , which is enough to cover the earth with a layer of 3 km depth. However, World's oceans cover about three-fourths of earth’s surface while the fresh water constitutes a very small proportion of this enormous quantity available on the earth. It is only about 35 million km3 or 2.5% of the total volume. Of these, 24 million km3 or 68.9% is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions and another 29.9% is present as ground water (shallow and deep groundwater basins up to 2,000 metres). The rest 0.3% is available in lakes, rivers and 0.9% in soil moisture, swamp water and permafrost atmosphere.

A graphical *distribution* of the locations of water on Earth shows that only 3% of the earth's water is fresh water. Most of it in icecaps and glaciers (69%) and groundwater (30%), while all lakes, rivers and swamps combined only account for a small fraction of 0.3% of the Earth's total freshwater reserves.



Irrigation Tank

Irrigation Tank is a perfect example of human management of water for agriculture and have recorded history from 7th century onwards. A Tank is a simple rainwater harvesting structure designed by ancients using indigenous wisdom and constructed with the support of the native rules. As per record 500,000 tanks exist in the country, of which 150, 000 tanks are located in the semi arid region of the Deccan plateau. Of these Andhrapradesh and Telangana has the largest number of tanks in India –some 74,000 –and as well as the largest area irrigated by tanks. They are located in hydrological favorable sites some of them in sequential chains or cascades effectively capturing the rainfall and serving multiple uses with irrigation having the major share..

Sir Arthur Cotton, a well known British engineer who worked in India at the time of colonial imperialism exclaimed on seeing the constructed tanks:

"the natives have constructed tens of thousands of tanks in almost every kind of soil with earthen bund without the puddle bank, which English engineers fancied necessary" .

Science of Tanks

Understanding the various limitations of the soils have and the constraints set by geology, the civilizations that had lived in this area have developed mechanisms for replenishing the groundwater. These mechanisms are known as tanks and they are found almost in all low –rainfall, arid and semi-arid regions of the south peninsula. Tanks are built in a chain and size predominantly determines the order of succession. The surplus water from one tank moves into the succeeding tank till the entire chain terminate at the beginning or empties into a river. As each tank is fed by the preceding smaller tank, focusing on single tank does not bring out the role of tanks in the preservation of rainwater for percolation purpose. Tanks are predominantly found in those parts where the rainfall is below 750 mm.

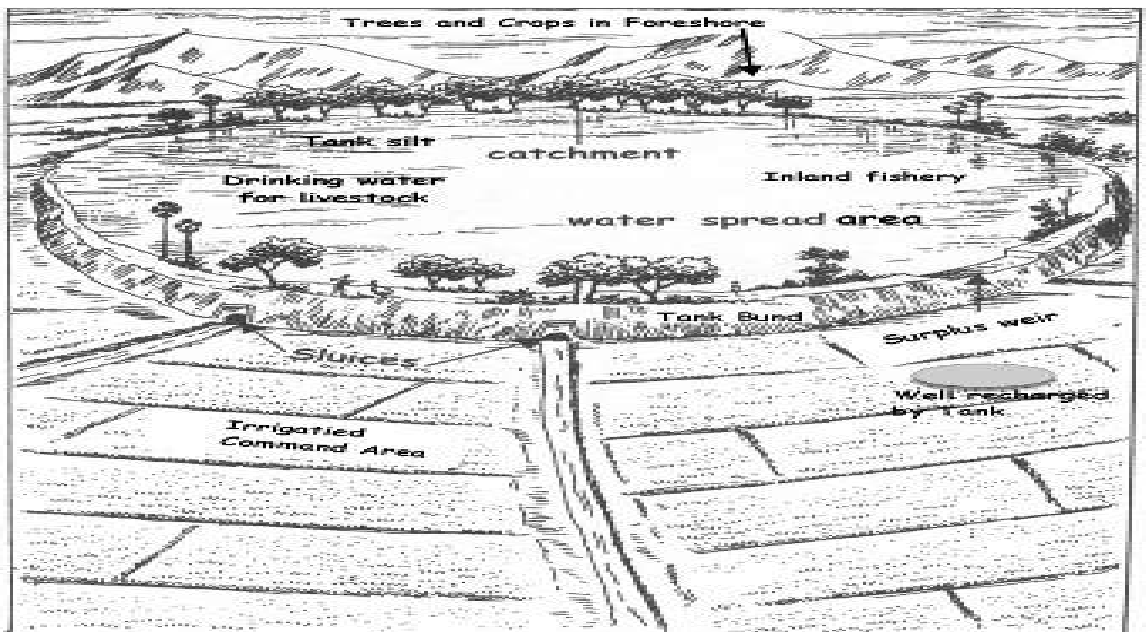
Every drop of rain has to be conserved within the soil for the purpose of raising good crops. In such areas every drop is conserved a step towards the conservation of ground water. In such a situation the ability to irrigate is chiefly a function of the optimum level required for replenishing the ground water. When the replenishment is below the optimum level the irrigation potential of a tank tends to be low or totally absent. In order to enable the tanks to replenish ground water to the optimum level, devices more or less similar to tanks in physical structure, but of a smaller size were built into the system of tanks. Each tank has such a device incorporated into it. Such devices were called by various names and are known as Kuntas in Andhrapradesh. Kunta: These pits serve an areas ranging from acres to tens of acres .these structures are the conservation points for the preservatio0n of water at different points. By holding back the runoff at each point they help the soil erosion and help to infiltrate water into the soil. Conservation of water is one of the major functions of the kunta but apart from it they prevent soil erosion and flow of silt into the bigger tanks. Kuntas are located strategically in between the fields in the catchments area. The water has never a chance to flow as a single course for more than a single distance .kuntas periodically check the free flow and thereby reducing the velocity of water flow and retarding the soil erosion. Runoff water is made to overflow the kuntas and there by shedding all its silt sediment .this built in mechanism helps in auto desilting at the Kunta level itself and the quantity collected at the Kuntas is small and the farmers themselves can desilt the kuntas every year. Each kunta overflows into a tank nearby. Unfortunately these kuntas have been grossly neglected by the government.

Tanks are classified into small, medium and large, and many small tanks flow into medium tanks and medium tanks into large. In this sense a tank can be defined as a technology for the conservation and utilization of runoff water for percolation and irrigational purposes. As one report on tank irrigation says: Tank irrigation has a long history and many currently used tanks were constructed in the past centuries. The tanks have existed in India from time immemorial, and have been an important source of irrigation especially in southern India. They account for more than one-third of the total irrigated area in Andhra Pradesh, Telangana, Karnataka and Tamil Nadu states. The tank irrigation system has a special significance to the marginal and small scale farmers who make a very large number essentially depending on tank irrigation as these systems are less capital-intensive and have wider geographical distribution than large projects (Palanisami, 2000). Even the Data from the Agricultural Census of India for five time points namely 1970-71, 1976-77, 1980-81, 1985-86 and 1990-99 indicated that the resource poor farmers (owning less than 2hectares) still account for major share of tank-irrigated area in India. Marginal (less than 1 ha.) and small farmers (1-2 ha) together accounted for about 40 percent of tank-irrigated area in 1970-71, which further increased to nearly 55 percent in 1990-91 thus accounting for nearly two third of tank irrigated area. On the other hand, the share of tank irrigated area used by large farmers declined from 13.59 percent to 6.02 percent during this period. Since the farmers belonging to marginal and small size group are mostly poor, they couldn't afford for cost intensive irrigation sources like groundwater as in the case of medium and large farmers and tank irrigation continues to play a crucial role among small and marginal farmers even today. This is also true across different states where tank irrigation has considerable presence even today(Narayanamoorthy, 2004).

John Ambler (1994) aptly describes the usefulness of tank systems as follows:

> "*Tanks need to be thought of in terms of a wide complex of natural resources, physical facilities, land use patterns and managerial institutions. The tank is not simply an irrigation system that starts from the reservoir down. It is also a collection point for run-off from the catchment area, pond for pisciculture, source of silt for fertilization and construction material, a recharge structure for local groundwater, a location for cultivation on common lands, a source of drinking water for livestock, and finally, an irrigation system for crops. To help keep in mind this multiplicity of uses which spans the administrative ambit of several government departments, it is useful to think of tank complexes rather than tanks,which too often connote only the direct surface irrigation aspects of these systems.*"

Even in the 21st century, the tanks, not only in Indian context, but also in South Asian context have very high relevance in practicing Integrated Water Resources Management(IWRM).



Tanks and their Functions

The tank system has four different functions in irrigated agriculture: soil and water conservation, flood control, drought mitigation and protection of environment of surrounding area. Likewise, development of tank irrigation has to undergo the four phases, namely, water acquisition or harvesting, storage, disposal of surplus water, distribution and management of water in the command area by an institution. The tank complex comprises the catchments area, the feeder channel, tank bund; water spread area, sluice outlets, command area, field distributaries (water courses) and surplus weir.

The South Indian and specially the tanks of Telangana are known for their antiquity and are created essentially as a source for providing supplementary irrigation during monsoon season. Tank irrigation has thus a rich heritage on account of long historical antecedents in various regions of India. Over centuries, tanks and ponds constituted an important supplementary source of water to the distressed poor.

6350 TMC unused Godavari River water in 2013-14

The Godavari river and its tributaries together 6350 TMC water flows into bay of Bengal without any utilization in 2013-2014 rainfall year. In the previous year 2012-13 also 3080 TMC water wasted into the Sea. Godavari River origins from Western Ghats in Maharastra and flows770 KMs in Andhra Pradesh, out of these 600 KMs travels in Telangana state itself. The only one major irrigation project SriRamSagar (SRSP) (91 TMC) was constructed. There is very much potential to construct at least10 barrages on Godavari River within the Telangana state. The underdevelopment model appears in agriculture sector. Imbalance utilization of water leads the poverty in this region. Even today Telangana people are suffering for drinking water. The inevitable solution is only to utilize the Godavari and Krishna river water in this region. Godavari River flows770 KMs in Andhra Pradesh, out of these 600 KMs travels in Telangana itself. The only one major irrigation project SriRamSagar (SRSP) (91 TMC) was constructed. There is very much potential to construct at least 10 barrages on Godavari River within the boundaries of Telangana. The only one small project constructed on River Krishna is Jurala (11.9TMC) which irrigates Telangana area. Nagarjuna Sagar irrigates Andhra region with gravity canal, in Telangana with lift irrigation. Telangana people are demanding to construct the Ichampally project, but the AP Government shows much interest to construct the Polavaram Project.

Performance of tanks over years

In a 10-year period, three years the tank get normal supply, five-years get deficit supply and two years they fail completely (Palanisami,2000). Given the rainfall uncertainties, the tank performance is seen declining over years. There are above-outlet problems such as poorly maintained structures (bunds, surplus weirs). Catchments is mismanaged and forest land practices in a sustained manner.

The only solutions to threats of desertification, severe drought as assessed by a study, is the fill all old irrigation tanks built from the times of Sri kakathiya.

Under the Sreeram sagar, Devadula, Rajoli Banda, Gutpa, Ali sagar schemes, the promised quantity of water is to be utilized by filling all the irrigation tanks, including steam beds.

The total capacity of all the irrigational tanks of Telangana is 250 TMcft and if all the irrigation tanks are de-silted, their capacity will increase.

If all the tanks in the taluks are fed, the water table will increase in all the ayacut areas of the irrigation tanks. According to the experts, about 2000 tmcft of rainwater is going waste without being tapped or used for recharging ground water.

Lack of maintenance funds affects repairs to minor irrigation projects.

A news paper report has it that:

- 230 Tanks in Telangana developed breaches or piping’s or other damages.
- Influential MLA’ get repairs done to tanks in their constituencies.

Plumetting groundwater levels

- The ground water level which was in between 80-150 ft in Telangana districts has fallen to 300 to 500ft.
- The water table has decreased by 5.32 to 6 meters in Telangana region.
- An estimated 500000 bore wells a year are the main reason for the depletion of the water table.
- The main reason for the framer suicides in the state is the inadequate irrigation facilities and failure of bore wells.
- As the prospects of tank irrigation is limited by silting of water bodies and various other causes, farmers are forced to dig bore wells.
- Over years the performance of the tanks has been declining. The share of tank irrigated area in India has declined from *16.51 percent in 1952-53 to 5.18 percent in 1999-2000*, whereas the share of groundwater irrigation has increased from 30.17 percent to 55.36 percent during this period.
- The Famine Commission of 1878 brought to light quite forcefully the deteriorating conditions of tanks and advocated a systematic policy of maintenance.
- Siltation of the tank bed has reduced the water storage capacity ranging from 20 to 30 percent.
- There are severe encroachment in the tank foreshores

- In fact, it had been found that large number of tanks have become defunct in less tank intensive (i.e., 76% of Panchayat Union tanks and 64% of Public Works Department tanks have become defunct) compared to tank intensive regions, where the percentage of defunct tanks is less1 (Palanisami, 2000).
- Mostly tanks are reported to be functioning only in normal and excess rainfall years and not so in poor and low rainfall years.
- As a consequence migration to towns from villages is taking place. The lands are not being maintained and becoming useless for cultivation.
- Due to the declining commitment on the maintenance of the tank structures, the upkeep of the structures is a cost affair for the farmers when they really want to use the tank for irrigation during normal supply periods.
- The livestock support activities are also completely gone in the village eco-system thus eroding the livelihood options in the village. Farmers used to take the silt using bullock carts and after the introduction of the social forestry scheme in the 1980s in the water spread area, silt removal from the tanks was prevented thus making the bullock operations limited.
- Somehow in the recent years, the microfinance concept has been emerged among the rural women who are managing the families with livestock and credit integration. But livestock also need adequate fodder. Hence, if the tanks are not properly managed then the entire tank ecosystem based rural economy will be completely collapses.
- The impact of the social forestry was already felt in terms of increasing silt accumulation in the tank water spread area and it will be difficult to sustain the tanks if the social forestry is allowed to continue. But at the same time, even without social forestry in the tanks, there are possibilities that the prosophis trees will be spreading fast and it will have severe impact than the social forestry with accacia trees which have market (timber) value.
- It is seen in several locations, due to intensification of watershed development programs by the Government, several structures such as small check dams and percolation ponds are developed in the upstream of the tanks thus affecting the inflows into the tanks. Hence a clear demarcation should be done between the watershed programs and tank improvement programs.
- Disappearance of the supply channels is very common. House construction works due to population increases and village development activities such as roads, schools, buildings are concentrated in the government poramboke (common) lands which are the main sources of inflow to the tanks as well as interlinking the tanks in the chain. This is one of the reasons why tanks are not getting adequate storages even though the rainfall is normal.
- The traditional village institutions like panchayats who looked after the tank catchments and tank structures and facilitated the inflows into the tanks regularly during rainy seasons also disappeared, as they could not be paid by the farmers due to frequent tank failures.
- The growing self-interest and non-cooperation by the well owners in the routine and maintenance also make the tank management a difficult task. This is because in several villages, well owners feel that the tanks will not be much useful, as most of the periods they are dry. Also the reliability of the tanks for recharging the wells has also gone down due to siltation and encroachment.
- The rice supplies in the village ration shops to some extent make the poor farmer households to prolong their livelihood with the dried-up tanks. But the major issue is how long the ration shops will sustain the villages and the tanks.
- Many people now raise the question: Do we really need the tank bund which makes 1:2 or 1: 4 water spread : command area?. The 1:2 ratio (i.e., for every one hectare of water spread, only 2 hectares of command area is available) is very attractive for making the rain fed tanks into rain fed land as there is not much differences between the tank irrigation and rain fed agriculture. This aspect is gaining important since in most of the time, the tanks are empty and people think about using the water spread area for rain fed cultivation due to its fertile silt.

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Impact of Climate Change on Agriculture and Food Production

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ABSTRACT

Agriculture represents a core part of the Indian economy and provides food and livelihood activities to much of the Indian population. While the magnitude of impact varies greatly by region, climate change is expected to impact on agricultural productivity and shifting crop patterns. Global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. Climate change and its impact is a matter of great concern among all countries of the world because it has the potential to make vulnerable life on the earth. Therefore an attempt has been made here to examine the impact of climate change on the food security and agriculture production of India with special reference to the agro-climatic regions. The study revealed that climate change can adversely affect the all four dimensions of food security i.e. food availability, accessibility, utilization and stabilization.

INTRODUCTION

The agricultural sector represents 35% of India's Gross National Product (GNP) and as such plays a crucial role in the country's development. Food grain production quadrupled during the post-independence era; this growth is projected to continue. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Climate change can affect crop yields (both positively and negatively), as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth, as well as the prevalence of pests. There are always two kinds of processes behind the climate change one is natural and other is human being induced. Anthropogenic activities are more responsible for climate change. Climate change has become one of the most important global environmental challenges of 21st century facing humanity with implications for food production and food sustainability. It has been at the centre of scientific and political debate in recent years, today, more than at any time in the past there is an almost unanimous consensus among scientists, politician, policy-makers, administrators and the common people alike that climate has changed and that it is still changing (IPPCC,2007).

Predicted climate change impacts on agriculture

The predicted changes to agriculture vary greatly by region and crop.Findings for wheat and rice are reported here:

Wheat Production

1. The study found that increases in temperature (by about 2ºC) reduced potential grain yields in most places. Regions with higher potential productivity (such as northern India) were relatively less impacted by climate change than areas with lower potential productivity (the reduction in yields was much smaller);
2. Climate change is also predicted to lead to boundary changes in areas suitable for growing certain crops.
3. Reductions in yields as a result of climate change are predicted to be more pronounced for rain fed crops (as opposed to irrigated crops)and under limited water supply situations because there are no coping mechanisms for rainfall variability.
4. The difference in yield is influenced by baseline climate. In sub tropical environments the decrease in potential wheat yields ranged from 1.5 to 5.8%, while in tropical areas the decrease was relatively higher, suggesting that warmer regions can expect greater crop losses.

Rice Production

1. Overall, temperature increases are predicted to reduce rice yields. An increase of 2-4ºC is predicted to result in a reduction in yields.

2. Eastern regions are predicted to be most impacted by increased temperatures and decreased radiation, resulting in relatively fewer grains and shorter grain filling durations.
3. By contrast, potential reductions in yields due to increased temperatures in Northern India are predicted to be offset by higher radiation, lessening the impacts of climate change.
4. Although additional CO2 can benefit crops, this effect was nullified by an increase of temperature.

Climate Change and Food Security in India

India has many reasons to be concerned about climate change, because a majority of population depends on climate sensitive sector i.e. agriculture, forestry and fishing for livelihood. The existing problem of food security in our country, if not addressed in time, will become more acute due to change in the climate. It will become more difficult to ensure food security under the changing climate for country like India where more than one third of the population is estimated to be absolutely poor and one half of all children are malnourished in one way or another (Dev and Sharma, 2010).To examine the impact of climate change on Indian agriculture sector is quite complex as several factors are concerned in this phenomena. For the detail discussion about impact of climate change on food security we have taken the four components of food security and discuss the impact of climate change on these components in the Indian context.

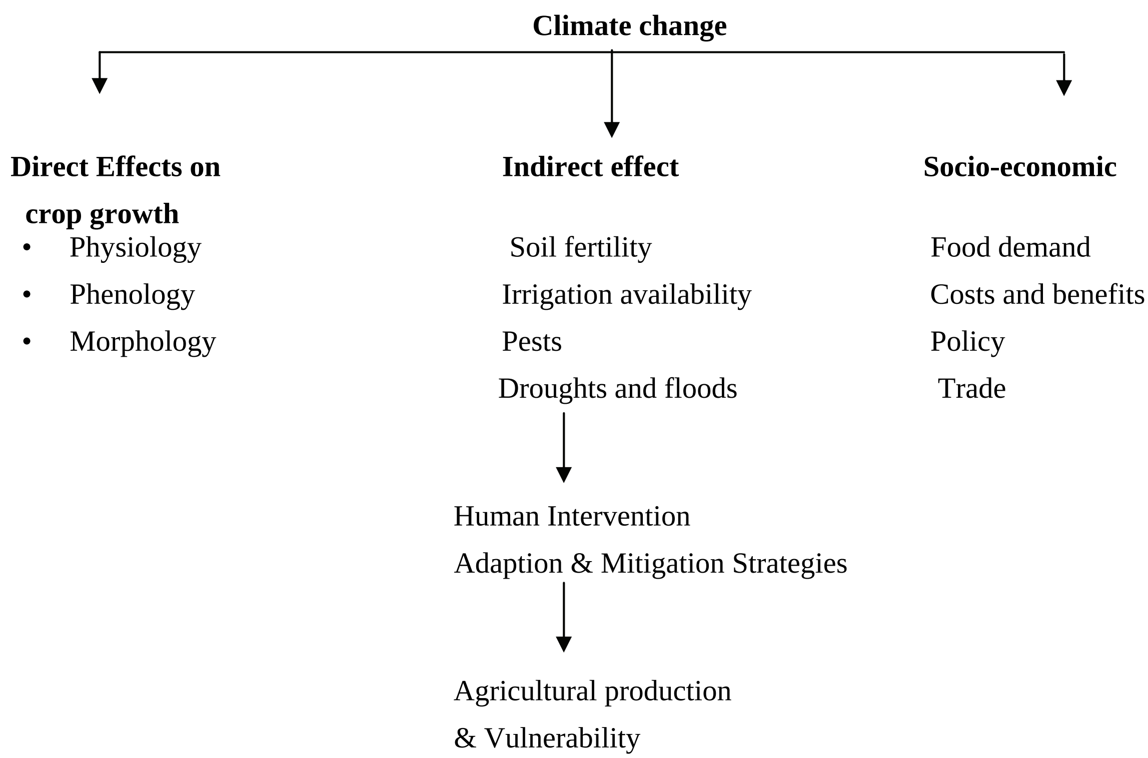

Chart: Assessment of Vulnerability of Agriculture to Climate Change

Climate Change and Food Production

The evaluation of climate change impacts on agricultural production, food supply and agriculture based livelihoods must take into account the characteristics of the agro- ecosystem where particular climate-induced changes in biochemical processes are occurring, in order to determine the extent to which such changes will be positive, negative or neutral in their effects (FAO-2008 P. 21) greenhouse fertilization effect will produce local beneficial effects where higher level of atmospheric CO2 stimulate plant growth. This is expected to occur primarily in temperate zones with yield expected to increase by 10 to 25%. (IPCC, 2007c) These effects are not likely to influence projections of world food supply, (Tubiello et al., 2007). But in India tropical type of climatic condition prevails so here most probably the greenhouse fertilization will have negative impacts.

Climate Change and Storage, Processing and Distribution of Food Grain

Food production varies spatially, so food needs to be distributed between regions. The major agricultural production regions are characterized by relatively stable climatic conditions but many food-insecure regions have highly variable climates. The main grain production regions have a largely continental climate, with dry or at least cold weather conditions during harvest time, which allows the bulk handling of harvested grain without special infrastructure for protection or immediate treatment. Depending on the prevailing temperature regime, however, a change in climatic conditions through increased temperatures or unstable, moist weather conditions could result in grain being harvested with more than the 12 to 14% moisture required for stable storage. Because of the amounts of grain and general lack of drying facilities in these regions, this would create hazards for food safety, or even cause complete crop loses, resulting from contamination with microorganisms and their metabolic products. It would leads to a rise in food prices if stockiest have to invest in new storage technologies to avoid the problem (FAO, 2008). Transport infrastructure limits food distribution in developing country like India. Where infrastructure is affected by climate, through either heat stress on roads or increased frequency of flood events that destroy infrastructure, there are impacts on food distribution, influencing people access to markets to sell or purchase food (Abdulai and Crole Rees, 2001).

Climate Change on Food Access

Food is allocated through market and non-market distribution mechanisms. Factors that determine whether people will have access to sufficient food through markets are considered in the affordability. These factors include income-generating capacity, amount of remuneration received for products and goods sold or labor and services rendered and the ratio of the cost of a minimum daily food basket to the average daily income (FAO, 2008). Non market mechanisms include production for own consumption, food preparation and allocation practices within the household, and public food distribution schemes. The approximately 70% population of India live in rural areas. For rural India where people who produce a substantial part of their own food, climate change impacts on food products may reduce availability to the point that allocation choices have to be made within the household.

Climate Change on Food Utilization

Food insecurity is usually associated with malnutrition, because the dieting patterns of people who are unable to satisfy all of their nutritional requirements don't consist of nutritious food grains. Declines in the availability of mild foods and limits on small-scale horticultural production due to scarcity of water or labor resulting from climate change could affect nutritional status adversely. In general, however, the main impact of climate change on nutrition is likely to be felt indirectly, through its effects on income and capacity to purchase in order to diversify their food basket. In India climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risk for food security, food safety and human health. Increased incidence of water-borne diseases in food-prone areas like U.P., Bengal, Orissa, Bihar, Andhra Pradesh and Maharashtra etc; changes in vectors for climate responsive pests and diseases, and emergence of new diseases could affect both the food chain and peoples physiological capacity to obtain necessary nutrients from the foods consumed. These will expose crops, livestock, fish and humans to new risks to which they have not yet adopted. They will also place new pressures on care giver within the home. Malaria in particular is expected to change its distribution in a result of climate change (IPCC, 2007a). In coastal area of India more people may be exposed to vector-and water-borne diseases through flooding linked to sea-level rise. Food safety may be compromised in various ways. Increasing temperature may cause food quality to deteriorate, unless there is increased investment in cooling and refrigeration processing of perishable foods to extend their shelf-life.

Climate Change on Food Sustainability

Many crops have annual cycles and yields which fluctuate with climate variability, particularly rainfall and temperature. Maintaining the continuity of food supply when the production process is seasonal in nature is a therefore challenging task. Droughts and floods are a particular threat to food stability and could bring about both chronic and transitory food insecurity. As we know India is a country which is more prone to drought and floods. Both are expected to become-more frequent, more intense in India and less predictable as a consequence of climate change. In rural areas which depend mostly on rain fed agriculture has the 70% of the total population of India which depends on the local food supply. Changes in the amount and timing of rainfall within the season and an increase in weather variability are likely to aggravate the precariousness of local food system. Increasing instability of supply, attributable to the consequences of climate change, will most likely lead to increases in the frequency and magnitude of food emergencies with which the global food system is ill equipped to cope. Climate change might exacerbate conflict in numerous ways, although links between climate change and conflict should be presented with care. Increasing incidence of drought may force people to migrate from one area to another, giving rise to conflict over the access to resources in the receiving area. Resource scarcity can also trigger conflict and which could be driven by the global environmental change.

CONCLUSION AND REMARK

The climate change calamity can then become a blessing in terms of reorientation of our agricultural research and development strategies based on the principles of ecology economics, equity, employment and energy security. The path ways to an evergreen revolution are organic farming and green agriculture (Swaminathan, 2008). Diversification of agriculture away from staple crops to horticulture, floriculture and commercial crops can also increase the income of small farm holders (Thakur and Chand, 2013). There is a great deal of uncertainty regarding climate change, but there are some certainties. The prospects of Indian food security under the upcoming climate change will depend a numbers of immediate measure i.e.to reduce the vulnerability of food system to climate change and other global environmental changes, which has started looming large the very existence of human kind. A multifaceted approach of adoption in terms of increasing food production, improving food distribution and increasing economic access to food as well as different mitigation options for reduction of green house gases needs to be adopted. Adaptation to climate change impacts should not be approached as separate activity, isolated from other environmental and socio-economic concerns that also impact on the development opportunity of poor people (OECD, 2003). There are need to maintain up-to date agro-metrological data and to develop some methods and tools for assessing extreme weather impacts and guiding adaptation. We have to protect our existing livelihood system and diversify the sources of food and income. Most important things are to manage agriculture; land and water with more efficiently.

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THEME - III

Hydropower, Bio-Diversity, Catchments Treatment and EIA

Acts for Inter Linking of Rivers and for Solving ISWD

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ABSTRACT

The sectoral water demands has increased manifold over the years and several issues are cropping up in meeting the demand in time and space. This warrants planning and implementation of Intra and Inter linking of rivers with no further loss of time. In the process of implementation several hurdles will arise including Legal. Therefore a Law has to be enacted by the Parliament exclusively for implementing linking schemes. In solving Inter-State Water Disputes the Tribunals take enormous time than expected to decide and to give its Report, and there after the process to implement the decision is also taking a long time. In order to reduce the period the ISWD Act has to be amended. In this article few suggestions are made for that.

INTRODUCTION

Civilisation and human settlement emanated along the banks of rivers and streams and people used the flowing waters for their livelihood. Slowly the people started using the land adjoining the rivers to produce grains for their food for which the water flowing through the rivers was used. Then, the flowing water was sufficient to meet the sectoral demands. Due to civilisation and developmental activities and population growth over the centuries, the demand for water increased in all sectoral uses. Naturally the issues and challenges to meet the growing demand in time and space cropped up due to scarcity, lack of integrated approach, climate change, environmental issues, failure of monsoon, regional interest, etc.

Need for IBWT and Water Policy

While the gap between water supply and demand increases in some river basins, the water resources of some basins cannot always be said to be fully utilized in the basin itself. For example, in the Ganga, Mahanadhi, Godhavari, etc., a good deal of monsoon flows are not harnessed and flows to sea. There are some basins in our Country including the State of Tamil Nadu where the essential requirements, viz., domestic and irrigation needs, could not be fully met by local resources. Anticipating this scenario, the Irrigation Commission as early as in 1972 recommended that in any study connected with the development of water resources of a basin, the feasibility of utilizing its surplus should be given due consideration. Followed by it, the National Water Policy of 1987, 2002 and 2012 have also recommended Inter and Intra basin transfer from surplus basins/ sub-basins to needy basin/ sub-basin.

Worldwide there are more than 130 inter linking schemes which are in operation transferring about 540 BCM (19,090 TMC). Thanks to the technological advance in tunnelling and pumping to cross the ridges. In the near future it is expected that through 30 links about 940 BCM (33,230 TMC), in addition to the above, water would be transferred from one basin to other. Dr. K.L.Rao, former Union Minister, in 1972, suggested Inter Basin Water transwer (IBWT) as a national grid, and Capitan. Dastur in 1977 suggested a Garland Canal, but later both were found to be technoeconomically not viable. In 1980, Government of India (GoI) formulated the National Perspective Plan(NPP) for Water Resources development which includes IBWT. Then, in 1982, GoI formulated the National Water Development Agency (NWDA) specifically for studying the possibility of inter linking the rivers and to prepare project reports for such linking prospects with the aim to relieve the water stress faced by the deficient States and to mitigate the problems faced by flood prone States. Since then it has prepared Feasibility Reports (FR) for Himalayan and Peninsular links. From the Peninsular link viz., Mahanadhi- Godhavari-Krishna-Pennar-Palar-Cauvery-Vaigai-Gundar link, Tamil Nadu will get about 214 TMC at the AP-TN border. The policy of NWDA is to firm up the projects and to prepare the Detailed Project Report (DPR) only after getting the concurrence of the co-basin States. But the efforts made by NWDA to arrive at a consensus among the basin States over the past three decades for implementing ILR are not fruitful. Only in two links out of 30, NWDA could so far arrive at a consensus among the States. For some links they could not even conduct field survey. In some case the

State which earlier agreed for the FR is not co-operating for further investigation and preparation of project report. Thus, the Policy of Government of India to link the rivers to transfer water from surplus basins/sub-basins to deficit basins/sub-basins could not be implemented as it wanted to do under NPP.

Supreme Court on IBWT

It is relevant to state here that the Hon'ble Supreme Court in PIL, Writ petitions (civil) 512 & 668 of 2002, on Inter Linking of Rivers has observed/ordered as under, *63. We would recommend, with all the judicial authority at our command, that these projects are in the national interest, as is the unanimous view of all experts, most State Governments and particularly, the Central Government. But this Court may not be a very appropriate forum for planning and implementation of such a programme having wide national dimensions and ramifications. It will not only be desirable, but also inevitable that an appropriate body should be created to plan, construct and implement this inter linking of rivers program for the benefit of the nation as a whole.*

64. Realizing our limitations, we would finally dispose of this Public Interest Litigation with the following directions:-

(I) We direct the Union of India and particularly the Ministry of Water Resources, Government of India, to forthwith constitute a Committee to be called a `Special Committee for Inter-linking of Rivers …………………..

Xxxxxxx xxxxxx xxxxxx

(IX) Keeping in view the expert reports, we have no hesitation in observing and directing that time is a very material factor in the effective execution of the Interlinking of Rivers project. As pointed out in the Report by NCAER and by the Standing Committee, the delay has adversely affected the financial benefits that could have accrued to the concerned parties and the people at large and is in fact now putting a financial strain on all concerned.

(X) It is directed that the Committee shall take firm steps and fix a definite timeframe to lay down the guidelines for completion of feasibility reports or other reports and shall ensure the completion of projects so that the benefits accrue within reasonable time and cost.

Xxxxxxx xxxxxx xxxxxx

(XIII) There are projects where the paper work has been going for the last ten years and at substantial cost to the public exchequer. Therefore, we direct the Central and the State Governments to participate in the program and render all financial, administrative and executive help to complete these projects more effectively.

Xxxxxxx xxxxxx xxxxxx

(XV) The Committee constituted under this order shall be responsible for carrying out the inter-linking program. Its decisions shall take precedence over all administrative bodies created under the orders of this Court or otherwise.

Xxxxxxx xxxxxx xxxxxx

66. We not only express a pious hope of speedy implementation but also do hereby issue a mandamus to the Central and the State Governments concerned to comply with the directions contained in this judgment effectively and expeditiously and without default. This is a matter of national benefit and progress. We see no reason why any State should lag behind in contributing its bit to bring the Inter-linking River Program to a success, thus saving the people living in drought-prone zones from hunger and people living in flood-prone areas from the destruction caused by floods.

Thus while all institutions, experts and the highest Court of the Country opined for speedy implementation of ILR to tide over the gap between demand and supply, in reality the progress is too slow. This necessitates to enact an Act to implement ILR without hurdles.

No need for obtaining concurrence from upper riparian for Intra-linking

Whenever a lower riparian state (tail end state) wants to utilize the surplus flood flows of a river by diverting to a deficit basin, that is, by Intra linking, the need to get the concurrence from the upper riparian state is unwarranted, since in no way it affects the utilization or use by the upper riparian state. These proposals aim to reduce the problems faced by flood water to certain extent, and also benefit the drought prone areas. Therefore, instead of putting a hurdle by asking the lower riparian State to get the concurrence of the upper riparian state, GoI should encourage and provide financial support. While the policy of GoI is for diverting the surplus waters from a basin to a deficit basin, imposing the above said condition is not in line with the Water policy of GoI. Therefore, NWDA should **not impose the condition, namely, obtaining the concurrence of upper riparian States by lower riparian State, especially tailend State, for implementing intra linking schemes.**

Law for implementing Inter linking of rivers

For implementing **Inter linking of rivers,** the schemes which are of National importance, the Union of India has to enact a law in Parliament by virtue of powers conferred under Article 246 Entry 56 List I (Union List) and 248 (I) read with entry 97 of Union list I under 7th Schedule of Constitution, for speedy implementation of inter linking of rivers to alleviate the problems of poor people living in drought prone and water short areas of the Nation.

Inter state water disputes

Conflicts are not a feature peculiar to co-riparian States in India. Disputes between the Nations in sharing the waters of inter-state rivers have long been common in the world. United States of America, European Countries, African Countries, etc., had faced with Inter State Water Disputes in the past. Both the GoI Act of 1935 and the Constitution of India of 1950, have listed irrigation as a State subject, and inter-State rivers as a Union subject. This has, to some extent, aggravated the problem. Disputes relating to the waters of inter-State rivers had risen even before the enforcement of the GoI Act 1935. The dispute in sharing Cauvery waters arose between then Madras and Mysore as far back as 1884, which resulted in 1892 Agreement, and again the dispute cropped up in 1909 and ended with an agreement signed in 1924, on both occasions the Agreements were reached after long correspondence and negotiations. The dispute again flared up between the successor States of Madras, now Tamil Nadu, and Mysore, now Karnataka, since 1972, which had been adjudicated by a special Tribunal, viz., Cauvery Water Disputes Tribunal (CWDT), from 1990 to 2006, and pronounced its Decision and Report on 05.02.2007. The Decision of CWDT was notified in GoI Gazette after six years on 19.03.2013. Still, this 40 years old dispute is not completely over. Civil appeals on the Decision of the CWDT filed in the Hon'ble Supreme Court and Clarification petitions filed in CWDT are pending, since 2007.

It does not mean that the dispute arise always among the basins states. There are examples of Inter State water issues which are settled amicably by negotiation/ arbitration / reconciliation. Parambikulam Aliyar Project, which is a mammoth project, has been constructed based on the Agreement entered into in 1970 after negotiation between the State of Tamil Nadu and State of Kerala. The other example is Krishna Water Supply Project in which the States of Maharashtra, Karnataka, and Andhra Pradesh agree to supply to Tamil Nadu each 5 TMC, totally 15 TMC, from the Krishna waters to meet the drinking water supply of Chennai Metropolitan city in the year 1977.

Conflicts in water sharing will grow because the sectoral demands continue to increase with the swelling population. With the utilizable waters becoming scarer and scarer more disputes arise between the States and Nations. India has to deal with intra-state, inter-state, and international disputes. No doubt participatory and conciliatory approach is preferable to settling the disputes by adjudication which is a long drawn process. In this scenario, it is worth to look into the existing system of settling the Inter State Water Disputes.

Inter-State Water Disputes (ISWD) Act 1956

The ISWD Act enacted under Aticle 262 of our Constitution, is for the adjudication of disputes between party States in the use of waters in a river basin by exclusive Tribunals. No other court has jurisdiction on such disputes. Since 1969 seven separate Tribunals were constituted under the provisions of ISWD Act 1956, to adjudicate river water disputes. The ISWD Act has provided for step-by-step procedure for adjudicating an inter-State water dispute by a Tribunal. The Act was amended in 1980 and again 2002.

Constitution of the Tribunal

The ISWD Act, Section 3 (as amended in 2002), provides for any State Government to request the GoI to refer the water dispute to a Tribinal that had arisen or apprehend to arise. When such a request is received and when GoI is of the opinion that the water dispute cannot be settled by negotiation, the GoI within a period not exceeding one year from the date of receipt of such a request (as per Section 4(1) of the Act) shall by notification in the official Gazette constitute a Water Disputes Tribunal for adjudicating the dispute. The Chief Justice of India then appoints the Chairman and Members of the Tribunal. Thus constituted Tribunal may appoint two or more Assessors to assist them as per Section 4(3) of the Act. This time limit to decide on constituting a Tribunal may be reduced to six months.

Report and Decision under Section 5(2)

As per the Section 5(2) of the Act the Tribunal shall investigate the matters referred to it and forward to the GoI a report with its decisions. While the Act was amended in 2002 a period not exceeding three years has been fixed for giving its report and decisions. However, GoI may extend this period for a further period not exceeding two years, provided that, if the decision cannot be given for unavoidable reasons.

Further Report under Section 5(3)

The Act under Section 5(3) provides for the GoI and party States to request the Tribunal to give explanation or guidance upon any point not originally referred to the Tribunal, within 3 months from the date of the report and decisions of the Tribunal pronounced under Section 5(2) of the Act. On such reference the Tribunal may forward to the Central Government a ‘further report’ within one year from the date of such reference. This period (one year) may also be extended by the GoI for such a period as it considers necessary. A time limit has to be fixed even for the extension period.

Publishing in the official Gazette

The GoI as per Section 6(1) of the Act shall publish the report and decisions of the Tribunal in the official Gazette. Only then the decision shall be final and binding on the parties to the dispute and shall be given effect to, and it shall have the same force or as an order or decree of the Supreme Court. The decisions of the Tribunal are expected to be published in the official Gazette immediately after the Tribunal sends its report. However, in the Act no time limit has been fixed for the above action. Since the order of tribunal is equivalent to a decree of the Hon’ble Supreme Court as per the Act amended in 2002, the provision to notify the award is not necessary. Therefore, to that extent an amendment to the ISWD Act is required.

Implementation of the Decision

The GoI to give effect to the decision of the Tribunal has to frame a “Scheme or Schemes” and it has to be notified in the official Gazette as per Section 6A (1) of the Act. Scheme thus framed and every regulation made under a Scheme shall be laid before each House of Parliament while it is in session for a total period of thirty days which may be comprised of one or more successive sessions. Both the Houses may modify the Scheme. In the Cauvery dispute it took seven years for framing a Scheme to implement the Interim order dated 25th June 1991. For the final Award dated 5th February, 2007 GoI has not constituted the scheme recommended by the Tribunal, viz., Cauvery Management Board and Cauvery Water Regulation Committee. Thus framing a Scheme itself take considerable time depending on the political balance between the GoI and party States. Presently some Tribunal frame a scheme and includes in their report, some gives only its recommendation. If the Tribunal itself framed a “scheme” and included in its report then delay and ambiguity could be avoided. If the Act is amended suitably the implementation of the decisions of the Tribunal under Section 5(2) and 5(3) would not get delayed.

Functioning of the Tribunals in India

For each inter-State river water dispute a separate Tribunal is constituted under the ISWD Act. Procedurally speaking a Tribunal is more informal, it need not strictly adhere to the rules of evidence, it can adopt a more flexible approach and it can combine in both legal and technical talents, which give it certain advantages. Out of the seven Tribunals, the CWDT has taken a very long time, 16 years and 8 months, to pronounce its verdict. The time taken by the other Tribunals are given in Table-1.

Table 1.

Tribunal	Party States	Period for 5(2)	Period for 5(3)
Godavari Water Disputes Tribunal (GWDT)	Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Odisha	10.04.1969 to 27.11.1979 (10 years & 7 months)	26.02.1980 to 07.07.1980 (5 months)
Krishna Water Disputes Tribunal (KWDT) - I	Maharashtra, Karnataka and Andhra Pradesh	10.04.1969 to 24.12.1973 (4 years & 8 months)	16.09.1975 to 27.05.1976 (8 months)
Krishna Water Disputes Tribunal (KWDT) - II	Maharashtra, Karnataka and Andhra Pradesh	19.06.2006 to 30.12.2010 (4 years & 6 months)	28.03.2011 to 29.11.2013 (2 years & 8 months)
Narmada Water Disputes Tribunal (NWDT)	Madhya Pradesh, Maharashtra, Gujarat and Rajasthan	06.10.1969 to 16.08.1978 (8 years & 10 months)	16.11.1978 to 07.12.1979 (1 year)
Ravi Beas Water Disputes Tribunal (RBWDT)	Haryana, Punjab and Rajasthan	02.04.1986 to 30.01.1987 (10 months)	19.08.1987 (Continuing)
Cauvery Water Disputes Tribunal (CWDT)	Tamil Nadu, Karnataka, Kerala, and Puducherry	02.06.1990 to 05.02.2007 (16 years & 8 months)	04.05.2007 (Continuing) Note: Civil Appeals are also pending in the Hon'ble Supreme Court.
Mahadayi (Mandovi) River Water Disputes Tribunal (MWDT)	Goa, Karnataka and Maharashtra	16.11.2010 (Continuing)	—
Vansadhara River Water Disputes Tribunal (VWDT)	Andhra Pradesh and Odisha	24.02.2010 to 17.12.2013 (3 years & 10 months)	Note: Civil Appeals on 5(2) order is pending in the Hon'ble Supreme Court.

Reconstitution of the Tribunal

The constitution of the CWDT itself was changed thrice. Firstly the Chairman of the Tribunal himself resigned in July 1996, (i.e.) after hearing the case for about 5 years. Secondly a Member of the Tribunal who heard the case for about 12 years passed away, and thirdly the Chairman resigned due to ill health. GoI took about 5 months, 3 months and more than a year, respectively to reconstitute the Tribunal. GWDT was reconstituted twice since one member resigned within 8 months after constituting the tribunal, and for the second time due to the demise of a member after hearing the case for about 6 years. Similarly the NWDT was reconstituted thrice. Delay in reconstitution of a Tribunal generates further delay in delivering the Award. As per section 4(2) of the Act only Sitting Judges are appointed to the Tribunal. In all the Tribunals only Judges with a balance service of about six months or less have opted for and appointed. Perhaps if Judges with a longer balance of service are appointed the unavoidable reconstitution of the Tribunal could be minimised.

Equitable apportionment & Helzinki Rules

In India, the Riparian thory has been adopted all along in deciding on water sharing issues. Priority of use had always been accepted. Existing uses have been given priority while formulating new proposals. In recent times, the Equitable apportionment theory is followed while sharing the waters of a basin among the basin States. KWDT and CWDT have adopted Equitable apportionment theory. Government of India has not issued any guidelines or formulated policy guidelines on adopting Equitable apportionment theory. However, the Tribunals have adopted Helsinki Rules, which was developed by International Law Association in the conference held in Helsinki in 1966. In the Rules chapter 5, viz., Guidelines for equitable distribution, the relevant factors to be considered are listed. However, emphasis has to be given for the existing uses while considering new uses by the co-basin states.

Infrastructure for the existing uses have been developed over the years by incurring huge expenditure. Tax payers money and the hard labour of the farmers or stake holders are involved. The sustainable livelihood accrued over the years cannot be ignored while considering the new uses in the co-basin states. The article VIII of the Helsinki rules states as below:-

"1. An existing reasonable use may continue in operation unless the factors justifying its continuance are outweighed by other factors leading to the conclusion that it be modified or terminated so as to accommodate a competing incompatible use."

Therefore, while considering equitable distribution of waters of a basin, greater consideration has to be given for the existing uses and it should not be disturbed unless it is proved not beneficial. The Campione Consolidation of the ILA Rules on International Water Resources 1966-19999 which is similar to Helsinki Rules has also consider the past utilisation of the waters of a basin, including in particular existing utilisation as a relevant factor. In the UN convention, 1997, a resolution was made to adopt the Laws of the non-Navigational uses of International water courses which is similar to Helsinki Rules. India is not a party to that. Hence, it need not adopt these rules as it is. Existing beneficial past uses in the guise of equitable apportionment cannot be omitted as done by CWDT in apportioning the waters of Cauvery basin. GoI has to issue policy guidelines on this.

Permanent Single Water Disputes Tribunal

Union of India has aired its view on constituting a "A permanent Water Disputes Tribunal at Centre", a single Tribunal as stated supra. At present designated Tribunals for water disputes are functioning. The establishment of a Permanent Tribunal (Single Tribunal) will be ineffective. The disputes that arise in several river basins are very varied in purport and content. Also river basins differ widely in the total availability, utilization and nature of use of water in them. Socio economic conditions and other parameters that are to be considered in allocating the resource in a basin vary from basin to basin. It is only because each river basin is unique in its characteristics and the water disputes that arise are complex in their mode, unlike the usual civil and criminal cases normally dealt with the Courts, it is felt that it is wise to leave such disputes to be handled by the Tribunals which are special courts with all powers together data and direct the party states to lead evidence on all technical and other aspects of the disputes. Hence, the idea of constituting a Permanent Water Disputes Tribunal, single Tribunal for the adjudication of disputes, amongst the States regarding inter-state Rivers, needs reconsideration and not to be pursued.

Appeal provision

The experience of Tamil Nadu in the case of Cauvery Water Dispute is,

The Tribunal pronounced its award on 05.02.2007 and it was notified on 19.02.2013, i.e., after a delay of six years. The Civil appeals filed by the party States in April/May 2013 are pending in the Hon'ble Supreme Court, since then. There is no time limit for disposing the Civil appeals. It is not known when they will be taken up for hearing. Therefore, it is felt that once the decision is taken under Section 5(2) and clarification issued under Section 5(3) of the ISWD Act, no further provision is required for an appeal. For that the law needs to be amended.

CONCLUSION

Inter and intra linking of rivers are to be executed with no further loss of time to tide over the gaps in water demand and supply and to meet the needs in time and space. In the process of imlementation several hurdles including legal would arise. Therefore, to meet them a law is felt necessary for implementing inter linking of rivers. Government of India through the Parliament has to enact a law, by virtue of the powers conferred under the Article 246 Entry 56 List I (Union List) and 248(1) read with Entry 97 of List 1 (Union List) of the Seventh Schedule of the Constitution, for implementing the interlinking of major rivers in the Country, so as to facilitate early execution of Interlinking of Rivers Project.

The Tribunals constituted under ISWD Act 1956 is taking enormous time than expected to give its report. Even though amendments to the Act has been made in 2002 fixing time period for the disposal of the issues, the decisions of the tribunal are stuck either in the Supreme Court or in the process of implementation of the decision. In order to quicken the process of settling the Inter State Water Disputes through the Tribunals the ISWD Act 1956 has to be revisited for efficient use of the available water equitably which would help to proceed with the development and efficient utilisation of the resource and strengthen the unity in our Country. Some of the sections of the ISWD Act have to be amended. They are

- In the section 3(1) of the Act the period to constitute a Tribunal by GoI has to be reduced from one year to less than six months.
- To avoid frequent reconstitution of the Tribunal the section 3(2) of the Act has to be amended such that a judge with considerable balance service is considered for nomination.
- In section 5 (3) the extension period of the Tribunal too has to be fixed.
- Since the order of tribunal is equivalent to a decree of the Hon'ble Supreme Court the provision to notify the award in GoI Gazette is not necessary and hence that provision under section 6 (1) has to be repealed.
- The Tribunal itself should frame a Scheme for implementing its decision and include it in its report instead of recommending a Scheme which has to be approved by the Parliament, as per section 6A (1). For that this section needs amendment.
- Since the Tribunal decides and pronounces its award both under sections 5(2) and 5(3), there should be no appeal provision in any other Court including Supreme Court.

GoI has to issue policy guidelines on equitable apportionment considering the beneficial uses of the water existing for long in a basin.

Note: The views expressed by the author are his own.

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Evaluate the Environmental Impact of Red Mud Utilization and Explore the Means to Allay the Leaching Problem

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ABSTRACT

Red mud is one of the major waste produced from aluminum industry which utilize bauxite (Al2O3) as raw material to extract aluminum out of it. This research work investigates the suitable utilization for a particular red mud samples depending upon its permeability and leachate characteristics. The Fly ash content was varied from 0%, 15% and 25% and gypsum content is varied from 0%, 0.25% and 0.75% of dry weight of the red mud. The main objective of this research work is to evaluate the environmental impact of red mud utilization and explore the means to allay the leaching problem. The effect on the toxic metals in the leachate coming out from the compacted mix when fly ash is added solely or when combined with gypsum to red mud is to be clarified. The permeability and leachate characteristics are studied for different flowing periods from 1 to 7 days of each sample combination. An attempt further was made to understand the metal concentration in the leachate of raw red mud, red mud – fly ash and red mud-flyash–gypsum combinations. It is revealed from the test results and analysis Total amount of metals leaching from compacted red mud fill per day can be minimized by stabilizing red mud with fly ash and gypsum. But the response to stabilization depends on the presence of metals.

INTRODUCTION

Depending on the source of bauxite used in aluminum industries, red mud which is the waste product of this process may contain different toxic metals and may contaminate the ground water. When water flows through red mud fill, it may carry toxic metals and may contaminate surface water sources also. The presence of toxic metals may not be considerable sometimes but biomagnifications of these metals may aggravate the situation. Thus, these toxic metals emanating from red mud may be responsible for different health hazards of surrounding habitats. There are different means available to mitigate leaching problems. Thus stabilization of red mud with fly ash, gypsum may be one of the most useful method to mitigate the environmental problems, leaching and dusting. Through stabilization process, the exposed surface area can be reduced along with encapsulation of metals, to minimize the leaching of metals. In the present investigation, an attempt has been made to study the leachate properties of stabilized red mud by using fly ash and gypsum. On the basis of economy consideration, fly ash was selected as stabilizing material small percentages of gypsum was also used to enhance strength of the matrix and for better encapsulation of heavy metals from Leachate.

Subrat Kumar Rout et.al (2012) had determined the physical and chemical properties of red mud and made a comparative study of red mud with the soil and fly ash. A.R. Hind et al, (1999) studied the chemical properties of red mud. A chemical analysis would reveal that RM contains major constituents: silica, aluminum, iron, calcium, titanium. The minor constituents: Na, K, Cr, Ni, Ba, Cu, Mn, Pb, Zn etc. Y Zhang, et al, 2001 studied the incoherence and high content of fine sand and coarse silt determine the importance of permeability research of red mud. As per the Author, it is weakly permeable with k 2.57 x 10e-5 and 3.62 x 10e-5 cm/s. The filtration coefficient of red mud affected by penetrating water tends to increase gradually because of leaching of easily soluble salts and flocculation of Ca++ lead to rapid decrease of salts. Semra C oruh, et al, 2009 studied Use of fly ash, phospho gypsum and red mud as a liner material for the disposal of hazardous zinc leach residue waste . In the study, leachability of heavy metals from the zinc leach residue has been evaluated by mine water leaching procedure and toxicity characteristic leaching procedure (TCLP).

MATERIALS

Red Mud **-** For the present work the red mud was collected from HINDALCO Ltd, Uttar Pradesh. The geotechnical properties of red mud like specific gravity (3.02), plasticity index (13.7), compaction characteristics (OMC = 35.0, MDD = 1.57 gm/cc), Unconfined compression strength (0.123 MPa), permeability (5.786e-7cm/s). It can be seen that the red mud is highly alkaline with PH value of 11.3 and the specific gravity (3.02) is also very high compared to soil (usually 2.65). The high specific gravity of red mud is due to presence of iron rich minerals. As per IS soil classification it can be classified as silt of medium compressibility (MI).

Lime **-** Lime in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – Ca $[OH]_2$), or lime slurry can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone – $CaCO_3$) into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. For the present work hydrated lime is used.

Gypsum - Anhydrous gypsum, Analytical quality is being used. Gypsum enhances the pozzolanic reaction between Red mud and hydrated lime. The analytical quality was chosen to avoid the interference of impurities which may retard the initial hydration process.

Test Program

The effect of variation of fly ash and gypsum on the red mud is studied for different aspects. Nine samples of varying fly ash and gypsum content by dry weight of red mud, as shown in Table 1 were prepared and tested for permeability and leachate analysis.

Table 1. Sample Combinations

S.No.	Sample
1	RM + 0 FA + 0 G
2	RM + FA + 0.25G
3	RM + FA + 0.75G
4	RM + 25FA + 0 G
5	RM + 25FA + 0.25G
6	RM +25FA + 0.75G
7	RM + 15FA + 0 G
8	RM + 15FA + 0.25G
9	RM + 15FA + 0.75G

RM - red mud, **FA**-Fly ash, **G**-gypsum. (Numerals in the combination stand for the % by dry weight of red mud)

LEACHATE ANALYSIS OF STABILIZED REDMUD

In this investigation water was allowed to passing through compacted specimens and the water coming out from the samples was analyzed for metals. Here the testing procedure very close to the field condition where water will passage through compacted red mud media and subsequently join the ground water. The effluent coming out from the outlet of the Permeability mould was collected in sampling bottle. The bottles were washed with acetone and distilled water before collecting the samples. To prevent volume change and evaporation, the samples were kept in refrigerator and analysis was done by using PC based double beam Spectro Photo Meter without any delay. The lowest of the allowable limits for drinking water of World Health Organization (WHO, 1984), Guidelines for Canadian Drinking Water Quality (GCDWQ, Department of Health and Welfare, 1979) and National primary Drinking water standards of EPA, USA (1980), the Indian drinking water standards and European drinking water standards are compared for present research work. The operating properties of the instrument for estimation of the metals analyzed for the present research are given in Tables presented bellow.

Table 2. Metal Concentrations in Leachate (ppm) for RM+0 FA+0 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	8.32	0.42	ND	ND	0.20	ND	0.27	0.30	0.21	0.35	ND	ND	0.25	ND
2	2 Day	8.01	0.44	ND	0.19	ND	0.12	ND	0.30	ND	0.34	ND	0.29	0.24	0.19
3	3 Day	7.60	0.41	0.21	0.15	ND	0.08	0.12	ND	ND	0.32	ND	ND	ND	0.18
4	4 Day	6.50	0.39	0.19	0.13	ND	0.02	ND	ND	ND	0.32	ND	0.26	0.22	ND
5	5 Day	7.12	0.34	0.17	0.12	ND	0.03	ND	ND	ND	ND	0.31	0.25	ND	ND
6	6 Day	6.10	0.31	0.15	0.11	ND	0.03	ND	ND	ND	ND	0.34	0.26	ND	ND
7	7 Day	6.00	0.31	0.14	ND	ND	ND	ND	ND	ND	ND	ND	0.24	ND	ND

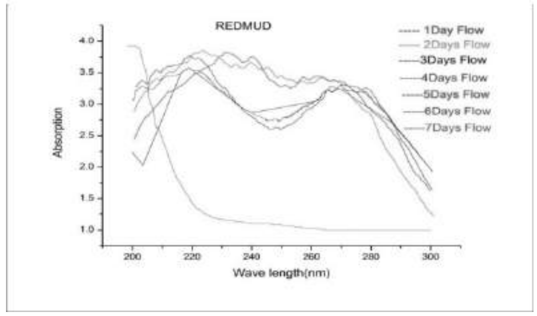

Figure 1. Wave length Vs Absorption

Table 3. Metal Concentrations in Leachate (ppm) for RM+25 FA+0 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	8.41	0.36	ND	ND	ND	0.21	0.45	ND	0.17	ND	ND	ND	ND	ND
2	2 Day	7.60	0.38	ND	0.18	ND	ND	ND	ND	ND	ND	ND	0.25	ND	0.23
3	3 Day	6.80	0.38	ND	0.17	ND	ND	ND	ND	ND	0.17	0.12	0.26	0.17	0.21
4	4 Day	5.70	0.37	ND	0.17	ND	ND	ND	ND	ND	ND	0.14	ND	0.16	0.19
5	5 Day	5.10	0.36	ND	0.14	ND	ND	0.24	ND	ND	ND	ND	0.25	0.15	0.22
6	6 Day	4.90	0.35	ND	0.12	ND	0.17	ND	ND	ND	ND	ND	ND	0.11	ND
7	7 Day	4.30	0.29	ND	0.12	ND	0.13	ND	ND	ND	ND	0.05	ND	ND	ND

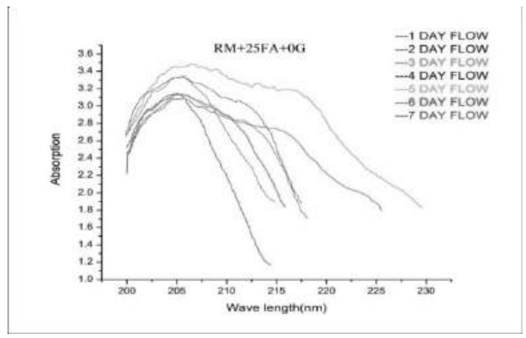

Figure 2. Wave length Vs Absorption

Table 4. Metal Concentrations in Leachate (ppm) for RM+15 FA+0 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	6.52	0.40	ND	ND	ND	0.39	ND	ND	0.20	ND	0.15	0.28	ND	ND
2	2 Day	5.61	0.38	0.22	ND	ND	0.14	0.27	0.30	ND	0.34	0.14	ND	ND	0.18
3	3 Day	5.24	0.37	ND	0.20	ND	ND	0.20	ND	ND	0.31	0.12	0.23	0.19	0.21
4	4 Day	4.15	0.34	ND	0.19	ND	ND	ND	0.28	ND	0.32	0.11	0.21	0.20	ND
5	5 Day	4.01	0.35	ND	0.17	ND	0.02	ND	ND	ND	ND	ND	0.21	0.18	0.20
6	6 Day	3.98	0.31	ND	0.17	ND	0.03	ND	ND	ND	ND	ND	ND	0.16	ND
7	7 Day	3.70	0.31	ND	0.15	ND	0.03	ND	ND	ND	ND	ND	0.21	0.17	ND

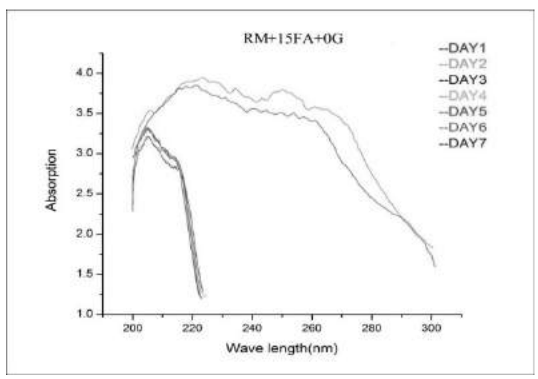

Figure 3. Wave length Vs Absorption

Table 5 Metal Concentrations in Leachate (ppm) for RM+0 FA+0.25 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	8.12	0.41	ND	ND	0.13	ND	ND	ND	ND	0.34	ND	0.24	ND	ND
2	2 Day	7.91	0.39	ND	0.18	0.12	ND	ND	ND	ND	0.33	ND	0.23	ND	0.15
3	3 Day	7.5	0.37	ND	0.15	ND	ND	ND	ND	ND	0.32	ND	ND	ND	0.14
4	4 Day	6.7	0.37	0.19	0.14	ND	0.07	ND	ND	ND	ND	0.31	0.25	ND	ND
5	5 Day	6.31	0.36	0.18	0.19	ND	0.06	0.2	ND	ND	ND	0.29	0.25	ND	ND
6	6 Day	5.9	0.34	0.16	0.16	ND	0.03	ND	ND	ND	ND	0.29	ND	ND	ND
7	7 Day	5.81	0.31	0.15	0.14	ND	0.02	0.2	ND	ND	ND	0.27	0.21	ND	ND

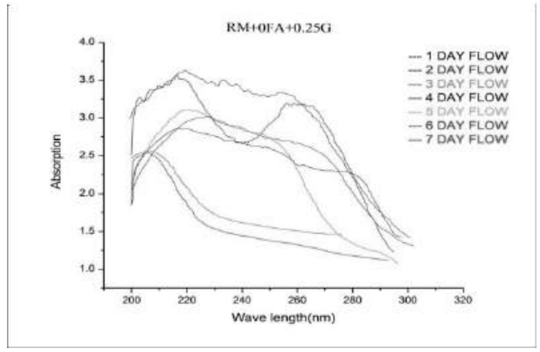

Figure 4. Wave length Vs Absorption

Table 6. Metal Concentrations in Leachate (ppm) for RM+25 FA+0.25 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	7.51	0.40	ND	0.18	ND	ND	ND	ND	ND	0.24	0.21	0.15	ND	ND
2	2 Day	6.24	0.38	ND	0.17	ND	ND	0.27	ND	ND	ND	0.23	0.13	ND	ND
3	3 Day	5.27	0.37	ND	ND	ND	ND	ND	ND	ND	0.23	ND	0.11	ND	0.15
4	4 Day	4.15	0.39	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.13	ND	0.18
5	5 Day	3.84	0.35	ND	0.16	ND	0.17	ND	ND	ND	ND	0.16	0.12	ND	0.14
6	6 Day	3.31	0.32	ND	0.13	ND	0.13	0.26	ND	ND	ND	0.08	ND	ND	ND
7	7 Day	3.12	0.31	ND	0.09	ND	0.18	0.23	ND	ND	ND	ND	ND	ND	ND

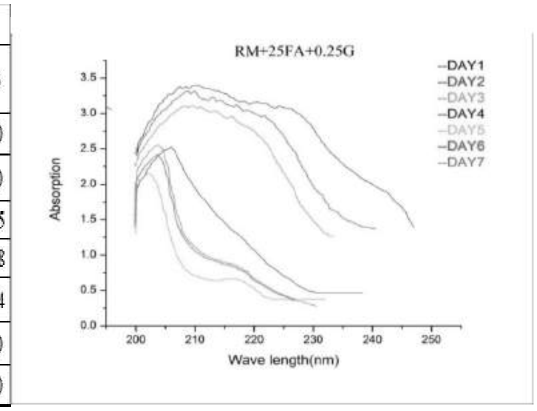

Figure 5. Wave length Vs Absorption

Table 7. Metal Concentrations in Leachate (ppm) for RM+15 FA+0.25 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	4.15	0.36	ND	0.21	ND	ND	ND	ND	ND	ND	ND	0.25	ND	ND
2	2 Day	4.03	0.35	ND	0.22	ND	ND	0.26	0.32	ND	0.30	ND	0.24	ND	0.17
3	3 Day	3.70	0.33	ND	0.21	ND	ND	ND	ND	ND	0.28	ND	ND	ND	0.17
4	4 Day	3.64	0.34	ND	0.23	ND	ND	0.24	0.30	ND	0.28	0.12	ND	ND	0.12
5	5 Day	2.95	0.32	ND	ND	ND	0.15	ND	ND	ND	ND	0.09	0.22	ND	0.09
6	6 Day	2.70	0.30	ND	0.21	ND	0.17	ND	ND	ND	ND	0.15	ND	ND	ND
7	7 Day	1.60	0.29	ND	0.24	ND	0.17	ND	0.31	ND	ND	ND	ND	ND	ND

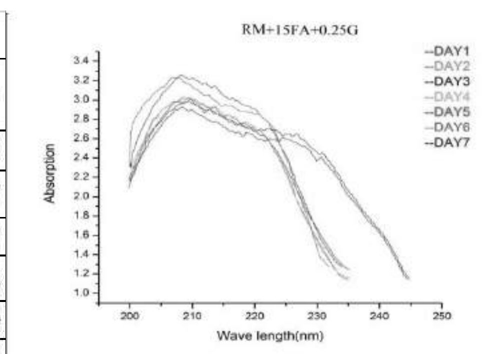

Figure 6. Wave length Vs Absorption

Table 8. Metal Concentrations in Leachate (ppm) for RM+0 FA+0.75 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	7.64	0.39	ND	ND	0.12	ND	ND	ND	ND	0.34	0.31	0.22	ND	ND
2	2 Day	7.2	0.38	ND	0.17	0.08	0.08	ND	ND	ND	0.32	ND	0.21	ND	ND
3	3 Day	6.8	0.38	ND	0.15	ND	0.07	ND	ND	ND	0.31	ND	0.23	ND	ND
4	4 Day	5.7	0.37	0.2	0.13	ND	0.05	ND	ND	ND	ND	0.29	ND	ND	ND
5	5 Day	5.2	0.35	0.2	0.12	ND	0.02	0.2	ND	ND	ND	0.28	ND	ND	ND
6	6 Day	4.9	0.32	0.2	0.1	ND	0.01	0.21	ND	ND	ND	0.24	0.21	ND	ND
7	7 Day	4.6	0.29	0.2	0.1	ND	0.05	0.18	ND	ND	ND	0.24	0.21	ND	ND

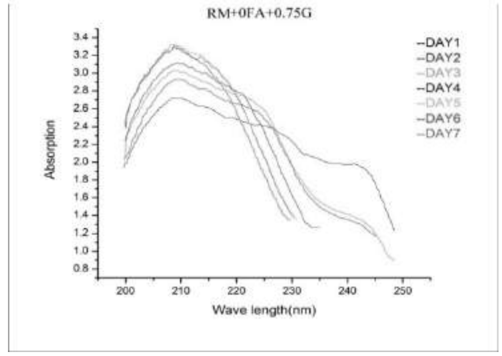

Figure 7. Wave length Vs Absorption

Table 9. Metal Concentrations in Leachate (ppm) for RM+25 FA+0.75 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	4.26	0.41	ND	ND	ND	0.42	ND	ND	ND	ND	0.33	0.28	ND	ND
2	2 Day	4.12	0.40	ND	ND	ND	0.36	0.21	ND	ND	ND	0.29	ND	ND	0.21
3	3 Day	4.07	0.39	ND	0.17	ND	0.38	0.23	ND	ND	ND	ND	0.29	ND	0.19
4	4 Day	3.92	0.38	ND	0.15	ND	0.36	0.18	ND	ND	0.21	ND	ND	ND	ND
5	5 Day	3.21	0.40	ND	0.18	0.81	ND	0.15	ND	ND	ND	0.39	0.28	ND	0.15
6	6 Day	2.97	0.38	ND	0.14	ND	ND	ND	0.28	ND	0.22	ND	ND	ND	ND
7	7 Day	2.70	0.35	ND	0.12	ND	0.31	ND	ND	ND	ND	0.27	0.23	ND	ND

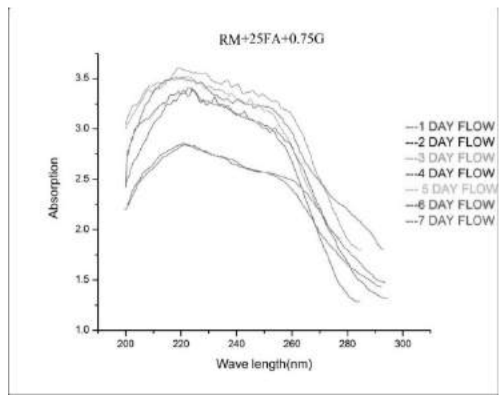

Figure 8. Wave length Vs Absorption

Table 10. Metal Concentrations in Leachate (ppm) for RM+15 FA+0.75 G Sample

S.No.	Flow period	Permeability, K(10 e-6) in cm/s	Metal concentration in ppm												
			Fe	Al	Si	Na	Ca	Cr	Mg	As	Mn	Cu	Ni	Zn	Pb
1	1 Day	3.94	0.29	ND	ND	ND	0.31	ND	ND	ND	ND	0.38	0.24	ND	ND
2	2 Day	3.71	0.27	ND	0.21	ND	0.33	ND	0.31	ND	ND	0.36	0.23	ND	0.18
3	3 Day	3.58	0.21	ND	0.22	ND	0.29	ND	ND	ND	ND	ND	0.24	ND	0.16
4	4 Day	3.40	0.18	ND	ND	ND	0.28	ND	0.34	ND	ND	0.33	0.21	ND	ND
5	5 Day	2.18	0.15	ND	0.23	ND	0.26	ND	ND	ND	ND	0.31	ND	ND	0.13
6	6 Day	1.20	0.12	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND	0.11
7	7 Day	0.80	ND	ND	ND	ND	0.01	ND	ND	ND	0.27	0.26	ND	ND	ND
8	8 Day	0.70	ND	ND	ND	ND	0.01	ND	ND	ND	0.27	0.26	ND	ND	ND

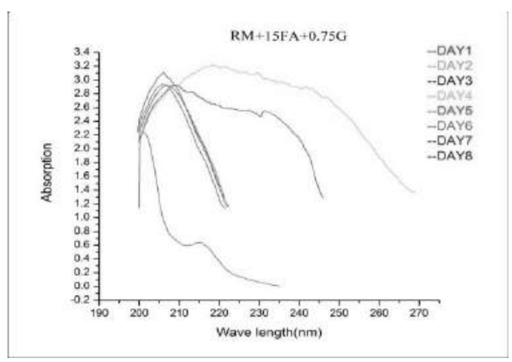

Figure 9. Wave length Vs Absorption

CONCLUSIONS

The important conclusions drawn from this study are as follows:

1. It is observed from Table 2 to 10 that the concentration of Fe is increasing with increase in gypsum for all combinations of raw red mud. But with stabilization by fly ash the concentrations of Fe is decreasing and is in the slightly above the limits for drinking water standards based on drinking water guide lines of World Health Organization (WHO, 1984), the Indian drinking water standards and European drinking water standards. The Fe concentration is very low for 15FA and 0.75G combination as compared to the others.
2. The concentration of Al in leachate for raw red mud was increasing with flow period. After mixing with gypsum alone the Al concentration is slightly increasing 0.14ppm to 0.2ppm with increase in flow period. But for stabilized red mud with fly ash and gypsum the Al was not determined in the leachate coming from the samples. The Al concentration in leachate was very nearer with drinking water standards irrespective of the sample proportion of raw red mud and flowing period.
3. The concentration of Si was decreased with increasing gypsum content and flowing period. But with stabilizing fly ash the Si concentration was increasing randomly. It may be due to the solubility of Si which is present in the fly ash.
4. The concentration of Na in leachate coming out from unstabilized red mud was slightly high, but with stabilization the concentration of Na in the leachate has not determined.
5. The concentration of Ca in leachate of raw red mud was very less. But by stabilization of red mud with fly ash the Ca concentration is increasing but the concentration value for Ca was below the allowable limit for drinking water quality but for some of the samples at a few flow periods, the concentration is altered randomly.
6. The Cr concentration in leachate for raw red mud was slightly decreased with increasing flow period and gypsum content. But with addition of fly ash only the Cr concentration in leachate was increased and the value was higher than the allowable limit for drinking water quality. But for some samples of 0.75G the Cr content is not determined.
7. The concentration of Mg in leachate coming out from Unstabilized fly ash was high, but with stabilization of red mud, the concentration of Mg in the leachate has decreased to very low value compared to drinking water standard irrespective of the sample proportion and flowing period. This may be due to the formation of $Mg(OH)_2$ in presence of low lime in fly ash.
8. The concentration of As in leachate was found at a 1 day flow periods of raw red mud and red mud stabilized with fly ash alone. This concentration exceeds the allowable limit for drinking water standards. But by addition of gypsum to stabilized red mud with fly ash the As was not found irrespective of flow periods.
9. The concentration of Mn in the Unstabilized red mud is higher. By stabilizing the red mud and with increase in flow period the Mn content was decreased below the maximum allowable limit for drinking water quality.
10. The concentration of Cu was decreased with increasing gypsum content and flowing period. But with stabilizing fly ash the Cu concentration was decreasing upto 15% of fly ash and then increasing randomly for 25% of fly ash content.
11. The concentration of Ni in the unstabilized red mud for 7 days flow period samples is above the allowable limit compared with drinking water quality. But with increased in fly ash and gypsum content the Ni concentration was reduced slightly. But for some samples with different flow periods this was altered.
12. The concentration of Zn in leachate was found for raw red mud and red mud stabilized with fly ash alone. This concentration exceeds the allowable limit for drinking water standards. But by addition of gypsum to stabilized red mud with fly ash the Zn concentration was not found irrespective of flow periods.
13. The concentration of Pb in the unstabilized red mud for 7 days flowing period samples is above the allowable limit compared with drinking water quality. But With addition of gypsum, the concentration of Pb is reduced.

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Environmental Friendly Alternative to Conventional Fuels for Hybrid Diesel Electric Power Systems

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ABSTRACT

Power is an important component of any nation. Continuous power needs can be met not only through single source, but also by integration of multiple alternate sources like solar, wind, tidal, diesel etc. to a hybrid electric power system. This hybrid system shall have the advantage of being economical and most importantly being environmentally friendly too. The hybrid systems can typically be exploited in different areas within the country. Diesel engine happens to be one of the most sought after element of power generation in a hybrid system. Diesel engines offer the flexibility in a hybrid system asa back-up or even as parallel power installations for grids thus making it a major control system. In spite of so many advantages the use of diesel engine integrated hybrid power generation systems are less preferred as they are dependent on a non-renewable fuel that is diesel. The paper highlights the scope for use of an alternate environmentally friendly fuel that can help in boosting our power generation through hybrid systems. One such alternative fuel is the biodiesel and is discussed in detail. In addition, efficiency assessment of a biodiesel production setup is dealt with.

INTRODUCTION

Though there are several conventional andnon-conventional power generation systems in India, severe power shortage associated with power quality problems still happens to be a major issue. Large voltage and frequency fluctuations, scheduled and unscheduled power cuts and load restrictions are still present because of the gap between the power demand and supply (Table 1).

Table 1. Energy and peaking availability during the year 2014-15 in India (CEA Report, 2015)

	Energy (MU)	Peak (MW)
Requirement	1,068,923	148,166
Availability	1,030,785	141,160
Shortage	-38,138	-7,006
(%)	-3.6	-4.7

Central Electricity Authority’s load generation balance report (2015) states that during the year 2014-15, though the total ex-bus energy availability increased by 7.4% over the previous year and the peak met increased by 8.7%, the shortage conditions prevailed in the country both in terms of energy and peaking availability.This short fall is being partially met through India’s renewable energy resources. Though the installed capacity of renewable energyhas grown from 3.9 GW in 2002-03 to about 33.8 GW in December 2014(LGBR Report, 2015) it still happens to be an insignificant component of the overall power consumption. Considering this, it becomes inevitable that this power requirement is bound to be met by increasing the stress on non-renewable sources thus putting environment in greater danger concentrating only on power requirements. One of the solution to the above problem being the use of non-conventional fuels like solar power, wind energy, tidal energy etc., which used on a standalone basis pose a significant disadvantages as they are scattered in different places throughout the country and largely dependent on weather and climatic conditions thus having an irregular power output. By combining these energy sources (hybrid) we can obtain an energy source that is both dependable and consistent. GOI assists through IREDA, a Public Limited Government Company to promote, develop and extend subsidized financial assistance for renewable energy and energy efficiency /conservation projects. Private entrepreneurs can take advantage of this assistance and play a vital role in green power generation and ensure energy security in the country. IREDAtoo is exploring options for setting up ofpower generation projects, particularly, based on Wind andSolar energy. In addition it is also planning to partner for setting up of Grid and Off-grid Renewable Energy

Power generation under consortium of Oil Marketing Companies which willplay an important role in the near future. Considering this it becomes equally more relevant to realize the role hybrid power systems shall play in power augmentation especially with the use of biodiesel (a renewable resource unlike conventional diesel) in generating clean power.

Hybrid Power Generation

Hybrid power system isincorporating or connecting or integrating different power generation sources with one major control system to get electricity in required quantity and quality. Generally this major control system happens to be the conventional diesel engine because diesel engines offer a significant advantage over other prime movers as back-up or parallel power installations for grids having typically high efficiency in part-load and full-load operation. Diesel power generators have the ability to complement the other generation sources by a swift response to load changes and also provide the grid with stabilizing spinning and non-spinning reserves in fluctuating conditions (Anon, 2010). Hybrid system can be configured in three different ways (Nema and Dutta, 2012):

(i) Grid connected

(ii) Off-grid with distribution system and for direct supply

(iii) Isolated off-grid

The first configuration is able to rely on grid if the hybrid system has problems. Similarly feeding the power to the grid, thereby, boosting the voltage and minimizing power cuts strengthens the grid. For off-grid configurations, the hybrid can either be connected to many load centers or can act as a source of supply for one or two loads, thus avoiding the need of a distribution system. An isolated off-grid system is usually used to charge batteries or supply power to small rural industry/households. These sources can generate energy in the form of AC power. But if the generated power is not utilized immediately then they can be stored in a battery as DC. Any appliance that run on DC current are directly connected to battery but most of the house hold appliances use AC power to run, the stored DC power needs to be re-converted into AC which is done using an inverter. An Inverter is an electrical circuit capable of turning DC power to AC power. The inverter has built in protection against short circuit, overheating, low battery voltage and overload. Figure 1 shows a schematic representation of a hybrid power generation from source to consumption.

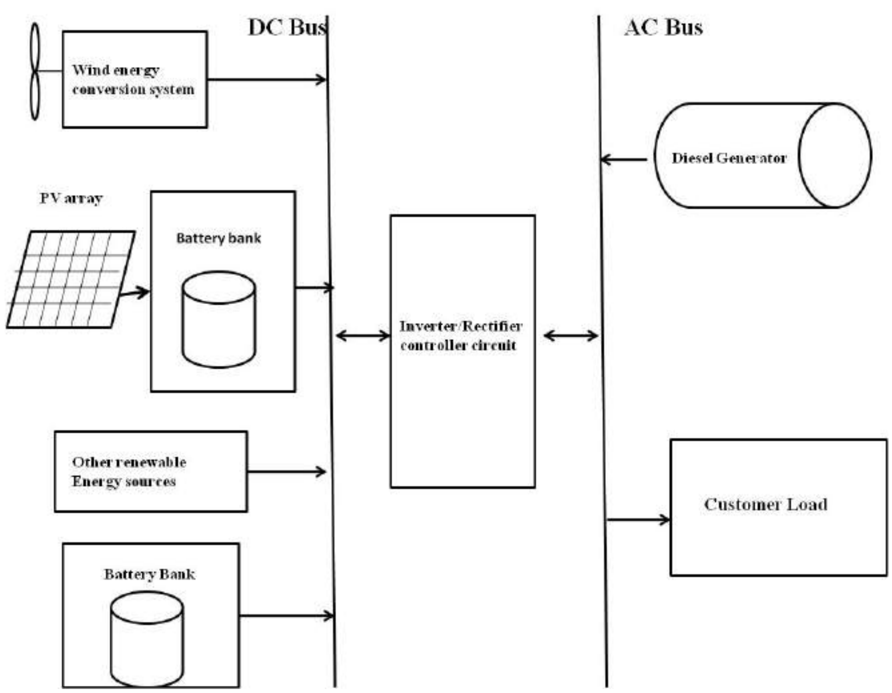

Figure 1. Representation of a hybrid power system (Deepak*et al.* 2011)

Concerns Related to Fossil Fuels

Diesel being a fossil fuel not only has its own supply and sustainability questions but also some disadvantages to be taken care off (Ajanovic, 2010):

- They are non-renewable energy sources combined with high demand. Figure 2 shows the ever increasing demand for fossil fuels as well as a significant increase in its import thus raising the cost of the fuel.
- Currently the use of fossil fuels is by far faster than their rate of formation.
- As reserves shrink, extraction of fossil fuels becomes more difficult and eventually becomes cost ineffective.
- There are always environmental and human costs involved in extraction and production of fossil fuels.
- Fossil fuel consumption produces green house gas (GHG) emissions.
- Much of fossil fuels have to be imported from politically unstable countries, making their supply unreliable.

Diesel generators due to the above fact have high running and maintenance costs. Despite the above disadvantages, diesel generators have the capability to burn a variety of fuels - natural gas, distillate oils, bio diesel and bio oils from diverse sources - that foster cleaner exhaust gas and lower greenhouse gas emissions for electricity generation. Such flexibility makes generating systems less sensitive to fuel price fluctuations than a single-fuel solution, adding an economical bonus to the environmental benefit. This flexibility offered by generators will help in utilization of biodiesel.

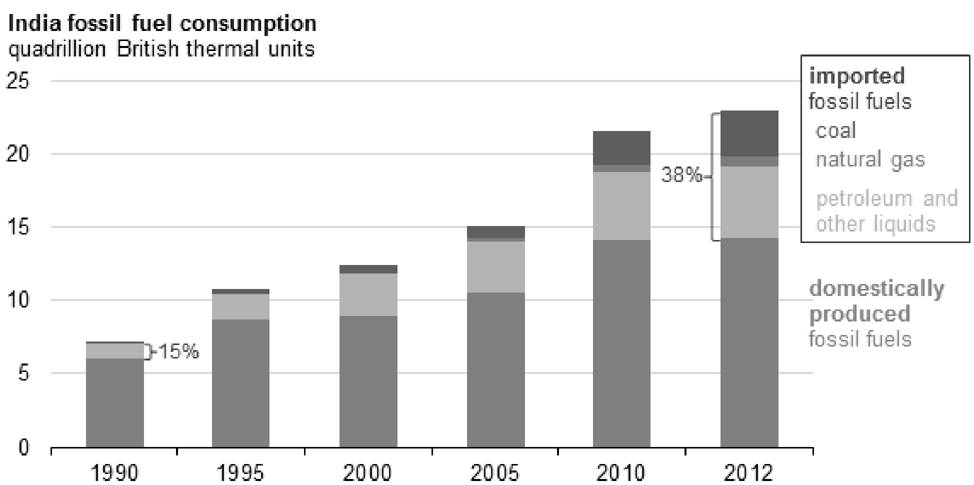

Figure 2. Shows the ever increasing demand for fossil fuels (open source online download).

Biodiesel

Biodiesel is an alternative to conventional diesel fuel made from renewable resources, such as non-edible vegetable oils. The oil from seeds (e.g., Jatropha and Pongamia) can be converted to a fuel commonly referred to as "Biodiesel." No engine modifications are required to use biodiesel in place of petroleum-based diesel. Biodiesel can be mixed with petroleum-based diesel in any proportion. Biodiesel is considered "climate neutral" because all of the carbon dioxide released during consumption has been sequestered out of the atmosphere during crop growth. The use of biodiesel results in lower emissions of unburned hydrocarbons, carbon monoxide, and particulate matter. Biodiesel also increases catalytic converter efficiency in reducing particulate emissions. Chemical characterization also revealed lower levels of some toxic and reactive hydrocarbon species when biodiesel fuels were used (Anon, 2011). The fuel consumption in the world particularly in developing countries has been growing at alarming rate. Diesel prices are approaching record highs and they will deplete within few decades, it is clear that more can be done to utilize domestic non-edible oils while enhancing our energy security. The economic benefits include support to the agriculture sector, tremendous employment opportunities in plantation and processing. Jatropha and Pongamia are known just crude plants which grow on eroded soils and even in hot climate and hardly require any water to survive. These are the strong reasons, enforcing the development of biodiesel plants. In addition to the non-edible vegetable oils edible oils too can be used to produce biodiesel. Even the left over oils from the deep fry pans of the fast food chains can be a great source.

Biodiesel Production

There are three basic routes to biodiesel which is an alkyl ester production from oils and fats:

(i) Base catalyzed transesterification of the oil with alcohol.

(ii) Direct acid catalyzed esterification of the oil with methanol.

(iii) Conversion of the oil to fatty acids, and then to Alkyl esters with acid catalysis.

Base Catalyzed Transesterification

A fat or oil is reacted with an alcohol, like methanol, in the presence of a catalyst to produce glycerin and methyl esters or biodiesel. The methanol is charged in excess to assist in quick conversion and recovered for reuse. The catalyst is usually sodium or potassium hydroxide which has already been mixed with the methanol. The majority of the alkyl esters produced are done with the base catalyzed reaction because it is the most economic for several reasons (Anon, 2015)

(i) Low temperature (150 F) and pressure (20 psi) processing.

(ii) High conversion (98%) with minimal side reactions and reaction time.

(iii) Direct conversion to methyl ester with no intermediate steps.

(iv) Exotic materials of construction are not necessary.

Table 2 gives the comparison of some of the salient properties of Jatropha based biodiesel with conventional diesel (Anon, 2011). The process of manufacture of biodiesel and the properties of biodiesel are more or less similar for Jatropha and Pongamia.

Table 2. Jatropha biodiesel properties compared with petro-diesel (Anon, 2011)

Property	Biodiesel	Petroleum diesel
Density @ 30C	0.88	0.85
Combustion point	192	55
Kinetic viscosity	4.84	228
Calorific potential	41	45

Efficiency of Biodiesel (Mathematical aspect)

Energy efficiency in biofuel production and utilization of it in a hybrid as a fuel for the diesel generator which usually is a major control system is important. Different agricultural systems have different energy returns, in order to consider all the energies involved in cultivation as well as production the concept of EROEI was formulated (Cleveland, 2008., Mulder and Hagens, 2008., Hall and Day, 2009**)** which is an energy efficiency indicator for a given agro-ecological system.

Energy Return on Energy Invested (EROEI)

Production of any biofuel is a work process as stated by Cleveland (2008) in which the materials i.e. the feedstock crops are concentrated, refined and transformed at free energy costs and is also a function of land, labour, water and many more raw materials which themselves need input energy. This energy return on energy investment can be calculated by the following equation:

$$\text{EROEI} = \frac{\text{Energy required to get that energy}}{\text{Energy returned to society}} \qquad (1)$$

The energy input and energy output are all different in different technologies besides, energy comes in different qualities which may be hard to compare and hence EROEI is based on a solid thermodynamic principles. Mulder and Hagens (2008) classify the level of EROEI analysis as 1^{st}, 2^{nd} and 3^{rd} order EROEI based on input and output energy. The first order EROEI deals with only direct energy and non-energy inputs and direct energy outputs i.e., it includes energy input from cultivation, transportation and energy for conversion of feed stock at a refinery plus the direct energy output of methyl ester (biodiesel) formed. It misses many critical energy inputs (example steam energy) and ignore co-products which makes it superficial yet is helps in deciding or getting an overall idea about the project. The second order EROEI analysis include indirect energy and non-energy inputs and co-products into analysis which requires critical energy allocation method and defining for boundaries thus including cost of other products as well as waste products in addition to what is included in first order EROEI and making it more accurate energy indicator. The third order EROEI analysis incorporates additional energy cost for externalities of energy production system. Here external costs and energy costs due to negative effects of whole production system are as well taken into account and hence considered to be most accurate. EROEI value of less than 1 is considered to be ‘unsustainable’. Hall and Day (2009) calculated the minimum EROEI to be 3:1 in order to support continuing economic activity and social function. (Melese, 2011)

CONCLUSION

It can be seen that hybrid power generation ensures continuity in power supply and helps in utilization of alternate sources power generation and fuels.As renewable sources of power generation are invariably dependent on many external factors they are not preferred as standalone power generation system, however they shall be effective when integrated into hybrid power generation.Constructing a hybrid with all the possible renewable power sources feasible at that location with diesel generator as the major control system, ensures continuous power supply as well as provides backup in case the renewable sources fail to generate the required amount of power. In addition, diesel substitution with biodieselnot only keeps a tab on non-renewable resource exhaustion but also makes way for a cleaner environment.

ACKNOWLEDGEMENT

I am extremely thankful to Principal, RV College of Engineering for his continued inspiration. I am thankful to my teachers for their guidance and support at RV College of Engineering, Bangalore.

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Environmental Impact Assessment on Kolleru Lake by using Geographical Information System: A Model Study

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ABSTRACT

An assessment for physico-chemical and biological quality of kolleru lake waters and surrounding of waters in the kolleru lake waters. The study of kolleru lake water quality was assessed during three months. . The study included physico-chemical and biological parameters for water and suitable remediation methods. A low value of Dissolves Oxygen and a high value of BOD were observed during all three months. Considerable amount of data was generated between the various parameters was done using Geographical Information System GIS 10.1 version software. It was found that the pollution occurred generally in two zones one concentrated in the sampling points nearer the industrial side. Environmental changes taking place in the lake should be monitored with the help of GIS and Satellite based image maps should be used as a basic input parameters for environmental mapping & monitoring of the lake environment

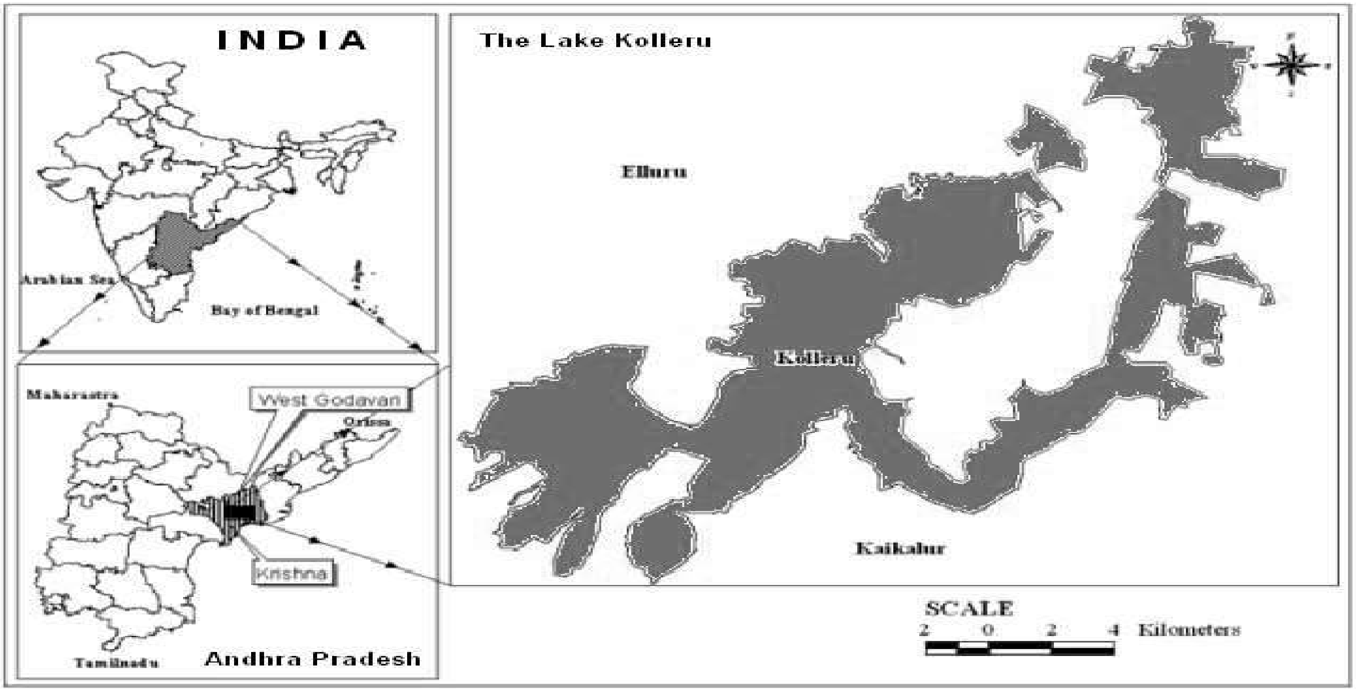
Keywords: Kolleru Lake, GIS, Pollution

1. INTRODUCTION

Kolleru Lake is suffering from the unsatisfied greed of people and selfish interests of mankind who exploit the lake's integrity. Thousands of fish tanks were dug up effectively converting the lake into a mere drain. This had great impact in terms of pollution, leading to difficulty in getting drinking water for the local people. This is in addition to the loss of ecological diversity and intrusion of sea water into the land masses and its fallout in terms of adverse influence on the rainfall pattern in this region. This imbalance has an adverse effect on the thousands of acres of crop in the upper reaches of sanctuary in view of stoppages of water flow into the sea because of obstruction by bunds of the fish tanks that appeared illegally. Kolleru Lake Satellite images taken on February 9, 2001 by the Indian remote sensing satellite found that approximately 42% of the 245 km² lake was occupied by aquaculture, while agriculture had encroached another 8.5%. The area under aquaculture consisted of 1050 fish ponds within the lake and 38 dried-up fish ponds, which together covered an area of 103 km². The agricultural encroachments were mostly rice paddies. Surprisingly no clear water could be found in the satellite image. The rest of the lake is being diminished by water diversions or was infested with weeds like elephant grass and water hyacinth. Rich in flora and fauna, it attracts migratory birds from northern Asia and Eastern Europe between the months of October and March.

1.1. Description of Study Area

Kolleru Lake is one of the largest freshwater lakes in India located in state of Andhra Pradesh. Kolleru is located between Krishna and Godavari delta. Kolleru spans into two districts - Krishna and West Godavari. The lake serves as a natural flood-balancing reservoir for these two rivers. The lake is fed directly by water from the seasonal Budameru and Tammileru streams, and is connected to the Krishna and Godavari systems by over 68 in-flowing drains and channels. This lake is a major tourist attraction. Many birds migrate here in winter, such as Siberian crane, ibis, and painted storks. The lake was an important habitat for an estimated 20 million resident and migratory birds, including the Grey or Spot-billed Pelican (Pelecanus philippensis). The lake was declared as a wildlife sanctuary in November 1999 under India's Wildlife Protection Act of 1972, and designated a wetland of international importance in November 2002 under the international Ramsar Convention. The wildlife sanctuary covers an area of 308 km².



1.2 Topography of Study Area

- Satellite data of IRS 1D, LISS III from 2004 and Survey of India topographic maps from 1967 were processed using image processing techniques in erdas imagine and analysed in Geographical Information System (GIS) such as ARC GIS 9.1
- This wetland spreads between $16^0$30’ to $16^0$45’N Latitude and $81^0$05’ to $81^0$20’E Longitude.
- Thus the total catchment area of Kolleru comes to 8923.99 sq.km

2. SCOPE AND OBJECTIVES

2.1 Scope

The present work is mainly to assess the impacts of pollution from industrial sources and agricultural sources on the physico–chemical and biological quality of Kolleru Lake. The scope of work further involves studying the feasibility of various technologies for the treatment of lake water to rejuvenate these. This work suggests suitable methods of remediation to use the waters for irrigation purposes.

2.2 Objectives

- To assess the physical and chemical quality of kolleru lake water.
- To conduct the GIS mapping of the physico-chemical data obtained from the water analysis by using GIS 10.1 version.
- Identify the pollutants and perform laboratory scale experiments for the removal of these pollutants.
- To suggest suitable bio-remedial methods for the resurrection of the kolleru lake water.

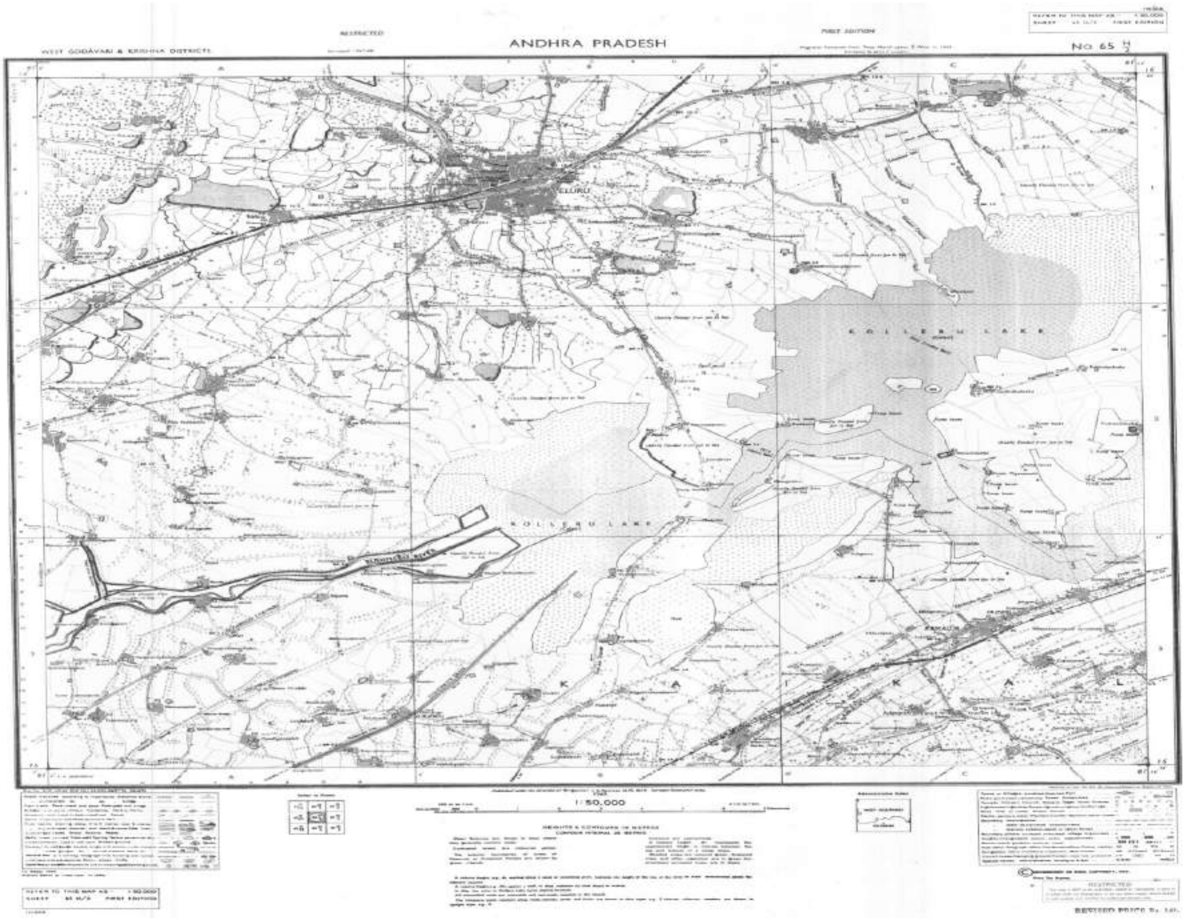


Figure 1. Toposheet of Kolleru Lake

Table 1. Name of Industries

Name of the industry	Product	River/drainage/channel carrying the effluents
Andhra Pradesh Diary Industry	Bottled Milk, Animal Oil Milk Powder.	Budameru river
Krishna Paper mills	Craft Paper	Budameru river
Agricultural Chemical Ltd.	Furbural	Budameru river
The KCP Ltd.	sugar, molasses, bagasse, Filter cake, Industrial Alcohol, Fuel Oil, Carbon Dioxide	Chandraiah drainage
Lakshmi Chemical Industries	Naphthol	Chandraiah drainage
Kolleru Paper Ltd.	Writing, printing paper	Pedapadu drainage
Mohiddin Tambi tanneries co	Semi Tonned leather	Thammileru river
West Godavari Co-op. Sugars Ltd	Sugar, Molasses, Filter cake	Ramileru river
Sri Raja Rajeswari Paper mills	Paper, Paper boards	Thammileru river.

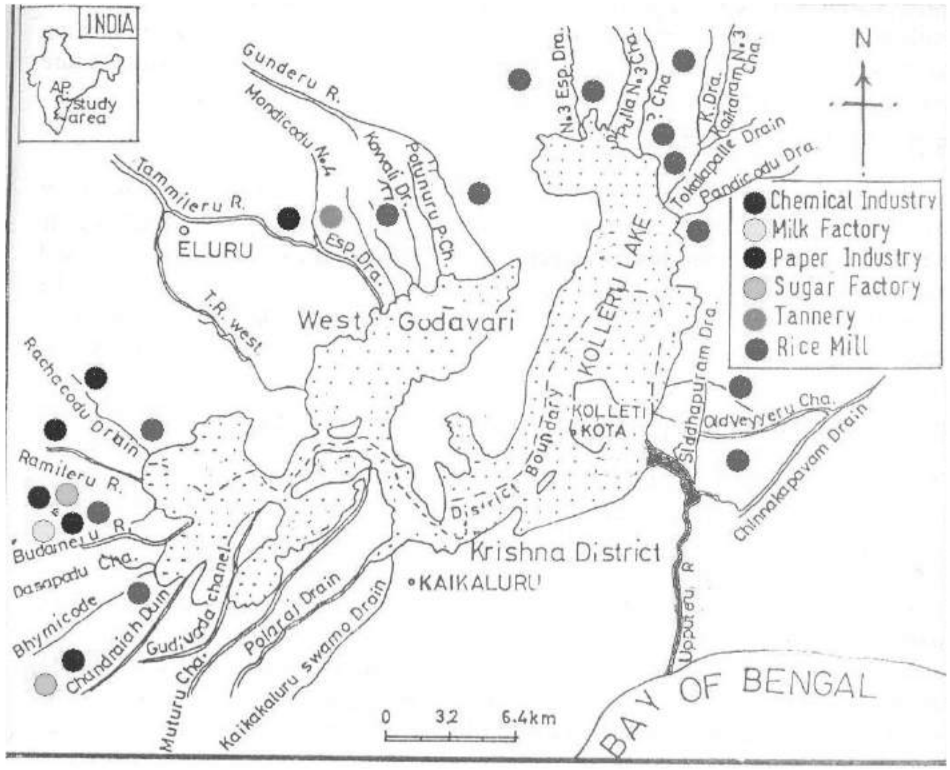


Figure 2. Type of Industries Map near Kolleru Lake

3. RESULTS & CONCLUSSIONS

3.1 Materials and Methods

Water samples have been collected throughout the lake, of three season of the year. For each sampling we have collected 14 samples around the lake. Samples were collected according to procedures prescribed in UNESCO document. The collected samples were labeled properly indicating the exact position where the samples are collected at the lake. Some field measurements are also done at the lake itself (D.O, pH, etc.) and then the remaining samples are brought to the laboratory in ice containers and analyzed for parameters. Major contions such as Na, K, Ca, Mg and anions such as chlorides, sulphates, phosphates, and levels of BOD, COD and total solids were by determined by standard methods (APHA 1998).

3.2. Results

Table 2. Physico Chemical Analysis of Kolleru Lake :December Month

S.No.	Parameter	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	8.6	8.2	7.9	7.6	8.0	8.0	7.2	8.4
2	Alkalinity	336	208	186	179	225	201	183	270
3	Total Chlorides	180	221	230	186	198	177	252	259
4	Biological Oxygen Demand	300	270	220	280	365	210	230	290
5	Total Solids	760	542	521	500	568	498	510	500
6	Total Suspended Solids	169	252	224	220	110	125	110	048
7	Total Dissolved Solids	591	290	297	280	458	373	400	458
8	Dissolved Oxygen	2.8	2.9	3.5	2.9	3.8	2.2	2.6	3.5

All the units are in mg/l, except pH

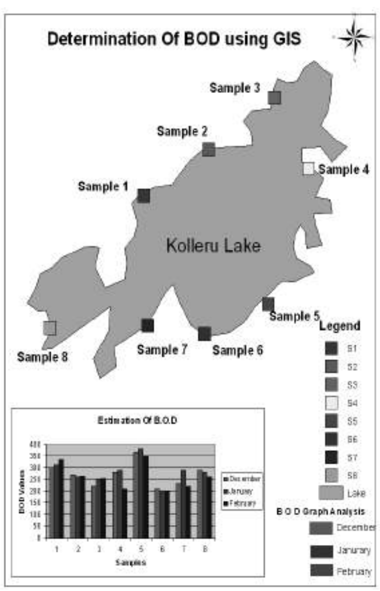
Table 3. Physico chemical analysis of kolleru Lake : January Month

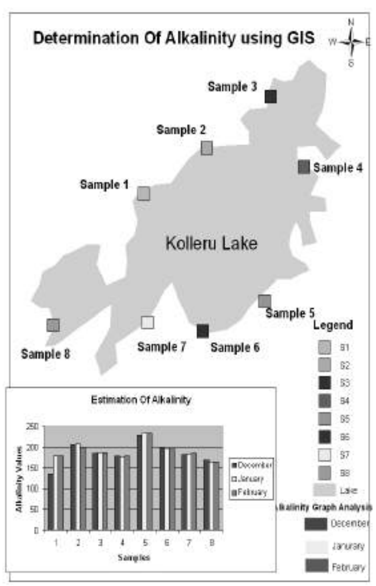
S.No.	Parameter	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	8.4	8.9	8.2	7.6	7.9	8.2	8.5	7.8
2	Alkalinity	179	209	187	178	234	198	185	165
3	Total Chlorides	185	220	277	185	200	230	251	260
4	Biological Oxygen Demand	310	260	250	290	380	200	290	280
5	Total Solids	700	520	510	497	802	541	498	523
6	Total Suspended Solids	146	129	212	121	150	293	109	133
7	Total Dissolved Solids	610	391	298	376	652	248	389	390
8	Dissolved Oxygen	2.5	2.9	3.5	3.0	3.2	2.9	2.6	3.3

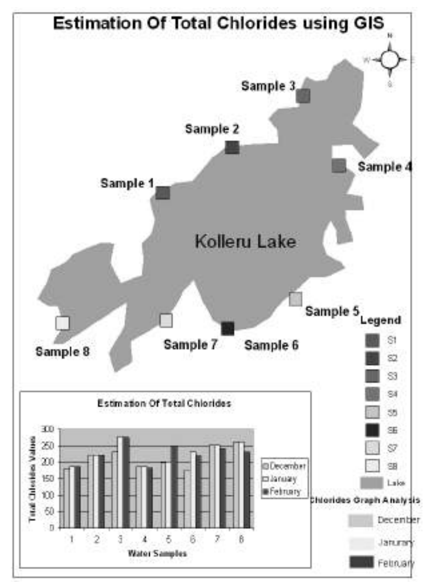
All the units are in mg/l, except pH

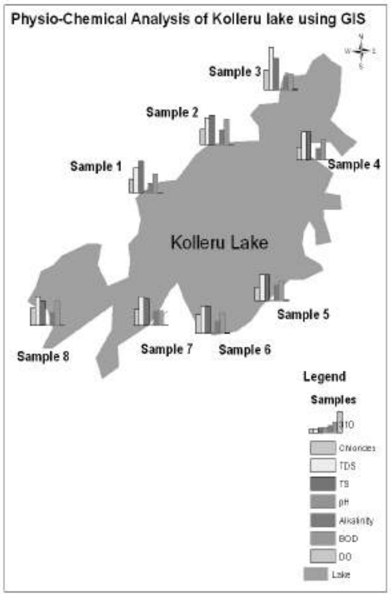
Table 4. Physico chemical analysis of kolleru Lake: February season

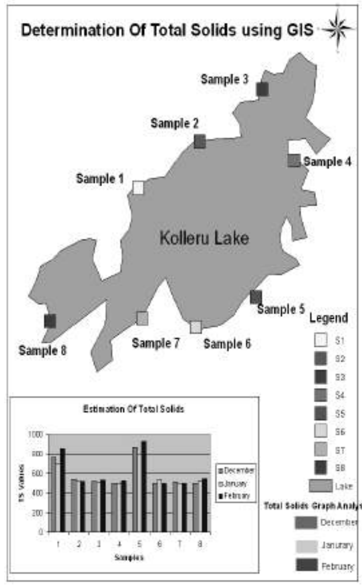
S.No.	Parameter	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	8.0	7.2	8.0	8.4	8.6	7.9	8.2	6.5
2	Alkalinity	179	201	188	279	165	197	186	162
3	Total Chlorides	185	221	275	182	249	219	240	230
4	Biological Oxygen Demand	332	265	252	210	350	200	221	262
5	Total Solids	856	520	532	523	923	497	498	552
6	Total Suspended Solids	223	109	135	117	242	116	464	102
7	Total Dissolved Solids	623	411	397	406	690	381	340	450
8	Dissolved Oxygen	2.8	2.3	3.4	2.8	3.1	2.7	2.7	2.6

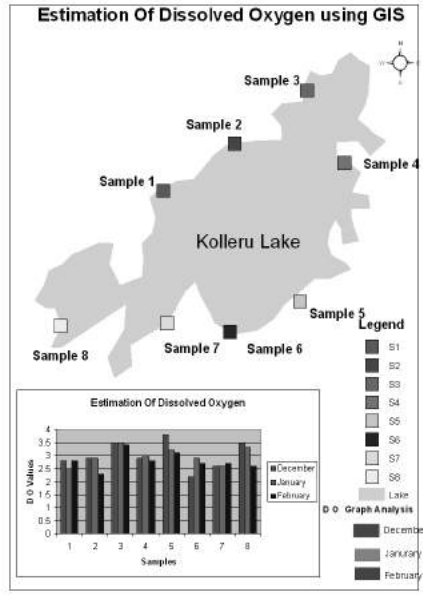












3.3 CONCLUSION

- An assessment for physico- chemical and biological quality of waters, surrounding area was carried out. Certain remedial measures were undertaken and reported in this study. As a part of the study the water quality of the lake was assessed during three months for the variations
- The study included physico-chemical and biological parameters for water and suitable remediation methods. The samples were collected at various sampling points, which were identified, based on reachability and proximity of inlet and all around the lake. The water samples indicated high TDS values in the range 725 mg/l. Similarly high Chlorides were observed 377 mg/lit
- Polluted Lake water must be done by primary, secondary and tertiary treatment.A low value of Dissolved Oxygen and high value of BOD was observed during all three months. Environmental changes taking place in the lake should be monitored with the help of GIS and Satellite based image maps should be used as a basic input parameters for environmental mapping & monitoring of the lake environment. Geographical Information System technology must be used in their assessment of pollution as it useful to analyze and get the solution easily with more accuracy. AND Every citizen & every industrialist must be aware of the pollution & its effects and must be encouraged to follow the eco friendly development**.**

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Determination of Pressure and Discharge Relationship in Drip Irrigation System

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ABSTRACT

The experiment was conducted at the research farm of irrigation and draingage engineering at jalgaon (Jamod) to examine change of pressure on discharge variation along with the efficiency of drip irrigation in terms of emission uniformity

For the study, aspect was consider, regarding the space between the two dripper with two different diameters of laterals. Two diameter viz. 12 mm and 16 mm were used with the dripper spacing of 15 cm and 20 cm and four pressure viz. 0.5, 0.75, 1.0 and 1.5 kg/cm^2. The system was operated for 1 hour considering water requirement of major crops in jalgaon (jamod). The study revealed that the discharge was increased as pressure increased. Out of two diameter and spacings best results were obtained for 16 mm lateral with spacing of 20 cm. For 4 lph dripper, the recommended discharge was obtained at 1.0 kg/cm^2 pressure. The values of x were ranges between 0.1 to 0.2. The value of CV was found to be excellent that is < 5%. In most of cases the Emission Uniformity (EU) was maximum for 16 mm lateral with 20 cm spacing at 1.5 kg/cm^2.

Keywords: Dripper, water requirement, emission uniformity, pressure discharge variation.

1. INTRODUCTION

Water is scare, precious natural resources and most crucial element which is required to planned, developed, conserve and manage in sustainable manner. Optimum management of available water resources at farm level is needed because of increasing demands, limited resources, water table variation in space and time, and soil combination (Kumar and Singh, 2003). Drip irrigation can potentially provide high application efficiency and achieve high application uniformity. In many irrigation methods, drip irrigation is popular for a plant crops because water can be irrigated directly to the root zone of the crop (Tray 1998).

In this trickle irrigation system all emitters should discharge equal amounts of water, but due to manufacturing variations, pressure differences, emitter plugging, aging, friction head losses throughout the pipe network, emitter sensitivity to pressure and irrigation water temperature changes, flow rate differences between two supposedly identical emitters exist. Accurate emitter manufacturing is necessary in order to achieve a high degree of system uniformity. Along with above factors, variation in pressure cause change in discharge rate of two identical dripper and non uniformity of water application to the soil, ultimately leads to reduction in crop yield. Therefore, it would be more rational if irrigation water is applied according to the change of required soil wetted patterns during plant growing period. A poor designed and managed pressurized irrigation system results in non uniform water distribution. In such system, the most valuable outcome of evaluation process is irrigation uniformity. Uniformity of drip irrigation system is usually a combination of measuring the variability of emission from individual emitter and pressure variation within the entire system.

2. MATERIAL AND METHODS

2.1 Experimental site

The study was conducted at the research farm of Irrigation and Drainage Engineering Jalgaon (Jamod). The field was carefully selected for conduction the study. The 15 m lateral with two diameters (12 mm and 16 mm) were selected with two discharge rates of 4 lph and 8 1ph.

2.2 Materials Required

The following materials were used for determining the effect of pressure or discharge variation.

Moisture boxes

The aluminum moisture boxes of 7.5 x 2.5 cm were used for the collection of soil sample. The 99 numbers of moisture boxes were used for study.

Pressure gauge

The pressure gauge was fitted in lateral to maintain the pressure of 0.5, 0.75, 120, 1.5 Kg/ cm^2.

Lateral

The lateral is made up of low density polyethylene chloride. 12 mm and 16 mm diameter lateral connected to the underground sub main pipe to apply the water at the field. The lateral was used with 4 lph and 8 lph drippers with 15 cm and 20 cm dripper spacing.

Drippers

The turbo key plus online drippers of 4 lph and 8 1ph were used. Two types of NPC online dripper were used keeping a spacing of 15 cm and 20 cm.

Joiner

Two types of joiner were used *i.e* 16 x 16 mm for 16 mm diameter lateral and 16 x 12 mm for 12 mm diameter of lateral.

End cap

End cap was used to control the flow of water at the end of the lateral. Two types of End cap were used *i.e* 16 mm and 12 mm diameter.

Measuring Cylinder

The measuring cylinder of 100 ml capacity was used to measure the collected discharge.

2.3 Pressure and Discharge Relationship

Emitter flow rates may fluctuate as pressure along the lateral line varies due to friction, elevation, and/or accidental restrictions, resulting in a non-uniform water application (Braud and Soon, 1980). Effect of different pressure on flow rate of drip emitters was determined by using the equation developed by Keller and Karmeli (1974).

$$q = Ke\ H^x$$

Where,

q = emitter discharge, (lph),

Ke = emitter discharge coefficient that characterize the emitter dimensions,

H = operating pressure at the emitter, in kPa and

X = emitter discharge exponent.

Keller and Krameli (1974) introduced the coefficient of variation as a statistical measure for emitter manufacturing variation. This coefficient of manufacturer's variation was included in design equations for emission uniformity.

$$CV = \frac{Sq}{qave} \times 100$$

Where,

CV = discharge coefficient of variation (%),

Sq = standard deviation of discharge rates of the emitters in the sample (lph) and

q_{av}. = mean of emitter discharge rate (lph).

2.4 Determination of Emission Uniformity

To determine if water and chemicals are applied uniformity, it is necessary to evaluate emitter discharge uniformity and system performance. For determination of emission uniformity of drip irrigation, the system was operated for one hour and discharge was collected. Emission uniformity of drip irrigation system determined by equation

$$EU(\%) = \frac{qn}{qa} \times 100$$

Where,

EU = emission uniformity of emitters (%)

q_n = average discharge from emitters in the lowest 25 % of the discharge range (lph)

q_a = average discharge of all emitters in 1ph.

3. Result and discussion

3.1 Pressure and discharge relationship

Table 1. Variation in discharge with pressure for 12 mm lateral with 20 cm dripper spacing

Pressure (kg/cm^2)	Size of Dripper	
	4 lph (Qave)	8 lph (Qave)
0.5	2.25	5.80
0.75	3.34	7.00
1.0	3.36	7.75
1.5	4.29	8.45

Table 1. shows the discharge of 4 1ph and 8 lph dripper for 12 mm lateral with dripper spacing of 20 cm and discharge rate was more than recommended value for 4 lph and 8 lph dripper *i.e* 4.29 and 8.45 lph.

Table 2. Variation in discharge with pressure for 16 mm lateral with 20 cm dripper spacing

Pressure (kg/cm^2)	Size of Dripper	
	4 lph (Qave)	8 lph (Qave)
0.5	3.02	5.44
0.75	3.56	5.86
1.0	3.92	6.74
1.5	4.75	7.87

Table 2 shows the discharge of 4 lph and 8 lph dripper for 16 mm lateral with dripper spacing of 20 cm. From the table it was observed that better result can be obtained for 8 lph dripper having the spacing 20 cm.

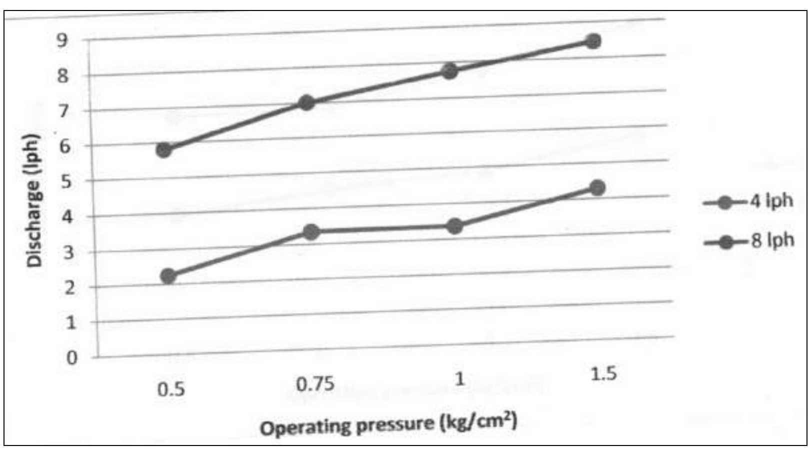

Figure 1. Discharge verses pressure for 4 lph and 8 lph dripper on 12 mm lateral with 20 cm dripper spacing

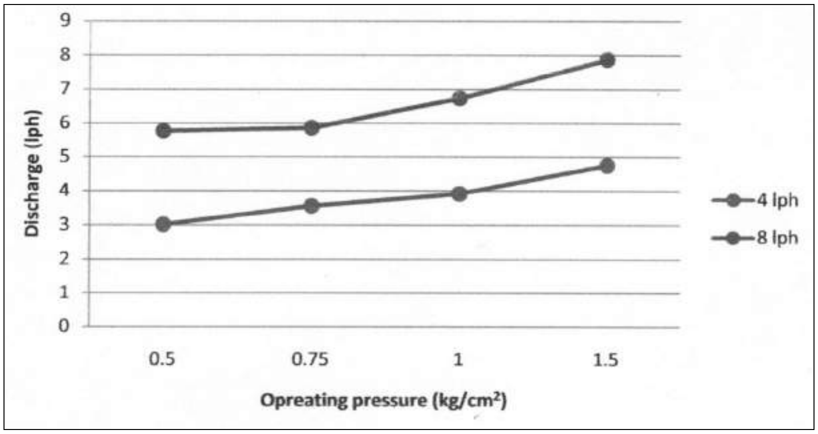

Figure 2. Discharge verses pressure for 4 lph and 8 lph dripper on 16 mm lateral with 20 cm dripper spacing

Above graphs shows the increasing trend in discharge with pressure. Graphs shows that for 1.5 Kg/cm^2 pressure, the discharges were gone beyond recommended value as the drippers are NPC, hence if can be concluded that the drip system should be operated up to 1.0 Kg/cm^2 pressure in clayey soil for drippers spacing of 15 cm and 20 cm.

The values of Ke and x were determined by linear regression analysis of a logarithmic plot of the measured discharge against applied pressure which were plotted on Fig. 3, 4, 5 and 6.

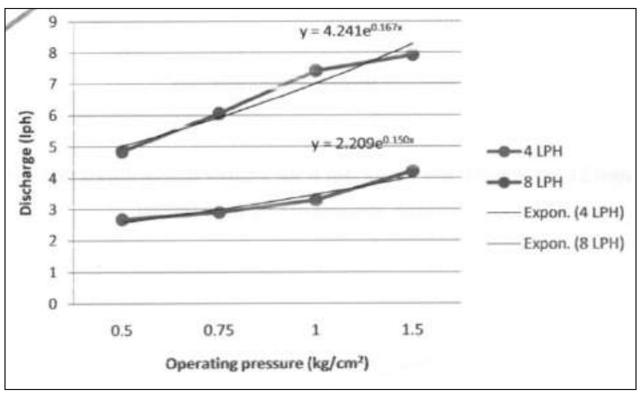

Figure 3. Exponential values for 4 lph and 8 lph dripper on 12 mm lateral with 15 cm dripper spacing

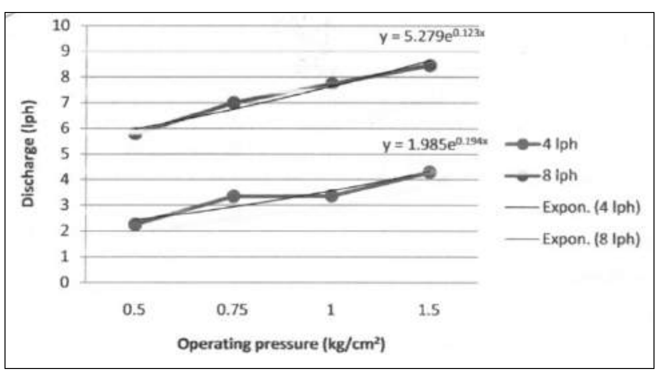

Figure 4. Exponential values for 4 lph and 8 lph dripper on 12 mm lateral with 20 cm dripper spacing

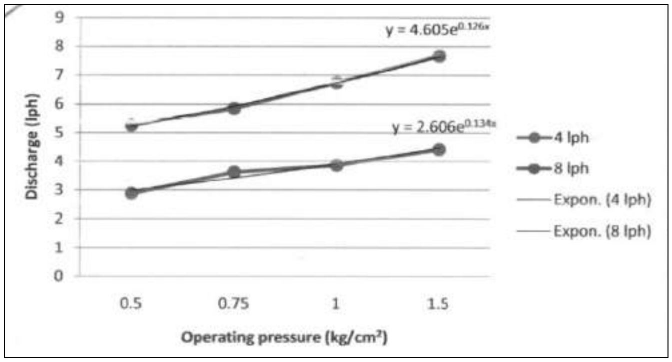

Figure 5. Exponential values for 4 lph and 8 lph dripper on 16 mm lateral with 15 cm dripper spacing

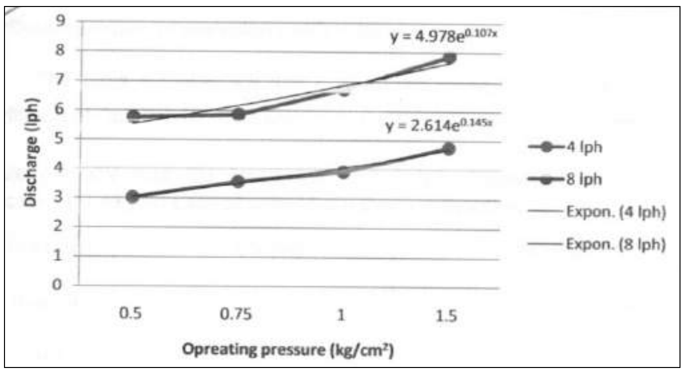

Figure 6. Exponential values for 4 lph and 8 lph dripper on 16 mm lateral with 20 cm dripper spacing

Discharge was plotted on y axis and pressure was plotted on x axis and exponential equation was obtained for 4 1ph and 8 1ph dripper.

From the all figure it can be concluded that the value of x were range between 0.1 to 0.2.

3.2 Determination of emission uniformity and coefficient of variation

Table 3. CV and EU for 4 lph and 8 lph dripper at different pressure for 12 mm lateral with 20 cm dripper spacing

Preesure (kg/cm^2)	CV (%)		EU (%)	
	4 lph	8 lph	4 lph	8 lph
0.5	5.52	5.75	91.4	91.2
0.75	6.10	6.17	91.2	91.1
1.0	4.40	3.45	93.3	94.8
1.5	3.34	2.78	94.5	96.1

From the above table was found that maximum emission uniformity of 4 lph dripper and 8 lph dripper was 94.5 % and 96.1 % respectively at 1.5 Kg/cm^2 pressure. So it can be concluded that the 1.5 Kg/ cm^2 pressure was a better for 12 mm lateral with 20 cm spacing for 4 lph and 8 lph dripper.

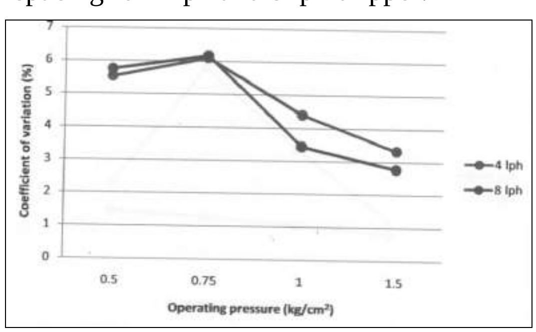

Figure 7. Coefficient of variation against the pressure for 4 lph and 8 lph on 12 mm lateral with 20 cm dripper spacing

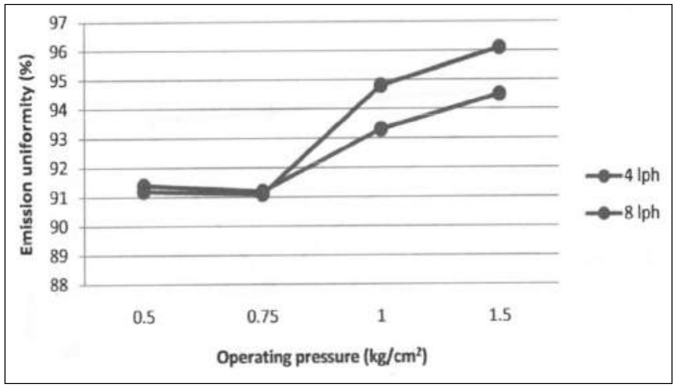

Figure 8. Emission uniformity against the pressure for 4 lph and 8 lph on 12 mm lateral with 20 cm dripper spacing

Table 4. CV and EU for 4 lph and 8 lph dripper at different pressure for 16 mm lateral with 20 cm dripper spacing

Preesure (kg/cm^2)	CV (%)		EU (%)	
	4 lph	**8 lph**	**4 lph**	**8 lph**
0.5	2.7	8.4	96.6	85.04
0.75	5.4	7.8	91.3	89.9
1.0	3.7	6.1	95.1	93.6
1.5	2.9	5.9	96.1	93.5

From the above table was found that emission uniformity for 4 lph dripper was 96.1 % and 96.6 % at 1.5 and 0.5 Kg/ cm^2 pressure and for 8 lph dripper was 93.6 % and 93.5 % at 1 Kg/ cm^2 and 1.5 Kg/ cm^2 pressure. So it can be concluded that the 1.0 Kg/cm^2 pressure can be consider better for 16mm lateral with 15 cm dripper spacing for 8 lph dripper and 1.5 Kg/ cm^2 was better for 4 lph dripper.

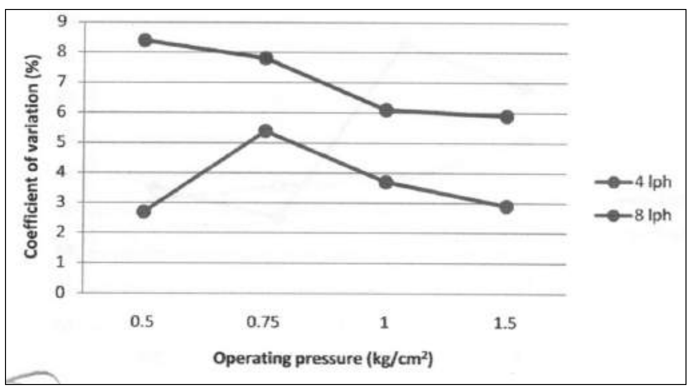

Figure 9. Coefficient of variation against the pressure for 4 lph and 8 lph on 16 mm lateral with 15 cm dripper spacing

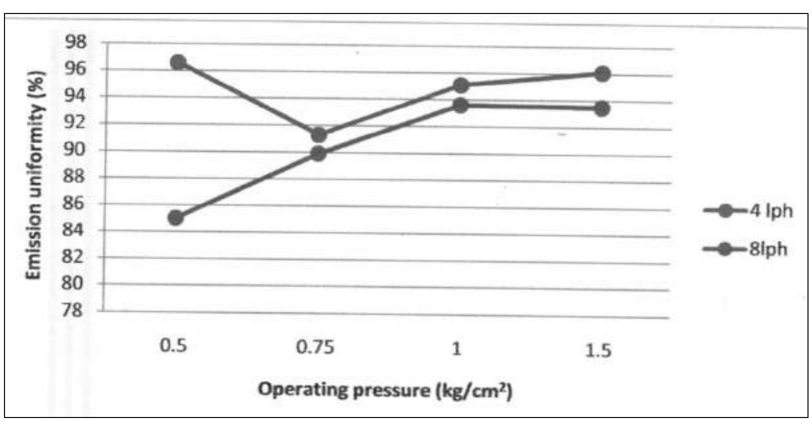

Figure 10. Emission uniformity against the pressure for 4 lph and 8 lph on 12 mm lateral with 20 cm dripper spacing

CONCLUSIONS

1. For 16 mm lateral with 20 cm spacing, recommended discharge was observed at 1.5 kg/cm^2 for 4 lph *i.e.* 3.92 and at 1.5 kg/cm^2 for 8 lph *i.e.* 7.87 lph.
2. The discharge rate gives most accurate results at the pressure of 1.0 kg/cm^2 for 4 lph and 8 lph *i.e.* 3.36 and 7.751ph for 12mm lateral for the spacing of 20 cm between drippers and most accurate results were obtained from 16 mm lateral with 20 cm spacing.
3. For 12 mm lateral with 20 cm spacing the CV was excellent at 1.0 and 1.5 kg/cm2 for 4 1ph and 8 1ph dripper. The emission uniformity of 4 lph and 8 1ph dripper was 94.5% and 96.1% at 1.5kg/cm^2.
4. The CV was an excellent at 0.5, 1.0 and 1.5 Kg/cm^2 pressure for 4 lph dripper and an average at 0.75, 1.0 and 1.5 Kg/cm^2 for 8 lph dripper. The emission uniformity was 96.6% at 0.5 Kg/cm^2 pressure for 4 lph and 93.6% at 1.0 Kg/cm^2 pressure for 8 lph dripper for 16 mm lateral with 15 cm dripper spacing.

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Study on Soil Pollution in the Industrial Areas of Visakhapatnam by Assessment of Physico-Chemical and Heavy Metal Parameters

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ABSTRACT

The present study area was covered with industrial area of Visakhapatnam city, Andhra Pradesh State, India. We have studied the parameters like pH, availability of N, K, Fe, MN, Cu & Zn of soil in the study area (Industrial area of Visakhapatnam city) in the season of June 2013 to May 2014. pH values ranges from 5.4 to 8.2 and 5.1 to 8.7 during the years of 2013 and 2014 with means of 7.08 and 7.15. Available N concentrations vary from 36 to 186 mg/kg with mean of 86.7 mg/kg in June (2013) while 46 to 195 mg/kg with mean of 97.6 mg/kg in May (2014). Available potassium varies from 219 to 560 mg/kg with a mean of 381.1 mg/kg during June (2013) whereas varies from 245 to 605 mg/kg with a mean of 411.7 mg/kg during May (2014). The concentration of available Iron varies from 9.13 to 36.94 mg/kg with a mean of 24.88 mg/kg during June (2013) whereas 10.12 to 38.96 mg/kg with a mean of 27.5 mg/kg during the May (2014). The results of the study also indicated that the contents of all these micronutrients were higher at nearby industrial area when compared far to the industrial area or residential area of the study area soil. The concentration of Available Manganese varies from 1.16 to 34.88 mg/kg with mean of 22.15 mg/kg during June where as 1.89 to 36.54 mg/kg with a mean of 25.18 mg/kg during May within the years of 2013 and 2014. The available zinc concentration varies from, during the June (2013) 1.89 to 6.42 mg/kg with mean of 5.34 mg/kg whereas 2.13 to 6.78 mg/kg with mean of 5.56 mg/kg during May (2014). The concentration of available copper varies from 1.38 to 8.75 mg/kg with a mean of 5.04 mg/kg during the June whereas 1.75 to 9.27 mg/kg with a mean of 5.32 mg/kg during May with in the years of 2013 and 2014.

INTRODUCTION

In modern economies, various types of activity, including agriculture, industry and transportation, produce a large amount of wastes and new types of pollutants. Soil, air and water have traditionally been used as sites for the disposal of all these wastes. Soil is considered the "skin of the earth" with interfaces between the lithosphere, hydrosphere, atmosphere, and biosphere (Chesworth, 2008). The production of our food and the quality of our environment are related to the wise use of the soil as well as the health of the soil. The most common kinds of waste can be classified into four types: agricultural, industrial, municipal and nuclear (Alloway 1995). Agricultural wastes include a wide range of organic materials (often containing pesticides), animal wastes, and timber by-products. Many of these, such as plant residues and livestock manure, are very beneficial if they are returned to the soil. However, improper handling and disposal may cause pollution. Industrialization has long been identified as the bedrock of national development, hence the assertion that no nation can grow beyond its level of industrialization. However, the soaring trend of industrialization has engendered significant environmental pollution. Various pollutants are discharged into the environments as waste from manufacturing processes. Among these pollutants; heavy metals constitute a major threat. Industrial products such as paints, pesticides, fertilizers among others have trace metals as components in them. Environmental contamination by heavy metals has become an issue of concern, due to the fact that heavy metals unlike some other pollutants are not biodegradable. Consequently, they are not detoxified but are bio-accumulated in the environment.

Various researchers have opined the need for continual monitoring of the concentration of trace metals in soil. To this end, various studies have been carried out on determination of heavy metals in industrial areas. However most of these studies were carried out in industrial cities with long period of industrialization. It is therefore necessary to carry out a study of this nature. Such study will no doubt accentuate the need for a more constant monitoring of heavy metal concentration of soil in industrial areas and also serve as relevant input into the existing global record on soil pollution by heavy metals in industrial areas. The fertility problem and nutrient deficiencies in Indian soil has progressed over the time. Indian soils are generally deficient in nitrogen, phosphorus and marginally adequate in potassium. Zinc deficiencies are widespread across the country. The essential micronutrients are metals (except B and Cl) and its uptake is affected by soil (Lindsay, 1991; Stevenson, 1986; Lake et al., 1984), plant (Barber, 1995; Marschner, 1995)microbial and environmental factors (Romheld andMarschner, 1986; Clark and Zeto, 2000).In India, the main reasons for land degradation are cultivation on steep and fragile soils with inadequate investments in soil conservation or vegetation cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing (Belay, 2003; Hurni, 1988).

A substantial and unfortunate fact about industrialization and industrial production is generation and release of toxic waste products. Although these wastes can be treated, reused and recycled still thousands of chemicals are released and find their way into the environment. Unfortunately, the inadequate information regarding wastetoxicity and post-disposal behaviour, poor planning, improper disposal and poor management of disposal sites stimulates serious contamination problems at industrial and hazardous waste disposal sites. An example is several available reports about the genotoxicity of soils contaminated with chemicals originated from industrial sources. Heavy metals are among these chemicals and constitute a main group of soil pollutants that their contamination in environment affects all ecosystem components. Although heavy metals are present as natural components of soils, toxic contamination may frequently occurs at industrial and mining sites. Heavy metals such as Cu, Zn, Mn and Fe are essential for plant growth, they have mild significant role in the plant physiology. The uptake of these heavy metals by plants is an avenue of their entry into the human food chain with harmful effects on health. Although the nutrient content of wastes makes them attractive as fertilizers, when untreated wastes are used in crop production, consumers risk to contact diseases like cholera and hepatitis, or to undergo heavy metal contamination. Soil samples were collected from sites chosen for their industrial activities at surface level of Industrial area due to uncontrolled industrial activities, decline of soil fertility, rainfall variability and pests and diseases. Therefore, this study was initiated to investigate the influence of different land uses on the soil pollution of the soils of the industrial area of the Visakhapatnam city, Andhra Pradesh.

Methodology: Study Area

Topography

Visakhapatnam is Situated in between 17^0 40’ 30” and 17^0 40’ 45” North latitude and 83^0 16’ 15” and 83^0 21’ 30” East longitude. Visakhapatnam is an industrial area, because of its geographical location with a natural harbour attached nationwide attention, which led to the establishment of several industries Thus in this present study industrial belt sand its surrounding area has been selected (Srikanth, 2012).

Characterized by Eastern Ghat Mobile Belt (EGMB), the topography of Visakhapatnam is undulating with hill ranges (320–504 m above MSL) on northern, southern and western sides, and the Bay of Bengal on eastern side, sloping towards centrally located salt marshland (4 m above MSL) from all the sides (Fig. 1). The hills consist of thick soil cover and deciduous forests. The eastern side constitutes upland with a height of 65–75 above MSL and the slope is towards Bay of Bengal. Kailasa range and Yarada range are two important hill ranges present. Kailasa hill range limits the Visakhapatnam city in the northern boundary whereas the Yarada range is located in the southern side (Figs. 1). These two ranges are being separated from each other by a vast tidal basin, a few scattered hillocks and portions of low land. The Dolphin’s nose is formed by Yarada range. The largest stream passing over the city is Naravagedda which runs from northwest towards salt marshland.

Collection of soils from the study area

Three main factors such as depth, sampling intensity per unit area of site sampled, and the sampling design have been considered when developing soil-sampling protocols to monitor change in major soil fertility parameters. A preliminary soil survey, and appropriate sampling and planning to accommodate spatial variation at a plot or compartment level, are important considerations to measure changes in surface soil chemical and physical properties. At the beginning, a general visual field survey of the area was carried out to have a general view of the variations in the study area.

Figure 1 Showing location of the Study area

Soil sampling procedure followed was free sampling survey method as recommended by Young (1976) in the field and as many samples as necessary have been taken within the boundaries of the study area. Representative soil sampling sites were selected based on industrial activities area of Visakhapatnam city. Following the general site selection, three representative fields were selected from nearby industry or around industry. Which were replicated three times, and from each site, and thirty soil samples were collected from total study area from same depths. During collection of samples; dead plants, furrow, old manures, wet spots, areas near trees and compost pits were excluded. One composite soil sample was then prepared from the each site for the all soil depth. Global Positioning System (GPS) and clinometers were used to identify the geographical locations and slopes of the sampling sites, respectively.

Table 1 Sampling Locations with code

S.No.	Location	Code	Longitude & Latitude
1	Nalco Bridge Starting	S_1	17 42 56.26 N 83 16 56.58 E
2	Essar-Midlle of The Bridge	S_2	17 42 59.69 N 83 16 18.2 E
3	Bridge Down-Toll Gate	S_3	17 42 55.17 N 83 16 1.9 E
4	Krishna Gate-Naval Dockyard	S_4	17 42 23.8 N 83 15 34.62 E
5	HPCL-After Naval Dockyard	S_5	17 41 45.17 N 83 15 31.7 E
6	INS Sathavahana	S_6	17 41 41.68 N 83 15 49.29 E

7	Opp.Head Quarters of Eastern Naval Command	S_7	17 41 33.83 N 83 16 6.3 N
8	Amar Park-Scindia	S_8	17 41 19.2 N 83 16 6.1 E
9	Malka Puram Police Station	S_9	17 41 20.3 N 83 14 42.62 E
10	HPCL Malkapuram	S_{10}	17 41 21.48 N 83 14 29.24 E
11	Sriharipuram	S_{11}	17 41 22.8 N 83 14 7.58 E
12	Coramandal Gate	S_{12}	17 41 24.67 N 83 14 1.35 E
13	Gajuwaka Depot	S_{13}	17 41 23.18 N 83 13 24.33 E
14	New Gajuwaka	S_{14}	17 41 11.84 N 83 13 2.61 E
15	Old Gajuwaka Junction	S_{15}	17 41 7.94 N 83 12 12.59 E
16	ChattivaniPalem	S_{16}	17 41 20.22 N 83 12 18.84 E
17	BHPV	S_{17}	17 42 4.47 N 83 12 19.14 E
18	Nathayyapalem	S_{18}	17 42 29.35 N 83 12 18.75 E
19	Airport	S_{19}	17 43 11.10 N 83 12 14.17 E
20	NAD Kotha Road	S_{20}	17 44 33.0 N 83 14 11.71 E
21	Marripalem	S_{21}	17 44 25.93 N 83 14 59.34 E
22	Kancharapalem	S_{22}	17 44 2.97 N 83 16 27.29 E
23	Gnanapuram Bridge Down	S_{23}	17 43 28.18 N 83 17 7.27 E
24	Railway Station-Gnanapuram	S_{24}	17 43 14.71 N 83 17 14.59 E
25	Port Circle -Gnanapuram	S_{25}	17 43 3.26 N 83 17 23.98 E

Soil Laboratory Analysis

The soil samples collected from representative fields' with three replications were then air-dried, mixed well and passed through a 2 mm sieve for the analysis of selected soil physical and chemical properties. The major part of the soil analysis was carried out at the Department of Environmental Sciences, Andhra University using standard laboratory procedures in the analysis of the selected physicochemical properties considered in the study.

Table 2 Laboratory methods used for chemical analysis of soil

S.No.	Particulars	Method used
1	pH	pH meter
2	Electrical Conductivity (mili mhos)	Solubridge conductivity meter method (Black,1965)
3	Available N (kg ha-1)	Alkaline permanganate method (Subbaiah and Asija, 1956)
4	Available P (kg ha-1)	Olsen's method (Olsen *et al.*, 1954)
5	Available K (kg ha-1)	Flame photometric method (Jackson, 1967)
6	Micro component (Zinc, Iron, copper, Manganese) ppm	Atomic absorption Spectrophotometric method

Analysis of soil physical, macro and micro nutrients

Soil particle size distribution was determined by the Boycouos hydrometric method(Bouyoucos, 1962; Van Reeuwijk, 1992) after destroying OM using hydrogen peroxide (H_2O_2) and dispersing the soils with sodium hexameta phosphate ($NaPO_3$).

The pH of the soils was measured in water and potassium chloride (1M KCl) suspension in a1:2.5 (soil: liquid ratio) potentiometrically using a glass-calomel combination electrode (Van Reeuwijk, 1992). The electrical conductivity (EC) of soils was measured from a soil water ratio of 1:2.5 soaked for one hour by electrical conductivity method as described by Sahlemdhin and Taye (2000). Available nitrogen was estimated by alkaline permanganate method. (Van Reeuwijk, 2002).

Available phosphorus was determined by Olson's method. Available potassium in the soil was estimated by cold dilute H_2S0_4 method (Hunter and Pratt, 1957) as described by Black (1965).

Micronutrient Analysis Procedure

Available micronutrients (Fe, Cu, Zn and Mn) were extracted by DTPA as described by Sahlemedhin and Taye (2000) and all these micronutrients were measured by Atomic Absorption Spectrophotometer in the Private Soil testing laboratory.

RESULTS AND DISCUSSION

Determination of physicochemical parameters and heavy metal concentration in soils is very important for determining the pollution level of soils.Biogeochemical cycling is apparently a very important determinant of heavy metal content in the soil. This process increases the heavy metal content of plant essential elements (Fe, Mn, Zn and Cu) (Yerima et al., 2013)

Table 3 Physical, macro and micro nutrient analysis of soil during the month of June2013

S.No.	location	pH	EC	OC	N	P_2O_2	K_2O	Zn	Fe	Mn	Cu
1	Nalco Bridge Starting	7.6	0.96	L	62	64	550	5.97	23.25	1.16	3.60
2	Essar-Midlle of The Bridge	7.7	1.8	L	85	42	405	5.42	32.00	20.66	2.70
3	Bridge Down-Toll Gate	6.8	0.58	M	126	38	312	5.66	36.94	12.11	5.16
4	Krishna Gate-NDl	5.4	0.83	L	46	66	512	5.53	30.20	32.32	3.47
5	HPCL-After Naval Dockyard	5.6	2.9	L	86	82	548	5.91	35.96	27.54	4.70
6	INS Sathavahana	6.4	0.63	M	132	28	306	6.32	26.24	30.30	8.75
7	Opp.Head Quarters of Eastern Naval Command	6.9	0.37	L	96	34	242	6.13	32.84	22.60	5.60
8	Amar Park-Scindia	7.4	0.23	L	45	36	270	5.84	9.13	28.64	7.54
9	Malka Puram Police Station	7	0.26	M	136	72	262	5.82	28.46	23.68	5.05
10	HPCL Malkapuram	7.3	0.24	L	52	86	283	5.72	31.44	15.58	1.92
11	Sriharipuram	7.4	0.51	L	85	42	460	6.13	17.77	22.48	5.79
12	Coramandal Gate	7.1	0.04	L	96	56	265	6.19	24.54	29.26	1.68
13	Gajuwaka Depot	5.7	0.83	L	64	102	312	6.09	31.26	27.34	1.96
14	New Gajuwaka	6.6	0.33	L	82	96	254	4.20	33.00	23.06	6.40
15	Old Gajuwaka Jn.	7.7	0.36	L	96	80	560	5.62	17.60	15.01	5.82
16	ChattivaniPalem	7.6	0.95	L	98	52	335	6.42	29.70	16.57	8.73
17	BHPV	7.4	6.21	M	186	32	219	5.82	26.00	18.68	7.11
18	Nathayyapalem	7.2	0.28	L	72	38	280	5.17	21.64	24.12	6.12
19	Airport	7.2	0.23	L	84	56	292	5.04	16.62	32.86	5.03
20	NAD Kotha Road	7.4	0.53	L	46	92	426	4.36	18.10	20.74	5.99
21	Marripalem	7.5	0.21	L	52	28	245	5.10	17.19	10.16	5.30
22	Kancharapalem	7.8	0.35	L	82	42	560	3.96	13.41	21.98	2.42
23	Gnanapuram Bridge Down	8.2	0.78	L	75	56	550	4.55	14.40	19.09	8.42

24	Railway Station-Gnanapuram	7.7	1.42	M	148	72	548	4.75	29.96	22.98	2.52
25	Port Circle -Gnanapuram	6.5	1.2	L	36	61	531	1.89	24.36	34.88	4.15
	Min	5.4	0.04		36	28	219	1.89	9.13	1.16	1.68
	Max.	8.2	6.21		186	102	560	6.42	36.94	34.88	8.75
	Mean	7.08	0.92		86.7	58.1	381.1	5.34	24.88	22.15	5.04

Table 4 Physical, macro and micro nutrient analysis of soil during the month of May 2014

S.No.	**location**	**pH**	**EC**	**OC**	**N**	**P_2O_2**	**K_2O**	**Zn**	**Fe**	**Mn**	**Cu**
1	Nalco Bridge Starting	7.4	1.2	L	75	89	605	6.12	24.56	1.89	3.78
2	Essar-Midlle of The Bridge	7.3	2.3	L	93	46	423	5.76	33.14	25.63	2.91
3	Bridge Down-Toll Gate	6.4	0.63	M	135	49	351	5.89	38.92	13.65	5.67
4	Krishna Gate-Naval Dockyard	5.1	0.89	L	56	78	542	5.75	32.45	36.54	3.87
5	HPCL-After Naval Dockyard	5.7	2.5	L	91	92	569	6.23	38.96	32.12	5.12
6	INS Sathavahana	6.3	0.68	M	143	36	354	6.78	27.85	35.61	9.22
7	Opp.Head Quarters of Eastern Naval Command	6.8	0.48	L	110	46	289	6.54	33.65	29.35	5.89
8	Amar Park-Scindia	7.6	0.36	L	62	47	281	6.12	10.12	32.45	7.96
9	Malka Puram Police Station	7.2	0.35	M	157	86	289	5.89	30.12	26.31	5.62
10	HPCL Malkapuram	7.3	0.28	L	63	92	305	5.82	32.78	16.34	2.13
11	Sriharipuram	7.8	0.68	L	92	86	463	6.34	18.56	26.31	6.18
12	Coramandal Gate	7.6	0.1	L	110	71	305	6.25	24.37	35.42	1.75
13	Gajuwaka Depot	5.9	0.96	L	68	125	347	6.45	36.45	29.12	2.11
14	New Gajuwaka	6.9	0.42	L	93	110	269	4.36	35.12	25.23	6.52
15	Old Gajuwaka Junction	7.9	0.46	L	105	96	586	5.89	19.23	16.23	5.93
16	ChattivaniPalem	7.4	1.1	L	109	63	387	6.37	31.45	17.89	8.96
17	BHPV	7.8	7.23	M	195	48	245	5.93	29.34	19.32	7.23
18	Nathayyapalem	7.6	0.36	L	96	59	307	5.34	24.89	28.45	6.27
19	Airport	7.0	0.34	L	94	72	335	5.23	18.96	35.65	5.32
20	NAD Kotha Road	7.3	0.64	L	52	110	472	4.67	23.56	25.67	6.22
21	Marripalem	7.7	0.32	L	57	35	268	5.36	23.12	13.56	5.38
22	Kancharapalem	7.6	0.48	L	96	59	582	4.39	19.96	22.34	2.65
23	Gnanapuram Bridge Down	8.7	0.87	L	86	73	563	4.55	15.62	23.14	9.27
24	Railway Station-Gnanapuram	7.5	1.56	M	157	89	587	4.96	35.26	25.12	2.63
25	Port Circle -Gnanapuram	6.9	1.36	L	46	78	569	2.13	28.96	36.14	4.35
	Min	**5.1**	**0.10**		**46**	**35**	**245**	**2.13**	**10.12**	**1.89**	**1.75**
	Max.	**8.7**	**7.23**		**195**	**125**	**605**	**6.78**	**38.96**	**36.54**	**9.27**
	Mean	**7.15**	**1.06**		**97.6**	**73.4**	**411.7**	**5.56**	**27.50**	**25.18**	**5.32**

* All samples are measured in mg/kg except pH and EC.

In OC ' L 'represents low and 'M 'represents medium

Table 5 Mean values physical, macro and micro nutrient analysis during the study period of 2013 and 2014

	June - 2013			May - 2014		
	Min.	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**
pH	5.4	8.2	7.08	5.1	8.7	7.15
EC	0.04	6.21	0.92	0.1	7.23	1.06
OC	L	M	L	L	M	L
Av. N	36	186	86.7	46	195	97.6
Av. Phos	28	102	58.1	35	125	73.4
Av. K	219	560	381.1	245	605	411.7
AZ	1.89	6.42	5.34	2.13	6.78	5.56
AFe	9.13	36.94	24.88	10.12	38.96	27.5
AMn	1.16	34.88	22.15	1.89	36.54	25.18
ACu	1.68	8.75	5.04	1.75	9.27	5.32
Overall Mean of 2013 and 2014	**33.59**	**105.49**	**65.70**	**38.57**	**114.72**	**72.72**

This study provides an informative data and helps to understand the contamination of soils of Visakhapatnam industrial area and the possible factors that imposes various threats in the area. The major source of pollutants in the study area are local anthropogenic activities, agricultural runoff and by industrial effluent. In the present study it was found that physico- chemical characteristics of the soil have crossed the maximum permissible limit, due to heavy mixing of effluent waste and domestic sewage it was noticed that the physicochemical parameters indicates balance of the industrial area was disturbed. This was regularly observed and monitored during field visits of the study area. The study concluded that the soil quality of the industrial area has been severely deteriorated.

In the present study, most of the sampling locations except control point of pH were moderately acidic (4.0 to 6.0) showing a significant impact on yield potential and plant nutrient requirements. The adverse effects of acidic soil pH (pH < 6.0) can be seen on plant growth and the different adaptability of plant to soil pH will influence the nutrient uptake. As acidity increases, the growth rate and final yield of crops progressively decrease and the nutrient requirements will also increase. Present study area is low in pH (5.4 to 8.2) due to long-term acid-leaching processes and is very low in available nutrients because they are formed well below the zone of active nutrient cycling and/or fertilization and liming.

Electrical conductivity values in the present study were tolerable levels except one sampling location i.e., BHPV (S_{17}) (7.23dS/m) the maximum value was recorded in may(2014) and the lowest Coramandal gate (S_{12}) (0.04dS/m) EC of the soils were obtained under the industrial areas soils, respectively. All the soil sampling points of the electrical conductivity have shown not suitable for plant growth and ground water quality due to lead soil pollution to the study area. The low EC value under the industrial soils can be associated with the loss of base forming cations (Ca^+ and Mg^+).

Available nitrogen of the study, the highest value recorded at BHPV (S_{17}) (186mg/kg) and (195 mg/kg) during June (2013) and May (2014) on the industrial soils and lowest (36 mg/kg) recorded at Port-circle – Gnanapuram (S_{25})duringJune (2013) under residential cum industrial area of the study area. Immobilization, leaching and denitrification of fertilizer nitrogen may result in as much as 50% fertilizer nitrogen lost. Substantial amounts of nitrogen are supplied from organic matter in the soil as a result of mineralization. Soil microorganisms can also tie up soil nitrogen as fresh organic residues decay.

The highest concentrations of available P contents were observed under Residential soil of Gajuwaka Depot (102 mg/kg), New Gajuwaka (96mg/kg) and Old Gajuwaka Junction (82mg/kg) similar to Nitrogen and Potassium. This can be attributed to leachate to high inorganic fertilizer from the nearby fertilizer manufacturing industries. The data also revealed that available P was higher (102 mg/kg) in the clay and loam soils. Available phosphorus concentrations were decreased when compared industrial areas have higher available P in their up-stream area soils (which has direct contact with plant roots) compared their low lying areas or down-stream areas. More to importantly, the general decline in available P contents can be ascribed to (1) the remarkably high degree of phosphorus fixation which occurs at low pH levels and (2) losses through crop harvest and erosion which are characteristic features of agricultural soils in the tropics.

Available potassium concentrations of the study, the highest recorded at Old Gajuwaka Junction (S_{15}) (560 mg/kg)>Kancharapalem (560mg/kg) >and Gnanapuram Bridge Down (550mg/kg) > Railway Station – Gnanapuram (548mg/kg) during both year and overall the study and highest values recorded at Old Gajuwaka Junction (S_{15}) (560 mg/kg) and Kancharapalem (560mg/kg) respectively. 60% of the sampling locations were below the 500mg/kg. While lowest concentration recorded BHPV (S_{17}) (219 mg/kg) soils were higher concentration and indicating the nutrient pollution of Potassium. Potassium deficient soils tend to be light to medium textured, alkaline, carbonated and imperfectly to poorly-drained in their natural state. Organic soils are also frequently deficient in potassium. Potassium deficiencies are limited to highly weathered soils in the grey and dark grey soils of polluted areas. Most of the rest of the province has adequate amounts of soil potassium.

The availability of micronutrients has little to do with crop removal. They are needed in extremely small quantities and often, as the case with iron, the soil contains thousands of times more than the crop needs for maximum production. Soil properties such as pH and organic matter govern micronutrient availability to plants.

Iron deficiencies are generally not observed in the soils of the study areas during the study period. The level of available iron in the soil is extremely pH dependent on high pH soils because lime reduces the availability of iron.At very low soil pH levels (and also in waterlogged conditions), iron is reduced from its oxidised Fe3+ form – in which it is generally found in dry and alkaline conditions – to its highly soluble and readily available Fe2+ form. Conversely, where a soil is well aerated and well drained, with good structure and porosity, iron toxicity is unlikely to be a problem. In the study areas were found higher levels of iron concentrations (9.13 to 38.96 mg/kg) However, where soil oxygen levels are low, Fe and Mn can often reach levels in the soil solution which are too toxic for plant roots. Most of the soils have low pH> 5.5 and soils are not water logged, Fe availability should not be a problem.

Manganese deficiencies are most common on organic soils and high pH mineral soils but the study areas have lower pH levels (< 6.0) and concentrations of manganese were higher for the suitable for crop growth and indicated soil pollution due to leaching of the manganese effluent material or waste dump to the area.. Organic soils with a high pH are the most likely to respond to manganese fertilizer.

In the present study area have indicated low pH levels and sandy soils due to reasons for the Zinc concentrations (1.89 mg/kg)that the results reveal that 90% of the samples were above the nutrient availability limits (<0.700 mg/kg). The results of the study all the sampling locations have high Zinc concentrations when compare to higher at all the sampling area soils and except two sampling point recorded higher concentrations over all the study area. Whereas most common in spring when conditions are cool and wet. Zinc deficiencies have been suspected in some irrigated lands, but research trials have not confirmed this.

Copper deficient soils tend to be either sandy or light loam soils with relatively high levels of organic matter (6-10%). High levels of soil phosphorus or heavy applications of manure are often associated with a copper deficiency on these soils. In the present study areas have abundant copper source and copper deficiency or pollution were very rare anywhere in the world. Soils average copper concentration were 1.68 to 9.27 mg/kg but organic matter and soil pH were predominant factors for availability of copper in the soils whereas the copper concentration mean values were higher concentration were observed when compared other nutrient availability of the standards prescribed by the authorities in the present study area.

ACKNOWLEDGEMENT

It gives me immense pleasure to express a deep sense of gratitude to my Research guide, **Prof. T. Byragi Reddy,** in the Department of Environmental sciences at Andhra University, for suggesting my paper work and continuous guidance throughout my course of work

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A Survey on Waste Collection by Rag Pickers at Greater Hyderabad Municipal Corporation, Telangana

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ABSTRACT

The household solid waste consists of hazardous materials resulted from items like tube lights, dry battery cells used in radio and torch etc, nail polish remover, blades, sprays and other miscellaneous items. There is no specific methodology suggested or adopted for collection and disposal of household hazardous waste generated in Indian family. All activities in SWM involve risk, either to the worker directly involved or to the nearby residents. The rag pickers live in rows of huts a little away from the dumping yard. There life begins and ends only and only in an atmosphere surrounded by garbage and stench. The present paper discusses about the role of rag picker in the solid waste collection and its potential adverse health impacts on rag pickers.

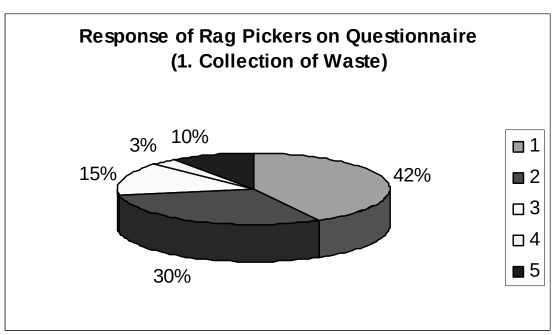
Keywords: SWM, Rag Pickers, Potential adverse impacts.

INTRODUCTION

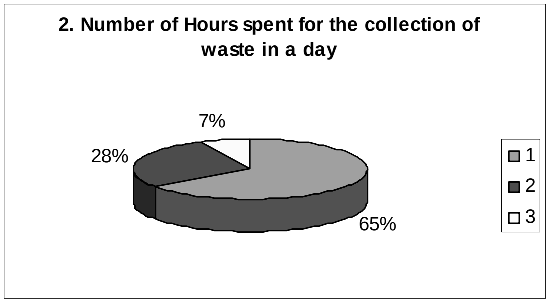
Management of MSW has become a significant environmental problem especially in metropolitan cities. Hyderabad is one of the major metropolitan city in India, with an area of 650 km^2 and population of about one crore, it generates 4000 metric tones of solid waste per day. With rapid urbanization, unplanned growth of industries, the problem of solid waste management has compounded at an alarming rate.. This study attempts to assess the occupational hazards of the rag pickers (Waste Collectors). The GHMC garbage dumping yard located in Jawahar nagar on the city outskirts in Shamirpet Mandal near Kapra municipality, Hyderabad. Children with sacks on their shoulder near garbage bins and dumps are a common sight. But one finds not only children, but people of all age groups at the vicinity of the city's biggest dumping yard at Jawahar nagar, sifting through the garbage to earn a living. The snow ball method intended to gather information on the role of rag pickers in waste reduction, and to find out their socio - economic status, health and hygienic problems was followed (lyer and Dhanalakshmi, 1998). The survey was conducted among waste pickers in the corporation area during September - December, 2009. For this a structured interview schedule was devised. One hundred and fifty out a total of about 950 rag pickers involved in the activity were randomly selected and interviewed.

RESULT

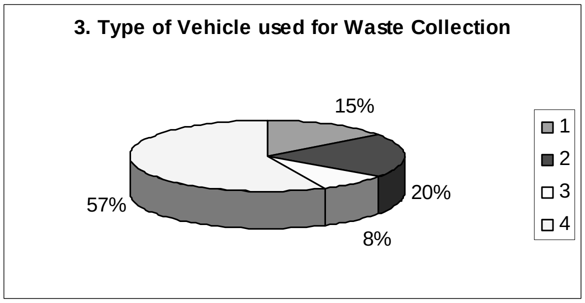
1. ***Collection of Waste*:** Collection of waste is an important step in the solid waste management. In the investigation it was found that 42% of the rag pickers are collected the waste from residential areas; 30% collected from Market and commercial areas; 15% of them collected from hospitals; 10% of rag pickers collected from railway stations and 3% of rag pickers collected the waste from offices and educational institutions.



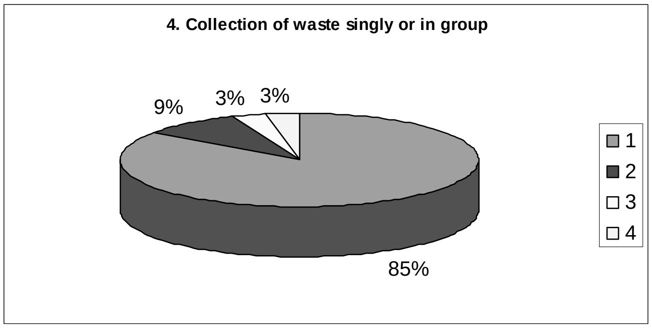
2. ***Number of Hours spent for the Collection of Waste in a Day:*** Spending time on waste collection depends on the quantity of waste generated. In the study it was found that majority (65%) of the rag pickers spending 5-8 hrs in a day for the collection of waste; 28% of the rag pickers spending more than 8 hrs and 7% spending more than 8 hrs a day and 7% spending less than 5 hrs in a day.



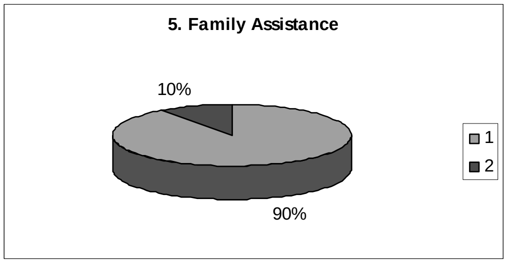
3. ***Type of Vehicle used for Waste Collection:*** Rag pickers used different types of vehicles to collect the waste. It is revealed that 57% of rag pickers were not using any vehicle for waste collection; 20% using tri cycle; 15% suing bicycle and 8% using motor cycle.



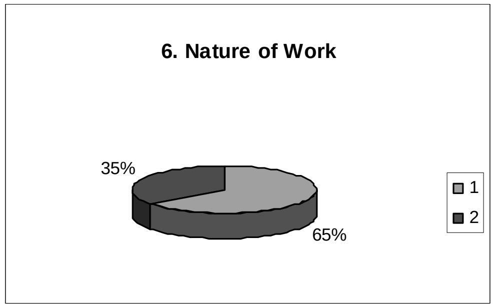
4. ***Collection of Waste Singly or in Group:*** Rag pickers are collected the waste singly and in group. In the present study it was noted that majority (85%) of rag pickers colleting the waste singly; 9% of them collecting in group of 2; 3% of them collecting the waste group of 3 and 3% are collecting group of 4. This pointed out the reluctance of pickers to co - operate and share the earnings.



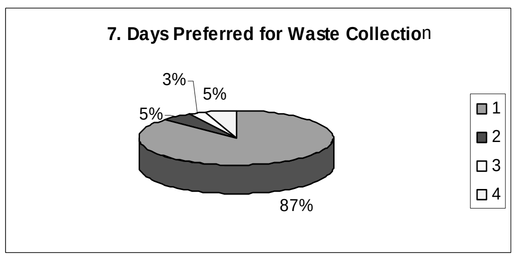
5. ***Family Assistance*:** Some times family members are assisted to rag pickers in the collection of waste. During the investigation it was found that 90% of the rag pickers were assisted by their family members whereas 10% of them were not assisted by their family members.



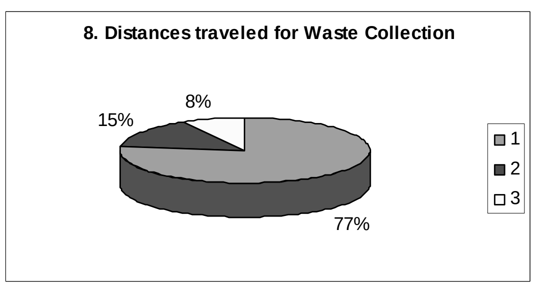
6. ***Nature of Work:*** Rag pickers are worked on full – time and part time basis. The survey result showed that 65% were full time workers and 35% were part time workers. A rag picker began his work as early as 4 am, in order not to miss the waste. Whenever the bag was full, they returned to the store or trade centre to sell these earnings.



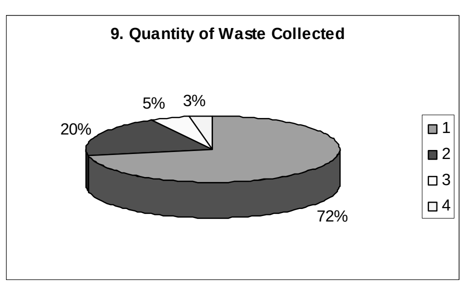
7. ***Days Preferred for Waste Collection:*** Most of the rag pickers preferred to the collect the waste on all days except Sundays and holidays. In the study it was cleared that a major percentage (87%)of the rag pickers roamed for collection on all days excluding working days and holidays whereas a minor group 5% preferred holidays; 5% to go on all days and 3% preferred to collect on Sundays and other public holidays.



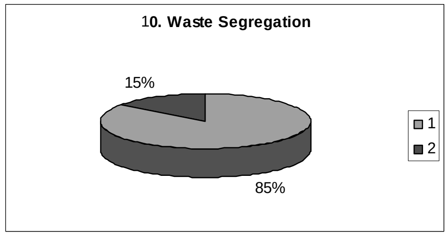
8. ***Distances Traveled for Waste Collection:*** Rag pickers usually traveled a distance of 1 – 20 km for collection of waste. In the present study it was noted that majority of the rag pickers 77% traveled a distance between 1-5 km; 15% traveled a distance between 5 - 10km and 8% traveled a distance of above 10 kms to collect the waste.



9. ***Quantity of Waste Collected:*** Usually, the quantity of waste collected in a day depends on the number of hours spent for collection and number of houses covered. In the survey it was observed that only 3% collected more than 75 kg/day, 5% collected waste between 50-75 kg; 20% collected waste between 25-50 kg and 72% collected waste below 25 kg/day.

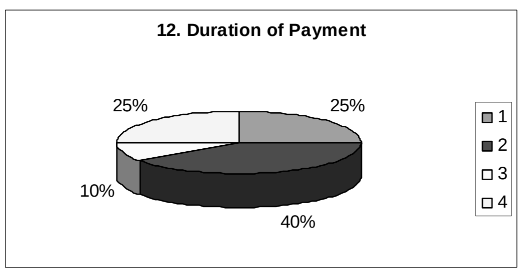


10. ***Waste Segregation:*** Segregation is an important aspect in solid waste management. Proper segregation of waste would lead to better options and opportunities for its scientific disposal. During the survey, it was revealed that 85% of the rag pickers collected waste materials without being segregated the site and remaining 15% of rag pickers segregated the waste materials at the site itself.

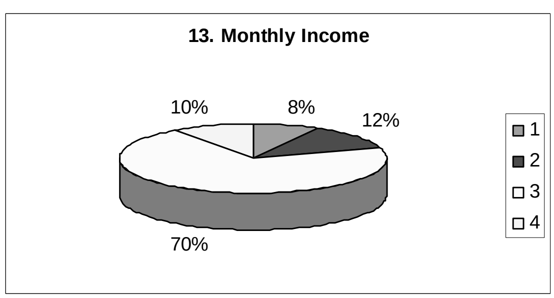


11. ***Sale of Collected Waste:*** After segregated the recyclable materials from the waste, most of the rag pickers have the habit of selling the waste. In the investigation it was observed that 80% of waste collectors sold the collected waste materials on the same day itself.

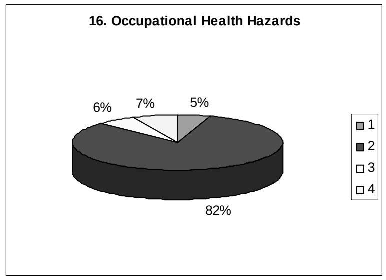
12. ***Duration of Payment:*** Rag pickers sold the waste on the payment basis. few rag pickers received the money on same day, few of them at the weekend, few at the month end etc. In the study we noted that 25% of the rag pickers received the cost of waste collected on the same day itself. However, 40% received money at the weekend and 10% received money at the end of the month and 25% of them received the money based on the quality / quantity of collection. Rag picking being their livelihood most of them wanted to have the remuneration on same day.



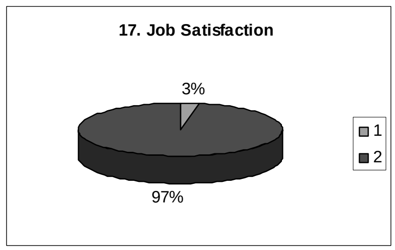
13. ***Monthly Income:*** Due to collection and selling the waste, rag pickers are earning money. Majority 75% of the waste collectors earned Rs. 1000 - 1500 per month, 12% of the respondents earned Rs. 500 -1000, 10% earned a monthly income ranging more than 1500; 8% of them earned Rs. 200 - 500 per month.



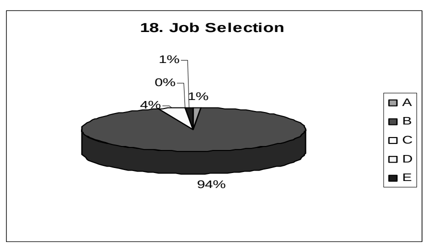
14. ***Occupational Health Hazards:*** In most of the cases, there is a chance of cause of health hazards to rag pickers. In the survey it was indicated that 82% had wounds or injuries; 6% had body pains; 5% had skin or lung diseases and 7% said that they were not faced any health problems. Lack of precautionary safety measures and lack of awareness regarding health were the main causes of health diseases. Rag pickers did not take care of their health because of ignorance and poverty.



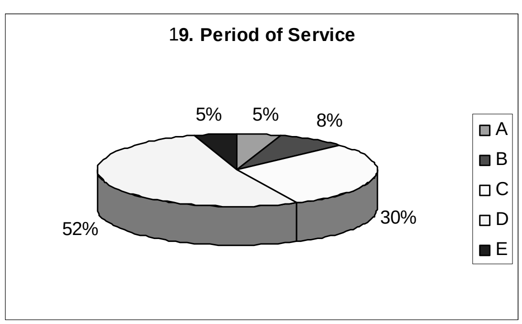
15. ***Job Satisfaction:*** Job satisfaction is very important in any profession. During the survey we asked the rag pickers about the job satisfaction, 97% of the respondents were not satisfied with rag picking job because of the hardship involved in the long hours of work and poor remuneration; other (3%) however, expressed satisfaction.



16. ***Job Selection*****:** One question asked to waste collectors was the reason for taking up this particular job. The answer of 94% of collectors was that there was no other alternative available to them. But 4% showed a special interest towards this job and 1% of them were hereditary rag pickers. It was further understood from interviews that the reason for taking up the job was family circumstances mainly some of them were wanders who later joined company with rag pickers.



17. ***Period of Service:*** Once the rag picker entered and got adjusted to that environment, it is not easy to come out of from that service. In the present study it was cleared that 60% were working for 3 years in this field; 30% worked for 2years; 8% for one year; 5% for one year and 5% worked for less than one year.



DISCUSSION

The survey conducted among the waste collectors of GHMC focusing on their socio - economic and health status, and involvement in waste recovery and recycling revealed their notable role played in waste management. In the corporation waste collectors belonging to both sex and almost all age groups have been found involved in scavenging work. The present investigation showed that young, middle and old aged people were engaged in rag picking. Out of 150 rag pickers, 18% belonged to the age below 25 years, 70% to the age group 26 - 50 years whereas only 10% belonged to the age group 51-75 years. About 75000 people were managing their livelihood by segregating and collecting inorganic wastes in Hyderabad (Reddy et. al., 1998). The present, study in GHMC I was found that majority of the rag pickers opted plastics and metals because of the easiness to sell them at better price but generally they collected every thing they could access. Another observation of the present study was that the rag pickers worked alone as single individual and not as groups.

CONCLUSION

It is true that in developing countries, solid waste workers and waste pickers routinely touch the waste they collected and stepped on waste because they typically wore only sandals. Therefore, they are easily susceptible to various infectious diseases. A study on waste pickers working at Calcutta's Dhapa dump site in 1980's showed that they had respiratory diseases, diarrhea, protozoal and helmenthic infestation (Nath, 1980). Rag pickers in Kathmandu, Nepal had very poor health due to the consumption of unhygienic food and working in polluted environment and suffered from diarrhea, cold and scabies. They were highly exposed to tetanus and other infections caused from cuts by sharp metal pieces, broken glass and other solid wastes (CWIN.1989). Waste pickers were reported to have headache to have at many dump sites like that in Kathmandu and Bangkok (Kulgskulniti et. al., 1991).

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Impact Assessment of Sub-Surface Dams and its Effects on Water Quality and Water Quantity – A Case Study in Rayalaseema Region

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ABSTRACT

The underground water can be stored and used in the particular place mainly by constructing Sub-surface dams in the area. Construction of the sub-surface dams are mainly carried out across the river in such a manner that the sand deposits available in that region is excavated till the hot rock base is attained and such excavation is carried out the considerable extension on both side of the width of the river for stability in the structure to withstand the forces acting on the structure and mainly the working of the dam takes as the water in the river get percolates deeper into the sand and the flow takes place below the sand. So the structure constructed will acts as obstruction for the flow of the water and certainly ground water table will be enhanced in that region and ultimately money spending for extracting water for irrigation, the work we had taken mainly includes the assessment of sub-surface dams in three villages namely Gajukuntapalli, Chowdepally and Mahammdabad cross around Kadiri region, Anantapur district in Rayalaseema Region and suitability of construction is checked and also check the water quality for drinking and irrigation status and depth of water improved in that study area.

1. INTRODUCTION

Subsurface dams built of soil across riverbeds have proved to be the most reliable and inexpensive water source in arid and semi-arid areas. Subsurface dams prevent floodwater, which has filled the spaces between the sand particles in riverbeds, from being drained downstream thereby drying up the sand in riverbeds. The working principle that the considered in working of the subsurface dams is the principle of stopping the underground flow in the given region. The water that fall on the river surface with get penetrate deeper into sand and had a underground flow, the dam that has constructed act as a hurdle for the stopping of the water in the underflow. Subsurface dams in Kadiri region are mainly constructed to retain ground water in the particular region to use the available water effectively for the purpose of irrigation in the surrounding areas, the design of the structures doesn't involve major structural considerations where it is designed to sustain the water force effectively.

2. OBJECTIVES

Water sample are collected from different areas in study areas and water quality analysis carried out to water suitability for irrigation and drinking purpose. Hydrometer analysis conducted in the study area to determine the depth of ground water status in that area.

3. STUDY AREA

In Rayalaseems region Ananthapur is considered to be considered to be one of the major districts and it comprises of town named Kadiri that is located nearly 96kms from Ananthapur city. As it is a major drought prone area to serve the purpose of water for irrigation in Obuladevaracheru mandal in Kadiri region three subsurface dams are constructed in three villages name Gajukuntapalli, Mohammdabad cross and Chowdepally villages and so check its suitability impact assessment if carried in the three village and villages background information is given here under

3.1 Gajukuntaplli

Gajukuntaplli is the village that is located at a distance of 17kms from Kadiri with a population of around 1269 of 646 males and 623 females and children of age group 0-6 years of nearly 110 with one anganwadi centre, public health centre and primary school upto 7th standard as per statistical information is concerned and irrigational provisions that facilitated in the village are given in table 1.

Table 1

Particulars	Gajukuntalli	Inagaluru
No. of filter wells	16	12
No. of Dug wells	5	4
No of Deep bore wells	3	2
No. of Drinking water bore wells	1	1
No of farmers	61	28
Area under irrigation (in acres)	38	33
No. of cattle	308	250
No. of sheep	550	645

3.2 Chowdepalli

Chowdepally is the village that is located at a distance of 25kms from Kadiri with a population of around 613 of 301 males and 312 females and children of age group 0-6 years of nearly 72 with one anganwadi centre and primary school upto 7th standards as per statistical information is concerned in table 2.

Table 2

S. No.	Particulars	Villages		Total
		Chowdepalli	Lingalavaripalli	
1.	No. of villages covered	1	1	2
2.	No. of filter wells	40	2	42
3	No. of Dug wells	18	28	46
4	No of Deep bore wells	5	22	27
5.	No. of Drinking water bore wells	3	2	5
6.	No of farmers	154	131	285
7.	Area under irrigation (in acres)	305	153	458
8.	No. of cattle	356	195	551
9.	No. of sheep	1550	2355	3905

3.3 Mohammadabad cross

MM cross is the village that is located at a distance of 23kms Kadiri with a population of around 646 of 333 males and 313 females and children of age group 0-6 years of nearly 53 with one anganwadi centre, public health centre and primary school up to 7th standard in table 3.

Table 3

S. No.	Total of No. of Villages	3 villages (Mohammadabad, Vanchireddipalli, Vanchireddy palli colony)
1.	Total number of farmers	89
2.	Total irrigation extent	118 acres
3.	No. of filter wells	29
4.	No. of Dug wells	24
5	No of Deep bore wells	18
6.	No. of Drinking water bore wells	3
7.	Livestock population	458 cattle, 1260 sheep
8.	Length of the SS Dam	120 meters
9.	Depth of the SS Dam	9 meters
10.	Number of labour days created	3520 labour days
11.	Total cost	15.15 lakhs
12.	Duration of construction	3 months (January – March 2007)

The detailed map show in outlay of three villages in Kadiri region.

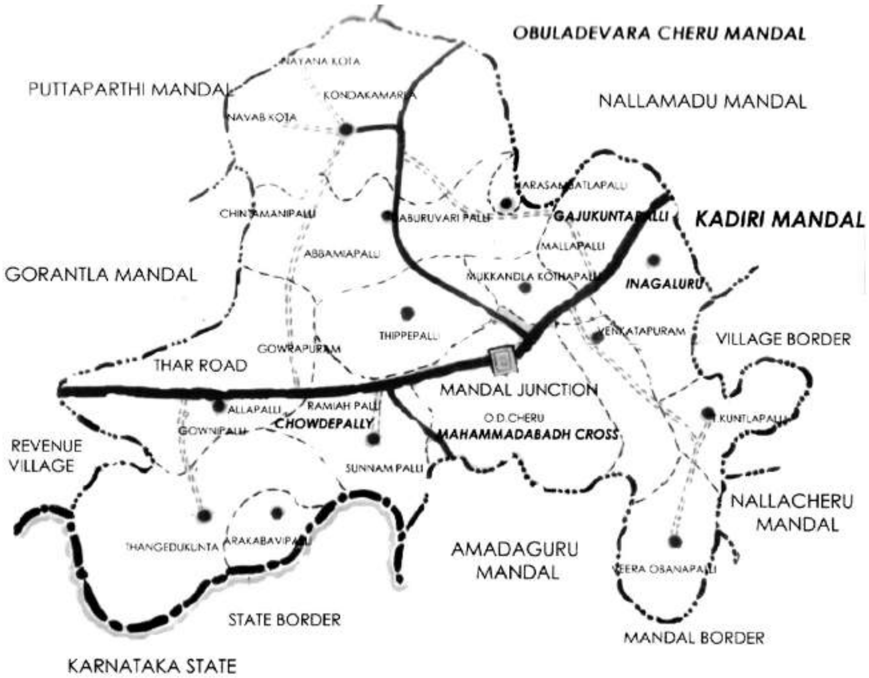

Figure 1 Detailed Map showing outlay of three villages

4. METHODOLOGY

4.1 Water Quality Analysis

Water quality analysis are mainly conducted to check the suitability of water samples for irrigational purpose and for drinking and to get reason for declined production if certain components are not upto standard values.

Water quality analysis is also carried in the three areas from where water samples are collected, nearly 5 water samples are collected from 5 different fields and mainly the tests conducted are to evaluate. Ph dissolved oxygen, Chlorides, Fluorides, Acidity, Alkalinity, Hardness, Total solids. Total dissolved solids, Residual chlorides and the obtained values are compared with standard values.

4.2 Hydrometer Analysis

Hydrometer test is mainly carried out by following way – The site at which the depth of ground water to be determined is selected and it should be facilitated with suitable inlet for hydrometer tip i.e., it should contain pipe then tip of hydrometer is inserted into the pipe till the tip of hydrometer touches the surface of the water. As soon as the up touches the surface of the water it gives alarming sound indicating the depth of water then wire is taken out from the pipe and depth is determined. By this way depth of determined at the specified sites using Hydrometer.

Hydrometer test is mainly conducted to determine the depth of ground water at the proposed sites. This is carried out by using instrument called Hydrometer as shown in Figure 2.

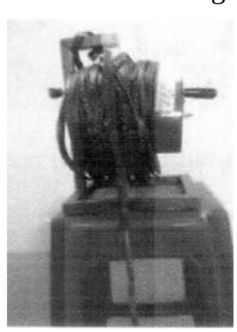

Figure 2 Hydrometer

5. RESULTS AND DISCUSSIONS

From the water samples that has collected from different areas it is observed that samples collected from Chowdepally and Mohammadabad cross contains the chemicals at optimum content and does not cause much damage for the productivity of crops in the particular region where as water samples collected from areas names Inagaluru and Gajukuntaplli differs in Hardness, Total dissolved solids, chlorides and fluorides from the standard value. Hence optimum treatment of water in the Gajukuntapalli is mainly essential for better productivity and the drinking purpose. The results are given in table 4.

Table 4 Qualitative parameters of water collected in different fields

Name of the Village	Mohammada bad cross	Gajukunta palli	Chowde pally	Chowde pally	Ingaluru
Type of bore	**Filter bore**	**Filter bore**	**Pedha bore**	**Filter bore**	**Filter bore**
Parameter					
pH	7	7	7	7	7.5
Dissolved oxygen (mg/l)	7	5.6	6.5	5	3.5
Chlorides (mg/l)	49.15	210.99	154.89	137.02	321.69
Fluorides (mgl/l)	1.5	2.0	1.5	0.8	0.4
Acidity	10	5	8	18	22
Alkalinity (mg/l)	250	100	106	107	112
Hardness	340	370	490	165	658
Total solids (mg/l)	240	1000	140	760	240
Total dissolved solids (mg/l)	240	420	480	620	960
Residual chlorides	0.1	0.2	0.1	0.2	0.3

6. CONCLUSION

1. Water quality analysis conducted in the region is suitable for irrigation and drinking purpose.
2. Inagaluru and Gajukuntaplli differs in Hardness, Total dissolved solids, chlorides and fluorides from the standard value. Hence optimum treatment of water in the Gajukuntapalli is mainly essential for better productivity and the drinking purpose.
3. Depth determined near subsurface dam at Gajukuntapalli 15 feet at the upstream of the somavathi river behind the dam.
4. Depth determined near subsurface dam at Chowdepally 20 feet at the downstream of the Somavthi river by the side of the dam.
5. Depth determined near subsurface dam at Mohammadabad cross 23 feet at the upstream of the Somavathi river by the side of the dam.

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Hydro Power Development and Eco-Logical Issues

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ABSTRACT

Hydropower is renewable energy resource; it uses Earth's water cycle to generate electricity. Water from the Earth's surface evaporates forms clouds to rain back to earth. The movement of water as downstream creates kinetic energy which is converted into electricity. Electricity is produced by forcing water, often held at a dam, through a hydraulic turbine connected to a generator. In this paper several advantages, eco- logical effects, greenhouse gases reduction comparing with thermal power plants were described. Although hydropower has no air quality impacts, construction and operation of hydropower dams can significantly affect natural river systems as well as fish and wildlife populations. Several uses like power generation, irrigation, drinking water supply to towns and villages. Large amount of vegetation is growing along the river bed when a dam is built, it can decay in the lake that is created, causing the buildup and release of methane, a greenhouse gas. Often, water at the bottom of the dam is inhospitable to fish as it is oxygen-poor compared with water at the top. Hydropower plants can alter sizable portions of land when dams are constructed, flooding land that may have once served as wildlife habitat. This can further disturb wildlife ecosystems and fish populations. It also displaces the native population who live in the area, who has to be rehabilitated to a new location.

INTRODUCTION

Hydroelectric power is currently the largest renewable energy source. It meets six percent of the world's energy supply and fifteen percent of world's electricity and sixteen percent of Indian electricity demand.

Table 1 All India installed capacity (in MW) of Power Stations
(As on 31.05.2015)

Region	Thermal	Nuclear	Hydro	RES	Grand Total
ALL INDIA	189313.56	5780.00	41632.43	35776.96	272502.95

NOTE:- 1.RES include SHP, BP, U and I, Solar and Wind Energy. Installed capacity in respect of RES (MNER) as on 31.03.2015 (As per latest information available with MNRE)

Table 2 Installed capacity (in MW) of Power Utilities in the Telangana STATE

Thermal	Nuclear	Hydro	RES	Grand Total
7247.45	148.62	2012.54	61.25	9469.86

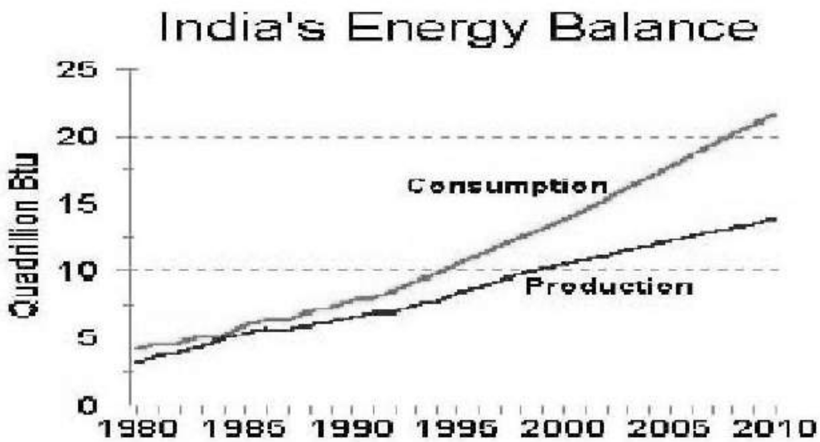

Figure 1

Table 3 Power deficit in India (1997-2003)

Year	Energy requirement (MU)	Energy Availability (MU)	Energy Shortage (MU)	Energy Shortage (%)
1997-98	424505	390330	34175	8.1
1998-99	445584	420235	25349	5.9
1999-00	480430	450594	29838	6.2
2000-01	507216	467400	39616	7.8
2001-02	522537	483350	39187	7.5
2002-03	545963	497890	48093	8.8
2003-04	559264	519396	39866	7.1
2004-05	591373	548115	43258	7.3
2005-06	666109	630408	35701	7.7

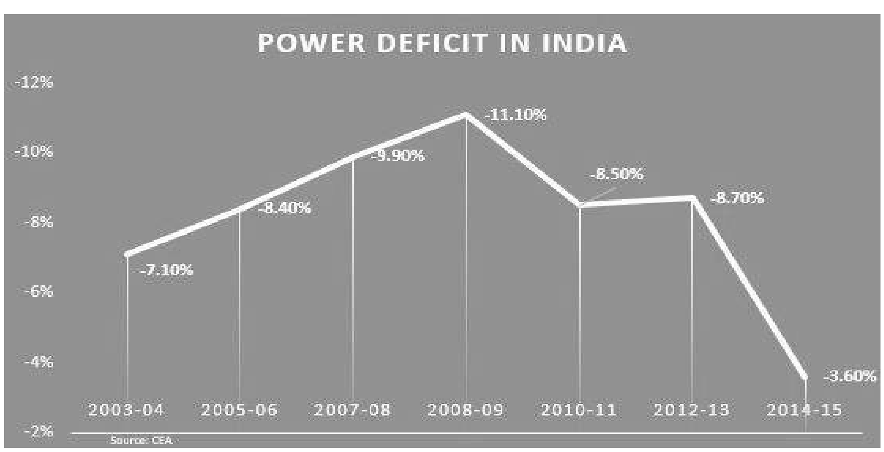

Figure 2 Power deficit in India(2003-2015)

India has huge power deficit which needs to be addressed. To fill this gap renewable energy is to be added to the grid as conventional energy sources are very polluting and will add to further pollution. Hydropower energy is one of the most reliable and efficient and cheap compared to conventional energy sources. So hydropower development is done to solve power deficit problem of India.

Atmospheric emissions from the coal-fired power plants are responsible for a large burden on human health. In 2010-11, 111 plants with an installed capacity of 121 GW, consumed 503 million tons of coal and generated an estimated 580 ktons of particulates with diameter less than 2.5 µm ($PM_{2.5}$), 2100 ktons of sulfur dioxides, 2000 ktons of nitrogen oxides, 1100 ktons of carbon monoxide, 100 ktons of volatile organic compounds and 665 million tons of carbon dioxide.

Hydropower Equation

Power in kilowatts can be determined by the following equation:

$$\mathbf{kW = H \times Q \times 62.4 \times 0.746 \div 550 \times e} \quad (1)$$

where

H = head, in ft.

Q = flow, in cubic ft. per second

62.4 lbs. = weight of 1 cubic ft. of water

0.746 kW = 1 hp

550 foot-lbs./sec. = 1 hp

e = an overall efficiency factor* (usually 0.5 for small microhydro systems)

Combining and reducing all these factors results in the following equation:

$$\mathbf{kW = H \times Q \div 24, \text{ when using cfs; or}} \quad (2)$$

$$\mathbf{W = H \times Q \div 12, \text{ when using gpm}} \quad (3)$$

A conventional source of energy like coal and diesel based power plants are not just polluting but also uses exhaustible sources of energy i.e. fossil fuels. These power plants release toxic gases into the atmosphere like carbon monoxide and hydrogen sulfides and greenhouse gases like carbon dioxide and methane. These gases contribute to global warming and climate changes. Which lead to natural calamities like floods and typhoons (or hurricanes or depression), causing huge loss of life and property.

Dams for Hydroelectric Power

On September 30th, 1882, in Appleton, Wisconsin, U.S.A., and the first ever dam was built to harness the potential energy in water stored in high levels above the sea. This energy source is being increasingly used these days as it very dependable. Dams are built where water moves swiftly with a sizable volume. After water is stored in the dam it is carried through penstock and hit the turbine blades through a nozzle, causing the turbine to spin. After this the water is discharged to river downstream. The turbine axis is coupled to axis of the alternator which produces electricity faraday's law of electromagnetic induction.

Advantages of Dams

Dams come with many advantages. First we have access to an unlimited source of water. Also dams are so robust that they could last for many years to come, some last for century or more. Adding to these advantages, dams don’t add to much pollution unlike nuclear and fossil fuels sources do to the environment which has now turned to major problem which is to be tackled.

By the construction of dams local communities benefit from industrial developments that provide capital for new economic development around those communities.It indirectly impacts communities because employees working on the project invest in housing for them and their families. It indirectly impacts communities because employees working on the project invest in housing for them and their families.

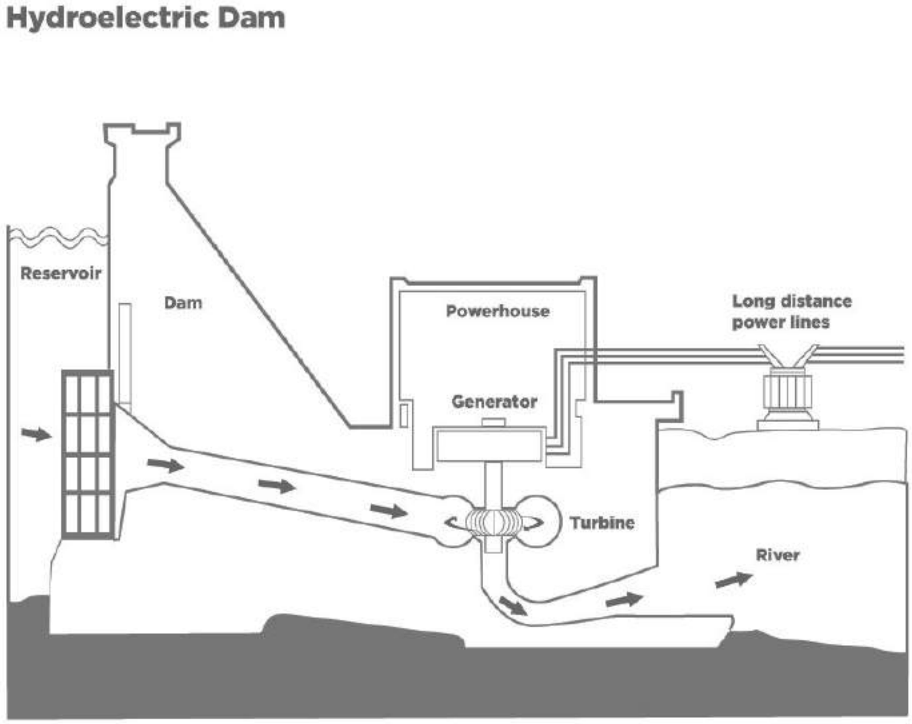

Figure 3

Drawbacks of Hydroelectric Power via Dams

There are disadvantages towards having a dam. Dams are costly they require a lot of expensive equipment. Also dams require a lot of place to build. Sometimes people residing in the nearby areas may have to be displaced from their ancestral lands and be rehabilitated, as their homes may be submerged in water. This means that they lose their farms and businesses. In some countries, people are forcibly removed so that hydro-power schemes can go ahead.

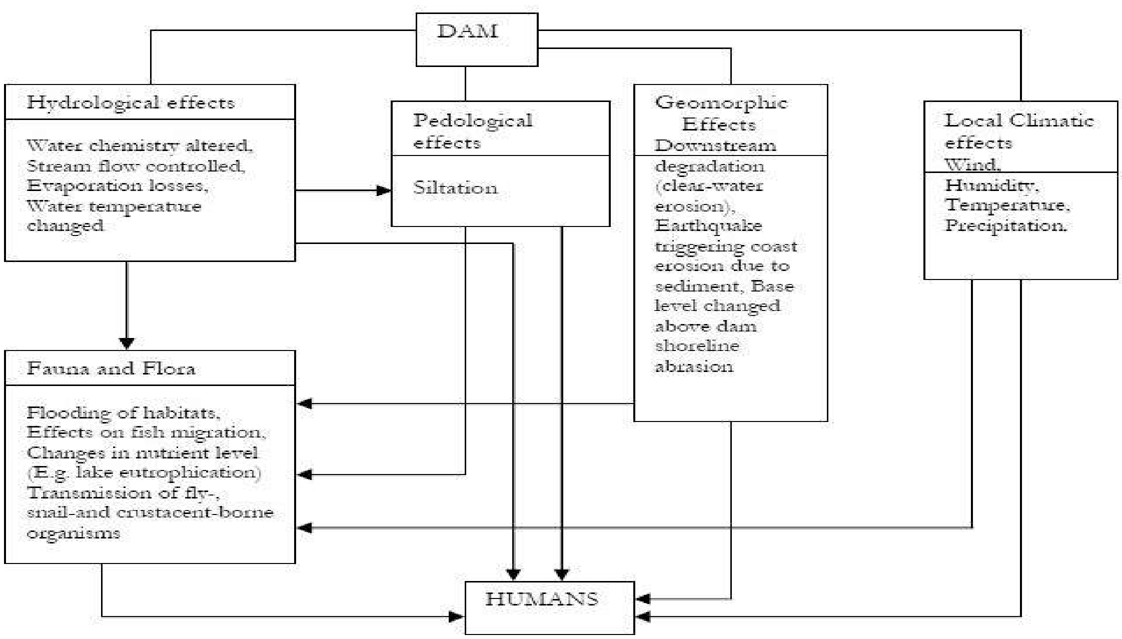

Figure 4

Dams themselves may be threatened by silting of reservoirs caused by soil erosion, which may reduce dam's ability to store water and generate electricity. Public health problems may increase because of higher population and accident probability.Due to availability of huge amount of water surface there is always a chance of encouraging mosquito breeding. Dams can endanger little known plant and endangered species. Many tropical plants or animals with potentially high economic value will be lost forever if dams reservoirs are build, as many tropical plants and fishes are to be named.

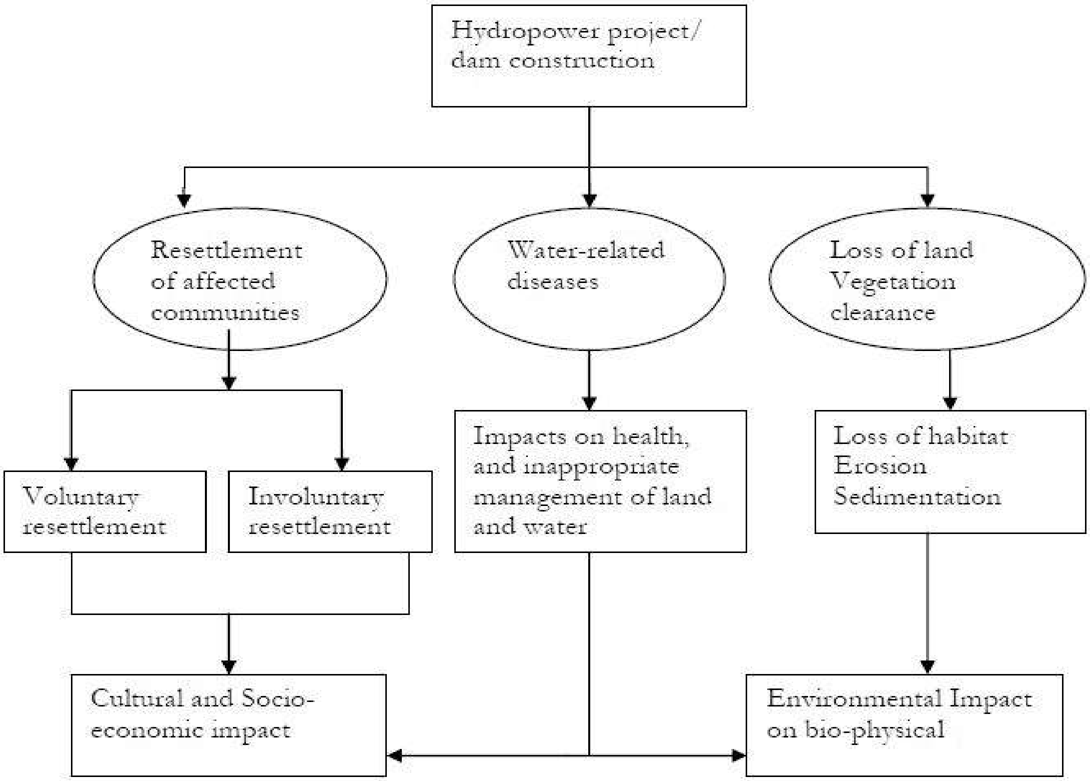

Figure 5

Dam failures are the largest manmade disasters in terms of loss of life and property. The building of large dams can cause serious geological damage. For example, the building of the Hoover Dam in the USA triggered a number of earth quakes and has depressed the earth's surface at its location. Although modern planning and design of dams is good, in the past old dams have been known to be breached (the dam gives under the weight of water in the lake). This has led to deaths and flooding. Dams built blocking the progress of a river in one country usually means that the water supply from the same river in the following country is out of their control. This can lead to serious problems between neighboring countries.

Impacts due to presence of Dams and Reservoirs

- Imposition of reservoir of a river valley (loss of habitiat)
- Changes in downstream morphology of riverbed, delta, coastline due to altered sediment load and increased erosion
- Changes in downstream water quality: effects on river temperature, nutrient load, Turbidity, dissolved gases, concentration of heavy of heavy metals and minerals
- Reduction of biodiversity due to blocking of movements of organisms (e.g. salmon).

Impacts due to pattern of dam operation

- Changes in downstream hydrology
  (a) Change in total flows; volume

(b) Change in seasonal flows (e.g., spring flood becomes winter flood).

(c) Short-term fluctuations in flows (sometimes hourly);

(d) Change in extreme high and low flows

- Changes in downstream morphology caused by altered flow pattern
- Changes in downstream water quality caused by altered flow pattern
- Reduction in riverine/riparian/floodplain habitat diversity, especially because of elimination of floods

Dam and environmental impact

1. Dams block sediment, which can lead to increased erosion downstream
2. Reservoirs inundate marshes and previously dry land
3. Cold water released from deep within the reservoir changes the
4. downstream temperature of the river, preventing some types of fish from
5. breeding
6. Dams can block migratory fish, such as salmon
7. Dams alter flood cycles.
8. Water is lost due to evaporation

CONCLUSIONS

Hydropower being a renewable, non-polluting energy source but it has various environmental effects in its surroundings like natural river systems, fish, human and wildlife populations. But still to solve the problem of India’s power deficits year-on-year hydropower sources need to be developed. Proper measures must be taken to address the serious concerns which comes building of dams and reservoirs. If these concerns are addressed then construction of dams will not affect people and the environment adversely.

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Surface Topography on the Digital Elevation Model of Kunigal Taluk, Tumkur District, Karnataka using Geoinformatics

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ABSTRACT

This paper presents a method to extract the model of surface topography on Digital Elevation Model (DEM). The Data files have elevation of the terrain over a specified area, usually at a fixed grid interval. The geodatabase features smart enforcing integrity with attribute domains grouping features using subtype tables and relationships between feature classes and non-spatial tables. Digital representation by aerial photography and topography Model based on scale of original data is commonly a raster dataset. The Cell based data has a single elevation which represents the entire area. DEM provides the basis in modelling and analysis of spatio-topographic information. A Digital Elevation Model (DEM) is a digital representation of ground surface topography or terrain created by using ERDAS IMAGINE *Ver* 9.1 and processed by Arc GIS *Ver*. 9.2. DEM is reconditioned using the DEM reconditioning workflow. The main tool used in this process is the Fill Sinks tool, but other tools may be used if needed for correct determination of lakes or marking real sinks in the field.The analysis and interpretation of terrain morphology is created by digitally removing all of the cultural features by exposing the underlying terrain formations. The slope map is developed and consists of seven different slopes like nearly level (0-1deg),very gentle slope (1-3deg), gentle slope (3-5deg), Moderate slope(5-10deg) strong slope(10-15deg) moderate steep slope (15-35deg) and very steep slope(>35deg). The Surface topography is Important to know the terrain hydrology, environmental modelling, visualization of landscapes, aspect, slope, drainage networks, and stream channels modelling of hydrologic functions. From the topographic map determining the drainage network and estimating the slopes.

Keywords: DEM, ERDAS IMAGINE Ver. 9.1 and Arc GIS Ver. 9.2 etc.

1. INTRODUCTION

Surface topography commonly investigated by the use of distributed watershed models. These watershed models require physiographic information such as arrangement of the different thematic maps of the drainage and channel network, geomorphology, structural features, slope, soil and its catchment geometric properties. Traditionally, these parameters are obtained from maps or field surveys. DEM data are digital elevation data set recording the topographic surface expression of any area (http://www.gisdevelopment.net). Over the last two decades this information has been increasingly derived directly from digital representations of the topography (Jenson and Domingue, 1988; Mark, 1984; Moore *et al.,* 1991; Martz and Garbrecht, 1992). The digital representation of the topography is called a Digital Elevation Model (DEM). The automated derivation of topographic watershed data from DEMs is faster, less subjective and provides more reproducible measurements than traditional manual techniques applied to topographic maps (Tribe, 1992). Digital data generated by this approach also have the advantage that they can be readily imported and analyzed by GIS. The technological advances provided by GIS and the increasing availability and quality of DEMs have greatly expanded the application potential of DEMs to many Hydrologic, Hydraulic, water resources and environmental investigations (Moore *et al.,* 1991). Earlier investigations by different workers for the creation of DEM for watersheds elsewhere include; Youberg *et al*. (1998) used GIS to develop a method for deriving stream-water relationships for the selection of reference site characteristics from watershed parameters derived from a DEM and data collected from the field and Fels and Matson (1998) used DEMs to conduct a hydro geomorphic land classification.

1.1 STUDY AREA

In this paper, the analysis of Surface topography are reviewed and discussed with respect to the derivation of topographic data in support of DEM. In Kunigal is a town located in southern part of Tumkur district, Karnataka state, India. Kunigal taluk is bounded by latitude $12^{0}44^{'}38^{''}$ to $13^{0}8^{'}1^{''}$and longitude $76^{0}49^{'}43^{''}$ to $77^{0}9^{'}57$’’covering an area of 981.55 km^2.) in the study is bound 57 C/16, 57 G/4, 57 D/13, and 57 H/1 and 57H/2 (scale 1:50,000) were collected from Survey of India, Bangalore and the software’s used and Arc GIS 9.2 for digitization of study area and analysis. The study area exhibits the Dendritic to sub-dendritic drainage pattern have also carried out characteristics of geomorphic units together with slope, geology, lineaments, using Remote Sensing and GIS techniques. The climate of the area is semi-arid and is characterized by hot summer in March to May months, low rainfall and pleasant monsoon of winter season. The temperature varies from 21.0 to 34ºC during summer and 16.7 to 27.3ºC during winter season. The average annual rainfall is 802 mm. The area has sandy reddish brown soils with thickness varying from 0.50 - 2 m (Reddy and Rangaswamy, 1989). The study area is covered by hard rock formations such as Granites and Gneisses, facing acute water scarcity both for irrigation as well as drinking water purposes. The granites of Closepet Granite (CG) and gneisses forming part of Peninsular Gneissic Complex (PGC) which have been intruded by younger dolerite dykes (GSI, 1981 vol 112).

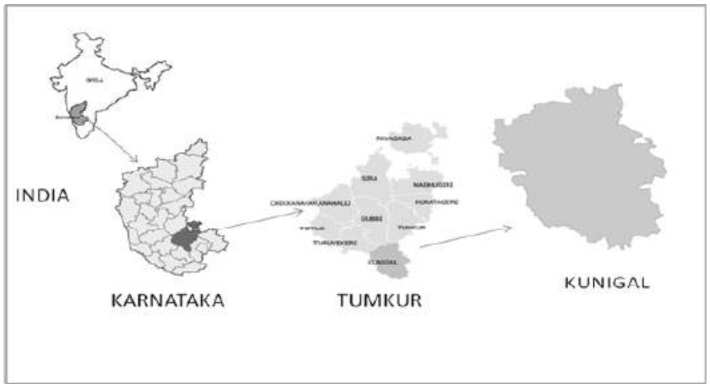

Figure 1. Study area map

The near surface exposures of these granites in the low laying areas are weathered and decomposed up to depth of 20 m. They are intersected by number of pegmatite veins with well developed joints. The surface runoff forms the rain fall it flowers towards to the western part of the study area. The contact between Closepet granite and Gneiss is irregular and transitional. The exposures of these Gneisses are found mostly in the low laying areas in the form of mounds and small ridges. These gneisses are comparatively more fractured and weathered than the Closepet granite. This hard rock's contain no primary porosity. Hence water percolates through secondary porosity formed by fracturing and weathering. Geomorphologically, the area is classified into Denudational hills, Residual hills, Inselberg, Pediment inselberg complex, Pediments, Shallow weathered pediplains, Moderately weathered pediplains, and Valley fill which are observed both in the Closepet granites and Gneisses.

1.2 METHODOLOGY

The corresponding IRS 1 C and 1 D Geocoded FCC of LISS III data used (NOV-2008). The contours (20m) represent the elevation ranging from 660 m to 1100 m above MSL shown in fig 2, and Cartosat DEM is downloaded from NRSC shown in fig 3, from this contour map developed.

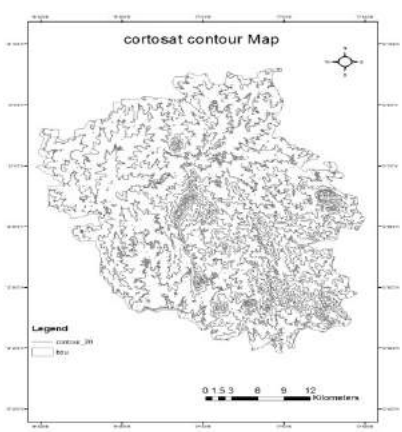

Figure 2. Contour Map

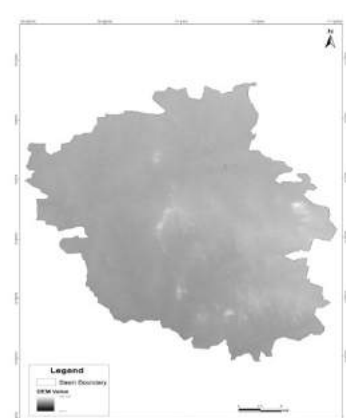

Figure 3. DEM Map

Contour values are then correspondingly assigned to the overlapping grid cells with the IDW (Inverse Distance Weightage) interpolation method. Five data layers including contour, spot height, LISS III Image, DEM and study area boundary are used as inputs into the interpolation process so that a raster data set of elevation with the required pixel resolution can be achieved. This output is further used in the illumination process to produce shaded relief images. Contour and spot height layers providing linear and random elevation data are estimated and distributed into grid system using interpolation process. Based on this grid, a color coded DEM has been generated. Stream layer is used to mark the draining courses flowing from upstream to downstream while the study area boundary tells the extent of limit. The Aspect and shaded relief functions of Arc*GIS Ver 9.2* (ESRI, 2001) and its supporting module The aspect map details shown in fig 4. *Arc Scene* software's which help in interpolation and illumination processes are used to obtain elevation data in grid shaded relief image is shown in fig 5.

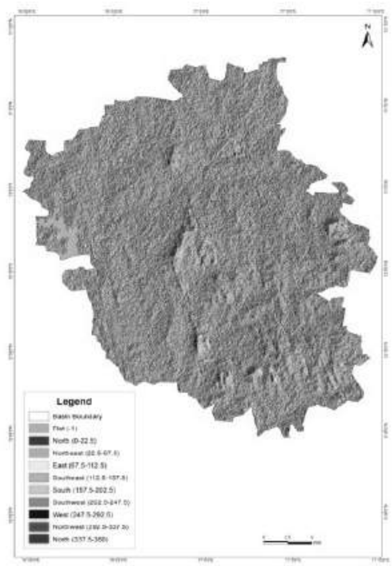

Figure 4. Aspect map

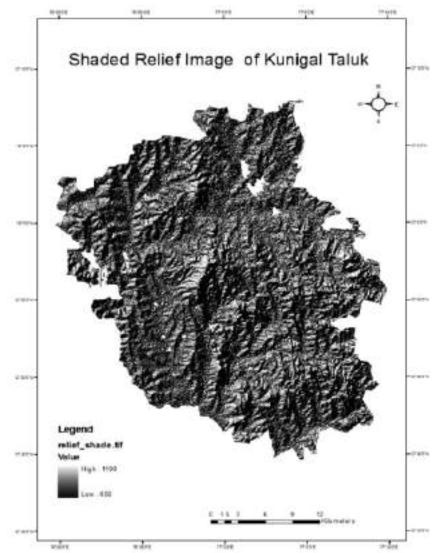

Figure 5. Shaded relief

This study evaluates the methodology and provides a basis for Digital Elevation Model (DEM) for Identification of surface topography future studies that intend to utilize Spatial Analyst for hydrologic or geomorphic research. The different DEMs of illuminated shaded relief with overlay of major roads and settlements, exaggerated perspective view, exaggerated perspective view of merged FCC satellite image draped over DEM of Kunigal Taluk are generated for further research work. In the present study, attempt has been made to create DEM for the kunigal Taluk using Spot heights and Contours. An integrated approach of Remote Sensing and GIS Techniques were used for identification of surface topography by using Arc GIS *Ver* 9.2.

The Spot height values measured upwards from a base datum on the earth's surface are called Spot heights and depth values are called soundings. These are portrayed on maps with point symbols and annotation of the numerical value Spot heights or soundings. The Contours are imaginary lines which represent the intersections that arise from horizontally slicing up landforms into equal vertical intervals like a layer cake. Imhof (1982) and SS Vittala et al (2006) defines them as "lines on the map depicting the metric locations of points on the earth's surface at the same elevation above Sea level". Contour lines are measured up from a base datum, usually Sea level and the lines measured down from the datum are called depth contours. The height difference between contours is called the contour interval (20m). Small scale regional maps will have a larger contour interval, and will be less accurate, and very large scale maps used for engineering and planning will have a very small contour interval and be very accurate.

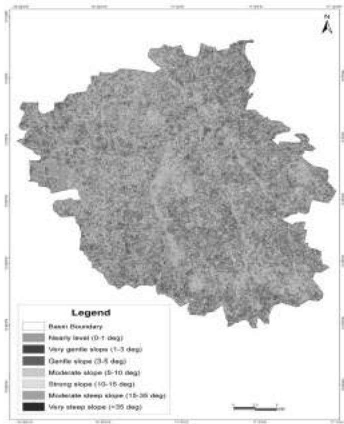

Figure 6. Slope map

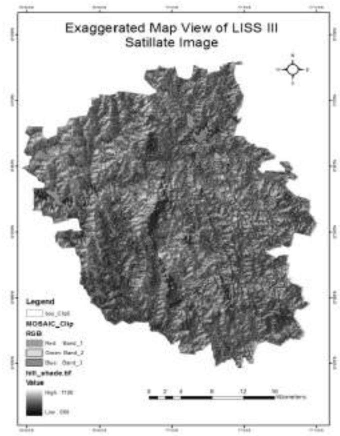

Figure 7. Exaggerated map of study area (Contour + DEM + LISS III)

RESULTS AND DISCUSSIONS

The DEM provides a detailed topographic picture of the study area NE, NW, SE and SW parts of the area show minimum relief (between 660 - 880 m above MSL) while in rest of the area, topography is undulating and plain in the central part. Eastern and north-eastern parts show maximum relief showing elevation of 880 to 1100m values above MSL. Analysis of DEM data has revealed the following information in the study area;

- The slope map is developed and consists of seven different slopes with is nearly level(0-1deg),very gentle slope (1-3deg), gentle slope (3-5deg), Moderate slope(5-10deg) strong slope(10-15deg) moderate steep slope (15-35deg) and very steep slope(>35deg) is shown in fig 6.
- Grey to black to red zones have maximum topographic gradient which is less , light red to black have gentle gradient with moderate to poor and the green and cyan zones have very low topographic gradient in(Fig. 4).
- Exaggerated perspective view of merged FCC satellite image draped over DEM (Fig. 7) reveals that dark red to red tone is shows the difference in elevation.
- Topographic wetness index map is shown in fig 8 blue area indicates the surface and groundwater potential zones where as orange area indicates the non groundwater potential zones.
- Careful observation of DEMs show that the slope is towards north- south west and drainages to flow in a south west direction and the surface water flow direction is from NE to SW and finally joins river south of river Simsha.

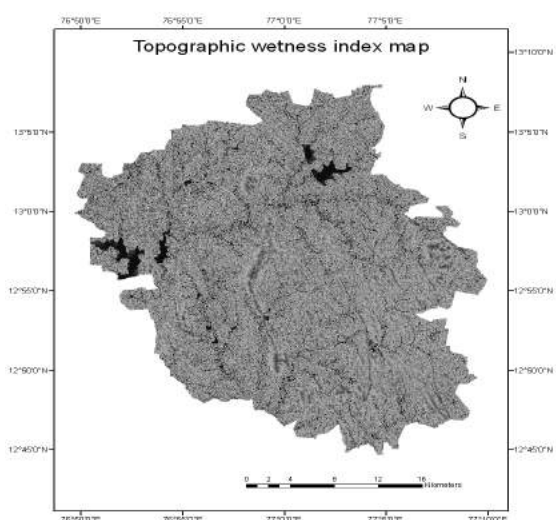

Figure 8. Topographic wetness index map

CONCLUSIONS

The Kunigal taluk of Karnataka State is well known as one of the areas showing in Tumkur district. The relief and topography and part have been selected as the study area for applying DEM data and LISS III Image is used for surface topography analysis. The DEM data can be created from GIS data layers i.e. contour line and spot height. The result is expressed as grid data of which their quality controls are the quality of original data and grid size assigned for interpolation process. The grid data are further processed to be shaded relief image by illumination method. The height exaggeration for grid data as well as Sun azimuth and angle for relief illumination can be varied to obtain different images with different enhanced features. Proper interpolation resolution and proper scale of shaded relief image, exaggerated perspective view and as well as topographic wetness index map will assist to achieve surface topography. To achieve the better result, integrated data should be employed for interpretation. Further DEM data can also be used for watershed prioritization, development and management in an acceptable level particularly when some other data are not available.

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Local Community Perceptions of Tourism Impacts in Promoting Mysore Globally

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ABSTRACT

This paper examines tourism impacts in Mysore district which is situated near Bangalore, the state capital of Karnataka in India. In Mysore, tourism is one of the fastest growing industries as well as the major source of foreign exchange earnings and employment. As a service industry, tourism has numerous tangible and intangible elements. Major tangible elements include transportation, accommodation, and other components of the hospitality industry. Major intangible elements relate to the purpose or motivation for becoming a tourist, such as rest, relaxation, the opportunity to meet new people and experience other cultures, or simply to do something different and have an adventure. The study clearly shows that the local community perceptions are supportive to tourism activities and the impacts of tourism are minimal. This paper focuses to promote Mysore a global destination, with the local communities' satisfaction of tourism impacts.

Keywords: tourism, tourism impacts, local community, perceptions, global destination.

INTRODUCTION

Tourism as social science deals with the study and understanding of communities (Maganga, 2014). The UNWTO (2009) defines tourists as people who travel to and stay in places outside their usual environment for at least twenty-four hours and not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited. According to UNWTO (2009) reported that impacts arise when tourism brings changes in value systems or behaviour, threatening indigenous identity. Changes often occur in community structure, family relationships, collective traditional life styles, ceremonies and morality. In addition to this, tourism can also generate positive impacts as it can serve as a supportive force for peace, foster pride in cultural traditions and help avoid urban relocation by creating local jobs. Socio-cultural impacts are ambiguous. The same, objectively described impacts are seen as beneficial by some groups and as negative by others. Culture transmits values and gives directions in life and a balanced society should provide a certain backing for its members

Mysore has plenty to offer and people enjoy visiting the palace, zoo, Brindavan Gardens, Chamundi Hills, St. Philomena's Church, Srirangapatana and Ranganathittu Bird Santuary. But the need of the hour is to identify fresh tourism circuits, promote new destinations and ensure that Mysore emerges as the base to explore places of tourist interest in a radius of 80 km to 120 km, so as to cover Bandipur, Nagarahole, Kodagu, Belur-Halebidu, Shravanabelagola and even Ooty and Wayanad. Table 1 and 2 provides the tourist arrival and population status in Mysore.

Table 1 Tourist arrival in Mysore during 2010 - 2012

Year	2010	2011	2012
Domestic	3.1 million	3.5 million	3.19 million
International	70,000	85,281	74,380

Table 2 Mysore census 2011- Population of Mysore

Population	29,94,744
Urban population	12,38,332
Rural population	17,56,412
Male population	15,11,206
Female population	14,83,538

Tourism in Mysore involves many activities that can have adverse tourism impacts. Many of these impacts are linked with the construction of general infrastructure such as roads, airports, tourism facilities, including resorts, hotels, restaurants and shops. The negative impacts of tourism development can gradually destroy the environmental resources on which it depends. On the other hand, tourism has the potential to create beneficial effects on the environment by contributing to environmental protection and conservation. It is a way to raise awareness of environmental values and it can serve as a tool to finance protection of natural areas and increase their economic importance. This paper analyses the significance of tourism impacts affecting local community satisfaction and promoting Mysore globally. This paper is organized as follows. In section 2 statement of problem, section 3 reviews the related literature and section 4 is devoted to the objectives. Section 5 hypotheses of the study, section 6 designed for methodology of the research and section 7 demonstrates the Hypotheses analysis. The major findings and discussion are demonstrated in section 8, section 9 suggestions on the obtained results and finally section 10 conclusion of the paper.

Problem Statement

Tourism an "industry without chimney" is one of the largest and dynamically developing sectors of external economic activities. Its high growth and development rates, considerable volumes of foreign currency inflows, infrastructure development, conservation policies, sustainable development plans and introduction of new management and educational experience actively affect various sectors of economy, which positively contribute to the socio-cultural, economic and environmental development of the country as a whole. This paper analyses the local community perceptions of tourism impacts in promoting Mysore globally.

Literature Review

Literature review presents a review of the available literature on the topic under study. Community impacts emerging from tourism development are often divided into three categories. First, economic category includes elements such as tax revenue, increased jobs, additional income, tax burdens, inflation, and local government debt. Second, sociocultural elements, encompass resurgence of traditional crafts and ceremonies, increased intercultural communication and understanding, increased crime rates and changes in traditional cultures. Third, environmental category includes protection of parks and wildlife, crowding, air, water and noise pollution, wildlife destruction, vandalism, and litter (Andereck, 1995). Table 3 shows the perceived impacts of tourism in the economic, social and environmental basis. Table 3 shows the perceived impacts of tourism in the economic, social and environmental basis.

Table 3 Key economic, social and environmental impacts of tourism perceived by local community

Writer(s)	Issue/Impact
McCool and Martin 1994; Perdue et al., 1990	Tourism boosts economic quality of life by improving tax revenues and increasing of personal income.
Johnson et al., 1994; Liu and Var, 1986	Tourism creates more employment opportunities, new investments, and profitable local businesses.
Johnson et al., 1994; Haralambopoulos and Pizam, 1996; King et al., 1993; Sathiendrakumar and Tisdell, 1989; Sharpley, 1994	Tourism improves standards of living through business opportunities and investment in infrastructure.
Haralambopoulos and Pizam, 1996; Liu and Var, 1986	Some negative economic impacts of tourism include an increase in the prices of goods and services, and inflation in property values.
de Kadt, 1979	The nature of contact with tourists can influence attitudes/ behaviour/values towards tourism.
Sharpley, 1994	Tourism instigates social interaction within the host community.
Dogan, 1989; Rosenow and Pulsipher, 1979	In areas with high levels of tourism development, there is often a loss of resident identity and local culture such as habits, daily routines, social lives, beliefs, and values.
Dogan, 1989	There are a variety of negative consequences such as a decline in traditions, materialism, social conflicts, and crowding.
Kousis, 1989	Tourism has negative effects on traditional family values. Burns and Holden, 1995 Culture is seen as a commercial resource.

Writer(s)	Issue/Impact
Brunt and Courtney, 1999; Haralambopoulos and Pizam, 1996; Mok et al., 1991; Tosun, 2002	Tourism is a potential determinant of crime.
Haralambopoulos and Pizam, 1996; Mok et al., 1991; Tosun, 2002	Tourism increases drug and alcohol use.
Lui and Var, 1986	Tourism declines the level of resident hospitality.
Brunt and Courtney, 1999, Gilbert and Clark, 1997; Perdue et al., 1990	Tourism can improve recreation opportunities, cultural activities and cultural heritage.
Liu and Var, 1986	Tourism increases cultural events, entertainment facilities, historical and cultural exhibits, and cultural exchange.
Burns and Holden, 1995	Hosts develop coping behaviours. Sharpley, 1994 Tourism contributes to the preservation of religious and historic buildings.
Andereck, 1995	Tourism has potential negative environmental consequences such as air and water pollution; destruction of wetlands and soil; plant destruction and deforestation; wildlife destruction as a result of hunting and fishing, disruption of natural habitats; forest fires.
Andereck, 1995; Brunt and Courtney 1999; Johnson et al., 1994; King et al., 1991; Liu et al.1987b; McCool and Martin, 1994; Perdue et al., 1990	Traffic and noise are some negative impacts of tourism.
Burns and Holden, 1995	The biggest problem is congestion/overcrowding.
Brunt and Courtney, 1999; Gilbert and Clark, 1997; Lankford, 1994	Tourism increases the amount of litter.

Results of the studies have suggested that community support for tourism development is essential for successful operation and sustainability of tourism. Choi and Sirakaya (2005), advocated that residents are major stakeholders in leisure and tourism management. According to Trakolis (2001) human communities, especially those living in and around protected areas, often have important and long-standing relationships with these areas. Local and indigenous communities may depend on the resources of these areas for their livelihood and cultural survival.

Ap (1992) and Lankford (1994) point out that the perceptions and attitudes of residents towards the impacts of tourism are likely to be an important planning and policy consideration for the successful development, marketing, and operation of existing and future programs and projects. Tourism can develop and grow when local residents have a positive attitude toward it and when they see their role in the process of the tourism development (Ambroz, 2008)

Objectives of the study

The main objectives of the present study are:

1. To study the tourism impacts in Mysore travel, tourism and hospitality industry.
2. To examine the local community perceptions of tourism impacts in Mysore.
3. To analyses the role of local community satisfaction to promote Mysore travel, tourism and hospitality industry globally based on tourism impact.

Hypothesis of study

Based on the literature review and to achieve the above objectives, following hypotheses were considered for the study:

H_0: There is no significant relationship between the tourism impacts affecting local community satisfaction and promoting Mysore globally.

H_1: There is significant relationship between the tourism impacts affecting local community satisfaction and promoting Mysore globally.

RESEARCH METHODOLOGY

Data Collection

In this paper, the primary form of data collection is self-structured questionnaire based on the previous review of literature. The technique of 5 point Likert Scale was used where 1 = strongly disagree; 2 = disagree; 3 = moderate; 4 = agree; 5 = strongly agree. The survey instrument had the following two sections:

(i) First Section was deal with the demographic profile of the respondents.

(ii) Second Section was related to items presented pertain to the different considered aspects of tourism impact that can affect local community satisfaction.

In this paper the secondary form of data collection is articles, reports, publications both in printed and electronic form, newspapers and writings in books.

Study area: The study area was Mysore City which is situated in the Karnataka state and is receiving more tourists every year while the number is growing day-by-day.

Sample design: Total 70 questionnaires were distributed while 58 responses were found valid and were considered for the study. The data collection was done at Mysore major tourist attraction places. The technique of Convenient Sampling was applied for data collection.

Data analysis: The data was analyzed for finding the descriptive analysis and correlation analysis with the help of statistical software SPSS version 15.0. The demographic profile of the respondents is presented in Table 4.

Table 4 Demographic Profile of the Respondents

Gender	Male Female	61.5% 38.5%
Age(in years)	18-37 38-57 58+	30.5% 43.5% 26%
Education level(completed)	Secondary & Higher Secondary school Under Graduate Post Graduate	23.5% 49% 27.5%
Income	14,999 or less 15,000-34,999 35,000-54,999 55,000-74,999 &75,000 or above	32.5% 18.5% 24% 19.5% 5.5%

Interpretation: It was found that the gender consists of 61.5% of Male and 38.5% of Female. Majority of the respondents were belonged to 38-57 age group while 58+ consisted of 26% and 30.5% of the respondents were belonged to 18-37 age group. The educational level of the respondents included the 23.5% studied till Higher Secondary Level while the respondents completed their Under Graduate was 49% and only 27.5% belonged to Post Graduate Level Educational group. The majority of the respondents i.e. 32.5% were belonged to the 14,999 or less income group while 24%, 19.5%, 18.5% and 5.5% were belonged to the income groups of 35,000-54,999; 55,000-74,999; 15,000-34,999; 75,000 or above respectively.

Table 5 Descriptive Analysis - Local community perceptions of tourism impacts

Q.No	Impacts		Explanation	Mean	Standard deviation	Overall Mean
1.	Social	s1	Trust in people	3.8	1.02	3.3
2.		s2	Human relations	3.5	0.97	
3.		s3	Begging	3.4	0.72	
4.		s4	Entertainment	3.5	0.97	
5.		s5	Conflict between family members	2.6	0.83	
6.		s6	Changes in personal appearance	3.8	1.02	

Q.No	Impacts		Explanation	Mean	Standard deviation	Overall Mean
7.		s7	Alcohol and drugs	2.8	0.99	
8.		s8	Friendliness	3.8	1.02	
9.		s9	Conflicts on the use of lands	2.8	0.99	
10.		s10	Theft and burglary	3.2	0.94	
11.	Economic	e1	Standard of living	3.8	1.02	3.2
12.		e2	Transportation	3.5	0.97	
13.		e3	Employment	3.8	1.02	
14.		e4	Arts and handicrafts	3.8	1.02	
15.		e5	Agriculture	2.8	0.99	
16.		e6	Prices of services and goods	3.4	0.72	
17.		e7	Prices of houses and land	3.5	0.97	
18.		e8	Restaurants and souvenir shops	3.2	0.94	
19.		e9	Revenue	3.8	1.02	
10.	Environmental	en1	Litter	3.5	0.97	3.4
11.		en2	Pollution	3.2	0.94	
12.		en3	Preservation of cultural resources	3.4	0.72	
13.		en4	Traffic congestion	2.8	0.99	
14.		en5	Preservation of natural environment	3.8	1.02	
15.		en6	Peace and silence	3.5	0.97	
16.	Q16		Do you agree to promote Mysore globally	4.08	0.98	

After knowing the demographic profile and descriptive analysis of the sample /respondents, the need is to identify the significant relationship between various parameters should be analysed. Therefore, the statistical technique of Correlation Analysis between tourism impacts affecting local community satisfaction and promoting Mysore globally is measured as shown in the below Table 6.

Table 6 Correlation analysis between tourism impacts affecting local community satisfaction and promoting Mysore globally

		Promoting Mysore globally
Tourism impacts affecting local community satisfaction	Pearson's correlation	.31
	Sig. (2-tailed)	.01
	N	58

Hypothesis Analysis

The correlation value of factors affecting local community satisfaction and tourism products promotion is r = .31, $p < .01$ (Please Refer Table 3), which means a positive relationship between them. Hence, hypothesis H_1 is accepted.

Major Findings

The following are the explanations of research findings, first the individual mean values were calculated and then the standard deviation value was calculated. After that, the test of correlation was applied to analyze the relationship between tourism impacts affecting local community satisfaction and promoting Mysore globally. The mean value of social, economic and environmental impacts of tourism are 3.3, 3.2 and 3.4 respectively, which have the tendency over "Neutral" and to somehow tend towards the area of "Agree", which meant that the social, economic and environmental impacts of tourism plays a significant role under local communities satisfaction phenomenon. In the next step, the overall mean value of three elements viz. social, economic and environmental impacts of tourism was calculated and that was 3.00 which again means that to have the tendency over "Neutral" and to somehow tend towards the area of "Agree", meant that all the three elements has played significant role under the local community satisfaction phenomenon.

After the descriptive analysis, the next step was to analyze the relationship between tourism impacts affecting local community satisfaction and promoting Mysore globally. We know that, the Correlation Coefficient (also known as Pearson correlation) is a dimensionless measure of the degree of linear association of two values, with value in the interval [−1, 1]. Moreover, the correlation coefficient always takes a value between -1 and 1, with 1 or -1 indicating perfect correlation and correlation coefficient is denoted by "r". Furthermore, in correlation analysis, the determination of effect also calculated where r = .10 (small effect), r = .30 (medium effect) and r = .50 (large effect) represented accordingly.

The factors affecting customer e-satisfaction and Tourism products promotion, the value of r = .31, p < .01 which means that the positive relationship was existed while the value approximately in the zone of r = .30 which concluded that there is a medium effect of tourism impacts affecting local community satisfaction and promoting Mysore globally.

SUGGESTIONS

A few suggestions to enhance tourism in Mysore are as follows:

1. To improve economic opportunities from tourism activities the local communities' needs education and enhancement of competencies in the locality of tourism clusters,
2. Environment friendly vehicles having a minimum effect on ecology of the destination would be encouraged in the tourism destination in the Mysore district,
3. Training programs for enhancing the skills of tourist guides and support staff in hospitality industry to provide authentic information and to communicate effectively with the tourists,
4. Entry points into the district should be increased to provide international, inter-state, intra-state tourists and expand existing airport capacity along with low cost terminal developments,
5. Information centers/kiosks and interpretation centers will be encourages at all major tourist destinations. Accredited tourist guide services will also be emphasised,
6. Three main principles of sustainable tourism development namely Ecological sustainability, Social & cultural sustainability and Economic sustainability should be practiced,
7. Home stay concepts in and around Mysore, rope way project to chamundi hill should be planned and developed.

CONCLUSION

Residents of Mysore have both positive and negative perceptions towards tourism impacts in their community. Local community acknowledges the economic benefits of tourism, the cultural and social benefits are also perceived as an advantage by residents, but to a low degree. At the same time, it is recognized that tourism creates different problems, including traffic congestion, pollution. The residents are satisfied with tourism impacts and development in their area. Thus local community promotes tourism products globally by sustainability of all the processes and value chains in the tourism, travel, hospitality and catering industries that enable organisations to maximise their efficiency and effectiveness.

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THEME - IV

Groundwater Exploration, Development, Recharge, Modeling and Quality

Augmentation of Groundwater Resource through Artificial Recharge to Maintain the Sustainability of Over Exploited Aquifers in the Hard Rock Terrain

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ABSTRACT

Water, considered by many as 'liquid gold' to be 'mined' for the very survival of all living organism in the world including our human race. The surface and ground water sources are depleting fast owing to over exploitation by unscrupulous pumping and wasteful flooding for irrigation, domestic water supply, industrial usage, animal feeding and other uses. Rain Water Harvesting / Artificial Recharge Techniques for augmentation of ground water resources are finding fast application to cope up with the increasing demands. However, the long term success of the technique requires correct understanding of the hydrogeological and hydrochemical situations of different areas of implementation. It is important that site specific artificial recharge techniques are to be adopted for the maximum benefits. Thalaivasal block of Salem district located in the central part of Tamil Nadu is under over exploited and the stage of development is 210%. In view of the above, a study was carried out in this block to maintain the sustainability of over exploited aquifers. Seven new Percolation ponds were constructed and desilting and strengthening of ponds were carried out in seven more village tanks in the study area. Recharge Shafts and Recharge Bore wells were constructed within the ponds/tanks to maintain the continuous hydraulic connectivity between impounded water and the weathered and fractured aquifers. Impact assessment study was made to understand the actual benefit gained by construction of artificial recharge structures. The study indicates that positive impact has been noticed in terms of depth to water level and the seasonal fluctuation. Increase in cropped area and the change in water intensive crops in the vicinity of the structures were recorded. The improvement in groundwater regime both quantitative and qualitatively has been confirmed. Overall improvement in the socio-economic condition of agrarian community were observed.

INTRODUCTION

Thalaivasal block of Salem district has the stage of groundwater development of 210% as per Ground Water Resource Estimation - 2004. Artificial recharge structures were constructed to improve the overall groundwater situation in the block. The scheme had been executed through the State Agency of Public Works Department, Sarabanga Basin Division, Namakkal with the technical and financial support of Central Ground Water Board. The schemes had been executed for a budget total outlay of Rs 111.00 Lakhs. In this project new types of recharge structures like recharge shafts and recharge bore wells have been constructed in the water spread area of desilted ponds and newly constructed percolation ponds to increase the rate of infiltration.

LOCATION

The Thalaivasal block is situated in the Eastern most part of the Salem district. The block is bounded by Kalvarayan hills (Villupuram district) in the North and Chinna Salem block in the East and South by Veppanathattai block (Perambalur district) and in the west by Gangavalli and Attur blocks. The block lies between East Longitudes; 78°37'00" – 78°50'00" and North Latitudes;11°23' 00" – 11°42'00" and falls in the Survey of India topo-sheets No. 58 I/10, 11 and 12. The location of Thalaivasal block is given in Figure 1. The extent of the block is 405 Sq. km. The block is accessible from National High Way between Ulundurpet to Salem. The block is covered by red lateritic, clayey soil, loamy, gravelly clay and black soils. In this block agricultural lands cover about 79% of block area and forestlands cover about 11% of block . The Block enjoys a tropical climate and the northeast monsoon chiefly contributes to the rainfall. The southwest monsoon rainfall is highly erratic and summer rains are negligible. The average rainfall is 651 mm. The mean daily maximum temperature varies from 19.2° C to 30.2°C.

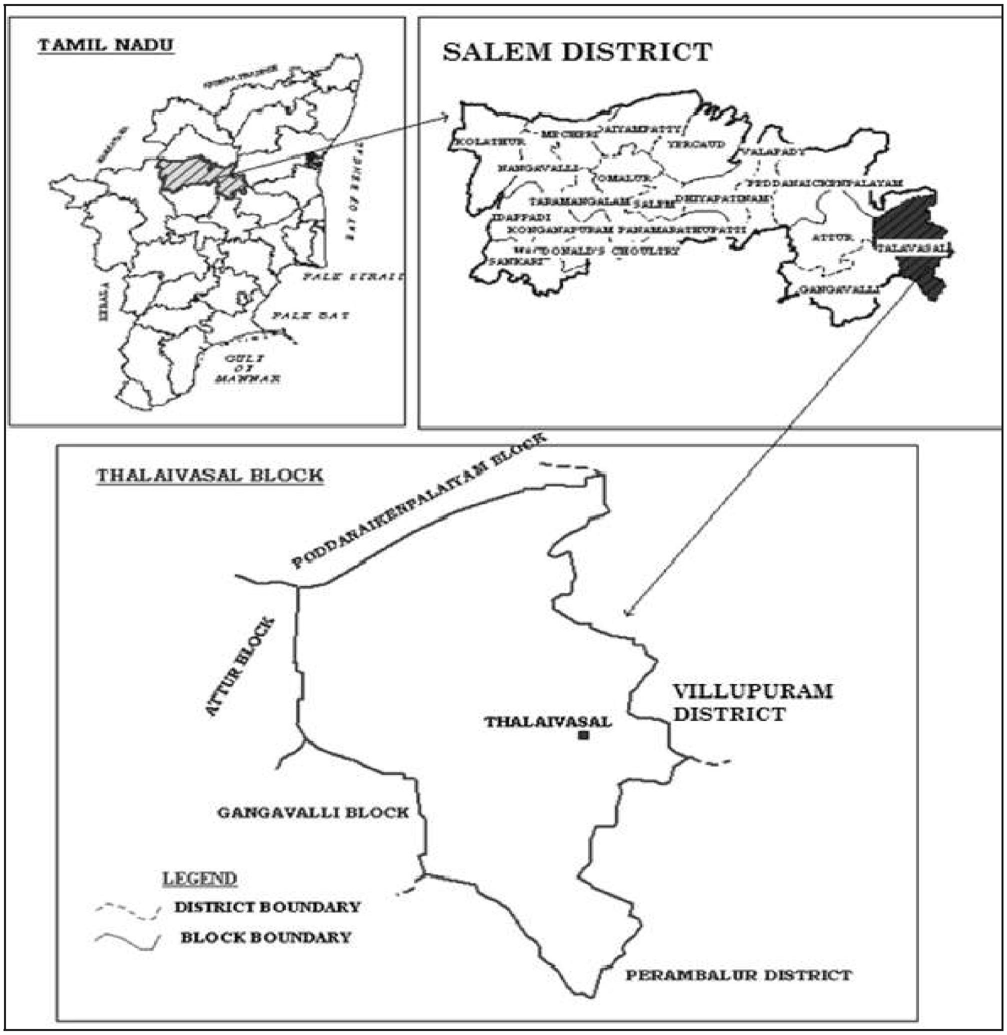

Figure 1 Location map

PHYSIOGRAPHY AND DRAINAGE

Thalaivasal block located in the eastern part of Salem district is boarded by hill ranges of Pachamalai hills in the southern part and Nearly 89% of the block area falls between moderately sloping and very steep sloping. The central part of the block is drained by Vasishta River with numerous streams originating from the northern part. The southern part of the block is drained by Swethanadhi. The drainage pattern is dentritic and the rivers are ephemeral in nature. The block area is covered by landforms such as buried pediment shallow and deep, pediment and bazada zones and also the structural hills in the northern part of the block.

GEOLOGY

The block area is chiefly underlain by Charnockites and two patches of fissile Hornblende-Biotite Gneiss as small patches in the central and southeastern parts of the block. Basic dykes are found in the southeastern fringes of the block. Shear zones are found trending east-west in the central part and confining to gneisses. Shears were also found in the northwestern fringes of the block. The geology of the Thalaivasal Block is given in Figure 2

HYDROGEOLOGY

Groundwater occurs under phreatic condition in the weathered charnockite and gneissic formations. Thickness of weathered zone ranges from 2 to 14 m. Dug wells down to a depth of 15 mbgl are common. Limited lineaments and fractures are also serves as repository for groundwater storage. Dug wells are the prime extraction structures for the irrigation purposes located in the buried pediments and bazada zones. Public water supply bore wells are being used mainly to exploit the shallow and deep-seated fractures in the charnockite and gneissic rocks.

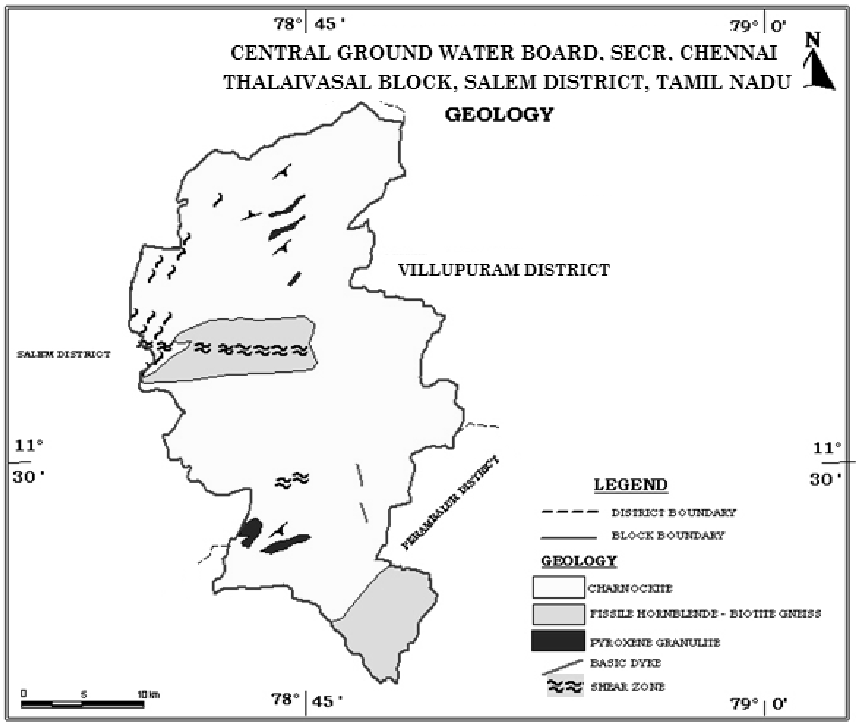

Figure 2 Geology

The depth to water level during Pre-monsoon varies from 4.60 to 15.50 m bgl and in the post-monsoon varies from 2.61 to 13.00 m bgl. The piezometric head varies during pre-monsoon from 4.50 to 13.10 m bgl and in the post-monsoon piezometric level varies from 4.82 to 10.40 m bgl. Analysis of long-term water level trend reveals a negative trend of – 0.192 m / year during pre-monsoon in the phreatic aquifer, where as in semi-confined aquifer, long term trend during pre and post monsoons are negative, viz., -0.496 m/yr and –0.898 m/yr respectively. The quality of formation water varies widely from good to brackish. The Electrical Conductivity value ranges from 804 to 3490 micro mhos/cm.

AVAILABLE SURPLUS RUN OFF

The data collected from State Ground & Surface Water Resources Data Centre (SG&SWRDC), Govt. of Tamil Nadu and Anna University, Chennai indicated that there is availability of surplus run off for recharge of ground water. The details are given below as Table-1.

Table 1 Available surplus runoff for artificial recharge in Thalaivasal Block, Salem District

Total Area of the Block (Sq. Km)	* Harnessable Surface water (MCM)	**Capacity of existing Tanks (MCM)	Committed supply for existing Tanks (MCM) (2 fillings)	Surplus available for AR (MCM)
405	94.42	5.30	10.46	83. 69

AIM AND OBJECTIVE OF THE SCHEME

The aim of the scheme is to augment the overall potential of the groundwater system, and to augment the drinking water and irrigation sources. It is learnt that percolation ponds and village ponds will be effective if recharge shaft/recharge well is combined with the structures. Hence, it has been decided to construct percolation ponds and desilting of existing tanks with recharge wells/shafts.

DETAILS OF RECHARGE STRUCTURES CONSTRUCTED

Fourteen structures were constructed at cost of Rs.111 lakhs. The project was carried out during the years 2009-2010. Out of the 14 Structures, seven are desilting of existing tanks with recharge shafts in villages namely, Sathapadi, Peria Punavasal, Navalur, Veeraganur, Velliyur, Thittachery and Lathuvadi Tanks. The new

Percolation Ponds are constructed in the villages namely Pagada Padi, Unattur, Kattukottai, Kavarpanai, Ladduvadi, Manivilanthan and Kamakka Palayam. Recharge borehole are constructed in the depth range of 60 to 100 m bgl in accordance with existing nearby production wells. The recharge shafts are in the depth range of 7 to 10 m bgl depending on the thickness of clayey formation in the area. The locations of artificial recharge structures is given in Figure 3 and the design and photographs are given in Figures 4 to 9. The quantum of water impounded in each structure is given in Table 2.

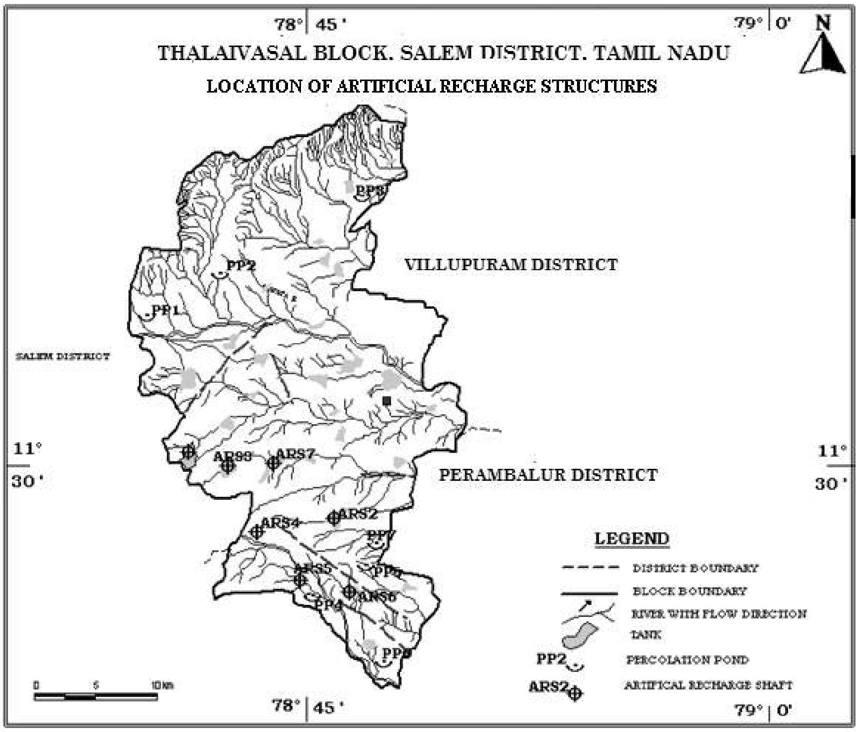

Figure 3 Location of artificial recharge constructed in Thalaivasal Block, Salem District

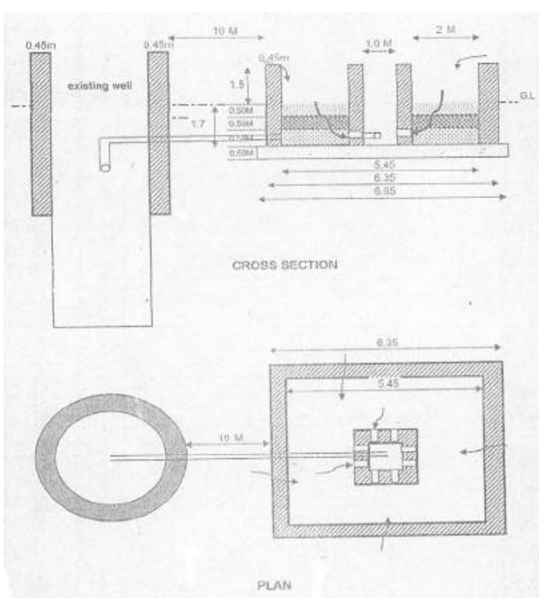

Figure 4 Design of Recharge Shaft

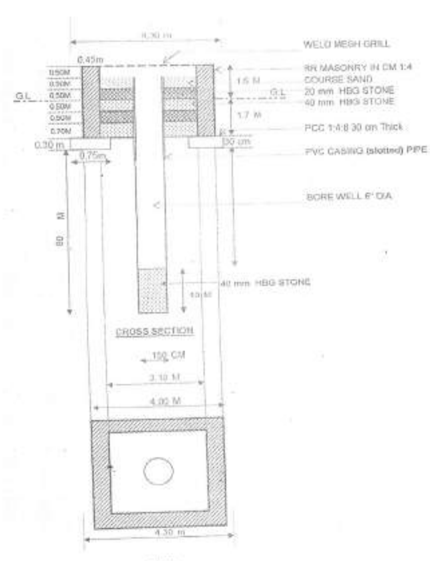

Figure 5 Design of Recharge Borewell

Figure 6 Percolation pond with recharge bore well, Lathuvadi

Figure 7 Desilted village pond with recharge bore well, Veeraganur

Figure 8 Dug well at Lathuvadi

Figure 9 Cropped area in Veeraganur

Table 2 Quantum of water impounded in each structure

Sl. No.	Name of work	Quantum of water (M cft)
1	Construction of Artificial Recharge structures along with desilting of Sathapadi tank in Sathapadi village.	2.23
2	Construction of Artificial Recharge structures along with desilting of Peria Punavasal tank in Peria Punavasal village.	1.85
3	Construction of Artificial Recharge structures along with desilting of Navalur tank in Navalur village.	1.85
4	Construction of Artificial Recharge structures along with desilting of Veeraganur tank in Veeraganur village.	2.23
5	Construction of Artificial Recharge structures along with desilting of Vellaiyur tank in Vellaiyur village.	1.98
6	Construction of Artificial Recharge structures along with desilting of Thittacheri tank in Thittacheri village.	1.99
7	Construction of Artificial Recharge structures along with desilting of Ladduvadi tank in Ladduvadi village.	1.98
8	Construction of percolation pond in Pagada Padi village.	1.16
9	Construction of percolation pond in Unattur village.	0.83
10	Construction of percolation pond in Kattukottai village.	0.92

Sl. No.	Name of work	Quantum of water (M cft)
11	Construction of percolation pond in Kavarpanai village	0.95
12	Construction of percolation pond in Ladduvadi village	1.98
13	Construction of percolation pond in Manivilunthan village	0.92
14	Construction of percolation pond in Kamakka Palayam village	0.90
	Total	22.29 or 0.6312 MCM

IMPACT ASSESSMENT

Change in Water Levels Scenario

Sixteen dug wells have been fixed as key wells near by the Artificial Recharge Structures in Thalaivasal Block to know the impact of AR structures on water level scenario in the area. Four water level measurements were carried out during June 2010, March 2011, May 2011 and Feb 2012 as a representative of pre-monsoon and post-monsoon water levels. The adat of Water levels measured are given in Table 3.

Table 3 Depth to water levels recorded in the vicinity of artificial recharge structures

S. No.	LOCATION	DTW (m bgl)			
		Before Construction		After Construction	
		June'10 (Pre-monsoon)	Mar-11 (Post-monsoon)	May-11 (Pre- monsoon)	Feb-12 (Post- monsoon)
1	Kattukuttai	13.4	5.75	12.9	2.20
2	Kattukuttai	23.3	5.35	13.33	1.60
3	Manivizhandan (S)	17.9	8.88	16.8	5.50
4	UnAttur	10.49	4.58	8.27	1.20
5	Kamakkapalayam	12.1	7.25	11.00	3.00
6	Navallur	13.9	3.00	6.00	2.60
7	Naduvallur	11.33	2.54	10.5	0.30
8	Punavasal	12.5	0.30	9.50	0.30
9	Sathapadi	12.8	0.30	10.00	0.30
10	Vellaiyur	12.21	1.00	10.00	0.30
11	Pagadapaddi	15.4	7.30	11.00	2.00
12	Lathuvadi	6.96	7.90	5.30	3.30
13	Kavarpanai	5.19	5.94	4.90	5.20
14	Lathuvadi	9.60	6.15	8.00	3.00
15	Thittacheri	10.84	0.15	8.50	0.30
16	Veeraganur	19.24	0.30	11.25	0.30
	Minimum	**5.19**	**0.15**	**4.90**	**0.30**
	Maximum	**23.3**	**8.88**	**16.8**	**5.50**
	Average	**12.9475**	**4.168125**	**9.828125**	**1.9625**

Pre monsoon water levels were recorded during June 2010 (before the construction of structures) and May 2011(after construction of the structures) to know the impact of the structures on water level. On comparison of the above two subsequent pre monsoon water levels (June 2010 vs May 2011) it is observed that rise in water level is recorded in all the key wells (Figure 10). The minimum rise in water level is 0.29 m and the maximum rise in water level is 9.97m (Table 4). The average rise in water level is 3.119 m. Similarly, comparison of two subsequent post monsoon water levels (March 2011 vs February 2012) it is observed that rise in water level is recorded in all the key wells (Figure 11). The maximum rise in water level is 5.30 m (Table 5). The average rise in water level is 2.25 m.

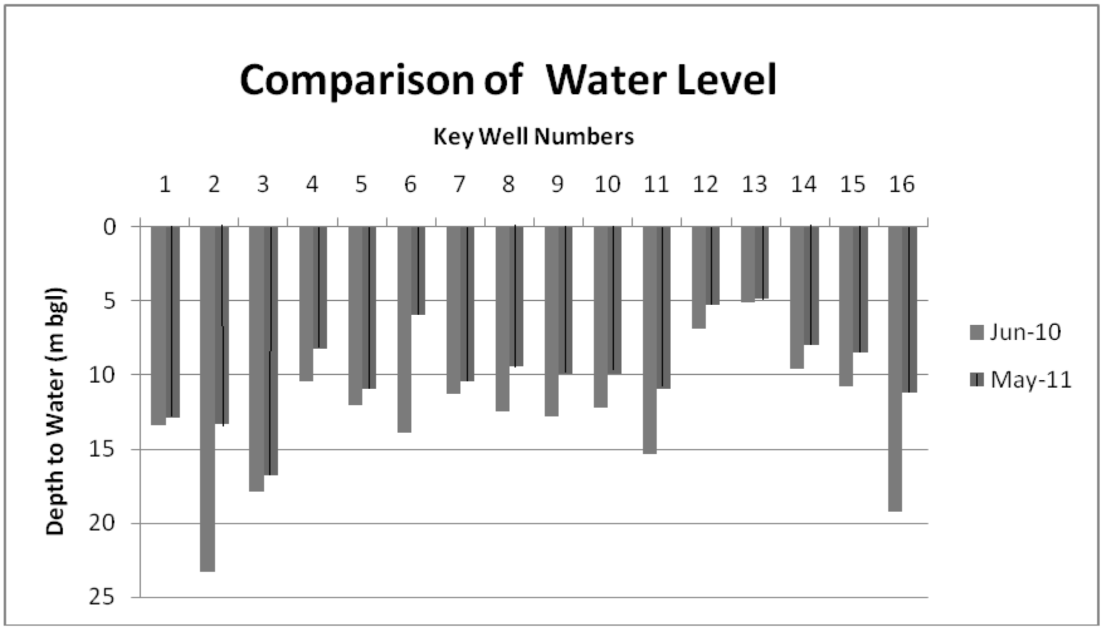

Figure 10 Comparison of water level during June 2010 with water level during May 2011

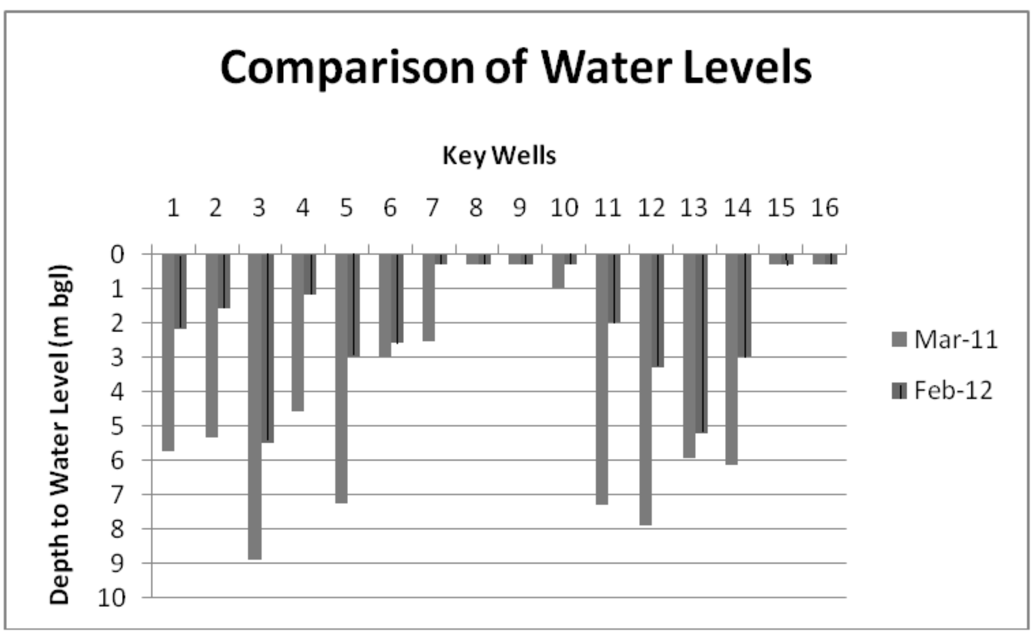

Figure 11 Comparison of water level during March 2011 with water level during February 2012

Table 4 Fluctuation in Water Levels (Pre monsoon)

S. No.	DTW (mbgl)		Change in Water Levels (m)	Rise / Fall
	June'10	May-11	(2 – 3)	
1	**2**	**3**	**4**	**5**
1	13.4	12.9	0.50	Rise
2	23.3	13.33	9.97	Rise
3	17.9	16.8	1.10	Rise
4	10.49	8.27	2.22	Rise
5	12.1	11.00	1.10	Rise
6	13.9	6.00	7.90	Rise
7	11.33	10.5	0.83	Rise
8	12.5	9.50	3.00	Rise
9	12.8	10.00	2.80	Rise
10	12.21	10.00	2.21	Rise
11	15.4	11.00	4.40	Rise
12	6.96	5.30	1.66	Rise
13	5.19	4.90	0.29	Rise
14	9.60	8.00	1.60	Rise
15	10.84	8.50	2.34	Rise
16	19.24	11.25	7.99	Rise
Minimum	**5.19**	**4.9**	**0.29**	Rise
Maximum	**23.3**	**16.8**	**9.97**	Rise
Average	**12.947**	**9.828**	**3.119**	Rise

Table 5 Fluctuation in Water Levels (Post monsoon)

S. No.	DTW (mbgl)		Change in Water Levels (m)	Rise / Fall
	Mar-11	Feb-12	(2 – 3)	
1	**2**	**3**	**4**	**5**
1	5.75	2.20	3.55	Rise
2	5.35	1.60	3.75	Rise
3	8.88	5.50	3.38	Rise
4	4.58	1.20	3.38	Rise
5	7.25	3.00	4.25	Rise
6	3.00	2.60	0.40	Rise
7	2.54	0.30	2.24	Rise
8	0.30	0.30	0.00	Rise
9	0.30	0.30	0.00	Rise
10	1.00	0.30	0.70	Rise
11	7.30	2.00	5.30	Rise
12	7.90	3.30	4.60	Rise
13	5.94	5.20	0.74	Rise
14	6.15	3.00	3.15	Rise
15	0.30	0.30	0.00	Rise
16	0.30	0.30	0.00	Rise
Minimum	**0.30**	**0.30**	**0.00**	Rise
Maximum	**8.88**	**5.50**	**5.30**	Rise
Average	**4.1775**	**1.9625**	**2.215**	Rise

CHANGE IN CROPPING PATTERN

Data on cropping pattern for the period from the year 2007-08 to 2010-11 for 14 revenue villages, where the Artificial Recharge Structures were constructed was collected from Department of Economics and Statistics, Attur and given below as Table 6**.**

Table 6 Abstract of the cropping pattern year-wise and crop-wise

Year –wise area under different crops (ha)					
Crops	2007-08	2008-09	2009-10	2010-11	Total
Banana	35	30	27	17	109
Paddy	1104	1652	1548	1624	5928
Maize	2835	2323	2015	1846	9019
Chilli	32	32	91	39	194
Curry Leaf	1	44	3	13	61
Turmeric	290	337	435	383	1445
Sugarcane	201	200	300	250	951
Tapioca	391	344	539	293	1567
Groundnut	295	434	114	139	982
Cotton	1474	1231	996	910	**4611**
Total	**6658**	**6627**	**6068**	**5514**	

On perusal of the above data, it is found the total cropping area remained same for 2007-08 and 2008-09 and it has reduced to 5514ha during the year 2010-11 which might be owing to the deficit rainfall occurred during the year 2009-10. Moreover, the data on cropping pattern in the vicinity areas where the Artificial Recharge Structures were constructed shows an increase in cropped area. The details on Commands of the 16 key wells were recorded by enquiries with the owners of the dug wells for both the pre and post period of artificial recharge structure construction.

Table 7 Abstract of crops raised in the vicinity areas of AR structures constructed

S. No.	Crops Grown	Cropped Area (Acres)		Difference	% of Difference
		Before Construction (2009-2010)	After Construction (2010-2011)		
1	Paddy	11.5	28.55	17.05	248
2	Sugar	2	7	5	350
3	Banana	2	4	2	200
4	Cotton	3.5	4.8	1.3	137
5	Tapoica	4	2	-2	50
6	Maize	9.3	8.8	-0.5	95
7	Turmeric	3	0	-3	0
8	Kolis	0	1.5	1.5	0
9	Oil Seeds	5	1	-4	20
10	Onion, Vegetables	4	0	-4	0
11	**Total Cropped Area**	**44.3**	**57.65**	**13.35**	**130**
12	**Total Water Intensive Cropped Area**	**19.5**	**39.55**	**20.05**	**203**

The command area under the dug well irrigation varies from 3 to 7 Acres. The crops raised in these well commands are both water intensive as well as less water intensive (Figure 12). The cropped area increased from 44 to 58 Acres, i.e., about 130% increase (includes second crop). Also it is noticed that there is a change in the areas of water intensive crops from 20 to 40 Acres, which is 203 % increase. Paddy, a staple food of this State, has increased from 12 to 29 Acres. Other major water intensive crops like; Banana and Sugarcane also increased to an extent of 200 % and 350 % respectively. Kolis-a medicinal plant has been introduced because of confidence gained due to water availability.

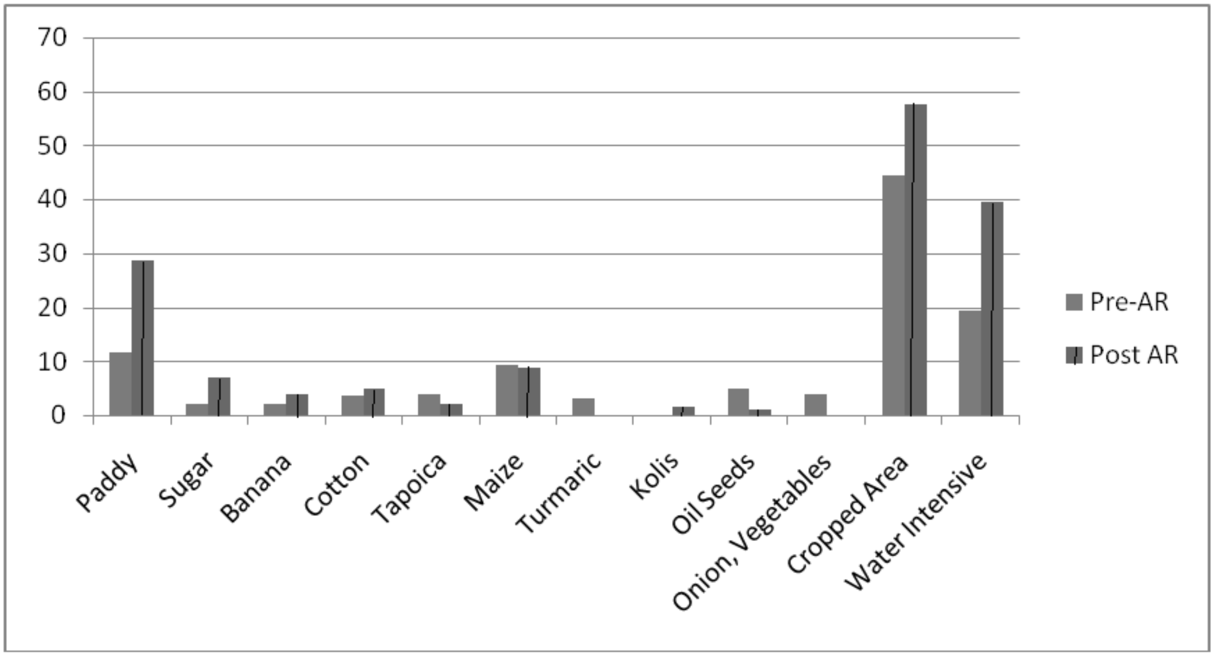

Figure 12 Chart showing the Cropping pattern in the Key well commands (Area in Acres)

CONCLUSION AND RECOMMENDATIONS

1. Desilting of tank with artificial recharge shafts/ recharge bore wells are the cost effective structures in the study area.
2. The positive impact on water level scenario has been noticed. The depth to water level is in the range of 4.9 to 16.8 m bgl in the pre-monsoon periods instead of 5.19 to 23.3 m bgl as observed prior to implementation.
3. During post-monsoon also the depth to water ranges were observed in the range of 0.30 to 5.50 m bgl instead of 0.30 to 8.88 m bgl prior to construction of artificial recharge structures.
4. The fluctuation between pre-monsoon water levels of June, 2010 and June, 2011 ie before and after construction of AR structures shows a rise in water level in the range of 0.29 and 9.97 m. Similarly, the two subsequent post monsoon water level between March 2011 and February 2012 showed a rise in water level in the range of 0.00 to 5.30 m only.
5. On analysis of the cropping pattern of the 14 revenue villages where AR structures were constructed, it is seen that there is a significant reduction in cropping area during the year 2010-11 owing to the low rainfall (641 mm) in the preceding year. However, cropped area recorded from the command area of the key wells in the vicinity of the structures increased from 44 acres during 2009-2010 to 58 Acres during 2010-11, i.e., an increase of 130% (includes second crop). Change in water intensive crops from 20 Acre to 40 Acres, also noticed despite the adverse change in the cropping pattern in the surround areas.

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Assessment of Groundwater Quality using Geostatistics and GIS in Haringhata Block, Nadia District, India.

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ABSTRACT

Quality of groundwater is one of the major concerns for sustainable management of this vulnerable and valuable natural resource. Present study aims at providing an overview of the current groundwater quality and determining the spatial distribution of groundwater quality parameters in terms of drinking water quality in Haringhata Block, Nadia district, West Bengal using an integrated approach of geostatistics and GIS. Data on six groundwater quality parameters (viz., pH, arsenic, total dissolved solids, EC, chloride and iron) of 16 observation wells in the study area for 8 year period (2004-2011) were used in the present study. Four geostatistical models namely, linear, circular, Gaussian, and exponential, were fitted to the experimental semi-variogram of the various groundwater quality parameters. Finally, the best-fit geostatistical models for various groundwater quality parameters were selected by comparing the observed values with the values predicted by empirical semi-variogram models. The best-fit geostatistical models thus obtained were used to generate spatial maps on various water quality parameters using QGIS 1.2 software. Among the four selected semivariogram models, exponential model yield greater prediction accuracy, i.e., R^2 = 0.887, 0.813 and 0.764 for EC, chloride and iron, respectively. Whereas Gaussian models fits best among the other three models for pH, arsenic and TDS with R^2 values 0.75, 0.87 and 0.84, respectively. The spatial maps showed that higher chloride, sulfate, conductivity and hardness concentrations are clearly situated in the northeast of the study area. Finally, it is concluded that the spatial maps generated by integrated geostatistics and GIS techniques would be very helpful in identifying critical zones (hydro chemical) in any area which in turn helps in efficient planning and utilization groundwater resources.

Keywords: Geostatistics, Geographical information system, Groundwater quality, Spatial interpolation.

1. INTRODUCTION

Groundwater is one of the most vulnerable and valuable natural resource of this planet. Last few decades have witnessed the excessive usage of groundwater due to the increase of water demand and the shortage of surface water due to accelerated growth of population and rapid industrialization. Contamination of groundwater may occur due to various types of human activities such as industrial, domestic and fertilizer usage in agricultural fields. In order to get groundwater quality data, water samples are normally collected from observation wells on periodic basis. In groundwater observations, it is assumed that the measured values can be applicable for a certain area. The more frequent the observation sites, the more precise the data. In a scattered groundwater observation network, geostatistical methods can be used to determine the values for the points where measurements are not taken or are not feasible to measure due to economic consideration or any other reasons. Geostatistical methods offer a variety of tools which are helpful in analyzing spatial variability and spatial interpolation to produce the prediction surface derived from measurements at known locations. Geostatistical methods along with geographical information system provide maps over an area which will prove to be very useful in developing groundwater management strategies. Different researchers (Kumar and Ahmed 2003; Ahmadi and Sedghamiz 2007, Cay and Uyan 2009; Liu et al. 2009; Adhikary et al., 2010) have reported the use of geostatistical approaches in groundwater study with valuable outcomes. Nas (2009) analyzed the spatial distribution of groundwater quality in Konya, Turkey using 156 groundwater samples. He used ordinary krigging method to produce the spatial pattern of water quality over the study area. Adhikary et. al, (2011) used an integrated approach of geospatial techniques and GIS to explore the spatial variability of groundwater quality and to prepare surface maps on different groundwater quality parameters for Najafgarh block, Delhi with successful and effective results.

The main aim of the present study was to determine the groundwater quality and to map their spatial variation in terms of suitability for drinking purposes. In the present study, four semivariogram models, viz., linear, circular, Gaussian, and exponential model were fitted to the experimental semivariogram and the best fit model was used to prepare spatial data for the different groundwater quality parameters namely , pH, arsenic, total dissolved solids, EC, chloride and iron for the study area. Ordinary kriging method was used for the preparation of thematic maps on different groundwater quality parameters. This study will help in identifying the hydrochemically critical zones in the study area and to plan proper management strategies for the area.

2. MATERIALS AND METHODS

1.1 Study Area

Haringhata Block, study area of this present study, is located in extreme south of Nadia district of West Bengal. The geographical extent of Haringhata Block lies within a latitude of $22^0 54^/$ N to $23^0 2^/$ N and longitude of $88^0 30^/$ E to $88^0 41^/$ E which covers an area of about 170.32 Sq. Km. The location of the study area is shown in Figure 1. The block comprises of 10 *Gram Panchayats* (GP). A small river system which is locally known as Jamuna is flowing through the block. The soil of the block is mostly clay loamy type. The climate of the block is characterized by oppressively hot summer, high humidity and high rainfall during the monsoon. Winter starts from the middle of November which continues up to the end of February. During the monsoon from June to September about 71% of annual rainfall occurs. The rainiest month is August. The mean annual rainfall is about 1400 mm. Average elevation of the block is 10 m from mean sea level.

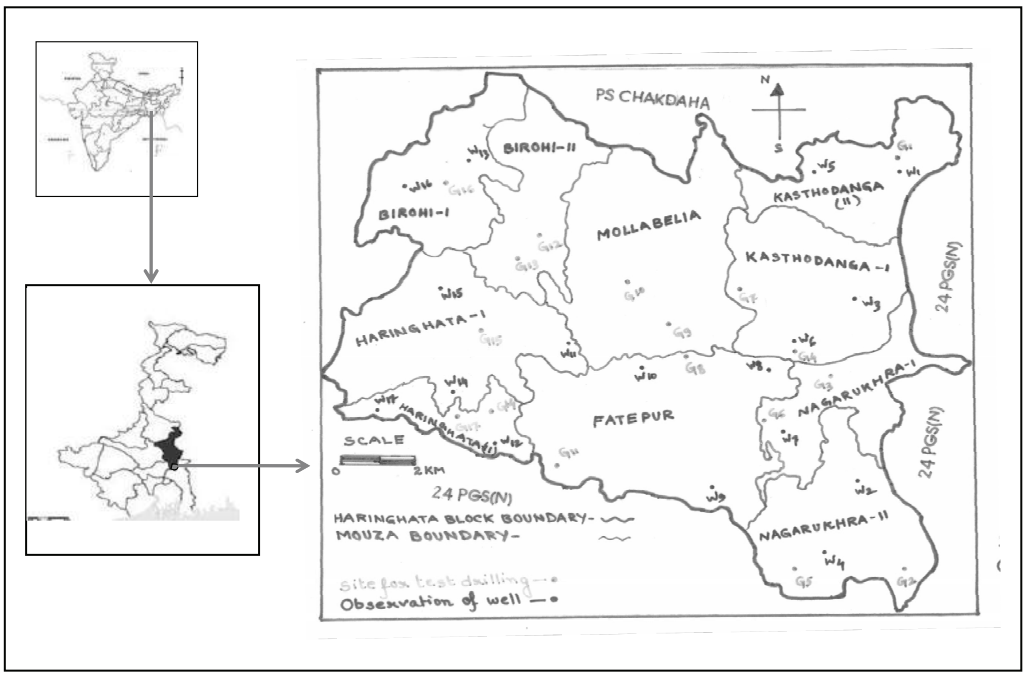


Figure 1 Location map of the study area.

2.2 Groundwater Sampling

Pre-monsoon groundwater quality parameters (viz., pH, arsenic, total dissolved solids, EC, chloride and iron) were collected for a period of 2004-2011 at 16 sites (Fig. 1) located in Haringhata Block from the SWID, Kolkata. Geographical coordinates of each sampling location was also recorded.

2.3 Modeling Spatial Variation of Groundwater Quality Parameters by Geostatistical Technique

In the present study, spatial maps of various groundwater quality parameters were prepared based on point observations (pre-monsoon groundwater quality data of 16 locations) by kriging technique. Kriging, like most interpolation techniques, is built on the assumption that things that are close to one another are more alike than those farther away (quantified here as spatial autocorrelation). The empirical semivariogram is a mean to explore this relationship. The empirical semivariogram ($\gamma(h)$) is defined as half the average quadratic difference between two observations of a variable separated by a distance vector h (Matheron, 1965). It is calculated according to the following formula:

$$\gamma(h)=\frac{1}{2N(h)}\sum_{i=1}^{N(h)}\left[z(x_i+h)-z(x_i)\right]^2 \tag{1}$$

Where, z(x) and z(x+h) are the values of the variable at point x and at a point of distance h from point x.

Kriging methods work best if the data is approximately normally distributed. Hence, normality of the spatial groundwater quality data was checked before geostatistical modeling. Quantile-Quantile (QQ) plot in Matlab environment was used to check the normality of the data and if the data is not normally distributed then log transformation was done to make the series closer to normal distribution. A semivariogram plot is obtained by plotting the average semivariance verses average distance. These values are then usually fitted to a theoretical model. In the present study, four geostatistical models namely, linear, circular, Gaussian, and exponential, were fitted to the experimental variogram of the pre-monsoon groundwater quality data. Finally, the best-fit geostatistical models for the groundwater quality of pre-monsoon season were selected based on highest R^2. Semivariogram parameters (Nugget, sill, range) were generated for each theoretical model. The best-fit geostatistical models thus obtained were used to generate groundwater quality maps for chloride, hardness, arsenic, EC, pH and TDS, by using QGIS 1.2 software showing locations that fell within "desirable" and "undesirable" ranges. Suitability of groundwater for drinking purpose was also be assessed based on the water quality data following the standard guidelines.

3. RESULTS AND DISCUSSIONS

3.1 Statistical Analysis of Groundwater Quality

A statistical analysis of groundwater quality in Haringhata Block was carried out in terms of six water quality parameters namely pH, electrical conductivity (EC), total dissolved solids (TDS), chloride, total iron and total arsenic. The location of the sites is shown in Fig1. Statistical analysis of the hydro-chemical parameters is given in Table 1.

Table 1. Statistical summary of the hydrochemical parameters of the study area

Parameter and Permissible Limits	Minimum	Maximum	Median	Mean	Standard Deviation	Remarks
pH (7-8.5)	7.92	8.42	8.27	8.21	0.16	All samples are within the limit
EC (700 µS/cm)	550	920	720	719.38	111.98	9 sites have crossed permissible limit
Chloride (200 mg/l)	20	90	50	53.13	19.91	All samples are within the limit
Iron (1 mg/l)	0.2	4	1.1	1.58	1.22	12 sites have crossed permissible limit
Arsenic (0.01 mg/l)	0.005	0.12	0.04	0.04	0.04	12 sites have crossed permissible limit
TDS (500 mg/l)	352	589	461	462.13	69.41	6 sites have crossed permissible limit

3.2 Spatial Analysis of Various Groundwater Quality Parameters

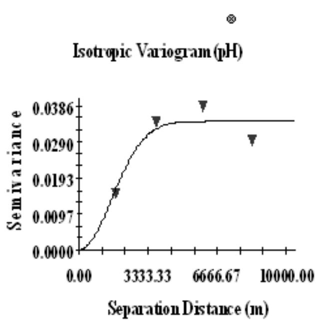
In the present study, spatial dependence of various groundwater quality parameters (pre-monsoon pH, EC, TDS, Chloride, Arsnic, Iron) of 16 water wells was explored using the Gamma Design software.

3.2.1 Modeling Semivariogram for the Various Hydrochemical Data

In the present study, four geostatitical models (linear, spherical, exponential, and gaussian) were tested for six groundwater quality parameters (pH, EC, TDS, Chloride, Arsnic, Iron) in Gamma design software environment. Prediction performances were assessed by cross validation. The parameters of the four theoretical geostatistical models (Nugget, Sill and Range) fitted to six water quality parameters along with R^2 values are summarized in Table 2. The best-fit theoretical model was selected based on highest R^2.

Table 2. Parameters of geostatistical models for spatial analysis of various groundwater quality parameters

Parameters		Geostatistical Model			
		Spherical	**Exponential**	**Gaussian**	**Linear**
pH	Nugget(m^2)	0.0001	0.0001	0.0001	0.011
	Sill(m^2)	0.035	0.041	0.0345	0.04
	Range(km)	5.71	10.11	2.23	8.892
	R^2	0.625	0.511	**0.75**	0.355
EC	Nugget(m^2)	10	10	10	Very poor fit fit
	Sill(m^2)	8352	16290	8649	-
	Range(km)	10.21	11.38	8.123	-
	R^2	0.785	**0.887**	0.823	-
Chloride	Nugget(m^2)	0.022	0.018	0.024	0.027
	Sill(m^2)	0.1976	0.1874	0.215	0.226
	Range(km)	2.5	1.35	1.97	2.1
	R^2	0.75	**0.813**	0.79	0.65
Arsenic	Nugget(m^2)	0.0003	0.0001	0.00052	0.00188
	Sill(m^2)	0.002	0.002	0.00159	0.002
	Range(km)	3.15	2.85	8.42	8.89
	R^2	0.78	0.76	**0.87**	0.54
Iron	Nugget(m^2)	Very poor fit	0.7	1.04	0.94
	Sill(m^2)	-	3.38	3.75	1.76
	Range(km)	-	24.7	34.43	11.56
	R^2	-	**0.764**	0.56	0.45
TDS	Nugget(m^2)	10.0	10	10.0	3.33
	Sill(m^2)	5294	5548	10960	6.13
	Range(km)	3.3	4.89	8.5	9.36
	R^2	0.45	0.75	**0.84**	0.67



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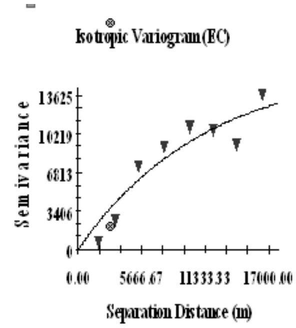

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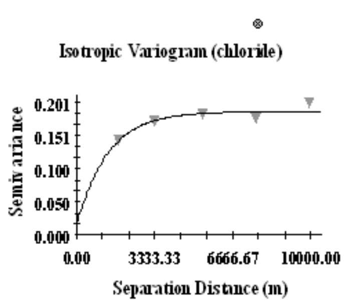
It is apparent from Table 2 that the exponential models yield greater prediction accuracy, i.e., R^2 = 0.887, 0.813 and 0.764 for EC, chloride and iron, respectively. Whereas Gaussian model fits best among the other three parameters, namely, pH, arsenic and TDS with R^2 values 0.75, 0.87 and 0.84, respectively. The fitted semi-variogram models for six groundwater quality parameters are presented in Fig. 2 a-f.



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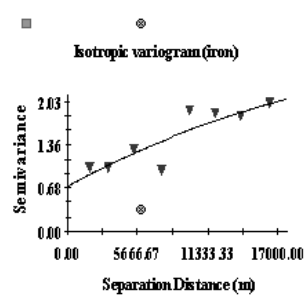

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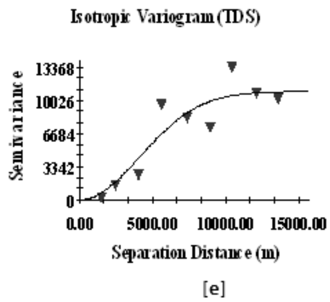


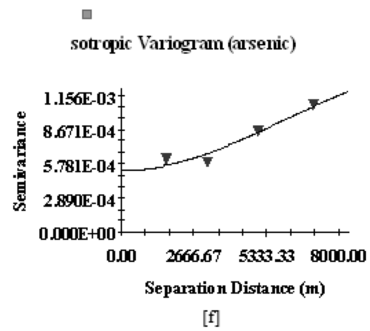


Figure 2 (a-f) Fitted semivariogram model to different groundwater quality parameters.

3.2.2 Generation of Surface Maps of various Groundwater Quality Parameters

After model validation the surface was generated to produce the six (pH, iron, arsenic, chloride, TDS and EC) groundwater quality maps as in (Figure 3 a-f).

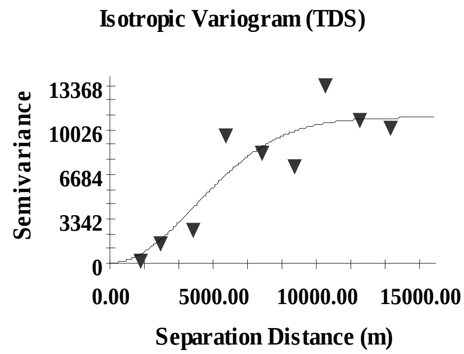
(a) ***Chloride:*** The minimum and maximum concentrations of chloride in the study area were measured as 20 mg/l and 90 mg/L. There was no water well in the study area in which the chloride concentration exceeds the Indian drinking water standards (200 mg/L). The surface map of chloride (Fig.3-a) generated for the study area indicated that chloride concentration increased from eastern side to western side of the area. In a wide area around the eastern part of the block has 40-60 mg/l chloride concentration.

(b) ***Arsenic:*** The acceptable level as defined by WHO for maximum concentrations of arsenic in safe drinking water is 0.05 mg/L. The arsenic concentration in the study area varies from 0.005 mg/L to 0.12 mg/L. Data revealed that 71 % of the sites are falling in non-desirable zone. As indicated by Fig. 3-b, arsenic concentration increased from eastern side to western side with a small area in the western side where low concentration of arsenic occurs. In a wide area around the western part of the block has more than 0.05 mg/l arsenic concentration which is more than the permissible limit.

(c) ***EC and TDS:*** The EC value in the study area varies from 550 to 920. According to Palmar (1993), irrigation water is classified into four groups according to its quality: low salinity (< 250 μS/cm); medium salinity (250-750 μS/cm); high salinity (750-2250 μS/cm); and very high salinity (>2250 μS/cm). Following this classification, the groundwater of Haringhata Block can be characterized as medium saline to slightly high medium saline. The EC values except at six sites (35% of the data points) are more than the recommended permissible limit for drinking purposes i.e., 700 μS/cm, indicating high mineralization in the block. The total dissolved solid tests measure the total amount of dissolved minerals in water. Since EC and TDS are usually linearly related, the plot of TDS in groundwater also indicates same variation as that of EC. More than 40 % sites of the block have TDS value beyond the desirable limit of 500 mg/l. Spatial distribution of these parameters are shown in Fig 3- c and 3- d.

(d) ***pH:*** The pH value of water is a very important indication of its quality. The pH of groundwater in the study area varies from 7.92 to 8.42 which indicate alkaline nature of groundwater in the block. Though the values of pH at all the 16 sites were found to be within the permissible limit for drinking water (i.e., 7 to 8.5), but at many sites it is very close to upper permissible limit recommended by WHO. Spatial distributions of pH concentrations are shown in Fig. 3-e. It is shown that the low pH concentrations occur in the eastern part of the block where as pH concentration increases towards the western part of the block.

(e) ***Iron:*** As per WHO norms the desirable limit for Iron in drinking water is 1 mg/L. The minimum and maximum concentrations of iron were measured as 0.2 mg/Land 4 mg/L in the study area and 53 % of the sites (9 sites) falling in non-desirable zone. Spatial distribution of iron concentration is shown in Fig. 3-f, which depicts that a large area of the block has iron concentration between 1-2mg/L. northwest corner has very high iron concentration.



Gaussian model (Co = 10.00000; Co + C = 10960.00000; Ao = 5810.00; r2 = 0.840; RSS = 2.79E+07)

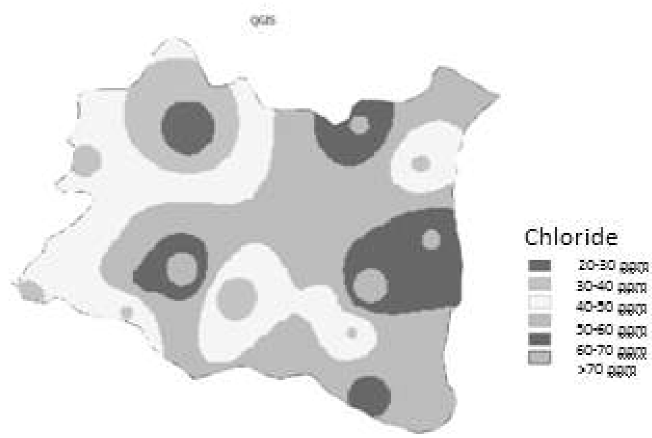


Fig.3-a

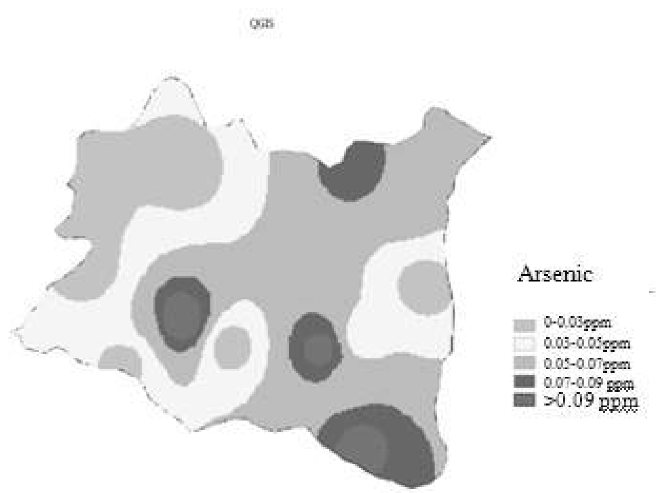


Fig.3-b

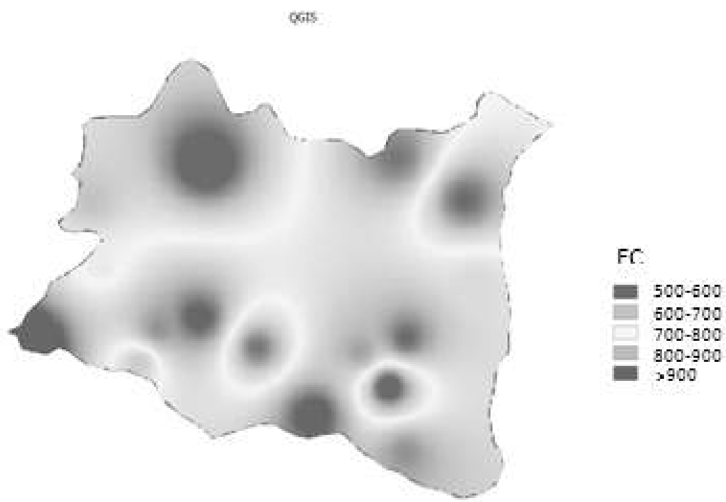


Fig. 3c

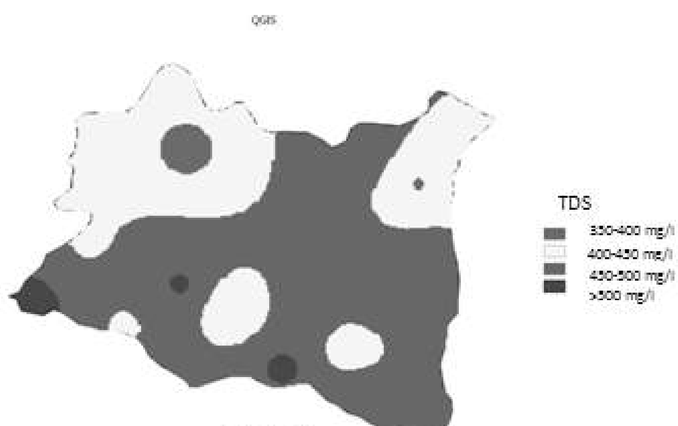


Fig.3-d

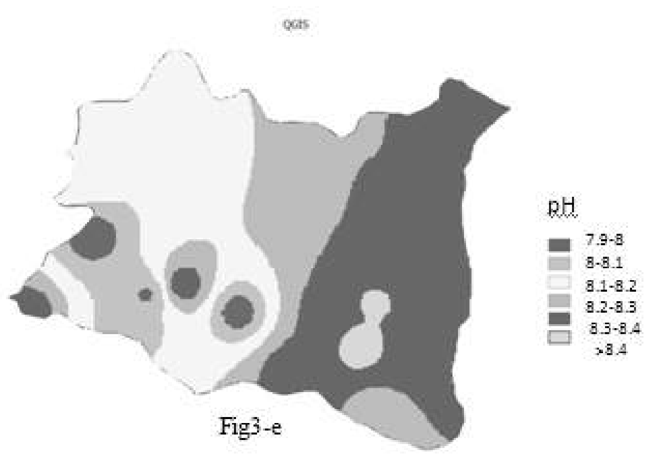


Fig3-e

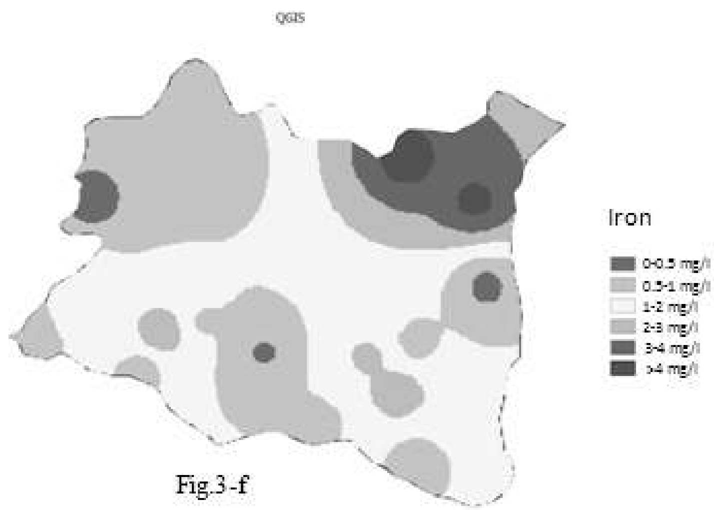


Figure. 3 (a-f) Spatial distribution of different water quality parameters of Haringhata Block.

4. CONCLUSIONS

Groundwater has been the mainstay for meeting the agricultural and domestic needs of India. In order to maintain the sustainability of this natural resource both quantitatively and qualitatively, proper management strategies are required to be developed and practiced. The present study aims at evaluating and mapping groundwater quality of Haringhata block, Nadia District using an integrated approach of geostatistics and GIS. In the present study, four semivriogram models were tested for each groundwater quality parameter. Prediction performances were assessed by cross validation technique. The geostatistical analysis revealed that exponential models yield greater prediction accuracy, i.e., R^2 = 0.887, 0.813 and 0.764 for EC, chloride and iron, respectively. Whereas, Gaussian model fits best for the other three groundwater quality parameters i.e., pH, arsenic and TDS with R^2 values 0.75, 0.87 and 0.84, respectively. The kriging technique helps in identifying critical areas (hydrochemically) in a groundwater basin, which in turn addresses the urgent need to implement suitable groundwater management strategies for the area. Finally, it is concluded that integrated geostatistics and GIS techniques are very reliable and helpful tools for sustainable management of groundwater resources.

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Hydrogeochemical Evaluation of Groundwater in South Chennai, Tamil Nadu, India

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ABSTRACT

Totally, 50 groundwater samples were collected during pre-monsoon (June 2014) and post-monsoon (January 2015) of the study area. The groundwater quality assessment has been carried out by evaluating the physico-chemical parameters such as pH, EC, TDS, TH, HCO_3, Cl, SO_4, Ca, Mg, Na and K. The dominance of anions and cations were of the order of $Cl^- > HCO_3^- > SO_4^- > NO_3$ and Mg > Ca > Na > K, respectively. The analytical results were compared with WHO standards. The most polluted locations are Besant Nagar, Palavakkam, Tharamani and Pallikarani where the samples recorded above permissible limits with reference to EC, TDS, TH, Chloride and Sodium which indicate seawater intrusion and anthropogenic activity. From Gibb's plot, it is being identified that water chemistry of the study area is being controlled by evaporation and some of the samples fall in rock-water interaction field for both seasons. From USSL diagram, it is inferred that most of the samples are falling in C3S1 and C4S1field that refers to “low sodium and medium salinity” and “low sodium and very high salinity”, respectively. The Wilcox diagram indicates that most of the samples are falling under “good to permissible” category and few samples are falling in “doubtful to unsuitable” category for irrigational purpose during both seasons.

Keywords: Hydrogeochemistry, Gibbs diagram, Wilcox and USSL diagram, South Chennai.

INTRODUCTION

Water is an essential and vital component of our life support system. Geochemical processes occurring within the groundwater and reactions with aquifer minerals have significant effect on water quality. Groundwater also plays an important role in agriculture, for watering of crops and irrigations of dry season crops. The coastal aquifers suffer saline water intrusion that becomes worldwide concern (Eragil, 2000; Cheng and Ouazar, 2004; Mhamdi *et al*., 2006; Zekri, 2008; Franco *et al.*, 2009; Nasab *et al*., 2010; Mondal *et al.*, 2010a). Groundwater chemistry based on hydrochemical data is useful for providing preliminary information on water types, classification of water for various purpose as well as identification of different aquifer and study of different chemical processes (Karanth, 1987; Saxena *et al*., 2003; Jalali, 2007; Sarwade *et al*., 2007). The industrial waste water, sewage sludge, solid waste materials are currently being discharged into the environment indiscriminately. These materials enter subsurface aquifers, resulting in the pollution of irrigation and drinking water (Forstner and Wittman, 1981). The seawater intrusion is a main cause of high salinity, and groundwater generally demonstrates high concentration not only in total dissolved solids (TDS) but also in cations and anions (Richter and Krietler, 1993) as well as increase of selective trace element (Saxena *et al*., 2004; Mondal *et al.*, 2010b). Seawater intrusion is defined as the migration of saline water from the sea into aquifer that are hydraulically connected with the sea. Seawater intrusion, thus, leads to the salinization of fresh water aquifers along the coastlines. In highly populated coastal regions with greater dependence on groundwater, the withdrawal usually exceeds the recharge rate which causes seawater intrusion. The density of seawater is marginally higher than that of fresh water. When seawater intrusion is a main cause of high salinity, groundwater generally exhibits high concentrations not only in total dissolved solids (TDS) but on some specific chemical constituents, such as Cl^-, Na^+, Mg^{2+}, and SO_4^{2-} (Dixon and Chiwell, 1992; Gimenez and Morell, 1997; Richter and Kreitler, 1993) as well as accumulation of selected trace elements (Saxena *et al*., 2004 and Mondal *et al*., 2010b). The coastal groundwater system is fragile and its evolution will help in the proper planning and sustainable management. Interpretation of hydro-chemical data suggests that calcium carbonate dissolution, ion-exchange processes, halite dissolution, silicate weathering, and irrigation return flow are responsible for the groundwater chemistry in the area. Thus, hydro-geochemical processes that control groundwater chemistry were identified. This will lead to improved understanding of the hydro-geochemical characteristics of the aquifer.

STUDY AREA AND GEOLOGY

The study area lies between 12°51' and 12°56'30" N latitude and from 80°3'30" to 80°14'30" E longitude and covers an area about 270 km^2. The rainfall in the study area is mainly controlled by northeast monsoon (October, November and December) with an average annual rainfall of 1200 mm. The study area is having a tropical climate with annual temperature from 24.3° to 32.9° C. The major part of the area has flat topography with gentle slope towards east. Geologically, the coastal aquifers underlained by ancient Archaean rocks up to Recent alluvium. The major part of the study area covers alluvium formations and it consists of sand, silt and clay. The study area and sample locations are shown in Fig. 1.

METHODOLOGY

Totally, 50 ground water samples were collected during pre-monsoon (June 2014) and post-monsoon (January 2015) from the bore well and dug wells. These samples were collected in 1 liter capacity polyethylene bottles. The pH, temperature, electrical conductance (EC), and total dissolved solids (TDS) were measured in situ using portable kit in a field. The samples collected were analyzed in the laboratory for concentration of major ions. Major ions like, Calcium, Magnesium, Chlorides and Bicarbonates were analyzed by titration method. The Na^+, K^+ were estimated using Flame photometer. Sulfates were estimated using UV-visible spectrophotometer. The analytical procedures followed as per the American Public Health Association (APHA, 1995). The base map of the study area was prepared using the Survey of India toposheets (66 D/1 and 66 D/5) and digitized using ARC GIS 9.3 software.

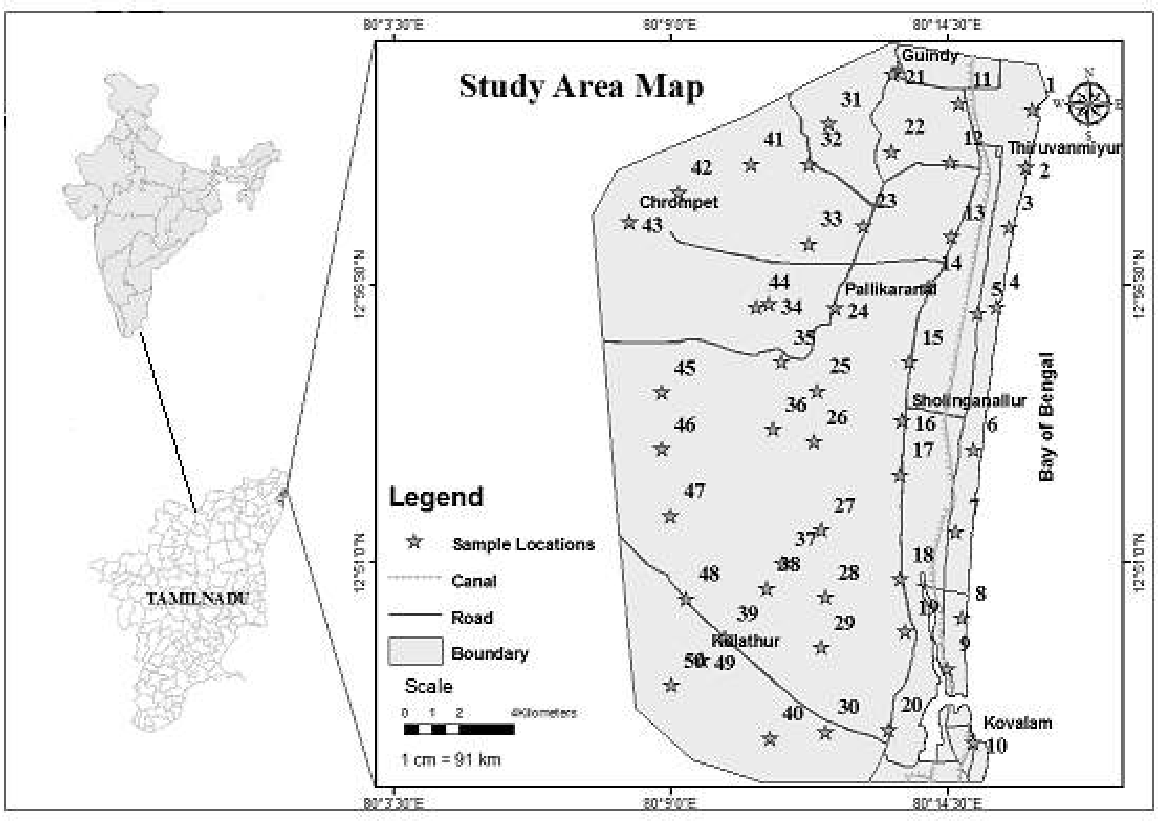

Figure 1. Study area with sample locations

RESULTS AND DISCUSSION

The results of the analysis are presented in Table 1 for the study area during pre and post monsoon of the year 2014-2015. Groundwater in the study area has pH ranging from 6.63 to 8.04 during pre-monsoon season, while in the post-monsoon it ranges from 7.3 to 8.8. They are within the permissible limit in both the seasons based on WHO (2004). EC is one of the measurement of strength and mineralization of natural water. In the study area, EC ranges from 644 to 41200 µS/cm during pre-monsoon, while in the post-monsoon it ranges from 514 to 12070 µS/cm. TH ranges from 200 to 7800 mg/l during pre-monsoon season, whereas, during post-monsoon season it ranges from 23.6 to 368.4 mg/l. TDS ranges from 451 to 28840 mg/l during pre-monsoon season, whereas, during post-monsoon it ranges from 333 to 7850 mg/l. According to WHO (2004) TDS is above permissible limit in both the seasons. TDS decreases after rains that dilute the groundwater. In the study area, Besant Nagar, Palavakkam, Tharamani and Pallikarani where the samples recorded above permissible limits WHO (2004) with reference to EC, TDS, TH, Chloride and Sodium which indicate seawater intrusion and anthropogenic activity.

Table 1 Minimum and maximum values for different parameters of the study area for pre and post monsoon seasons.

Parameter	Pre monsoon		Post monsoon	
	Minimum	Maximum	Minimum	Maximum
pH	6.63	8.04	7.3	8.8
EC µs/cm	644	41200	514	12070
TDS mg/l	451	28840	333	7850
Ca mg/l	10	1960	20	240
Mg mg/l	11	696	3.6	128.4
Na mg/l	26	5240	30.5	1232
K mg/l	4	370	1	85.8
HCO_3 mg/l	120	624	109.8	677.1
SO_4 mg/l	9	177	6	132
Cl mg/l	74	13400	35	4210
NO_3 mg/l	2	38	3	24

Major Cations

The ascendancy of cations is as follows Mg > Ca > Na > K during pre and post-monsoon seasons. Sodium ion concentration in the pre-monsoon season varies from 26 to 5240 mg/l while it ranges between 30.5 and 1732 mg/l during post-monsoon. Sodium concentration plays an important role in evaluating the groundwater quality for irrigation because sodium causes an increase in the hardness of soil as well as a reduction in its permeability (Tijani, 1994). Calcium ion concentration in the pre-monsoon season varies from 10 to 1960 mg/l while it ranges between 20 and 240 mg/l during post-monsoon samples. Magnesium ion concentration in the pre-monsoon season varies from 11 to 696 mg/l while it ranges between 3.6 and 128.4 mg/l during post-monsoon samples. Potassium ion concentration in the pre-monsoon season varies from 4 to 370 mg/l whereas; it ranges between 1 and 85.8 mg/l during post-monsoon samples. Comparing the WHO (2004), Na, Ca, Mg and K concentrations were above permissible limit in most of the samples. The WHO standards for anions and cations are presented in Table 2.

Major Anions

The ascendancy of anions is as follows Cl > HCO_3 > SO_4 >NO_3 during pre and post-monsoon seasons. Chloride ion concentration in the pre-moon season varies from 74 to 13400 mg/l while it ranges between 35 and 4210 mg/l during post-monsoon samples. Cl^- is higher due to the impact of saline water and base–ion exchange reaction (Freeze and Cherry, 1979). Bicarbonate ion concentration in the pre-monsoon season varies from 120 to 624 mg/l while it ranges between 109.8 and 677 mg/l during post-monsoon samples. Higher concentration of bicarbonate indicates the contribution of silicate and carbonate for chemical weathering. Sulphate ion concentration in the pre-monsoon season varies from 9 to 177 mg/l while it ranges between 6 and 132 mg/l during post-monsoon samples. Nitrate ion concentration in the pre-monsoon season varies from 2 to 38 mg/l whereas, it ranges between 3 and 24 mg/l during post-monsoon samples. Based on the WHO (2004), Cl, HCO_3 are above permissible limit in most of the samples, but SO_4 and NO_3 are within permissible limit. It indicates that most of the samples are not suitable for drinking purpose as well as agriculture uses.

Table 2 World Health Organisation Standards (2004)

World Health Organisation Standards (2004)			
Sl No.	**Characteristics**	**Requirement (Acceptable Limit)**	**Permissible Limit**
1	pH value	6.5-8.5	No relaxation
2	Total dissolved solids mg/l	500	1000
3	EC µs/cm	1400	-
4	Sodium mg/l (Na)	-	200
5	Calcium mg/l (Ca)	100	200
6	Magnesium mg/l (Mg)	50	100
7	Potassium mg/l (K)	20	42
8	Chloride mg/l (Cl)	250	1000
9	Sulphate mg/l (SO_4)	250	400
10	Nitrate mg/l (NO_3)	45	No relaxation

Box and Whisker Plot

Box plots can be used to compare ground water quality data (generally for the same parameter) between wells. The plots are constructed using the median value and the inter-quartile range (25 and 75 cumulative frequency measured as central tendency and variability) (U.S.EPA, 1992). It is a quick and convenient way to visualize the spread of data. The chemical composition of the groundwater samples is shown in the box plot Fig. 2. The abundance of the major cations is in the order of Mg > Ca > Na in both seasons. The abundance of major anions is in the order of Cl > HCO_3 > SO_4 during January 2015, and they have been pictorially represented in the box plot.

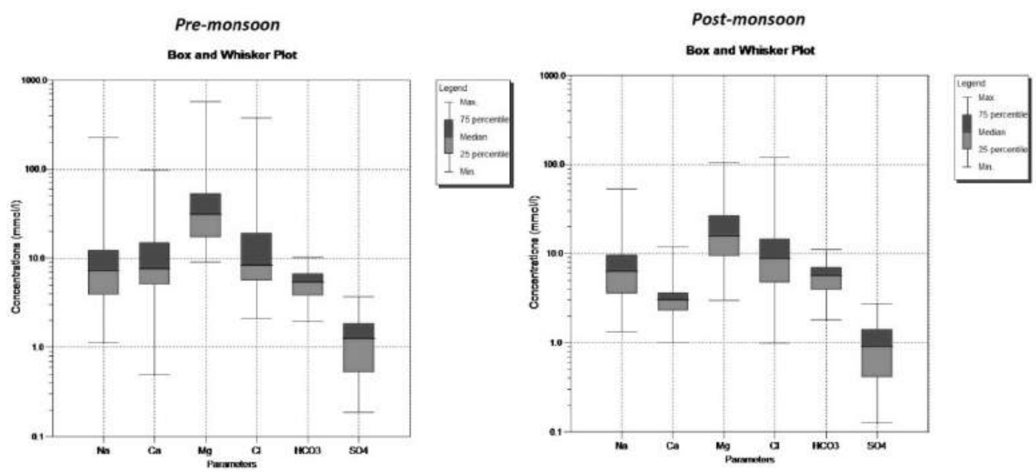

Figure 2. Box plots for Pre and Post monsoon seasons

Gibbs Plot

Reactions between groundwater and aquifer minerals have a significant role in water quality, which are also useful to understand the genesis of groundwater (Cederstorm, 1946). Groundwater chemistry in the study area is regulated by diverse processes and mechanisms. The chemical relationships of groundwater based on the lithology of aquifer have been studied following Gibb's Plot (1970). Three kinds of fields are recognized in the Gibb's diagram, namely, precipitation, evaporation/crystallization, and rock-water interaction. The weathering dominated water has high Ca and HCO_3^- concentration, and the evaporation/crystallization dominated water is characterized with high Na^+ and Cl^- contents. In the cation plot, illustrated in Fig. 3, most of the water samples fall in the field of evaporation and few of the water samples fall in the rock-water interaction for both the seasons of the study area. During both the seasons, the increase in evaporation increases the salinity and the concentration of the ions such as Na and Cl that increases with increasing TDS.

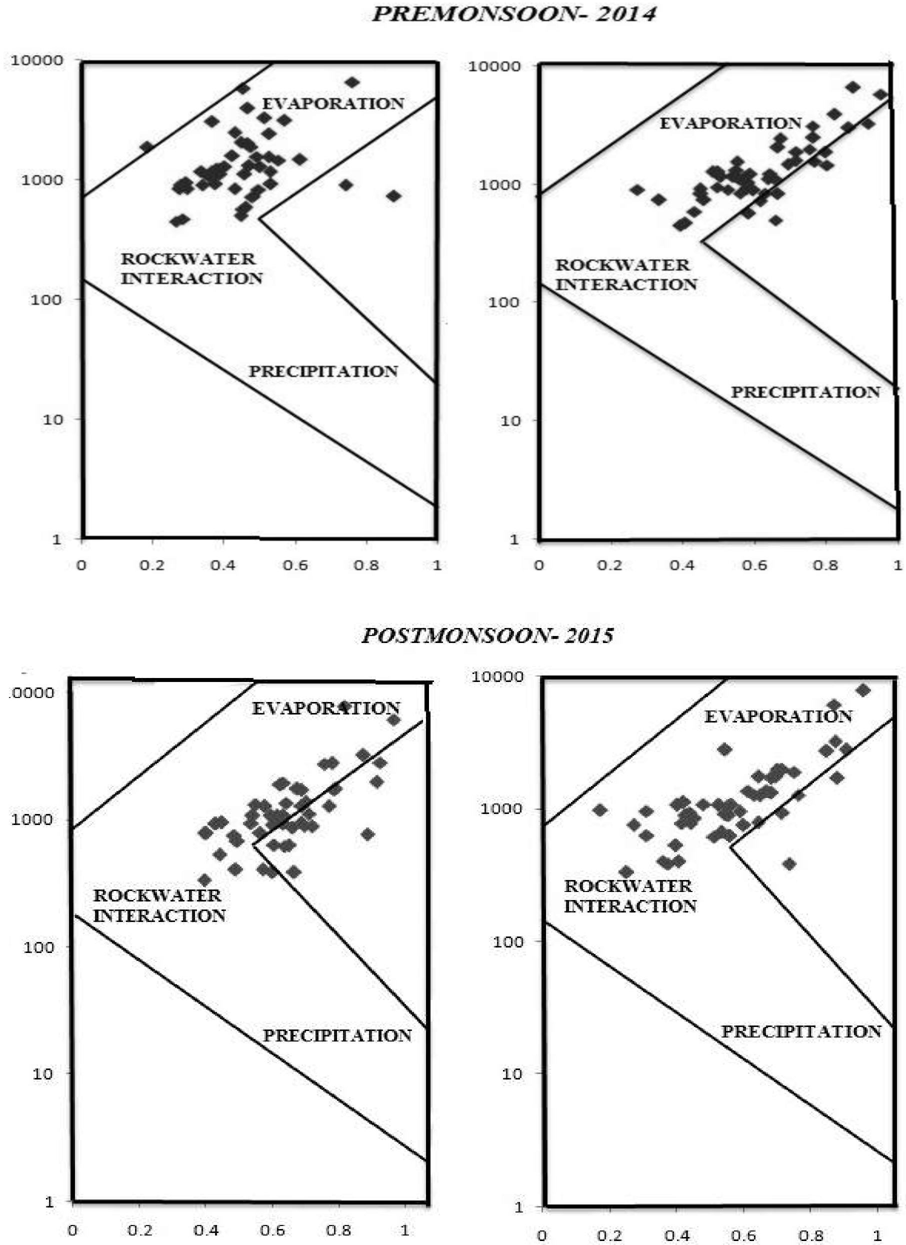

Figure 3. Gibb's plot for pre and post-monsoon seasons

Hydrochemical Facies

The piper diagram is extensively used by plotting the concentration of major cations and anions in the Piper trilinear diagram (Piper, 1994). On the basis of chemical analysis, groundwater is divided into three distinct fields, namely, two triangular fields and one diamond shaped field. The overall characteristics of the water is represented in diamond shaped fields like, $CaHCO_3$, NaCl, Mixed $CaNaHCO_3$, Mixed CaMgCl, CaCl, and $NaHCO_3$ types by projecting the position on the plots in the triangular field. In the study area, majority of the samples fall under the Mixed CaMgCl, CaCl and few samples NaCl types during both seasons as shown in Fig. 4. From the plot, it is observed that an alkaline earths (Ca^{2+} and Mg^{2+}) exceeds alkali (Na^+ and K^+) and strong acids exceeds weak acids.

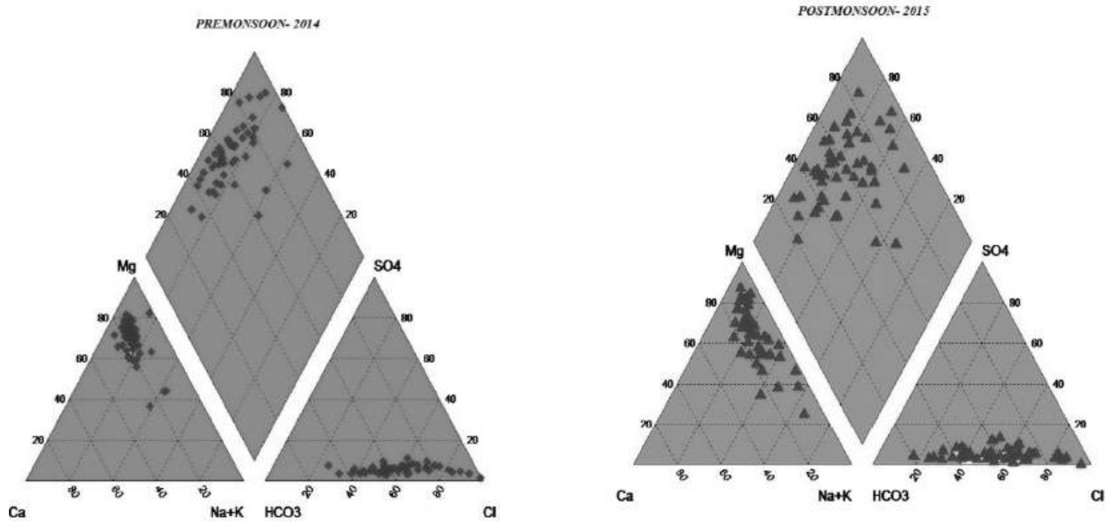

Figure 4. Piper diagram for pre and post monsoon seasons

USSL Diagram

The USSL diagram is a simple plot of sodium hazard (SAR) on the y- axis as S1, S2, S3, and S4 versus salinity hazard (EC) on the x – axis C1, C2, C3, and C4 shown in Fig. 5. Majority of the samples fall in C3S1 and C4S1 which indicate "low sodium with high salinity" and "low sodium with very high salinity" during pre- and post-monsoon seasons, respectively. This figure shows that all the water samples collected in the study area is suitable for irrigation.

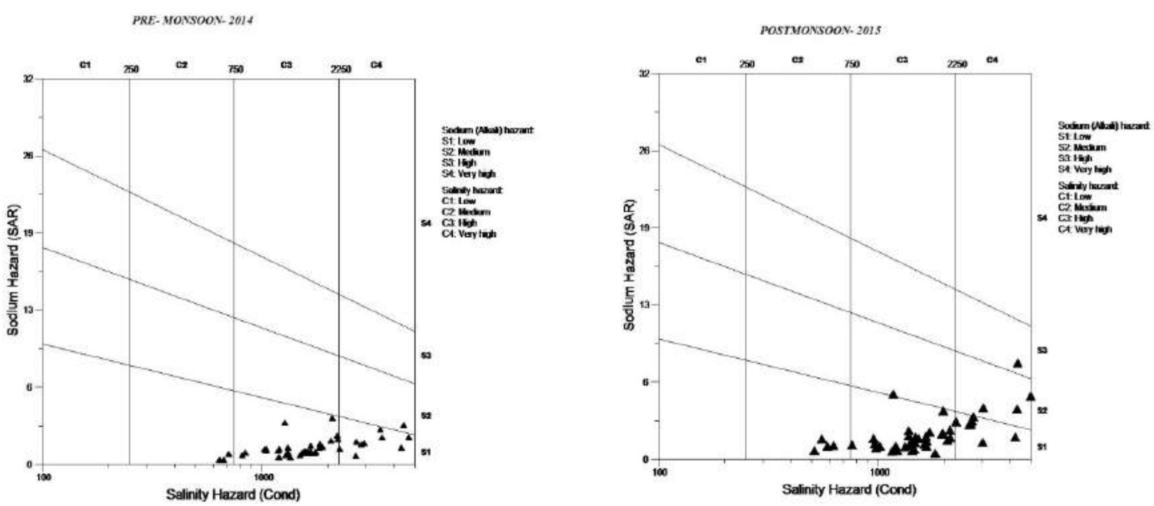

Figure 5. USSL diagram for pre and post monsoon seasons

CONCLUSION

Groundwater in the study area is alkaline in nature. TDS decreases during post-monsoon season. Based on the box and whisker plots, the abundance of the major cations is in the order of Mg > Ca > Na in both the seasons, and the abundance of major anions is in the order of Cl > HCO_3 > SO_4 during pre and post-monsoon seasons. The most polluted locations are Besant Nagar, Palavakkam, Tharamani and Pallikarani where the samples recorded above permissible limits with reference to EC, TDS, TH, Chloride and Sodium which indicate seawater intrusion and anthropogenic activity. The Gibb's plot indicate that most of the water samples fall in the rock-water interaction and evaporation, few samples fall outside the plot for both the seasons of the study area. During all the seasons the increase in evaporation increases the salinity and the concentration of the ions such as Na and Cl increases with increasing TDS. The Piper plot for the study area shows that the majority of the samples fall under the Mixed CaMgCl, CaCl and few samples fall under NaCl types during both seasons. From USSL diagram it is inferred that most of the samples are fall in C3S1 and C4S1 field that refers to “low sodium and high salinity” and “low sodium and very high salinity,” during both seasons.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial assistance provided by UGC under SAP DRS II program. They place on record their gratitude to Former Professor K.K.Sharma and Professor and Head i/c Dr.R.R.Krishnamurthy, Department of Applied Geology, University of Madras for their support to carry out this research work.

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Quality of Groundwater and Impact of Seawater Intrusion, East Thiruvallur District, North Chennai, Tamilnadu, India

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ABSTRACT

Fifty-five groundwater samples were collected from open and bore well during June 2014 and January 2015 to represent pre- and post-monsoon seasons of the study area. The samples were analyzed for physical and chemical parameters to know the quality of groundwater. The results of the analysis were interpreted by various geochemical diagrams like Gibb's plot, Wilcox diagram and Box and Whisker plot, USSL, and Giggenbach triangle diagram. According to the Gibb's plot, most of the groundwater samples fall in the field of "evaporation" during both seasons. The Wilcox diagram reveals that only 45 % of the samples are fit for irrigation purpose, otherwise they are either polluted by sea water intrusion or by effluents discharged from adjoining industries. The Box and Whisker plot reveals the order of abundance of major cations and anions during pre and post monsoon seasons. Majority of the samples fall in C3S1 and C4S2 category in USSL diagram. The Giggenbach diagram reveals that almost all the samples are of immature water. Comparing BIS (2012), Na, Ca, Mg, and K; Cl, HCO_3, and SO_4 concentrations were above permissible limit in most of the samples, indicating seawater intrusion along the coastal tract of the study area.

Keywords: Groundwater, Geochemical parameters, Gibb's plot, Wilcox diagram, Box and Whisker plot, Seawater intrusion.

INTRODUCTION

The increasing population, urbanization and industries are given rise to environmental stress and pollution all over the world. Most of the developed countries have already realized that human existence on the earth may be endangered if suitable steps are not taken for the abatement to the pollution of the water bodies that causes a serious threat to the mankind. Groundwater is the precious environmental components which receive large amounts of contaminants from urban and industrial sites. Discharge of agricultural wastes, industrial effluents and urban activities is considered to be the primary sources for increasing nutrient load in groundwater. Water quality gets modified along the course of the movement of water through several factors such as evaporation, oxidation/reduction, cation exchange, dissociation of minerals, precipitation, mixing of water, leaching of fertilizer, manure pollution and biological processes (Appelo and postma, 1999). Unused fertilizers, pesticides effluents discharged from industries and sewage water are the main contaminants in the groundwater (Venugopal *et al*., 2009). Groundwater with low pH values can cause gastrointestinal disorder and this water cannot be used for the drinking purposes. High TDS values are not suitable for both irrigation and drinking purposes (Davis and De Wiest, 1966; Fetters, 1990; Freez and Cherry, 1979).

Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formation and anthropogenic activities. Poor quality of water adversely affects the plant growth and human health (Wilcox, 1984; Thorne and Peterson, 1954; US Salinity Laboratory Staff, 1954; Todd, 1980; ISI, 1983; WHO, 1984; Hem, 1991; Karanth, 1997). Hydro-chemical data are useful for providing preliminary information on water types, classification of water for various purposes as well as identification of different groundwater and study of different chemical process based on the groundwater chemistry (Karanath,1987; Saxena *et al*.,2003; Jalali, 2007). The Groundwater quality in coastal region is generally affected due to natural processes such as saline water intrusion, evaporation, and interaction of groundwater with brines and sedimentary formations (Polemio *et al*., 2006; Srinivasamoorthy *et al*., 2011). The seawater intrusion is a main cause of high salinity, and the groundwater generally demonstrates high concentration not only in total dissolved solids (TDS) but also in major cations and anions (Richter and Kreitler, 1993) and increase of selective trace elements (Saxena *et al*., 2004; Mondal *et al*., 2010b). The present study brings out first hand information about the quality of groundwater and hence, forms a baseline data for further reference.

STUDY AREA AND GEOLOGY

The study area is around 250 sq km in North Chennai along the coast and towards inland, Thiruvallur District. It is mainly occupied by industries and factories. The study area falls in Fig.1.the geographical coordinates of13°00'59.8" to 13°13'53.3"N latitude and 80°16'36.0" to 80°19'46.8"E longitude as shown in Fig. 1. It shows the location of sampling stations. It is a coastal region that consists of alluvium, which helps in easy infiltration of the surface water. The district receives rain under the influence of both Southwest (June-August) and Northeast monsoon (September – November) seasons. The basement is composed of Precambrian Charnockite and outcrops of which are seen in the western and southwestern regions of the study area. The alluvial flood plains are of sandy-clay that overlies the basement rock. The weathered/fractured charnockite and alluvium forms the major aquifer system. The major sources of groundwater recharge are precipitation only. The rock mass consists of quartz, feldspar, biotite and pyroxene. The borehole lithology and rock quality designation, the charnockite rock mass, to a great extent, is classified as ‘excellent’ and ‘good’ (Arumugham, 1994). The groundwater requirement of this area is mostly met by wells penetrating up to upper Quaternary/Recent sediments.

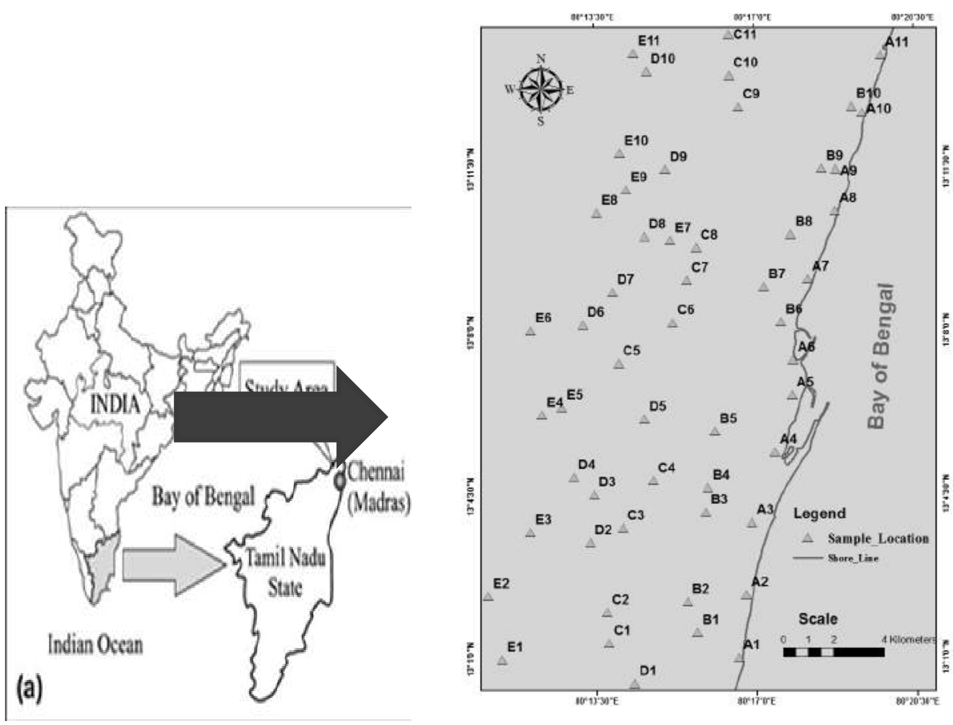


Figure 1. Study area showing sampling locations

SAMPLE MATERIALS AND METHODS

Water samples were collected from dug and bore wells in the study area using clear acid washed polyethylene bottles. One liter of water sample was collected in polyethylene bottles from various wells during the month of June 2014 and January 2015 representing pre monsoon and post monsoon seasons, respectively. Fifty five groundwater samples were collected for each of the seasons mentioned, for analysis of various physical and chemical parameters. pH was measured using portable pH meter and EC were measured by EC meter in the field itself. With respect to cations, Calcium and Magnesium were analyzed following volumetric method; Sodium and Potassium were analyzed using flame photometer; and with respect to anions, Chloride and Bicarbonate were estimated by volumetric method; Nitrate, and Sulfate were estimated by turbidity method. All chemical analyses were carried out following APHA method (APHA, 1998).

RESULTS AND DISCUSSION

Maximum and minimum concentration of major cations and anions of groundwater of the study area are presented in Table 1.Groundwater in the study area is generally alkaline in nature with pH ranging from 6.43 to 7.52 during pre-monsoon and in the post monsoon it ranges from 6.74 to 8.8. EC is an indirect measure of ionic strength and mineralization of natural water. In the study area, EC ranges from 664 to 35100 µS/cm during pre-monsoon, while it ranges between 822 and 15660µS/cm during post monsoon. In the pre monsoon season, the value of TDS varies from 465 to 24570 mg/l whereas during the post monsoon it ranges between 510 and 10230 mg/l. However, in most of the sample chemical parameters are increased in pre monsoon seasons.

Table 1. Maximum and minimum concentration of major cations and anions during pre and post monsoon season (2014-15)

Ions	Pre monsoon		Post monsoon	
	Min.	Max.	Min.	Max.
pH	6.43	7.52	6.74	8.8
EC	664 µS/cm	35100 µS/cm	822 µS/cm	15660 µS/cm
	mg/l	mg/l	mg/l	mg/l
TDS	465	24570	510	10230
Ca	34	3280	8	288
Mg	11	768	9	231
Na	49	2360	29.9	1700
K	6	135	0.1	155.9
Cl	77	11050	142	10394.4
HCO_3	160	560	109	817.4

Cations

Calcium ion concentration in the pre monsoon season varies from 34 to 3280 mg/l and post monsoon it ranges between 8 and 288 mg/liter. Magnesium ion concentration in the pre monsoon season varies from 11 to 768 mg/l while it ranges between 9 and 231 mg/l during post monsoon. Sodium ion concentration in the pre monsoon season varies from 49 to 2360 mg/l while it ranges between 29.9 and 1700 mg/l during post monsoon. The concentration of Calcium and Magnesium in the study area may be due to rock weathering. Magnesium may have come from the dissolution of magnesium calcite, gypsum, and unused chemicals (Garrels, 1976). The concentration of sodium in the groundwater of the study area may be due to rock weathering as well as fertilizer wastes from the industries. The feldspar of igneous rocks is a good source of sodium when weathered (Rajmohan *et al*., 2000).

Anions

Chloride ion concentration in the pre-monsoon season varies from 77 to 11050 mg/L while, it ranges between 142 and 10394 mg/L during post-monsoon samples. Bicarbonate concentration in the pre monsoon season varies from 160 to 560 mg/l and post monsoon ranges between 109 and 817 mg/L. Cl is higher due to the intrusion of saline water and base exchange reactions (Freeze and Cherry, 1979). Increasing chloride in ground water is from rainwater, which dissolves the chloride in wind-driven aerosols from the atmosphere (Lakshmanan *et al*., 2003).The increase in Na and Cl in the groundwater of the study area is due to the influence of seawater intrusion through the Bay of Bengal (Mondal *et al*., 2010). The higher chloride content in groundwater may be attributed to the presence of soluble chloride from rocks and saline water intrusion.

Wilcox Diagram

The role of sodium in the classification of groundwater for irrigation was emphasized because of the fact that sodium reacts with the soil and as a result, clogging of particles takes place, thereby reducing the permeability (Todd1980; Domenico *et al*., 1990). Na is an important cation which in excess deteriorates the soil structure and reduces crop yield (Srinivasamoorthy, 2004). The concentrations of ions are expressed in milli-equivalents per liter in Wilcox diagram (Wilcox, 1955). Water is classified based on the Na% with respect to other cations that are present in the water. Values of pre- and post-monsoon groundwater samples of the study area are plotted in the Wilcox diagram, and are shown in Fig. 2. The Wilcox diagram reveals that 25% of the samples are in the field "permissible to doubtful"; 22% of the samples in "doubtful to unsuitable "; 45% of the samples in "good to permissible" and; 4% of the samples fall in "unsuitable" category, during pre and post- monsoon seasons. It is inferred that a few samples are "unsuitable" for irrigation purpose and their locations are near the coast. The locations of samples that fall "permissible to doubtful" and "doubtful to unsuitable" are nearer to the factories and industries.

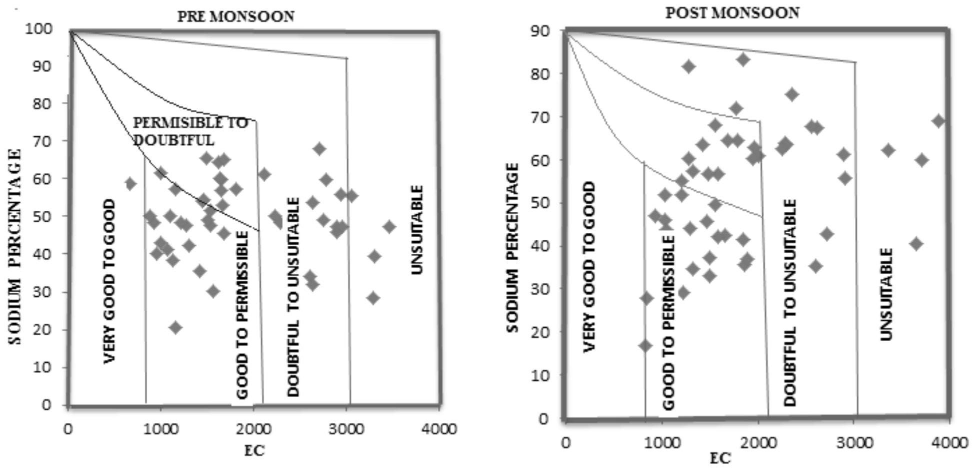
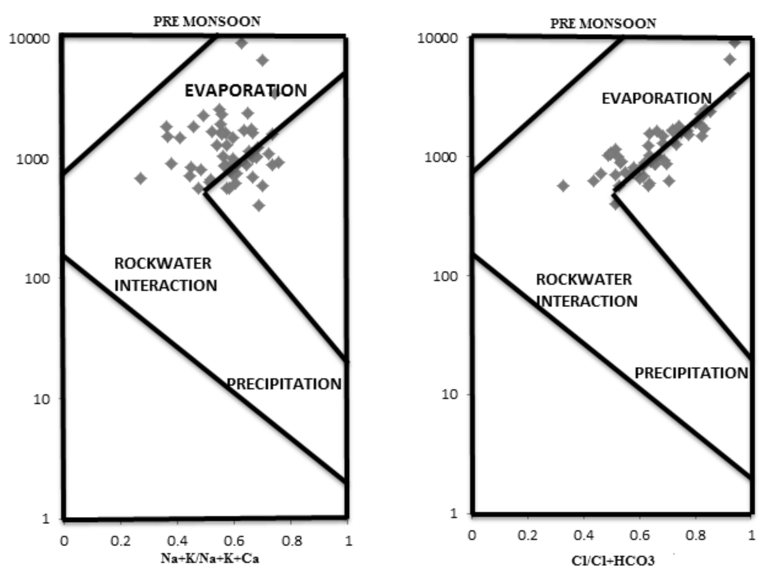


Figure 2. Wilcox diagram for pre and post monsoon seasons

Gibb's diagram

The water chemistry in the study area is regulated by diverse processes and mechanisms. Hence, Gibbs plot is employed in this study to understand and differentiate the influences of rock-water interaction, evaporation and precipitation (Gibbs, 1970). Gibbs demonstrated that TDS is plotted on "y"axis, and Na/(Na+Ca) and Cl/(Cl+HCO_3) is plotted on "x" axis which would provide information on the mechanism that controls the chemistry of water. The chemical data of groundwater samples are plotted in the Gibbs diagram (Fig.3) for the study area. The majority of the samples fall in evaporation field in pre and post monsoon. Groundwater samples of fresh and saline waters were individually scattered in the evaporation dominance fields for both seasons that indicates higher concentration of salts in the respective locations.



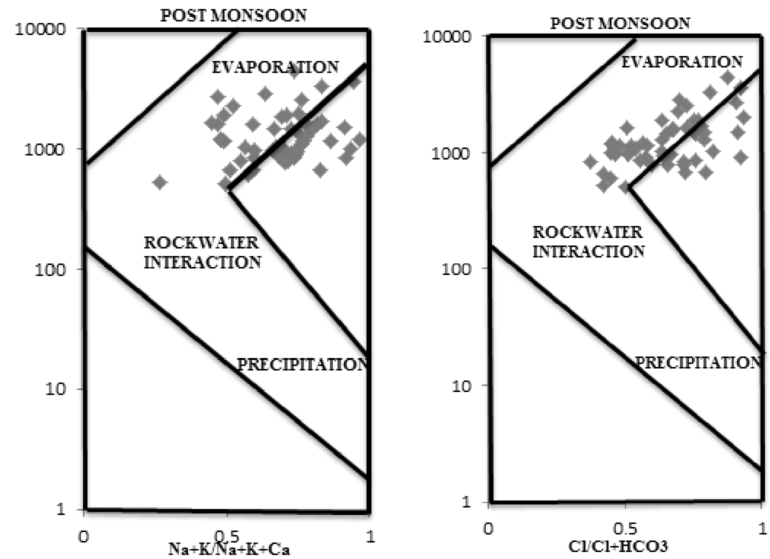


Figure 3. Gibb's diagram for Pre and Post monsoon seasons

Box and Whisker

The plots are constructed using the median value and inter-quartile range (25 to 75) cumulative frequency measured as central tendency and variability (U.S.EPA,1992), for the study area and is shown in Fig. 4. The abundance of the major Cations is in the order of Mg>Ca>Na and Ca>Na>Mg are the post monsoon and pre monsoon, respectively. The abundance of the major Anions is in the order of HCO_3>Cl and Cl>HCO_3 in post and pre monsoon (January 2015 and June 2014).

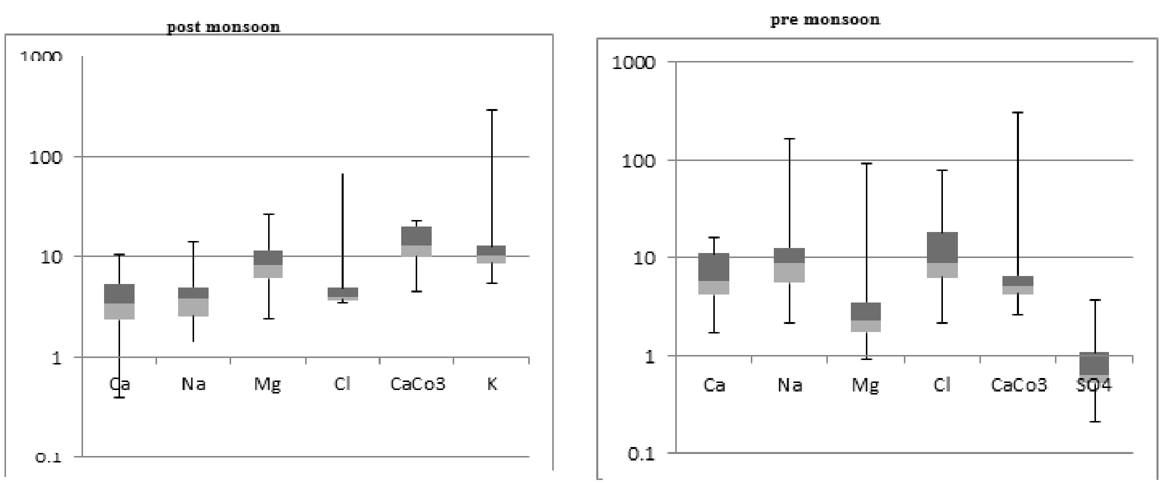
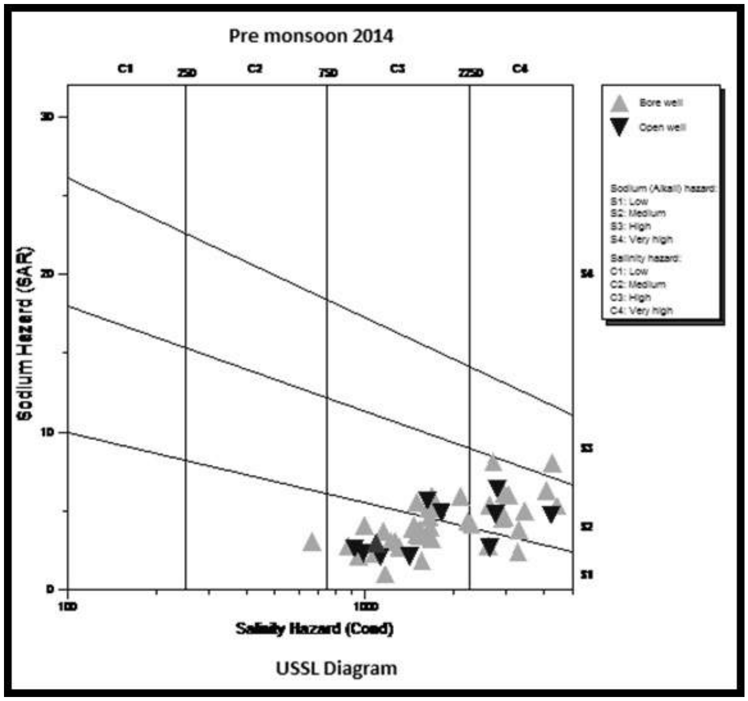


Figure 4. Box and Whisker plots for Post and Pre monsoon seasons

USSL Diagram

In USSL diagram, water can be classified into four types- C1, C2, C3 and C4 based on salinity hazard and S1, S2, S3 and S4 based on sodium hazard. Figure 5 shows the plot of groundwater samples grouped on the above basis for the study area. Almost 60% of the samples fall in C3S1 that are "permissible" for the irrigation in both pre and post- monsoon seasons; 25% of the samples fall in C4S2 that are "unsuitable" for irrigation in both pre- and post-monsoon seasons. The other 15% of the samples are in other fields. The location of the samples that fall in C4S2 that are "unsuitable" for irrigation in both seasons are attributed to addition of agricultural wastes, industrial effluents and urban activities apart from seawater intrusion in the study area.



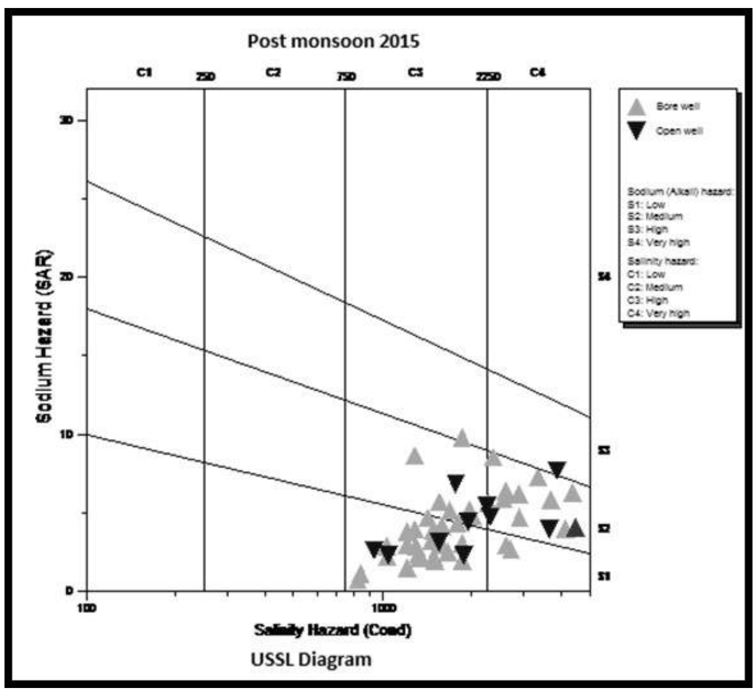
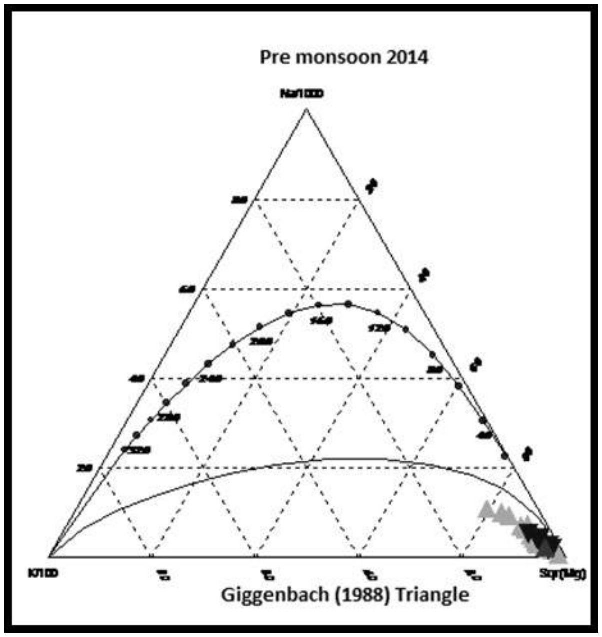


Figure 5. USSL diagram for Pre and Post monsoon seasons

Giggenbach Triangle

The Giggenbach triangle (Giggenbach, 1988) provides a visual aid to determine the water-rock equilibrium. According to this triangle all water samples fall under the category of immature water as shown in Fig. 6.



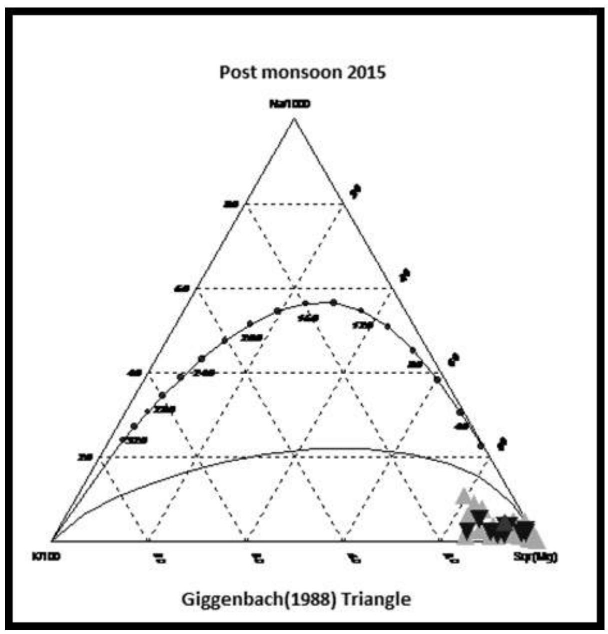


Figure 6. Giggenbach Triangle diagram for Pre and Post monsoon seasons

Seawater Intrusion

Considering the values of Na, Ca, Mg, and K, and Cl, HCO_3, SO_4 concentrations in the water samples of the study area, it is evident that most of the locations are having values above permissible limit, where their locations are in the coastal part from Royapuram to Thalankuppam that covers coastal tract of places called Royapuram, Fisheries office, Thiruchinnakuppam, Palangaithottikuppam and Thalankuppam where sea water intruded towards inland from the coastal tract upto 6 km in northern region of the study area (North Chennai), whereas, Puthupettai, Central, Nungampakkam, Erukkencheri, Chinnasekkadu, and Padikuppam, Lakshmipuram, Vadaperumpakkam and Tiyempakkam are in the southern region of the study area where the seawater intruded about 8 km (Central Chennai) inland.

In coastal cities, like Chennai, over-exploitation of groundwater in the coastal parts in the north are being severely affected by high concentration of chloride and total dissolved solids due to seawater intrusion. Such saltwater intrusion not only increases the chloride content in the groundwater, but also carries trace and major elements from the polluted coastal waters. Rengaraj *et al*., (1996) pointed out that salinity concentration dramatically increased for the past several years due to legal and illegal pumping of enormous volume of groundwater from the beach sandy areas. At the same time, the municipal wastes, industrial effluents and other waste disposals also contribute to groundwater contaminations. This groundwater contamination is undesirable to the health of humans who depend on groundwater of this city. Ramesh *et al*., (1995) reported several health hazards among people around the slum areas of these regions.

CONCLUSION

The study reveals quality of groundwater of the study area. The concentrations of Cations and Anions were above the permissible limits in some locations due to continuous discharge of domestic sewage and industrial wastes as well as seawater intrusion. Wilcox diagram reveals that the samples collected nearer to the coast are “unsuitable” and samples collected nearer to factories and industries are “doubtful to unsuitable” for irrigation. From Gibb’s diagram, it is inferred that majority of the samples fall in evaporation field which facilitate the increase in concentration of salts in the respective locations. Box and Whisker plot illustrates that the groundwater samples have abundance of cation as Mg>Ca>Na during post- and as Ca>Na>Mg during pre-monsoon seasons, whereas, the abundance of anion as HCO_3>Cl in post- and Cl>HCO_3 in pre-monsoon seasons. USSL diagram demonstrate that the samples that fall in C4S2 are “unsuitable” for irrigation due to addition of agricultural waste, industrial effluents, and urban activities apart from seawater intrusion. Considering the values that are recorded above permissible limit with reference to Na, Ca, Mg, and K as well as Cl, HCO_3 and SO_4, and the inference from USSL and Wilcox diagrams, it is concluded that the seawater intruded 6 km in the Northern and 8 km in the Southern region of the study area, which is North Chennai and Central Chennai.

ACKNOWLEDGEMENT

All the authors acknowledge the financial support provided under UGC-SAP-DRS II to this department under which this research work is being carried out. The authors are thankful to the facilities provided by the authorities of University of Madras. Our deep sense of gratitude to Prof. R.R. Krishnamurthy, Head i/c, Department of Applied Geology, University of Madras.

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Assessment of Groundwater Quality in Semi-Arid Regions for Drinking

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ABSTRACT

Groundwater, a dependable source in semi-arid regions needs water quality assessment to meet various demands. In the present study, the geochemical characteristics of groundwater have been studied for a region that receives moderate rainfall and high agriculture productivity. Groundwater samples are collected from 7 random locations distributed over the area post monsoon (April) and Samples are analyzed for physical and chemical parameters such as pH, electrical conductivity, TDS, carbonate, bicarbonate, chloride, sulphate, nitrate, calcium, magnesium, sodium, potassium, fluoride and total hardness. The results were evaluated and compared with WHO water quality standards. Water analysis reveals that the water is hard (540 mg/l), and high fluoride concentrationdue to the presence of alkaline earths such as calcium and magnesium and Bed rock containing fluoride minerals is responsible for high concentration fluoride ion in groundwater. Dominant hydrochemical facieses of the groundwater are (1) Ca-Mg-So_4-Cl; (2) Sodium chloride sulphate (3) mixed faces between Na–k and Mg; (4) Mixed zone. The water has to be treated for hardness and fluoride.

Keywords: Groundwater quality, Hydrochemistry, hydrogeology, NPS pollution.

1. INTRODUCTION

The groundwater is a major source of water for a wide range of beneficial uses, like meeting demands on water supply because of regional climate change and scanty surface water source or their unsuitability, being the most significant freshwater resource on the planet Earth especially in arid and semi-arid regions(Neshat et al. 2014). The assessment of water quality has become an important part of water resource studies, planning and management. It is gaining significant importance due to intense urbanization, industrialization and agricultural activities that are increasing the risk of contamination of soil and water. Water quality monitoring is important for the protection of public health (drinking or domestic use), agriculture, industry, fishing, recreation, tourism and protection of aquatic ecosystems. The knowledge of the water quality status as well as the processes affecting water quality is vital for Integrated Water Resource Management (IWRM) activities within the catchment (Dinka et al., 2015; Sappa et al., 2014).

The chemical composition of groundwater is regulated by various factors, which include atmospheric input (i.e., aerosols, etc.), mineral weathering through rock-water interaction, anthropogenic activities, and biogeochemical processes. The weathering of minerals generally exerts an important control on groundwater chemistry. This process generally dominates the concentration of the major cations in groundwater (Srinivasamoorthy et al., 2014).

2. STUDY AREA

Study area consists of two adjacent taluksi.e, Davangere and Harihar with latitudes between 14º10'0"- 14º40'0"N and longitudes 75º40'0"-76º10'0"E respectively (Fig. 1). The selected area is drained by Tungabhadra River. The region experiences a semi-arid climate; with a normal rainfall of 600mm.normally temperature in summer season varies from 32ºc-40ºC and in winter season 18ºc-22ºC. Agriculture is dominant Land use in the basin. Major crops like maize, jowar,rice,groundnut,sunflower,sugarcane are irrigated by two irrigation canals viz., Davangere branch and Harihar branch canal. In Davangeretaluk fractured granitic-gneisses, gneisses and hornblendedschists are the main water bearing formations. Ground water occurs within the weathered and fractured rocks under water-table conditions and semi-confined conditions. In Harihartaluk,schists are the main water bearing formation. Ground water occurs within the weathered and fractured rocks.

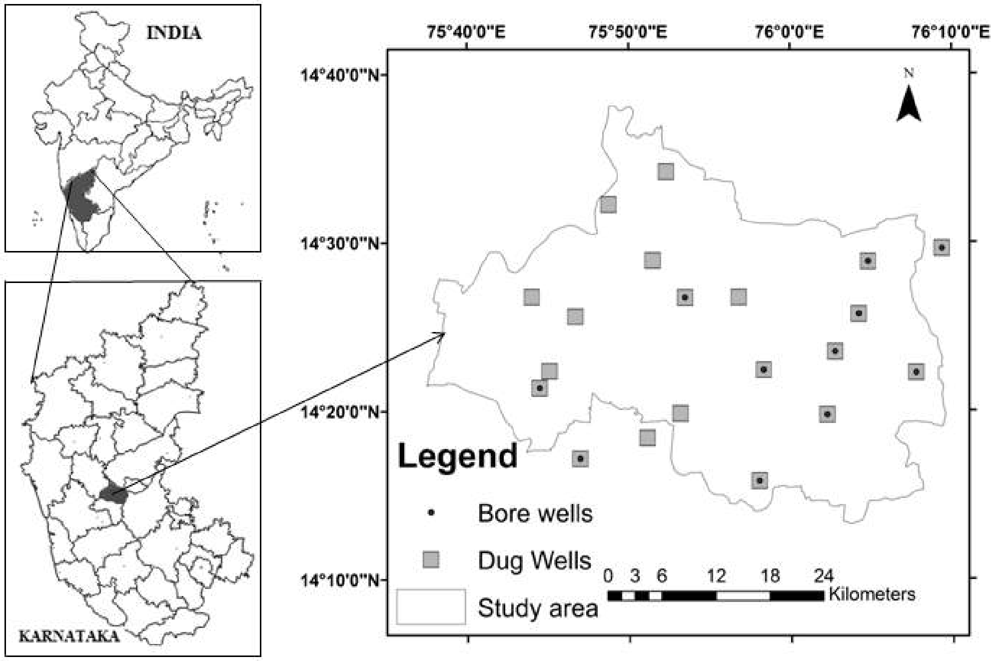

Figure 1 Location and groundwater locations in Davangere and Harihartaluks

3. WATER SAMPLING AND ANALYSIS

Groundwater samples were collected from 7 locations of the area during April 2015.Latitudes between 14º10'0"-14º40'0"N and longitudes 75º40'0"-76º10'0"E respectively (Figure 1). All samples were collected in laboratory certified clean bottles and location; date and time of sample collection were recorded. Laboratory analyses included major cations and anions. All samples were maintained in refrigerated conditions before analyses.

Table 1 Physico-chemical parameters(Ravikumar & Somashekar 2010; Kumar & Magesh 2014)

Parameters	characteristics	Method	Unit	WHO (2011)
General	pH	Electrode		6.5-8.5
	Electrical Conductivity (EC)	Conductivity-TDS METER	µS/cm	1500
	Total Dissolved Solids (TDS)	Conductivity-TDS METER	mg/l	1500
	Total Hardness (as CaCo3)	EDTA Titrimetric	mg/l	100
Major Cations	Calcium (as ca2+)	EDTA Titrimetric	mg/l	75
	Magnesium (Mg2+)	EDTA Titrimetric	mg/l	50
	Sodium (as Na+)	Flame Photometric	mg/l	200
	Potassium (as K+)	Flame Photometric	mg/l	12
Major Anions	Bicarbonates (as HCO_3^-)	Titrimetric	mg/l	500
	Chlorides (as Cl^-)	Titrimetric	mg/l	250
	Nitrates (as NO_3^-)	Spectrophotometer	mg/l	45
	Fluoride (as F-)	Spectrophotometer	mg/l	1
	Sulphates (as SO_4^{2-})	Colorimeter	mg/l	250

3.1 Water quality index calculation

The water quality index (WQI) was calculated for evaluatinginfluence of natural and anthropogenic activities based on several key parameters of groundwater chemistry.

To calculate the WQI, the weight has been assigned for the physico-chemical parameters according to the parameters relative importance in the overall quality of water for drinking water purposes. The assigned weight ranges from 1 to 5. The maximum weight of 5 has been assigned for nitrate and minimum weight 1 assigned for magnesium (Kumar et al., 2014; Ramakrishnaiah et al., 2009) .The relative weight is computed from the following equation.

$$W_i = w_i / \Sigma_{i=1}^{n} w_i \quad (1)$$

Where W_i is the relative weight

w_i is the weight of each parameter

n is the number of parameters.

The quality rating scale for each parameter is calculated by dividing its concentration in each water sample by its respective standards (World Health Organization 2011) and multiplied the results by 100

$$Q_i = (C_i/S_i) * 100 \quad (2)$$

Where q_i is the quality rating

C_i is the concentration of each chemical parameter in each sample in milligrams per liter

S_i is the World Health Organization standard for each chemical parameter in milligrams per liter according to the guidelines of the (WHO 2011)

For computing the final stage of WQI, the SI is firstdetermined for each parameter. The sum of SI values gives the water quality index for each sample.

$$SI_i = W_i * q_i \quad (3)$$

$$WQI = \Sigma SI_i \quad (4)$$

Where SI_i is the sub-index of i^{th} parameter

q_i is the rating based on concentration of i^{th} parameter

n is the number of parameters

4. RESULTS AND DISCUSSIONS

Table 2 Analytical results of groundwater samples in Davangere area (Post-monsoon, 2015)

Characteristics	**Locations[**Latitudes between 14º10'0"- 14º40'0"N and longitudes 75º40'0"-76º10'0"E**]**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
pH	6.6	6.7	6.8	6.7	6.8	6.8	6.9
EC	952.0	1836.0	1595.0	1276.0	523.3	872.2	744.1
TDS	524.4	1017.0	862.9	729.9	300.0	505.7	449.8
TH	468.0	402.0	540.0	206.0	184.0	230.0	178.0
HCO^{3-}	302.0	306.0	580.0	440.0	230.0	288.0	378.0
Cl^-	180.0	74.0	210.0	280.0	150.0	80.0	70.0
SO_4^{2-}	170.0	180.0	450.0	280.0	150.0	80.0	70.0
NO^{3-}	25.1	27.5	17.5	24.5	20.0	27.3	24.3
Ca^{2+}	55.2	132.0	76.8	24.8	37.6	24.8	24.8
mg^{2+}	76.8	17.3	83.5	23.5	21.6	40.3	27.8
Na^+	52.0	130.0	144.0	75.0	78.0	115.0	117.0
k^+	3.0	54.0	12.0	16.0	6.0	12.0	10.0
F	1.5	1.7	0.6	1.7	1.2	0.8	1.2

(All Concentrations are in mg/L, except pH and EC measured in µS/cm)

[1- Kandagallu; 2- Kukri; 3- Kukkavada; 4- Yekkegondi; 5- Kumbaluru6-Kamalapura; 7- Malebennuru]

Temperature and pH

The temperature variation ranges from 18to 38 ºC with a mean value of 28 ºC. The pH indicates the strength of the water to react with the acidic or alkaline material present in the water. It controls by carbon dioxide, carbonate and bicarbonate equilibrium. The combination of CO_2 with water forms carbonic acid, which affects the pH of the water. The pH in the groundwater is varied from 6.6 to 6.9. This may be attributed to the anthropogenic activities like improper irrigation process and weathering process in the study area.

Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity toconvey the electrical current. The most desirable limit ofEC in drinking water is prescribed as 1500 µS/cm. The value of EC is between 523.3 and 1595µS/cm. EC measures the ability of a material to conduct an electric current such that the higher EC indicates enrichment of salts in the groundwater. EC values are in permissible limits.

Total dissolved solids (TDS)

Total dissolved salts in the groundwater is between 300 and 1017 mg/l. Low TDS (373.52–862.9 mg/l)is observed in the samples 1, 3, 4, 5, 6 and 7 which indicates the influence of rock–water interaction in relation to recharge water. The high TDS observed in the study area is 1017 mg/l; the occurrence of high TDS is due to the influence of anthropogenic sources, such as domestic sewage, septic tanks and agricultural activities. According to WHO specification TDS up to 500 mg/l is the highest desirable and up to 1,500 mg/l is maximum permissible.

***Bicarbonate* (HCO$_3$)**

The concentration of carbonates in natural waters is a function of dissolved carbon dioxide, temperature, pH, cations and other dissolved salts. Bicarbonate concentration of natural waters generally held within a moderate range by the effects of the carbonate equilibrium. The concentration of bicarbonate is observed from 230 to 580 mg/l, few samples exceeding the permissible limits of bicarbonate.

***Chloride* (Cl)**

The chloride ion is the most predominant natural form of the element chlorine and is extremely stable in water. The chloride in groundwater may be from diverse sources such as weathering, leaching of sedimentary rocks and soil, domestic and municipal effluents. The range of chloride is found to vary between 24 and 280 mg/l for water samples. The desirable limit for chloride is 250 mg/l. For the study area it has been found that in certain locations the chloride concentration exceeds the maximum permissible limit.

***Sulphate* (SO$_4$)**

The concentration of sulphate is likely to react with human organs if the concentration exceeds the maximum allowable limit of 400 mg/l and causes a laxative effect on human system with the excess magnesium in groundwater.The content of $SO_4$is observed from 70 to 450 mg/l. However, the sulphate concentration in groundwater of the study area is exceeding the requirement desirable Limit (150 mg/l).Main sources of sulphates identified as leaching from fertilizers and municipal waste.

***Nitrate* (NO$_3$)**

The value of NO_3 in the groundwater is observed between 17.5 and 27.5 mg/l with an average value of 23.72 mg/l. All samples are not exceeding the permissible limit of 45 mg/l as per WHOstandard.But nitrate levels in other seasons are exceeding the limits. Nitrate-nitrogen exposure is strongly associated with several diseases, such as methemoglobinemia (blue baby syndrome), gastric cancer, thyroid disease and diabetes. Hence, increasing nitrogen contamination seriously threatens public drinking water supply and human health.

Calcium and magnesium (Ca and Mg)

Calcium and magnesium are directly related to hardness of the water and these ions are the most abundant elements in the surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride. The concentration of $Ca^{2+}$is between 24.80 and 132 mg/l, and concentration of Mg^{2+} is varied from 17.28 to 83.52 mg/l. The maximum concentration of calcium ions can cause abdominal ailments and is undesirable for domestic purposes as it causes encrustation and scaling. The higher concentration of Mg^{2+}(76.8 and 83.52 mg/l) isobserved in the groundwater sample nos. 1 and 3. The rest of the groundwater samples show Mg^{2+} from 17.28 to 40.32 mg/l.

Sodium and potassium (Na and K)

The concentration of Na^+ is varied from 52 to 144 mg/L. waters containing high sodium content are not suitable for irrigation as it tends to degrade the soil. Potassium concentration all groundwater samplescomes under permissible limit.Increasingsodium and potassium into groundwater due to agricultural activities.

Total hardness (TH)

The classification of groundwater based on total hardness (TH) shows that a majority of the ground water samples fall in the hard water category. The hardness values range from 89.5 to 814.55 mg/l with an average value of 211.59 mg/l. The maximum allowable limit of TH for drinking purpose is 500 mg/l and the most desirable limit is 100 mg/l as per the WHO standard. Groundwater exceeding the limit of 300 mg/l is considered to be very hard. Sample nos. 2 and 11 exceed the maximum allowable limit of 500 mg/l. The hardness of the water is due to the presence of alkaline earths such as calcium and magnesium.

Fluoride

The fluoride (F) concentration varies from 0.6 to 1.7 mg/l with an average value of 1.24 mg/l. Bed rock containing fluoride minerals is generally responsible for high concentration of this ion in groundwater. The fluoride concentration in groundwater of the study area is found that 71.42 % samples are within the maximum allowable limit (1.5 mg/l) and 28.57 % samples are exceeding the permissible limit. The high fluoride content in groundwater leads to dental and skeletal fluorosis such as mottling of teeth and deformation of ligaments (Selvam et al., 2013; Sudarshan et al., 2014).

Gibbs diagram

Gibbs diagram is widely used to establish the relationship ofwater composition and aquifer lithological characteristics. Three distinct fields such as precipitation dominance, evaporation dominance and rock–water interaction dominance areas are shown in the Gibbs diagram (Gibbs, 1970) (Aghazadeh and mogaddam, 2010; Sudarshan et al., 2014). The predominant samples fall in the rock–water interaction dominance and evaporation dominance field of the Gibbs diagram (Figure 2). The rock–water interaction dominance field indicates the interaction between rock chemistry and the chemistry of the percolated waters under the subsurface.

$$\text{Gibbs ratio (for anion)} = \frac{Cl^-}{Cl^- + HCO_3^-} \quad (5)$$

$$\text{Gibbs ratio (for cation)} = \frac{Na^+ + K^+}{Na^+ + K^+ + Ca^+} \quad (6)$$

Whereas all ionic concentration is expressed in meq/l.

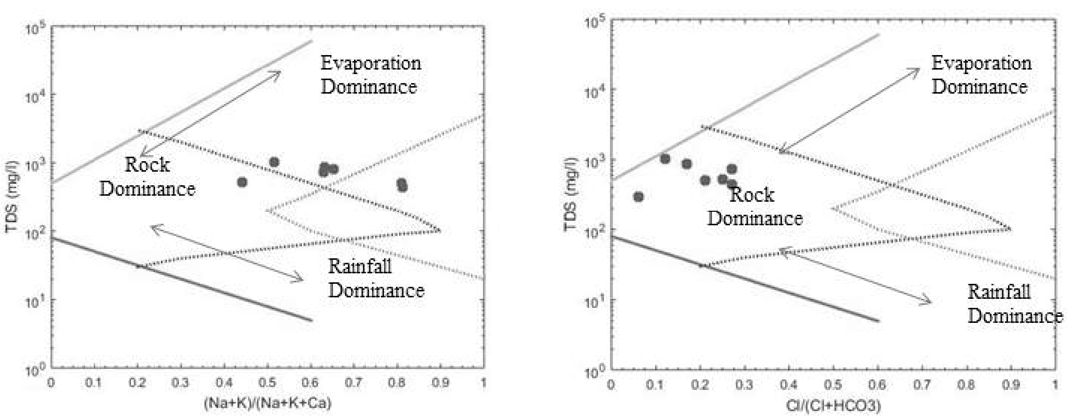

Figure 2 Gibbs diagram

HydrochemicalFacies

The term hydrochemicalfacies is a function of solution kinetics, rock-water interactions, and geology and contamination sources used to describe the quantities of water that differ in their chemical composition. A convenient method to classify and compare water types based on ionic composition is proposed by Piper, 1944 by plotting the chemical data on a trilinear diagram. Two main types water have been identified based on varying ionic concentrations: Ca^{2+}-Mg^{2+}-SO_4-$Cl^-$and Na^+-SO_4^{2-}—Cl^- (Figure 3).

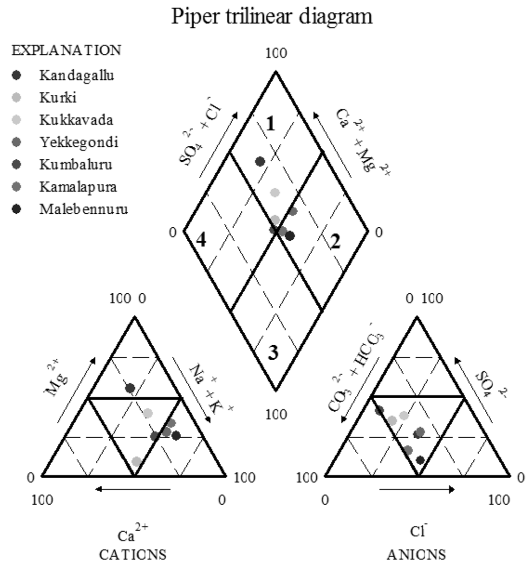

Figure 3 Piper diagram of the groundwater samples in the study area

Water quality index calculation (WQI)

The chemistry of groundwater is often used as a tool for discriminating the drinking and irrigation water quality. Water quality index (WQI) is an important parameter for identifying the water quality and its sustainability for drinking purposes. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall water. (World Health Organization 2011) standards for drinking water quality have been used to calculate the WQI. The relative weight (w_i) was assigned for water quality parameters based on their relative importance on water quality for drinking purposes (Table 4). The calculation of WQI for groundwater samples is shown in (Table 6). A total of 7location samples were analyzed for WQI. Among these, 71.43 % of the samples showed goodwater and 28.57 % of thesamples showed poor water category. This may be due to effective leaching and dissolution process of rock salt and gypsum-bearing rock formations. High concentration of EC, chloride, sodium followed by calcium clearly suggests that rock–water interaction process is the main source for degrading the water quality in the study area.

Table 3 Relative weight of physico-chemical Parameters

Parameters	WHO standards (2011)	Weight (wi)	Relative weight
pH	8.5	4	0.098
EC	500	4	0.098
TDS	500	5	0.122
TH	500	3	0.073
HCO^{3-}	240	3	0.073
Cl^-	250	4	0.098
SO_4^{2-}	45	5	0.122
NO^{3-}	75	2	0.049
Ca^{2+}	50	1	0.024
mg^{2+}	200	2	0.049
Na^+	200	2	0.049
k^+	600	4	0.098
F	1.5	2	0.049
		$\sum w_i$= 41	$\sum W_i$= 1.00

Table 4 Water quality classification ranges and types of water based on WQI values

Range	Type of water
<50	Excellent water
50-100	Good water
100-200	Poor water
200-300	Very poor water
>300	Water unsuitable for drinking purposes

Table 5 Water quality index (WQI) classification for individual locations

Location	WQI	Classification	Treatment
Kandagallu	83.42	Good water	Hardness and Fluoride
Kurki	115.37	Poor water	Treated for Industrial and domestic purpose due to EC, TDA, Ca, and F dominance
kukkavada	120.63	Poor water	Treated for alkalinity and Sulphates
yekkegondi	96.83	Good water	Chlorides and Sulphates treatment
Kumbaluru	56.86	Good water	Hardness
Kamalapura	67.42	Good water	Hardness
Malebennuru	63.05	Good water	Hardness

5. CONCLUSIONS

The study area is always under stress due to increasing population and more demand for water resources. The hydrochemicalanalysis of the study reveals that the groundwater is fresh and moderately high to hard. The order of the abundance of the major cation and anion is as follows: Mg>Ca>Na>k=F>SO_4>HCO_3>Cl>NO_3. Mg and F are dominant ions among the studied cations and anions.The concentration of potassium and nitrates ion is within the permissible limit for drinking purpose except few locations. 29 % of the groundwater samples have exceeded the permissible limit for bicarbonates and chlorides.According to Gibbs diagram, the predominantsamples fall in the rock–water interaction dominance and evaporation dominance field. The piper trilinear diagram shows that two main types water have been identified based on varying ionic concentrations: Ca^{2+}-Mg^{2+}-SO_4-$Cl^-$and Na^+-SO_4^{2-}—Cl^-. Based on the WQI classification 71.43% of the samples are falling under good water category and suitable for drinking water purposes. 28.57% of the samples are falling poor category.

ACKNOWLEDGEMENT

The authors are thankful to WRDO Bangalore for providing vectors and Department of Civil Engineering for providing Environmental Engineering PG laboratory at University B.D.T College of Engineering.

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Groundwater Flow Modeling of a Hard Rock Aquifer

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ABSTRACT

Quantification of the groundwater recharge is a basic pre-requisite for efficient groundwater resource development and this is particularly vital for India with widely prevalent semi arid and arid climate. For rapidly expanding urban, industrial and agricultural water requirement of the country, groundwater utilization is of fundamental importance. Reliable estimation of groundwater resources is therefore, a prime necessity (GEC, 2004). The present study area is primarily underlain by shales of pre-cambrian age. A three-dimensional groundwater flow model for the Pakhal lake catchment—a semiarid hard rock area in Warangal district with a single layer having potential aquifer of thickness 30 m is developed under steady state conditions using visual MODFLOW software. The groundwater recharge estimation is achieved with the help of soil infiltration method and water table fluctuation method that is well fitted into the flow model with an average recharge value of 11% of the average annual rainfall. The model calibration was achieved for a period of 10 years through trial and error method by adjusting two key parameters viz., recharge and hydraulic conductivity. It was found that the model was more sensitive to hydraulic conductivity. The model was run under steady-state conditions and simulated heads were assessed against observed heads. The results derived from modeling indicate that the average input to the aquifer system is 21.845 million cubic meters (Mcm), and the output is 21.838 Mcm. Results shows that Groundwater velocity is more sensitive to recharge and hydraulic conductivity. The information gathered will help for the future planning and protection of groundwater resources in this semi-arid micro-watershed.

Keywords: Groundwater Estimation Committee, Visual MODFLOW.

1.1 INTRODUCTION

With the demand increasing tremendously it is necessary to know the quantity of groundwater available, its recharge and augmentation. This can help in making policies which would limit groundwater use and avoid its over exploitation. It is not possible to see into the sub-surface, and observe the geological structure and the groundwater flow processes. Groundwater models are used to investigate the important features of groundwater systems, and to predict their behaviour under varied conditions. The development and evaluation of resource management strategies for sustainable water allocation, and for control of land and water resource degradation, are heavily dependent on groundwater model interpretation and predictions. Groundwater modelling involves simulation of aquifer and its response to various input and output systems. Groundwater models have been applied to investigate a wide variety of hydrogeologic conditions. More recently, groundwater models are being applied to predict the fate and transport of contaminants for risk evaluation (Wang and Anderson, 1982). The use of groundwater models to simulate groundwater flow and contaminant transport has greatly increased over the past decade (Thangarajan, 2006). Models are not a substitute for field investigations, but should be used as supplementary tools. Results are dependent on the quality and quantity of the field data available to define input parameters and boundary conditions (Wang and Anderson, 1982). The present study will provide the flow pattern of groundwater and surface water, response of the aquifer to the stresses due to abstractions and spatial variations, and at the end to be used for the better groundwater management for sustainable development of the study area by developing a Steady-state Groundwater flow model for Pakhal lake catchment area using Visual Modflow Premium 4.2 software.

1.2 DATA NEEDED

In order to conduct groundwater modeling studies, hydrogeological and aquifer data are required in addition to certain hydrometeorological/hydrological data as evident from the groundwater balance components as well as draft. Thus in general, data needed for groundwater modeling studies can be grouped into three categories: a) Physical framework, b) Hydrogeologic framework and c) Hydrometerological/Hydrological framework.

1.3 STUDY AREA

The Pakhal lake lying in $17^0$57'10''N and 80^0 E with sill level of 243.80 m is situated on Pakhal stream near Ashok Nagar village in Narasampet Taluk at a distance of 50kms from Warangal. The Pakhal lake watershed is underlain by shales of pre-cambrian age covering about 264.7 sq.km is situated in Warangal district, Telangana state which falls under semi-arid tropics. Rainfall mostly occurs during South-West monsoon from June-September and the mean annual rainfall is 1000 mm. The annual rainfall of catchment area is 1000 mm. The lake is not known to have dried up in the past since its capacity was kept 2 times the yield. Some outflow leaves the watershed across 1.505 km section of the dabeerpet tank in the west. Red loamy clays occur in the watershed with thickness ranging from 0.3 to 1.0 m. Paddy is the only irrigated wet crop grown in the ayacut of tanks. Maize, chillies and turmeric are the major rainfed crops grown during monsoon season. Second crop is mostly grown in the ayacut of tanks and is also supplemented with groundwater pumping. Groundwater occurs under water table conditions in the weathered and fractured parts of the hard rocks. Groundwater levels in bore wells generally start rising during last week of june till first week of October. There are five observation wells monitored regularly since 2005. The depth to water level during post monsoon (October) varies between 0.8-14.0 m (bgl) whereas it stands at 3.0-20.0 m(bgl) during pre-monsoon. Recharge to the groundwater regime mainly takes place from monsoon rainfall. Fig 1 shows Pakhal lake catchment area delineated using Arc GIS.

1.4 METHODOLOGY

As per the recommendations of the Ground Water Estimation Committee, the recharge due to rainfall was computed using both the methods viz., rainfall infiltration factor method and water level fluctuation method and depending on the percent variation, the recharge due to rainfall was used for computation. In present work, norms recommended by GEC 1997 were used. If the percent difference is within ±20%, the rainfall recharge was computed using water level fluctuation method. If the percent difference is either 80% or 120%, the recharge was computed using rainfall infiltration factor method. This situation is common in command areas where water levels are shallow and the aquifer is already saturated and hence the aquifer cannot accept the recharge and will go as rejected recharge. But the rainfall infiltration factor will not take into account this phenomenon of rejected recharge.

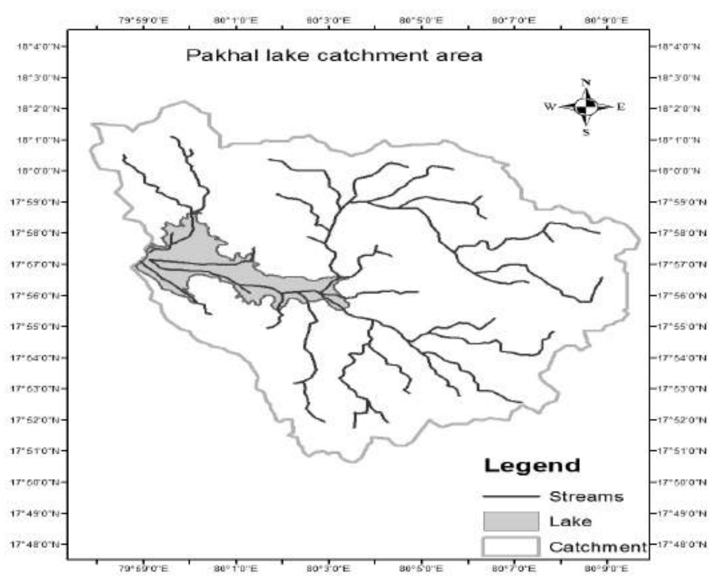

Figure 1 Pakhal lake catchment area using Arc GIS (DEM)

Firstly, delineate watershed (using DEM) using Arc GIS software, such that Pakhal lake as outlet point. Identify the surface water flow direction from flow accumulation map of watershed.

Groundwater Flow Modelling

The governing equation for groundwater flow is:

$$K_{xx}\frac{\partial^2 h}{\partial x^2}+K_{yy}\frac{\partial^2 h}{\partial y^2}+K_{zz}\frac{\partial^2 h}{\partial z^2}\pm W=\frac{S}{T}\frac{\partial h}{\partial t}$$

Where,

W = source/sink term, -ve is used for a source , +ve is used for a sink

T is Transmissibility, S is Storativity

The 3-D Modular Finite Difference Groundwater Flow Package visual MODFLOW (McDonald and Harbaugh, 1988) was selected for the simulation.

1.5 RESULTS AND DISCUSSIONS

1.5.1 Conceptual Model

A numerical groundwater flow model is the mathematical representation of an aquifer in a computer using the basic laws of physics that govern groundwater flow; we instruct the computer to consider physical boundaries of the aquifer, recharge, pumping, and interaction with rivers, or other phenomenon to model behavior of the aquifer overtime. These models will then be used to make predictions of how water levels might change in the future in response to changes in pumping and climate. The conceptual model represents the best idea of how the real system works. Developing a good conceptual model requires compiling detailed information on geology, water quality, recharge, interaction with water bodies including rivers , water levels, hydraulic parameters, and groundwater pumping. The model architecture refers to which computer program to use and the dimensions of the layers and cells that make up a model. Calibrating and verifying involve showing that the model can reproduce water levels measured in the past. A good calibration and verification gives confidence that the model produces reasonable predictions of water levels in the future. The dimensionality of the model should be selected during the formulation of the conceptual model. For one and two dimensional models, the grid should be aligned with the flow system so that there is no unaccounted flux into or out of the line or plane of the grid.

The grid cells were uniformly fixed at 500 m × 500 m. The ground surface elevations were taken from Digital Elevation Model (DEM) data.

1.5.2 Recharge inputs

Across pakhal lake catchment, recharge rates are spatially variable and affected by rainfall patterns, local scale topography, and soil thickness. Demand for water differs across the catchment depending on crop type and other factors; and water supply may be either from rainfall, ponds, canals or groundwater. Modelling using spatially varied recharge, based on the limited rainfall distribution IMD data (Indian Meteorological Department), was attempted but not found to improve the model results. Therefore, spatially uniform and temporally variable average recharge (and discharge) was applied across the basin. Most of the rainfall occurs during the monsoon months only (June to September). Therefore, all rainfall (and thus recharge) was modelled to occur in the monsoon (Khariff) season, and all pumping during the non-monsoon (Rabi) season (October to May).

The following relationships were derived, based on the rainfall-weighted annual recharge and pumping budgets versus annual rainfall data (Pavelic et al., 2012).

Recharge [mm] = 0.1133×rainfall [mm]−5E-13

Pumping (modelled as negative recharge) [mm] = −0.0737×rainfall [mm] +130

This method derives an average groundwater recharge coefficient of approximately 11% of rainfall. This coefficient is in agreement with other reported values for Shales such as in the Groundwater Resource Estimation Committee methodology (commonly known as GEC-1997) (Chaterjee and Purohit, 2009) and within the 3% and 13% range reported by Limaye (2010).

1.5.3 Steady State Calibration

The upper 30m the aquifer is the most transmissive layer. The vertical joints act as conduits to recharge the deeper aquifers. Higher specific yields arise in weathered and dissected sheet joint units, whereas the massive basalt unit has a lower specific yield (Saha and Agrawal, 2006). Initially the model was set-up as a single layer aquifer with a 20m thickness, but at several locations in upstream and downstream areas cells dried out during the simulation. Hence the model thickness was increased to 30m, which offers the best compromise between reality and the effective functioning of the model. Depth variations in specific yield within the upper 30m portion modelled were not applied as the model was intended to represent larger regional scale processes rather than local level variability. It was considered that the groundwater resource availability in the upper layer far exceeds that below, and is the most significant groundwater resource utilised in this region. The hydrogeologic properties of the bottom portion below 30m are more heterogeneous in nature, with much less data available, and were not included in the model. Therefore, the model aims to simulate groundwater flow for the upper active weathered zone associated with sheet joints, with a uniform thickness of 30m and uniform Sy within the range specified over the entire modeled domain.

1.5.4 Model and boundary conditions

Hydrogeological input parameters were selected from the ranges stated above for calibration purposes. The low hydraulic conductivities in this region, range from 0.01 to 1.5 m/d (Limaye, 2010). The vertical hydraulic conductivity (Kz) was set at 10% of the horizontal hydraulic conductivity (Kxy) to reflect the layered composition of the shale flows. The values selected to calibrate the model were taken from the range 0.05 to 1.2 m/d. Modelled volumes of groundwater pumping was simulated as negative recharge in the model. Fig 2 shows boundary conditions of the study area.

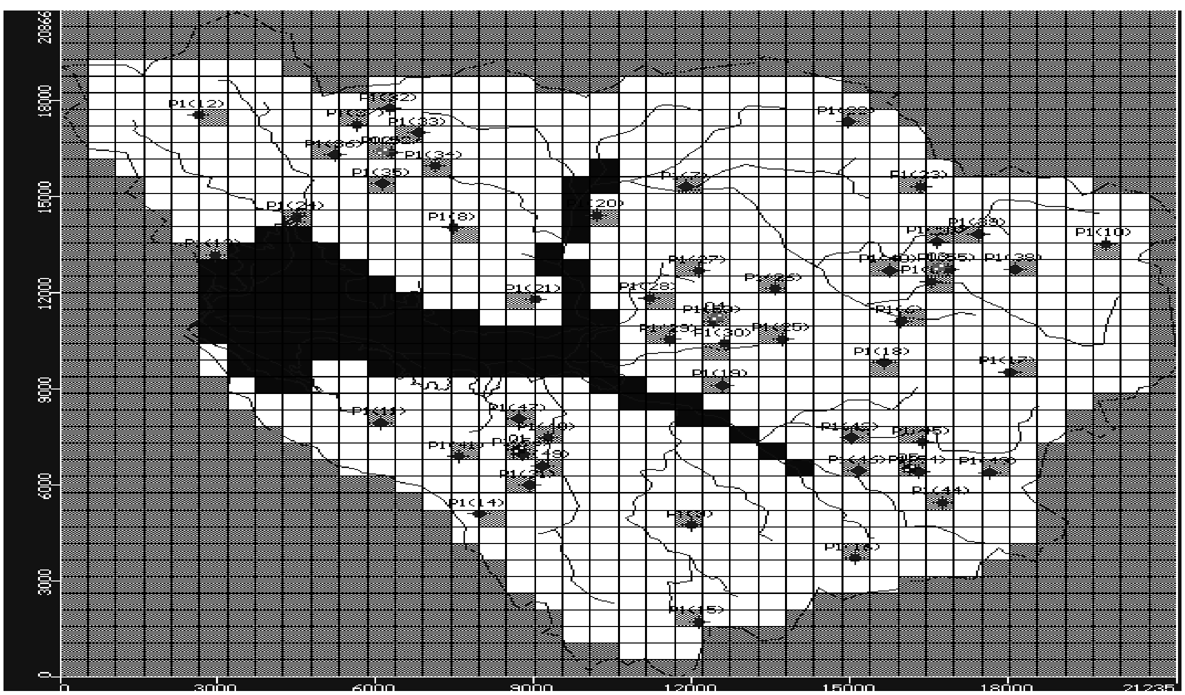

Figure 2 Groundwater flow model showing main streams passing over

1.5.5 Model calibration

The model was calibrated using data from 5 observation wells using the root mean square (RMS) and normalized root mean square (NRMS) error as the goodness of- fit measure. The model calibration was achieved through trial and error method by adjusting two key parameters viz., specific yield and hydraulic conductivity. It was found that the model was more sensitive to hydraulic conductivity. The hydraulic conductivity (Kxy) and specific yield (Sy) were evaluated for the calibration period of 10years with different Kxy inputs, ranging from 0.05 m/day to 1.2 m/day and specific yield inputs from 0.01 to 0.03. The vertical cross-section of potential aquifer is shown in fig. 3 below.

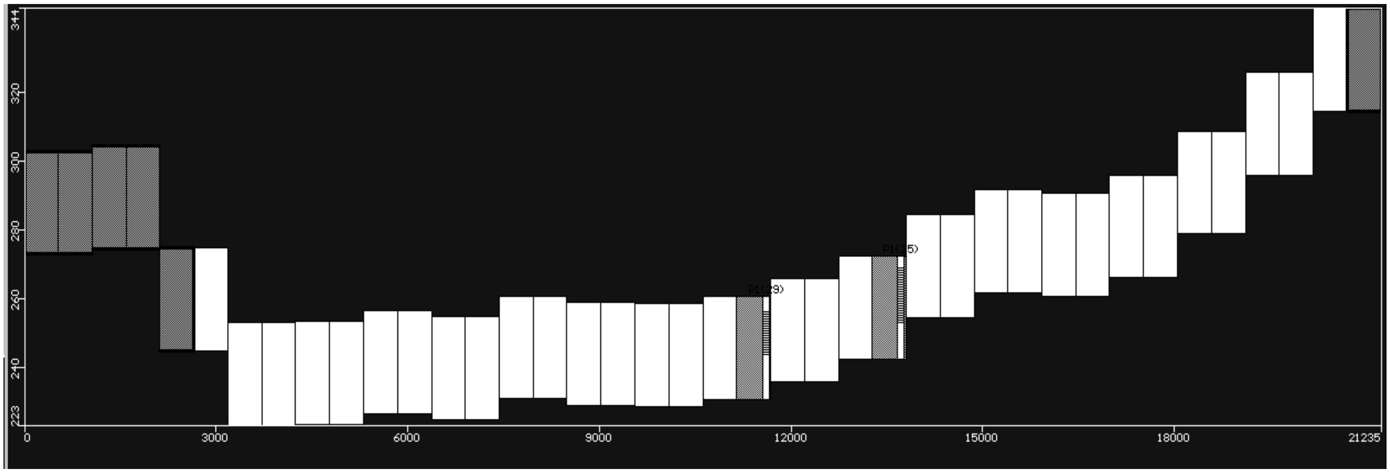

Figure 3 Vertical Cross-section of aquifer (row 20)

Initially the model was run under steady-state conditions and simulated heads were assessed against observed heads.The observed versus computed heads are shown in fig 4.

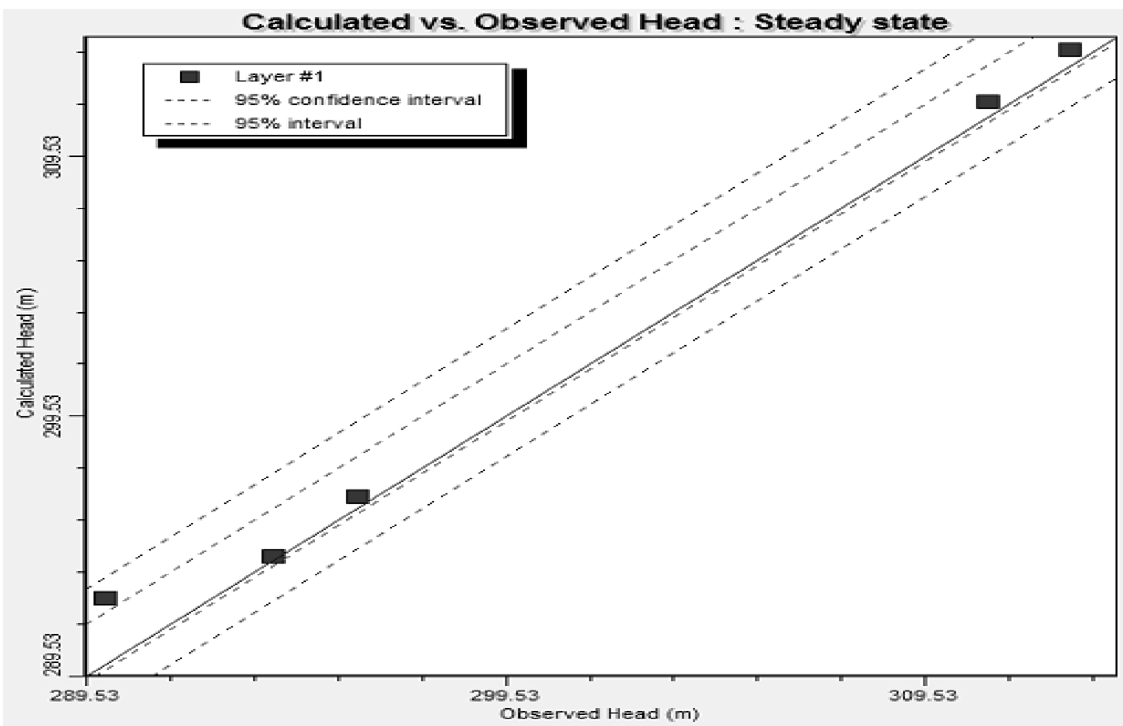

Figure 4 Observed versus computed heads in flow model during the Calibration

The computed groundwater levels of the steady state calibrated model are found matching with the observed water levels within 1.0 m. It was noticed during the processes of model calibration that variation of permeability produced negligible changes in the computed water levels and mainly the input and output stresses determined groundwater level configuration. The groundwater balance of pakhal watershed for steady state condition is summarized in Fig 5. An average annual input of 21.845 Mcm consisits of recharge due to rainfall, seepage from surface water bodies and irrigation return flow from paddy fields under tank ayacut areas. The output stresses include groundwater pumpage from bore wells to the tune of 0.989 Mcm, a base flow towards streams/rivers of 20.848 Mcm.

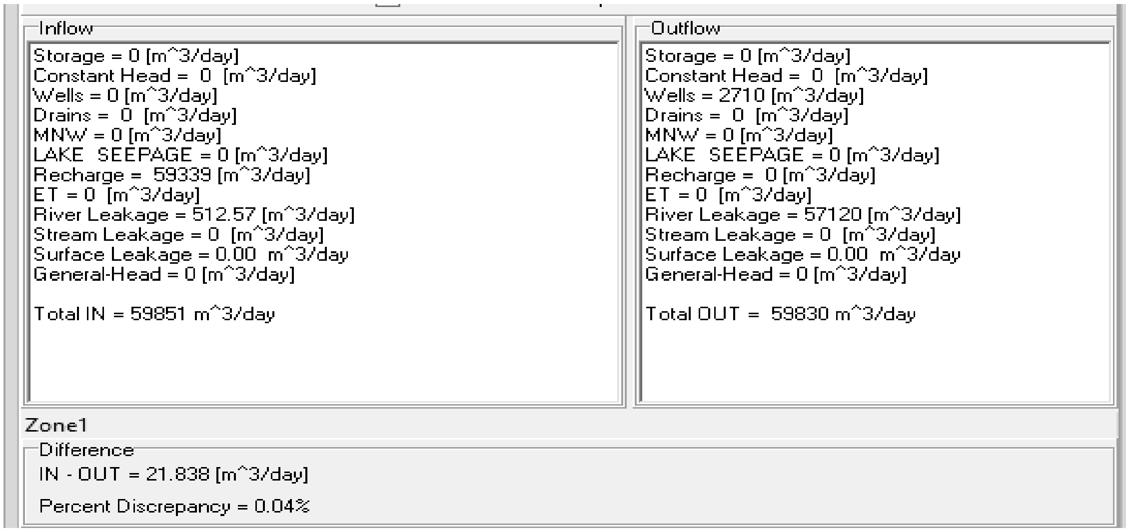

Figure 5 Zone -Budget calculation of Pakhal watershed

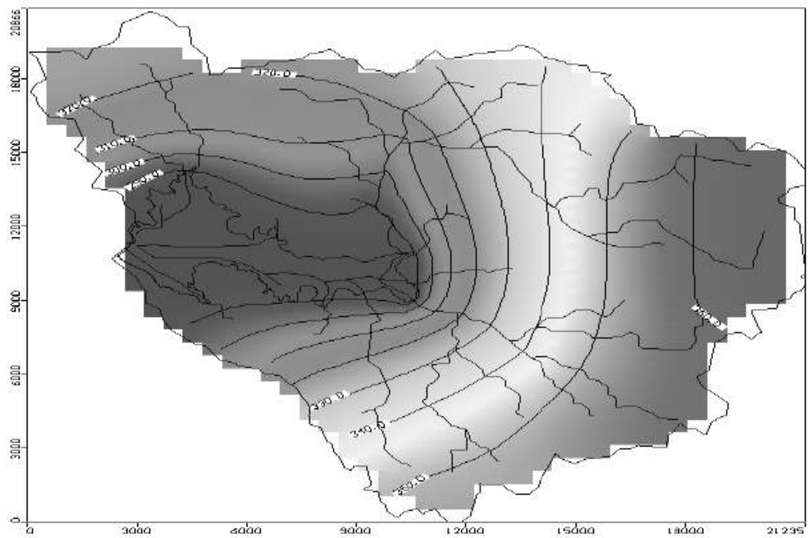

Figure 6 Elevation map showing Surface water flow

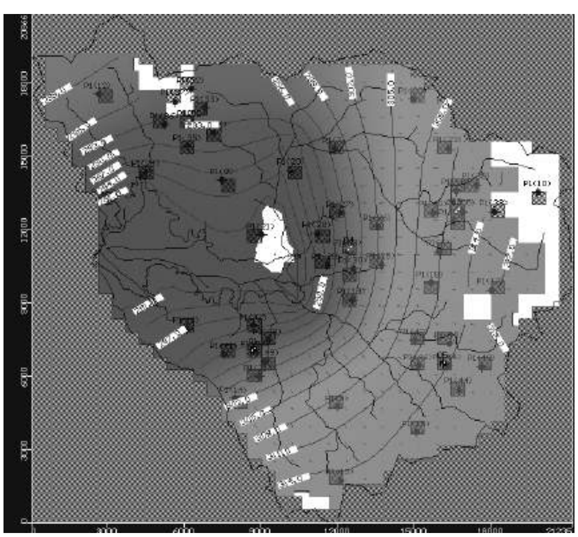

Figure 7. Water level Contour map of Pakhal watershed

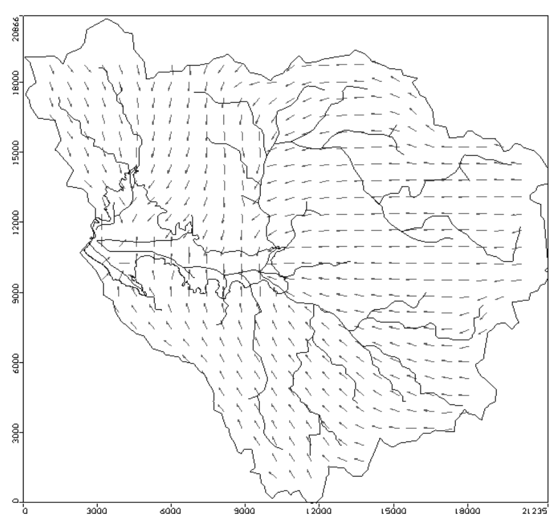

Figure 8. Groundwater flow direction in the study area

1.6 CONCLUSION

The Pakhal lake catchment is sensitively balanced with finite groundwater resources, and are at risk of being overexploited in the coming decades. Therefore, a three-dimensional groundwater flow model for Pakhal lake catchment with a single layer is developed under steady state conditions using visual MODFLOW software by assigning the necessary input and output parameters to the model.

The following conclusions are drawn from our study as

(i) Groundwater in the flow model flows towards the West of the study area as there is a steep slope towards the lake

(ii) In the year 2014, it was calibrated that average velocity of groundwater is about 0.39 m/day which depends on lithology of study area and aquifer parameters.

(iii) As the catchment area irrigation depends mostly on pumping of bore wells, groundwater draft is to be reduced gradually inorder to conserve the groundwater resource.

(iv) Groundwater velocity is more sensitive to recharge and hydraulic conductivity.

The information gathered will help for the future planning and protection of groundwater resources in this semi-arid micro-watershed.

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Assessment of Groundwater and Surface Water Resources in the Godavari Basin

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ABSTRACT

Godavari river is the third largest river in India. The basin falls in six different States viz., Maharasthra, Madhya Pradesh, Orissa, Chhattisgarh, Telangana and Andhra Pradesh. Majority of the population in the State depend on agriculture. The water flows are shared among these states in the Godavari basin. In recent years, due to dwindling nature of rainfall and surface water flows, farmers are forced depend on groundwater for theie agricultural needs. The over exploitation of groundwater leads to depletion of shallow aquifer and it is big threat to food security. For the sustainable management of water resources and sustainable agriculture development, the available water resources and its variation over time need to be well understood. In the present study area, two decadal (1998-2012) groundwater levels and surface water flows are extensively analyzed. The entire Godavari basin is divided into eight sub-basins namely Indravathi, Wainganga, Warda, Pranahita, Manjeera, Middle Godavari, Upper Godavari and Lower Godavari. The analysis of surface water flows over the two decades revealed that no major change in surface water flows of the upstream river basins. But there is drastic decrease in surface water flow in the downstream river areas of Godavari. The average water yields for whole Godavari basin is 332054 MCM and it ranges from 25980 MCM in Upper Godavari basin and 61093 MCM in the Wainganga basin. In the basin water groundwater level rise is controlled by morphological features. The study can help the policy makers to suggest optimal water utilization and to plan optimal cropping pattern based on water availability in the basin.

Keywords: Godavari basin, groundwater recharge, surface water flows, Manjeera river, Weinganga river and irrigation.

1. INTRODUCTION

The Godavari basin extends over states of Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh and Odisha in addition to smaller parts in Madhya Pradesh, Karnataka and Union territory of Puducherry having a total area of 3,12,812 Sq.km with a maximum length and width of about 1425 km and 583 km. It lies between 73°24’ to 83°4’ E longitudes and 16°19’ to 22°34’ N latitudes and accounts for nearly 9.5% of the total geographical area of the country (Fig. 1). The salient features of the basin are presented in the Table 1. The basin is bounded by Satmala hills, the Ajanta range and the Mahadeo hills on the north, by the Eastern Ghats on the south and the east and by the Western Ghats on the west. The Godavari River rises from Trimbakeshwar in the Nashik district of Maharashtra about 80 km from the Arabian Sea at an elevation of 1,067 m. The total length of Godavari from its origin to outfall into the Bay of Bengal is 1,465 km. About 64 km. from the origin, the Godavari is joined by Dharna, on its right bank and a short distance downstream the Kadana joins it from the left. The combined waters of the Pravara and Mula which rise in the hills of Akola join the river from left about 217 km. from the origin. About 338 km. from the origin, the river receives the combined waters from the Purna and Dudhna rivers and after a further 138 km. at the border of Maharashtra and Andhra Pradesh, the waters of the Manjira river joins it from the South. At this point, Godavari flows at an elevation of about 329 m. The river Pranhita, conveying the combined waters of Penganga, the Wardha and Wainganga, which drain Nagpur and southern slopes of the Satpura ranges, falls into Godavari about 306 km. below its confluence with the Manjira. The waters of the Indravathi join the river Godavari 48 Km downstream. The last major tributary is the Sabari, which joins the Godavari, 100 km. up-stream of Rajahmundry. The largest tributary of the Godavari is the Pranhita with about 34.87% coverage of drainage area. The Pravara, Manjira and Maner are right bank tributaries covering about 16.14%, the Purna, Pranhita, Indravathi and Sabari are important left bank tributaries, covering nearly 59.7% of the total catchment area of the basin. The Godavari in the upper, middle, and lower reaches make up for the balance 24.16%. The major part of basin is covered with agricultural land accounting to 59.57% of the total area and 3.6% of the basin is covered by water bodies. The basin spreads over 51 parliamentary constituencies (2009) comprising 21 of Maharashtra, 18 of Andhra Pradesh, 4 of Madhya Pradesh, 3 each of Chhattisgarh and Odisha and 1 each of Karnataka and Puducherry.

Figure.1. Location of the Godavari river basin

2. DESCRIPTION OF GODAVARI BASIN

The Godavari basin is bounded on the north by the Satmala hills, on the south by the Ajanta range and the Mahadeo hills, on the east by the Eastern Ghats and on the west by the Western Ghats. Except for the hills forming the watershed around the basin, the entire drainage basin of the river comprises rolling and undulating country – a series of ridges and valleys interspersed with low hill ranges. The upper reaches of the Godavari drainage basin are occupied by the Deccan Traps containing minerals, hypersthene, augite, diopside, enstatite, magnetite, epidote, biotite, zircon, rutile, apatite and chlorite. The middle part of the basin is principally Archean granites and Dharwars composed of phyllites, quartzites, amphiboles and granites. The downstream part of the middle basin is occupied mainly by the Cuddapah and Vindhyan metasediments and rocks of the Gondwana group. The Cuddapahs and Vindhyan are quartzites, sandstones, shales, lime stones and conglomerates. The Gondwanas are principally detritals with some thick coal seams. The Eastern Ghats dominate the lower part of the drainage basin and are formed mainly from the Khondalites which include quartz- feldspar- garnet- silllimanite gneisses, quartzite, calc-granulites and charnockites (GIS, 2006). In the coastal region the tertiary Rajahmundry sandstones crop out (Surinaidu et al. 2013). The present study is aimed to understanding of groundwater recharge process and water resource dynamics and to understand the morphological control on groundwater recharge in the whole Godavari basin that could help to better management of water resources for sustainable agriculture development.

3. METHODOLOGY

3.1 Morphometric analysis

The quantitative evaluation of drainage network characteristics of a basin using morphometric analysis can give information about hydrological nature of the rocks exposed within the drainage basin. The morphometric analysis was carried out to measure linear aspects and areal aspects that include ordering of the various streams, measurement of the catchment area and perimeter, length of the drainage channels, drainage density and frequency, bifurcation ratio, texture ratio, circularity ratio and constant channel maintenance, which helps to understand the nature of drainage basins. The different streams in the Godavari River and its sub-basins haves been derived using SRTM 90m resolution digital elevation model data. The entire sub-basin has been divided into 8 sub-basins and all morphometric parameters are measured for all 8 eight sub-basins using ArcGIS.

3.2 Groundwater and surface water trends

Groundwater data for the last two decades are downloaded from http://www.india-wris.nrsc.gov.in/. The surface water discharge data has been downloaded from Central Water Commission (CWC) web site http://www.cwc.nic.in/. The spatial and temporal groundwater trends have been analyzed with ArcGIS. Groundwater recharge at sub-basin scale in the Godavari river basin has been estimated by following Groundwater Resource Estimation committee (GEC) recommendations (GEC 2009).

4. RESULTS AND DISCUSSION

4.1.1 Drainage analyses

Quantitative analyses of the morphometric parameters have been carried out for the Godavari delta region. The derived sub-basins and drainage in the Ganga was shown in figure 2. The quantitative analyses of the morphometric characteristics of the basin include stream order, stream length, bifurcation ratio, drainage density, drainage frequency, stream frequency, relief ratio, elongation ratio and circularity ratio.

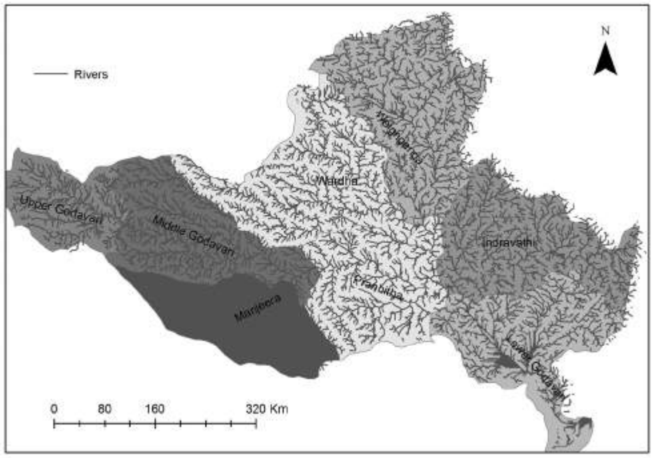

Figure. 2 Derived sub-basins and drainage in the Godavari basin

4.1.2 Relief Ratio/Relative relief (Rh)

The relief ratio, (Rh) is ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as relief ratio (Schumm, 1956).

Relief Ratio $R_h = H / L_b$

Where, Rh = Relief Ratio,

H = Total relief (Relative relief) of the basin in Kilometers

L_b = Basin length

The R_h normally increases with decreasing drainage area and size of sub-watersheds of a given drainage basin (Gottschalk, 1964). In Godavari delta the R_h value is range between 0.7 to 1.6km. The low values of R_h indicate very low slope and low relief, therefore the table indicated that low slopes are prevailing in lower Godavari and higher slope are prevailing in Pranahitha subbasin.

4.1.3 Drainage Density (D_d)

The measurement of D_d is a useful numerical measure of landscape dissection and runoff potential (Chorley, 1969). On the one hand, the D_d is a result of interacting factors controlling the surface runoff; on the other hand, it is itself influencing the output of water and sediment from the drainage basin (Ozdemir and Bird, 2009). D_d is known to vary with climate and vegetation (Moglen et al.1998), soil and rock properties (Kelson and Wells, 1989), relief (Oguchi, 1997) and landscape evolution processes. Horton (1932) has introduced drainage density (D_d) into American hydrologic literature as an expression to indicate the closeness of spacing of streams. It is defined as the total length of streams of all orders per drainage area.

Drainage Density $D_d = L_u / A$

Where, D_d = Drainage Density,

L_u = Total stream length of all orders

A = Area of the Basin (Sq.Km.)

The drainage density indicates the closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurements made over a wide range of geologic and climatic types that a low drainage density is more likely to occur in regions of highly resistant of highly permeable subsoil material under dense vegetative cover, and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler, 1964). The drainage density values of Godavari basin is range from 60.3 in Majeera to 80.1 km/km^2 in Middle Godavari. The low drainage density indicates the region has dense vegetative cover and medium textured drainage with to coarse grained soils indicates the existence of good groundwater resources.

4.1.4 Form Factor (R_f)

According to Horton (1932), form factor (R_f) is defined, as the ratio of basin area to square of the basin length.

$$\text{Form Factor } (R_f) = A / L_b^2$$

Where, R_f = Form factor,

A = Area of the basin (Km^2.)

L_b^2 = Square of Basin length

R_f value of 0 indicates a highly elongated shape and the value of 1.0, a circular shape with high peak flows for short duration but for elongated basin with low R_f with a flatter peak flows for longer duration. In the study area, the R_f range between 0.8 to 0.2. This indicates that high peak flows for short duration.

4.1.5 Circularity Ratio (R_c)

It is the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin (Miller, 1953)

$$\text{Circularity Ratio } (R_c) = 4 * Pi * A / P^2$$

Where, R_c = Circularity Ratio,

Pi = ‘Pi’ value i.e., 3.14

A = Area of the Basin (Sq.Km.),

P^2 = Square of the Perimeter (Km)

In the study area, the R_c values range between 0.3 to 0.6. The low value of circularity ratio indicated reflects the low slope, relief and structural in the sub-basins.

4.1.6 Length of Overland Flows (L_g)

The length of overland flow (L_g) approximately equals to half of the reciprocal of drainage density (Horton, 1945).

$$\text{Length of overland flow } L_g = 1 / D * 2$$

Where, L_g = Length of Overland flow,

D = Drainage Density

The computed value of L_g for the sub-basin is range from 0.025 to 0.031

4.1. 7 Constant of Stream Maintenance (C)

Schumm (1956) used the inverse of drainage density as a property termed constant of stream maintenance C. Thus Constant of stream maintenance (C) = 1/ D. This constant, in units of square metre per metre, has the dimension of length and therefore increases in magnitude as the scale of the land-form units increases. Specifically, the constant C tells the number of square metres of watershed surface required to sustain one linear foot of stream. In the present study the value range between 0.013 to 0.017

4.2 Surface water dynamics over 20 years (1990-2010)

The water yield also estimated for each sub-basin with the help of area and annual average rainfall. The total water yield in the basin is 332054 MCM. High water yield 61093 MCM is observed in the Wainganga sub-basin and low water yield 25980 MCM is observed in the Upper Godavari basin. In Godavari basin to understand the water resources dynamics, surface water discharge data at 56 gauging locations for two decades has been collected from Central Water Commission (CWC) for the period between 1990 to 2010. The data has been analyzed at sub-basin scale in the Godavari. The analysis indicated that the discharge rage from 35000 MCM to <5000 MCM in Indravathi basin from 1990 to 2010 and observed that decrease in 667 MCM/yr of flow over two decades. The surface water flows in the lower Godavari basin range from 70000 to <10000MCM and observed that 1977 MCM/yr decrease in flows. In the Manjira the flows varies from 900 to <10 MCM and observed that 29 MCM/yr flow decrement. However, in the Pranhitha the flows range from 25000 and decreased to 10 MCM. It is observed that about 748 MCM/yr is the surface water flow decrement. Whereas in the Wainganga, there is 144 MCM/yr flow decrease of flow from 1990 to 2010. There is no major change of observed flow in Upper sub-basins over the period in the Godavari basin. On the other hand, in the downstream river basins drastic decrease in water flows is observed. The extensive water resource development supported by intensive irrigation development tends to decrease in water flows. In addition dwindling nature of rainfall also causing decrease flow that may rise water and food security problems.

4.3 Groundwater analysis and recharge process in the Godavari basin

The average groundwater depth in the per-monsoon is 1.6 m bellow groundwater level (bgl) to > 35m bgl. In the post monsoon it range from 0.7 to 25 m bgl. indicate that, water levels range from 1-3 m in the most downstream part of the basin and >30 m in the Manjeera and Pranahita sub-basins upstream parts. The deep groundwater levels may attributed to topography, less recharge and more groundwater withdrawals in the area. In other part mostly the water levels range from 8-12 m the basin. indicated that water level range from 0.7 to 26m bgl. The post-monsoon water levels are relatively shallow than pre-monsoon, however the depth range almost follows the pre-monsoon trends. The shallow groundwater levels prevailing in the most downstream of the basin that Godavari delta near the Bay of Bengal. In the upstream part of the Manjira and Pranahita, the water levels are range between 11 – 22 m bgl. In the majority part of basin the post monsoon water levels are varying from 4-6 m bgl. The groundwater recharge is range between 0.2 to 15 in m the Godavari basin. In Manjira, Pranahita, lower Godavari, Wainganga and Indravathi the groundwater recharge range from 2.5 to 3.5 m. This is due to low storage capacity and less specific yield in these areas. The estimated temporal groundwater recharge for whole basin is range from 81351 to 74699 MCM from 1998 to 2012. Due to ever increasing groundwater boom for different purposes, the optimal cropping pattern based on annual groundwater recharge/renewable resources should be planned. The optimal groundwater withdrawals have to be defined for sustainable groundwater resources.

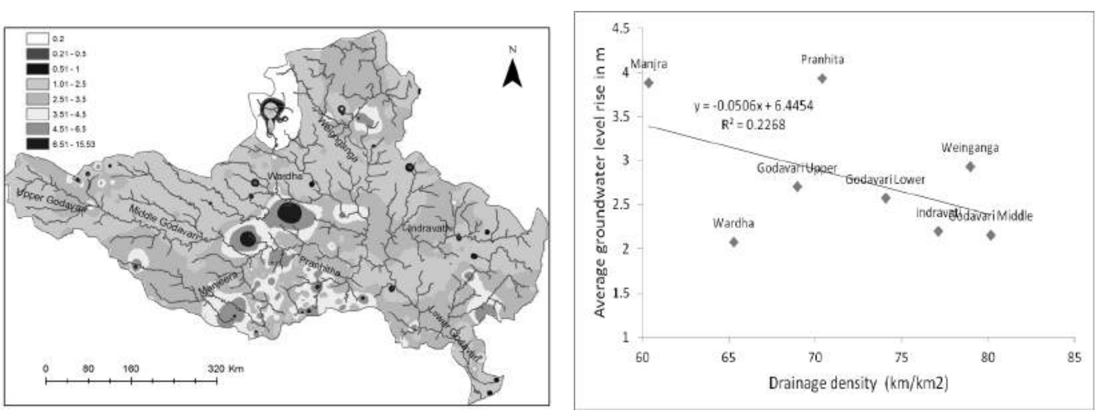

Figure. 3 Spatial distributed observed average (1998-2012) groundwater recharge (m) in the left and Relation between drainage densities to groundwater level rise in the right side

The specific yield is varying from 1to 7.5% in the Godavari. The average post-monsoon water level (1998 to 2012) is very shallow 4.62 m bgl in the Indravathi basin and it is maximum 12.86 m in the Manjira river basin. The pre-monsoon water levels are very deep in Manjira river basin (>16.74 m bgl) and relatively shallow in the Indravathi basin (6.82 m). In the upper Godavari basin the pre and post monsoon water levels are 10.34 and 7.61 m. In general more drain density can lead to more surface runoff and less recharge. In the present study the relation between water level rise to drainage is extensively analysed. The analysis results indicated negative relation to drainage density to water levels that indicated more recharge entering into the groundwater system in less drainage dense area, however less recharge is happening in more drainage dense areas (Fig. 3).

5. CONCLUSIONS

The Godavari basin is the third largest river basin in India and called as South Indian Ganga. The Godavari basin flows over six States of Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh and Orisha in addition to smaller parts in Madhya Pradesh and Karnataka of Puducherry having a total area of 3.12 lakhs Sq.km with a maximum length and width of about 995 km and 583 km. The gross water maximum water availability is 178 MCM and minimum water availability is 72 MCM. The average surface water flows range between 70000 to 10000 MCM in lower Godavari basin and in the Upper Godavari basin 1000 to 2500 MCM. Over the two decades from 1990 to 2010 there is no change in surface water availability in the upstream river basins and drastic decrease in surface water flows/availability is observed in the downstream river basins in the Godavari river basin.

Groundwater recharges in the Godavari basin is geologic is controlled and it is also depends on the drainage pattern and its density. The drainage density plays significant role on groundwater. The shallow groundwater level is observed in Indravathi and deep water levels in Manjira river basin. The highest groundwater recharge is observed in lower Godavari basin and low groundwater recharge is observed in Upper Godavari basin.

The optimal water utilization that includes both surface water and groundwater has to be defined for sustainable agriculture development and water security. The upstream water resource development has to be considered the downstream impacts and should be compensated. The over exploitation of groundwater resources in the costal aquifer may have adverse affects that can cause sea water intrusion. Therefore, special care has to be taken in defining optimal groundwater pumping in these areas. Numerical model can be used for water accounting and also for better management of water resources in the Godavari basin.

ACKNOWLEDGEMENTS

This paper is the part of my M.Tech thesis work. I would like to thank Dr. L. Surinaidu, Special Project Scientist, International Water Management Institute (IWMI) Scientist and Dr. M.V.S.S Giridhar, Assistant Professor,Head of the Departement(Centre for water Resources).Institute of Science and Technology, JNTUH, Hyderabad for their unprecedented encouragement and guidance in support of my M.Tech dissertation work

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A Comparison of Aquatic Plants Composition in Poondi and Velliamkundram Ponds of Madurai District, South Tamilnadu, India

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ABSTRACT

An extensive aquatic floristic investigation was conducted in two freshwater Ponds viz., Poondi and Velliamkundram Ponds during the year 2014 (January) – 2015 (April). These two ponds are located near to each other, measuring within a range of 2km distance away from each other and are located in Poondi and Velliamkundram Villages of Madurai District, Tamil Nadu, India. In the present study, 99 Plant species of 90 genera belong to 43 families were enumerated in Poondi Pond and 124 species of 101 genera belong to 46 families were occurred in Velliamkundram Pond. The present study reveals aquatic vegetation of all the growth forms occurred during water availability in the experimental ponds and while drying, the shift of the vegetation occurred. Continuous monitoring and conservation is important to safeguard the biological wealth of the study area.

Keywords: Poondi – Ephemeral Ponds – Velliamkundram – Aquatic Plants.

INTRODUCTION

Wetlands are the most productive ecosystem in the world. Ponds are one among the lentic freshwater bodies, they are small generally shallow water bodies, either form naturally or manmade which permanent or temporary hold water. The temporary ponds or ephemeral ponds are seasonal wetlands annually subjected to extreme and unstable ecological conditions, neither truly aquatic nor truly terrestrial. The ponds differ functionally from lakes, since their littoral structure and its productivity dominate the ecosystem (Wetzel et al., 2001). These ponds are serves as refuges for a wide variety of freshwater biota and are, as such, an irreplaceable type of habitat (Williams et al., 2008). Human population utilizes the pond and their resources for most of their needs from a time immemorial and hence pond becomes the life line of several organisms, including human beings.

Worldwide there are more than 100 families of aquatic plants. The aquatic plants are of various types, some emergent and rooted on the bottom and others submerged. Still others are free-floating, and some are rooted on the bank of the impoundments, adopting semi-aquatic habitat (Ahmad and Younis, 1979). The wetland plants contribute to maintaining key functions and related biodiversity in freshwater ecosystems. The temporary ponds are dominated mainly by annual and herbaceous perennials that appear during the availability of water and when pond is at varying degrees of desiccation. This phenomenon makes a remarkable shift in the vegetation and their different nature of abundance. Annual hygrophytes, hemi cryptophytes and geophytes vegetation is diverse and rich (Barbour *et al*., 2003; Deil, 2005). This habitat and its flora have been poorly studied and documented because of the ephemeral character of the flora, the changeable annual weather that has a great effect on the small, herbaceous taxa and the declining abundance of temporary ponds (Pinto – Cruz et al., 2009). For many years, conservation of aquatic ecosystems has been mainly directed to permanent waters. Temporary ponds have often been inconspicuous and poorly known due to their temporary nature and have been frequently destroyed by human action (Williams *et al.*, 2001; Zacharias *et al.*, 2007). In particular, conservation of temporary ponds is essential for species that may not survive in more permanent aquatic habitats, such as some species of macrophytes, Keeping the above mentioned facts in view, The objective of the present study was to undertake the Aquatic and semi aquatic vegetation analysis to find out the similarity and variations among those vegetation community existed between the two experimental ponds.

MATERIALS AND METHODS

Description of the experimental Ponds

The present study was conducted in two freshwater Ponds viz., Poondi pond (PP) (10º 00' 44.9'' N; 78º 11'14. 6''E) and Velliamkundram Pond (VKP) (10º 01' 19.8''N; 78º 11'32. 1''E). These two ponds are located near to each other, measuring within a range of 2km distance away from each other and are situated in Poondi and Velliamkundram Villages of Madurai District, Tamil Nadu, India. These two temporary ponds get major water resources from Mullai Periyar Channel. Besides this, the pond water is utilized for irrigation and for domestic requirements to the communities live on the banks of the pond.

Plant Diversity Survey

Aquatic and semi aquatic vegetation analysis was carried out during January 2014 to April 2015, by employing collection, identification and verification. Specimens of flowering and non-flowering vascular plants found in the study area were collected and processed in the laboratory. The Plants were identified with their botanical names, using standard keys and flora: Flora of central Tamilnadu by K. M. Mathew (1995), Flora of Tamilnadu vol-2 by Henry *et al.,* (1987), Flora of Eastern Ghats vol 3 and 4 by Pullaiah *et al* (2007; 2011) and Plants of Western Ghats vol 1 and 2 by Ganeshaiah *et al*., (2012). The valid names of the Plants were checked by Catalogue of life, IPNI (International Plant Name Index), GBIF (Global Biodiversity Information Facility), and Biodiversity portal. The voucher specimens are kept in the Department of Botany in Saraswathi Narayanan College, Madurai. Tamil Nadu. India.

RESULTS AND DISCUSSION

In the present study, a total of 99 Plant species of 90 genera belong to 43 families were enumerated in Poondi Pond and 124 species of 101 genera belong to 46 families were occurred in Velliamkundram Pond (Table 1). In comparison with Poondi Pond, Velliamkundram Pond has higher number of vegetation. This phenomenon could be attributed due to structural differences exists in the experimental ponds.

Table 1 A Comparative Checklist of aquatic and semi aquatic Plants of Poondi and Velliamkundram Ponds of Madurai District, Tamil Nadu, India.

S.N	Family	Binomial name of Plants	Study area	
			PP	VKP
1.	Acanthaceae	*Andrographis echioides* (L.)Nees.	*	√
2.	Acanthaceae	*Barleria mysoorensis* B.Heyne ex Roth	*	√
3.	Acanthaceae	*Blepharis maderaspatensis* (L.) Heyne .ex Roth Nov.	√	√
4.	Acanthaceae	*Dipteracanthus prostratus* (Poiret.) Nees.	√	√
5.	Acanthaceae	*Elytraria acaulis* (L.f.)	√	√
6.	Acanthaceae	*Hygrophila schulli* (Hamilt.) M. R. Almeida & S. M. Almeida	√	*
7.	Acanthaceae	*Justicia procumbens* L.	√	√
8.	Acanthaceae	*Lepidagathis cristata* Willd.	*	√
9.	Acanthaceae	*Peristrophe paniculata* (Forsskal) Brummitt	√	√
10.	Aizoaceae	*Mollugo nudicaulis* Lam.	√	√
11.	Aizoaceae	*Trianthema decandra* L.	*	√
12.	Aizoaceae	*Trianthema portulacastrum* L	√	√
13.	Amaranthaceae	*Achyranthes aspera* L.	√	√
14.	Amaranthaceae	*Aerva lanata* (L.)A.L. juss.	√	√
15.	Amaranthaceae	*Aerva javanica* (Burm.f.) Shult.	*	√
16.	Amaranthaceae	*Alternanthera pungens* Kunth.	*	√
17.	Amaranthaceae	*Alternanthera sessilis* (L.) R. Br. ex DC.	√	*
18.	Amaranthaceae	*Amaranthus spinosus* L.	√	√
19.	Amaranthaceae	*Amaranthus viridis* L.	√	√
20.	Amaranthaceae	*Digera muricata* (L.)C.Martius.	√	√
21.	Amaranthaceae	*Gomphrena celosioides* C. Martium.	√	√
22.	Amaranthaceae	*Gomphrena globosa* L.	√	√

23.	Amaranthaceae	*Pupalia lappacea* (L.) A.L.Juss. *var. velutina* (mog)Hook.f	√	√
24.	Apocynaceae	*Oxystelma esculentum* (L. f.) R. Br.	√	√
25.	Aponogetonaceae	*Aponogeton natans* (L.) Engl. & K. Krause.	√	*
26.	Araceae	*Lemna minor* L.	√	√
27.	Araceae	*Wolffia globosa* (Roxb.) Hartog & Plas.	√	√
28.	Aristolochiaceae	*Aristolochia indica* L.	√	√
29.	Asclepiadaceae	*Calotropis gigantea* R.Br	√	√
30.	Asclepiadaceae	*Calotropis procera* (L.) R.Br	*	√
31.	Asclepiadaceae	*Pergularia daemia* (Forsskal) choir.	√	√
32.	Asteraceae	*Acanthospermum hispidum* DC.	√	√
33.	Asteraceae	*Eclipta prostrata* (L.) L.	√	√
34.	Asteraceae	*Pentanema indicum* (L.) DC.	*	√
35.	Asteraceae	*Sphaeranthus indicus* L.	*	√
36.	Asteraceae	*Tridax progumbens* L.	√	√
37.	Asteraceae	*Parthenium hysterophorus* L.	√	√
38.	Asteraceae	*Xanthium strumarium* L.	√	√
39.	Boraginaceae	*Coldenia procumbens* L.	√	√
40.	Boraginaceae	*Heliotrobium indicum* L.	*	√
41.	Boraginaceae	*Heliotrobium ovalifolium* Forssk	*	√
42.	Brassicaceae	*Brassica juncea* (L.)Cosson.	*	√
43.	Caesalpiniaceae	*Cassia occidentale* L.	√	√
44.	Caesalpiniaceae	*Cassia angustifolia* L.	*	√
45.	Capparidaceae	*Cleome chelidonii* L. f.	*	√
46.	Capparidaceae	*Cleome felina* L.f	*	√
47.	Capparidaceae	*Cleome gynandra* L.	√	√
48.	Capparidaceae	*Cleome viscosa* L.	√	√
49.	Commelinaceae	*Commelina benghalensis* L.	√	√
50.	Commelinaceae	*Cyanotis axillaris* (L.) D. Don ex Sweet.	√	*
51.	Convolvulaceae	*Cuscuta chinensis* Lam.	√	√
52.	Convolvulaceae	*Evolvulus alsinoides* L.	√	√
53.	Convolvulaceae	*Ipomoea pes-tigridis* L.	*	√
54.	Convolvulaceae	*Ipomoea aquatica* Forsskal.	√	√
55.	Convolvulaceae	*Ipomoea carnea* subsp. *fistulosa* (Martius ex Choisy) D.F.Austin.	√	√
56.	Convolvulaceae	*Ipomoea obscura* (L.)Ker Gawler.	*	√
57.	Convolvulaceae	*Merremia emarginata* (N.L. Burm an) Hallier F	√	√
58.	Cucurbitaceae	*Citrulus colocynthes* (L.) Schrader.	*	√
59.	*Cucurbitaceae*	*Citrulus lanatus* (Thunb.) Matsumura.	*	√
60.	Cucurbitaceae	*Coccinia grandis* L.	√	√
61.	Cucurbitaceae	*Mukia maderaspatana* (L.) M. Romer	√	√
62.	Cucurbitaceae	*Solena amplexicaulis* (Lam.) Gandhi.	√	√
63.	Cyperaceae	*Cyperus rotuntus* L.	√	√
64.	Euphorbiaceae	*Acalypha indica* L.	√	√
65.	Euphorbiaceae	*Chrozophora rottleri* (Geisler) Adr.Juss.	*	√
66.	Euphorbiaceae	*Croton bonplandianus* Baillon	√	√
67.	Euphorbiaceae	*Euphorbia hirta* L.	√	√
68.	Euphorbiaceae	*Flueggea leucopyrus* willd	*	√
69.	Euphorbiaceae	*Jatropha gossipifolia* L.	*	*
70.	Euphorbiaceae	*Phyllanthus amarus* Schum & thonn	√	√
71.	Euphorbiaceae	*Phyllanthus madraspatensis* L.	√	√
72.	Euphorbiaceae	*Tragia involucrate* L.	√	√
73.	Euphorbiaceae	*Tragia plukenetii* R.Sm	*	√
74.	Fabaceae	*Abrus precatorius* L.	√	√
75.	Fabaceae	*Aeschynomene aspera* L.	√	√
76.	Fabaceae	*Alysicarpus longifolius* (Spreng) Wight & Arn.	√	√
77.	Fabaceae	*Alysicarpus monilifer* (L.) DC.	√	√

78.	Fabaceae	*Crotalaria verrucosa* L.	*	√
79.	Fabaceae	*Indigofera linnaei* Ali.	√	√
80.	Fabaceae	*Senna occidentalis* (L.) Link.	√	√
81.	Hydrochaitaceae	*Vallisneria spiralis* L.	√	√
82.	Lamiaceae	*Anisomeles malabarica* (L.)r. Br. ex. sims.	√	√
83.	Lamiaceae	*Leucas aspera* (wild)link	√	√
84.	Lamiaceae	*Ocimum basilicum* L.	√	√
85.	Lamiaceae	*Ocimum canum* Sims.	√	√
86.	Liliaceae	*Aloe vera* (L.)Burm f.	*	√
87.	Lythraceae	*Ammania baccifera* L.	√	√
88.	Lythraceae	*Ammannia auriculata* Willd.	*	√
89.	Malvaceae	*Abutilon indicum* L.	√	√
90.	Malvaceae	*Hibiscus micranthus* L.f.	√	√
91.	Malvaceae	*Hibiscus furcatus* Willd.	√	√
92.	Malvaceae	*Malvastrum coramantelicum* (L.) Garke.	√	√
93.	Malvaceae	*Sida cordifolia* L.	√	√
94.	Malvaceae	*Sida acuta* Burm f.	√	√
95.	Marsiliaceae	*Marsilia quadrifoliata* L.	√	√
96.	Molluginaceae	*Glinus lotoides* L.	√	√
97.	Nyctaginaceae	*Boerhavia diffusa* L.	√	√
98.	Nymphaeaceae	*Nymphaea nouchali* var. *pubescens* (Willd.) Hook. f. & Thomson.	√	√
99.	Onagraceae	*Ludwigia perennis* L.	*	√
100.	Papaveraceae	*Argemone Mexicana* L.	√	√
101.	Passifloraceae	*Passiflora foetida* L.	√	√
102.	Pedaliaceae	*Martynia annua* L.	√	√
103.	Pedaliaceae	*Sesamum orientale* L.	√	√
104.	Poaceae	*Arundo donox* L.	√	√
105.	Poaceae	*Chloris barbadata* Sw.	√	√
106.	Poaceae	*Cyanodon dactylon* L.	√	√
107.	Poaceae	*Dactyloctenium aegyptium* (L.) P. Beauv.	√	√
108.	Poaceae	*Echinochloa colona* (L.) Link.	√	√
109.	Poaceae	*Eragrostis unioides* Steudel.	√	√
110.	Poaceae	*Saccarum spontaneum* L.	√	√
111.	Portulacaceae	*Portulaca oleraceae* L.	√	√
112.	Rubiaceae	*Canthium parviflorum* Lam.	*	√
113.	Rubiaceae	*Hedyotis corymbosa* (L.) Lam	√	√
114.	Rubiaceae	*Hedyotis umbellatea* L.	√	√
115.	Salvadoraceae	*Azima tetracantha* Lam.	*	√
116.	Salvinaceae	*Azolla pinnata* L.	√	√
117.	Sapindaceae	*Cardiospermum helicacabum* L.	√	√
118.	Scropulaceae	*Becoba monneieri* (L.)Pennett.	√	√
119.	Solanaceae	*Datura metal* L.	√	√
120.	Solanaceae	*Physalis minima* L.	√	√
121.	Solanaceae	*Solanum torvum* Sw.	*	√
122.	Sterculiaceae	*Melochia corchorifolia* L.	√	√
123.	Tiliaceae	*Triumfetta pilosa* Roth.	√	√
124.	Typhaceae	*Typha domingensis* Pers.	√	*
125.	Ulmaceae	*Holoptelea indegridifolia* (Roxb). planchon.	*	√
126.	Verbenaceae	*Phyla nodiflora* (L.)E.Greene.	√	√
127.	Verbenaceae	*Vitex negundo* L.	*	√
128.	Violaceae	*Hybanthus eneaspermus* (L.) F. muell	√	√
129.	Vitaceae	*Cissus quadrangularis* L.	√	√
130.	Zygophyllaceae	*Tribulus terrestris* L.	√	√

PP – Poondi Pond, VKP - Velliamkundram Pond, √- Present, ∗ - Absent

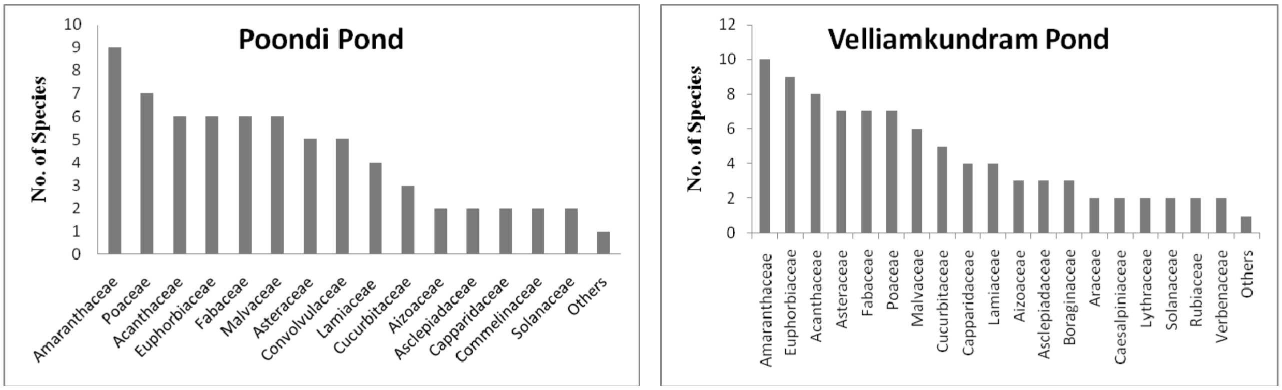

Figure 1 Plants species distribution in Poondi and Velliamkundram Ponds

In the present study, Amaranthaceae, Poaceae, Euphorbiaceae, Acanthaceae, Asteraceae, Malvaceae family plants are dominantly in both study areas (Figure 1). In particularly, *Nymphaea nouchali*, *Alternanthera sessilis*, *Amaranthus viridis*, *Ipomoea carnea*, *Ipomoea aquatic*, *Merremia emarginata*, *Saccarum spontaneum*, *Pergularia daemia*, *Phyla nodiflora*, are more commonly found in the ponds. The Poondi pond are covered by higher number herbaceous and shrubs, there is no tree species in their surface area but the Velliamkundram pond comprises the more number of herbaceous, shrubs and also more number of tree species (*Acacia*, *Prosopis* etc.,).

These plants were highly used by avian population for making their nests. *Ipomoea* species was found that it was used for the birds nest building. The edge plant *Phyllanthus reticulatus* is used for the nesting of water birds. The edge reefs form shelter for the aquatic insects, which in turn forms the prey to the water birds. Similarly, *Phyllanthus reticulatus* – a gregariously foliated shrub facilitates the migratory birds like Common Coot and Little Grebe Invariably to the forms, many of the aquatic vegetation serves as the feed to the water fowls and the present study results are corroborated with (Jha, 2013). Such a diverse plant community is beneficial to migrating and wintering water birds and similar emphasis was made in a previous study (Benedict and Hepp, 2000).

CONCLUSION

The knowledge of plant biodiversity of a pond is the basis for promoting conservation strategies. It provides information on spatial and temporal distribution of plants as well as selection of plants and their habitat which need to be conserved. Inhabitants around the study area are unaware about the importance of flora and fauna. Now, the study area is subjected to various anthropogenic activities (dumping of household garbage, washing, etc.) that may deteriorate the entire ecosystem. Continuous monitoring and conservation is important to safeguard the biological wealth of the study area. The significance of the study lies in the fact that aquatic plants reciprocate eco-biologically with the functional attributes of a water body. The survey of aquatic vascular plants shall provide basic information for further studies and eco-biotechnological applications of economically important aquatic plants.

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Challenges of Parameter Estimation in Groundwater Modeling

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ABSTRACT

Groundwater modeling generally is the method of choice to simulate the response of the groundwater system to planned stimuli. One of the key steps involved in setting up an appropriate groundwater model for flow and transport is the characterization of the system parameters. The model parameters must closely resemble the physical parameters for the model to reasonably mimic the behavior of the physical system. While some of the groundwater flow and transport parameters can be measured in the field or in the laboratory, such measurements are usually very scarce, time consuming, and prone to error. However the most serious discrepancy lies in that fact that the field and laboratory measurements are performed on a scale vastly different from the model scale. Thus, even for models constructed with parameters derived from field or laboratory measurements, the model results seldom match with the physical reality. To overcome this reality, use of inverse modeling or parameter estimation in the modeling field has gained prominence. However, the use of parameter estimation by inverse modeling can lead to serious misrepresentation of the parameters. The present paper discusses different theoretical and practical issues that may lead to erroneous parameter estimation.

INTRODUCTION

The degradation of groundwater resources in India as a result of agricultural, industrial and urban issues requires the evaluation of different strategies to reduce and control the effects of various contaminations. For this, the use of numerical, physical based models for water and contaminant transport are useful tools. The increasing popularity of numerical models is mainly due to two reasons. Firstly there is the avaibility of powerful and cheap computers to run complex physhical based models and secondly is the abilty of these numerical models to evalute the outcomes relative to different combinations of inputs. For example the movement of soil water and solute involves many complex interactions between soil, groundwater, river stage, drainage, soil salinity, contamination, crop type, and meteorological conditions which need to evaluated. The field experiments and data collection are always restricted to a subset of combinations. Since the outcome of these interactions is not linear, it is very difficult to evaluate all the possible outcomes based on a limited number of field experiments and/or measurements. A physically based model that can numerically simulate all the major processes related to the interactions between these factors can offer real benefits in terms of ability to simulate any number of situations very cheaply and quickly. However, it is first necessary to establish that the numerical model for the system is capable of reliably replicating the past system behavior. A numerical model that can not reliably replicate the past behavior of the system is of no use in predicting the future system behavior. A properly calibrated and validated numerical model is a powerful tool that allows one to reliably simulate any number of situations, predict the critical situations and establish monitoring and management plan.

A number of excellent numerical models for soil water movement in saturated and unsaturated zones are available in the public domain. MODFLOW-2005 (Harbaugh, 2005) is one of the more popular software developed by United States Geological Survey (USGS) which simulates steady and non-steady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. The software can incorporate flow from external stresses, such as flow to wells, areal recharge, evapo-transpiration, flow to drains, and flow through river beds. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic (restricted to having the principal directions aligned with the grid axes), and the storage coefficient may be heterogeneous. MIKE SHE from DHI is the other popular software (Hughes and Liu, 2008). It simulates water flow in the entire land based phase of the hydrological cycle from rainfall to river flow, via various flow processes such as, overland flow, infiltration into soils, evapo-transpiration from vegetation, and groundwater flow. It has been successfully used in studies related to water quality studies in connection with both point and non-point pollution. It can be used in regional studies covering entire river basins as well as in local studies focusing on specific problems on small scale. The three-dimensional movement of ground water of constant density through porous earth material may be described by the partial-differential equation

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)+W=S_s\frac{\partial h}{\partial t} \tag{1}$$

where K_{xx}, K_{yy}, and K_{zz} are values of hydraulic conductivity along the x, y, and z coordinate axes (L/T); h is the potentiometric head (L).

W is a volumetric flux per unit volume representing sources and/or sinks of water, (T^{-1}) S_s is the specific storage of the porous material (L^{-1}); and t is time (T).

When solute transport model is also coupled with the soil-water movement model, additional parameters related to the Fickian-based advection-dispersion equation, soil specific parameters such as longitudinal dispersivity and solute specific molecular diffusion coefficient in water is required. For solution of the ground water flow equation and the solute transport model, it is necessary to identify the physical parameters, sink and /or source terms and the initial and/or boundary conditions. The physical parameters are either estimated from laboratory and field experiments using direct measurement or inverse solution methods. These methods can be time consuming and expensive. Direct methods, either field or laboratory, use only limited number of samples and up-scaling of parameters based on limited number of tests may introduce significant error. Indirect methods such as pedotransfer functions (PTF) allow users to estimate these properties from limited soil information such as soil texture, bulk density and organic C quickly and cheaply, however PTF's do not most of the time reflect field behavior.

As an alternative to these methods of determining parameters needed for the numerical models, inverse modeling or parameter estimation techniques are increasingly being used. The basis for the inverse modeling is that in numerical modeling, mathematical equations are used to describe the physical processes in the system. These equations contain certain system specific parameters, and if these parameters are known then it may often be possible to evaluate the response of the system to a certain excitation or input to that system. Most of the time, though, field measurements giving output of the system in response to certain inputs to the system are available, but the parameters are uncertain. In such cases, if numbers representing the inputs or excitations are supplied to a numerical model representing the system and the model's parameters are adjusted such that model outputs matches with measurements made on the system, the effective parameters that define the behavior of the system are obtained. It is then concluded that the model with the quantified effective parameters will represent the system's behavior adequately as the latter responds to other excitations as well, excitations which we may not be prepared to give the system in practice. A model is said to be "calibrated" when its parameters have been adjusted in this fashion.

Issues in Parameter Estimation

The importance of solving inverse problems is thus obvious. But if physical parameters, initial and boundary conditions used in the model are not appropriate, the results obtain will be erroneous. Thus, it is clear that the role of parameter estimation is very crucial in groundwater modeling. But there are many inherent difficulties in running a parameter estimation exercise which should be understood before any parameter estimation exercise is undertaken. Some of the main challenges of Parameter estimation in groundwater modeling can be listed as follows (Sun, 1994 and Douglas 2007). .

a. *Ill-Posedness of the Inverse Problem*

   Quite often, the inverse solution in groundwater modeling is non-unique. A number of parameter sets can exist giving equally valid outputs. To handle such cases it is required to appropriately constrain the solution space of the parameters/variables.

b. *Stability*

   It is required that the solution be stable, that means that the variation in solution parameter can be arbitrarily small provided the variation of input data (physical parameters, initial and boundary conditions, control variables) are kept small.

c. *Selecting the parameters/variables for estimation* *d. Finding global optimum set of values*

The parameter estimation solution may become stuck at local minima which produce a solution without finding the globally optimum set of values

Methods of Parameter Estimation

An often used method of parameter estimation is manual calibration by 'trial and error' method. The main drawbacks of this method are that it can take a lot of time and for complex models with number of parameters involved it is difficult to judge the interaction between these parameters and in which direction they should be adjusted. It is also totally subjective depending on the modeler to determine when to stop the process. For complex models involving number of parameters, it is not possible to ensure that the best set of parameters is found.

The use of automated inverse modeling methods , where the process searches for the best possible set of parameters in an iterative way, by varying the parameters and comparing the measured response of the system with the numerical solution given by the model are an attractive alternative. The search is usually targeted towards finding the global minimum of an objective function defined by the error between measured and simulated values. There are many algorithms in use having different strategies for minimizing the objecting function. The strategies used for parameter estimation can be loosely categorized into local and global methods. Local methods include gradient based approach, where the model aims to minimize an objective function such that all the surrounding points have a greater value. Global methods on the other hand do not depend on a direct gradient, but rather use a random sampling approach.

A case study is presented here for which PEST software (Doherty et al. 2004) was used for parameter optimization. Parameter estimation (PEST) is a widely used calibration model, where parameter optimization is achieved using the Gauss-Marquardt-Levenberg method for which the discrepancies between model-generated numbers and corresponding field data are reduced to a minimum in the weighted least-squares sense.

Case Study for Parameter Optimization

This case study relates to the study of Land Retirement effects in the San Joaquin Valley of California, USA. In the San Joaquin Valley of California, a combination of lack of adequate out-of-basin drainage caused by topographic and environmental constraints, intensive irrigation practices, and the presence of a shallow underlying layer of low permeability soil has caused the root zone to become highly saline and the shallow water table to rise (Selmon et al.2000). The U.S. Department of interior through the Interagency Land Retirement Team undertook a study under the Land Retirement Demonstration Project (LRDP) located in western Fresno County of California to collect site specific scientific data on the effects of Land Retirement on the shallow water level and the soil salinity (Erysian et al. 2005). The project collected five years of continuous data on the changes in salinity levels in the soil profile and shallow water table (Fig.1, Fig 2).

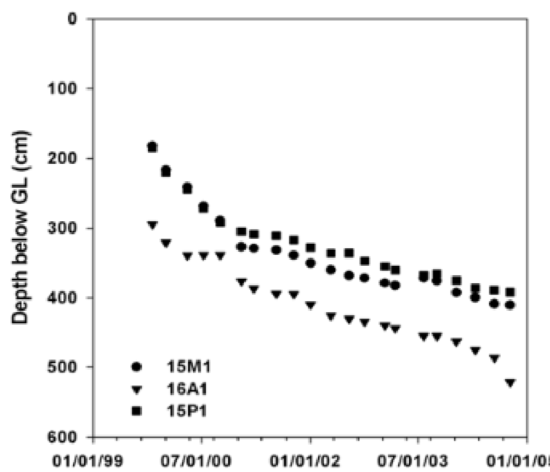

Figure 1 Changes in Shallow Water Level

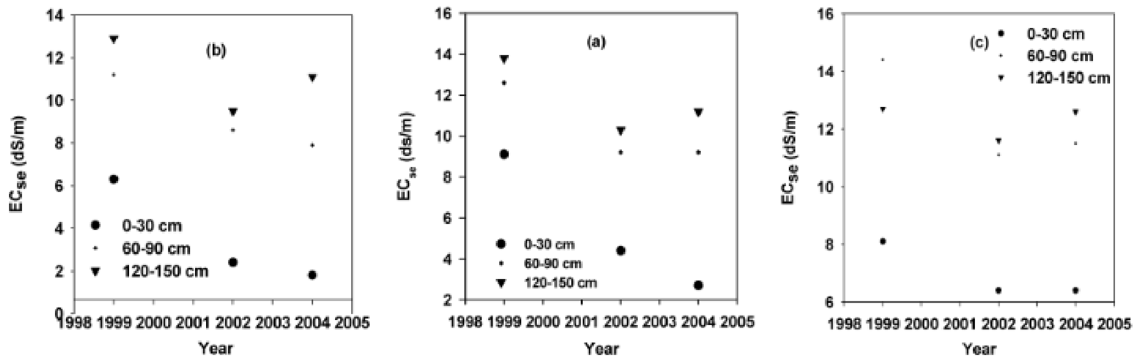

Figure 2 Changes in Soil Salinity

Based on the analysis of the data, it was concluded that the retirement of land led to gradual lowering of the shallow water table and also to the lowering of salinity levels in the root zone. However, based on the field data it was not possible to identify the factors that led to such an outcome. Could the same outcome be expected at other locations with different set of conditions? To answer this question, it was decided to develop a numerical model of the process and calibrate it with the measured data. Singh et al., 2010 developed a comprehensive theoretical and numerical modeling framework to evaluate the specific site conditions required for a sustainable land retirement outcome based on natural drainage. Using field data, principles of mass balance in a control volume, the HYDRUS-1D Software Package (Simunek et al. 2005) for simulating one-dimensional movement of water, heat, and multiple solutes in variably-saturated media, and PEST, a model-independent parameter optimizer, the processes of soil water and solute movement in root zone and the deep vadose zone were investigated (Fig 3).

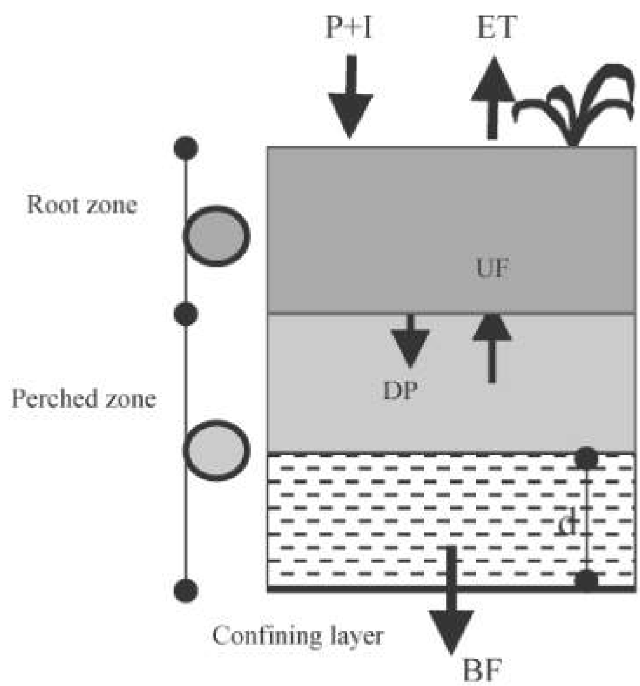

Figure 3 Control Volume for Mass Balance

The inverse modeling effort produced a set of unsaturated soil hydraulic parameters and downward flux (natural drainage) from the system by comparing the model generated values of vadose zone salinity and shallow water levels to the observed values (Table 1, Fig 4).

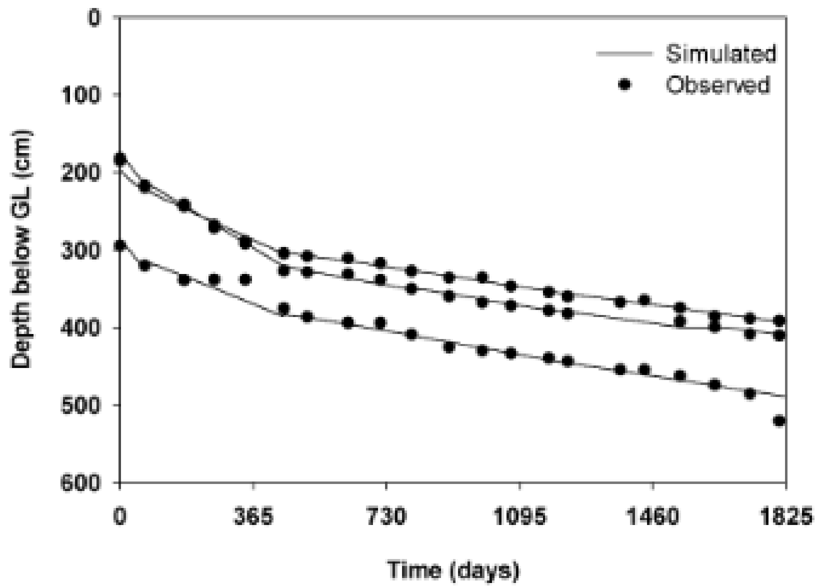

Figure 4 Observed and Simulated shallow water levels

Table 1 Optimized parameter values

Optimized parameter	Units	Sites		
		15M1	16A1	15P1
A (empirical parameter)	cm^{-1}	0.206	0.223	8.16E-02
η (empirical parameter)	-	2.79	2.39	1.70
K_s (Saturated hydraulic conductivity)	cm/day	7.9	3.0	3.0
D_L (Longitudinal dispersivity)	cm	25	3.8	4.7
D_W (Diffusion coefficient)	cm^2/day	111.7	45.34	7.39
BF_1(1-68 days)	cm/day	0.1781	0.1554	6.1E-02
BF_2 (69-448 days)	cm/day	8.4E-02	5.5E-02	4.41E-02
BF_3 (449-512 days)	cm/day	3.8E-02	2.4E-02	2.4E-02
BF_4 (513-1207 days)	cm/day	3.0E-02	2.5E-02	1.8E-02
BF_5 (1208-1827) days	cm/day	2.7E-02	2.2E-02	1.6E-02

The process yielded a difficult to obtain natural drainage rate as a function of water table height within the control volume (Fig 5).

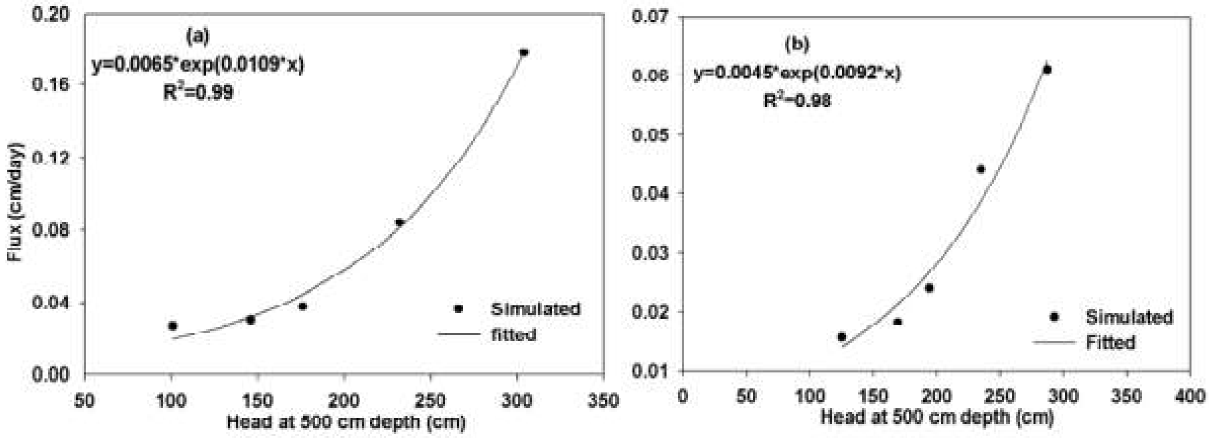

Figure 5 Bottom Flux as a function of head

The results showed that unsaturated soil hydraulic properties and the downward flux from the soil profile are the critical parameters in ensuring the success of land retirement programs. A 'natural drainage approach' to sustainable land management for drainage impaired land in general and retired lands in particular resulted from the use of parameter optimization approach.

CONCLUSION

The non uniqueness of the calibration process is a danger that one must contend with. One should be aware that inverse modeling process can be as much of an art as it is a science. Thus inverse modeling can only be used to complement the efforts in understanding a system and inferring its parameters. It cannot act as a substitute for experience; it cannot extract more information from a dataset than the inherent information content of that dataset.

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Assesment, Management and Modelling of Ground Water Quality - L B Nagar, Hyderabad and Impact of Industries Closure, India

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ABSTRACT

Impacts on ground water quality were carried out in the L B Nagar, Hyderabad by many of the researchers previously. As Environmental Act has forced to close sum of the Industries in the LB Nagar area, would like to observe the present status on the natural system in the area. About 30 water representative ground water samples will be collected from different stations to monitor the water chemistry of various Physical, Chemical and Trace Metals status. The study was carried out by collecting some ground water samples during Aug 2014 to Sep 2014.The results were compared with standards prescribed by IS 10500:2012.

Keywords: Ground Water Assessment and its Management & Modeling.

OBJECTIVES AND GOAL OF THE STUDY

The principal objective of the present study is to understand the hydrochemistry of ground waters in the study area and the Post Industrialization impact on ground water quality of the investigated area. The study area is situated on thickly populated area of Hyderabad district. Collected gound water samples different locations in study area will be studied for various Physical & Chemical parameters such as pH, Electrical Conductivity, Turbidity, Total Dissolved Solids, Alkalinity, Total Hardness, Calcium, Magnesium, Chlorides, Sulphates, Fluorides, Sodium, Potassium, Nitrate, Total Chromium, Copper, etc….

Planning

S. NO.	Activity	Time Schedule
1	The total numbers of 30 samples will be collected from wells.	August - 2014
2	Both Physical & Chemical parameters will be analyzed using standard laboratory techniques.	September – October , 2014
3	Trace metals analysis on AAS with appropriate treatment	November - December, 2014
4	Data collection and literature collection &analysis	December – January, 2015

INTRODUCTION

A study conducted on ground water quality in the city reveals that the city's ground water is polluted with many chemical contaminants being present in more than the permissible amounts. In view of the tests carried out, the board has suggested that the ground water in major parts of the city should not be used for drinking purposes unless it is treated for chemical and biological contamination. Even the HMDA has included the above suggestion in its environmental building guidelines. The study was conducted in the areas of Uppal, LB Nagar, Golconda, Yusufguda, Doctor's colony, Attapur, Bollarum industrial area, Sanjeevayya Park, Jeedimetla and Niralanagar. The ground water samples collected from all the above areas have failed in various crucial parameters and tests which include test of total hardness and calcium, sulphate, chloride, nitrate and magnesium contents. And the chemical components in these samples are present above the desirable quantities. This report says that in the areas of LB Nagar, the ground water is highly polluted by the disposal of industrial effluents. The areas surrounding Musi have ground water contaminated with organic pollution and the areas surrounded by the industries have ground water contaminated by the industrial pollution. Further, the ground water in Hyderabad has total hardness up to 1000 ppm, when the desirable hardness is just about 300 ppm. HMDA has warned the public that if the ground water is consumed without chemical treatment, it will lead to possible health risks such as cancers, blue baby disease, learning impairment and neurological disorders, dental and skeletal fluorosis, scaling of skin and hair loss.

Location

The area under investigation lies south of Moose River and included in the Survey of India toposheet no. 56/11/SW, this area falls in the latitude and longitudes 170 .34'.84'' N, 780 .55'.10'' E. The SIRIS factory is located on the Vijayawada national highway near L.B. Nagar. The investigated area is within the radius of 2 to 3 km from the factory. Geology of study area Geologically the area is of granitic terrain. Gray and Pink granites are exposed in the investigated area. The typical section of the ground exhibits three important layer top soil, morrum and bedrock. A gray granite quarry is to be seen just behind the SIRIS factory. The joints are present here trending in NNW-SSE (3350 bearing) direction with a dip of towards the west.

STUDY AREA

Lal Bahadur Nagar, well known as L.B.Nagar, is a commercial and residential hub in Hyderabad, India. It was once a Municipality in Ranga Reddy District in the Hyderabad . The major portion of the wastes disposed off into the atmosphere and the land is washed out by precipitation and runoff, filtration processes, and almost entire material and human waste load accumulates in surface water bodies and ground water aquifers. As world population increases the demand for food production, industrial activities and domestic purposes grows and leads to heavier withdrawals of the limited renewable freshwater resources. Simultaneously these human activities generate wastes which are discharged into the depleted water resources despoiling them.

Compared to surface water, ground water may seem to be less vulnerable to pollution, primarily because they are better protected by the overlying strata of soil and rocks. Though the overlying strata may act as a filter, pollutants do reach the water table and in view of the normal slow movement of ground water it may reside there for a considerable length of time. While ozone "holes" can be "sewn "and global warming controlled, damage to ground water can never be rectified. Few seem to realize this fact. According to National Environmental Engineering Research Institute (NEERI) 70 percent of the inland water is unfit for human consumption.

Two reasons are obvious for this kind of a situation.

1. It is due to bad planning with respect to the location of industries around the city
2. Because there is no check on the industries with respect to their indiscriminate disposal of untreated effluents into the natural ground. It is the duty of all researchers and scientists working in the field of ground water to come forward in detecting, assessing and restoring the quality of ground water resources

OBJECTIVES

To determine the factors that controlled the migration of effluents both horizontally and vertically in the subsurface environment

- To demarcate the boundaries of the affected area

- To determine the intensity of the ground water contamination
- Assessment of Water pollution
- To suggest a suitable technique for ground water¬ restoration

RESEARCH METHODOLOGY

The quality analysis has been carried out for the parameters like pH, total alkalinity, electrical conductivity, total dissolved solids, total hardness, calcium hardness, magnesium hardness, nitrites, nitrates, sulphates, chlorides and fluorides by following the standard methods prescribed as per IS: 10500-1994 codes**.**

RESULTS

Physicochemical Parameters of Groundwater: The Seasonal wise concentration of ions in groundwater samples is given in Table 1

The pH indicates the acidic or alkaline material present in the water. The pH of the groundwater samples in the study area ranges from 6.76 - 7.81 and 6.65 - 7.62 during post and premonsoon respectively. The groundwater in this area is generally acidic in nature due to granitic rock formation. The total alkalinity values in the study area are within the permissible limit and are ranging from 240-480 mg/l during post monsoon period and 230-460mg/l in pre-monsoon period. The high alkalinity of groundwater in certain locations in the study area may be due to the presence of bicarbonate and some salts. The alkaline water may decrease the solubility of metals.

The concentrations of Ca++, Mg++, Cl- , HCO3 - and total hardness were determined by volumetric method. Ca++ and Mg++ were determined by EDTA titration. For HCO3 - , HCl titration to a methyl orange point was used. Chloride was determined by titration with AgNO3 solution. Flame emission photometry has been used for the determination of Na+ and K+ . In this method water sample is atomized and sprayed into a burner. The intensity of the light emitted by a particular spectral line is measured with the help of a photoelectric cell and a galvanometer. Sulphate was determined by gravimetric method.

RESULTS AND DISCUSSION

The analytical data of successive for groundwater sample corresponding to June2014 and november 2014 are given mg/l is in table . Equivalents per million (epm) values are also calculated .

Physico-chemical attributes of groundwater:-

The properties of groundwater of the area under study, in terms of fundamental parameters, such as, pH, hardness, total dissolved solids and EC are given below.

Electrical Conductivity:-

The electrical conductivity with 400 µmhos/cm at 25o C is considered suitable for human consumption (WHO, 1984), while more than 1500 µmhos/cm at 25o C may cause corrosion of iron structures. On the basis of electrical conductance, groundwater is classified as given by Sarma and Narayanaswamy (1981)

Hydrogen Ion Concentration (pH)

Values of pH were measured at well sites, which range between 7.24 to 8.6 and 7.15 to 8.64 during pre-monsoon 2014 and post-monsoon 2014, respectively (Table). The groundwater thus is mildly acidic to slightly alkaline in nature.

Hardness

In the area of study the hardness value varies from 693 to 3560 mg/l and 652 to 3800 mg/l in pre-and post-monsoon 2014 and he average value for above period is 1480.9 mg/l& 1400 mg/l, respectively. It was found that all samples are higher than desirable limit for drinking purposes of >300 mg/l in above periods. So, all the sample are not fit for drinking purpose within the permissible limit of drinking water standard (BIS, 1991).

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) have been calculated by summing up all the major cations and anions (Table-1a and 1b) and the correlation between TDS and instrumentally determined EC excellent. TDS values for June, 2014 samples range from 2410 to 7500 mg/l, the average value for the samples being 4018 mg/l. The TDS values during November 2014 range between 2301 to 7484 mg/l with an average value of 4077 mg/l. The TDS concentration was found to be above the permissible limit may be due to the leaching of various pollutants in to the ground water which can decrease the pot ability and may cause gastro-intestinal irritation in human and may also have laxative effect particularly up on transits Drinking water becomes significantly unpalatable at TDS value >1000 mg/l. From this point of view, therefore, groundwater in the study area is not really ideal.

Drinking Water Quality

The groundwater samples for both the seasons shows the high TDS concentration and are above the permissible limit of 2000 mg/L WHO 1997 & BIS 1991 and making the water unsuitable for various domestic activities. Based on TDS values Davies and DeWiest (1996) propose a threefold classification of groundwater. Domestic (1,000 mg/L). According to this classification all the samples of both seasons are in category .

The SO4 concentration is also above the highest desirable limit of 400mg/l. The SO4 concentration of eight & nine samples in both the seasons cross the maximum permissible limit of drinking standards (BIS 1991).

The high concentration of nitrate in drinking water is toxic and cause blue baby disease / metaemoglobinaemia in children and gastric carcinomas. In both pre-and post-monsoon of samples of 2008, fluoride concentration exceeds the maximum permissible limit of 1.5mg/l which is hazardous for human consumption (BIS 1991).

Table 1 Results of Chemical analysis in mg/l

S.no	pH	EC	TDS	Hardness	HCO_{3-}	Cl	SO4	Na	Ca	Mg
1	8.2	2020	1350	800	142.3	369.0	142	55	182	450
2	7.5	3455	2500	ND	225.0	750.0	555	79	ND	ND
3	7.9	1700	1200	660	264.2	200.0	120	35	220	420
4	8.6	1300	1100	522	255.5	140.0	66	45	123	250
5	7.6	1740	500	500	44.6	260.0	99	56	162	166
6	6.7	1030	4500	326	121.0	145.0	125	52	88	1420.2
7	6.9	7500	4200	ND	140.1	1800	750	65	ND	ND
8	8.2	6300	923	ND	145.2	1400	1233	123	ND	ND
9	8.4	1420	902	560	111.3	190.0	99	75	150	225
10	8.9	1300	2355	570	52	220.0	67	15	160	195.3
11	7.4	3200	2030	1400	59	445.0	420	85	247	885.2
12	7.2	2003	4025	600	76.3	525.0	265	88	88	472.3
13	7.2	7000	1800	ND	84.2	1805	1444	90	ND	ND
14	7.3	4050	1330	500	99.5	375.0	175	85	75	357.3

SOME SAMPLE PHOTOS: GROUND WATER POLLUTION

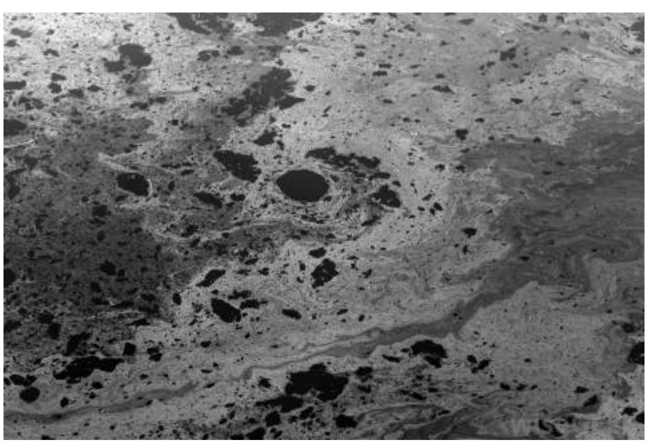

Table 1A Results of Chemical analysis in mg/l

S.NO	PARAMETERS	STUDY AREA RANGES	Acc to WHO
1	pH	6.3 – 8.5	6.5-8.5
2	Electric conductivity	1060 - 7500	2.13 - 1837
3	Total Dissolved Solids	750 - 2940	500-15000
4	Hardness	ND - 1466	300-600
5	Calcium	ND - 228	75-200
6	Cl (μg/l)	155 - 1905	250-1000
7	SO4 (μg/l)	48 – 1594	150-400
8	Mg (μg/l)	ND - 974	30-100
9	HCO3 (μg/l)	55.4 – 282.3	300 - 600
10	Na(μg/l)	15 - 168	<200

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Role of Non-Magnetic Biochars for Domestic Scale Fluoride Removal from Contaminated Drinking Water

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ABSTRACT

High fluoride content in drinking water is a worldwide problem and an environmental issue of global significance. In absence of alternative water source, defluoridation of water is the obvious choice of water planners to cater to the needs of the underdeveloped sections of the society. Various cost effective treatment options are in existence for defluoridation of drinking water. Amongst these, the ones based on carbon adsorbent, namely biochar, is found to be promising and versatile for removing fluoride. Currently, studies are being carried out to introspect the efficacy of non-magnetic biochars for water pollution remediation with respect to fluoride removal. Biochars are pyrolysed forms of carbon and produced from a wide range of easily available commercial materials. Biochars obtained from corn stovers and bagasses are reported to act as superior adsorbents of water fluoride. Biochars also find wide applicability in soil conditioning and carbon sequestration process. This paper reviews the properties, sorption characteristics, usage and opportunities of non-magnetic biochars. This paper also seeks to portend the future possible applicabilities of non-magnetic biochars as feasible alternative for domestic and commercial scale eco-friendly water treatment filter pack material.

Keywords: Adsorption, Biochars, Defluoridation, Drinking Water, Fluoride, Filter Pack.

1. INTRODUCTION

The spurt in human population and over-exploitation of water resources has resulted in water scarcity and consequent pollution in different parts of India. Fluoride contamination in groundwater is one such problem that has posed severe threats to man and his environs. Fluoride contamination occurs due to weathering and leaching of fluoride bearing minerals like fluorspars (CaF_2), fluorapatite [$Ca_5(PO_4)_3F$] and cryolite (Na_3AlF_6) that are formed through geogenic processes of volcanic and fumarolic eruptions. Due to absence of alternative water supply possibilities, defluoridation is the only way to get pollution free drinking water. A number of chemical mechanisms exist for water defluoridation such as ion exchange, oxidation-reduction, adsorption-desorption, precipitation, membrane separation, reverse osmosis, etc. Amongst the various commercial treatment techniques which are in use, adsorption is the most fundamental and widely used technology, simple to install and operate. The common adsorbents so far in use are activated carbon, activated alumina, bimetallic and polymetallic oxides, and various biological entities. However, each of these adsorbents has some advantages and flaws in regard to fluoride removal. Recently, non-magnetic biochars have gained enormous attention as cost effective, environment friendly, biological resource with enigmatic and versatile adsorption properties. This paper reviews the efficacy and applicability of non-magnetic biochars as feasible techno-eco-compatible adsorption media for domestic scale filter units.

2. NON-MAGNETIC BIOCHAR : DEFINITION AND CONCEPTS

Carbon is a versatile adsorbent. Biochar is a modified form of carbon. Biochar exhibits wide range of properties including presence of large specific aromatic surface area, porous structure and mineral components that makes non-magnetic biochar a characteristic and lucrative adsorbent. Chemical composition of biochar plays a vital role in adsorption efficacy. Surface chemical composition and properties varies with pyrolysis process, pyrolytic temperature, heat transfer rate, particle size distribution, reactor configuration, and feedstocks used. Carbon content in biochar is directly proportional to pyrolytic temperature, while nitrogen, hydrogen, and oxygen content are inversely proportional to pyrolytic temperature (Ahmad et al., 2012). At higher temperature surfaces of biochar are more aromatic (phenolic, hydroxylic and others) and less hydrophilic. Functional group density increases with the increase of oxygen-carbon ratio (such as hydroxyl, carboxylate, and carbonyl), that contribute to higher cation exchange capacity (CEC) for the biochar (Lee et al., 2010; Yuan et al., 2011; Kim et al., 2013).

3. NON-MAGNETIC BIOCHAR – A POTENTIAL FLUORIDE ADSORBENT

Biochars are obtained from a large number of organic residues such as solid wastes, corn stover, woods, animal litters, crop residues etc. Production of non-magnetic biochars is effected through pyrolysis of feedstocks. Various thermochemical processes such as slow pyrolysis, fast pyrolysis, hydrothermal carbonization (HTC), flash carbonization, torrefaction and gasification gives rise to different forms of biochars (Meyer et al., 2011). Slow pyrolysis generally produce non-magnetic biochars (Ahmad et al., 2012).

Amongst the various non-magnetic biochars, corn stover ma be the ideal precursor for fluoride removal. In India, use of corn stover biomass has been initiated as the basic feedstock for biochar production. Mohan et al. (2012) has established that moisture content of corn stover biomass is to be reduced to <10**%** through drying for 1-2 days. The dried biomass is then segregated into 10–15 mm small pieces.

Pyrolysis is then done for the non-magnetic corn stover biochar at 500^{o}C in reactor vessel, maintaining slow speed. In the above process, bio-oil is collected in a separate vessel at the time of biochar production. Corn stover is removed with an inert gas in a muffle furnace. For half an hour, the biomass is pyrolysed by maintaining a temperature of around 500^{o}C. The biomass is then cooled after half an hour. In another apparatus the biochar collection is carried out. The non-magnetic corn stover biochar, thus produced, is then kept in air tight container for detailed characterization and sieving into the desired mesh size.

4. APPLICABILITY OF BIOCHAR IN WATER TREATMENT

Non-magnetic corn stover biochar is not only familiar for fluoride removal, but for other organic-inorganic pollutants as well. Efficacy of fluoride adsorption through biochar is inversely proportional to pH. Adsorption efficacy of non-magnetic corn stover biochar is optimum at pH 2.0. At such pH, some of the surface functional groups undergoes protonation and adsorption efficacy remains higher, but at higher pH it acts reversely. But the efficacy of fluoride adsorption through non-magnetic corn stover biochar is noteworthy. Result shows that fluoride adsorption rate of non-magnetic corn stover biochar are quite satisfying and after treatment fluoride concentration in treated water remains within permissible limits. The removal efficiency depends largely on conditions like temperature, pH, biochar dosage, etc. Non-magnetic biochars contain both acidic and basic sites with various types of functional groups like hydroxyl (OH), aldehyde (RCHO), carboxylic acid (RCO_2H), ketone (RCOR), ether (ROR), anhydride, quinine ($C_6H_4O_2$), lactone, pyrone, catechol, hydroxyketone and much more. Many of these groups are hydrophilic as well as hydrophobic and some of these groups like anhydrides, lactones, quinones and ether do not adsorb fluoride due to the presence of lone pair of electrons (Mohan et al., 2012).

5. PROPOSED DOMESTIC FILTER WITH BIOCHAR FIXED PACK

A prootype filter may be designed based on the above biochar. The filter will be a single column and made up of stainless steel or by galvanized iron sheet. It need to have a single outlet for collection of treated water sample. The filter media may be packed in three layers:

The fixed pack formed of non-magnetic corn stover biochar will remain sandwiched between two unsorted gravel layers at the top and bottom. The lowermost layer will be the unsorted gravel layer that acts as a filter bed, and the topmost layer is the protective zone for the biochar layer underneath to prevent contamination. Water percolates through the uppermost gravel layer and comes in contact with the non-magnetic corn stover biochar layer, wherein adsorption starts. Flow rate of water is a vital factor in such studies. If the contact time of water with non-magnetic corn stover biochar increases, the adsorption efficacy also increases. The flow rate is proposed to be kept at an average of 30 ml/ min.

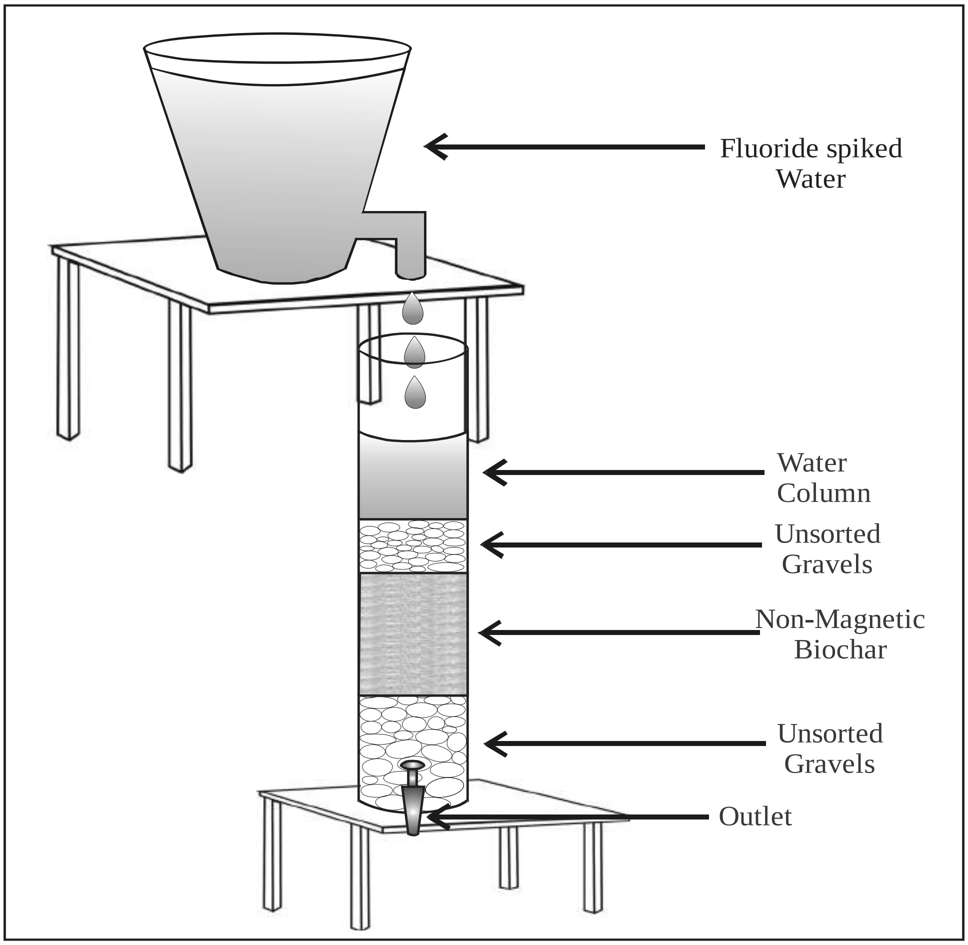

Figure. 1 Schematic Diagram of Proposed Filter Packs with Biochar

6. CONCLUSION

Non-magnetic biochars, particularly from corn stovers, are simple and effective alternatives in lieu of conventional adsorbents. Maize is easily available and the obtained maize biochar is a renewable resource. The removal efficacy may be controlled with different adsorbent conditions. Thus, an eco-friendly, economic, commercial filter bed (fixed pack) based on biochar treatment technique may be adopted as a future course of work for water supply to undeveloped rural population at large.

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Assessment of Groundwater Quality with Special Reference to Fluoride Concentration in parts of Mulugu-Venkatapur Mandals, Warangal District, Telangana State

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ABSTRACT

Serious problems are faced in several parts of the world due to the presence of high concentration of fluoride in drinking water which causes dental and skeletal fluorosis to humans. Warangal district in Telagana State, India is one such region where concentration of fluoride is present in groundwater. Since there are no major studies in the recent past, the present study was carried out to understand the present status of groundwater quality in Warangal and also to assess the possible causes for concentration of fluoride in groundwater. Pre-monsoon samples from 50 wells were collected and analyzed for fluoride concentration using an ion chromatograph. The fluoride concentration in groundwater of this region ranged from 0.28 to 5.48 mg/l with a mean of 1.18 mg/l. About 68% of the samples collected were suitable for human consumption. However, 24% of the samples were having less than the required limit of 0.6 mg/l, and 32% of the samples possessed high concentration of fluoride, i.e., above 1.5 mg/l. Weathering of rocks and evaporation of groundwater are responsible for high fluoride concentration in groundwater of this area apart from anthropogenic activities including irrigation which accelerates weathering of rocks.

Keywords: Groundwater, Fluoride, Alkalinity.

INTRODUCTION

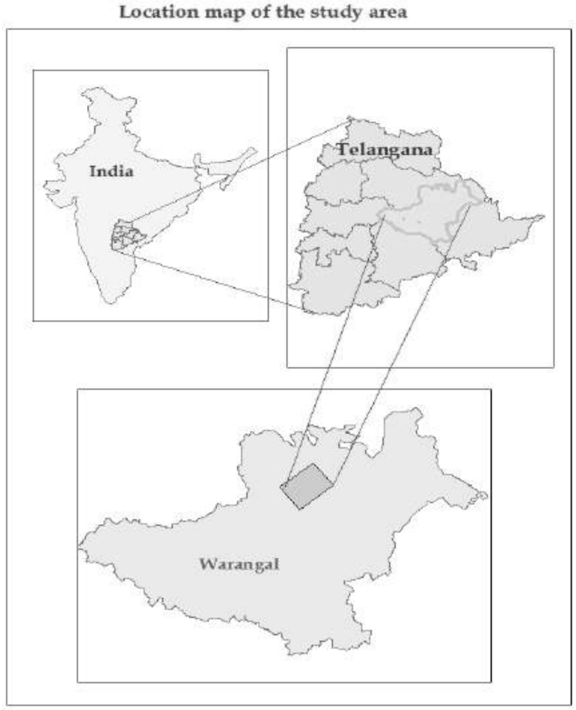
Fluoride helps in mineralization of bones and formation of enamel of teeth. A daily dose of 0.5 ppm is required for proper formation of enamel and bone mineralization which otherwise may result in formation of dental fluorosis characterized initially by opaque white patches, staining, mottling and pitting of teeth, lack of enamel formation, and bone fragility (Cao et al. 2000; Rwenyonyi et al. 2000; Vieira et al. 2005; Edmunds and Smedley 2005; Ayenew 2008; Banerjee 2014). Long-term intake of fluoride-enriched water may cause bilateral lameness and stiffness of gait (Suttie 1977; Oruc 2008). Common natural fluoride sources in groundwater are the dissolution of some fluoride bearing minerals, such as fluorite (CaF2), muscovite, biotite, hornblende, villianmite, tremolite, fluorapatite, and some micas weathered from silicates, igneous, and sedimentary rocks, especially shale (Handa 1975; Pickering 1985; Wenzel and Blum 1992; Datta et al. 1996; Zhang et al. 2003; Fawell et al. 2006; Msonda et al. 2007; Jha et al. 2010; Singh et al. 2011a, b, c). Unstable minerals such as sepiolite and palygorskite may also have a dominant control on fluoride concentration in groundwater (Kim et al. 2005; Jacks et al. 2005). Fluorine has been rated as the 13th most abundant element on earth and is dispersed widely in nature (Mason and Moore 1987; Ayoob and Gupta 2006; Viswanathan et al. 2009). Due to its maximum electronegativity and reactivity among all chemical elements, the elemental fluorine state occurs rarely in nature.

Intake of F ([1.5 mg/L in drinking water) for a prolonged period is known to cause damage to the teeth enamel (dental fluorosis), skeletal complications known as skeletal fluorosis and non-skeletal fluorosis (WHO 1994). In India about 62 million people including 6 million children face the problem of fluorosis due to consumption of fluoride contaminated drinking water. Traces of fluoride can be found in air, most foodstuffs and beverages, particularly in tea but the principal daily intake source for humans (75 %) is drinking water (Mahvi et al. 2006). It is known now that the 97 % of global freshwater is stored in subsurface and groundwater resources. Also, it has been estimated that more than 50 % of the world's population depends on groundwater for survival. Additionally, in many parts of the world, especially in arid and semi-arid climates, there is no alternative for communities to supply drinking water. Accumulation of F in crops, particularly in areas where soil is irrigated with F contaminated water may pose an additional threat to human health. It is the total amount of F absorbed in a human body that needs to be considered i.e., the sum of F intake from water, food (Malde et al. 2011) as well as air (Batra et al. 1995; Srikantia 1977). In some areas where fluorosis is endemic, F ingestion through food constitutes a significant portion of the total daily intake (Kumari et al. 1995; Malde et al. 1997, 2011). It is essentially related to declining groundwater level due to over exploitation, mainly for irrigation, resulting in virtual drying up of the shallow unconfined aquifers. This has led to exploitation of deeper aquifers containing high levels of fluoride (Gupta and Sharma 2005).

STUDY AREA

The proposed study area is located in the North eastern fringe of the Warangal district, and falls in Mulugu, Venkatapur revenue mandals (Fig.1). It is about 200 sq km and falls in toposheet nos. 56N/15, 56N/16, and extends from latitude 18^0 10'-18^0 20'N and Longitude 79^0 55'-80^0 5'E. Warangal has a predominantly hot and dry climate. Summer starts in March, and peak in May with average high temperatures in the 42 °C (108 °F) range. The monsoon arrives in June and lasts until September with about 550 mm (22 in) of precipitation. A dry, mild winter starts in October and lasts until early February, when there is little humidity and average temperatures in the 22–23 °C (72–73 °F) range. The average annual rainfall of the district is 955 mm, which ranges from nil rainfall in December to January to 272 mm in July. July and august are the wettest months of the year. The mean seasonal rainfall distribution is 797 mm in southwest monsoon (June-September), 115 mm in northeast monsoon (Oct-Dec), nil rainfall in winter (Jan-Feb) and 43mm in summer (March–May). The percentage distribution of rainfall, season-wise, is 83% in southwest monsoon, 12 % in northeast monsoon, nil percentage in winter and 5 % in summer. The study area forms a part of the stable southern Indian shield consisting of peninsular complex (PGC), Pakal group, Mulugu subgroup. Mulugu subgroup occupies a major part of the study area and comprises Arkose, shale with dolomite quartzite, shale, quartzite, Limestone, sandstone, gneisses, granite and dolorite dykes. Sandstone, shale, quartzite, arkose of pakal group are exposed in the NE part of the study area. PGC rocks are intruded by the basic intrusives (dolerite).These are younger intrusives, these types of younger intrusives are very hard and dense. In the study area Archean peninsular gneissic complex are unconformably overlain by sedimentary rocks of Middle Proterozoic age, consisting the pakal group of rocks comprises calcareous sediments (Limestone), quartzites and shales.

Location map of the study area



HYDROGEOLOGY

Ground water occurs in all the geological formations in the district. The major rock types occurring in the Mulugu subgroup occupies a major part of the study area and comprises Arkose, shale with dolomite quartzite, shale, quartzite, Limestone, sandstone, gneisses, granite and dolorite dykes. The occurrence and movement of the ground water is a consequence of a finite combination of topographical, climatological, hydrological, geological, structural and pedagogical factors, which together form integrated dynamic system. All these factors are interrelated and inter dependent, each providing a insight into the total functioning of this dynamic system. The crystalline rocks like granite and gneisses lack primary porosity. They develop secondary porosity through fracturing and weathering over ages and thus become water bearing. The movement of ground water is controlled by the degree of inter-connection of secondary pores/voids. The depth to bed rock varies from few meters to 30 m bgl. Ground water occurs under unconfined conditions in weathered zone and under semi confined conditions in the fractures and fissures. The Pakhals comprise mainly sandstones, quartzite, limestones, shales and phyllites. They are hard, compact and possess limited primary porosity. However, subsequent fracturing and fissuring followed by weathering enabled them to form aquifers locally. The thickness of weathered zone varies from 8 to 20m. The depth ranges of the dug wells vary from 6 to 10 m bgl. The premonsoon water levels vary from 5 to 20 m bgl and the post monsoon water levels vary from poor aquifers except wells tapping weathered shales and sandstones.

MATERIALS AND METHODS

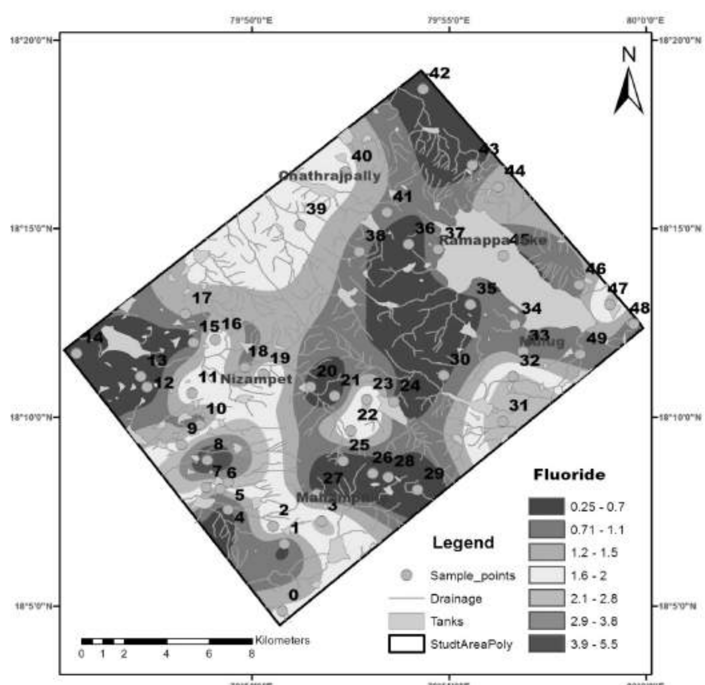
The samples were collected from hand pumps and dug wells during May 2014. The average depth of the hand pumps was 150 feet. First the water was left to run from sampling source for 4–5 min, before taking the final sample. Samples were collected in pre-cleaned sterilized polyethylene bottles of 1 L capacity. pH and EC were determined on site by portable pH meter and EC meter. Total dissolved solids were estimated by ionic calculation method. Bicarbonates were determined using titration method. Na and K were determined in Flame photometer. Total hardness (TH) and Ca2 were analysed titrimetrically using standard EDTA. Mg2 was computed, taking the difference between TH and Ca^{+2} values. Na and K were measured by flame photometer. Cl- was estimated by standard AgNO3 titration and $SO4^{+2}$was measured by the turbidimetric method.

Fluoride concentration was determined by ionic chromatography.

The sampling locations were mapped with the help of hand held Global Positioning system (GPS) receiver and are reported in Universal Transverse Mercator (UTM) coordinates. The spatial distribution of fluoride concentration in the study area is delineated. Piper tri-linear diagram to evaluate the geochemistry of groundwater of the study area was plotted with the help of Arc GIS- software.

RESULTS AND DISCUSSION

Groundwater samples of the study area are acidic and alkaline in nature, pH in the area ranged from 6.7 to 8.0 with average value of 7.4 depicting weak alkaline conditions dominant within groundwater system in the study area. TDS ranged from 201 to 3,612 µs/cm. Very high values of TDS in the region are due to salt encrustations because of the geogenic and anthropogenic activities.



The fluoride concentration in the groundwater samples ranges from 0.25 to 5.45 mg/L (mean 2.85 mg/L), with 32 % of the samples containing fluoride concentrations that exceed the WHO drinking water guideline value of 1.5

mg/L and 10 % samples exceeding the BIS guidelines of 1 mg/L. Almost, SW- part of the study area exhibits fluoride concentration more than the permissible values as per WHO guidelines, with few exceptions in the central and north eastern region of the study area. The lowest concentration of Fluoride is reported from Ramakrishnapuram village i.e.0.28 ppm which is below the WHO & BIS standards and Maximum concentration of fluoride i.e. 5.45 ppm is reported from Gangirenigudem village, located to the Western part of the study area. The highest concentration of fluoride i.e. 5.45 ppm found in the Granitic terrine and more than 1.5 ppm concentration of Fluoride reported from from the following villages such as Rajapally(2.1 ppm), Sadanpally(2.6 ppm), Abbapur(2.0 ppm), Mallampally(2.05 ppm), Jangalpally (2.4 ppm) and Madanpally(2.0 ppm), Manchinilla pally (1.9 ppm), Nizampet (1.57 ppm), Koppula (1.95 ppm), Venkateshwarapally(1.91 ppm), Narsimhareddy pally (1.91 ppm), Chataraj pally (1.67 ppm), Keshapur (1.61 ppm), Madanpally (2.07 ppm)

Table 1 Analytical data of fluoride in the study area.

Fluoride Analytical Data for the Groundwater Samples from the study area			
Sr. No	**Sample ID**	**Fluoride (ppm)**	**Village Name**
1	H.P-1	1.604	Mallampally
2	B.W-3	1.889	Manchinillapally
3	H.P-4	2.1	Rajupally
4	D.W-6	2.596	sadanpally
6	D.W-9	5.484	ganginenigudem
7	D.W-10	1.57	Nizampet
8	D.W-12	1.958	koppula
9	H.P-17	2.007	Abbapur
10	H.P-20	1.918	Venkateshwarapally
11	H.P-23	1.911	Narsimhareddy pally
12	B.W-24	2.054	Mallampally
13	H.P-32	2.465	Jangalpally
14	D.W-33	2.125	Jangalpally
15	D.W-40	1.675	Chataraj pally
16	D.W-41	1.616	Keshapur
17	D.W-48	2.079	Madanpally
18	H.P-7	1.273	katrapally
19	H.P-8	1.299	Suryanaik thanda
20	D.W-18	1.17	Abbapur
21	H.P-38	1.033	Dubbapalli
22	H.P-45	1.432	Papayya pally

CONCLUSION

These analyses were performed to provide scientific evidence for policy support in groundwater resources management and planning in the region. High levels of fluoride in groundwater lead to health hazards such as dental fluorosis and skeletal fluorosis, leading to molting and pitting of teeth, stiffness and rigidity of joints, and bending of spinal cord. The concentration of fluoride (almost 42 % of the samples) was well above the maximum permissible limit set by Bureau of Indian Standards and World Health Organization. The study also finds that field kits can be a reliable method for onsite testing of fluoride and the households could be conveyed the results so that they avoid drinking and cooking with fluoride enriched groundwater and thus lower exposure to fluoride and its health impacts. The results indicate that the high fluoride in groundwater is basically geogenic in nature. Hydro-geological settings coupled with high evaporation rate and high temperature are controlling factors for fluoride enrichment. The interaction of water with fluoride-rich minerals enforces the geochemical facies of water towards Na-HCO3 type, which in turn favors dissolution of these minerals. The presence of high HCO3, sodium, and pH favors the release of fluoride from aquifer matrix into groundwater. The granite in the area contains abundant fluoride and during weathering, fluoride can leach and dissolve the aquifers. The oversaturation of samples with respect to calcite and under saturation with respect to fluorite makes it feasible for fluoride to get released in groundwater. The climate coupled with geochemical processes is found to be main controlling factors for higher concentration of fluoride. It is recommended therefore, that piped water should be provided to the residents for drinking and cooking purposes after proper analysis only. Besides, the use of existing handpump and tubewells, having high fluoride sources, may be restricted for washing, bathing and other such purposes

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Ground Water Exploration and Exploitation in Ranga Reddy District

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ABSTRACT

In this paper, a brief practical review is presented on the statistical evidence showing that the ground water in Ranga Reddy district and the entire Hyderabad district is a rugged terrain with denudation hill of granitic rocks rising up to a height of 613m above m.s.l., and ridges of dolerite and quartz reefs extending over several kms. The western part of the area is a plateau with step-like topography. The sea is drained by the eastward flowing Musi River. Osmansagar and Himayatsagar are located west of the Hyderabad which forms the main source of drinking water to the twin cities of Hyderabad and Secunderabad. The picturesque Hussainsagar lies in between the twin cities. Use of water for irrigation purposes from Musi has however, been banned because of the rights created for Hyderabad City water supply in the shape of Osman Sagar and Himayath Sagar for drinking water and irrigation rights to Musi projects in Nalgonda District. A reservoir called Osmansagar across the Musi and another called Himayathsagar across the Eisa river. a tributary of the Musi are situated at a distance of 19.31 and 9.66 Kms. respectively from Hyderabad.

Keywords: Ground water, resources, ranga reddy, water.

INTRODUCTION

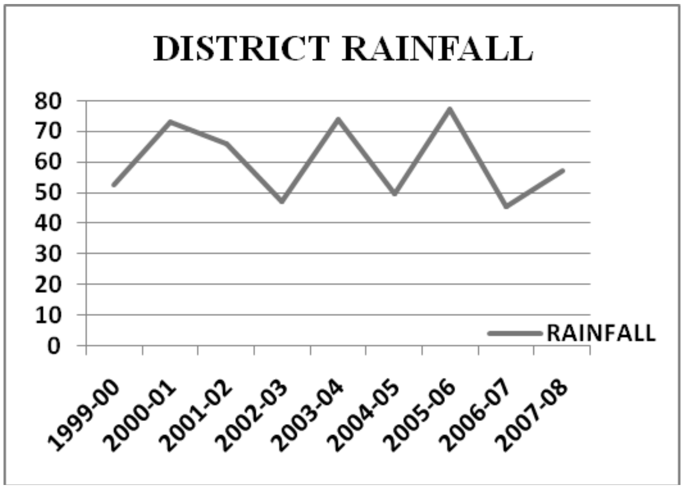
The Ranga Reddy District area predominantly exposes, rocks of Peninsular Gneissic Complex (PGC) along with enclaves of schists (older metamorphic), basic dykes (proterozoic), Bhima group comprising Upper; Proterozoic sedimentary formations and a thin cover of Deccan Traps (Cretaceous to Paleogene) and laterite. The schistose rocks trending NNW-SSE to NW-SE, occur as enclaves within the granitiods. They include predominantly amphibolites, hornblende-biotite schist, occasional quartzite, ferruginous quartzite, hornblendes, pyroxene granulite, talc schist an garnetiferous quartz-sericite schist. Bands of migjatites resulting from intermixture of the granitoids and the older metamorphic occur at several places. Granite (s.s) is widely distributed throughout the area. It is grey to pink, medium to coarse-grained, porphyritic or nonporphyritic and massive. It occupies higher topographic levels forming denudational hills, dome-shaped mounds (inselbergs) and boulder outcrops.

The granitoid complex is associated with profuse injections of aplite and fine grained quarzo-feldspathic veins and pegmatite, quartz veins and reefs which trend NW-SW, N-S and NNE-SSW. The length of these bodies varies from few metres to a few hundreds of metres with the widths varying from 7 to50m. Basic intrusive which include dolerite, gabbro and pyroxenite, cut across all the rocks in the area. These dykes are oriented E-W, NE-SW and N-S with widths of 7 to 50m and lengths upto several kms. Upper Proterozoic sediments of Bhima Group unconformable overlie the granotoids in the western most part of the area. These area represented mainly by limestone sequence intercalated with shale and sandstone. The basaltic lavas of the Deccan Traps cover either the Bhima sediments of the granitoids , around Vikarabad, Tandur and Pargi. These include different flows of basalt and intertrappean beds. The thickness of each flow varies from 15 to 20m. intertrappean beds, red bole and vesicular tops are some of the characteristic features in the Deccan Trap country.

The vesicles are filled with secondary minerals like chalcedony, drusy quartz, calcite and zeolites. The Deccan basalts are hard and fine to medium-grained. Infra-trappean beds are thin and comprise conglomerate, chert and sandstone. Infra-trapean beds(Upper Cretaceous) comprise conglomerate, grit, sandstone, marl and chert. The thickness of infra-trappean, varies from 0.5 to 8m and these are fossiliferous. In situ weathering of basaltic flows resulted in the development of laterite. The District has a normal Rainfall of 781.5mm the bulk of which is received through the South West Monsoon during the period from June to September. The Actual Rainfall received during the year 2003-2004 is 885.7 mm.

District Rainfall

Ranga Reddy district receives a normal annual rainfall of 783mm, which ranges from 558mm at Shamirpet mandal to 961mm at Vikarabad mandal. The annual rainfall data of 37mandals for the period 2000-2005 along with its departure from normal is given in table-2. The spatial variance of annual rainfall was very high during the year 2004-05 which 28%. The district had 34%defict rainfall during the year 2004-05, which had a minimum of 373mm at Kandukur mandal and maximum of 1012mm at Shankarpally mandal.



The mean district rainfall distribution and its departure from normal for the period 1995-2005 was depicted in graphically in Fig.2 the figure indicates that the mean rainfall ranges from 597mm in 2004-05, which is 24% less than normal to 1133mm in 1998-99, which is 45% above normal. During the last decade rainfall was below normal in 4years viz., 1997-98, 1999-2000, 2002-03, and 2004-05. The cumulative departure of annual from normal indicates the extent of drought at a place. In the district, the cumulative departure of annual rainfall was categorized as scanty i.e., more than 60% below normal, in 14mandals and 'deficit' i.e., below normal by 20% to 59% in 5 mandals. In the remaining 18mandals, the rainfall was above normal. On an average, the district rainfall condition was 'scanty' i.e., deficient by -34%from normal.

1depth of Water Level

In order to monitor the changes in ground water scenario Central Ground Water Board established a network of observations wells, dug wells, piezometric wells and collects data 4times a year viz., in the months of January, May, August and November.

Pre-monsoon*:* During pre-monsoon period in the month of May, 2005 depth to water level varied between 2.78 and 26m with general depth to water level range of 10-20m. A majority of the observation wells 62% registered water levels in the range of 10-20m, followed by 30% of 5-10m range in the western part of the district 6% of the wells recorded water level of more than 20m in the south eastern portion of the district

Post-monsoon: The depth to water level ranges from a minimum of G.L. to maximum of 19.76m. during post-monsoon period. About 42% of the wells registered water levels of 2-5m, 33% wells registered 5-10m, 21% wells registered 0-2m and 6% wells registered 10-20m in the south eastern portion of the district.

Water Level Fluctuation

The rise in water level between pre-monsoon and post-monsoon ranges between 0.34-16.10m. The rise in water levels is mostly between 2-12m

Ground Water Exploration

The Central Ground Water Board undertook special ground water exploration studies under Canadian Assisted Ground Water Project(CAGP) during 1971-75. An area of about 4764sq.km was covered under this project in the district. During the studies, 81 Exploratory Wells and 45 Observation Wells were constructed in both granitic and basaltic terrain. Later 11 exploratory wells were converted into piezometers.

The depth of borewells ranges from 36-164m. the discharge of wells ranged from meager to 2lps. The productive aquifer zones in granitic terrain were met at depth between 15 and 50m bgl. The transmissivity of fractured granites ranged from 19 to 290sq.m/day. The specific yield of pheratic aquifers range from 0.001 to 0.004.

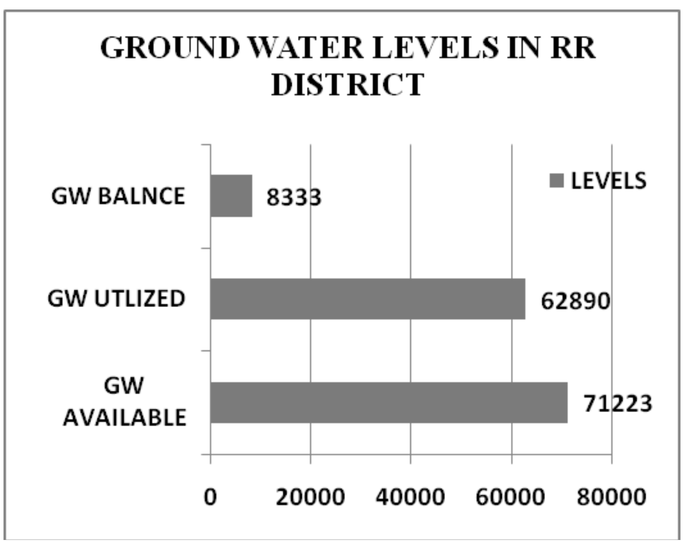
In lateritic basaltic terrain, ground water occurs in laterite-basalt contact zones, weathered and fractured basalts, vesicular basalts and lenses associated with inter-trappean beds. The transmissivity of vesicular basalts ranges from <1 to about 198 sq.m/day. The specific yield varies from 0.01 to 0.02.

A study of lithological logs of these wells reveals that the thickness of the Deccan Traps range between 30 and 77m. Weathered vesicular fractured and massive traps are normally encountered successively. The thickness of weathered zone ranges from few cm to about 18m. in granitic terrain, the exploratory wells drilled down to 164m has revealed that in general the weathered zone is followed by massive granite with occasional fractured zones of limited thickness. The number and depth of fractured zones encountered vary widely from place to place. Safe yield estimates have been made based on data collected on exploratory boreholes drilled by CGWB and other agencies. The safe well yield in upland(recharge) areas of granitic terrain ranges from 1 to 5ha.m/yr. In general, lower values of safe yields prevail in uplands and higher values in valley bottoms.

During 1996-97, 17 piezometers were constructed for the purpose of monitoring the water levels. The depth range of these wells varies from 20 to 70m. Out of 17 piezometers drilled, 8 are located in granitic terrain while the remaining were drilled in basaltic terrain. In basaltic terrain at 3 location, the bed rock i.e., granite was encountered at Kammeta. Tangedipalli and Kankal at depth of 6m, 24m and 16m respectively. The yield of piezometer wells was less than 1 lps except at Kammeta, where 3lps was recorded. Except the piezometer at Kammeta, all the piezometers have been drilled in pheratic aquifer first water bearing zone. The transmissivity of the aquifer varies from 2 to 5 sq.m/day. During 1998-99, one test well(1 exploratory and 1 observation well) was drilled at Rayaprolu.

Ground Water Resources

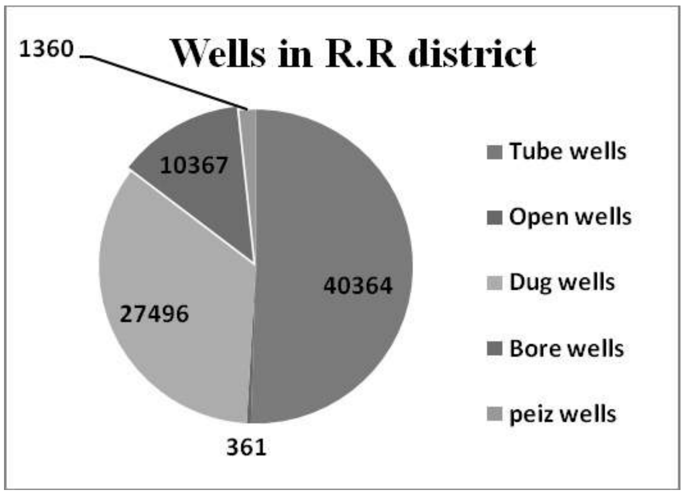
Based on the Ground Water Estimation Committee (GEC-97) norms ground water assessment was done in 2004. The mandal wise details are presented in table3.13 Ground Water resource available is 71,223 ha.m and the Ground Water Utilization is 62,890 ha.m and the Ground Water Balance is 8,333 ha.m for future development.



- Ground water availability in the district is 71223 ha.m
- Ground water utilization in the district is 62890 ha.m
- Ground water balance in the district is 8333 ha.m

Status of Ground Water Development

The district is mainly dependant on ground water for its irrigation due to scanty rainfall and less surface water resources. Majority of the mandals (22) utilize more than 70% of the available ground water resources. Based on stage of ground water development 15 mandals are categorized as safe (less 70% of available resource), 8 semi critical (70-90%) to critical (90-100%) and 12 over exploited (more than 100%). The minimum stage of development is 9% in bala mandal and the maximum stage development of 187% is in Shamirpet mandal. Most of the irrigation in the area is met with the help of 67,860 ground water extraction structures in the form of dug wells, dug-cum borewells and borewells. Since the ground water potential zones ae limited in extent and confined to narrow zones in the district. The intensity of ground water development is very high in pockets spread over in the district. In the district as a whole also, the well density is 9sq.km. Mandalwise distribution well density is furnished. A perusal of the table shows that the well density /sq.km is lowest in the Balanagar mandal(1 well) and is height in Shankarpalli (17well). To meet the domestic water needs of 1681 habitation, 10,367 ground water extraction structures are constructed.

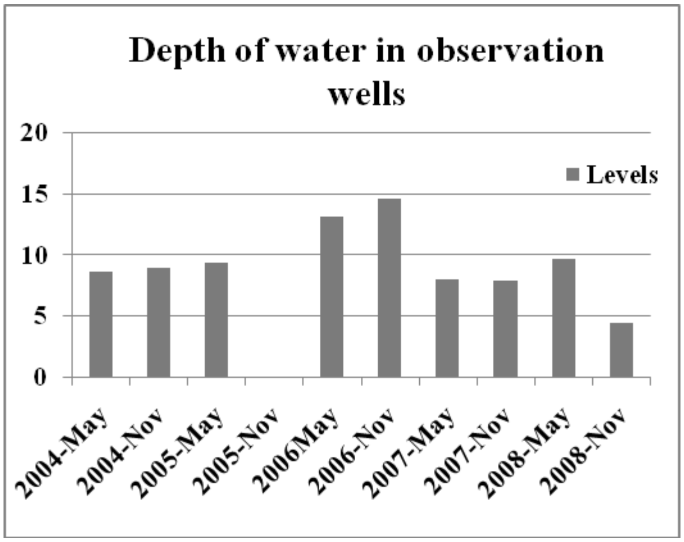


Water Conservation and Artificial Recharge

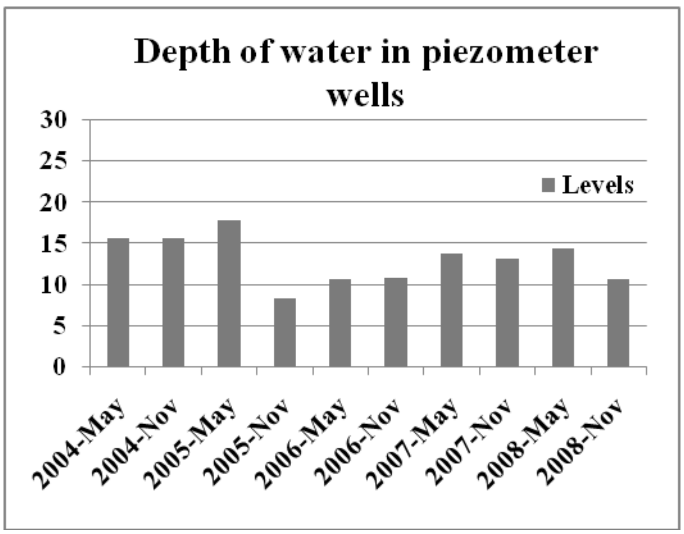
The geomorphological, hydrological, rainfall and landuse pattern in the areas provides ample scope for locating suitable locations for the construction of various types of artificial recharge structures. Central Ground Water Board has constructed a sub-surface dyke during the year 1996-97 at Mondigaurelli village of Yacharam mandal, covering 3.4sq.km of water shed, which has created an additional irrigation potential of 14 ha. Ground Water conservation and artificial recharge works have been taken up by District Water Management Agency in the district under Neeru-Meeru, Watershed and RIDF programs. The structures constructed under these schemes are percolation tanks, check dams, and farm ponds. So far, about 2385 structures are under execution in different mandals to bring each watershed under cultivation to its potential. Modern Irrigation methods viz., Drip and Sprinkler for selected crops will reduce wastage of water. By creating awareness among farmers at village/mandals level and also impart training to the district officials, NGO, water user agencies on water conservation techniques/cropping patterns, water can be saved to a large extent and distress situation among farmers can be brought down substantially. So far, such type of mass awareness programme were conducted at Hayathnagar, Chevella, Keesara mandals, and training programme was also conducted at RangaReddy district Headquarters.

Ground Water Levels

The water levels in observation wells and peizometric wells are represented in the graph for last five years are shown as



The pre monsoon and post monsoon levels are shown in the bar graph for last five years



Ground Water Quality

Depth integrating samplers are used in obtaining samples of water for estimating non-volatile constituents. The former consist only of a mechanism for holding and submerging the bottle. On lowering the bottle at a uniform rate, water enters throughout the vertical profile. Point samplers are use for collecting water at a specific depth below the water surface . in operation the bottle is worked and then thrown into the water with an excess of line. When the bottle comes to rest the suspension line is jerked, removing the cork. The bottle is allowed to fill in place and then stopped while being withdrawn from water all submerging the bottle.

Special equipment and careful technique is necessary for the collection of dissolved gases and constituents affected by aeration. Before a well water sample is taken, the well should be pumped for some time so that the sample will represent the ground water from which the well is fed. All bottles should be rinsed with water to sampled before collecting the sample for analysis. If water sample is collected in glass bottles, sufficient air space may be provided, but if polythene bottles are used, they may be completed filled. All particulars regarding the sample should be return in the field itself, immediately after sampling, and tagged to the sample bottle. Polythene or glass bottles of 1 to 2 litres capacity are usually used for collection of samples. The sample number, date and other particulars are entered in the register in the laboratory. Sample of water should be analysed as quickly as possible after collection. Special treatments may be given for prevention, fixation and handling of water samples before analysis. Otherwise the quality of water may change and many of the heavy metal ions normally present in small quantities in natural water may not remain in water till the sample is analysied. The sample should be freed of its sediment and acidified to about a pH of 3.5 with glacial acitic acid at the time of collection. A little formaldehyde (0.2 m/100 ml) is added to retard mold growth. Seals of the bottles should be tightened before storage. High temperature should be avoided in the storage room.

Quality Characterization of Ground Water in Ranga Reddy District

Hydrogeochemical investigations were carried out in Ranga Reddy district, Hyderabad, India, to assess the quality of ground water for its suitability for domestic and irrigation purposes. The area falls under a semi-arid type of climate and consists of granites and pegmatite of igneous origin of Achaean age. Forty-five representative ground water samples were collected from bore wells to monitor the water chemistry of various ions, comprising Ca^{+2},Mg^{+2},Na+,k+, CO_3^{-2},HCO_3^{-}, $SO4^{-2}$,NO_3^{-},Cl^{-} and F^{-}. The results showed that the concentrations of these ions are above the permissible limits for drinking and irrigation purposes. The pollution with respect to NO_3^{-}, Cl^{-} and F^{-} is mainly attributed to the extensive use of fertilizers and large-scale discharge of municipal waste in to the open drainage system of the area. It is a well–known fact that a polluted environment has a detrimental effect on the health of people, animal life and vegetation. During the last few years, there have been reports of undesirable changes in ground water quality by the people in habiting the study area, which are due to an increase in urbanization, industrialization and agricultural activities. In view of this, hydrogeochemical investigations were carried out in Ranga Reddy district, Hyderabad, to asses the quality of ground water for its suitability for domestic and irrigation purpose

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A Study of Musi River, Ground Water and its Impact on Health of Down Stream Villages of Hyderabad

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ABSTRACT

Environmental sanitation constitutes a serious problem, particularly in the mega cities. Hyderabad has seen rapid economic development and urbanization, and this has included the upgrading of traditional sanitation systems. But the speed of this transition raises concerns about the coexistence of diverging sanitation practices and their impact. This paper discuss about the burden of illness and severity of communicable diseases in recent days due to poor hygienic and to explore the importance of treated water supply. The present study focussed on the Musi River contamination released into the Musi by various sources in the Hyderabad city. These pollutants are responsible for the degradation of aquatic ecosystems and groundwater resources and to provide eco toxicological diagnostic services that would allow them to monitor the harmful impacts caused by the emittants.The areas from peerizadiguda to Pratapasingaram selected for analysis are located at down streams of Musi and the Musi conditions in these regions made worst due to heavy dumping of the organic waste, sewage from various sources from industrial and municipal waste. And the safe water supply for these areas is very less and people of these areas depend on ground water and poor hygiene, sanitary and polluted ground waters, interventions are causing health hazards in these of areas. So, safe treatment of our wastewater and its return to the natural environment (rivers or the sea) is a key part of the water cycle. It protects the life in our rivers and ensures that all water sources are clean and may be easily used for the public supply.

Keywords: water pollution, hygiene, and sanitary, health.

INTRODUCTION

Water is the most essential commodity for all living creatures. Organisms cannot survive without water. Water is one of the most essential constituents of the human environments. The expansion of agriculture and industrial development has not only increased water consumption considerably but has also affected water quality. Water is easily polluted because of its great ability to dissolve substances. Even before raindrops touch the earth, they stand picking up pollutants. Once on the ground, water picks up things rapidly, and becomes contaminated. Hyderabad city discharges about 600 million liters per day untreated sewerage water into Musi River. The drinking water in entire area is brought from distant places; they were spending lots of money. There are at least 30 villages with a population of 1.00.000 that are directly affected in this region. The quality of water in Musi is beyond description (1). Health problems can ensue for agricultural workers due to pathogenic bacteria, viruses and parasites present in the wastewater as well as for consumers of wastewater-irrigated produce particularly if the produce is not cooked before it is consumed. Hookworm infections are more common in agricultural workers who go barefoot in wastewater- irrigated fields (van der Hoek et al, 2002).

This review was done to explore the impact of poor water treatment, hygiene, and sanitary interventions on health conditions, to reduce new and emerging infectious diseases have brought important new challenges to public health. In this research a systematic study has carried out on surface and ground waters pollution in the Musi River Basin, to evaluate its contamination, and causes. Samples of water were obtained from individual water sources (wells) from villages and from surface water sources. Contamination from different sources reaches groundwater through leaching of organic and inorganic fertilizers, animal waste, domestic effluents and industry. The untreated municipal sewage and solid waste into water bodies increases nitrogen concentrations and sometimes can reach more than 60mg/l. The present study is an attempt to report a comparative account of health effects due to untreated municipal sewages, untreated effluent and water quality of the River Musi surrounding water ground. Groundwater pollution has been reported in many aquifers because of high concentration of organic and inorganic compounds in groundwater. The differences in health risks that these variations represent lead to different priorities for the treatment and provision of drinking water. Microbial contamination of drinking water remains a significant threat and constant vigilance is essential, even in the most developed countries. More recent research has suggested a possible association between disinfection by-products and cancer and adverse reproductive outcomes, but potential risks are largely outweighed by the benefits of drinking water with a low microbial load

STUDY AREA

The study area is the upper part of the Musi basin a tributary of river Krishna of Telagana in India and downstream of Hyderabad. The area falls in the Survey of India Topographic map number 56K/10 to a scale of 1:50,000. The area lies between to 17 ° 22 ' 58.8 "N latitude and to 78 ° 39 ' 39.276 "E longitude. The area is located between peerizadiguda to pratapasingaram of Ranga Reddy District, Telagana. The groundwater and river water quality analysis has been carried out for the water samples collected from the five locations located peerizadiguda bore well, RTC colony bore well, parvathapuram bore well, muthylaguda bore well, Pratapasigaram bore well. In the present work attempts have been made to detect the quality by using conventional hydro geochemical methods.

METHODOLOGY

Ground water samples are collected from each location and Physical Properties and chemical properties and biological parameters are analyzed by using suitable methodologies for, PH, TDS, Turbidity, Total Hardness, chlorides sulphates and BOD water quality parameters are assessed. A study has made on these selected areas of population for health hazards due water born diseases by sampling method.

RESULTS AND INTERPRETATION

Table 1 Ground water quality parameters of the study area

parameters	peerizadiguda	RTC colony	Parvathapuram	Muthylaguda	Pratap singaram	Indian standard of drinking water
p^H	7.97	7.83	8.23	7.89	8.51	6-8
TDS	1250mg/l	1820 mg/l	2410 mg/l	2175 mg/l	2250 mg/l	500mg/l
Turbidity	8 NTU	7 NTU	7.3 NTU	7.56 NTU	8.2 NTU	10NTU
Total hardness	340 mg/l	355 mg/l	328 mg/l	329 mg/l	342 mg/l	100 mg/l
chlorides	140 mg/l	138 mg/l	135 mg/l	209 mg/l	202 mg/l	200 mg/l
sulphates	345 mg/l	231 mg/l	246 mg/l	302 mg/l	359 mg/l	200 mg/l
BOD	2.2 mg/l	1.2 mg/l	2.4 mg/l	2.3mg/l	2.6mg/l	3mg/l

1. p^H of the water of the study area are between 8.51 to 7.81 the Parvathapuram and Pratap singaram ground water samples are not within normal range. Hence they are not suitable to be consumed as drinking water, why because due to the industrial effluents, the pH is also altering with the different time intervals at the same stations.
2. TDS, the presence of dissolved salts in the water sample and the study area shows very high amount of TDS which indicates the water in not suitable for direct consumption and different components are responsible for the different types of the health hazards. Like diarrhea, joint pains, skin allergies, gastrointestinal disturbances, and vomiting. These symptoms also persist even by the consumption of agriculture productivity of those areas.
3. Turbidity and colour is slightly varying in the study area, it is due to leaching of Musi River which contain high amount of organic and inorganic wastes.
4. Total hardness is less than total alkalinity then the difference indicates the presence of sodium bicarbonate, It also influences the soil fertility. Excess Alkalinity in water is not good to consume and relatively not better and can cause gastrointestinal.
5. Chlorides: Chloride levels in the study are slightly beyond the limits. It indicates that excess presence of Chlorine in water leads to gastrointestinal, diarrheic, and skin allergies
6. Sulphates induces the formation of sulphuric acid, Hydrogen sulphate, its man may be a cause for the gastrointestinal and skin allergies.
7. BOD are within the limits for the ground water samples of the study areas.

Table 2 Field survey conducted randomly on Jan15 to April-15 in the study area for health hazards

Study Areas	Sample distribution	Skin diseases %	Diarrheic %	Arthis %	Gastero intestinal problems%	Skin allergies %	Malaria %
peerizadiguda	57	55	35	45	45	65	35
RTC colony	63	68	46	52	50	75	45
Parvathapuram	43	46	32	56	44	68	48
Muthylaguda	65	54	37	55	34	85	55
Pratap singaram	85	86	52	65	48	83	58

It has been found that the pollution has been given rise four major problems namely, pollution of drinking large incidence of diseases like arthritis, diarrheic, skin allergies, stomach pain, malaria, food poison, eye diseases, pediatric problems and jaundices diseases suffered by the people, impact on the live stock and cropping pattern in sample villages. Studies conducted by I.P.M. Institute of Preventive Medicine, Hyderabad, Andhra Pradesh. Have certified that water highly polluted containing BOD, COD , TDS, TSS, Nitrates, phosphors, Alkalinity, Total Hardness , , chloride, Fluoride, etc, are rich in these ground water and due to this has force people to buy water from outside , resulting extra burden on their family budget. But people of these areas are with less economic standards. So, they have satisfy with available ground waters and impact of pollution of Musi River surrounding ground water on these selected areas as health effects.

CONCLUSIONS

The city of Hyderabad disposes very large quantities of untreated domestic sewage into the dry bed of the Musi River. Sewage disposal had a mixed impact on downstream users. Poor water quality had a negative impact on farmer health and undesirable. As a result, people in poor areas are falling victim to water-borne diseases. Non-implementation of the environmental laws and hazard planning and growth of Hyderabad city have reduced the Musi river to a sewer drain carrying the domestic and industrial waste generated in Hyderabad city adversely impacting on the river ecology. Drinking water treatment as applied to public water supplies consists of a series of barriers in a treatment train that will vary according to the requirements of the supply and the nature and vulnerability of the source. The Guidelines are now based on Water Safety Plans that encompass a much more proactive approach to safety from source-to-tap. The contamination of drinking water by pathogens causing diarrhoeal disease is the most important aspect of drinking water quality. The problem arises as a consequence of contamination of water by faecal matter, particularly human facial matter, containing pathogenic organisms. The areas from peerizadiguda to Pratap singaram selected for analysis are located at down streams of Musi and the Musi conditions in these regions made worst due to heavy dumping of the organic waste, sewage from various sources from industrial and municipal waste. And the safe water supply for these areas is very less and people of these areas depend on ground water and poor hygiene, sanitary and polluted ground waters, interventions are causing health hazards in these of pratap singaram. So, safe treatment of our wastewater and its return to the natural environment (rivers or the sea) is a key part of the water cycle. It protects the life in our rivers and ensures that all water sources are clean and may be easily used for the public supply.

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Regional Groundwater Flow Modeling of a Watershed in Choutuppal

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ABSTRACT

Due to global concerns over water resources and the increase of environment awareness the importance of considering Groundwater resource has become increasingly evident. By creating a Groundwater model it is possible to understand the present and feature scenarios of groundwater. Hence the present study was selected for groundwater flow modeling in a shallow weathered and fractured zone. A region was selected in southern part of India, Telengana state a watershed is situated near Choutuppal village having an area of 6.125 km^2 in the Nalgonda district 60 km to the south-east of Hyderabad. By using Visual MODFLOW 4.2 premium software Maximum model elevation 359m (amsl), Minimum model elevation 262m (amsl) with 2 layers, Grid cell size 50mx50m and giving the properties such as hydraulic conductivity, porosity, recharge, specific yield, specific retention and also the boundary conditions, the model was run for the steady state condition. It was observed that Groundwater flow is towards north side of the region. The groundwater flow velocity in the groundwater was 0.038m/d in x direction, 0.259 m/d in y direction and 0.00022m/d in z direction. Highest head was 342 m and lowest was 324 m. An over draft was observed (2.761 m^3/d) due to excess of draw out of water for various requirements.

Keywords: Groundwater, Confined/Unconfined aquifer, Regional model, Visual Modflow.

INTRODUCTION

The groundwater has become a highly dependent source of water. Hence studying and understanding of the surface and sub surface parameters of a region is very essential for feature dependency on groundwater. It is very difficult to see and understand the complex subsurface moments of water. Groundwater model is prepared to understand the flow moments and predict the present and feature scenarios of groundwater resource of a region. Regional scale groundwater flow modeling studies helps in water resource evaluation and quantifying sustainable yields and allocations to users can be achieved**.** Hence, the present study was undertaken to create a steady-state groundwater model for predicting the flow directions in the study area and to develop a model to simulate regional groundwater flow for proper groundwater management.

REVIEW OF LITERATURE

Haitjema (2010) viewed that a Regional finite-difference models tend to have large cell sizes, often of about 1–2 km on a side. Although, the regional flow patterns in deeper formations may be adequately represented by such a model, the intricate surface water and groundwater interactions in the shallower layers are not. It was proposed to replace the upper MODFLOW layer or layers, in which the surface water and groundwater interactions occur, by an analytic element model (GFLOW) that does not employ a model grid; instead, it represents wells and surface waters directly by the use of point-sinks and line-sinks. For many practical cases, it suffices to provide GFLOW with the vertical leakage rates calculated in the original coarse MODFLOW model in order to obtain a good representation of surface water and groundwater interactions. However, when the combined transmissivities in the deeper MODFLOW layers dominate, the accuracy of the GFLOW solution diminishes.

A model should be constructed as to reasonably portray the behavior of the full-scale system (aquifer) and simulate all the relevant physical parameters, which describe the significant characteristics of the latter. There are enormous models which have come either to predict the future behavior or study the system dynamics (Thangarajan, 2006). To study the interflow characteristics in the multi aquifer setup of a mountainous watershed, a study area in the Maharashtra state of India has been examined. The three-dimensional groundwater flow algorithm MODFLOW has been used to develop the base case model, incorporating observed subsurface flow conditions. The objective is to study the behavior of artificial recharge techniques, such as percolation tanks and recharge wells, in an unusual flow condition of a mountainous watershed. Results of the analysis indicate that the interflow followed an integrated and continuous hydraulic gradient across multi aquifers. Finite aquifer extents supplement the recharge and discharge processes. These findings could be useful in planning artificial recharge schemes. (Majumdar, 2009)

For analyzing groundwater velocity and its response to various pumping strategies in two stages, viz., steady and transient conditions Mondal (2011) developed a groundwater flow model for a tannery belt using Visual MODFLOW Premium 4.4. The steady state model was calibrated for April 2001; whereas the transient model was employed to forecast groundwater flow under various pumping strategies. The results showed that the total groundwater abstraction was about 80.43% of the groundwater recharge, but 10.25% was used up by evapotranspiration. The groundwater velocity, which is important for contaminant migration, varied from 0.21 to 0.52 m/d in the tannery cluster. The model was more sensitive to recharge from rainfall, hydraulic conductivity and specific yield. Finally, the model showed that the aquifer could sustain a pumping rate of 24892 m^3/d without further decline in water level.

RESULTS AND DISCUSSIONS

The study area consists of southern part of India, in Telengana state a watershed situated near Choutuppal village in the Nalgonda district 60 km to the south-east of Hyderabad (Latitude: 17_1704700N; Longitude: 78_5501200E) as shown in Fig.1.The lithological description consists of Red soil from the first decimeters to 1.0m rich in iron and/or aluminum oxides. Sandy regolith from about 1–3 m deep: yellowish color, sandyclay composition, sandy texture with a lot of quartz grains. – Saprolite from about 3 to 13–24 m deep, derived from in situ weathering of granite. The upper part of the granite is highly weathered and fractured but the fracture frequency decreases rapidly with depth, and did not reveal the presence of any vertical geological heterogeneity. The thickness of the saprolite varies from place to place and increases northward.

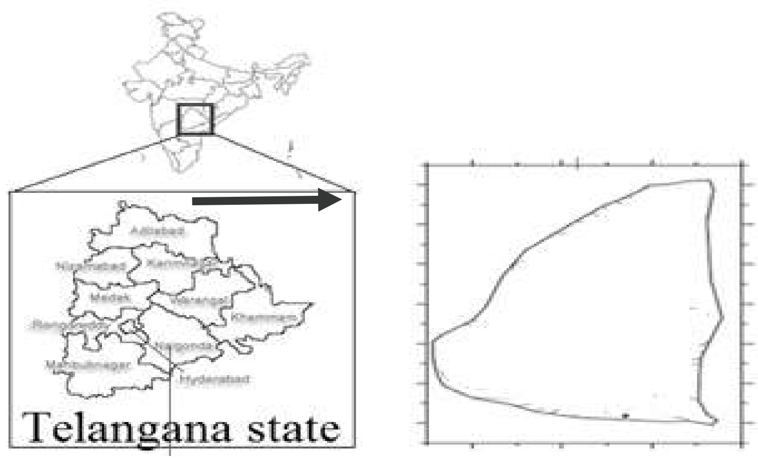


Figure 1 Study area

The model area has a rectangular geometry and is 1.75 km from East to West and 3.5 km from North to South. In order to set up the model in MODFLOW with a set of codes, the area of interest (an area: 6.125 km^2) was divided into a series of grid blocks or cells. According to Haitjema, regional groundwater flow patterns in deeper formations can be adequately represented by large cell sizes of about 1-2 km. In the present study, as shown in Fig.2 different values for rows and columns were given for obtaining convergence to the model domain. The model was checked for various values and concluded to have 35 columns and 70 rows.

The geographic boundaries of the model domain are given in the world co-ordinate system, and have lower left corner co-ordinates at 278250 and 280000 representing X and Y co-ordinate respectively. These values were used as X min and Y min in the model setup window of Visual MODFLOW. Similarly, the upper right model corner is 1912250 and 1915750 for the X and Y coordinates and these are used as X max and Y max in the model setup window of Visual MODFLOW

In the present study, a cell size of 50m x 50m amounting to a total number of grids equal to 2450, of which 1391 active grids were considered . The elevation of the top of shallow aquifer is 359m (amsl), while the bottom is

262m (amsl). Both the top and bottom elevations of the aquifer were defined with respect to above mean sea level (amsl) in grid form with the use of SURFER v.9.0 using the kriging method and converted into ASC-format, which was imported into the model under the MODFLOW environment. Fig.3 indicates the thicknesses of the two layers along the entire cross section (278250 Easting to 280000 Easting) of the aquifer.

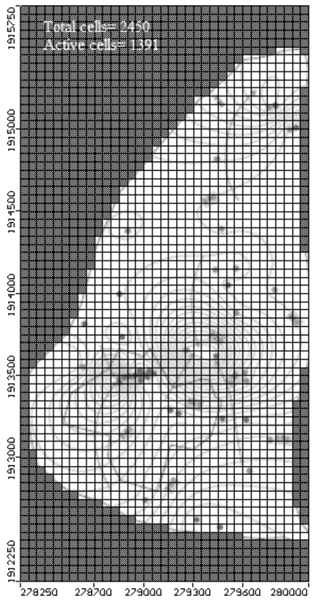


Figure 2 Discritization of cells

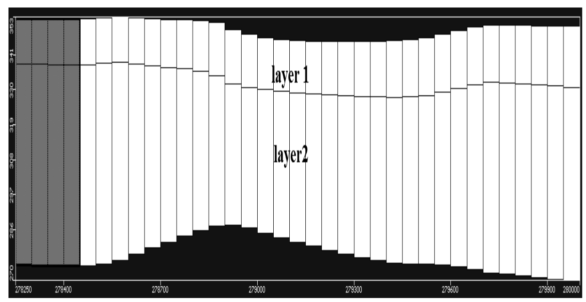


Figure 3 Typical cross sections of layers

The hydraulic conductivity of the saprolite (Layer 1) in the hard rock aquifer of the study area varies between 0.0864m/d and 8.64m/d. The hydraulic conductivity values in the fractured zone (Layer 2) were estimated by extrapolating the observed conductivity values from the observation wells which are present in the EHP (NGRI) using Modflow environment by kriging method. The hydraulic conductivity values assigned for different zones of the two layers as shown in Fig.4

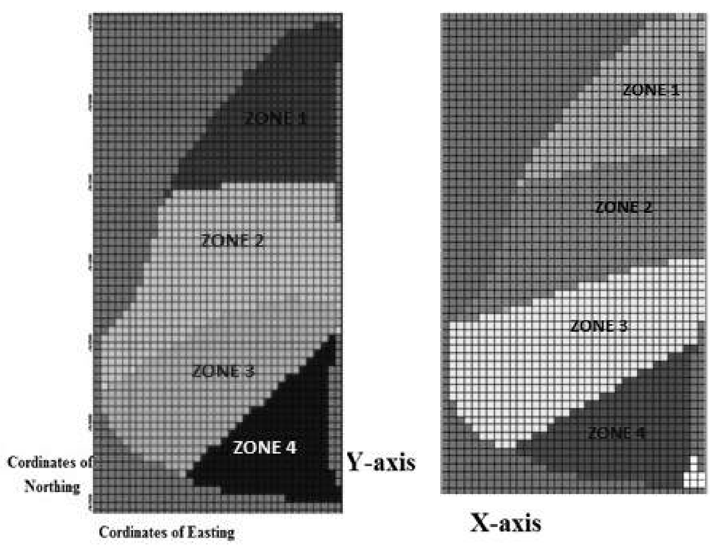


Figure 4 Hydraulic conductivity of layers

The spatial distribution of the input recharge is shown in Fig.5. This data was classified into six zones. The average annual recharge is about 50 mm/year. Hence, the recharge values for adjusted for the convergence of the solution ranging from 30 to 70 mm/year. Fig.6 shows window of the software in which assigning of inputs in the soft ware for constant head boundary condition. Constant head boundary of 335m (amsl) was assigned as input for the present study area for 365 days. The constant head values were assigned only to the cells at the model boundary.

One of the methods of expressing model results is through the water balance. Water balance data provides both as an indication of the relative magnitude of flow components as well as a means to check that the model solution has remained stable. If there is an error in the iterative solution, then it is likely to show up in the water balance. External stresses such as wells, areal recharge, and drains are simulated to calculate the water budget of the total area. Flow budget calculated to show the difference between the inflow and outflow in the model domain is indicated in Table 1. In a steady-state simulation, no change in storage occurs and presents the percentage contribution of each component i.e., 530.11m^3/d of the input is from recharge and 158.74m^3/d is from constant head boundary. Fig.7 shows zone budget details.

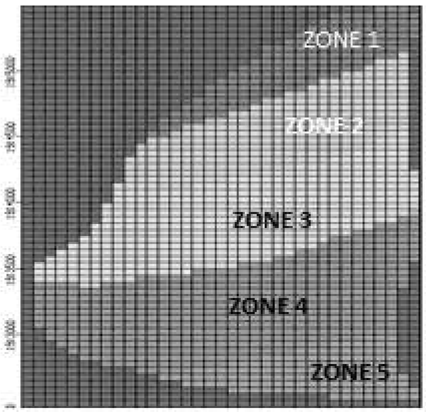


Figure 5 Recharge zones

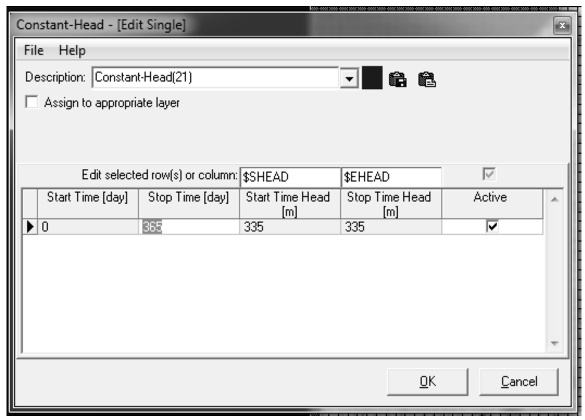


Figure 6 window of input boundary condition

Table 1 Water balance results

Item	In (m^3/d)	Out (m^3/d)
Constant head	0	158.74
Well	0	357.37
Et	0	0
Recharge	530.11	0
Total	530.11	532.87

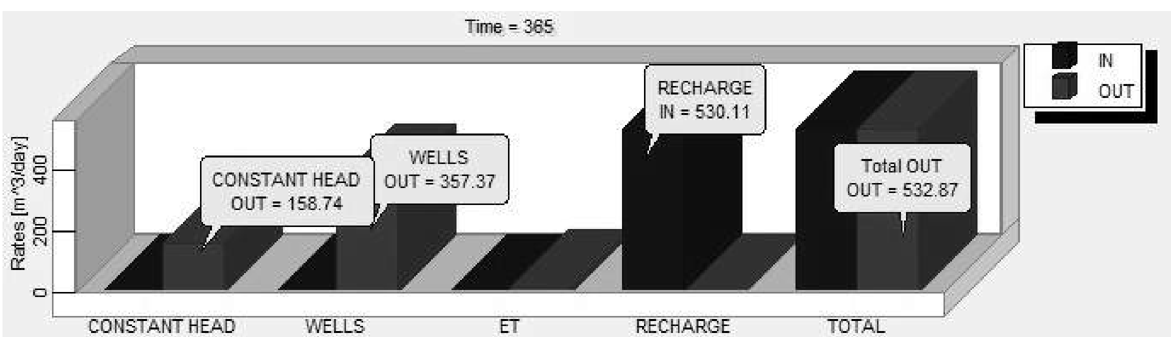
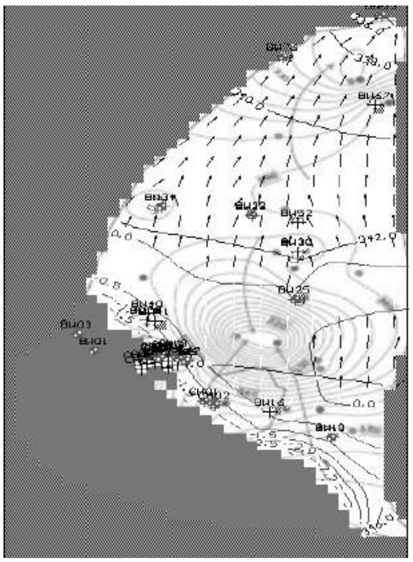


Figure 7 Zone budget

The first layer in Fig.8 shows some of the dry cells in that region. The arrows in Fig.8 are depicting the groundwater movement towards North. The analysis of the first layer indicates, if there is a continuous movement of groundwater about a year, the flow will be moving towards North resulting in no flow condition in dry cells. These cells indicate that there is no groundwater movement in that layer. The second layer shown in Fig.9 indicates that there are no dry cells and the flow direction is towards north of the selected region. The highest equipotential line in the region is 342m (amsl) and the lowest was 336m (amsl)



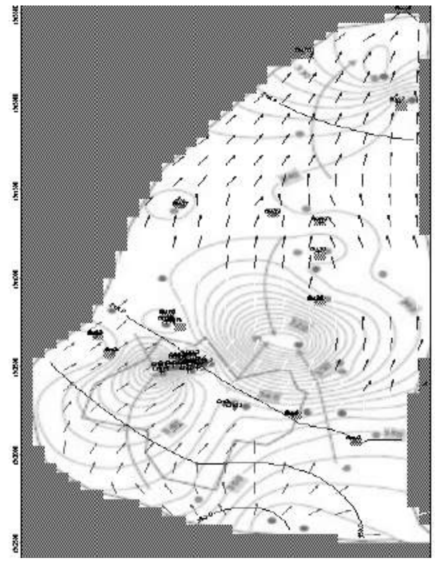


Figure 8 Groundwater flow movement in layer 1 **Figure 9** Groundwater flow movement in layer 2

The model is calibrated to ensure that the simulated water levels are matched with the observed water levels. It is important to show that there is no systematic error involved in the spatial distribution of differences between modeled and measured heads, observations heads for the steady state.

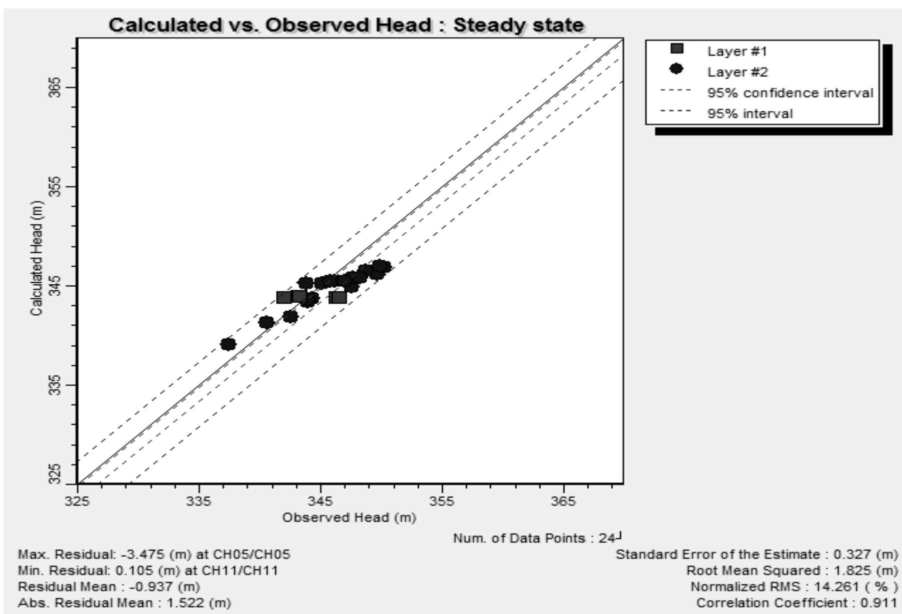


Figure 10 Calculated vs observed heads for steady state

The simplest way to do this is to present a scattergram. Scattergram plot is produced with measured heads on the horizontal axis, and simulated heads on the vertical axis, with one point plotted for each pair of data at selected monitoring sites. Fig 4.10 shows the linear regression plot of the measured and observed heads with a coefficient of determination (R^2) as 0.911, which indicates a very high degree of correspondence between the simulated and interpolated heads.

Simulation of the steady state condition of the groundwater system has been done. However, there are uncertainties in input parameters involved during the model calibration. The model has several limitations due to its assumptions. For steady-state conditions, the transient hydrologic processes are ignored. These include variable and intermittent pumping-well rates, as well as seasonal and annual fluctuations in precipitation, and evapotranspiration. To reduce these limitations as much as possible, the following improvements are recommended for future modeling. Collecting and evaluating data to improve critical components of the system such as the aquifer and boundary conditions.

CONCLUSIONS

Based on the present investigation the following conclusions are drawn. The flow of ground water is towards the north side of the region. The maximum velocity in the first layer is 0.18m/d. The maximum velocity in the second layer is 0.077m/d. The observed and calculated heads are in a good agreement with the model with a correlation coefficient of 0.91. An over draft (difference between in flow and out flow) of 532.87-530.11 = 2.76 m^3/d was observed due to excess with draw of water for various requirements.. From the equipotential lines it is possible to decide the depth of drilling for the proposed wells in the study area. The ground water head is decreasing from 342m (south) to 324m (north). Therefore, it is suggested to go for wet/cash crops in this region as the prospects of groundwater availability are high.

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THEME - V

Water Quality, Water Treatment, Pollution and Society

Defluoridation of Water using: Activated Carbon Derived from Collard Green Leaves: Batch Techniques

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ABSTRACT

The ability of Collard green leaves based thermally activated carbon to eliminate fluoride from aqueous solution has been investigated. The batch adsorption studies were carried out at neutral pH as the functions of contact time, adsorbent dose, adsorbate concentration, temperature and effect of co-anions, which are commonly present in water. The rate of adsorption was rapid during initial 115 minutes and attained equilibrium. Adsorption isotherms have been modeled by Langmuir, Freundlich isotherms. The data indicate that prepared adsorbent surface sites are heterogeneous in nature and that fits into a heterogeneous site binding model. The enthalpy change (ΔH°) and entropy change (ΔS°) for the adsorption reaction are calculated as +7.648 kJ/mol and +0.05 J/mol K respectively. The adsorption is endothermic in nature. Field studies were carried out with the fluoride containing water sample collected from a fluoride-endemic area in order to test the suitability of the sorbent at field conditions and obtained good success rate.

Keywords: Fluoride, Collard green leaves, adsorption, isotherms, kinetic models**.**

INTRODUCTION

High fluoride levels in drinking water has become a critical health hazard of this century as it induces intense impact on human health including skeletal and dental fluorosis [1]. Though fluoride is an essential constituent for both humans and animals, it can be either beneficial or detrimental to human health depending on the intensity of fluoride in drinking water [2]. In India, the problem is common in places such as Telangana, Tamilnadu, Karnataka, Kerala, Rajasthan, Gujarat, Uttar Pradesh, Punjab, Orissa and Jammu and Kashmir [3]. Free fluoride level in drinking water was identified at 5.01 mg/L in Beemarum, Hasanparthy block of telangana [4]. Fluoride survey in Hasanparthy of Telangana showed a positive correlation between prevalence of dental fluorosis in children and levels of fluoride in potable water is 3.24 mg/L [5]. Adsorption is one of the significant techniques in which fluoride adsorbed onto a membrane, or a fixed bed packed with resin or other mineral particles. Many natural and low cost materials such as red mud [6,7], zirconium impregnated coconut shell carbon [8], cashew nut shell carbon [9], ground nut shell carbon [10] and clays [11] have been used as adsorbents for fluoride removal from drinking water. Recently, amorphous alumina supported on carbon nanotubes [12], aligned carbon nanotubes [13], ion exchange polymeric fiber [14], and an ion exchanger based on a double hydrous oxide of Al and Fe ($Fe_2O_3Al_2O_3xH_2O$) [15] have been assayed for removing fluoride from drinking water as well as industrial wastewater. Thus, it is important to develop or find cheaper adsorbents for fluoride removal from water that have greater fluoride adsorption capacities like the above said adsorbents. This paper concentrates on investigate low cost material for fluoride sorption which can effectively remove fluoride from aqueous solutions at a relatively low level. The novel adsorbent obtained by burning, carbonization and thermal activation of the Collard green leaves, possess appreciable defluoridation efficiency. The thermally activated carbon should have high surface area and strong sorption capacity towards various sorbates [16] and mixed bed activated alumina and coconut shell charcoal [17]. This adsorbent is abundantly available in all dry and wet lands in huge amount. We report here the results of defluoridation studies using Collard green leaves. This study leads to the assumption that fluoride deposition occurs by the forces of adsorption over the surface of the activated carbon and this was characterized by the surface morphological studies of the adsorbent material. In addition, the dynamics and kinetics of the adsorption process are discussed.

MATERIALS AND METHODS

Adsorbent preparation

In the present study, the derived activated carbons from Collard green leaves, common name, tree cabbage, was utilized for the removal of fluoride from its aqueous solution. The Collard green leaves, was cut into small pieces and they were washed several times with water to remove the dirt and other materials attached to its surface. Final washings were done with double distilled water and the leaves were dried in shade. Then the material was dried at 105-110°C for 24 hours and then the carbonized material was powdered and washed well with doubly distilled water to remove the free acid and dried at the same temperature for 3 hours. Later the dried adsorbent was thermally activated in Muffle furnace at 800^0C (here we avoid acid treatment for charring). The resulting product was cooled to room temperature and sieved to the desired particle sizes. Finally, the product was stored in vacuum desiccators until required.

Sorption experiments

The sorption isotherm and kinetics experiments were performed by batch adsorption experiments and were carried out by mixing 1.35 g (obtained by the study effect of adsorbent dose) of sorbent with 100 mL of sodium fluoride containing 3 mg/L as initial fluoride concentration. The mixture was agitated in a thermostatic shaker at a speed of 250 rpm at room temperature. The defluoridation studies were conducted for the optimization of various experimental conditions like contact time, initial fluoride concentration, adsorbent dose, particle size and influence of co-ions with fixed dosage. The reagents used in this present study are of analytical grade. A fluoride ion stock solution (100 mg/L) was prepared and other fluoride test solutions were prepared by subsequent dilution of the stock solution. All the experiments were carried out at room temperature. Fluoride ion concentration was measured with a specific ion selective electrode by use of total ionic strength adjustment buffer II (TISAB II, HI 4010-10, 10 ppm Fluoride std.) solution to maintain pH 5–5.5, at 27.4^0C and to eliminate the interference effect of complexing ions [9]. The pH of the samples was also measured by Glass electrode with bench meter (HI 2216, HANNA Instruments). All other water quality parameters were analyzed by using standard methods [18]. Kinetic studies of sorbent were carried out in a temperature controlled mechanical shaker. The effect of different initial fluoride concentrations viz., 2, 4, 6, 8 and 10 mg/L at four different temperatures viz., 303, 313, 323 and 333 K on sorption rate were studied by keeping the mass of sorbent as 1.35 g and volume of solution as 100 ml in neutral pH. The fluoride concentration retained in the adsorbent phase, q_e (mg/g), was calculated according to [19],

$$q_e = \frac{(C_0 - C_e)}{W} \tag{1}$$

where qe is the amount of fluoride adsorbed (mg/g); C_o and C_e are the initial and residual concentration at equilibrium (mg/L), respectively, of fluoride in solution; and W is the weight (g) of the adsorbent.

Theory of Isotherm models

The abilities of two widely used isotherms, the theoretical Langmuir, empirical Freundlich, isotherms, to model the adsorption equilibrium data were examined. *Langmuir adsorption isotherm* [20] is perhaps the best known of all isotherms, which is often applied in solid/liquid system to describe the saturated monolayer adsorption. It can be represented as:

$$q_e = \frac{q_m K_a C_e}{1 + K_a C_e} \tag{2}$$

where C_e is the equilibrium concentration (mg/L); q_e is the amount of ion adsorbed (mg/g); q_m is q_e for a complete monolayer (mg/g); K_a is adsorption equilibrium constant (L/mg). To evaluate the adsorption capacity for a particular range of adsorbate concentration, the aforementioned equation (Eq. (2)) can be used as a linear form as follows:

$$\frac{C_e}{q_e} = \frac{1}{q_m} C_e + \frac{1}{K_a q_m} \tag{3}$$

The constants q_m and K_a can be determined from a linearised form of Eq. (3) by the slope of the linear plot of C_e/q_e versus C_e.

Freundlich adsorption isotherm [21] based on adsorption on heterogeneous surface is the earliest known relationship describing the adsorption equilibrium and is given by:

$$q_e = K_F C_e^{1/n} \tag{4}$$

where q_e is the amount of ion adsorbed (mg/g); C_e is the equilibrium concentration (mg/L); K_F and $1/n$ are empirical constants, indicating the adsorption capacity and adsorption intensity, respectively. The Eq. (4) may be converted to a linear form [22] by taking logarithms:

$$\log q_e = \log K_F + \frac{1}{n}\log C_e \quad (5)$$

The plot of log q_e versus log C_e of Eq. (5) should result in a straight line. From the slope and intercept of the plot, the values for *n* and *K*F can be obtained.

RESULTS AND DISCUSSION

Effect of contact time and initial fluoride concentration

Contact time plays a very important role in adsorption dynamics. The effect of contact time on adsorption of fluoride onto Collard green leaves is shown in Fig. 1. Batch adsorption studies using the concentrations 2.0, 3.0, 4.0, 6.0, 8.0 and 10.0 mg/L of fluoride solution and with 1.35 g of the adsorbent were carried out at 303K as a function of time to evaluate the defluoridation and adsorption rate constants. The adsorption of fluoride increases with time and gradually attains equilibrium after 115 minutes. From Fig. 1, the time to reach equilibrium conditions appears to be independent of initial fluoride concentrations. Therefore 115 minutes was fixed as minimum

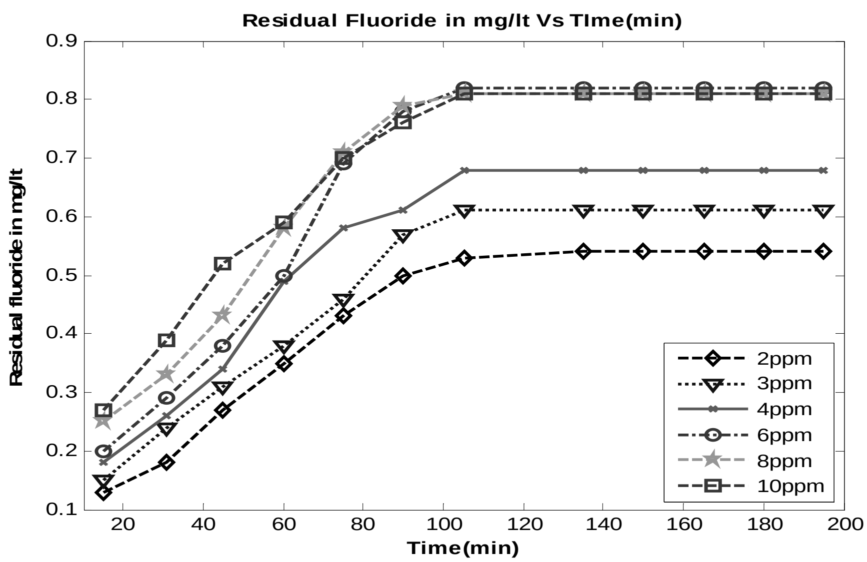

Figure 1 Residual of fluoride adsorbed on Collard green leaves, versus time for different initial fluoride concentration

Contact time for the maximum defluoridation of the sorbent: The adsorption of fluoride increased from 0.51 to 0.84 by increasing fluoride concentration from 2.0 to 10.0 mg/L. Further, it was observed that the removal curves are smooth and continuous indicating the possibility of the formation of monolayer coverage of fluoride ion at the interface of adsorbent.

Effect of particle size

The defluoridation experiments were conducted using collard green leaves with five different particle sizes viz. > 53, 53–106, 106–150, 150–225 and 225–303 µm. As the adsorption process is a surface phenomenon, the defluoridation efficiency of the sample with 53µm registered high defluoridation efficiency due to larger surface area. The percentages of fluoride removal by the sample with different particle sizes are studied. Hence, the material with particle size of 53 µm has been chosen for further experiments. Higher percentage of adsorption by Collard green leaves with smaller particle size is due to the availability of more specific surface area on the adsorbent surface.

Influence of Adsorbent dose

The influence of varying concentrations of adsorbent on the adsorption of fluoride at neutral pH is shown in Fig. 2. While increasing the adsorbent dose proportional removal observed for fluoride until some extent. After that, the curve lapse as flat indicating the higher fluoride adsorption occurs at 1.35 g and the followings remains constant.

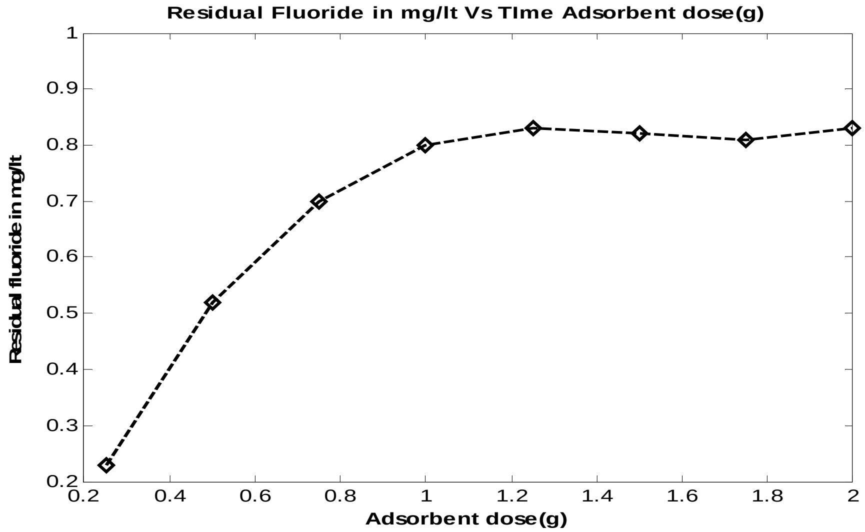

Figure 2 Variation of fluoride removal for different adsorbent dosage at constant temperature.

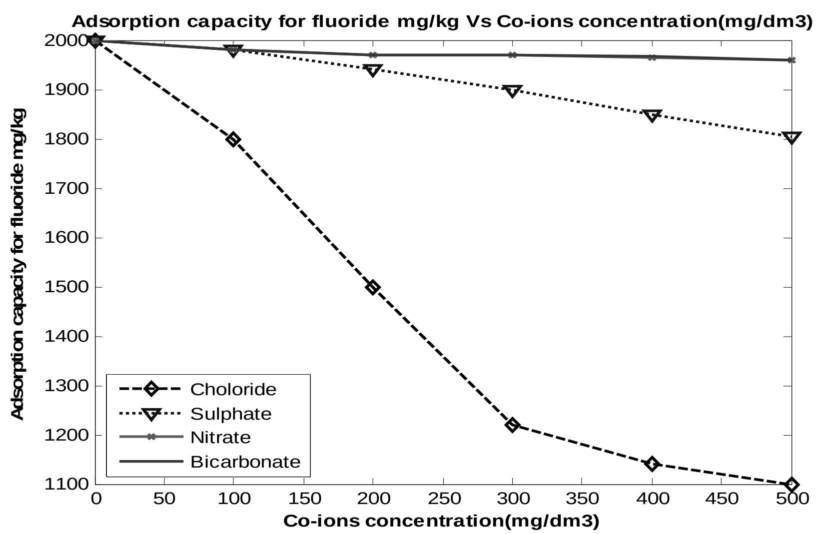

Figure 3 Interference of co-ions on defluoridation studies using Collard green leaves adsorbent.

Effect of Interfering co-ions

The effects of coexisting anions such as sulfate, nitrate, chloride, and bicarbonate on fluoride adsorption by the Collard green leaves adsorbent were examined and the results are given in Fig. 4. Chloride and nitrate did not perceptibly interfere with fluoride removal even at a concentration of 500 mg/L, while sulfate began to show some adverse effects when the SO_4^{2-} concentration increases. However, bicarbonate showed great competitive adsorption with fluoride. The fluoride adsorption amount decreased quickly from 83.7 to 51.5% with the increase of bicarbonate concentration 0–300 mg/L, and then decreased slightly with further increase of bicarbonate concentration. This may be attributed to the competition of bicarbonate ions with the fluoride ions at the active site, on the surface of the sorbents. The selective nature of the fluoride by the sorbent depends on size, charge, polarizability, electro negativity difference, etc. The order of interference for fluoride removal observed as in the following order, $HCO_3^{-} > SO_4^{2-} > Cl^{-} \geq NO_3^{-}$ for the adsorbent Collard green leaves. Similar trend was reported while studying zirconium impregnated cashew nut shell carbon as a sorbent for fluoride removal [9] and bio adsorbent like Cynodon dactylon [23].

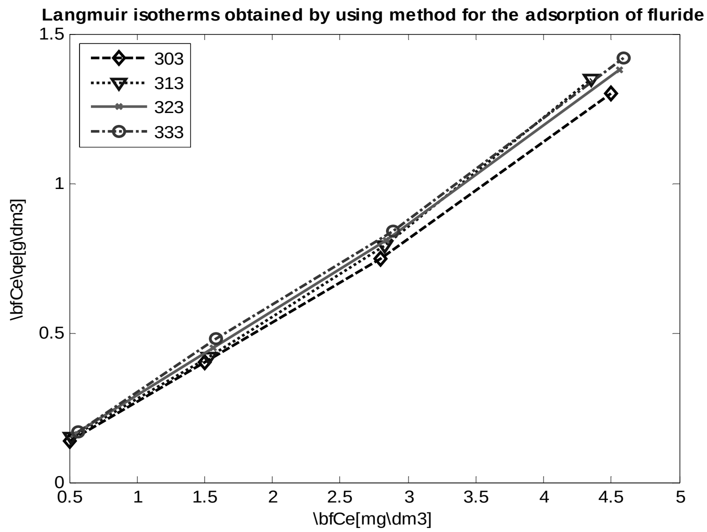

Figure 4 Langmuir isotherms obtained by using linear method for the adsorption of fluoride using activated adsorbent at various temperatures.

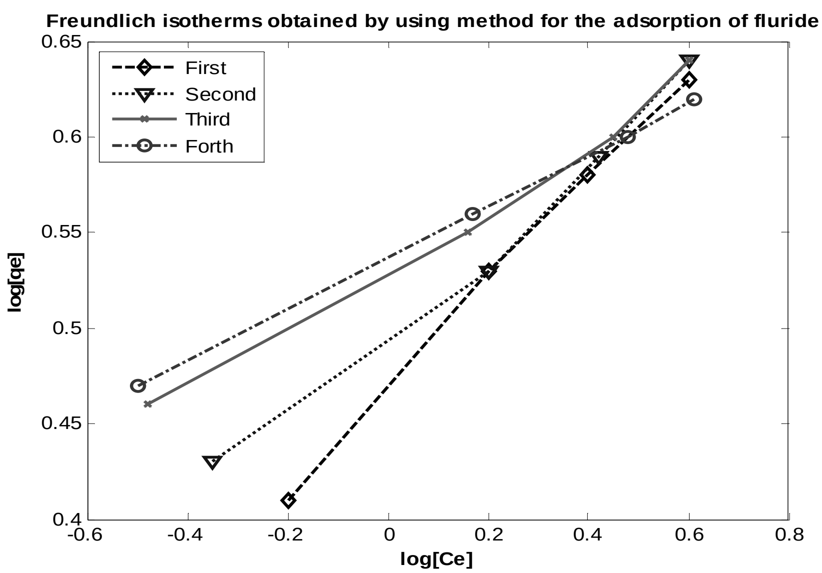

Figure 5 Plot of the Freundlich isotherm for fluoride adsorption on Collard green leaves.

Adsorption isotherms

The equilibrium data isotherm analysis for fluoride adsorption onto the Collard green leaves at pH 7.0(± 0.2) and a temperatures of 303, 313, 323 and 333 K are shown in Fig. 4, 5. Results indicate that the adsorbent has a high affinity for fluoride adsorption under these conditions. The equilibrium data has been analyzed by linear regression of isotherm model equations, viz. Langmuir (Fig. 4), Freundlich (Fig. 5). The related parameters obtained by calculation from the values of slopes and intercepts of the respective linear plots are shown in Table 1. The present data fit the Langmuir models (Fig. 4) well ($r2 > 0.99$). The average monolayer adsorption capacity (qm) obtained for Collard green leaves is 4.502 mg/g. However, the Freundlich isotherm model, based on multilayer adsorption, described the data fairly well (r =0.994–0.997).

Table 1 Isotherm parameters obtained using the linear method for the adsorption of fluoride onto Collard green leaves at different temperatures.

Isotherm	Parameters	Temperatures (K)			
		303	**313**	**323**	**333**
Langmuir isotherm	*q*m (mg/g)	4.529	4.601	4.673	4.704
	*K*a (dm3/mg)	1.497	1.802	2.001	2.213
	r	0.987	0.999	0.976	0.999
	SSE	0.011	0.012	0.012	0.013
Freundlich isotherm	*K*F $((mg/g)(dm3/mg)^{1/n}$	3.034	3.313	3.441	3.453
	1/n	0.213	0.202	0.198	0.181
	r	0.984	0.986	0.987	0.999
	SSE	0.017	0.013	0.009	0.009

This indicated that the adsorption of fluoride onto the adsorbent might be happened by chemisorptions with physical forces. Hence, the order of isotherm equations obeyed by the present data is Langmuir > Freundlich isotherm.

The effect of isotherm shape can be used to predict whether an adsorption system is ‘favorable’ or ‘unfavorable’

Thermodynamic parameters

The effect of temperature has a major influence in the sorption process and hence the sorption of Collard green leaves was monitored at four different temperatures 303, 313, 323 and 333 K under the optimized condition and thermodynamic parameters viz., and free energy change (ΔG^o), standard enthalpy change (ΔH^o) and standard entropy change (ΔS^o) were calculated [24]. Thermodynamic parameters related to the adsorption process, i.e., Gibbs free energy change (ΔG^o, kJ mol^{-1}), enthalpy change (ΔH^o, kJ mol^{-1}), and entropy change (ΔS^o, J mol^{-1} K^{-1}) are determined by the following equations:

$$\Delta G^o = - RT\ln Kc$$

$$\Delta G^o = \Delta H^o - T\Delta S^o$$

where Kc is the equilibrium constant, which can be obtained from Langmuir isotherm, R is the universal gas constant, 8.314 J mol^{-1} K^{-1}, and T is absolute temperature (K) and presented in Table 2 (Fig. 6). The negative values of ΔG^o indicated the spontaneity of the sorption reaction. The positive values of ΔH^o indicated the endothermic nature of the sorption process. The positive value of ΔS^o showed the increasing randomness at the solid/liquid interface during sorption of fluoride. The results showed the increase in adsorption capacity of fluoride with increasing temperature, which is presumably due to control of the adsorption process by diffusion phenomenon. Thus, the result indicates the endothermic nature of the diffusion controlled adsorption process. It also indicates the increased disorder in the system with changes in the hydration of adsorbing fluoride ions [24].

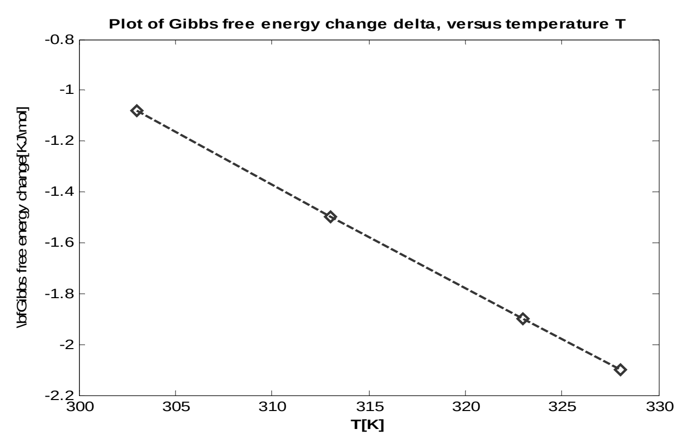

Figure 6 Plot of Gibbs free change ΔG^o, verses temperature T.

Table 2 Thermodynamic parameters of fluoride sorption on Collard green leaves.

S.No	Thermodynamic Parameters	Temperature (K)	Thermodynamic Values
1	ΔG^o (kJ/mol)	303	-1.163
		313	-1.502
		323	-1.896
		333	-2.016
2.	ΔH^o (kJ/mol)		8.726
3.	ΔS^o (J/mol K)		0.038

Field trial

The defluoridation efficiency of Collard green leaves in the field level was experienced with the sample collected from a near by fluoride-endemic villages. About 0.5 g of sorbent was added to 100 mL of fluoride water sample and the contents were shaken with constant time at room temperature. These results are presented in Table 3. There is a significant reduction in the levels of other water quality parameters in addition to fluoride. It is evident from the result that the sorbent, *Collard green leaves* based adsorbent can be effectively employed for removing the fluoride from water.

Table 3 Physico-chemical parameters of defluoridated drinking water from field

Water quality parameters	Before treatment	After treatment
Fluoride (mg/L)	3.14	1.01
pH	8.5	7.1
Electrical conductivity (µS/cm)	412	217
Chloride (mg/L)	132	61
Total hardness (mg/L)	402	214
Total alkalinity (mg/L)	342	198

Regeneration study

Any adsorbent is economically viable if the adsorbent can be regenerated and reused in many cycles of operation. For checking the desorption capacity of the sorbent, the material was subjected to an adsorption at an initial fluoride concentration of 3 mg/L. The exhausted adsorbent was regenerated using 0–10% NaOH. At 2% NaOH concentration, Collard green leaves based adsorbent had desorbed up to the level of 67.4% of fluoride. To test the adsorption potential of regenerated adsorbent, two more cycles of adsorption–desorption studies were carried out by maintaining the initial conditions of the same. In third cycle, the adsorbent capacity has shown 17%. From the observations this adsorbent having somewhat reuse potential for fluoride removal.

CONCLUSION

The defluoridation studies of the bioadsorbent Collard green leaves have been carried out in batch mode. The most excellent defluoridation occurred at the optimum time 105 minutes to get the success rate as 83.77% while keeping 3.0 mg/L fluoride concentration and 1.35 g dosage of adsorbent at neutral pH. Thus, it shows superior adsorptive efficiency than previously studied defluoridation works using natural adsorbents [8–10,17,23]. However, the presence of bicarbonate ions interfere the effective removal of fluoride using this adsorbent. The sorption of fluoride using this adsorbent Langmuir isotherms. The sorption process was found to be spontaneous and endothermic in nature. Field studies indicated that Collard green leaves could be used as an effective defluoridating agent. The used adsorbents could be regenerated by 67.4% using of 2% sodium hydroxide. Based on the above said description, Collard green leaves bioadsorbent could be used to remove fluoride selectively from water.

ACKNOWLEDGEMENT

Financial support for the project by the Department of Science and Technology (DST), Government of India, New Delhi under WOS-A (SR/WOS-A/CS-107/2011) research project for giving funding and also SR Eng. College for providing the necessary facilities for the preparation of the paper is gratefully acknowledged.

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Sizing of Street Pipeline for Equity Distribution of Water

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ABSTRACT

Water distribution networks are considered as one of the most important entity in the urban infrastructure system and need careful design not just to serve current requirement but also meet those of phasing construction. The inherent problem associated with the water distribution network is the unequal pressure distribution throughout the network and this pressure becoming insufficient to serve the requirement of increase in population and urbanization. In a country like India where the drinking water supply is intermittent, the users near the source enjoy good discharge with sufficient water head whereas, the users at a faraway junction, never get to experience this. Also, in a street pipeline connection, the service pressure is hardly met and even if it is done, it is not achieved throughout the network. This project aims at sizing the street and building pipeline for equity distribution of water using hydraulic simulation and independent evaluation of head loss in the house connecting pipe using EPANET software. The street pipeline network is designed for the existing population and for phasing construction of Kailashnagar, Trichy, Tamilnadu. The design for meeting the requirements of phasing construction was made in several methods and all the methods were analysed to finally adopt a best economical design serving the requirements of the population growth. For the design of building pipeline connection, a benchmark network was adopted and analysed to get the size of pipeline that serves the purpose

Keywords: water distribution network, equity distribution, hydraulic simulation, epanet.

INTRODUCTION

A water distribution system is one of the major requirements in urban and regional economic development. An economical design of water distribution network is the aim of any agency dealing with the design of water distribution network. Moreover, due to insufficient availability of funds, the design includes only the existing requirement. But what is forgotten here is the protocols of any design of water distribution network, i.e. meeting service pressure head. As stated earlier in abstract, the service pressure is not completely achieved. Moreover, due to urbanization, the designed pipelines prove insufficient to carry the required discharge. And this problem integrates along downstream. Several methods are available today for designing a water distribution network. But this project aims at providing a simple methodology which can be easily understood as well, adopted in design. With the use of computers, the designing procedure becomes fast and lucid. In this project, water distribution network is designed for street pipeline and building pipeline i.e. street to house connecting pipelines. The street to house connecting pipelines play an important role in country like India, as the supply here is intermittent. In this case, in cities like Trichy, the service pressure is hardly reaches 1m. For this reason, the optimized network obtained is considered to design this building pipeline connection. Next comes street pipeline, the problem here is insufficient water supply, pipes and pipe sizes. This happens because the design does not look in phasing construction requirements. In this project, street pipeline was designed for Kailashnagar, Trichy, Tamilnadu, as this area experiences the above stated problem. The distribution network was designed for existing demand and for demand due to phasing construction. For the design of phasing construction requirement, several methods were used to arrive at same result i.e. achieve service pressure head and as economic as possible. The pressure benefit due to the methods used is also discussed. Critical pipes in the network was also identified and mentioned. The effect of increase in tank elevation on pressure head was also dealt. And at the end, the cost comparison was made. The comparison is not meant for obtaining the cost incurred to design for phasing construction requirement but to decide the most economic method.

OPTIMIZATION METHOD

1. Initially, all the links were given a diameter of 200mm(any value that gives a pressure of 3m or more at all the nodes)
2. Next, the diameter of the pipe having the least velocity was decreased to its previous commercial diameter available and the network was run and checked for a minimum pressure of 3m at all the nodes.
3. If the pressure at nodes is more than 3m, the first two steps were repeated till a minimum of 3m pressure is achieved throughout the network.
4. If the pressure at nodes is less than 3m, the diameter of pipe is changed back to its previous diameter, and the diameter of next least velocity pipe is decreased.
5. In this way the network was optimized to get a minimum service pressure of 3m at all the nodes as well as making the design as economical as possible.

Case Study-Kailash Nagar, Trichy City

Kailashnagar, Trichy was considered for the design the water distribution pipeline network. This area has seen growth in its population over last few years. The growth in population poses a problem on the existing water distribution network making it insufficient to meet the growing demand.

The water distribution pipeline network was designed for the existing population and also for phasing construction.

Preparation of Water Distribution Network

Google maps were used to obtain the map of the area and also the lengths of each street. The site was visited to count number of houses along each street and the position of water tank. The empty plots were also counted to design the distribution network for phasing construction. The information about the area, the distribution network, the supply source were obtained from the municipality of the area, which are mentioned below:

Capacity of tank=1 lakh litre, Tank elevation=3m, Source of water: kollidam, Diameter of tank = 6m, Tank depth=6m, Number of house connections = 350

With the help of the data collected, a network was made on EPANET software, which required number of junctions, number of links, lengths of the links, demand at each node, elevation of all the nodes, reservoir elevation, and service water head.

- For making the network, major streets were considered for the layout of pipelines (or the links) and their lengths were obtained from Google maps.
- Demand at each node was calculated with the help of number of houses counted. The demand was first found for each street and it was assigned to the nodes using 50-50 node assignment rule. Number of person per house was assumed to be 6.

  Demand Q=135*6*3 lpd

  Where 135= average per capita demand in lpcd

  6= number of person per person, 3= peak factor
- Elevations of the nodes were obtained from the Google maps.
- Reservoir capacity, water height, and elevation were obtained from the municipality office.
- Service water head at each node was assumed to be 3m.

Once the network was made, it was optimized to get a minimum service pressure of 3m at all the nodes, as discussed above. The optimized Epanet network of Kailashnagar for its current demand is shown below.

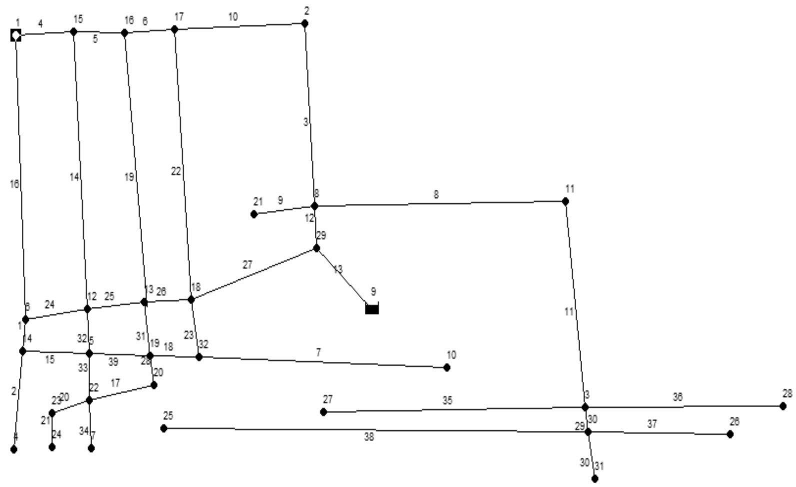

Figure 1. Water distribution network of Kailashnagar

Sizing Of Building Pipeline Connection

In India, the drinking water supply is intermittent and not continuous. And in cities, like Trichy, the service pressure is hardly met and moreover the supply time is insufficient as well. The above optimized network with service pressure of 3m is then considered to find the size of street to house connecting pipeline i.e. building pipeline connection.

Calculation of Demand Per House

Bottom to top approach was followed to size the pipeline in this network. To size the building pipeline, Hazen-William equation and Darcy equations were used and number of person per house was assumed to be six. From the available demand at nodes, demand in pipes were found using 50-5- node assignment rule. In similar way, demand in all the 39 links were found. In India, per capita demand is 135lpd. Now to meet the uncertainties, this was multiplied by 3(factor of safety). This demand is to be supplied in three hours of the intermittent supply which gives 135lpcd in one hour. Now this demand is multiplied by 6(number of person per house). And hence, demand per house was calculated.

Calculation of Size Of Pipeline

For calculation of pipeline size, Hazen-William equation and Darcy equation were used. The length of pipe connecting street to house was assumed to be 10m. the required nodal pressure head was assumed as 3m. The available pressure head in pipeline was calculated by taking average of the pressure head at the nodes at it's end. The nodal pressure head was subtracted from this available pressure head to allow for the head loss and hence head loss was calculated. This head loss was then substituted in the two equations to get the size of the pipes.

Table 1. Diameter of building pipeline connection

Link id	diameter using Darcy eq. (mm)	Diameter using H-W eq. (mm)
1	7.337671418	7.575087471
2	7.33804423	7.575482619
3	7.317615008	7.553830186
4	7.337578233	7.574988703
5	7.333856642	7.571044167
6	7.32617031	7.562897546
7	7.327925568	7.564757896
8	7.317890051	7.554121687
9	7.31578297	7.551888533
10	7.32082771	7.557235144
11	7.32617031	7.562897546
12	7.30104411	7.536268282

Link id	diameter using Darcy eq. (mm)	Diameter using H-W eq. (mm)
13	7.283269099	7.517431437
14	7.333392239	7.570551947
15	7.335529957	7.572817716
16	7.337485055	7.574889943
17	7.333206527	7.570355111
18	7.319266198	7.555580182
19	7.325708818	7.562408426
20	7.336274388	7.573606743
21	7.337951016	7.575383821
22	7.313953681	7.549949806
23	7.30231082	7.537610709
24	7.334228292	7.571438078
25	7.325247502	7.561919492
26	7.313496787	7.549465581
27	7.297792898	7.53282276
28	7.327463413	7.564268069
29	7.333113682	7.570256705
30	7.335716022	7.573014927
31	7.321379309	7.557819757
32	7.332092848	7.569174729
33	7.333949544	7.571142633
34	7.334785979	7.572029171
35	7.336367473	7.573705406
36	7.332556758	7.569666424
37	7.335995173	7.573310801
38	7.338510404	7.575976725
39	7.328202945	7.565051881

Design for Phasing Construction

One of the major problem that water distribution system go through is not being sufficient enough to meet the population demand, reason being old design which focuses only on the existing requirement. With the growth in infrastructure, population, water distribution systems prove insufficient to meet the demand. This project also aims to design the distribution network to meet the demand due to phasing construction. The methodology adopted for the design and optimization is described below:

1. Along with the number of houses, empty plots were counted during the site visit. And this number was included in this design.
2. The demand from these plots were included in the network, which was calculated as :

New demand, Q_1= old demand Q_2 + demand due to phasing construction Q_3

Where

Q_3 = number of plots*6*135*3

6 = number of persons per house

135 = per capita demand

3 = peak factor

Upon including the network, the network was again optimized for a minimum service pressure of 3m. Optimization was done in five ways which are described in next section.

Optimization at Initial Stage

In this method, the demand due to phasing construction (one obtained from empty plots) was included in the existing demand and together the network was optimized from beginning, following the method discussed earlier. Now to incorporate these changes in the existing network, pipes whose diameter is varying in the initial design and design due to phasing construction, pipes can be replaced with the new obtained ones. The advantage of this method is, it gives the design of the complete network (also including empty plots) at once which can be put to use in beginning and hence suffers no problem due to phasing construction at a later stage.

Optimization by Pipe Replacement

In this method, demand changes were made after the increase in population growth i.e. the demand due to increase in population was added to the already existing network (the optimized network 1) and then the network was optimized by increasing the pipe diameter. This method gives the design of network once population has increased (i.e. the empty plots are occupied).

Optimization by Addition Of Parallel Pipes

Replacement of existing pipes with new pipes is one method of meeting the new demand. But this method leads to excavation of soil, digging out old pipes and replacing them with the new ones. And at the end, the old pipes are of no use, which again leads to an uneconomical design. Why not use the existing pipe and for meeting the increased requirement, design a separate pipeline. Yes, this method not just proves economical but also reuses the existing pipeline in the network. To achieve this, in the next optimization method, parallel pipes were added to the existing pipes wherever required to meet the new demand requirement. The methodology adopted is similar to the one described earlier, the only difference is, instead of reducing the pipe diameter, a parallel pipe was added to the respective pipe and the procedure was repeated to get a minimum pressure of 3m throughout the network. The optimized network obtained is shown below.

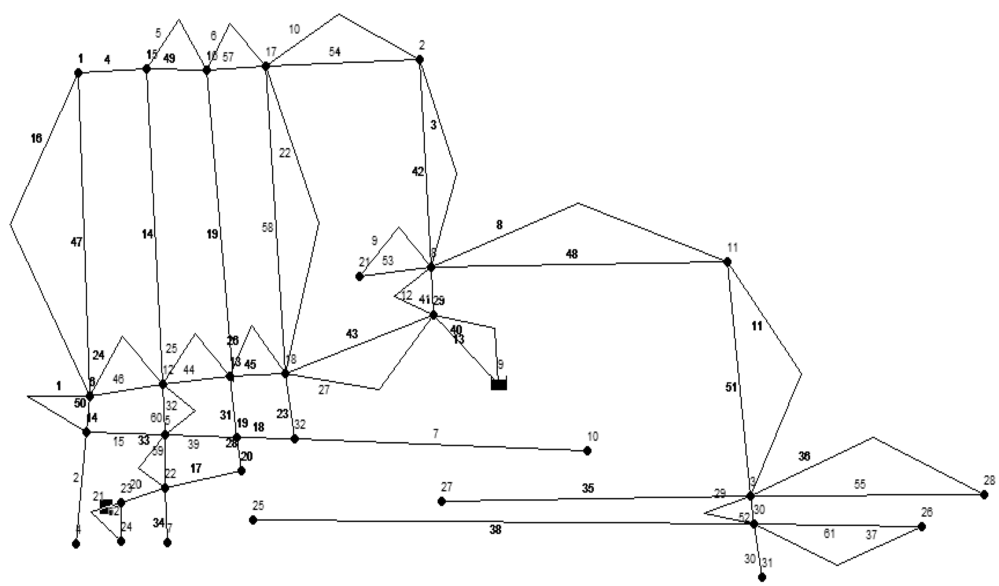

Figure 2. Addition of parallel pipes network

Selective Addition of Parallel Pipes

When water flows down through the reservoir to the pipeline, the pipe connecting the source (reservoir) has to convey water for the entire distribution network. The diameter being insufficient for the phasing construction demand, the velocity in the pipe is high and hence is the pressure and therefore experiences a greater head loss. The same happens to the pipes near the source. Therefore, if the change is brought in these pipes for reducing the head loss incurred, it is possible to increase the service pressure to 3m throughout the network. This idea was worked and the network obtained upon optimization is shown below, which involoves very few additional pipes than the method discussed above. Also, adding a pipe parallel to the shortest pipe in the network than to the long pipe nearer to the source proved more economical.

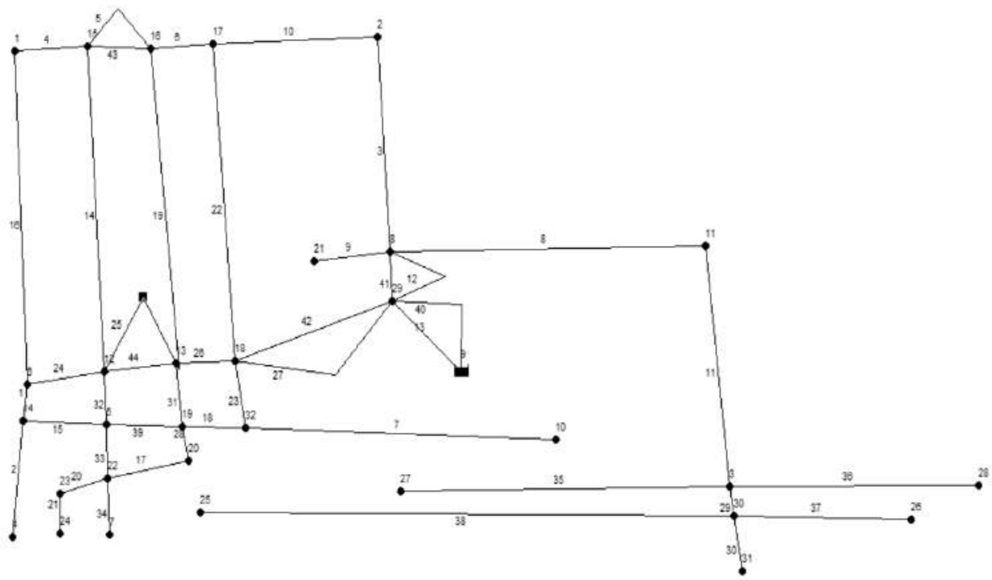

Figure 3. Selective addition of parallel pipes network

Pressure Benefit Comparison

While designing any water distribution network for meeting the requirement of phasing construction, it is not just the cost that matter. When several methods are in hand, the one giving high overall pressure should also be checked. This pressure benefit (overall increase in pressure before and after designing the network for phasing construction requirement) can be found by subtracting the pressure head at each node before and after and cumulating this value of all the nodes. The pressure benefit of all the five methods is shown below:

1. Optimization at initial stage =30.32m
2. optimization by pipe replacement=31.71m
3. optimization by addition of parallel pipes=37.15m
4. selective addition of parallel pipes=36.42m

Critical Pipes

This section deals with the changed pipe sizes after including the new demand. The table below shows that diameter of pipes before the demand due to phasing construction was made and after it by the four different optimization methods.

Table 2. Critical pipes

Link id	Diameter for existing demand (mm)	Diameter for phasing construction			
		D_1 (mm)	D_2(mm)	Diameter of parallel pipe added	
				D_3(mm)	D_4(mm)
16	75	75	75	110	
1	75	75	75	75	
2	75	75	75		
4	75	75	75		
5	75	75	75	75	75
6	75	75	90	75	
10	75	75	110	75	
11	200	200	200	110	
17	75	75	75		
20	75	75	75		
21	75	75	75	75	
22	125	75	125	90	

Link id	Diameter for existing demand (mm)	Diameter for phasing construction			
		D_1 (mm)	D_2(mm)	Diameter of parallel pipe added	
				D_3(mm)	D_4(mm)
24	75	140	75	75	
25	90	160	90	75	75
26	140	160	140	90	
27	200	200	200	110	75
29	140	140	140	75	
30	75	75	75		
32	75	75	75	75	
33	75	75	75	75	
34	75	75	75		
35	75	75	75		
36	75	75	75	75	
3	75	140	110	90	
8	200	200	200	110	
9	75	75	75	75	
12	160	200	200	90	90
14	75	75	75		
19	75	75	75		
28	75	75	75		
31	75	75	75		
37	75	75	75	75	
38	125	125	125		
13	200	200	250	110	200
7	75	90	75		
15	75	75	75		
18	125	125	125		
39	75	75	75		

Cost Comparision of Various Methods

Now after obtaining the pressure benefit of all the methods, next the cost analysis on the methods was performed. The objective of this cost analysis is not to find the exact cost incurred by the four methods adopted for phasing construction design but to find a method which would be more economical than the others. Of the four methods adopted, the first methods was not analysed in this section as the rates of pipelines and the excavation work varies with time. Also, as it was seen that in method 3, almost all the pipes required a pipe parallel to them. Hence this method as well was not considered in this cost analysis. Now remains two methods which are pipe replacement and selective addition of parallel pipes. Upon adopting the standard market rates, the cost came as 1.2lacs for pipe replacement method and 61 thousand rupees for selective addition of parallel pipe method, thereby making the latter method more economical.

RESULTS AND DISCUSSIONS

Design of street pipeline connection

The diameter of pipeline to be adopted in field is provided in table 1. If the obtained diameter is adopted, it is possible not just to get required quantity of water throughout the network but also the required service pressure. And hence, houses either near the source or away from source will be able to receive water with a head of 3m.

Design of street pipeline for phasing construction

The design for meeting the requirement of phasing construction can be made in several ways which has been discussed in this report earlier. One of the option is to include this new demand at the beginning by counting number of possible plots and design the network for the total demand. One more method could be replacing the pipes at a later stage when population has grown i.e. all the area is occupied.

Another method is addition of pipes parallel to the existing pipes. Going through the protocols of method explained in this report, it was observed that most of the pipes required a parallel pipe along them, which makes the method uneconomical. Hence, this method was not further included for further analysis.

Coming to the last method discussed, selective addition of parallel pipes, and this method is similar to the previous one. The difference lies in identification of pipes with maximum head loss and changing it diameter first, rather than following protocols. When parallel pipes were added to the pipes near the source, an increase in pressure throughout the network was seen. Once the pressure reached near to service pressure, pipes of small length were given parallel pipes to finally lift the pressure above service pressure wherever required. Pressure benefit obtained from the methods used was worked out, and found maximum in case of method 4, that is addition of parallel pipes. Coming to economic viability of the methods adopted, selective of addition of parallel pipes proved better than the others. The pressure benefit of this method is also nearer to the maximum pressure benefit. Thereby, satisfying both pressure requirement and economic feasibility.

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Effect of Photocatalysts and Light Sources on the Degradation of Vat Red R1

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ABSTRACT

Photocatalytic degradation of Vat Red R1 dye, used in textile industry using different photocatalysts and light sources were experimented on laboratory scale. 10 wt % metals doped with TiO_2 (Cu-Ni/TiO_2) and ZnO (Cu-Ni/ZnO) as photocatalysts were synthesized by three methods Viz. complex precipitation (CP), deposition precipitation (DP) and wet impregnation (WI) methods. The raw photocatalysts were activated by calcination at three different temperatures (180^0C, 200^0C and 300^0C) for 1 hour duration. Batch experiments were conducted with the initial concentration 0.002 mg/l to 0.01 mg/l of Vat Red R1 at pH 7 using the above photocatalysts. The extent of dye degradation was determined by UV – VIS spectrophotometry. The Cu-Ni/TiO_2 catalyst prepared by WI method is observed to show maximum dye removal of 97.70% for the initial dye concentration of 0.008 mg/l under UV irradiation. The other catalyst, Cu-Ni/ZnO showed maximum dye removal of 76% for the initial dye concentration of 0.002 mg/l under UV irradiation. The two catalysts found to perform better colour removal after calcination at 180^0C. In photocatalytic degradation using visible light, the catalyst Cu-Ni/TiO_2 prepared by WI method (calcined temperature at 180^0C) showed maximum colour removal of 99.20%. The photocatalyst Cu-Ni/ZnO at the same calcinations temperature showed maximum colour removal (95 %) for the concentration of 0.002 mg/l of Vat Red R1. From these results, it is observed that the maximum colour removal was experienced with the use of Cu-Ni/TiO_2 (calcination temperature 180^0C) in visible light. The increase in initial concentration has resulted in decrease of colour removal for both the phtocatalysts. The photocatalysts were characterized using Powder X – ray Diffraction (XRD), Fourier Transfer Infrared (FTIR) and Scanning Electron Microscopy (SEM).

Keywords: Cu–Ni Bimetallic Photocatalysts, Vat Red R1, TiO_2 and ZnO Photocatalysis.

1. INTRODUCTION

Various dyes have been used in textile dyeing, paper pulp, plastic, leather, cosmetics and food industries (Gulnaz et al., 2004). Colour dye stuff when discharged from these industries creates health hazards and environmental problems. The photocatalysis is new, fast, convenient and less expensive method for degradation of the dye (Michael et al., 1992, Chin Mei Ling et al., 2004). Among the various oxides of photocatalysts TiO_2 and ZnO are very effective photocatalysts owing to their high band gap (ZnO, 3.17 eV and TiO_2 3.2 eV). Efforts are on to increase its efficiency by incorporating stable optical sensitizer with changes within the semiconductors system to make it more effective in receiving and utilizing solar energy (Chatterjee et al., 2005). These include: doping TiO_2 and ZnO with various transition metals such as Pt, Au, Ag, Cr, V (Anpo et al., 2003; Bosc et al., 2007), non metals (like N) (Hong et al., 2005) and anchoring an organic dye sensitizer molecule on its surface (Chatterjee et al., 2005). Present works aims at sensitizing bimetallic photo-catalysts, Cu-Ni/ TiO_2 and Cu-Ni/ ZnO using various methods and study their photo-degradation properties on VR1dye under UV and visible light sources.

2. MATERIALS AND METHODS

2.1 Materials

Vat Red R1 (VR1) was used as a model dye for photocatalytic degradation study. Copper nitrate trihydrate Cu $(NO_3)_2.3H_2O$ and nickel nitrate hexahydrate, Ni $(NO_3)_2.6H_2O$ were used to dope titanium dioxide and zinc oxide. 10 wt% bimetallic Cu-Ni/ TiO_2 and Cu-Ni/ ZnO with 5:5 copper and nickel ratios were prepared using complex precipitation (CP), deposition precipitation (DP) and wet impregnation (WI) method.

2.2 Preparation of photocatalysts by CP and DP methods

Calculated amounts of metal salts were weighed and dissolved in distilled water, followed by the addition of glycerol in 2:1 glycerol: metal molar ratio and stirred continuously. TiO_2 and ZnO were then added with continuous stirring for one hour. For CP method, precipitates formed during the titration of the above mixture with 0.25M NaOH, maintained at a temperature 8-10^0C were collected until final of pH 14 is reached. The precipitates were then filtered and dried in oven at 75^0C for 18 hours. The same procedure was used for the deposition precipitation (DP) method except that the precipitation temperature was 25^0C and the final pH was 8.5 (Chong et al. 2011).

2.2.1 Preparation of photocatalyst by WI method:

TiO_2 and ZnO support was added into the copper and nickel salt solution to prepare 10 wt% photocatalysts. The suspension was stirred for 1 hour and the solvent was evaporated in a water bath at 80^0C until a thick paste was obtained. This paste was then dried in an oven at 120^0C for 18 hours. The dried catalysts were ground into fine powder and stored in desiccators at room temperature until it is being used (Chong et al. 2011).

2.3 Photocatalytic Degradation Study of Vat Red R1

Reaction study was carried out at pH 7 and room temperature (~ 27^0C). About 1 g of Photocatalyst was added to 10 ml of distilled water and sonicated for 10 min at 25^0C followed by the addition of 1 ppm VR1 solution to give a final volume of 30 ml. The suspension was stirred using a magnetic stirrer for two hours in dark and later this suspension was illuminated for 1 hour using 125 W UV lamp and 500 W halogen lamp (visible light source). Reaction parameters were photocatalysts prepared using different methods and calcination temperatures (180^0C, 200^0C, and 300^0C). After 1 hour reaction time, samples were centrifuged twice prior to monitoring the absorbance of solution at 613 nm wavelength using UV/VIS spectrophotometer (Thermo, Helios Zita). Control experiments were also conducted without the addition of photocatalysts.

3. RESULTS AND DISCUSSIONS

3.1 Characterisation of photocatalysts

XRD (XRD – Shimadzu, XRD 6000, made in Japan)

The x-ray diffraction data were recorded by Cu Kα radiation (1.5406 A^o). The intensity data were collected over a 2θ range of photocatalysts prepared by complex precipitation method (before and after treatment of Vat Red R1) and wet impregnation method (before and after treatment of Vat Red R1) are 25.327^0- 53.976^0, 25.1995 - 37.74^0, 25.208 – 55.012^0 and 25.314^0 – 39.097^0. The average grain size of the samples was estimated with the help of Scherrer equation using the diffraction intensity of four peaks (showed maximum intensity) based on the before and after treatment of Vat Red R1 by complex precipitation and wet impregnation method. The mean grain size (D) of the particles was determined from the XRD line broadening measurement using Scherrer equation (Rita John et al., 2011).

$$D = 0.89\lambda / (\beta \cos\theta) \quad (1)$$

where λ is the wavelength (Cu Kα), β is the full width at the half- maximum (FWHM) of the Cu-Ni/ TiO_2 (before and after treatment of Vat Red R1) line and θ is the diffraction angle. The calculated particle sizes are, at CP method (before treatment of dye) the dimension is 0.99 nm, after treatment of dye by the same method the particle dimension was found that 1.972 nm and the catalyst prepared by WI method , the particle dimension showed that (before and after treatment) 2.90 nm and 3.63 nm respectively. The above result showed that after treatment of dye the particles size are increased.

The peaks appearing at 25.32^0, 48.09^0, 53.97^0(before treatment of dye) can be perfectly indexed to (110), (200), and (210) respectively by wet impregnation method. After treatment of dye the 2θ values of 25.19^0, 47.95^0, 37.69^0 that correspond to (100), (111) and (100) planes, respectively by the above method. As well as the peaks appeared by complex precipitation method on before treatment of dye, the peaks appearing at 25.2^0, 47.98^0 and 55.01^0 are perfectly indexed to (100), (111) and (220) and after treatment of dye by the above method the peaks appearing at

25.19^0, $47.98^0$and 37.74^0 are indexed to (100), (111), (110) respectively. A number of strong Bragg reflections can be seen which correspond to the (111), (200) and (220) reflections of face centered cubic symmetry (FCC) of copper and nickel. The powder XRD patterns of fresh calcined photocatalysts clearly reveal that the presence of Cu and Ni containing phase detected in all samples. The above result indicates that after photocatalytic degradation particles sizes are increased. The peaks of WI method and CP method of Cu-Ni/ TiO_2 before treatment are $2\theta = 25.$ 32 and 25.20 respectively and after treatment are $2\theta = 25.19$ and 25.90 respectively, corresponding to the peak of anatase TiO_2.

FT-IR (FTIR – Shimadzu, Prestige - 21)

The IR spectra of photocatalyst by WI method after calcinations at 180^0C and dye loaded catalyst is shown in Fig. 1.

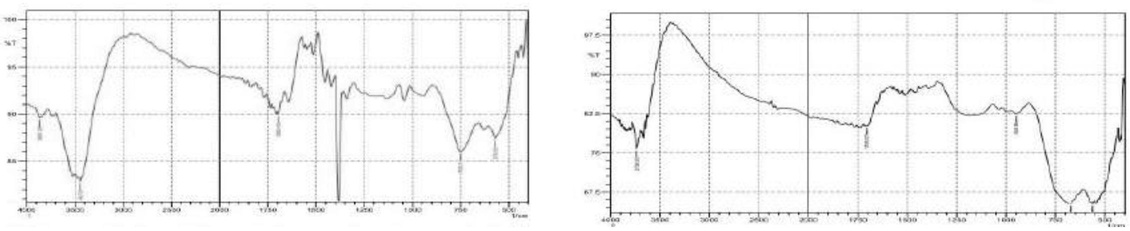

Figure 1. FTIR images of Cu-Ni/ TiO_2 by WI method before and after treatment

The adsorption spectra displayed a number of absorption peaks, indicating the complex nature of the catalysts. FTIR spectrum of Cu-Ni/ TiO_2 by wet impregnation method shows that the peak positions are at 3738.05, 1705.07, 948.98 cm^{-1}. The band at 3738.05 cm^{-1} is due to NH_2 aliphatic and aromatic group, 1705.07 cm^{-1} stretch vibration of keto group. 94898 cm^{-1} shows bending of O-H carboxylic acid. FTIR spectrum of Cu-Ni/ TiO_2 by WI method with treatment of VR1 shows that the peak positions are at 3867.28, 3446.79, 1695.43, 750.31, 570.93 cm^{-1}. The band at 3867.28 cm^{-1} is due to NH_2. While 3446.79 cm^{-1} is an indication of the presence of the stretch vibration of the bonded hydroxyl groups on the catalyst. The strong absorption peak at 1695.43 cm^{-1} is evidence of stretch vibration of keto group. The IR spectra of photocatalyst by CP method after calcinations at 180^0C and dye loaded catalyst is depicted in Fig. 2.

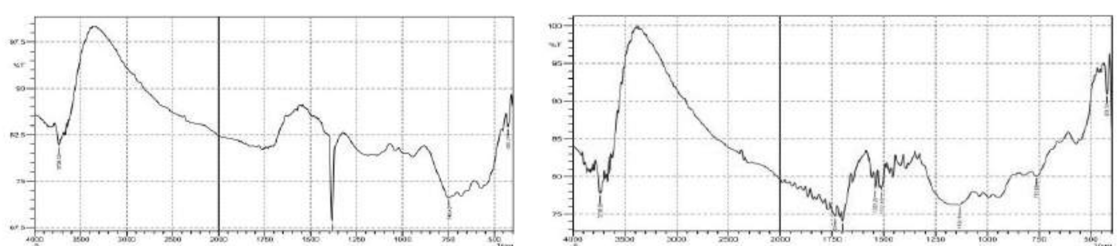

Figure 2. FTIR images of Cu - Ni/ TiO_2 by CP method before and after treatment

FTIR spectrum of Cu-Ni/ TiO_2 by CP method shows that the peak positions are at 3736.12 cm^{-1}, 746.45 cm^{-1}, 426.67 cm^{-1}. The band at 3736.05 cm^{-1} is due to NH_2 aliphatic and aromatic group, 746.45 show methylene rocking monosubstitution with C-Cl stretch and 426.67 cm^{-1} shows S-S stretch. FTIR spectrum of Cu-Ni/ TiO_2 by CP method with treatment of VR1 shows that the peak positions are at 3738.05, 1539.20, 1512.19, 1134.14,761, 424.34 cm^{-1}. The band at 3738.05 cm^{-1} is due to NH_2 aliphatic and aromatic group, the strong absorption peaks like 1539.20 cm^{-1} and 1512.19 cm^{-1} show both are aromatic N–O compound. The band at 1134 cm^{-1} is due to the presence of sulphonates. 761.88 show methylene rocking monosubstitution with C-Cl stretch and 424.34 cm^{-1} aryl disulfides (S-S stretch). The results shows that after treatment of catalyst the peaks are increased and it is a good indication for the effective adsorption of VR1.

SEM ((SEM – JOEI - JSM 6390)

SEM images showing the shapes and morphology of the Cu-Ni/ TiO_2 prepared by WI and CP methods before and after treatment of VR1 are depicted in Figure 3a and 3b.

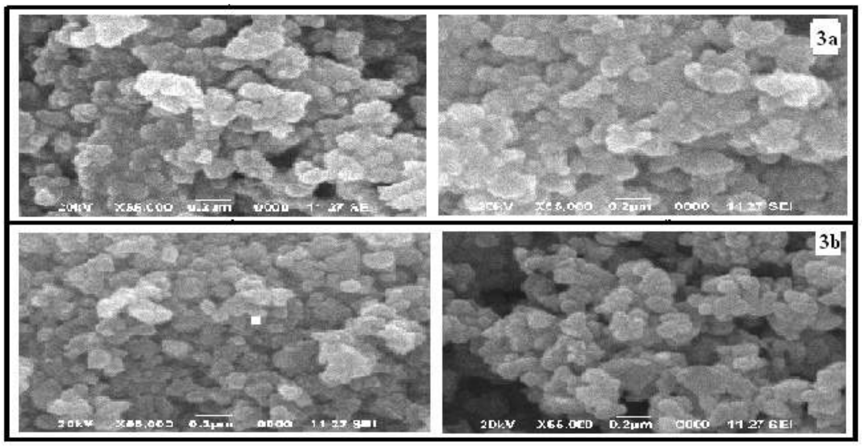

Figure. 3a & 3b SEM images of photocatalysts (WI & CP) before and after treatment

The SEM photographs showed that particle size was increased after degradation. The surface structure was found rough and heterogeneous porous in nature before and after treatment. After degradation of dye the catalyst Cu-Ni/ TiO_2 has considerably number of pores where there is good possibility for dye to be trapped and adsorbed onto these pores and it is a good sign for effective adsorption of dye Vat Red R1.

3.2. Photocatalytic degradation studies

3.2.1 UV light source

The result obtained for Photocatalytic activity of Cu-Ni/TiO_2 and Cu-Ni/ZnO prepared by CP, DP, and WI methods observed that the photocatalyst of Cu-Ni/TiO_2 at CP methods showed maximum removal of VR1 at 180^0C of calcined temperature. It was observed that 90% removal of 0.0002 mg/l VR1. The DP and WI methods showed maximum removal was found at 180^0C calcined temperature and 0.002 mg/l and 0.004 mg/l of VR1. In DP method 85 % of colour removal was found at 0.002 mg/l of VR1 and WI method the maximum removal was showed at 97.74% of 0.004 mg/l of VR1. In photocatalytic degradation with UV lamp, the catalyst Cu-Ni/ZnO showed maximum removal of 66.5% (at 0.008 mg/l), 68.75 % (at 0.008 mg/l) and 76% (at 0.008 mg/l) respectively using the CP, DP, WI method.

3.2.2 Visible light sources

The photocatalyst prepared by CP, DP, WI methods showed better activity at 180^0C and 200^0C of calcined temperatures. It was observed that the photocatalyst prepared by using Cu-Ni/TiO_2 at calcined temperature 180^0C by WI method showed maximum colour removal. It found that 99.20 % of 0.002 mg/l of Vat Red R1 was removed. The comparison of photocaalyst prepaired by using Cu-Ni/ZnO was found that maximum removal 95 % at 180^0C calcined temperatutre of 0.002 mg/l of vat red R1. The reference experiments under similar conditions without the presence of photocatalysts were also carried out. Under the same concentration of Vat Red R1 (0.002 mg/l), 20% dye removal under UV and 25% dye removal under visible light sources were observed. Similarly experiments were carried out by adding the catalysts in the absence of light sources to same concentration of Vat Red R1. The results showed 35% and 31% dye removal respectively by the Cu-Ni/TiO_2 and Cu-Ni/ZnO catalyst.

4. CONCLUSION

Photocatalytic degradation studies of vat Red R1 dye were carried using different photocatalysts and UV and visible light sources. 10 wt % metals doped TiO_2 (Cu-Ni/TiO_2) and ZnO (Cu-Ni/ZnO) as photocatalysts were synthesized by three methods viz. complex precipitation, deposition precipitation and wet impregnation methods. The study showed that among the three methods of preparation, the WI method is the best method for VR1 degradation. Comparison of calcinations temperature (180^0, 200^0, and 3000) revealed that photocatalyst calcined at

180^0C showed best photocatalytic activity for dye removal. Also Cu-Ni/TiO_2 is proved more efficient catalyst than Cu-Ni/ZnO in the removal of Vat Red R1. In this system studied, total removal of dye was possible in a practical time scale. According to XRD and SEM analysis, after degradation of dye the catalyst Cu-Ni/ TiO_2 has considerably number of pores where there is good possibility for dye to be trapped and adsorbed onto these pores and it is a good sign for effective adsorption of dye Vat Red R1.

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Dietzia sp. JC367, a Diesel-degrading Bacterium Isolated from a Diesel oil Contaminated Habitat at Dwaraka, Gujarat

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ABSTRACT

Diesel oil is a complex mixture of a wide variety of hydrocarbons. Environmental contamination caused by diesel oil discharges is of huge concern as it is lethal to all forms of life. The microbiological diversity keeps the environment in check by enzymatically breaking down complex hydrocarbons and plays a vital role in the removal of oil discharges from the marine and terrestrial ecosystems. These hydrocarbonoclastic bacteria have an ecological potency for using hydrocarbons (monocyclic, polycyclic, aliphatic, or even aromatic) as their sole carbon source and hence are prospective sources in bioremediation processes of hydrocarbon contaminated sites. Unearthing novel hydrocarbon degrading microorganisms is imperative in removing these pollutants from the environment in a non invasive and cost effective mode. A Gram-stain-positive, aerobic, diesel-oil degrading, rod shaped actinobacterium was isolated from a water sample collected from a hydrocarbon contaminated habitat in Dwaraka, Gujarat, India. The strain designated JC367 was oxidase and catalase positive. Strain JC367 grew optimally at 20-35 ^{o}C and at pH 7-9. Based on the 16S rRNA gene sequence analysis, strain JC367 belonged to the genus *Dietzia* within the family *Dietziaceae* and was closely related to *Dietzia lutea* (98.9 %), *Dietzia cinnamea* (98.3 %), *Dietzia aerolata* (98.1 %) and other members of genus *Dietzia* (<98.0 %). Strain JC367 could utilize diesel-oil as sole source of carbon and energy and exhibited good degradation characteristics for diesel range n-alkanes. In conclusion, this study demonstrated that *Dietzia* sp. JC367 can be exploited for treatment processes of various hydrocarbon contaminated sites.

INTRODUCTION

Petroleum and its derived products are major sources of energy. The consumption of petroleum hydrocarbons and its derivatives is increasing every day and as a result they have become the most common environmental pollutants. Biodegradation and bioremediation is an effective strategy in removal of these pollutants in an environmentally friendly and cost effective mode (Das *et al*., 2010). In this paper, we report a bacterium belonging to the genus *Dietzia* capable of degrading diesel oil. The genus *Dietzia* was first proposed by Rainey *et al*., in 1995 and comprises aerobic, Gram stain positive and non-spore-forming rods. Members of the genus *Dietzia* are chemoorganotrophic and can thrive in the presence of hydrocarbons (Yumoto *et al*., 2002).

Methodology

Strain JC367 was isolated from oil contaminated water sample collected from Beyt Dwaraka, Gujarat, India during December, 2014. The water sample that yielded strain JC367 had a pH of 7, temperature of 26 ^{o}C and salinity of 1.2 % (w/v). Water sample with traces of oil was inoculated into 250 ml conical flasks containing 100 ml mineral salts media [consisting (g.l^{-1}): KH_2PO_4 (0.5), $MgSO_4.7H_2O$ (0.2), NH_4Cl (0.6), NaCl (10), $CaCl_2.2H_20$ (0.05), 5 ml of ferric-citrate solution (0.1 %, w/v)] with diesel-oil 2 % (v/v) as carbon source and was incubated at 25 $^{\circ}$C under shaking at 100 rpm for three days. Purification of the bacteria was achieved by repeated streaking on nutrient agar.

Genomic DNA was extracted and purified from strain JC367 according to the method of Marmur (1961). 16S rRNA gene amplification and sequencing was done as described previously (Subhash *et al*., 2013). Identification of phylogenetic neighbors and calculation of pairwise 16S rRNA gene sequence similarity were achieved using the EzTaxon-e server (Kim *et al*., 2012). The CLUSTAL_W algorithm of MEGA 5.2 was used for sequence alignments and MEGA 5.2 (Tamura *et al.*, 2011) software was used for phylogenetic analysis of the individual sequences. Distances were calculated by using the Kimura correction in a pairwise deletion manner (Kimura, 1980). Neighbor-joining (NJ) method in the MEGA 5.2 software was used to construct phylogenetic tree. Percentage support values were obtained using a bootstrap procedure based on 1000 replications.

Morphological properties (cell shape, cell size, motility) of strain JC367 grown on nutrient broth was observed directly or after Gram-staining using Olympus BH-2 phase-contrast microscope. Hanging-drop method was also employed to test the motility. The pH range for growth was tested using nutrient broth, adjusted to different pH values (pH 4.0-11.0, intervals of 0.5 units) by using the appropriate biological buffers as described previously (Subhash *et al*., 2014). NaCl [0 -10 % (w/v) at 0.5 % intervals] and temperature (4, 10, 15, 20, 25, 30, 35, 40, 45 and 50 ^{o}C) ranges for growth were examined in nutrient broth and growth was measured turbidometrically at 540 nm in a colorimeter (Systronics). Various biochemical tests such as hydrolysis of starch, casein and Tween 80; oxidase, catalase and nitrate reduction tests were performed by the procedures as outlined in Cappuccino & Sherman (1998). Utilization of organic carbon compounds as carbon and energy source for organo-heterotrophic growth was tested in a mineral medium as previously described (Lakshmi *et al*., 2011) containing specific organic compound (0.35 % w/v or v/v) replacing sodium pyruvate. Growth was measured turbidometrically (OD at 540 nm) after 48 h. Nitrogen source utilization was tested by replacing ammonium chloride with different nitrogen sources ($NaNO_3$, $NaNO_2$, glutamate, aspartate, glutamine, and urea).

To determine the diesel-oil degradation capability, strain JC367 was grown in 250 ml conical flasks containing 100 ml mineral salts media [consisting ($g.l^{-1}$): KH_2PO_4 (0.5), $MgSO_4.7H_2O$ (0.2), NH_4Cl (0.6), NaCl (10), $CaCl_2.2H_20$ (0.05) and 5 ml of Ferric-citrate solution (0.1 %, w/v)] with diesel-oil 10 % (v/v) as carbon source and was incubated at 30 $^{\circ}$C under shaking at 100 rpm for three weeks. Un-inoculated flask served as control. Cells were harvested by centrifugation (10000 g for 15 min at 4 ºC). The diesel-oil in the supernatant was extracted with 50 ml of dichloro methane (DCM) and collected by centrifugation at 10000 g for 10 min at 4 ºC.

The % of degradation was calculated as follows

Weight of residual diesel oil = Weight of beaker containing 50 ml of DCM + residual diesel oil
– Weight of beaker containing 50 ml of DCM

Amount of diesel oil degraded = Weight of diesel oil added in the media – Weight of residual diesel oil

% degradation = Amount of diesel oil degraded / Amount of diesel oil added X 100

RESULTS

EzTaxon-e server search analysis revealed that strain JC367 was most closely related to the members of genus *Dietzia*, and the highest sequence similarity was observed with *Dietzia lutea* (98.9 %), *Dietzia cinnamea* (98.3 %), *Dietzia aerolata* (98.1 %) and other members of genus *Dietzia* (<98.0 %). The results of phylogenetic analysis of the 16S rRNA gene sequences suggested that strain JC367 clustered with the members of genus *Dietzia* and formed a separate clade along with the type strain of *Dietzia lutea* (Fig. 1).

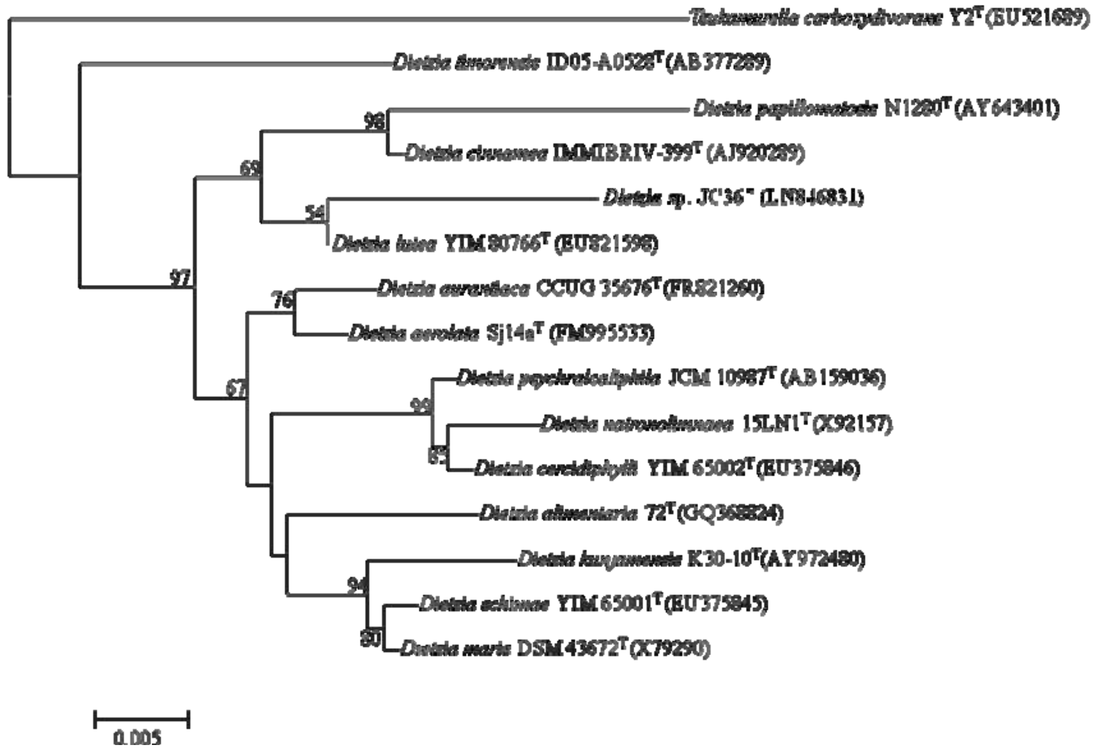

Figure 1. Neighbor-joining tree based on 16S rRNA gene sequences showing phylogenetic relationship between strain JC367 and its closely related phylogenetic neighbors. The tree was constructed by neighbor-joining method using MEGA 5.2 software and rooted by using *Tsukamurella carboxydivorans* Y2^T as out group. Numbers at nodes are the percentage of bootstrap (based on 1000 resamplings). The GenBank accession numbers for 16S rRNA gene sequences are shown in parentheses.

On nutrient agar, colonies of JC367 are round, flat to raised, orange colored with 1-2 mm in diameter. Cells were motile, non endospore forming, Gram-stain-positive and straight rods measuring 2-4 µm long and 1-2 µm wide (Fig. 2).

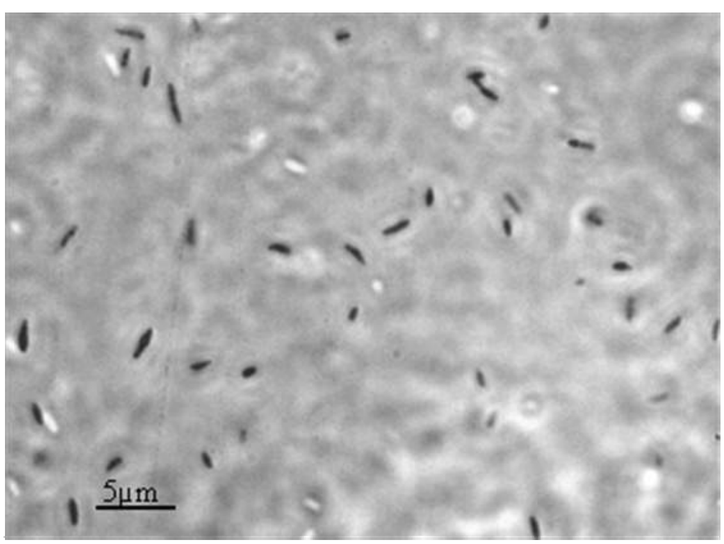

Figure 2. Phase contrast micrograph of strain JC367

Strain JC367 grew at a pH range of 7-9 with optimum at pH 7. NaCl is not required for growth of strain JC367 but can tolerate up to 8 % (w/v). Growth temperature range of strain JC367 is 20-35 °C (30 °C optima). Strain JC367 was positive for catalase and oxidase and is negative for hydrolysis of casein, starch and Tween 80. Good growth occurs with acetate, butyrate, citrate and glucose as sole carbon source and energy. Arabinose, cellobiose, fumarate, galactose, lactate, ribose, salicin, sucrose, sorbitol and xylose are not used as sole source of carbon and energy. Ammonium chloride was used as sole nitrogen source by strain JC367. Strain JC367 was very effective in degrading diesel oil as 60 % removal was observed with in a period of three weeks.

ACKNOWLEDGMENTS

The infrastructural support provided at Jawaharlal Nehru Technological University Hyderabad by TEQIP and DST-FIST is acknowledged. KR and AM thanks the CSIR and UGC for the award of research fellowships.

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Citizen Science Model for Safeguarding Urban Freshwater Ecosystems

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ABSTRACT

Citizen Science promises to bring a fresh perspective to strengthen the environment conservation efforts. Citizen science has the potential to bring youth and science together at the field level and empower them with knowledge, understanding and conviction to build conservation movements at the local level. Data and other information generated through citizen science projects have been shown to be reliable and accurate. There is evidence that data from citizen science research projects are increasingly accepted in the academic literature (UNEP, 2014). Physical and chemical parameters of all the waterbodies are being monitored at regular interval by citizen scientists. 756 data sets were generated from rivers, streams, lakes and ponds in 39 urban and peri-urban areas across the four cities in India. This is helping the scientists to have multiple data sets within a short span of time. We believe that the future decisions regarding the freshwater must be based on objective science. We also believe that by involving a diverse range of people in scientific research and education, they gain the knowledge, skills and motivation needed to take responsibility for the conservation of freshwater. The opportunity of working with volunteers has been an enriching experience.

INTRODUCTION

In India, the total water availability in the form of precipitation amounts to 4000km^3, out of which only 28 per cent (1123km^3) is available as utilizable water in the form of surface (690 km^3) and groundwater (433km^3). There are wide variations in the availability of water across the country with the drier regions having greater fluctuations in rainfall thus increasing the vulnerability of people to water scarcity. The water demand is increasing, while the water availability is declining over the years (Kumar *et al*, 2005). Most importantly, the available water and related aquatic ecosystems are seriously degraded, with almost 70 per cent of its surface water resources contaminated by organic or inorganic pollutants (Kumar and Murty, 2011). This has resulted in the loss and added costs of using most sources for human consumption as well as irrigation and industrial needs. This loss of ecosystem functioning and services is most acute in urban areas, where pollution is often the highest, principally due to industrial and domestic activities. India is known for its rich traditions and local knowledge practices. In this rapidly changing world such knowledge systems need to be integrated with scientific understanding to tackle new environment challenges. Creating and developing an effective citizen science model that fosters partnership between people, science and scientists will be a significant step towards this end.

The aquatic habitats in urban areas provide a wide range a key ecosystem benefits to cities and citizens. Some of these water bodies harbour a great diversity and concentration of bird species. When the quality of water bodies in urban areas get degraded, the entire ecosystem dependent on these, including human lives, becomes vulnerable. Conservation of freshwater bodies including wetlands thus becomes imperative in the context of an environment where water is scare. Citizen science promises to bring a fresh perspective to strengthen the environment conservation efforts. Citizen science has the potential to bring youth and science together at the field level and empower them with knowledge, understanding and conviction to build conservation movements at the local level. Earth watch Institute India brings together institutions and individuals to understand and inform critical urban freshwater issues by combining scientific field research with experimental learning programmes. The freshwater watch programmes aims at inspiring citizens to value water resources, understand the local freshwater challenge and take proactive action for water conservation and management.

The model of citizen science can help scientists to sustain their research and help in long term monitoring of urban freshwater to influence policy decisions. Technology like mobile application can plan an important role in bridging the gap between citizens and scientists. Earthwatch Institute India along with its partner The Indian National Trust for Art and Cultural Heritage (INTACH), Delhi; Nature Environment & Wildlife Society (NEWS), Kolkata; Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER), Pune and Institute of

Science & Technology Jawaharlal Nehru Technical University, Hyderabad is implementing a citizen science programme on freshwater called the FreshWater Watch. The programme is being implemented in four cities i.e., Hyderabad, Pune, Kolkata and Delhi.

THE STUDY

FreshWater Watch research is investigating the health of freshwater ecosystems on a scale never seen before, collecting data from different locations. What these locations have in common is that the waterbodies are rarely monitored, yet are affected by changes in local land use and climate. Information from different kinds of waterbodies is being collected to understand how each type reacts to pressures from population density, agricultural activity and land use. The collection of data is being used by scientists to determine trends in freshwater health, locating the areas of particular concern, and attempting to establish general statements of cause and effect. One *hypothesis* of the study is that increased urbanisation across the world is having adverse effects on water quality and is changing the natural cycles and processes within freshwater ecosystems.

Local Study

Water is a global challenge but water issues are inherently local. So the programme works with a network of freshwater experts from different cities who have a strong interest in understanding and preserving their local waterbodies. There are a variety of local research projects that are ongoing and specific to the region and local water issues. While these projects contribute data for the field research, they also address local water management, education and learning aspects by engaging students and teachers in the area of water conservation.

At this level of FreshWater Watch, we form partnerships with corporate sector as well as schools, NGOs and other groups to support our local research and learning activities.

MATERIAL and METHODS

A standard methodology is being practised as part of the project in all the four cities across India. Physical and chemical parameters of all the waterbodies are being monitored at regular interval by citizen scientists. Data for physical parameters are collected by a visual assessment of the waterbody which describe the surrounding land use/vegetation/pollution sources. Visual assessment of water level and velocity (with an opportunity to note any short or long term changes to the site).

Water flow conditions are estimated as the speed of the water i.e., surging, steady, slow or still. Visual assessment of the water colour and the presence and characteristics of any algae is also noted.

Turbidity is measured with the help of Secchi tube. The Secchi tube is a 0.5 metre plastic tube with a Secchi disc at the bottom. The tube has a graduated, non-linear scale of Nephelometric Turbidity Units (NTU) on the side. Measurements are based on the depth of the water at which the Secchi disc is no longer visible to the observer peering into the top of the tube.

In biochemical water quality, nitrate and phosphate are measured with a colorimetric approach using reagent tubes with concentration ranges that are appropriate for urban and non-urban ecosystems. Nitrate concentrations are estimated colourimetrically using N-(1-napthyl)-ethylenediamine (Adeloju, 2013) in seven specific ranges from 0.2 mg l^{-1} to 10 mg l^{-1} $N\text{-}NO_3$. Phosphate concentrations are estimated colourimetrically using inosine enzymatic reactions in seven specific ranges from 0.02 mg l^{-1} to 1.0 mg l^{-1} $P\text{-}PO_4$ (Strickland & Parsons, 1968). The data generated is then uploaded onto the data base.

The uniqueness of this programme is the monitoring of the water bodies by the citizen scientists in a consistent manner. The participants are initially trained for a day by the scientists before they become Freshwater Watchers. The FreshWater Watchers can choose to monitor streams, small rivers, ponds, lakes, ditches, canals and wetlands. A typical FreshWater Watcher visits their water bodies at least four times per year, as most water bodies change throughout the seasons. Scientists at local level have identified water bodies and point of data collection which the participants monitor at regular level. FreshWater Watch data is set into a wider geographical context with climate, land use, population, hydrological, socio-economic, water management and governance data.

This allows the programme scientists to identify what factors most influence water quality. Comparisons will be made between different areas within cities and between different water body types, all within a geographic information system. The data gathered is made available for use by scientists and local authorities to improve the management of our freshwater resources.

RESULT and DISCUSSION

The Fresh Water Watch programme will continue till 2016 and it's early to come up with conclusion. Detail analysis of the datasets generated as part of the programme will be done at the end of the programme in 2016. Here the results are summarized based on the datasets generated till date.

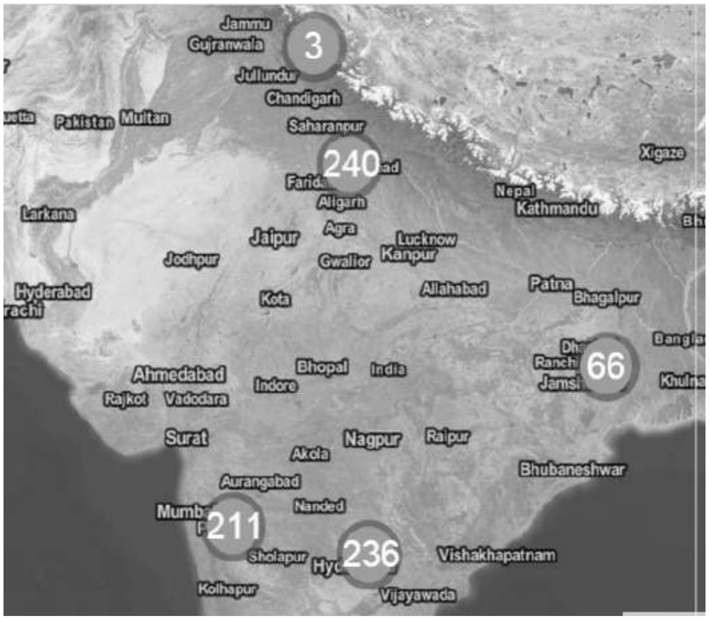

Figure 1. Datasets from different locations

Between March 2013 and July 2015, 844 trained citizen scientists collected 756 datasets from rivers, streams, lakes and ponds in 39 urban and peri-urban areas across India (Figure 1). Sites were selected by local scientists (80% of the samples) or selected by participants. The study cities were based on the availability of participants in corporate sponsored volunteer programmes.

Phosphate: In the study cities, the average phosphate concentration ranged from 0.08 mg/l to 0.67 mg/l. Seasonal variation of phosphate concentrations showed the maximum in the rainy season in Pune and Kolkata, while Hyderabad showed a maximum in the winter. These seasonal dynamics indicate the potential differences in phosphate sources with respect to rain driven nutrient flows. Low phosphate during summer was recorded that may be attributed to abundance of phytoplankton during summer season. Low level of phosphate in summer has also been reported by Shinde *et. al*. (2011), Chary (2003) and Rao (2004).

Nitrate: Average Nitrate concentrations ranged from 0.20 mg/l to 1.99 mg/l. Highest nitrate concentrations were recorded in the rainy season in Hyderabad and highest in the winter in Delhi and Pune. Similar results have been reported by Gohram (1961), Rajashekhar *et. al. (2007) and* Shinde *et. al*. (2011).

Turbidity: Average turbidity ranged from 57 to 121 NTU. High turbidity was recorded during rainy season in most of the cities. Similar results have been reported by Narayana (2008), Shinde *et. al*. (2011), Reddy *et. al.* (2009), Muhammad et.al. (2007) and Kulkarni *et. al.* (1995).

This experiential learning model of data collection is helping the citizens to be the change makers as aware citizens, develop an ownership towards their city waterbodies and take positive actions towards water conservation at local level.

The data generated as part of the freshwater programme clearly demonstrates that citizen scientists can generate valuable data which can be used for scientific research studies. This model of data collection can help the scientists in monitoring the waterbodies for long term and with minimal time of scientists in data collection. At the same time the scientists/researchers can use the data collected from other cities and regions and compare their results with other sites. Scientists are increasingly recognizing the benefits of public knowledge and open participation. The statistical power provided by large amounts of data can be used to obtain valuable insights into scientific questions (UNEP, 2014).

Volunteers taking part in environment-related studies can sample wide geographic areas more quickly and at lower cost than professional research teams (UNEP, 2014). Freshwater Mobile application and web portal makes it easy for the participants to get more information about the programme and makes data collection and uploading easy. As technological advances are made, enabling more people to take part in the exploration of our world, one opportunity presented by citizen science is the growing capacity to involve communities and strengthen civil society while protecting the environment (UNEP, 2014).

The future trends for freshwater will be influenced not just by climatic factors but also by policy decisions, the action of millions of individuals of individuals, the type of and access to water infrastructure and services, changes in technology and affluence (and a whole host of other factors).

ACKNOWLEDGEMENT

We would like to extend our thanks to HSBC India for their support. We would also like to thank HSBC India employee volunteers, who contributed to field related activities as part of this research.

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Evaluation of the Quality of Drinking Water Sources with Reference to Physico-Chemical and Microbiological Parameters in the Villages of Venkayya-Vayyeru Canal Area, W.G.Dt., A.P. India.

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ABSTRACT

Drinking water is a basic requirement for life and a determinant of standard of living. However, besides government efforts, supply and demand side factors of both surface and ground water determine the level of drinking water available to people. A Physico-chemical and of micro biological study in twenty four villages of Venkayya-Vayyeru Canal area has been carried out to assess the quality of drinking water sources. Water samples were collected from Canal, Summer-storage tanks, Treated drinking water and NTR sujala, NGO and R.O waters available in those villages. The samples were analyzed for Turbidity, pH, TDS, EC, Hardness, Alkalinity, DO, BOD, COD, Ammonia, Nitrites, Nitrates, Sodium, Potassium, Chlorides, MPN, TFC, E.Coli etc., are measured as standard APHA methods. The resulted parameters were compared with the drinking water standards of WHO and BIS: 10500. Poor water quality problem has been observed in more number of villages. Inadequate resource management and institutional systems seems to be major causes for present problems.

INTRODUCTION

The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer[9].One should take proper managerial action to use and conserve water from mountains, wells, rivers and also rain water for use in drinking, agriculture and industries (Rig-Veda). The resources of water on earth are limited and are reducing every year. The United Nation has predicted that by the next two decades there will be 17% more demand of water compared to resources available. According to global study by International Food Policy Research Institute (IFPRI), the world is on a path towards rapidly deteriorating water quality in many countries. The first of its kind study indicates that up to 1 in 3 people will be exposed to a high risk of water pollution in 2050 (from increased amounts of N&P) and up to 1 in 5people will be exposed to a high risk of water pollution reflected by increased levels of BOD[6].

Clean drinking water is a basic human need. Each person on earth at least requires 20-50 liters of clean fresh water a day. Polluted water is not just dirty-it is deadly. Some 1.8 million people die every year of diarrheal diseases like Cholera. Tens of millions of others are seriously sickened by a host of water related ailments- many of which are easily preventable[8]. Efforts to prevent death from diarrhea to reduce the burden of such diseases as Ascaris, Dracunculiasis, Hookworm, Shistosomiasis and Trachoma are doomed to failure unless people have access to safe drinking water. Besides all that has been said above, the most important and dangerous problem faced by some sections of population is pollution of water through industrial pollutants, leakage of sewerage pipes, mixing of groundwater and drainage water in the areas where shallow groundwater conditions exist particularly during rainy season. This mixing of drinking water in shallow bore wells and drainage (sewerage) water is common during rainy season in the areas located along major rivers like Godavari and Krishna, in Canal command areas and Deltaic areas. Most of the villages located in such areas do not have underground drainage and toilets are constructed with local pits. Lack of connectivity of pits and locations of final disposal in far off places causes mixing of drinking water with sewerage flow. In such localities, particularly during rainy season, several diseases like diarrhea, jaundice will affect the population. Priority should be given to schemes dealing with sanitation and water[2].

STUDY AREA

West Godavari is one of the 13 districts of Andhra Pradesh, India. West Godavari district occupies an area approximately 7700 square kilometers. It has 46 mandals; out of which 20 are in Upland and the rest in Deltaic region. The delta region is abundant with water sources and so agriculture and aquaculture and industries based on these two are thriving well in this region. The water samples are collected from 24 villages namely- Muddapuram, Ravipadu, Pippara, Chintapalli, Jallikommara, Bhuvanapalli, Ganapavaram, Bavayyapalem, Peddakapavaram, Chinakapavaram, Gummuluru, Undi, Akiveedu, Kalisipudi, Cherukuvada, Ajjamuru, Ayi-Bhimavaram, Cherukumilli, Juvvalapalem, Elurupadu,Pathellameraka, Kalavapudi,Modi and Kalla.

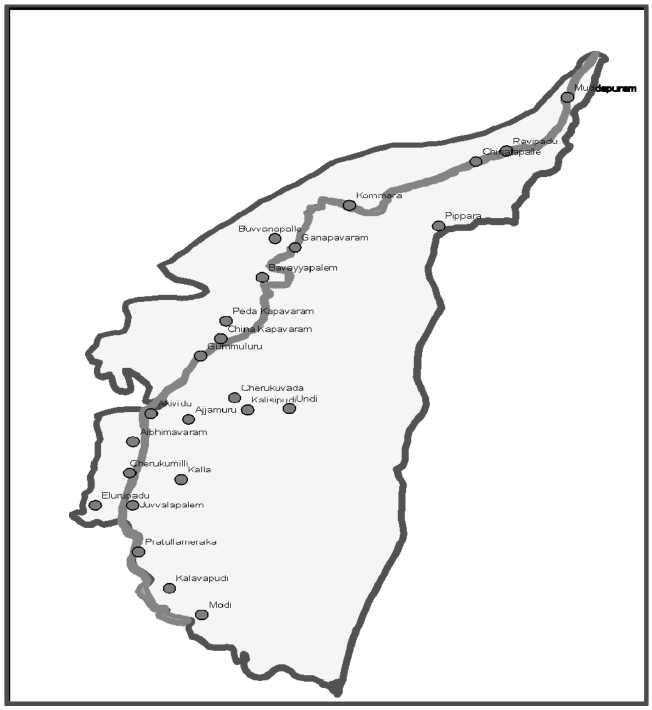

Figure 1. Villages of Venkayya Vayyeru Canal Area, West Godavari, A.P.

RESULTS AND DISCUSSION

Turbidity: Turbidity is the cloudiness of water caused by a variety of particles and is another key parameter in drinking water analysis. It is also related to the content of diseases causing organisms in water, which may come from soil runoff. The values vary from 0.6 to 14.4 with an average of 6.8 in canal water.

pH: This is a measure of the intensity of the alkaline or acid condition of water. It is the way of expressing "Hydrogen ion concentration". pH varies from 8.0 to 8.8 with an average of 8.3 where as the standard value is in between 6.5 to 8.5. In four places Ganapavaram, Bavayyapalem, Peddakapavaram and Chinakapavaram the pH values are slightly more than 8.5. In other 20 villages the values are within the range.

Total Dissolved Solids (TDS): TDS is composed mainly of Carbonates, Bicarbonates, Chlorides, Phosphates and Nitrates of calcium, magnesium, sodium, potassium, manganese. In addition to that organic matter and other salts may also contribute to TDS. The TDS values vary from 130ppm to 840ppm with an average of 298.2ppm.The desirable range of TDS is between 150 to 500ppm. Although majority of the villages have the values within the range, in Kalavapudi, Prathellameraka and Elurupadu the TDS values are more than 500ppm.However the values are higher (even though within the range) in Gummuluru, Akiveedu, Juvvalapalem, Cherukumilli, Chinnakapavaram, Ayi-Bhimavaram etc., may be due to the back waters from the Bay of Bengal through Upputeru which is nearer to these villages.

Electrical Conductivity (EC): The conductivity of water is an expression of its ability to conduct an electric current. As this property is related to the ionic content of the sample which is in turn a function of the dissolved (ionisable) solids concentration, the relevance of easily performed conductivity measurements is apparent. For many surface waters the following approximation will apply: Conductivity (μS/cm) x 2/3 = Total Dissolved Solids (mg/l). The TDS and EC values well obeyed this equation.

Total Hardness (TH): Total hardness of water is characterized by content of Calcium and Magnesium salts[5]. It is the total of Calcium hardness and Magnesium hardness.

Calcium Hardness: High levels may be beneficial and waters which are rich in Calcium are very palatable. This element is the most important and abundant in the human body and an adequate intake is essential for normal growth and health. The maximum daily requirement is of the order of 1 - 2 grams and comes especially from dairy products.

Magnesium Hardness: Magnesium is also an essential element of the body particularly for cardiovascular functions. Hardness values vary from 40ppm to 145ppm with an average of 100ppm. The maximum permissible value of hardness for drinking water is 300ppm and all the water samples are below that level.

Table 1. Physico-chemical and Biological analysis of Venkayya-Vayyeru Canal water

S.N	Village	PH	TDS	EC	TH	TA	TURB	NH3	NO2	NO3	DO	BOD	COD	Na	K	Cl
1.	Muddapuram	8.1	120	180	75	92	0.6	0.0	0.0	26.4	7.4	3.6	9.6	27	2	56.2
2.	Ravipadu	8.2	130	200	80	92	2.8	0.7	0.0	22.1	6.4	3.6	19.2	30	2	85.0
3.	Pippara	8.5	140	200	130	124	3.4	0.01	0.02	2.76	5.8	2.5	6.8	32	3	28.3
4.	Chintapalli	8.3	140	200	75	76	4.3	0.5	0.0	23.4	6.6	3.6	48.0	28	2	127.0
5.	Jallikommara	8.2	200	300	95	96	5.7	0.5	0.0	21.3	6.6	3.6	22.4	49	2	70.9
6.	Bhuvanapalli	8.3	210	310	125	100	4.8	0.5	0.1	18.6	6.2	2.4	41.6	52	2	127.6
7.	Ganapavaram	8.8	230	320	105	156	7.7	0.5	0.3	15.4	5.0	6.0	9.6	49	3	99.2
8.	Bavayyapalem	8.8	290	430	125	116	9.0	0.6	0.0	7.8	5.6	6.0	19.2	65	2	155.9
9.	Peddaka-pavaram	8.6	240	350	60	120	10.2	0.7	0.1	18.6	6.8	3.6	16.2	67	3	127.6
10.	Chinnakap-avaram	8.6	320	470	140	128	11.2	0.3	0.0	9.4	7.8	1.4	3.2	67	3	212.7
11.	Gummuluru	8.4	490	720	220	152	3.1	0.8	0.7	8.8	7.4	2.4	5.6	87	3	255.2
12.	Undi	8.4	140	210	50	60	11.2	0.5	0.1	4.5	5.8	4.2	9.0	24	0	17.7
13.	Akiveedu	8.0	340	470	40	132	3.0	0.23	0.02	2.48	4.4	3.6	19.2	65	3	96
14.	Kalisipudi	8.1	140	210	65	75	12.1	0.6	0.0	4.2	5.2	4.6	11.5	24	0	22.1
15.	Cherukuwada	8.3	130	200	65	75	8.5	0.5	0.1	3.9	5.4	2.4	8.2	25	0	22.1
16.	Ajjaram	8.0	130	200	75	85	9.5	0.3	0.2	4.5	4.6	3.5	9.6	25	0	26.5
17.	Ayi-Bhimavaram	8.0	320	490	70	140	1.3	0.43	0.06	2.99	4.8	3.6	20.2	57	2	92
18.	Cherukumilli	8.2	350	480	45	152	8.0	0.35	0.01	2.41	3.8	2.4	10.5	58	2	128
19.	Juvvalapalem	8.1	380	550	100	164	2.1	0.36	0.02	3.17	4.2	2.4	12.6	77	4	106
20.	Elurupadu	8.2	600	850	115	220	1.0	0.63	0.08	3.96	4.8	3.6	9.6	99	4	191
21.	Prathalameraka	8.2	840	1200	145	224	14.4	0.83	0.05	4.52	5.8	3.6	15.6	118	6	284
22.	Kalavapudi	8.5	720	1460	135	220	10.8	0.87	0.27	4.65	5.6	4.8	12.6	130	12	383
23.	Kalla	8.1	260	390	170	110	11.8	0.04	0.04	1.42	5.5	2.7	8.5	75	5	60.5
Averages		**8.3**	**298.2**	**422.1**	**100.2**	**116.9**	**6.8**	**0.46**	**0.09**	**9.4**	**5.7**	**3.4**	**15.15**	**53.9**	**2.6**	**120.6**

Chlorides: Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l Cl). In fresh waters the sources include soil and rock formations, sea spray and waste discharges. Sewage contains large amounts of chloride, as do some industrial effluents. At levels above 250 mg/l Cl water will begin to taste salty and will become increasingly objectionable as the concentration rises further. In the present study the chloride values varies from 17.7 ppm to 383ppm with an average of 120.6ppm. In three villages Gummuluru, Prathellameraka and Kalavapudi the Chloride values are more than 250 ppm due to sea water contamination.

Nitrates: Relatively little of the nitrate found in natural waters is of mineral origin; most of the nitrates are coming from organic and inorganic sources, the former including waste discharges and the latter comprising chiefly artificial fertilizers. However, bacterial oxidation and fixing of nitrogen by plants can both produce nitrates. Interest is centered on nitrate concentrations for various reasons. Rivers with high levels of nitrate are more likely to indicate significant run-off from agricultural land than anything else. Nitrate levels in the study area are ranged from 2.67 to 26.4 ppm well within the range of standard value 45ppm.

In summer storage tanks where water is stored for treatment purpose, the pH values vary from7.9 to 9.7 with an average of 8.4. Whereas TDS values varies from 150 to 770ppm with an average of 379ppm and same trend observed in EC values. Hardness values vary from 40 to 170 ppm with an average of 102 ppm. Alkalinity values in storage tanks varied from 92 to 224ppm with an average of 160.6 ppm. Sodium values vary from 26ppm to 116ppm, whereas chloride values vary from minimum 35.4 to maximum 266.8ppm with an average of 134.13ppm. DO values vary from 2.4 to 7.5 ppm with an average of 6.2ppm? BOD values vary from 1.2 to 19.2ppm with an average of 4.5ppm, whereas COD values vary from 3.2 to 64 ppm with an average of 17.5ppm. Nitrates ranges from 1.42 to 24.2 ppm with an average of 7.95 ppm.

pH values of treated water varied from 8.1 to 8.9 with an average of 8.7 which is higher than canal water and summer storage water. The pH values have crossed the limit of 8.5 in Pippara, Ganapavaram, Bavayyapalem, Peddakapavaram, Chinnakapavaram and Juvvalapalem. TDS values vary from 60 to 1000ppm with an average of 340ppm.The TDS value has crossed 500ppm mark in Peddakapavaram, Prathellameraka and Modi.TDS average value of treated water is higher than canal water by 42ppm, but lower than summer storage tank by 39ppm.The same is reflected in EC values. Total hardness and alkalinity values are more or less remains same with summer storage tanks.

Table 2. Summer storage tanks in the villages of along Venkayya- Vayyeru canal

S.No	Village	pH	TDS	EC	TH	TA	TURB	NH_3	NO_2	NO_3	DO	BOD	COD	Na	K	Cl
1.	Muddapuram	8.3	150	230	140	208	21.6	0.3	0.0	18.8	6.8	6.0	18.4	26	1	70.9
2.	Ravipadu	7.9	160	230	80	100	3.8	0.5	0.0	23.7	6.8	4.4	48.0	33	2	70.9
3.	Pippara	8.6	160	250	115	155	9.2	0.01	0.02	2.75	5.8	4.8	12.8	40	6	35.4
4.	Chintapalli	8.2	190	280	100	116	2.0	0.5	0.2	24.2	6.4	1.2	3.2	42	3	141.8
5.	Jallikommara	8.4	210	310	100	112	8.5	0.5	0.0	11.4	7.2	6.0	13.2	49	4	155.9
6.	Bhuvanapalli	8.1	320	470	75	140	8.9	0.5	0.1	24.1	6.6	3.6	19.2	76	4	127.6
7.	Ganapavaraman	8.9	310	450	135	136	12.1	0.5	0.2	12.6	6.8	3.6	12.8	57	8	141.6
8.	Bavayyapalem	8.8	410	610	165	168	2.3	0.4	0.0	8.5	7.0	3.6	25.6	83	5	141.8
9.	Pedakapavaram	8.5	490	730	205	92	10.6	0.5	0.0	6.3	6.8	2.4	19.2	87	3	198.5
10.	Chinnaka-pavaram	8.6	410	610	190	148	5.8	0.6	0.1	12.2	6.6	1.2	9.6	80	4	184.3
11.	Gummuluru	8.5	460	700	175	192	2.0	0.0	0.2	7.8	6.8	1.2	6.4	82	2	266.8
12.	Undi	8.1	170	250	40	125	18.8	0.37	0.07	4.33	6.8	7.2	22.0	30	7	35.45
13.	Akiveedu	8.4	450	650	90	216	1.0	0.81	0.0	3.13	6.6	4.8	12.6	74	5	128

14.	Kalisipudi	8.3	190	280	50	140	1.8	0.14	0.01	2.12	6.2	6.0	20.4	34	3	35.45
15.	Cherukuvada	7.9	230	330	55	145	1.7	0.18	0.03	2.42	2.4	6.0	24.6	39	3	49.63
16.	Ajjaram	8.2	400	580	80	170	0.3	0.13	0.01	3.51	6.4	7.2	28.4	79	5	120.5
17.	Ayi-Bhimavaram	8.3	460	660	90	192	6.0	0.26	0.0	2.51	5.2	3.6	18.2	75	2	131
18.	Cherukumilli	8.5	410	590	75	188	1.9	0.38	0.0	3.21	6.8	4.0	16.6	72	6	121
19.	Juvvalapalem	8.3	560	810	95	196	0.7	0.64	0.0	3.13	6.4	19.2	64.0	97	4	177
20.	Elurupadu	8.2	600	850	75	176	0.7	0.47	0.0	2.43	6.6	2.0	8.0	76	4	124
21.	Prathel-lameraka	8.5	510	750	95	224	6.8	0.80	0.02	4.13	5.4	2.5	18.6	90	8	156
22.	Kalavapudi	8.3	740	1080	100	188	6.0	0.83	0.05	3.93	4.4	1.2	9.8	116	8	262
23.	Modi	8.3	770	1220	135	188	1.0	0.38	0.03	2.39	5.8	4.0	18.6	115	9	255
24.	Kalla	9.7	340	490	170	140	12.9	0.04	0.0	1.42	7.5	4.2	22.4	75	5	88.62
	Averages	**8.4**	**379**	**503**	**102**	**106.6**	**6.1**	**0.4**	**0.04**	**7.95**	**6.2**	**4.5**	**17.5**	**67.8**	**4.6**	**134.13**

Table 3. Panchayat Treated drinking water: Physico-Chemical parameters

S.No	Village	pH	TDS	EC	TH	TA	TURB	NH_3	NO_2	NO_3	DO	BOD	COD	Na	k	Cl
1.	Muddap-uram	8.5	150	220	115	100	2.8	0.02	0.0	32.8	6.4	4.4	16	28	1	85
2.	Ravipadu	8.3	170	250	65	112	1.4	0.0	0.0	24.2	5.6	1.4	3.2	37	2	170.1
3.	Pippara	8.7	170	260	135	155	9.2	0.01	0.0	3.04	5.0	4.0	12	39	5	35.45
4.	Chintapalli	8.4	230	310	115	128	6.4	0.5	0.0	11.3	6.4	1.2	3.6	46	3	112.7
5.	Jalliko-mmara	8.3	240	340	110	108	6.3	0.5	0.1	13.2	6.8	1.2	5.6	53	4	115.9
6.	Bhuva-napalli	8.4	340	490	120	140	0.3	0.5	0.1	21.7	6.6	2.4	22.4	77	4	184.3
7.	Ganapa-varam	8.9	300	450	205	144	4.7	0.1	0.0	12.7	7.6	1.2	3.2	59	8	127.6
8.	Bavay-yapalem	8.7	420	620	175	232	0.9	0.1	0.0	18.6	6.4	1.2	9.6	84	5	184.3
9.	Peddakapav aram	8.6	530	780	225	144	0.6	0.0	0.0	10.6	7.4	1.2	6.4	93	5	212.7
10.	Chinnakapa varam	8.6	410	600	190	188	0.6	0.0	0.0	5.5	6.6	1.2	6.4	80	3	155.9
11.	Gum-muluru	8.5	460	680	170	176	0.2	0.0	0.1	7.7	7.6	1.2	9.6	82	3	155.9
12.	Undi	8.4	190	270	50	110	0.1	0.0	0.0	4.32	7.0	1.2	6.4	35	9	38.99
13.	Akiveedu	8.4	390	550	85	190	0.3	0.06	0.01	2.71	6.0	2.4	9.6	73	3	35.0
14.	Kalisipudi	8.2	170	250	45	170	3.6	0.21	0.02	1.98	4.8	6	20	32	3	31.9
15.	Cheru-kuvada	8.1	280	400	70	180	0.2	0.13	0.01	1.52	7.8	4.8	16.4	54	5	56.72
16.	Ajjaram	8.4	400	580	75	170	0.1	0.17	0.0	3.67	6.4	3.6	12	75	4	120.53
17.	Ayi-Bhim-avaram	8.2	60	80	20	45	0.2	0.04	0.00	0.10	5.8	1.2	8	32	0	43
18.	Cheru-kumilli	8. 2	400	580	75	188	0.7	0.30	0.03	2.38	4.6	1.2	9	79	8	117
19.	Juvv-alapalem	8.7	480	700	90	188	1.0	0.28	0.01	2.55	4.6	2.4	12	91	3	156
20.	Elurupadu	8.2	400	580	85	188	1.5	0.11	0.01	2.18	6.4	1.2	6	64	5	121
21.	Prathella-meraka	8.3	560	790	110	212	1.1	0.08	0.01	3.72	5.8	1.5	8	91	5	177
22.	Kalavapudi	8.2	80	110	10	28	0.2	0.00	0.08	1.73	7.4	1.2	6.4	30	0	46
23.	Modi	8.4	1000	1460	135	196	0.4	0.26	0.01	3.90	6.6	1.6	8.8	134	9	376
24.	Kalla	8.3	350	510	155	190	1.1	0.05	0.0	1.55	6.0	1.2	4.6	75	12	85.08
	Average	**8.7**	**340**	**494**	**109**	**153**	**1.8**	**0.1**	**0.02**	**8.0**	**6.3**	**2.08**	**9.38**	**64.0**	**4.7**	**132.0**

Table 4. NTR Sujala/ NGO Drinking water with R.O.

S.No	Name of the village	NTR/NGO name	pH	TDS	EC	TURB.	DO	TH	TA	Na	K	Cl
1.	Muddapuram	NTR	7.9	60	90	0.9	7.2	6.0	28	34	0	25.0
2.	Ravipadu	NTR	8.3	20	30	0.2	7.2	9.5	24	9	1	13.4
3.	Peddakapavaram	NTR	8.0	30	50	0.1	7.4	8.5	56	9	0	8.5
4.	Undi	NTR	8.1	60	80	0.1	5.8	15	45	12	2	17.7
5.	Akiveedu	Amrutha	7.1	50	70	0.1	6.6	15.0	25	19	4	28.3
6.	Kalisipudi	NTR	7.9	50	80	0.1	6.5	20	45	10	0	17.9
7.	Cherukuvada	NTR	7.0	60	80	0.4	6.0	7.5	35	23	1	24.8
8.	Ajjmuru	NTR	8.2	40	50	0.3	6.5	15	35	4	0	14.1
9.	Ayi-Bhimavaram	NTR	8.2	60	80	0.2	5.8	20	45	32	0	43.0
10.	Kalavapudi	NTR	7.7	20	30	0.3	6.2	5	16	10	6	18.0
	Averages		**7.8**	**45**	**72**	**0.2**	**6.0**	**12.5**	**35.4**	**19.8**	**1.4**	**21.07**

Table 5. NTR Sujala/NGO drinking water without R.O.

S.No	Name of the village	NTR/NGO name	pH	TDS	EC	TURB.	DO	TH	TA	Na	K	Cl
1.	Pippara	Dr. water	8.9	200	290	0.5	6.0	110	70	39	5	35.45
2.	Chintapalli	NTR	8.2	90	140	0.5	7.2	50	60	24	1	70.1
3.	Jallikommara	NTR	8.1	140	210	0.6	7.4	35	56	34	0	47
4.	Bhuvanapalli	NTR	8.5	330	490	6.6	6.8	100	144	78	4	184.3
5.	Akiveedu	Nandi	7.5	80	110	0.1	5.8	15	35	25	0	35
6.	Cherukumelli	NTR	7.8	350	510	0.4	6.4	50	50	66	4	67
7.	Elurupadu	Sattibabu foundation	8.2	670	980	2.4	6.2	115	232	107	5	216
8.	Prathellameraka	NTR	8.3	410	600	1.5	6.6	80	152	77	4	117
9.	Ganapavaram	RajuVegesna	9.4	280	410	1.2	7.2	125	136	67	7	113.4
10.	Bhavayyapalem	Dr. Water	8.9	170	270	0.6	7.2	150	80	53	2	99.2
11.	Kalla	NTR	8.0	90	130	0.1	7.0	60	35	31	2	24.8
	Average		**8.3**	**255**	**376**	**1.3**	**6.7**	**81**	**95.4**	**54.6**	**3**	**91.7**

Table 6. Average values of various sources of water

S.No	Source	pH	TDS	EC	TH	TA	TURB	NH_3	NO_2	NO_3	DO	BOD	COD	Na	K	Cl
1.	Canal	8.3	298	422	100	117	6.8	0.46	0.09	9.4	5.7	3.4	15.1	53.9	2.6	120.6
2.	S.S.Tank	8.4	379	503	102	106	6.1	0.4	0.04	7.9	6.2	4.5	17.5	67.8	4.6	134.3
3.	P.T.W.	8.7	340	494	109	153	1.8	0.1	0.02	8.0	6.3	-	-	64.0	4.7	132.0
5.	N.G.O. (R.O.)	7.8	45	72	12.5	35.4	0.2	0	0	0	6.0	-	-	19.8	1.4	21.0

When the average values of various sources of water are taken the following facts were noticed. The pH value of Canal, S.S.Tank, P.T.W and NGO (Without R.O) ranged from 255-379ppm which is within the range of required standard (150-500ppm) whereas in case of NGO. with R.O. processed water is very low (45ppm), EC values are also based on TDS values, Hardness values ranges from 81 to109ppm without R.O. and it is just 12.5 ppm with R.O. processed waters. Total alkalinity also ranges from 95.4 to 153ppm without R.O. and it is only 35.4 ppm in the case of R.O. waters. Sodium ranges 53.9 to 67.8 ppm without R.O. and it is 19.8 ppm with R.O.process. Chlorides range from 91.7 to 134.3 ppm without R.O. and it is 21ppm with R.O. waters. In total R.O. processed waters have very low values of minerals when compared to other types of processed or unprocessed water. According to F.Kojisek, water with less mineral content is not good for drinking[7].

Microbiological Quality of Drinking Water

The presence of Total Coli form bacteria in water is measured in the form of MPN index. i.e. Most Probable Number in 100 ml water sample. Coli form bacteria naturally present in the gastro intestinal tract of human and animals. The presence of Coli form bacteria in water indicate that, water has been contaminated with fecal matter of human and other animals. Presence of E.Coli in water indicates recent fecal contamination and may indicate the possible presence of disease causing pathogens such as bacteria, virus and other parasites. MPN index and E-Coli in drinking water are used as indicators to measure the degree of pollution and sanitary quality of drinking water.

CFU values	**MPN Values**
0/100ml—No risk	5% No risk
1-10ml/100 ml---low risk	20% proper disinfection needed
11-100 ml/100ml--- high risk	75% not suitable
101-1000 ml/100 ml-----	Very high risk

Category	MPN/100ml	Water quality
A	0	Good- safe for drinking
B	<50	Not good- applicable to disinfection treatment
C	>50	Polluted- requires stringent methods of treatment

Table 7. Microbiological characteristics of Panchayat treated drinking water in different villages

S.NO	**Village**	**MPN/100ml**	**TFC/100ml**	**TBC cfu/1ml**	**E.Coli cfu/1ml**
1.	Muddapuram	460	240	$64x10^5$	$44x10^3$
2.	Ravipadu	43	0	$180x10^5$	$6x10^3$
3.	Chintapalli	>2400	210	$154x10^5$	$124x10^3$
4.	Jallikommara	23	23	$127x10^4$	0
5.	Bhuvanapalli	1100	150	$182x10^4$	$57x10^2$
6.	Ganapavaram	7	0	$50x10^4$	0
7.	Bavayyapalem	23	0	$15x10^4$	0
8.	Peddakapavaram	0	0	4	0
9.	Chinnakapavaram	460	240	$120x10^4$	0
10.	Gummuluru	210	210	$118x10^4$	$4x10^2$
11.	Undi	1600	0	$180x10^5$	0
12.	Akiveedu	9	0	$184x10^5$	0
13.	Kalisipudi	>2400	540	$150x10^4$	$34 x10^2$
14.	Cherukuwada	240	0	$20x10^4$	0
15.	Ajjamuru	>2400	23	$117x10^4$	0
16.	Ayi-Bhimavaram	>2400	23	$127x10^4$	0
17.	Cherukumilli	>2400	210	$120x10^4$	$10x10^2$
18.	Juvvalapalem	>2400	220	$160x10^5$	$15x10^2$
19.	Elurupadu	>2400	210	$40x10^5$	0
20.	Prathellameraka	23	0	$15x10^4$	0
21.	Kalavapudi	>2400	240	$118x10^4$	0
22.	Modi	53	0	$23x10^3$	0
23.	Kalla	460	150	$182x10^4$	$37x10^2$
24.	Pippara	>2400	43	$120x10^4$	$126x10^2$

If microbiological values of Panchayat treated water are observed only one sample out of 24 villages is observed to be good and safe for drinking; and another 6 samples may be suitable with proper disinfection; whereas 17 samples are not at all suitable for drinking purpose, that reflects the negligence in the treatment process. In case of NGO supplied (NTR sujala /NGO/R.O) waters 2 out of 20 are found to be safe and suitable for drinking, and another 3 samples may be fit for drinking with a better disinfection process, whereas 15 out of 20 are not at all suitable for drinking. So, the quality of Panchayat treated water and NGO treated water are more or less same and in majority of villages people are not getting proper potable water.

Table 8. Microbiological characteristics of NTR Sujala/NGO drinking waters in different villages

S.NO	Village	Name(NTR/NGO)	MPN/100ml	TFC/100ml	TBC cfu/1ml	E.coli cfu/1ml
1.	Muddapuram	NTR sujala	43	9	$60x10^5$	$22x10^3$
2.	Ravipadu	NTR sujala	1100	75	$100x10^5$	$130x10^3$
3.	Chintapalli	NTR sujala(R.O.)	210	20	$100x10^5$	$35x10^3$
4.	Parimella	NTR sujala(R.O.)	150	39	$156x10^4$	$24x10^2$
5.	Bhuvanapalli	NTR sujala(R.O.)	>2400	>2400	$147x10^5$	$123x10^3$
6.	Ganapavaram	RajuVegesna	75	4	$100x10^4$	$4x10^2$
7.	Bavayyapalem	Dr.Water (R.O)	23	0	8	0
8.	Peddakapavaram	NTR sujala(R.O.)	0	0	0	0
9.	Undi	NTR sujala (R.O)	540	5	$30x10^5$	0
10.	Akiveedu	Nandi Foundation(R.O)	9	0	4	0
11.	Kalisipudi	NTR sujala (R.O)	0	0	0	0
12.	Cherukuwada	NTR sujala (R.O.)	94	0	10	0
13.	Ajjmuru	NTR sujala (R.O.)	130	4	$20x10^5$	0
14.	Ayi-Bhimavaram	NTR sujala (R.O.)	>2400	23	$60x10^4$	0
15.	Cherukumilli	NTR sujala	>2400	30	$156x10^4$	0
16.	Elurupadu	Sattibabu foundation	>2400	45		0
17.	Prathellameraka	NTR sujala	>2400	39	$45x10^5$	$10x10^2$
18.	Kalavapudi	NTR sujala (R.O.)	>2400	55	$50x10^5$	$15x10^2$
19.	Kalla	NTR sujala	460	0	$53x10^5$	$37x10^2$
20.	Pippara	Dr.Water	150	0	$50x10^4$	0

ACKNOWLEDGEMENTS

This is part of the work under the project No. DST/TM/WTI/2K14/183(G), sponsored by Technology Mission Cell: Water and Solar Energy, Department of Science and Technology, New Delhi. The authors express their sincere gratitude to Dr. D.R. Prasada Raju former Scientist-G/Adviser & Head (TMC), Dr. Sanjay Bajpai, Associate Head, Scientist F and Dr. Neelima Alam, Scientist-D, Technology Mission Cell: Water and Clean Energy, Department of Science and Technology and Government of India, New Delhi for their encouragement and guidance. We are also acknowledging the Principal and Management of S.R.K.R. Engineering College, Bhimavaram for their support in our research work

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River Water-Quality Model for Nonpoint Sources

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ABSTRACT

Water is essential for life on Earth, and any changes in the natural quality and distribution of water have ecological impacts that can be threatening. Water resources management involves the monitoring and management of water quality and quantity. Water quality models can be effective tools to simulate and predict pollutant transport in water environment and moreover they serve as a base for environmental management decisions. Because of strict rules and regulations point source discharges have been controlled around the world, and attention has turned to regulate nonpoint sources, which are often harmful, untreated, intermittent and difficult to control. Agriculture and urban activities are considered major nonpoint pollution sources. Nutrients are essential to life processes of aquatic organisms. The major nutrients of concern are carbon, nitrogen, and phosphorus. Nutrients if present in adequate quantities can be used to meet the biochemical requirements of the organisms otherwise can become critical components of eutrophication and hence become integral part of water-quality modeling. The presently available nonpoint source pollution models are very complex and require large amount of data and hence an attempt has been made to develop a simple model for such pollution sources. Nutrients are modeled by using a system of coupled mass balance equations describing each nutrient compartment and transport processes. The developed model is used to predict nitrogen concentration in River Kabini, Mysuru. The results were in well agreement with the measured data, with some exceptions.

Keywords: Nonpoint pollution, Agriculture, Nutrients, River water-quality model.

INTRODUCTION

Water is essential for human civilization, living organisms, and natural habitat. River water is a crucial resource for drinking, irrigation, industry, transportation, recreation, fishing, hunting, support of biodiversity and sheer aesthetic enjoyment. Water quality degradation in rivers is occurring as a result of wastewater entering the rivers from urbanization, industrialization, mining, agriculture and other activities. The evaluation and analysis of water pollution from both technological and economic points of view is a very important issue in the ecology. As with any system, the natural water body responds in a variety of ways depending upon the nature of inputs and forcing functions. The chemical inputs to which the quality of the system responds may be classified as point and nonpoint sources. Pollutant discharges from point sources are often continuous, with little variability over time. Often they can be monitored by measuring discharge and chemical concentrations periodically at a single place. Point sources are relatively simple to measure and regulate, and can often be controlled by treatment at source. Nonpoint inputs can also be continuous, but are more often intermittent and linked to seasonal agricultural activity or irregular events, such as heavy precipitation or major construction. Nonpoint inputs often derive from extensive areas of land and are transported overland, underground, or through the atmosphere to receiving waters. Consequently, nonpoint sources are difficult to measure and regulate. Sediments and nutrients are the most commonly recognized nonpoint pollutants; others include toxic contaminants (heavy metals and man-made chemicals such as pesticides and solvents), airborne inputs and pathogens (disease-causing organisms) from human or animal waste.

Agriculture is the main cause of nonpoint-source pollution that affects streams and aquifers. The driving force of nonpoint source pollution is the rainfall-runoff process, which tends to be a complex non-linear, time-varying and spatially distributed process in agricultural watersheds. In agricultural watersheds, variable amounts of pesticides can be released to streams and aquifers through surface runoff and leaching, jeopardizing sources of drinking water. Modeling is a valuable tool in the analysis of the risk of contamination caused by nutrients and pesticides and in evaluating the effect of management practices in that process.

MATERIALS AND METHODOLOGY

Study area

The Kabini or Kapila is a river of southern India. It originates in the Wayanad District of Kerala state and flows eastward to join the river Cauvery at Tirumakudal Narasipur in Karnataka, which drains into the Bay of Bengal. Its coordinates are latitude 12° 13′ 0″ N and longitude 76° 54′ 39″ E. The total length of the river is about 240 km. For this study, stretch of river Kabini in Mysuru district is selected.

Data and monitoring sites

The monitoring stations as depicted by “Figure 1.” taken for this study covered four stations S1–S4 along the river. The monitoring works were conducted in December 2014. The fieldwork consisted of collecting a single sample in each station. The timings of samplings were varying. The test of physical parameters such as flow, temperature, pH, and DO were performed at the sites. “Table 1.” shows the hydraulic characteristic of the river. In this study only nitrogen modeling is considered.

Figure 1. Monitoring stations along Kabini River

Table 1. Hydraulic characteristics at monitoring stations along Kabini River

Monitoring Stations	Flow (m^3/s)	Velocity (m/s)	Depth (m)	Width (m)	Dispersion Coefficient (m^2/s)
S_1	23.4	0.120	1.388	70	10.648
S_2	23.4	0.130	1.300	68	11.503
S_3	23.4	0.109	1.135	65	19.690
S_4	23.4	0.121	1.380	70	10.650

Development of model

Certain elements are referred to as nutrients because they are essential to life processes of aquatic organisms. The major nutrients of concern are carbon, nitrogen and phosphorus. Nutrients are important in water quality modeling because nutrient dynamics are critical components of eutrophication. Algal growth is typically limited by either phosphorus or nitrogen. Nitrogen is important in water quality modeling for reasons other than its role as a nutrient. For example, the oxidation of ammonia to nitrate during the nitrification process consumes oxygen and may represent a significant portion of the total BOD. Also, high concentrations of unionized ammonia can be toxic to fish and other aquatic organisms.

Nutrients are present in several different forms in aquatic systems:

(a) Dissolved inorganic nutrients
(b) Dissolved organic nutrients
(c) Particulate organic nutrients
(d) Sediment nutrients
(e) Biotic nutrients

Only the dissolved inorganic forms are available for algal growth. These include dissolved carbon dioxide, ammonia, and nitrite and nitrate nitrogen, orthophosphate and dissolved silica. Each nutrient undergoes continuous recycling between the major forms listed above which is illustrated in "Figure 2." for nitrogen. Nutrients are also introduced through waste loads (both point and nonpoint sources).

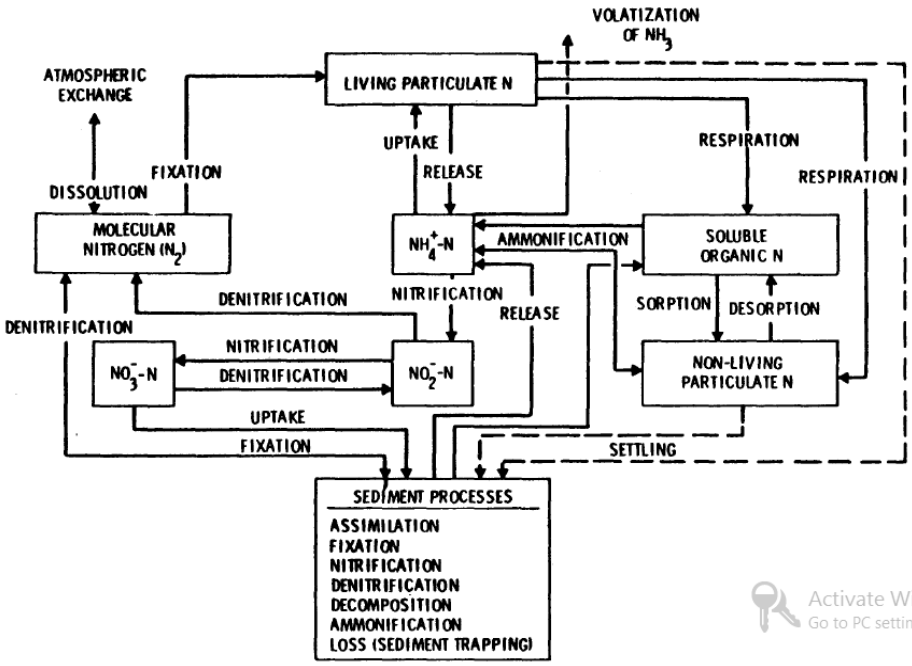

Figure 2. Processes related to modeling of nitrogen

Nutrient dynamics are governed by the following processes:

(a) Photosynthetic uptake
(b) Excretion
(c) Chemical transformations
(d) Hydrolysis of dissolved organic nutrients
(e) Detritus decomposition
(f) Sediment decomposition and release
(g) External loading

Nutrients are modeled by using a system of coupled mass balance equations describing each nutrient compartment and each process listed above, plus the transport processes of advection and dispersion.

$$u_x = \frac{ds}{dx} = E\frac{d^2S}{dx^2} - V_s + f_1 e_s + K_1 S + K_{org} S_{org} + f_2 K_{det} S_{det} + f_3 K_{sed} S_{sed} \qquad (1)$$

Where: S = dissolved inorganic nutrient concentration, mass/volume, S' = another inorganic form of the nutrient which decays to the form S, mass/volume, S_{org} = dissolved organic nutrient concentration, mass/volume, S_{det} = suspended particulate organic nutrient concentration, mass/volume, S_{sed} = organic sediment nutrient concentration, mass/volume, K_1 = transformation rate of S' into S, Time^{-1}, K_2 = transformation rate of S into some other dissolved inorganic form of the nutrient, Time^{-1}, K_{org} = hydrolysis rate of dissolved organic nutrient, Time^{-1}, K_{det} = decomposition rate of particulate organic nutrient, Time^{-1}, K_{sed} = decomposition rate of organic sediment nutrient, Time^{-1},V_s = photosynthetic uptake rate of nutrients S, mass/volume.time, e_s = soluble excretion rate of nutrients by all organisms, mass/volume.time, f_1 = fraction of soluble excretions which are inorganic, f_2 = fraction of detritus decomposition products which are immediately available for algal uptake, f_3 = fraction of sediment decomposition products which are immediately available for algal uptake, u_x = velocity component in x direction, Length. Time^{-1}, E = Dispersion coefficient, Length^2. Time^{-1}.

Equation (1) is divided into seven equations considering each process and transport and the solutions are as follows:

$$S_1 = C_1 e^{\sqrt{\frac{u_x}{E}x}} + C_2 e^{-\sqrt{\frac{u_x}{E}x}} - \frac{V_s}{u_s} \tag{2}$$

$$S_2 = C_1 e^{\sqrt{\frac{u_x}{E}x}} + C_2 e^{-\sqrt{\frac{u_x}{E}x}} - \frac{f_1 e_s}{u_s} \tag{3}$$

$$S_3 = C_1 e^{0x} + C_2 e^{\left(\frac{u_x - K_1}{E}\right)x} \tag{4}$$

$$S_4 = C_1 e^{\frac{\frac{u_x}{E} + \sqrt{\left(\frac{u_x}{E}\right)^2 + \frac{4K_2}{E}}}{2}x} + C_2 e^{\frac{\frac{u_x}{E} - \sqrt{\left(\frac{u_x}{E}\right)^2 + \frac{4K_2}{E}}}{2}x} \tag{5}$$

$$S_S = C_1 e^{0x} + C_2 e^{\left(\frac{u_x + K_{org}}{E}\right)x} \tag{6}$$

$$S_6 = C_1 e^{0x} + C_2 e^{\left(\frac{u_x - f_2 K_{det}}{E}\right)x} \tag{7}$$

$$S_7 = C_1 e^{0x} + C_2 e^{\left(\frac{u_x - f_s K_{sed}}{E}\right)x} \tag{8}$$

RESULTS AND DISCUSSIONS

"Table 2." shows the results for the water quality parameters. "Table 3." shows the input parameters for the model. "Table 4." shows the results for model run for Kabini River. Amongst the four monitoring stations chosen three were near to agricultural fields and hence ammonia nitrogen and nitrate nitrogen concentrations are more in those samples. The results were in well agreement with the measured data, with some exceptions. Some errors in this modeling are inevitable as the field work consisted of collecting a single sample in each station.

Table 2. Water quality measurement at monitoring station along Kabini River

Monitoring Stations	DO (mg/L)	pH	NO_3 (mg/L)	NO_4 (mg/L)
S_1	7.5	7.53	2.377	1.920
S_2	6.9	7.51	1.939	0.928
S_3	7.7	7.86	0.380	0.125
S_4	7.6	7.67	1.732	0.895

Table 3. Input parameters for model

V_s (µg/L.s)	e_s (µg/L.s)	f_1	f_2	f_3	K_1 (s^{-1})	K_2 (s^{-1})	K_{org} (s^{-1})	K_{sed} (s^{-1})	K_{det} (s^{-1})
5.2E-4	2E-4	2E-5	1	1	1.19E-5	2.49E-5	9.68E-6	1.1E-5	4.6E-6

Table 4. Model results

S_1 (µg/L)	S_2 (µg/L)	S_3 (µg/L)	S_4 (µg/L)	S_5 (µg/L)	S_6 (µg/L)	S_7 (µg/L)	S (µg/L)
1921.453	1712.67	19.258	13.37	7.17	9.31	9.8	3693.03
1739.928	1574.37	14.19	5.75	7.19	9.52	10.02	3360.97
114.5066	106.08	11.96	6.5	4.48	9.63	10.13	0263.29
2006.585	1779.66	18.531	13.45	7.23	10.09	10.59	3846.14

Dispersion coefficient is calculated by the formula given below:

$$E = \frac{\beta * Q^2}{u_x * D^s} \tag{9}$$

$$\beta = E_q \frac{B}{Q^2} \tag{10}$$

Where

β = Non-dimensional diffusion factor

D = Channel depth

Q = Flow

E_q = Diffusion factor, (E_q =0.0488 m^2/s).

Photosynthetic uptake rate of nutrients "S" and soluble excretion rate of nutrients by all organisms is calculated by the formulae given below:

$$V_s = \alpha * \mu * A \tag{11}$$

$$e_s = \alpha * r_a * A \tag{12}$$

$$S = S_1 + S_2 + S_3 + S_4 + S_5 + S_6 + S_7 \tag{13}$$

Where: α = Nutrient fraction of algal cells, (α = 7.2 gN/1 gA), A = Algal concentration = 25 (µg/L), μ = Gross growth rate of algae = 0.25/d and r_a = Algal respiration rate = 0.1/d. "Table 3." shows the input parameters for model. V_s and e_s are calculated using above mentioned values. Rate constants are chosen according to river conditions.

CONCLUSION

The model represented the field data quite well with some exceptions. Model has to be validated and sensitivity analysis has to be performed.

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Application of CCME Water Quality Index to Monitor the Water Quality of River Hindon, India

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ABSTRACT

River Hindon which is the major tributary of the river Yamuna, has been subjected to immense pollution and degradation due to large amount of untreated domestic and industrial waste discharged from Ghaziabad and Noida districts of Uttar Pradesh, India. The present study investigated the use of Canadian Council of Ministers of the Environment water quality index (CCMEWQI) to classify the quality of the river water into excellent, good, fair, marginal and poor. CCMEWQI provides a convenient means of summarizing comprehensive water quality data that can be easily understood by the public, water distributors, planning managers and policy makers. The parameters under consideration were total suspended solids, total dissolved solids, pH, biological oxygen demand (BOD), chemical Oxygen demand (COD), chloride, fluoride, nitrate, iron and copper. The index results indicated that the water quality of river Hindon ranged from fair to marginal. Total suspended solids, BOD, nitrate, fluoride and iron were found to be the most critical pollutants affecting the water quality of the river stretch. This implicates that most stretch of river in the mentioned districts is deteriorated with respect to quality of water for drinking and recreational purposes. This calls for immediate attention towards the monitoring and control of discharge of pollutants into the river.

Keywords: River Hindon, CCMEWQI, Water quality.

INTRODUCTION

Water is an imperative natural source and supreme requirement for all living beings. Rivers are important resources for human civilizations as they meet water demand for various uses apart from supporting flora and fauna, improving aesthetic and landscape quality, Moderating climate and providing resource for hydropower (Sharma *et al.,* 2008). Rapid population growths, land development along river basin, urbanization and industrialization have subjected the rivers to increase stress, giving rise to water pollution and environmental deterioration (Sumok, 2001). Maintenance of the integrity of water sources is the need of present situation and for that a comprehensive river quality monitoring programme should be developed. Traditional approaches to monitor the water quality of river include the comparison of measured parameter with the local norms but it lacks information on the spatio-temporal basis and does not reflect overall water quality (Debels *et al.,* 2005).

Water quality index is an effectual tool which aims at providing solitary numerical value for the large and comprehensive water quality data to illustrate the water quality. Therefore, it is a simple tool for decision makers on the quality and possible uses of a water body (Bordalo *et al.,* 2001; Cude 2001; Kannel *et al.,* 2007).

The WQI involves the comparison of various water quality parameters with respect to a particular standard for the same, provided by statutory body to formulate a single value. This value is indicative of components and their concentrations in the water sample (Khan *et al.,* 2003; Abbasi 2002). The index method, (Horton 1965) has been the basis for development of various other indices by agencies accountable for water supply and control of water pollution. For example, US National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), British Columbia Water Quality Index (BCWQI), Oregon Water Quality Index (OWQI), and the Florida Stream Water Quality Index (FWQI) (Debels *et al.,* 2005; Kannel *et al.,* 2007; Abbasi 2002).

The CCME WQI is based on a formula developed by the British Columbia Ministry of Environment, Lands and Parks that was modified by Alberta Environment, The Index incorporates three elements: Scope - the number of variables not meeting water quality objectives, Frequency - the number of times these objectives are not met and

Amplitude - the amount by which the objectives are not met. The index produces a number between 0 (worst water quality) and 100 (best water quality). These numbers are divided into 5 descriptive categories to simplify presentation. This index doesn't give any weighted numbers but treats the values of parameters in mathematical way to ensure that all parameters contribute adequately in the final number of the index. This model is flexible, allowing one to choose the parameters to use and standardize them according to the objectives and area of study (Prasad and kothathi, 2012). Present study illustrates the use of CCME water quality index to classify the water quality of river Hindon due to its simplicity but vigorous nature of reporting water quality issues (UNEP, 2007; CCME, 2001). Besides its influence on the water policy makers due to its simplicity, it is however not the substitute for detailed analysis of water quality data (Khan *et al.*, 2004).

MATERIAL AND METHODS

Study Area

The River Hindon is one of the important rivers in western Uttar Pradesh (India) having a basin area of about 7000 km^2 and lies between latitude 28^0 30' to 30^0 15' N and longitude 77^0 20' to 77^0 50'E. The river originates from Upper Siwalik (Lower Himalayas) and flows through five major districts, viz., Saharanpur, Muzaffarnagar, Meerut, Ghaziabad and Greater Noida, a distance of about 200 km before joining the river Yamuna downstream of Delhi (Jain *et al.,* 2005). The major land use in the basin is agriculture, with little forest cover. The basin is densely populated because of the rapid industrialization and agricultural growth during the last few decades. The present study includes the stretch of River ranging from its entrance into Ghaziabad to its confluence with the Yamuna River in Tilwada village, Noida. Water samples were collected from eight different sites.

Study sites along the selected river stretch and their latitude and longitude are presented in Table 1.

Table 1. Study sites along with their latitude and longitude.

Site No.	Site Name	Latitude	Longitude
S1	Karehda	$28^0$40'32.7" N	$77^0$24'23.2"E
S2	Road Bridge	$28^0$40'24.3"N	$77^0$24'05.8"E
S3	Railway Bridge	$28^0$40'01.7"N	$77^0$23'58.6"E
S4	Chijarsi Ghaziabad	$28^0$38'11.0"N	$77^0$23'39.4"E
S5	Chijarsi Noida	$28^0$38'08.0"N	$77^0$23'39.2"E
S6	Kulsera	$28^0$31'47.9"N	$77^0$26'00.4"E
S7	Shafipur	$28^0$24'52.52"N	$77^0$29'20.65E
S8	Tilwada	$28^0$24'52.52"N	$77^0$29'50.98"E

Sampling procedure and analysis

Sampling was done periodically in the month of May 2014, December 2014 and August 2015 and total 24 water samples were collected in Plastic bottles by following the procedure as described by APHA (1998). All samples were analyzed for ten water quality parameters which includes Total suspended solids, Total dissolved solids, pH, Biological Oxygen demand, Chemical oxygen demand, Chloride, fluoride, Nitrate, Copper and Iron.

Calculation of CCMEWQI

CCMEWQI was calculated by set of ten analyzed water quality parameters. CPCB recommended standards for inland surface water were applied to categorize River water.

Canadian council of ministers of the environment developed a water quality index which includes three essential measures of variance (Scope, Frequency and Amplitude). These measures of variance come together with a set of range of values (Table.2) classifying quality of water into five classes namely; poor, marginal, fair, good and excellent.

Table 2. CCME-WQI categorization scheme

Rank	WQI Value
Excellent	95-100
Good	80-94
Fair	65-79
Marginal	45-64
Poor	0-44

The detailed formulation of the WQI as described in the Canadian WQI Technical report (CCME, 2001) is as follows:

Mathematical formulation of the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) is

$$\text{CCME WQI} = 100 - \left[\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}\right] \quad (1)$$

Where, F1 (Scope) represents the extent of water quality guideline non-compliance over the time period of interest.

$$F_1 = \frac{\text{No. of failed variables}}{\text{Total no. of variables}} \times 100 \quad (2)$$

F2 (Frequency) represents the percentage of individual tests that do not meet objectives (failed tests).

$$F_2 = \frac{\text{No. of failed tests}}{\text{Total no. of failed tests}} \times 100 \quad (3)$$

F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps.

Step 1: Calculation of Excursion

Excursion is the number of times an individual concentration is

1. Greater than the objective when the objective under consideration is maximum. In this case the excursion is calculated as

$$\text{Excrusion}_i = \frac{\text{failed test value i}}{\text{objective j}} - 1 \quad (4)$$

2. Less than the objective when the objective under consideration is minimum. The expression for the excursion in this case is given as:

$$\text{Excrusion}_i = \frac{\text{objective j}}{\text{failed test value i}} - 1 \quad (5)$$

Step 2: Estimation of Normalized Sum of Excursions

The normalized sum of excursions (nse), represents the collective amount by which individual tests are out of compliance. It is estimated by summing the excursions of individual tests from their objectives and dividing by the total number of tests for both those meeting objectives and those not meeting objectives

$$\text{nse} = \frac{\sum_{i=1}^{n} \text{excrusion i}}{\text{Sum of tests}} \quad (6)$$

Step 3: Estimation of F3 (Amplitude)

F3 (Amplitude) is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range of values from 0 to 100.

$$F_3 = \frac{\text{nse}}{0.01\text{nse} + 0.01} \quad (7)$$

The water quality objectives described by Central pollution control board for inland surface water quality was used in this model (Table 3).

Table 3. water quality objectives used in the model

Water Quality parameter	CPCB guideline value
pH	5.5 to 9
Total Suspended Solids	100
Total Dissolved Solids	2100
Biological Oxygen Demand	30
Chemical Oxygen Demand	250
Chloride	1000
Fluoride	2
Nitrate	10
Copper	3
Iron	3

RESULTS AND DISCUSSION

The physicochemical analysis of water samples reveals that mainly four parameters namely TSS, BOD, nitrate and iron were exceeding objective value at all the stations. Fluoride is also found to be deviated from its objective value at stations S3, S5 and S6.

Total Suspended Solids

The CPCB guideline for total suspended solids is 100 mg/l whereas the average concentration of TSS in River Hindon varies from 25 mg/l to 637 mg/l, which is much above the permissible limit.TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life.

Biological Oxygen Demand

BOD value indicates the organic pollution in the stream, which impose adverse effect on the water quality of aquatic system. The objective value of BOD according to CPCB is 30 mg/l. The BOD value in the stream ranges from 11.4mg/l to 82.8mg/l among various study sites, which clearly shows that BOD values are much above the prescribed standards. Elevated values of BOD may be attributed to the mixing of sewerage and various nalas into the stream.

Nitrate

Nitrate is a significant parameter of river water showing pollution status and anthropogenic load on river (Suthar et al. 2010). The average nitrate value observed in River Hindon is 35.4 mg/l which exceeds Indian inland surface water standards (CPCB 1995). Higher nitrate contents in Hindon water suggested the mixing of sewerage water in river system.

Iron

Increase in the level of iron in water may be attributed to the excess of iron in the soil and corresponding siltation. The average Iron value of River stretch is 6.26 mg/l which is much above the prescribed standard.

Table 4. Summary Findings of Water Quality Analysis.

Parameter	N	Minimum	Maximum	Mean
pH	24	7.03	8.10	7.4896
BOD	24	11.40	82.76	50.6172
COD	24	16.00	192.00	99.6667
Nitrate	24	3.10	134.00	35.4136
Chloride	24	39.76	309.66	156.08
Fluoride	24	.07	9.03	.9787
TDS	24	243.00	1031.00	569.2
Copper	24	.00	.17	.0302
Iron	24	.83	24.24	6.2620
TSS	24	25.00	637.00	204.5

Water Quality Index

Water Quality Index results indicates that quality of river water ranges from fair to marginal with respect to Indian standards for inland surface water. The results shows that water quality index at S1 and S2 i.e. 67.6 and 74.6 respectively, is of "Fair" category which further deteriorate along S3 to S7 and comes under "Marginal" water quality and again on station 8, it is found to be of Fair quality as shown in Figure 1. The overall water quality index of the river comes under marginal category which implicates that water quality of river is frequently threatened or impaired and conditions are often depart from natural or desirable levels.(CCME, 2001)

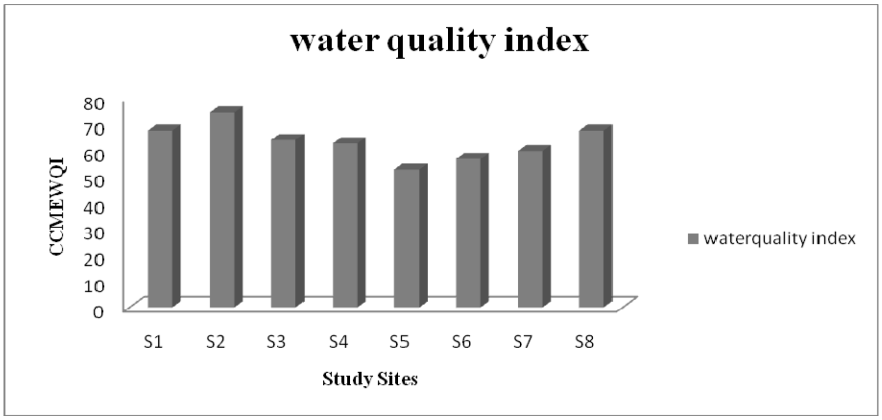

Figure 1. Water Quality Index Observed at various stations.

CONCLUSION

This study suggests that the water quality of River Hindon is impacted mainly due to TSS, BOD, nitrate and iron as these parameters are found to be exceeding water quality objectives prescribed by CPCB for inland surface waters. All these influencing factors can be attributed to the mixing of sewerage, urban flow and anthropogenic activities along the course of river.

Based on the CCME WQI model, the water quality of the River Hindon is categorized as fair to marginal, which suggests that the water quality is frequently threatened, and there is a need of proper management plan to check sewage system and discharge of urban as well as industrial waste. The determination of water quality index will be used for evaluation and management purposes over time and space and will act as a key indicator towards the changes in environmental parameters.

This study confirmed that use of CCME WQI model to assess water quality does recognize the specific problematic variables/parameters that may be contributing towards lowering the CCME WQI values. This information can be of immense value for water users (public), water suppliers (municipalities and city councils), planners, policy makers, and scientists reporting on the state of the environment.

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Performance of Metal Oxide Nano-Aggregates as Fluoride Filtration Media Pack in Domestic Water Filters: An Appraisal

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ABSTRACT

Development of cost effective, eco-friendly domestic filtration units based on synthetic fixed bed media packed with metal oxide nano-aggregates as filter medium may serve as long term solution to ensure supply of fluoride free drinking water to the plebeians of rural society. Bi-metallic or poly metallic nano-crystallites have recently drawn attention for their efficacy in this line. Incorporation of one metal into other metals causes morphological and structural modifications, lattice defects, and size gradation of the resultant metallic nano-products. Such rearrangement enhances the porosity, surface area, activated sites with oxygen and hydroxyl groups which, in turn, trigger the adsorption dynamics. The resultant media can be effectively utilized for design and development of innovative filter packs for treatment and supply of fluoride free drinking water to the fluoride affected poor population at an affordable price. The article embraces to revisit and propagate the excellent adsorption efficacy of metal nanocomposites packed in domestic filters in a bid to restore the fragile physiological and socio-economic conditions of fluoride riddled end users.

Keywords: Groundwater, Fluoride, Metal Oxides, Nano-aggregates, Domestic Filter.

1. INTRODUCTION

Fluoride is an essential trace element for human health. It is required in minute quantities for normal mineralization of bones and skeletal structures, dental enamel formation, etc. But intake of fluoride beyond permissible limit creates fluorosis, a deadly disease. Fluoride enrichment in groundwater is, therefore, recognised as one of the major threats to human health by European Union (EU), World Health Organisation (WHO) and Environmental Protection Agency (EPA). Fluoride contamination is thus considered as topmost priority, after microbial pollution, to ensure drinking water quality by regulatory authorities. At present, 32 countries of the world are reportedly endemic in fluorosis (Ayoob et al., 2006). WHO has stipulated a guideline of less than 1.5 mg/L fluoride in drinking water. Treatment by way of defluoridation at household level is the only practicable solution to overcome the problem of excess fluoride in drinking water, and consequent prevention of fluoride induced diseases worldwide. Preferred treatment materials need to be packed into filter units for satisfactory removal of contaminants through the flowing water. The filter pack may be natural (such as sand, bone dust, biomass) or synthetic (such as metal oxides, graphene-metal combinations, activated alumina,) or combination of both (biochars). The thickness of the fixed bed determines the efficacy of the treatment envisaged. The water flow rate governs the travel and residence time. The objective of this article is to enumerate a concept of domestic water filter packed with innovative metallic oxides for successful and cost-effective water treatment at poorest households in the remotest rural corners of India.

2. METAL OXIDES AS ADSORBENTS FOR WATER DEFLUORIDATION

Metal oxide nanocomposites may be prepared and tried under simulating lab based conditions to effectively act as a fluoride scavenging media. Fluoride, due to high electronegativity and small ionic size, is classified as a hard base, which has natural strong affinity towards metals. There is strong affinity of fluoride for positive surface charges and surface hydroxides. multivalent metal ions like Al(III), Fe(III), Zr(IV), Ce(IV), etc.((Jiao et al., 2002).

Various forms of nanocrystalline bi-metallic oxides of [Fe-Ce], [Ce-Zr], [Fe-Al], [Fe-Sn], [Mg-Al], [Al-Ce], [Mn-Ce] and poly-metallic oxides of [Fe-Al-Cr], [Fe-Al-Ce] are being studied in the laboratory under different physico-chemical, thermodynamic and kinetic conditions.

Synthetic hydrous iron(III)-chromium(III) bimetal mixed oxides have been tested for fluoride removal from water. Maximum fluoride removal is encountered at pH 3.0 and also at a very high pH. The fluoride removal decreases in the range of pH 3 to 5 which can be explained due to decrease of positive surface charge density or ligand exchange capacity of mixed oxides (Biswas et al., 2010). Iron(III)-Tin(IV) nanoaggregates, another synthetic admixture, are also being tested as an adsorbent for fluoride removal from aqueous phase through lab-bench scale experimental trials. The fluoride adsorption capacity of this synthetic mixture remains nearly constant under pH 5.0 to 7.5, which may be apparently due to neutral or near neutral solid surface (Biswas et al., 2009). Hydrous Ce(IV)-Zr(IV) show strong affinity toward fluoride anion in pH range 2 to 3 (Biswas et al., 2007); but these metals are expensive and work well in acidic range, which restricts their use for drinking water treatment. Cerium(IV)-Iron(III) bimetal oxide has high adsorption capacity for fluoride. Optimum pH for fluoride removal by this bi-metallic oxide is also in acidic range. The adsorption capacity decreases significantly with increase in pH (Jiao et al., 2002). Therefore, an inexpensive adsorbent with high fluoride adsorption at near neutral pH is desirable. Mixing or doping of expensive metals with cheaper counterparts such as iron, aluminium on supportive matrices may be considered as an economic way to reduce cost and facilitate high fluoride adsorption capacity. Fluoride adsorption efficiency of some bi-metallic and poly-metallic oxides is listed in Table- 1.

Table 1. Fluoride Adsorption Efficiency by Some Bi-Metallic/ Poly Metallic Oxides

	Name and Nature of the Compound	**Experimental pH Condition**	**Initial Conc. of Spiked Solution (mg/L)**	**Effective Adsorption Envisaged (mg/g)**	**References**
1.	[Fe(III)–Ti(IV)]	6.4	10-50	10.47	Biswas et al., 2009.
2.	[Ce(IV)–Zr(IV)]	5.5	5	19.43	Ghosh et al., 2014.
3.	[Fe(III)-Cr(III)]	6.5	10-50	16.34	Biswas et al., 2010.
4.	[Fe(III)–Al(III)]	6.5	20	88.48	Zhao et al., 2010.
5.	[Fe(III)–Al(III)]	6.9	10-50	17.73	Basu et al., 2012.
6.	[Fe(III)–Zr(IV)]	6.8	5-50	8.21	Biswas et al., 2007; 2008.
7.	Sulfate-doped Fe_3O_4/Al_2O_3	7	50	70.4	Chai et al., 2013.
8.	Mg–Al	6 - 7	40	16.2	Chang et al., 2011.
9.	Al–Ce	6 - 7	1	27.5	Liu et al., 2010.
10.	Mn–Ce	6 - 7	1	45.5	Deng et al., 2011.
11.	[Fe(III)–Al(III)–Cr(III)]	5.6	10-80	31.89	Biswas et al., 2010.

Adsorption of fluoride by bi-metallic or poly-metallic oxides is also a function pH_{ZPC} (the pH point of zero charge) of the adsorbents (Das et al., 2005). Bicarbonates, phosphates, sulphates are the major anions that exert competitive influence on fluoride removal by adsorption, and the treatment reduction is observed in the order : bicarbonate > sulphate > phosphate.

3. REMOVAL OPTIMALITIES

Iron is selected as the base element in most of metal oxide mixture for its extreme natural abundance and excellent pollution scavenging property. Metals such as zirconium, cerium, aluminium, tin, lanthanum, magnesium, manganese are experimentally proven to possess strong affinity to form chemical linkage with fluoride. Therefore, combinations of iron with various metal oxides in varying proportions could be undertaken to increase the surface area and number of surface active sites. The differences in size and surface area of these diverse ions enhance adsorptive capacity. But except iron, aluminium and tin, most of these raw materials are very expensive that limits their applicability as nanotreatment media for environmental remediation. These nanoparticles show outstanding fluoride removal efficiency in lab bench scale studies (Ghosh et al., 2014), and they are well known as anion-selective media.

Combination of one metal with other metals changes the lattice structure of new composites affected by enhanced grain and structural porosity, high surface area, presence of activated oxygen and carboxyl groups, surface active sites, lattice defects, etc. During preparation of nanocrystalline aggregates, the finest size portion is ensured through dilute conditions of the precipitating salt solution. If the solute concentration is at a higher range, there will be continuous influx of precipitate upon the centres of nucleation favouring formation of macro and mega crystals. It is usually witnessed that up to three metals can be used for better adsorption, after that efficiency of removal sharply diminishes.

Nanoaggregate formation can affect the individual magnetic properties of nanoparticles due to various chemical activities that occur during the developmental phase. It is observed that oxidation, dipole-dipole attraction and agglomeration lead to loss of magnetism. When iron features as one of the elements of nanoaggregates, use of external magnetic field for recovery of nanoparticles is emphasized that is an advantage of magnetic nano-adsorbents (Biswas et al., 2010).Thus use of iron nanoparticles to form nanoaggregates is considered economic for environmental cleanups. Recyclability and scope of reuse of these adsorbents reduces the cost of water treatment as well. Paramagnetic properties of nanoaggregates can enhance their recyclability further.

It is now being experimentally established that bi-metallic or poly-metallic nanoadsorbents are competent medium for rapid defluoridation of water. Extensive study on certain physico-chemical parameters such as Eh-pH condition, adsorbent dosage, contact time etc. are essential to ensure desirable removal of fluoride by the prepared filter medium packed with innovative nano-metal oxide aggregates. The desired filter materials, after preparation on lab bench scale, need to be subjected to batch process experimentation. The thermodynamic controls and reaction kinetics would be noted and optimized systematically to bring about efficient fluoride removal. In the next step, preparation of synthetic nanostructured materials is to be undertaken on bulk scale in the laboratory. They would again be tested for their fluoride scavenging behaviour under varying laboratory conditions (Eh-pH, thermodynamic and kinetic controls) in the presence of spiked F-solutions and fluoride rich natural groundwater collected from field. The methodology involves ‘batch process’ followed by ‘column experiments’ and ‘prototype filter bed’ trials. The miniature filters will be replaced by the finally designed unit later after field validation.

CONCLUSION

The article presents an appraisal on applicability of bi- / poly-metallic nanoaggregates for removal of fluoride from drinking water. Different controlled experimental conditions for fluoride removal by nanocomposites are successfully established in literature. Design and fabrication of filter medium with metal oxide nanocompounds can be effective for domestic scale defluoridation of water. Miniature filter units packed with metal oxide nanoaggregates in different physico-chemical states, behaviour and structural form can serve as techno-eco-economic compatible approach for potable water treatment. These improvised innovative nanocomposites of metal oxide packed in domestic filters are target specific, and ensures free fluoride from water at affordable price for the poor, backward communities residing in discrete rural hamlets.

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Seasonal and Temporal Variations on Physico-Chemical Water Quality Parameters of the HussainSagar Lake, Hyderabad

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ABSTARCT

The present investigation deals with the assessment of the physico-chemical parameters andcorrelation coefficient of the Lake HussainSagar, Hyderabad, Telangana. Seasonal variations of 11 physico-chemical parameters were observed at five different sampling stations. The physico-chemical characteristics and correlation coefficient were studied and analyzed during February 2010- October 2012.Correlation coefficient indicates showed high significant positive and negative relationship ($p <0.01$ level) and also show significant positive and negative relationship ($p < 0.05$ level). 11 physico-chemical parameters were taken in consideration for the analysis of the lake water quality such as pH, Temperature, Total dissolved solids (TDS), Total suspended solids (TSS), dissolved oxygen(DO), Nitrates (as N), Ammonical Nitrogen (as N), Total Nitrogen, Total Phosphorus, Chemical oxygen demand(COD), Carbonaceous Biological oxygen demand(cBOD or BOD_5).

Keywords: Physico-chemical parameters, seasonal variations, Correlation coefficient, HussainSagar Lake.

INTRODUCTION

Natural resource scarcity is now a serious problem, especially that of water in view of population growth and economic development (Garg R K, 2009). Among all the fresh water resources of the world, Rivers, lakes, reservoirs and wetlands are some of the important because they supply water for the population in the whole year. Lakes and ponds sustain as a stationary component of the hydrological cycle and maintain the balance of the surrounding ecosystem and components on which other systems depend. With unprecedented developmental activities, human beings are responsible for polluting most of fresh water bodies all over the world, thus decreasing the potability of water (Gupta S K, 2005). The quality of water can be quite flexible and water polluted up to certain extent in general sense can be regarded as pure (Goel P K, 2006). The health of lakes and their biological diversity are directly related to health of almost every component of the ecosystem (Indra, 2006 and Krishnan, 2007).The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. The effective long-term management of a lake requires a fundamental understanding of its hydro morphological, chemical and biological characteristics. The physico-chemical factorsare very important in estimating the constituents of water and concentration of pollutant or contaminant.

STUDY AREA

World famous silicon city, Hyderabad metropolis is the city of glittering lakes. Among all those lakes, Hussain Sagar stands as the oldest. It is an artificial lake built right at the centre of city of Hyderabad. Hussain Sagar Lake is “The Largest Heart Shaped Lake” in India. The Lake was constructed in 1562 A.D mainly to store drinking water brought from the river Musi, a tributary of Krishna. The lake represents one of the thousands of impoundments on Deccan plateau in peninsular India, developed for storage of surface water runoff in this semi-arid region which has an annual average rain fall ranging between 600-1000 mm. The lake was utilized for irrigation and drinking water needs up to 1930 after which the lake became a cess pool/ collection zone for the wastes from the twin cities of Hyderabad and Secunderabad. Gradually the lake became receptacle of sewage and industrial effluents from catchment areas. As a result of heavy anthropogenic pressures such as unplanned urbanization, the entire ecosystem of Hussain Sagar Lake has changed. The water quality has deteriorated considerably during the last three decades. In the last 50 years there has been drastic reduction in its morphometry due to encroachments and large scale reclamation for developmental activities around the lake ecosystem. What stands today as the lake area is hardly 2/3rd of its original in the middle of last century.

The lake holds water perennially fed by 4 canals (now called nalas) and both of its outlets lead to Musi River. The urbanisation of the surrounding areas of the lake from which nalas emerge out has resulted in a variety of water pollution problems. The nalas now act as the point sources for municipal and industrial pollution. Urbanisation has also brought a multitude of pollution problems which could collectively called as urban pollution. These more subtle sources, which are common to most urban lakes, include surface sewage disposal systems, discharge of industrial effluents, tipping of ashes and letting out of heated waters from the government mint and a thermal station situated at the northern bank of the lake. This urban pollution has had a significant impact on the water quality of the lake. Much of the periphery of the lake is densely settled with many houses and some commercial establishments. The morphometric features of the lake are given in Table-1.

Table 1. Physio-graphic features of Lake Hussainsagar.

Year of construction (Completed)	1562 AD	Average depth	5.2 m
Basin area (Combined Catchment Area)	240 km^2	Depth (variable)	1 to 9 m
Direct Catchment area	67 km^2	Storage volume (spill)	28.6 X 106 m^3
Shoreline length	14 km	Maximum operating level (Above M.S.L)	514.93 m
Maximum water spread area	5.7 km^2	Normal operating level (Above M.S.L)	513.43 m
Capacity (Volume)	27.1 million m^3	Road bund level (Above M.S.L)	518.16 m

On Average, the lake is 510 mt. above the mean sea level (MSL).The Lake basin isbounded on west by Banjara hills. The 240 Km^2 watershed of Hussain Sagar is divided into four sub basins viz. Kukatpally, Dullapally, Bowanpally and Yusufguda. There are about 80 Lakes in Hussain Sagar Catchment. The Depth profile of the lake is shown in Figure-1.

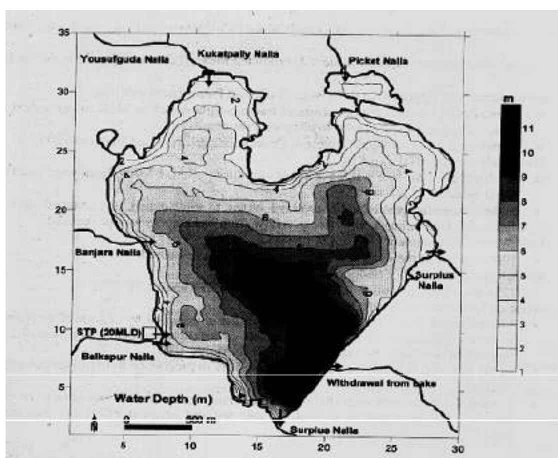

Figure 1. In-lets and depth profile of HussainsagarLake, Hyderabad, India.

Among the four influent streams or nalas, 3 (Balkapur, Banjara & Picket Nalas) contribute Municipal/Domestic wastewater whereas Kukatpally nala discharges both domestic and industrial effluents. The industries located in upstream area of kukatpallynala are of various types and sizes. There are industries dealing with basic industrial chemicals, manufacture of paints, metal products and steel rerolling mills, glass products, rubber goods, aircraft batteries, distillation products, alloys, fruit juices, pharmaceuticals etc.

HussainSagar has 2 outlets which are basically surplus weirs allowing excess water to River Musi. One of the outlets is located opposite to Hotel Marriot and the other at liberty.There is a luxuriant of water hyacinth in the HussainSagar Lake due to the nutrients provide by organic matter present in sewage and some industrial wastes. The water hyacinth causes excess loss of water through transpiration which is much more than the evaporation from open surface and thus leading to eutrophication. Since 1990 after pollution of Hussainsagar reached an alarming proportion, culminating in to massive fish kills of 1993, otherwise complacent state Government was forced in to action.Investigations of the water quality of this lake and its feeder channel have been undertaken by state and local agencies and university departments. These efforts have been successful in defining most of the urban pollution sources and in providing some water quality data.Two sub-basins, Kukatpally and Dullapally, of the lake are highly industrialized zones. TheKukatpally sub-basin has three industrial areas viz, Kukatpally, Balanagar and Sanathnagarwhile in Dullapally one sub-basin, Jeedimetla, are developed as industrial hubs under a plannedprogram of industrialization (Shiva et al, 2014).

Wide varieties of products are manufactured by 300 odd industrial units and effluentsgenerated bring in a cocktail of toxic waste in to the lake from Kukatpallynala. Though interception, diversion andtreatment of industrial effluents was undertaken as a part of management intervention, thevolume of waste generated exceeds treatment capacity of CETP in the Jeedimetla area and toxiceffluents continue entering the lake through Kukatpally stream, the main feeding channel (Associated Industrial Consultants pvt.Ltd, 1993).Hyderabad Urban Development Authority (HUDA) with support from Japan Bank of International Cooperation (JBIC) has initiated an ambitious project titled – HCIP (Hussain Sagar Lake and the catchment area improvement program) initiative in 2006 with a budget of 370 Crores rupees for rejuvenation/restoration of HussainSagar Lake(Shiva et al, 2014). The project has the following important components:

(i) Floating material and Shoreline Cleaning
   (a) Cleaning of Shoreline
   (b) Removal of Floating material, Water hyacinth
   (c) Disturbance of Algal Bloom
   (d) Collection & Stacking Solid Waste material
(ii) Treatment of Inflows
   (a) Stoppage of inflows (Interception and Diversions)
   (b) Sewage Treatment Plants – To Maintain Water Balance
(iii) Improvement in quality of lake water
   (a) Dredging of Sediments (About 1,000,000m^3)
   (b) Aeration and Oxidation
(iv) Protection of Lakes and Nalas in Catchment Areas
(v) Public Awareness / Peoples Participation /Peoples Movement

To sustain water balance & hydrology of the lake, An STP of 20MLD capacity was commissioned on balkapur nala in 1998 and 30MLD capacity on picket nala in 2008. A5 MLDcapacity WWTP is also constructed near Rangadhamini Lake which is connected to Kukatpallynala (HUDA, 2005). Treated water from these treatment plants, is let in to the lake to sustain its hydrology. This measure is also expected to improve the lake water quality to the level of SW-II; suitable for bathing, contact water sports and commercial fishing (Table-2).

Table 2. Central Pollution Control Board (CPCB) water quality standards/norms.

Parameter	**Surface Water Quality of HussainSagar Lake - At Outlet (Annual Average)**	**Water Use SW-II (Bathing)**	**CPCB revised criteria**		
			A Excellent	**B Desirable**	**C Acceptable**
pH	7.6	6.5-8.5	-	-	-
BOD	30-48	<3	<2	<3	<6
DO	0.99	>4	>90%	>80%	>60%
Turbidity	High	<30	-	-	-
Coliform Count	>1600	<100	<20	<200	<2000

Climatic Variation with Seasons

The climate of Hyderabad may be described as essentially a tropical monsoon type which is a product of the effects of the South-West and North-East monsoons. Generally the climate is hot and dry and the annual rainfall is chiefly brought about by South-West monsoon.

The South-West monsoon usually sets in about the end of May or early in June and continues with some intervals, till the end of September. The North-East monsoon commences in October and usually over by the end of December. The weather is mainly dry and sunny during this period and generally free from rains. The hot weather commences with March and increases in intensity towards the end of May. Apart from direct precipitation, the lake receives its water supply from city drains and sewage (Kodarkar, 1995 and ILEC, 2005).

Water Sampling

Municipal sewage may differ from place to place and the factors which contribute to variations in characteristics of the domestic sewage are daily per capita use of water, quality of water supply and the type, condition and extent of sewerage system, and habits of the people.

Characterization of wastes is essential for an effective and economical waste management programme. It helps in the choice of treatment methods deciding the extent of treatment, assessing the beneficial uses of wastes and utilizing the waste purification capacity of natural bodies of water in a planned and controlled manner.The monitoring objectives will be the primary factor influencing when to sample. The most critical time period in a lake is typically during the growing season.

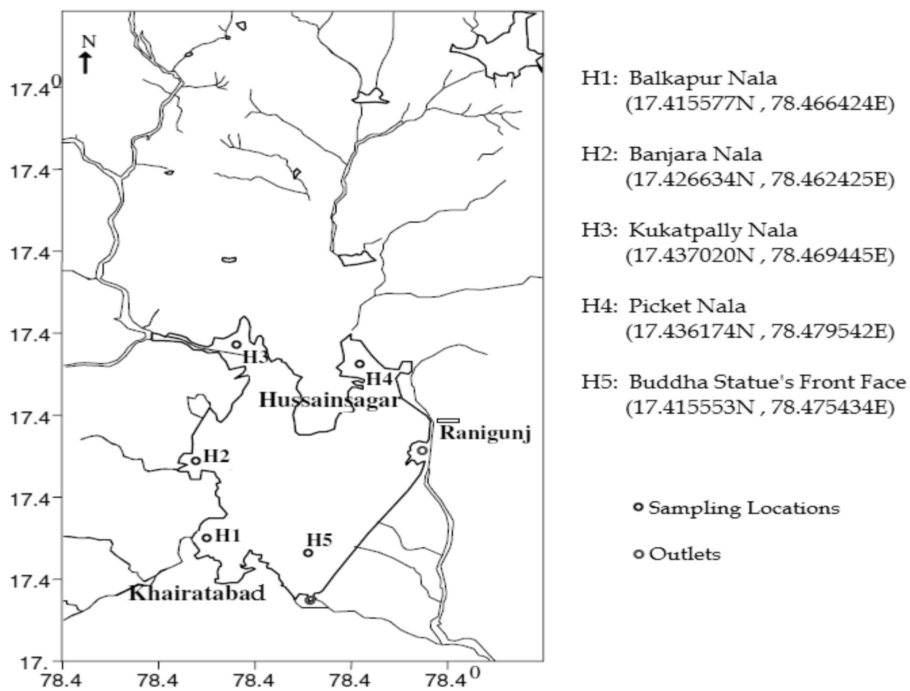

Figure 2. Representation of Sampling Locations and Outlets of HussainSagar Lake

Samples are collected at about the same time of day during each time of sampling i.e. between 9 - 10 AM. This allowed for some consistency in daylight hours and in all the indirect effects daylight has on the different lake processes(Shiva et al, 2014).The analysis of wastewater from all sampling points has been monitored/tested for the contaminants at the Vitro labs weekly once starting from Feb 2010 to Oct 2012.

All samplings represent instantaneous water quality at the particular time. Water samples were collected in acid washed sterile polyethylene bottles, transported to the laboratory on ice, and analyzed with in a day. Water samples were analyzed for most water quality influencing 11 physicochemical parameters, which included pH, Temperature, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen(DO), Nitrates (As N),Ammonical Nitrogen (As N), Total Nitrogen, Total Phosphorus, Carbonaceous Oxygen Demand (COD), Biological Oxygen Demand (BOD). The parameters were determined using the standard methods mentioned in Table 3 for the examination of water and wastewater (Trivedi and Goel, 1984 and APHA 1998). The feature of this report is to analyse the parameters and present the variations between these parameters.

Table 3. Methods used for Experimentation.

Sl.No	Parameter	Units	Method/Instrument Used
1.	pH	-	Digital pH meter
2.	Temperature	^oC	Thermometer
3.	Total Dissolved Solids (TDS)	Mg/L	Digital conductivity meter
4.	Total Suspended Solids (TSS)	Mg/L	Oven drying method
5.	Dissolved Oxygen (DO)	Mg/L	Winkler method
6.	Biochemical Oxygen Demand (BOD)	Mg/L	5 days incubation at 20° C and titration for initial and final DO
7.	Chemical Oxygen Demand (COD)	Mg/L	Open Reflux Method
8.	Nitrates (as N)	Mg/L	Automated cadmium reduction method
9.	Ammonical Nitrogen (as N)	Mg/L	Spectrophotometer (Phenate method)
10.	Total Nitrogen (TN)	Mg/L	Alkaline Persulphate digestion method
11.	Total Phosphorus (TP)	Mg/L	Automated ascorbic acid reduction method

RESULTS and DISCUSSIONS

The Seasonal averages along with Coefficient of variation (%) of all 11 physico-chemical parameters for all three seasons at five sampling locations are given in Table 4. Correlation Coefficient between various physico-chemical parameters for Kukatpallynala is tabulated in Table 5 (as it is highly contaminated compared to other influent streams/nalas).

Table 4. Seasonal Variation of different parameters from five sampling points.

Seasonal variations of different parameters at Balkapur Nala (H1) for the span Feb-10 to Oct-12											
	BOD	**COD**	**TOTAL P**	**TOTAL N**	**TSS**	**DO**	**pH**	**Temp**	**TDS**	**Nitrates (as N)**	**Ammonical Nitrogen (as N)**
Summer	52.50	193.00	3.87	20.22	70.00	0.90	7.72	27.00	940.00	4.70	11.94
C.V. %	0.42	0.37	0.30	0.24	0.43	0.81	0.08	0.08	0.23	0.28	0.38
Monsoon	32.50	112.00	3.24	18.91	77.50	0.65	7.55	26.00	724.00	3.64	12.29
C.V. %	0.36	0.37	0.30	0.25	0.44	0.85	0.09	0.06	0.23	0.28	0.30
Winter	46.50	146.00	3.45	16.06	72.50	0.75	7.83	26.00	832.50	3.37	11.20
C.V. %	0.46	0.37	0.39	0.12	0.29	0.82	0.08	0.09	0.16	0.20	0.15
Seasonal variations of different parameters at Banjara Nala (H2) for the span Feb-10 to Oct-12											
	BOD	**COD**	**TOTAL P**	**TOTAL N**	**TSS**	**DO**	**pH**	**temp**	**TDS**	**Nitrates (as N)**	**Ammonical Nitrogen (as N)**
Summer	72.5	224	4.6	21.16	77	1.2	7.305	27.5	1098	4.47	13.33
C.V. %	0.40	0.33	0.25	0.24	0.49	0.83	0.09	0.08	0.19	0.31	0.34
Monsoon	39	140	3.775	18.355	71.5	0.6	7.395	26	773	3.7	12.89
C.V. %	0.26	0.23	0.45	0.19	0.38	0.99	0.08	0.06	0.16	0.24	0.21
Winter	59	194	3.365	19.31	81.5	0.55	7.335	26	785	4.43	13.36
C.V. %	0.34	0.27	0.53	0.15	0.53	0.95	0.09	0.09	0.22	0.20	0.20
Seasonal variations of different parameters at Kukatpally Nala (H3) for the span Feb-10 to Oct-12											
	BOD	**COD**	**TOTAL P**	**TOTAL N**	**TSS**	**DO**	**pH**	**Temp**	**TDS**	**Nitrates (as N)**	**Ammonical Nitrogen (as N)**
Summer	85	287	5.035	25.99	110.5	0.3	7.415	27	1222	7.2	19.83
C.V. %	0.32	0.26	0.31	0.21	0.42	0.82	0.08	0.08	0.19	0.29	0.21
Monsoon	68	230	4.725	21.535	113.5	0.55	7.195	26	949	5.39	15.11
C.V. %	0.41	0.34	0.35	0.22	0.44	0.82	0.04	0.06	0.14	0.27	0.25
Winter	95	320	4.355	23.875	92	0.3	7.24	26	999.5	5.35	17.165
C.V. %	0.46	0.39	0.38	0.11	0.39	0.82	0.06	0.09	0.14	0.23	0.14

Seasonal variations of different parameters at Picket Nala (H4) for the span Feb-10 to Oct-12											
	BOD	COD	TOTAL P	TOTAL N	TSS	DO	pH	Temp	TDS	Nitrates (as N)	Ammonical Nitrogen (as N)
Summer	42	140	3.975	20.1	59.5	1.1	7.83	27	1004	4.85	12.91
C.V. %	0.42	0.38	0.34	0.30	0.43	0.86	0.07	0.08	0.09	0.39	0.27
Monsoon	30.5	107	3.075	15.92	77	0.55	7.54	26	893.5	3.4	10.83
C.V. %	0.31	0.28	0.25	0.19	0.42	0.99	0.05	0.06	0.11	0.26	0.20
Winter	35	117	3.335	15.3	62.5	0.6	7.45	26	862	2.86	9.98
C.V. %	0.32	0.29	0.24	0.09	0.53	1.03	0.05	0.09	0.14	0.13	0.07
Seasonal variations of different parameters at Budha Statue (H5) for the span Feb-10 to Oct-12											
	BOD	COD	TOTAL P	TOTAL N	TSS	DO	pH	Temp	TDS	Nitrates (as N)	Ammonical Nitrogen (as N)
Summer	40	132	4.21	18.94	70.5	1.6	7.11	27	1152	5.55	10.65
C.V. %	0.45	0.41	0.34	0.28	0.45	0.78	0.11	0.08	0.20	0.38	0.26
Monsoon	20.05	92.00	2.69	13.54	47.00	0.78	7.79	25.50	827.17	2.97	8.84
C.V. %	0.74	0.39	0.42	0.31	0.38	0.94	0.04	0.06	0.13	0.27	0.36
Winter	31.5	104	3	12.43	44.5	0.85	7.56	26	825	2.77	8.38
C.V. %	0.33	0.27	0.50	0.11	0.40	0.46	0.06	0.09	0.18	0.20	0.12

Table 5. Correlation Matrix among the Different Parameters atKukatpallyNala.

BOD	1										
COD	0.996	1									
TOTAL P	0.722	0.74	1								
TOTAL N	0.401	0.45	0.48	1							
TSS	0.476	0.51	0.46	0.80	1						
DO	0.802	0.81	0.50	0.39	0.41	1					
pH	0.654	0.67	0.73	0.70	0.81	0.53	1				
Temp	0.913	0.91	0.82	0.39	0.46	0.76	0.67	1			
TDS	0.809	0.84	0.71	0.72	0.69	0.75	0.74	0.82	1		
Nitrates (as N)	0.802	0.81	0.74	0.73	0.70	0.76	0.85	0.81	0.91	1	
Ammonical Nitrogen (as N)	0.321	0.38	0.43	0.97	0.73	0.31	0.61	0.31	0.69	0.66	1

*All Units are in Mg/L except pH (pH Scale) and Temperature (^{o}C).

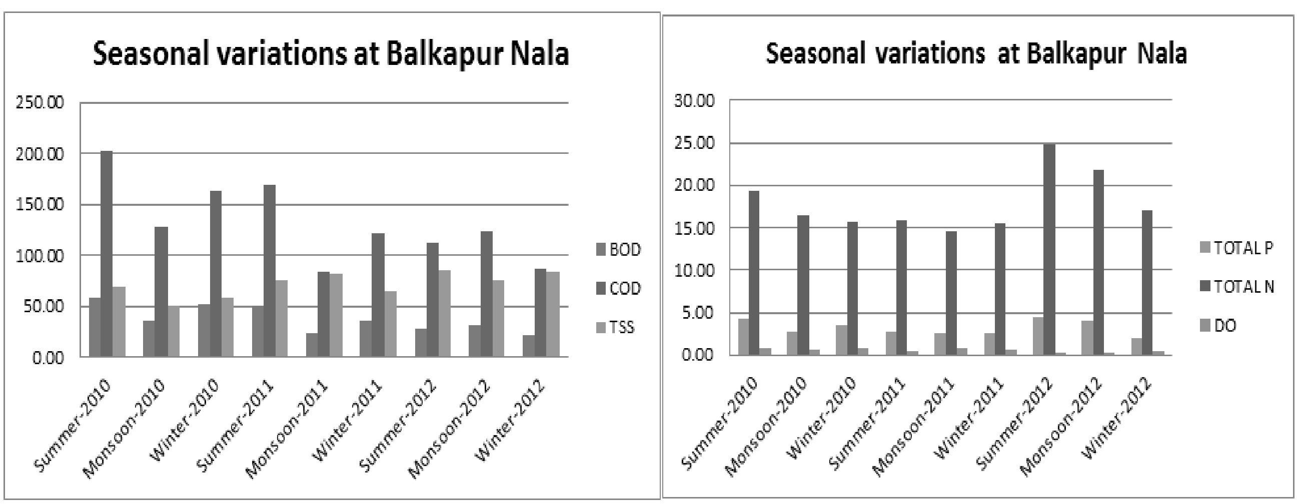

Figure 3. Representation of Seasonal Variations at Balkapurnala

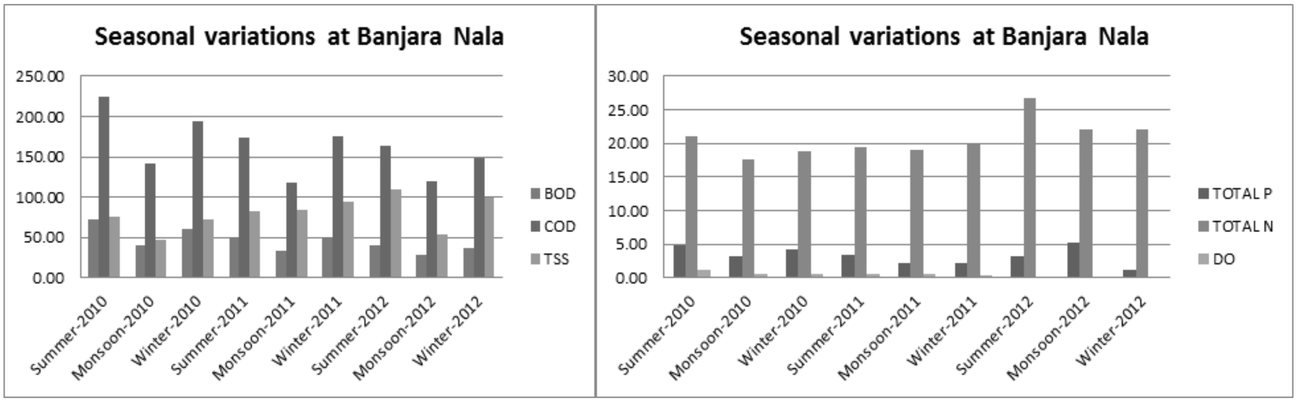

Figure 4. Representation of Seasonal Variations at Banjaranala

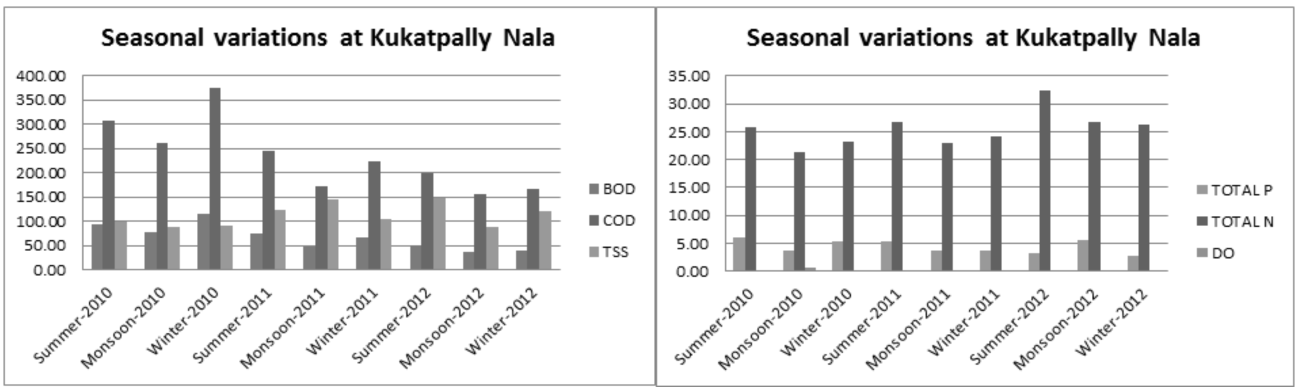

Figure 5. Representation of Seasonal Variations at Kukatpallynala

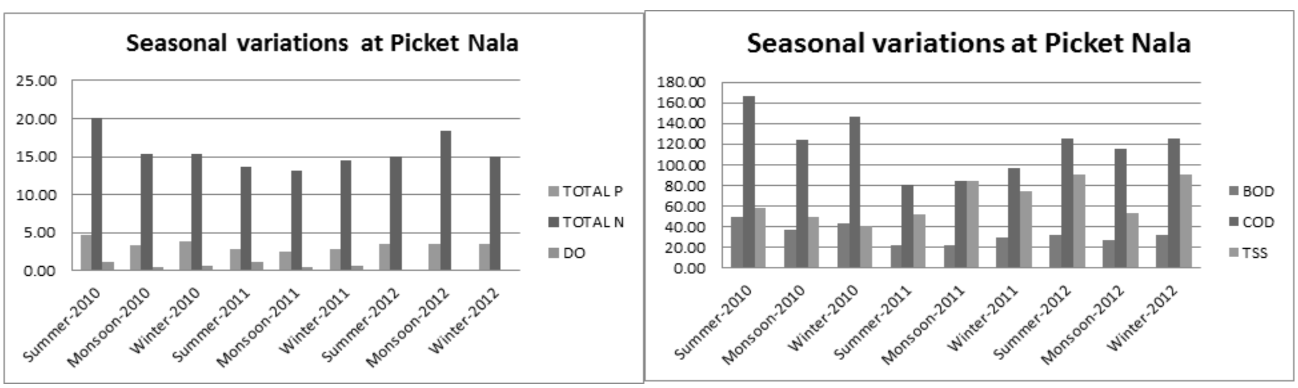

Figure 6. Representation of Seasonal Variations at Picketnala

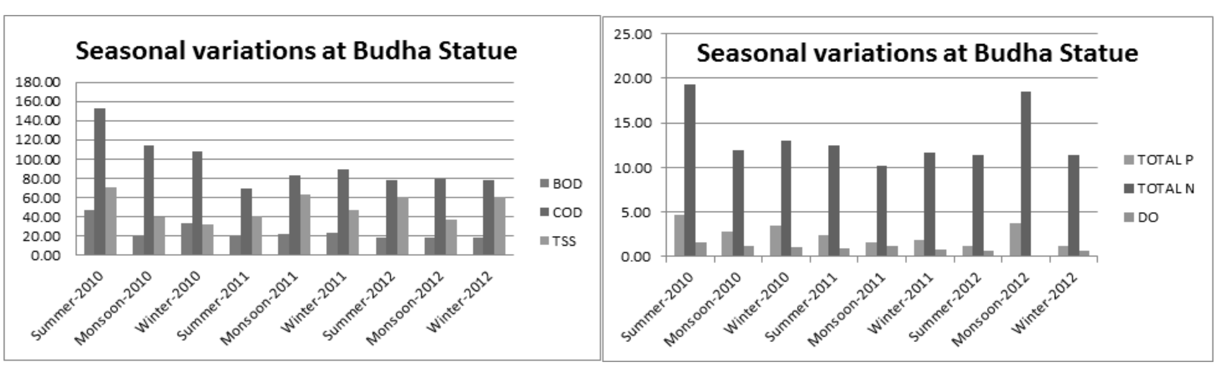

Figure 7. Representation of Seasonal Variations at Buddha Statue front face.

CONCLUSIONS

The water quality of HussainSagar Lake is deteriorating due to anthropogenic activities like, discharge of domestic sewage and effluents from industrial activities without any pretreatment. In Summer/post-winter, the pollution load is more prominent as compared to other seasons. The validity of the results obtained from lake indicated the correlation found between the variables. The obtained BOD values (also crossed the permissible limit of CPCB i.e.<30 mg/l) showed the contamination of water indicates decline in DO of the water; which affects the sustainable life of plant and animals in the lake. The deterioration in water quality is found due to higher amount of organic pollutants in the lake water and deposits in benthic zone. During summer season, the water quality has significantly changed due to lean inflows that tend to alter ecological niche, aquatic flora and fauna, benthos, other aquatic organisms and self-purification of the lake system while in monsoon season, all the pollutants except Total Suspended Solids gets diluted. Results from the correlation matrix show that a parameter that is important in contribution to lake water quality variation for one season may not be important for another season. Therefore, when selecting water quality parameters for the establishment of pollutant load reduction goals (PLRGs) and the development of total maximum daily loads (TMDLs), the seasonal variation of parameters on river water quality must be considered. It is suggested that the lake water should not be used for domestic purposes as traces of pollutants present in water at outlet which may lead to harmful effects on human body. More extensive study is called for to conserve water resources from further deterioration and to protect the overall health of the lake. We suggest that the strict measures should be taken against by HUDA and industries polluting the HussainSagar Lake.

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Assessment of Groundwater Quality with Special Emphasis on Fluoride Contamination in South-Eastern Part of Ranga Reddy District, Telangana State, India.

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ABSTRACT

Mahashwaram town around 30 km SW of Hyderabad city, has lot of agricultural activity and from industries and generally it a part of peninsular gneissic complex. Thirty seven samples each in pre and post-monsoon have been analyzed for major ions pH, EC, TDS, Ca, Mg, TH, Na, K, CO3, HCO3, Cl, NO3, SO4 and F. Emphasis is on fluoride concentrations ranges from 0.28 to 2.10 mg/l and 0.44 to 3.03 mg/l during pre-monsoon (PRM) and post-monsoon (POM) seasons, respectively. Results showed that groundwater samples were contaminated by presence of fluoride ion. During PRM 62% and POM 84% of samples recorded higher fluoride when compared with Indian Drinking water standard (1 mg/l) and (35% and 60%) of samples recorded higher fluoride when compared with World Health Organization tolerance limit (1.5 mg/l). Principal Component analysis indicates like weathering, ion exchange, and anthropogenic contributes to groundwater chemistry.

Keywords: Fluoride, spatial distribution, PCA analysis and Maheshwaram area.

INTRODUCTION

Fluoride contamination in drinking water due to natural and anthropogenic activities has been recognized as one of the major problems worldwide imposing a serious threat to human health. Fluoride ion occurs in natural waters commonly in concentrations less than 1.0 mg/l and seldom outside the range from 0.01 to 10.0 mg/l. Groundwater is a major source of human intake of fluoride, including its subsequent incorporation into food items. The main source of fluoride in groundwater is considered to be fluoride-bearing minerals such as fluorspar, flourapatite, cryolite, and hydroxylapatite in rocks (Farooqi et al. 2007) by prolonged water-rock interactions (Carrillo-Rivera et al. 2002). The amount of F occurring naturally in groundwater is governed principally by climate, composition of the host rock, and hydrogeology. Some anthropogenic activities such as use of phosphatic fertilizers, pesticides and sewage and sludge, depletion of groundwater table, etc., for agriculture have also been indicated to cause an increase in F concentration in groundwater (EPA 1997). Fluoride in groundwater evokes considerable interest due to its unique character as regards to its impact on physiological system of living beings. Due to excessive fluoride intake, enamel loses its luster. Dental fluorosis is characterized by discoloration in the form of spots or horizontal streaks on the tooth surface. Many investigations have been made related to origin and hydrogeochemistry of high fluoride in groundwater from different parts of the world Laxman Kumar et al. 2015, Moghaddam and Fijani 2008; Salve et al. 2008; Tirumalesh et al. 2007; Sreedevi et al. 2006; Subbarao et al. 2006. In these research's groundwater samples were obtained from dug/bore wells and examined for fluoride ions and high fluoride have been identified to be originated from water–rock interaction and hence the influence on the groundwater chemistry (Appelo and Postma 2005) and anthropogenic sources like application of fertilizers, industrial effluents, and household domestic effluents.

STUDY AREA

The study area covering about 240 sq. km falls in Ranga Reddy district of Telangana State. It is located 35 km from Hyderabad, India on Srisailam highway. Study area lies in between North Latitudes 17° 02' to 17° 14' and East Longitudes 78° 18' to 78° 34' **(Fig. 1)** and falls in the Survey of India toposheet No. E44 M/8 and E44 M/12. The Study area receives rainfall (638 mm) both by northeast and southwest monsoons. It is entirely underlined by Pennisular gneissic complexes. The geology of the study area is grey and pink granites occupy dominant portion of the study area. These rocks are composed of quartz, feldspar, biotite and hornblende (Fig. 1). The climate of the study area is generally hot. Average Temperature in summer is 40^0C, in winter is 14^0C.

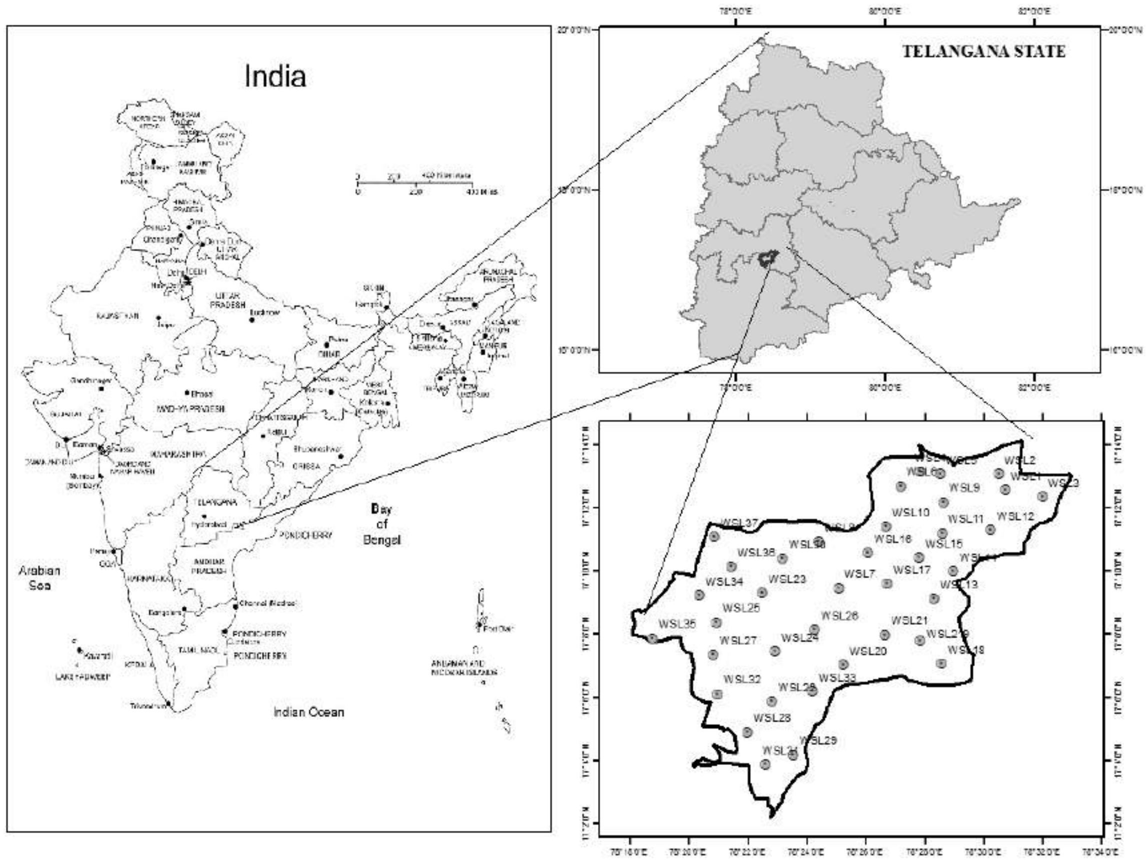


Figure 1. Study area with water sample locations

MATERIALS AND METHODS

In order to assess the groundwater quality, 37 groundwater samples have been collected. The water samples collected for two seasons pre- and post-monsoon. Sampling was carried out using pre-cleaned polyethylene containers. Samples were analyzed in the laboratory for the major ions chemistry using standard methods (APHA 1995). The pH was measured with Digital pH Meter (Model 802 Systronics) and EC was measured with Conductivity Meter (Model 304 Systronics), Sodium and Potassium was measured with Flame photometer (Model Systronics 130). Total Dissolved Solids were estimated by calculation method. Sulphates and Nitrates were measured with Spectronics 21 (Model BAUSCH & LOMB), Carbonate, Bicarbonate, Calcium, Magnesium, Total Hardness, and Chloride by titrimetric methods, Fluoride concentration was measured with Orion ion analyzer with fluoride ion selective electrode. The concentration of EC is expressed in microsiemens/cm at 25ºC and TDS, TH, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, $C1^{-}$, SO_4^{-}, NO_3^{-}, CO_3^{-}, HCO_3^{-} and F^{-} are expressed in mg /l.

RESULTS AND DISCUSSION

Groundwater in general was alkaline in nature, and higher EC values were noted during pre-monsoon (PRM) season. HCO_3 in the study area was higher during post-monsoon (POM) (707.60 mg/L) due to weathering of silicates. The concentration of Cl was higher in POM (735.55 mg/L) indicating leaching from upper soil layers due to industrial and domestic activities and dry climates (Herman Bouwer 1978). SO4 was higher in POM (249.0 mg/L) indicating breaking of organic substances from topsoil/water, leachable sulfate preset in fertilizer, and other human influences (Miller 1979; Craig and Anderson 1979). NO_3 was higher in POM (264.0 mg/L) indicating leaching of organic substances from weathered soil (Table 1). The concentration of fluoride found in the ground water samples was higher in (62% and 84%) during PRM and POM when compared with the Indian Drinking Water Standard of maximum permissible limit of 1.0 mg/L (BIS 2009). The values of fluoride in (35% and 57%) of samples during PRM and POM were higher than the maximum tolerance limit (1.5 mg/L) recommended by World Health Organization (WHO 2004). Ingestion of water with fluoride concentration above >1.5 mg/L causes

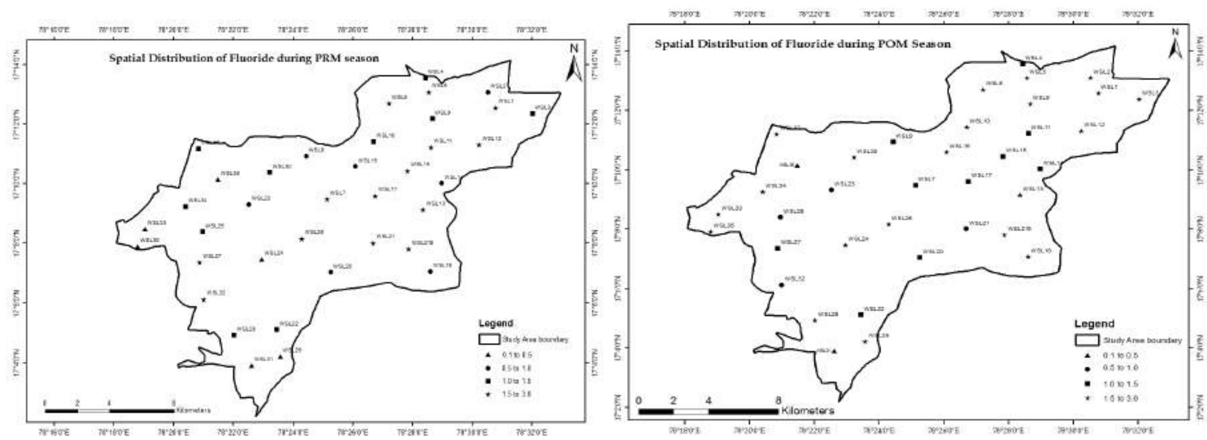
Fluorosis (Madhnure et al. 2007). High degree of weathering, easy accessibility of circulating water to the weathered rocks due to intensive and long-time irrigation are responsible for the leaching of fluoride from their parent minerals present in soils and rocks. Further concentration has been brought about due to semi-arid climate of the region and long residence time of groundwater in the aquifer (Wodeyar and Sreenivasan 1996). Higher concentration was noted that due to presence of dominant fluoride bearing minerals like apatite, hornblende, and biotite which has enhanced the fluoride concentration.

Table 1. Statistics of water chemistry from the study area

Constituents	Range of observed values		Mean		Median		Standard deviation	
	PRM	**POM**	**PRM**	**POM**	**PRM**	**POM**	**PRM**	**POM**
pH	6.7-8.60	6.60-7.60	7.36	7.15	7.30	7.20	0.43	0.26
EC	600-5250	500-3800	1501.62	1343.24	1350.00	1200.00	762.87	719.00
TDS	384-2510	320-2432	769.84	859.68	723.20	768.00	371.18	460.16
Na	16-189	17-200	70.00	93.89	65.00	85.00	39.80	42.91
K	1-147	1-10	6.43	3.95	2.00	3.00	23.81	2.00
TH	30-880	40-400	310.95	187.16	280.00	195.00	178.55	62.49
Ca	24.58-260.10	12.29-79.87	91.94	35.15	88.06	32.77	51.97	17.87
Mg	1.22-66.88	1.22-58.37	20.67	24.65	15.81	25.54	17.69	13.16
CO3	0-30	0-102	3.00	5.27	0.00	0.00	7.94	17.75
HCO3	54.9-55.10	36.60-707.60	271.86	377.38	280.60	359.90	104.74	149.41
Cl	35.5-667.40	28.40-713.55	200.14	187.09	163.30	127.80	146.31	164.78
SO4	16-100	12-249	39.19	52.86	36.00	31.00	18.20	56.60
NO3	030-70	4-264	25.43	63.57	16.00	40.00	22.03	61.35
F	0.28-2.10	0.44-3.03	1.18	1.57	1.30	1.68	0.57	0.65

SPATIAL DISTRIBUTION

The spatial distribution of fluoride in the groundwater (Fig. 2a and b) was attempted to identify regions and locations of widespread fluorosis. During PRM, fluoride (<0.5 mg/l) was noted in 19% of the samples in seven locations (14, 24, 29, 31, 33, 35 and 36) and concentration (0.5-1.00 mg/L) was observed in 19% of samples in 07 locations (2, 8, 14, 16, 18, 20 and 23). Concentrations ranging from 1.0 to 1.5 mg/L were observed in 27% of samples in three locations (3, 4, 9, 10, 22, 25, 28, 30, 34 and 37). Higher concentration (1.5-3 mg/L) was observed in 35% of samples in two locations (1, 5, 6, 7, 11, 12, 13, 15, 17, 21, 26, 27 and 32). In general, fluoride was higher in both litho units. During POM, fluoride (<0.5 mg/L) was noted in 5% of the samples in three locations (31 and 36) and concentration (0.5-1.00 mg/L) was observed in 11% of samples in seven locations (21, 23, 25 and 32). Concentrations ranging from 1.0 to 1.5 mg/L were observed in 24% of samples in nine locations (4, 7, 8, 11, 14, 15, 17, 20 and 22). Higher concentration (1.5- 4.5 mg/L) was observed in 57% of samples in twenty one locations (1, 2, 3, 5, 6, 9, 10, 12, 13, 16, 18, 19, 24, 26, 28, 29, 30, 33, 34, 35 and 37). In general, higher fluoride was observed in both litho units. During PRM, enhanced concentrations of fluoride (>1.5 mg/L) were confined to inferior samples (24%) but during POM higher concentrations were confined to further samples (57%) indicating the function of infiltrated rainwater which dissolves additional fluoride ions from source rocks. In general, seasonal fluctuations were noted higher when compared with lithological influence during both the seasons.



(a) (b)

Figure 2a. Spatial distribution of fluorid*e during PRM season.* ***b.*** *Spatial distribution of fluoride during POM*

PRINCIPAL COMPONENT ANALSIS

In this study, Principal Component Analysis (PCAs) performed on the groundwater chemical data reduced the dimensionality from the 14 original physico-chemical parameters determined in each pre- and post-monsoon groundwater samples to 4 (PCs), which cumulatively explained 69.68 and 74.57% of the data variance. Table 2 shows the PC, the loadings and the percentage variance explained by each PC. The PC loadings are used as the correlation between the original physico-chemical variables (Praus, 2007). In hydrochemical applications, the PCs can be interpreted in terms of geochemical processes such as water–rock interactions, by an examination of the loadings of the original chemical parameters on each of the PCs (Chen et al., 2007). The first PC which has the highest eigenvalue and accounts for the highest variance usually represents the most important process or mix of processes controlling the hydrochemistry (Yidana et al., 2010).

In pre-monsoon major eigenvalues (PCS_1, PCS_2, PCS_3 and PCS_4) were found in groundwater samples in southeastern part of Ranga Reddy district which could explain 69.68% of the variability, was mainly influenced by Na, HCO_3, TDS, SO_4, pH, Cl, Ca, and F. This component represented major cations and anions resulting from the mineral weathering and water–rock interactions in the aquifer (Purushotham et al., 2011). Therefore, this natural process plays a significant role in the occurrence of F in study area. PCS1 accounts 31.92% variance in the data. The variable present in this factor are TH, Ca, Mg, Cl, Na and HCO_3 which indicates ion-exchange and carbonate weathering. PCS_2 accounts for 16.02% of total variance, with the high loading for EC and TDS. EC is positively correlated with the concentration of ions, which can thus be indirectly calculated from EC. Therefore, EC can be regarded as a water salinization index. PCS3 suggested that F in groundwater is substantially influenced by Na, SO_4 and pH, contributing 12.40% of total variance. PCS4 accounts for the 9.40 of variance in the data. This has high positive loading of pH, CO_3 and SO_4.

In the Post-monsoon season the four PCS (PCS_1, PCS_2, PCS_3 and PCS_4) which were found to be responsible for the variation in groundwater quality explains 35.56%, 15.27%, 13.69% and 10.10% of variance respectively in the data. Here again PCS_1 shows high loading for TH, Ca, Cl, Na and HCO_3 but there are three more variables showing high loading that is NO_3, Ca, Mg, TH, CO_3 and K. This is a remarkable change in PC loading which not only signifies the high recharge and leaching in the area but also highlights the descriptive capabilities of multivariate techniques as effective tools in groundwater evaluation. Furthermore, high loading of NO_3 in factor 2, provides hint of the huge amount of fertilizers being used in the area.

Table 2. Factor analysis for water samples during PRM and POM

Variables PRM	Factor 1	Factor 2	Factor 3	Factor 4	Variables POM	Factor 1	Factor 2	Factor 3	Factor 4
TH	0.907	-0.094	-0.192	0.078	TH	0.492	0.487	0.605	-0.272
Cl	0.822	0.047	0.204	-0.045	Ca	0.461	0.549	-0.226	-0.212
Ca	0.809	-0.190	-0.201	-0.021	Mg	0.197	0.119	0.881	-0.144
Mg	0.760	-0.191	-0.182	0.197	Cl	0.868	0.031	-0.141	-0.115
Na	0.717	-0.019	0.532	-0.096	pH	-0.703	-0.112	0.288	0.138
HCO3	0.622	-0.515	0.117	-0.029	TDS	0.948	-0.068	-0.118	0.151
pH	-0.582	-0.152	0.496	-0.017	EC	0.948	-0.068	-0.118	0.151
TDS	0.235	0.953	0.017	0.057	F	-0.082	-0.692	0.379	0.243
EC	0.237	0.950	0.055	0.020	Na	0.673	-0.458	0.279	0.231
F	0.186	0.002	0.748	0.428	HCO3	0.712	-0.434	0.272	-0.087
SO4	0.345	0.117	0.512	-0.247	CO3	-0.078	0.513	-0.022	0.609
K	0.154	0.041	-0.116	-0.762	SO4	0.643	0.095	-0.276	0.409
NO3	-0.027	-0.009	-0.211	0.647	K	-0.078	0.513	-0.022	0.609
CO3	-0.454	-0.208	0.393	-0.074	NO3	0.116	0.626	0.416	0.143
Total	4.469	2.243	1.733	1.309	Total	4.977	2.137	1.916	1.409
% of Variance	31.919	16.021	12.381	9.350	% of Variance	35.553	15.265	13.687	10.064
Cumulative %	31.919	47.941	60.322	69.672	Cumulative %	35.553	50.818	64.505	74.569

CONCLUSION

The study area Southeastern part of Ranga Reddy district, Telangana State, India with a total spread of 246 km2 area. It is entirely underlined by peninsular gneissic complexes. The geology of the study area is grey and pink granites occupy dominant portion of the study area. These rocks are composed of quartz, feldspar, biotite and hornblende. The present study is an attempt to demarcate fluoride-vulnerable zones and to identify major geochemical process controlling the incidence of fluoride in the groundwater of study area. The fluoride concentration ranges from 0.28to 2.10 mg/l and 0.44 to 3.03 mg/l during pre-monsoon and post-monsoon seasons, respectively. Results showed that collected water samples were contaminated by presence of fluoride ion. During PRM 62% and POM 84% of samples recorded higher fluoride when compared with Indian Drinking water standards (1 mg/l) and (35% and 60%) of samples recorded higher fluoride when compared with World Health Organization tolerance limit (1.5 mg/l). The spatial distribution of fluoride indicates lower concentration of fluoride during PRM than POM due to aggressive nature of in filtering rainwater to dissolve additional fluoride ions. Four PCA were extracted during PRM and POM indicating the combined action of hydro geochemical processes like weathering, ion exchange, and anthropogenic inputs are the key factors that determine the groundwater chemistry in the study area.

ACKNOWLEDGMENTS

Thanks are due to Head, Department of the Applied Geochemistry, Osmania University, Hyderabad, for providing necessary laboratory facilities. Laxman Kumar Duvva thanks the UGC, New Delhi for providing Research Fellowship in Science for Meritorious Scholars (RFSMS) during the progress of the research work.

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Surface and Ground Water Efficiencies on Irrigation Lands under Nizamabad District

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ABSTRACT

The drainage in agriculture is a process of removal of excess water from the soil which may be due to irrigation, rainfall or both. The drainage accelerates microbial decomposition of the accumulated organic matter and more rapid release of nutrients making the soil more productive. The excess water discharged by flow over the water surface is referred to as 'surface drainage' where as the flow through the soil is termed as 'internal or sub-surface drainage'. The drainage efficiency is the ratio of total annual water drained from the system to total annual water delivered to the system plus effective rainfall minus water used by crops.

The district falls under Godavari river basin. The two tributaries Manjira and Maneru join the Godavari. The Manjira flows from South East to North West and then towards North, takes an easterly turn and then flows in NNE direction before joining the Godavari at Kadakurthi (Sangam). The Maneru river flows from Kamareddy towards south east in the district. The drainage predominantly forms dendritic pattern, which is governed by lithology of the area in absence of structural control. Granitic and basaltic terrains mainly exhibit this type of pattern while the rare parallel to sub-parallel drainage pattern locally exhibited in alluvial areas.

Keywords: Sri Ram Sagar Project, Crops, Crop Patterns, Surface Water, Ground Water, Drainage Efficiencies.

1. INTRODUCTION

The Nizamabad district, named after the Nizam of Hyderabad Asaf Jah VI is one of the ten districts of Telangana region. The total geographical area of the district is 7956 sq.km i.e., about almost 3 percent of the total area of the State. The district is located in North Western part of the State bordering Maharashtra State. It lies between 18º 05" 00' and 19º 00" 00' North latitudes and 77º 32" 00' and 78º 40'" 00' East longitudes (Fig.1). Nizamabad district is primarily an agrarian district ranking first among Telangana districts of the State with almost 80% populace living in rural areas. The district has a population of 25,52,073. Density of population in the district is 321 persons/ km2

The important functions of water are related to consumption, production and ecology, and hence water is intimately linked to food supply and livelihood security. Consumption of water is for drinking by humans and livestock; availability of water in sufficient quantity and of required quality will therefore have direct bearing on the quality of life. Water, when used for irrigation, enhances agricultural productivity. In its ecological function, water when contaminated leads to poor quality of life, with the result that appropriate management strategies are required to protect wetlands and maintain ecosystems and habitats. Over-abstraction from aquifers in coastal areas leads to the additional risk of salt-water intrusion into fresh water. Threats to aquifers include anthropogenic pollution, excessive abstraction leading to pollution, well-head contamination and naturally occurring contamination causing change in acidity or alkalinity of the aquifer. Access to reliable and good quality water through proper management reduces the costs of water supply and economic development.

Groundwater is important in many areas of the state because it is more reliably available in specific quantity than surface water supplies. Groundwater, until recently, has been viewed as a sustainable resource for irrigation and accounts for nearly 50 per cent of the net irrigated area in the state. At present groundwater meets 85 per cent of domestic needs in rural areas and perhaps 30 per cent of urban demand and 50 per cent of industrial demands. However, increase in demand and lack of well-defined property rights, accessibility to institutional financing for development of agro wells and provision of subsidized electricity for pumping groundwater for irrigation have led to overdevelopment in semi-arid parts of the state..

Figure 1. Nizamabad District Andhra Pradesh

2. TOTAL AMOUNT OF WATER RELEASED TO VARIOUS FIELDS

2.1 SURFACE WATER

Paddy is the predominant crop under the command area of SRSP with I.D crops like Maize, Cotton, Chillies, turmeric, ground nut etc, both in Kharif and Rabi seasons.

The year 2004-05 being the drought year and hence the year 2003-04 is considered for working out the drainage efficiency.

Total quantum of water released to fields during 2003-04 is 2832.38 M.m3.

Table 1. The crop wise area irrigated during the year 2003-04 in the command

Name of the crop	**Area irrigated during**		
	Kharif	**Rabi**	**Total**
Paddy	125389	58261	1,83,650
I.D crops (Maize)	78453	-	78453
Maize	-	48825	48825
Ground nut	-	11758	11758
Total	**203842**	**118844**	**322686**

2.2 GROUND WATER

Table 2. The ground water availability and utilization in Mandals of the command area

S.No	Name of the Mandal	G.W availability in Ha. m.	G.W utilization in Ha. m
1	2	3	4
1	Nirmal	2630	1382
2	Laxman Chanda	2435	1618
3	Mamda	3394	836
4	Khanpur	2712	960
5	Kaddam (Peddur)	4587	1507
6	Ibrahim Patnam	2689	938
7	Mallapur	3693	1159
8	Raikal	12785	1571
9	Sarangapur	4142	1492
10	Dharmapuri	4071	1472
11	Veigatoor	2308	934
12	Ramagundam	2201	444
13	Kamanpur	2202	582
14	Manthane	1346	304
15	Matharam (MNT)	398	163
16	Sri Ram pur	2042	613
17	Peddapalli	3745	1318
18	Julapally	1438	369
19	Dharmaram	3147	870
20	Gollapally	2285	1064
21	Jagitial	3781	1789
22	Medipalli	2167	678
23	Koratla	3183	1386
24	Met Palli	1974	946
25	Pegadapalli	1683	986
26	Chppadandi	1576	614
27	Sultanabad	2498	1195
28	Odela	2314	907
29	Jammikunta	5910	2572
30	Veena Vanka	4407	1346
31	Manakondur	4627	1395
32	Karim nagar	1802	669
33	Jhimmapur	-	-
34	Keshava Patnam	3225	1169
35	Huzurabad	3223	1700
36	Kamalapur	3138	1529
37	Elakathurthy	840	386
38	Balkonda	4794	3973
39	Mortad	1895	1553

40	Vailpur	896	589
41	Hasanparthy	3884	2528
42	Wardhannapet	1514	1080
43	Nellikudur	4930	3094
44	Maripeda	1490	712
45	Dornakal	3273	2298
46	Kuravi	5968	3040
47	Mahabubabad	4418	2358
48	Kesamudram	4701	2466
49	Nekkonda	3915	2702
50	Gudur	2147	720
51	Narsampet	1434	844
52	Chenna Rao pet	3145	1650
53	Parvathagiri	3063	1887
54	Sangam	1697	1133
55	Naka Belli	1539	937
56	Duggondi	1521	931
57	Geesukonda	831	623
58	Atmakur	4791	1935
59	Shayam pet	2606	1419
60	Parkal	4079	2000
61	Regonda	3846	2223
62	Mogulla Pally	3206	2197
63	Chityal	5525	2904
64	Muluq	1935	762
	Total	**1,93,641**	**87,420**

2.3 AMOUNT OF WATER REQUIRED BY VARIOUS CROPS

Irrigation water requirements as per Modified Penman Method considering the crop areas of 2003-04. Since 2004-05 is a drought year and there was no irrigation under the project } 3678.75 M.m^3

Paddy in Kharif = $\frac{125389 \times 1.552}{100}$ = 1946.04 M.m^3

I.D Maize in Kharif = $\frac{78453 \times 0.228}{100}$ = 178.87 M.m^3

2124.91 M.Cum

Paddy in Rabi = $\frac{58261 \times 2.060}{100}$ = 1200.18 M.m^3

Maize in Rabi = $\frac{48825 \times 0.548}{100}$ = 267.56 M.m^3

Groundnut in Rabi = $\frac{11758 \times 0.688}{100}$ = 80.90 M.m^3

Total in Rabi = 1548.64 M.m^3

2.4 AMOUNT OF WATER DRAINED OUT FROM THE COMMAND AREA

The quantum of water released to the fields during the year 2003-04 and the irrigation water requirements for the above years as indicated in paras 5.1 and 5.2 are as under.

1. Total quantum of water released to the fields during 2003-04 (Annexure – 2) — 2832.38 $M.m^3$
2. Irrigation water requirements as per 'Modified Penman Method' for 2003-04 — 3673.55 $M.m^3$
3. Rain water component in the command area during 2003-04 — 1588.23 $M.m^3$

   1) $\frac{0.788 \times 1,85,718}{100} = 1463.45\ M.m^3$

   2) $\frac{0.105 \times 1,18,844}{100} = \frac{124.78}{1588.23}\ M.m^3$

4. Ground water potential (Potential due to rain water and canal water) = (Ground water availability – utilisation) = 1, 93,641 – 87,420 (As per table in para 5.1.2) = 1,06,221 Ha. m or 1,062.21 $M.m^3$

As seen from the above, the total water released through canal system during 2003-04 to the fields for irrigation 1,25,389 ha, wet plus 78,453 ha I.D (Maize) in Kharif and 58,261 ha wet, 48,825 ha Maize and 11,758 ha Ground nut in Rabi (2832.38 $M.m^3$) is less than the crop water requirement worked out as per Modified Pen man Method (3673.55 $M.m^3$). Also the canal releases plus rain water component (2832.38 + 1588.23 = 4420.61 $M.m^3$) is less than of crop water requirement plus the ground water potential (3673.55 + 1062.21 = 4735.76 $M.m^3$). This indicates that there is no drainage problem. Further there are about one thousand Minor Irrigation tanks existing within SRSP command. Some of the M.I tanks integrated in the canal system are serving as balancing tanks. The excess surface drainage either flows into these tanks or to the nearest natural valleys and hence there is no drainage problem in the command.

3. ADEQUACY AND PERFORMANCE OF EXISTING DRAINAGE SYSTEM

The topography of the command area is rolling type with high undulations. The slope of the land ranges from 1 % to 3 % and the area comprises of prominent ridges and valleys formed by severe erosion of soils.

There is no specific drainage system in the command area of SRSP. Only field drains within the out let command are constructed along with intermediate drains and link drains to connect them to the main natural drain.

The drainage system in particular at valley crossings of canals have been desilted near structures for safe length on upstream and downstream of the structure for easy functioning of the natural drains. Aqueducts, under tunnels, syphons and super passages are constructed on canal net work system to allow the rivers streams and drains to cross the canals from Right side to Left side to avoid disturbance / dislocation of the natural system. All the water from the command will drain into the natural drains which are well defined surrounding to the distributory ayacut and hence no drainage problems are encountered.

4. PROBLEMS OF WATER LOGGING, SALINITY & ALKALINITY

It is observed that water logged ayacut of about 48,594 ha is found to be existing in the command area of SRSP in the parts of Korutla, Jagitial, Dharmapuri, Gollapally, Sultanabad, Raikal and Sarangapur Mandals. In these areas the depth of water levels were found to be from 0 to 2 m depth. An area of 1,36,381 ha of the command area was found to be prone to water logging since the depth of water level was found to be from 2m to 6m. Conjunctive use of ground water and surface water is recommended in these areas. Salinity in water is also observed in few villages. Tolerance crops like Maize, Cotton are recommended in these Villages. Under the above circumstances and in view of the water logging areas and prone to water logging areas, the conjunctive use of ground water and SRSP water is stressed. It is also proposed to introduce the irrigated dry crops with rotational water supply specially during Rabi season.

Conjunctive use of ground water makes it possible for optimal use of surface and sub surface resources and maximizations of agriculture out put. Adoption of conjunctive use of ground water necessitates in the following circumstances.

- To supplement canal I.D supply of growing paddy / Sugarcane
- To support sugar cane crop during non canal supplies.
- To meet the initial requirement of water in case canal supplies are not forth coming in the start of Kharif season allowance paddy nurseries can be raised using ground water.
- To tide over the period of lean supply from canal, I.D crops are grown (Protective Irrigation).
- To supply exclusively for crops in areas not served by canal in Rabi season.

At present there are about 78,000 wells existing in the command area of SRSP. Proposals are also there to take up new wells in the SRSP command area thus encouraging conjunctive use.

The problem of water logging has to be studied in depth to avoid salinity or alkalinity. Land reclamation, correction of zinc deficiency may solve this problem to some extent. Leaching of salts by arranging under ground filters may solve the problem.

5. DRAINAGE EFFICIENCY

There is no specific drainage system in the command area of Sri Ram Sagar Project. The field drains tend to decrease the water losses at the field level. The command area is having sufficient slopes to drain out surplus rain water to the nearest valleys or streams which are again draining into the tanks in the command area. Hence there is no problem of surface drainage. The sub surface water adds to the irrigation potential which is being utilized as conjunctive use. There are about 78,000 wells in the command of SRSP which can be used as conjunctive use. Further there are proposals to take up new wells in the SRSP command area thus encouraging conjunctive use.

CONCLUSIONS & RECOMMENDATIONS

- To avoid the problem of water logging (salinity or alkalinity) the following are suggested which may solve the problem to some extent.
- Land reclamation (adding suitable earth in the water logging area), correction of zinc deficiency may solve this problem to some extent. Leaching of salts by arranging under ground filters may solve the problem to some extent.
- Raising of suitable crops like Sugarcane, tolerance crops like Maize, Cotton etc., has to be studied in depth and suitable necessary measures taken to mitigate the problem
- The sub surface water adds to the irrigation potential which can be utilized as conjunctive use through well irrigation.
- This water can be used as supplementation for growing paddy crop Sugarcane, for initial requirement for growing paddy nurseries and supplies to the areas not served by canal as per actual utilization.

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Seasonal Variations in the Quality and Chemistry of Groundwater in Erravagu Sub-basin, Guntur District, Andhra Pradesh

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ABSTRACT

An investigation was been carried out in Erravagu sub-basin of Guntur District, Andhra Pradesh by collecting a total of 40 groundwater samples for two seasons namely pre-and post monsoon to decipher hydrogeochemistry and groundwater quality for determining its suitability for drinking and irrigation purposes. The study area is underlain by peninsular gneissic complex and granite intrusives of Archaeans, and shales, phyllites, limestone and quartzites of Proterozoic age. The quality of groundwater is characterized by alkaline nature, fresh to brackish and moderate hard to very hard during pre- and post-monsoon periods. This is not suitable for drinking as well as for irrigation in most locations. The chemistry of groundwater in the study area is controlled by rock weathering, mineral dissolution, ion exchange and evaporation. This is also supported by the dominance of Na^+: HCO_3^- facies. The sources of anthropogenic origin appear to be caused for elevation of various chemical variables, which is responsible for brackishness in the water. Pipers diagram also suggest that the groundwater quality is initially fresh and is subsequently modified to brackish.

Keywords: Groundwater Quality, Erravagu Sub-basin, rock weathering, brackish.

INTRODUCTION

Groundwater utility has been rapidly increased due to unavailability of the surface water and failure of the seasonal monsoons. If water is suitable for drinking then it is suitable for every purpose. Determination of groundwater composition is of utmost importance from the point of view its suitability for various uses like drinking, irrigation and industries etc. An attempt has been made to understand the geo chemical evolution of groundwater and assess its suitability for drinking and irrigation. Recent studies related to the chemistry and quality of groundwater has been carried out in river basins in different parts of the country. The present study is on Erravagu sub-basin of Guntur district, Andhra Pradesh.

STUDY AREA

The Erravagu sub-basin is located in between North latitudes of $16^0 20' 20''$-$16^0 27' 45''$ and East longitudes of 79^0 $52'$ $06''$ - 80^o $04'$ $30''$ in the central part of the Guntur District of Andhra Pradesh (Fig. 1). The climate of the area is semi-arid with an average annual temperature of 18.5^0C (winter) to 43^0C (in summer). The average annual normal rainfall is 782 mm. The Erravagu originating from hill ranges located in the southwest and northwest flows towards the northeast. The drainage pattern shows dendritic to sub-dendritic. Canal irrigation is common.

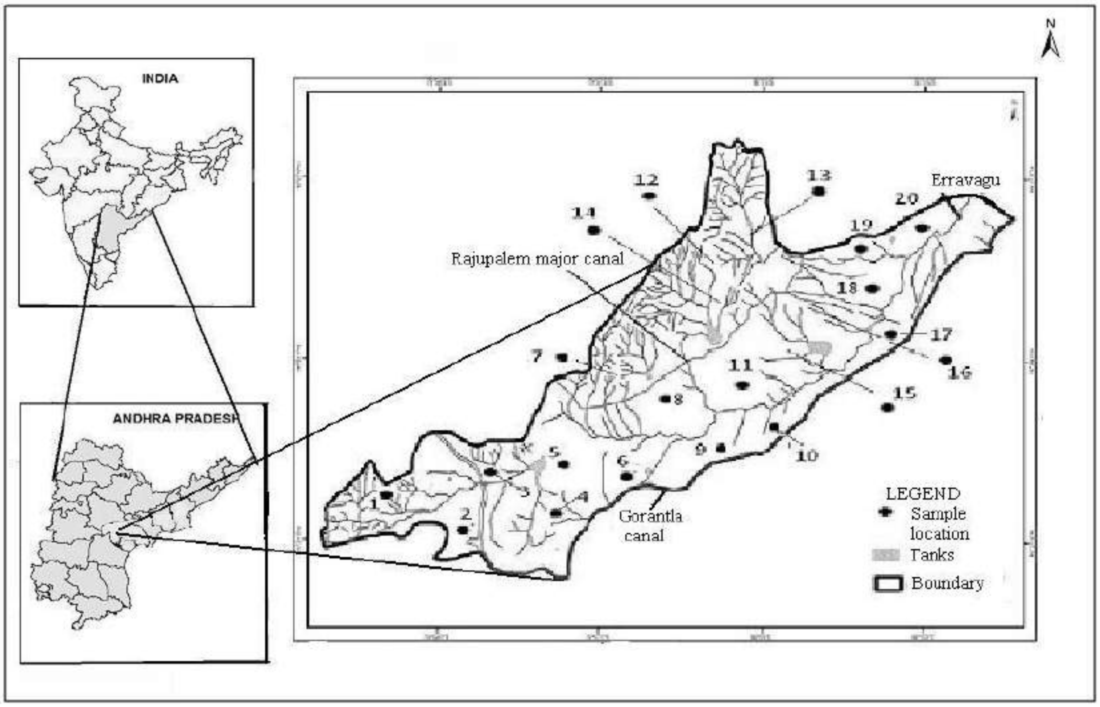

Figure 1. Location Map of the Erravagu Sub-basin.

The area is characterized by undulating topography, sloping towards the northeast. The altitude varies from 349 m amsl (in the south-west part) to 95 m amsl (in the northeastern part). The Study area exposes peninsular gneissic complex (grey pink granites) as basement rocks, unconformably overlain by the quartzites, shales, phyllites and limestones belong to Nallamalai and Kurnool groups of Proterozoic age. The Nallamalai formation is intruded by younger granites. The basement rocks occur on the northeastern part, while the Cumbhum quartzite, shale and phyllite exposes in the southeastern and southwestern parts of the area. The Narji Limestone and Owk shales occur in the south central and northwestern portions of study area. The gneisses and granites are highly fractured and weathered. The crystalline rocks, calcareous and argillaceous formations are the main aquifers and control the groundwater chemistry of the study area.

METHODOLOGY

A total of 40 groundwater samples collected during May 2010 and November-2010 were used for determination of pH and electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA) as CaCO3, total hardness(TH) as $CaCO_3$, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-) and fluoride (F^-), following the standard procedure of APHA (1992), in the Panchayit Raj Department, Guntur and Lam Agricultural Form, Guntur. The analytical precision of the measurements of major cations and anions was determined by computing the ionic balance error, which is, generally, within $\pm$5 % (Domenico and Schwartz, 1990).

RESULTS AND DISCUSSION

Groundwater quality

The pH ranges from 7.6 to 8.9, 7.2 to 8.6 during pre-and post-monsoon periods indicating alkaline nature, Most of the samples are within the standard drinking water quality limit of 6.5 to 8.5 (BIS, 2003), except two samples (2 and 14) during both the seasons. The EC is in between 540 and 4640 µS/cm(pre-monsoon),465 to 4400 µS/cm(post-monsoon) reflecting a wide variation in the activities of geochemical processes. The TDS varies from 346 to 2970 mg/l (pre-monsoon), 298 to 2816 (post-monsoon). According to the TDS classification (Fetter, 1990), 50% of the total groundwater samples during the pre-monsoon and 60% of the samples during post-monsoon belong to fresh category while the rest to brackish. The TA value ranges from 190 to 513 during pre-monsoon and 172 to 412 during post-monsoon. 10%, 35%,55% during pre-monsoon and 5%,35% ,60% during post-monsoon come under Moderately hard, hard and Very hard water type based on TH.(Table 1) (Sawyer and Mc Carty,1967) The very hard type of water develops soap lather.

Table 1. Criteria for groundwater quality for drinking and irrigation based on TDS and TH

Parameter	Range	Pre-monsoon		Post-monsoon		Water Quality
		Sample Nos	% of samples	Sample Nos	% of samples	
TDS (mg/l)	<1000	4-7,12-13,16-19	50	1,4-7,12-13,16-19	60	Fresh
	>1000	1-3,8-11,14-15,20	50	2,3,8-10,14,15,20	40	Brackish
TH (mg/l)	<75	-	-	-	-	soft
	75-150	1,13	10	1,13	10	Moderately hard
	150-300	2,7,12,14,16-18	35	2,5,12,14,16,17,19	35	Hard
	>300	3-6,8-11,15,19,20	55	1,3,4,6-11,15,18,20	60	Very hard

During pre-monsoon the concentrations (mg/l) of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} vary from 16 to 96, 10 to 112, 78 to 454 and 3 to 404, respectively ,while during post-monsoon they vary from 24 to 84, 26 to 110, 65 to 346, 4 to 262 respectively indicating that Na^{+} and K^{+} ions are the dominant ions in the groundwater. The concentration of Na^{+} to the total cations ranges from 37.5 – 87.89% (pre-monsoon),32.01 – 80.92% (post-monsoon) due to silicate weathering and/or dissolution of soil salts stored by the influences of evaporation and anthropogenic activities (stallard and Edmond, 1987; Meyback,1987; Subba Rao 2008), in addition to agricultural activities and poor drainage conditions. Moreover, the higher content of Na^{+} than that of Ca^{2+} is because of ion exchange and high solubility of Na^{+} than the later. The second dominant cation is K^{+}, which contributes 0.48 to 43.48% (pre-monsoon), 1.03 to 34.4% (post-monsoon) to the total cations. The high concentration of K^{+} is mainly derived by the weathering of K-feldspar and mica. The contribution of Ca^{2+} and Mg^{2+} to the total cations is 3.65 to 25% and 2.8 to 27.67% respectively in the pre-monsoon, while it in the post-monsoon ranges from 5.78-33.5%, 9.48-39.56% respectively. The concentrations of Ca^{2+} and Mg^{2+} ions in the groundwater are due to the country rocks, which are composed of limestone, dolomite and peninsular gneiss.

The concentration of HCO_3^-, Cl^- , $SO_4^{2,-}$, NO_3^- and F^- are in between 190 and 513 mg/l, 80 and 920 mg/l, 32 and 195 mg/l, 10 and 145 mg/l and 0.6 and 2.8 mg/l, respectively during pre-monsoon, while during post-monsoon values in mg/l ranges from 178 to 518, 40 to 840, 16 to180, 8 to 20 and 0.5 to 2.5 respectively. The HCO_3^- plus CO_3^{2-} content dominants in the groundwater, which is due to dissolution and leaching of calcareous aquifers, and decay of plants and organic matter. The contribution of HCO_3^- to the total cations is 29.7 to 75.8% during pre-monsoon, 28.71 to 81.07% during post-monsoon period. The origin of Cl^- is derived mainly from the domestic waste waters, septic tanks, and irrigation-return-flow and chemical fertilizers (Todd, 1980; Hem, 1991). Cl^- is the second largest anion contributing 12.24 - 54.82% (pre-monsoon), 7.86 – 59.11% (post-monsoon) to the total anionic concetration. The SO_4^{2-} may be derived from gypsum (Todd, 1980) which contributes 6 to 23% during pre-monsoon and 3 to 25 % during post-monsoon. The concentration of NO_3^- more than 10 mg/l in the water reflects the man-made pollution (Cushing et al., 1993; Ritzit et al., 1993). The contribution of NO_3^- to the total anions ranges from 0.7 to 12.9% during pre-monsoon, 0.7 to 13.1% during post-monsoon. The F^- content during pre-and post-monsoon in the groundwater ranges from 0.6 to 2.8,0.5 to 2.5 respectively. The F^- contribution to the total anions during pre-monsoon is 0.05 to 0.38%, while during post-monsoon it ranges from 0.05 to 0.5% which is due to host rocks that may contain the minerals such as apatite, hornblende, fluorite, clay and chemical fertilizers.

Geochemical Characteristics of groundwater

Hydro geochemical characteristics of groundwater are evaluated by Piper Trilinear diagram (Piper, 1944). Figure2 indicates that the 10% of the samples during pre-and post-monsoons is characterized by carbonate hardness (field 5) due to dominance of Ca^{2+} and Mg^{2+} with HCO_3^- + CO_3^{2-} ions over the Na^{+} + K^{+} and Cl^- +SO_4^{2-}ions, 50%(pre-monsoon),45% (post-monsoon) by non-carbonate alkali (field 7) due to abundance of Na^{+} and Cl^- ions which exceed 50% of Ca^{2+} + Mg^{2+} and HCO_3^- +CO_3^{2-} ions, and 40% (pre-monsoon),45% (post-monsoon) by mixed type (field 9) due to no-cation-anion ion pair exceeding 50%(Table2)

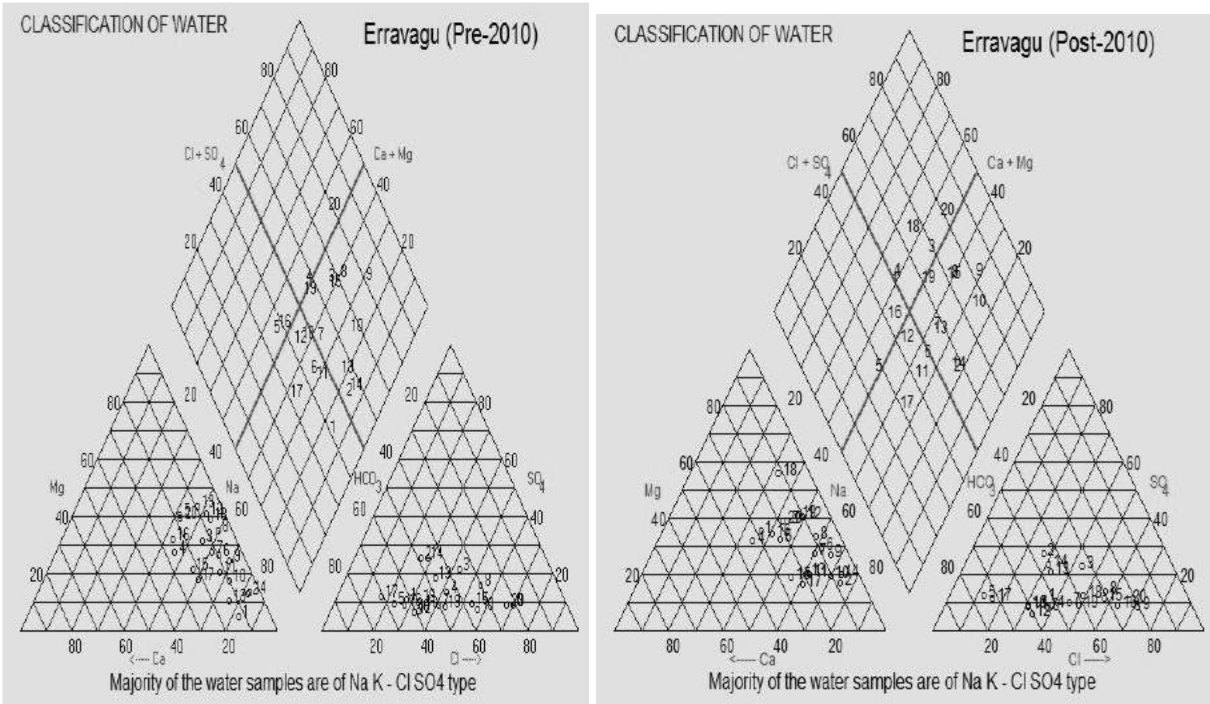

Figure 2. Geochemical classification of groundwater of the study area (after Piper, 1944)

Water infiltrates through the soil cover and percolates into the weathered/fractured rocks and attains this concentration. During this journey of water, anthropogenic activities play a major role in the change of groundwater quality and there by the chemistry of groundwater varies from place to place. Thus, the groundwater samples fall in the different fields in the Piper's trilinear diagram. The $Na^{+}HCO_3^{-}$ Cl^{-} and Na^{+} $Cl^{-}HCO_3^{-}$ are the dominant water types based on Pipers diagram.

Table 2. Geochemical characteristics of groundwater of study area (after Piper, 1944)

Zone	Geochemical characteristics	Pre-monsoon		Post-monsoon	
		Sample Numbers	% of samples	Sample Numbers	% of samples
1	Alkaline earths exceed alkalies	4,5,16,20	20	3,4,5,8,16,20	30
2	Alkalies exceed alkaline earths	1,2,3,6,7,8,9,10,11,12, 13,14,	80	1,2,5-7,9-15,17-19	70
3	Weak acids exceed strong acids	1,5,6,11,12,16,17,18	40	5,6,11,12,16,17	30
4	Strong acids exceed weak acids	2,3,4,7,8,9,10,13,14,15 ,19,20	60	1-4,7-10,13-15,18-20	70
5	Carbonate hardness exceeds 50% of alkaline earths and weak acids	5,16	10	5,16	10
6	Non- carbonate hardness exceeds 50% of alkaline earths and strong acids				
8	Carbonate alkali exceeds 50% of alkalies and weak acids	2,3,7-10,13-15,19	50	2,7-10,13-15,19	45
9	No cation and anion pair exceeds 50% of the total ions	1,4,11,12,16,17,18,20	40	1,3,4,6,11,12,17,18,20	45

Table 3. Comparison of groundwater quality with drinking water quality Standards of WHO (1984) and BIS (2003**)**

Chemical parameter	WHO (1984)	BIS (2003)	Pre-monsoon		Post-monsoon	
			Groundwater samples exceeding the safe limit		Groundwater samples exceeding the safe limit	
			Sample numbers	% of samples	Sample numbers	% of samples
pH (units)	7-8.5	6.5-8.5	2,14	10	2,14	10
TDS (mg/l)	500	500	1-4, 6-20	95	1-4, 6-20	95
TH (mg/l)	100	300	3-6, 8-11, 15,19,20	55	1,3,4,6-11,15,18,20	60
Ca^{2+} (mg/l)	75	75	15,20	10	15,20	10
Mg^{2+} (mg/l)	50	30	2-12,14-20	90	1-16, 18-20	95
Na^{+} (mg/l)*	200	-	1-3,8-10,13-15,20	50	2,8-10,14	25
Cl^{-} (mg/l)	200	250	8-10,15,20	25	8-10,15,20	25
SO_4^{2-} (mg/l)	200	150	2,3,8,9	20	2,3,9	15
NO_3^{-} (mg/l)	45	45	2,14	10	2,14	10
F^{-} (mg/l)	1.5	0.6-1.2	1,2,10,11,13,14,15	30	1,2,10,11,13,14,15	30

To ascertain the suitability of groundwater quality for drinking and Public health purpose, the analytical results of the chemical parameters of groundwater of the study area is compared with the standard drinking water quality guide line values recommended by BIS (2003) and WHO (2004).

The permissible range of pH is 7.1 to 8.5 for drinking water. Beyond this limit, it may affect the mucous membrane and water supply system. 10 % of the samples during pre-and post-monsoon are exceeding the permissible limit (Table.3). Based on TDS 95% of total samples during both the seasons are not-potable. Water with high TDS, has is inferior palatability and may induce an unfavorable physiological reaction in the transient consumer and gastrointestinal irritation in the human system. 10% of the total ground water samples are considered as unsafe with reference to Ca^{2+} for drinking (Table 3). The permissible limit of Mg^{2+} is 30 mg/l. for drinking. About 90% of the total ground water samples during pre-monsoon and 95% of the samples during post-monsoon are unsuitable for drinking. The prescribed safe limit of Na+ for drinking water is 200 mg/l. The concentration of Na^{+} in excess allowed limit of 200 mg/l for drinking water may cause Hypertension. 50%, 25% of the samples exceeds to this limit during pre-and post-monsoon seasons respectively. The recommended limit of Cl^{-} for drinking water is 250 mg/l. If this value exceeds it imparts bitter taste to water and may cause Cardio Vascular problems. About 25% of the total ground water samples during both the seasons exceed the safe limit. Sulphate is unsuitable, if it exceeds the permissible limit of 150 mg/l and causes a laxative effect on humans, together with Na^{+} or Mg^{2+} in drinking water. 20% of total ground water samples during pre – monsoon and 15% of the total groundwater samples during post-monsoon exceed the prescribed limit. Water, with more than 45 mg/l of NO_3^{-}, is not suitable for drinking. Beyond this limit in potable water, it may cause methamoglobinemia or blue baby disease in infants. 10% of the samples during both the seasons are exceeding the desired limit. Considerable amount of F- in the potable water is very essential for normal growth of bones in human system. The safe limit of F^{-} is 0.6 to 1.2 mg/l, less than 0.6 mg/l F - causes dental caries, while more than 1.2 of F - results fluorosis. About 30% of the total samples during both the seasons are found to contain excess Fluorides than safe limit.

Groundwater quality for Irrigation

As per the United States Salinity Laboratory (Richards, 1954) diagram used widely for classification of water quality for irrigation, 5%, 30%, 30%, 15% and 10% fall in the zones of C2S1, C3S1, C3S2, C4 S3 and C4S2 during pre-monsoon. 5%, 50%, 20%, 15% and 10% fall in the zones of C2S1, C3S1, C3S2, C4 S2 and C4S3 during post-monsoon. There was an increase in the water quality from pre- to post-monsoon. They come good (C2S1), moderate (C3 S2) and poor (C4S2 and C4S3) categories for irrigation. Thus, the application of gypsum, CaCl with organic manure and other methods of de-salinization and dealkalinization are necessary to improve the water quality.

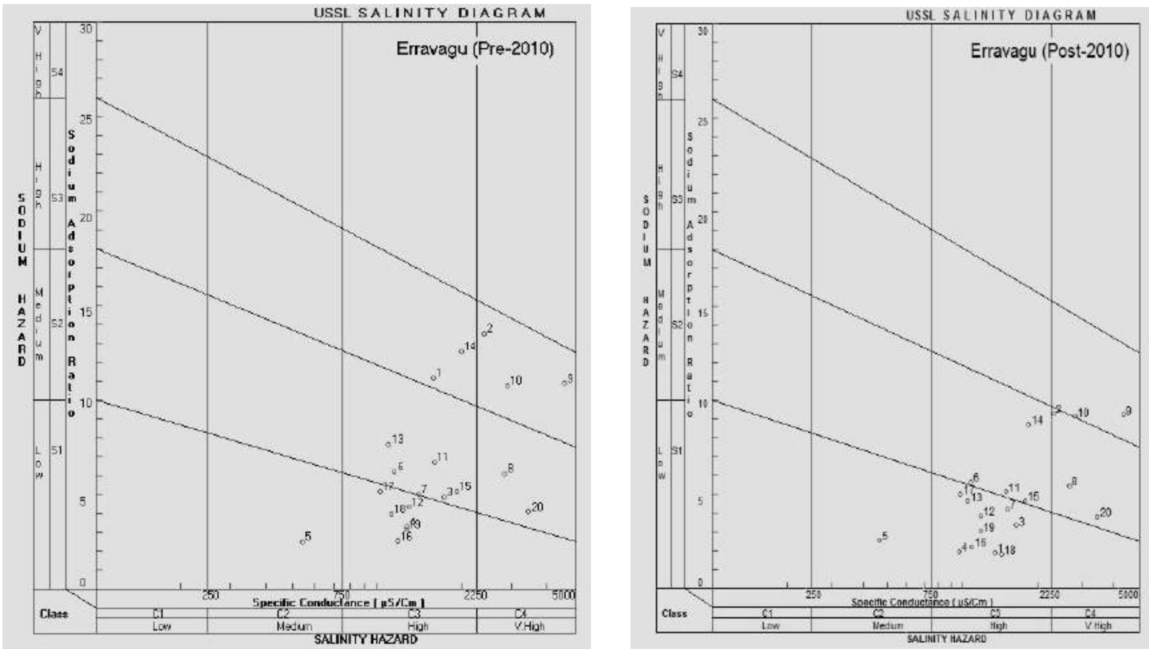

Figure 3. Classification of irrigation waters of the study area (after U.S.Salinity Laboratory Staff (after Richards, 1954)

CONCLUSIONS

The observed quality of groundwater in the Erravagu sub-basin of Guntur district, Andhra Pradesh shows alkaline nature with fresh to brackish and moderate hard to very hard type. The TDS, TH, Ca^{2+}, Mg^{2+}, Na^{+} , Cl, SO_4^{2-}, NO_3^{-} and F^{-} exceed the drinking water standards in most groundwater samples. Anthropogenic activities cause the deviation from the quality of groundwater derived from the rock-weathering. This is supported by the Pipers' diagram. Thus, the groundwater shows Na^{+}: HCO_3^{-} and Na^{+}: Cl^{-} facies, being a dominant of the first facies. Seasonally the groundwater quality is showing slight variation from pre-to post monsoon.

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THEME - VI

Water Conservation and Irrigation Management

Continuous Contour Trenches for Enhancing Soil Moisture and Growth of Perrennial Plantation in Micro-Catchment

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ABSTRACT

The area under study at the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola was divided into four micro-catchments (A, B, C and D). The micro-catchments A and C are treated with continuous contour trenches and B and D are without continuous contour trenches. The micro-catchment A and B are having Custard Apple (*Annona squamosa*) plantation and catchment C and D are having Hanumanphal (*Annona cherimola*) plantation. The soil moisture status at different depths was observed in different months during the year 2014 in all the micro-catchments. For the micro-catchments having custard apple plantation, it was observed that the soil moisture content in the micro-catchment, A was better in all months at all depths as compared to micro-catchment, B. For the catchments having Hanumanphal plantation, it was observed that the soil moisture content in the micro-catchment, C was better in all months at all depths as compared to non treated catchment, D. The micro-catchments treated with continuous contour trenches have shown better moisture regimes as compared to non treated micro-catchments. The enhanced moisture in the CCT treated micro-catchment have resulted into good growth of perennial plantation and thus the production of the plantation in CCT treated catchment was more as compared to non treated micro-catchment. This clearly indicates the benefits of continuous contour trenches for better moisture enhancement and good growth of perennial plantation.

Keywords: CCT, growth, plantation, soil moisture, micro-catchment.

INTRODUCTION

Conservation measures like contour strip cropping, field strip cropping, wind strip cropping, buffer strip cropping, mulching, contour bunding, terracing, bench terracing, channel terrace, narrow based terrace, contour trenching can be used in dryland. There are two types of contour trenches like continuous contour trenches and staggered trenches. Out of which continuous contour trenches are most preferable for dryland plantation like custard apple, lemon, guava, hanuman phal, papaya etc. due to CCT these dryland plantations can efficiently use water which was stored. CCT avoid the runoff generation so that nutrients are prevented to flow along with runoff water. The amount of water that can be retained in the soil profile is most critical, especially among dry spells. Therefore understanding the soil water regime of rainfed regions is important for efficient rainwater conservation and for its optimum uses for practical soil water management. Soil texture and the properties it influences, such as porosity, directly affects water and air movement in the soil with subsequent effects on plant water use and growth. When all pores are filled with water, the soil is 'saturated' and water within macropores will drain freely from the soil via gravity. Continuous contour trench system (CCT) system, developed for plantation in non arable lands in low rainfall areas, has been found to be very effective in soil and water conservation, leading to considerably high groundwater recharge (Nagdeve *et al*., 2009). CCTs are adopted for reducing runoff and enabling the water to infiltrate down to the ground. In the top portion of catchment area, contour trenches can be excavated all along a uniform level across the slope of the land. Bunds can be formed downstream along the trenches with material taken out of them to create more favourable moisture conditions and thus accelerate the growth of vegetation. Contour trenches breaks the velocity of runoff and for small catchments the infiltrated water can be helpful for increasing the soil moisture regimes.

Contour trenches

Contour trenches are used both on hill slopes as well as on degraded and barren waste lands for soil and moisture conservation and afforestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e., in both high and low rainfall conditions), varying soil types and depths. Trenches can be continuous or interrupted. The interrupted one can be in series or staggered, continuous one is used for moisture conservation in low rainfall areas and require careful layout (Thomas, 2010). Intermittent trenches are adopted in high rainfall areas. The trenches are to be constructed strictly on contours irrespective of the category. The size of the trench depends upon the soil's depth. Normally 1,000 sq cm to 2,500 sq cm. in cross section are adopted. The trench may be of 30 cm base and 30 cm top width and square in cross section or it can be trapezoidal with side slopes 1:1. Based on the quantum of rainfall to be retained, it is possible to calculate the size and number of trenches. In Vidarbha region of Maharashtra the trench size of 60 cm top, and 30 cm deep is commonly adopted.

STUDY AREA

The study was undertaken on the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in the Vidarbha region of Maharashtra. The site is situated at the latitude of 20^0 42’ North and Longitude of 77^0 02’ East. The altitude of this place is 307.41m above sea level. Soil survey of the catchment was carried out by traversing and sites for soil profiling were selected based on variations in soil types. In the present study three types of soils were identified viz. Inceptisol, Entisol and Vertisol. Taxonomically these soils are classified into the family of Vertic Haplustepts, Typic Ustorthents, Typic Haplusterts (Soil survey staff, 1994).

METHODOLOGY

The study area (1.0 ha) was divided into two catchments. One catchment was treated by preparing continuous contour trenches (CCTs) and other was without continuous contour trenches. Both catchments are having plantations of Custard Apple (*Annona squamosa*) and Hanumanphal (*Annona cherimola*). The small catchments were again divided into two parts, thus in entire area there are four parts. In each part the soil moisture was determined with Gopher Soil Moisture Profiler.

Determination of soil moisture

The access tubes are inserted into the soil in all the four micro catchments. Weekly soil moisture content was determined by inserting the sensitive sensor into the access tubes and the soil moisture content at different depths were recorded.

RESULTS AND DISCUSSION

The catchment A and B are having custard apple plantation and catchment C and D are having Hanumanphal plantation. The soil moisture status at the depths 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, cm was observed in different months during 2014 in all the four catchments and is presented in Fig.1. The soil moisture status was observed to be better in the catchments having continuous contour trenches as compared to untreated catchments. The CCT treated catchments A and C have shown better moisture regime over the untreated catchments B and D in the observed months. The soil moisture content at different depths in CCT treated catchments A and C was more as compared to the untreated catchments B and D in the observed months.

Impact of CCTs on fruit production of custard apple

Picking of custard apple was started in the month of November and was carried out up to end of December. The fruit production of custard apple in CCT treated and untreated micro-catchment is given in Table 1 and presented in Fig. 2. Positive response of CCTs on fruit production compared to untreated (T_2) micro-catchment for custard apple plantation has been observed. Average fruit production of custard apple in CCTs treated over untreated micro-catchment is more by 61.58 %.

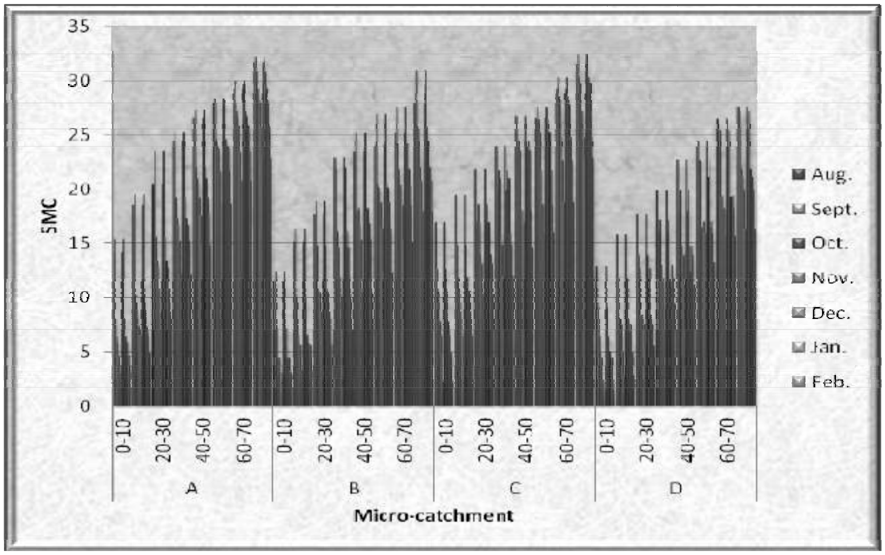

Figure 1. Soil moisture contents at different depths in different months

Table 1. Fruit production of custard apple in CCT treated and Untreated micro-catchment

Picking	Fruit production of Custard Apple (Kg)	
	Treated	**Untreated**
First	8.34	1.37
Second	20.00	10.00
Third	18.50	0.60
Fourth	11.07	5.40
Fifth	17.08	11.07
Sixth	16.58	8.16
Seventh	12.00	3.18
Total	103.57	39.78
Increase over untreated	61.58%	

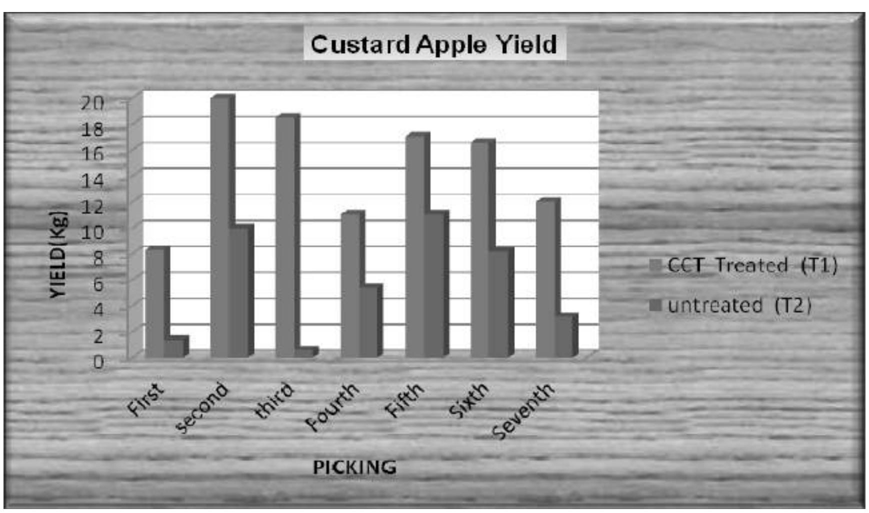

Figure 2. Picking wise fruit production of Custard Apple

Impact of CCTs on fruit production of atemoya (Hanuman Phal)

Picking of atemoya was started in the month of November and was carried out up to end of March. The fruit production of Hanuman Phal in treated and untreated micro-catchment is given in Table 2 and presented in Fig 3. Positive response of CCTs on fruit production has been observed as compared to untreated micro-catchment for Hanuman Phal plantation. Average fruit production of Hanuman phal in CCT treated micro-catchment over untreated micro-catchment is more by 77.08 %.

Table 2. Fruit production of atemoya in CCT treated catchment and untreated micro-catchment

Picking	Fruit production of Hanuman phal (Kg)	
	CCT Treated	Untreated
First	1.94	0.49
Second	3.35	1.61
Third	2.18	1.87
Fourth	21.47	4.48
Fifth	8.28	2.07
Sixth	7.33	1.90
Seventh	5.09	1.34
Eighth	81.51	1.86
Total	68.15	15.62
Increase over untreated	77.08%	

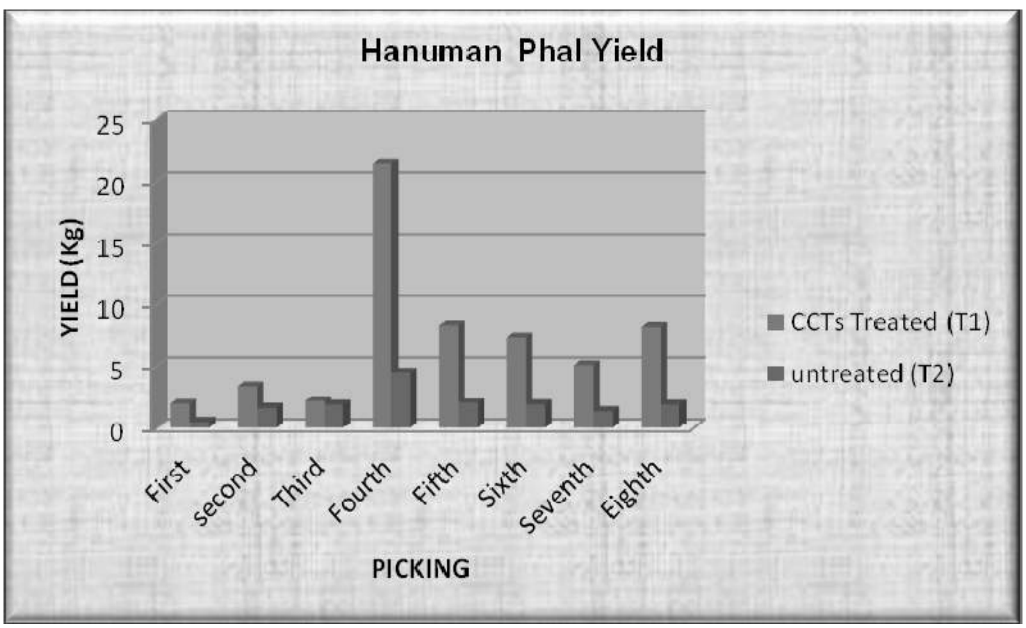

Figure 3. Picking wise fruit production of Hanuman Phal

CONCLUSION

On the basis of the moisture regimes of different catchments, it can be concluded that the catchments treated with continuous contour trenches have shown better moisture regimes as compared to non treated catchments. Average fruit production of custard apple and Hanuman Phal plantation in CCT treated (T_1) micro-catchment is more by

61.58% and 77.08% respectively over untreated (T_2) micro-catchment. This indicates the benefits of continuous contour trenches for better moisture enhancement in the catchment.

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Performance Evaluation of Site Specific Drip Fertigation

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ABSTRACT

Field experiments were conducted to evaluate the effect of site specific drip fertigation on growth and yield of chilli during September 2007 - February 2008 and August 2008 – February 2009 in completely randomized design (CRD) with six treatments and four replications. Two test plots, one from high fertility zone and one from low fertility zone were identified and delineated within the farmer's fields located at Thondamuthur village in Coimbatore district of Tamil Nadu State for raising the crop. Soil samples were analyzed for available N, P and K. Site specific nutrient recommendations were made using the Decision Support System for Integrated Fertilizer Recommendation (DSSIFER) software (Murugappan *et al.* 2004) for optimum yield. Hybrid chilli (Hot line) was used as test variety. Package of practices were carried out as per recommendations. Relevant observations on growth parameters at periodic intervals, root characteristics, yield and quality parameters of chilli were recorded and economics *viz.,* gross return, net return and Benefit Cost Ratio (BCR) were calculated. Drip irrigation was scheduled daily (24 hrs) and once in two days (48 hrs) based on the treatments with the computed quantity of water. Phosphorous was applied as one basal dose and two top dressings in the form of super phosphate in three split doses (basal, 30 DAP and 60 DAP). Nitrogen and potassium were applied through fertigation system. Fertigation was done once in five days starting from 15 DAP up to 150 DAP. From the study it could be concluded that adoption of site specific drip fertigation with daily drip irrigation in hybrid chilli is a viable proposition for the farmers who aim for greater income benefits utilizing optimal inputs.

INTRODUCTION

Precision agriculture is that which uses inputs most efficiently and judiciously to maximize productivity and profitability with minimum impact on soil and environment. Precision in terms of both time and quantity of inputs and agronomic practices, envisages a prospect, which can help in decreasing the cost of production and not having any adverse effect on soil and environmental health. Thus the intent of precision farming is to match agricultural inputs and practices to localized conditions within a field to do the right thing in the right place, at the right time and in the right way. Spatial variability of all essential plant nutrients existed in different operating systems at various scales. Significant correlations were found between crop yields and available soil nutrient levels at the corresponding sites in the field based on which site specific soil nutrient management strategy is proposed. Efficient use of available irrigation water is essential for increasing agricultural productivity for the alarming Indian population. Sustainability of any system requires optimal utilization of resources such as water, fertilizer and soil. There is a need to develop agro technologies, which will help in sustaining the precious resources and maximize the crop production, without any detrimental impact on the environment. Bringing more area under irrigation would depend largely upon efficient use of water. In this context, micro irrigation has most significant role to achieve not only higher productivity and water use efficiency but also to have sustainability with economic use and productivity. Fertilizer management is the most important agro-technique, which controls development, yield and quality of a crop. Fertilizer use efficiency is only 50 per cent in conventional practice of soil application. Location specific fertilizer management practices are essential for increasing fertilizer use efficiency for optimizing the fertilizer input and maximizing the productivity.

Every attempt is therefore necessary, in achieving this objective of higher water and fertilizer use efficiency. Under these circumstances, drip fertigation, which is known to be hi-tech and efficient way of applying fertilizers through irrigation system as a carrier and distributor of crop nutrients, holds bright promise (Magen, 1995). Fertigation has been found to be effective in saving labour and energy. Fertigation increases both water and nutrient use efficiency. It offers flexibility in fertilizer application to match crop's nutritional requirement at different growth stages. Introduction of simultaneous micro irrigation and fertigation opened up new possibilities for controlling water and nutrient supplies to crops and maintaining the desired concentration and distribution in the soil. By introducing fertigation, it is possible to increase the yield potential by three times with the same quantity of water, by saving about 45 to 50 per cent of irrigation water and increasing the productivity by about 40 per cent. When fertilizer is applied through drip irrigation, it was observed that the yield has been increased and about 30 per cent of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005).

Keeping the above points in view, field studies were carried out with the following objectives.

1. To study the response of site specific nutrient application with reference to fertility status using the hybrid chilli (*Capsicum annum.*L.) variety "hotline".
2. To study the soil moisture dynamics under different fertigation treatments.
3. To evaluate the economic feasibility of site specific drip fertigation system.

MATERIALS AND METHODS

Location of the study area

Studies were conducted in the farmer's fields located at Thondamuthur, Coimbatore district during the kharif season of 2007 and 2008. The study area of 50 ha is located between $10^{0}\,59^{'}\,26^{''}$ and $10^{0}\,59^{'}\,31^{''}$ N latitude, $76^{0}\,50^{'}\,4^{''}$ and $76^{0}\,50^{'}\,15^{''}$ E longitude with an average altitude of 500 m above MSL. Two test plots, one from low fertility area and other from high fertility area were selected for the study.

Crop raising

Chilli (*Capsicum annuum* L.) hybrid 'Hotline' variety was used for the study.

Soil properties

In both the test plots, the soil belongs to Thondamuthur series, having sandy loam soil (texture). The detailed physio-chemical properties of the soils are given in Table 1.

Table 1. Soil characteristics of the test fields

Soil characteristics	Particulars	Plot No. 1	Plot No. 2
Textural composition	Sand, per cent (%)	62	58
	Silt, per cent (%)	33	35
	Clay, per cent (%)	5	7
	Textural class	Sandy loam	Sandy loam
Chemical properties	Available N, Kg/ha	216.36	106.32
	Available P, Kg/ha	21.32	11.13
	Available K, Kg/ha	629.83	274.21
	pH	7.92	7.72
	Electrical conductivity (dSm^{-1})	0.27	0.19
Physical characters	Bulk density, g/cc	1.61	1.67
	Field capacity, per cent	22.73	23.07
	Permanent wilting point, per cent	11.68	11.84
	Infiltration rate, cm/hr	1.92	1.81

Experiment design and treatments

The experimental plot was laid out in a completely randomized design with six treatments and four replications. The treatment details are as follows:

- T1 Recommended dose of fertilizer for the through drip fertigation, providing daily drip irrigation.
- T2 Recommended dose of fertilizer for the crops through drip fertigation, providing alternate day drip irrigation.
- T3 Fertilizer dose based on the available nutrients in the field obtained from the nutrient status map through drip fertigation, providing daily drip irrigation.
- T4 Fertilizer dose based on nutrients in the field obtained from the nutrient status map through drip fertigation, providing alternate day drip irrigation.

T5 Manual application of fertilizer along with daily drip irrigation.

T6 Manual application of fertilizer along with alternate day drip irrigation.

R_4T_6	R_4T_5
R_3T_6	R_3T_5
R_2T_6	R_2T_5
R_1T_6	R_1T_5
R_4T_4	R_4T_3
R_3T_4	R_3T_3
R_2T_4	R_2T_4
R_1T_4	R_1T_3
R_4T_2	R_4T_1
R_3T_2	R_3T_1
R_2T_2	R_2T_1
R_1T_2	R_1T_1

Figure 1. Field layout plan of experimental plots

Soil samples were collected from the experimental sites one month before planting. The samples were analyzed for available N, P and K. Site specific nutrient recommendations were made using the Decision Support System for Integrated Fertilizer Recommendation (DSSIFER) software (Murugappan *et al.* 2004) for optimum yield.

Design and layout of the drip system

The design of the drip system is essentially a decision regarding selection of emitters, laterals and manifolds, sub main, main line and required pumping unit. The size of main, sub mains, laterals and pumps were decided based on the desired flow rate and pressure head in the system. Pressure drop due to friction in laterals and sub main was estimated using Hazen – William empirical equation for multiple outlet pipes. In the present study, the existing pumping system used by the farmers for irrigation was considered for the system and the flow and pressure requirement was regulated with the help of control valves. To economize the drip installation cost for chilli based on the wetting zone in the soil for 4 lph emitter, the spacing of lateral and spacing between emitters were selected as 1.5 m and 0.6 m respectively (Selvaraj, 1997). The application of fertilizer to various treatments was controlled by using control valves provided in the sub main and lateral flow control valves provided at the off take of laterals. Laterals were provided with end caps. The arrangement was done in such way that different treatment areas can be fertigated separately as per requirement and irrigation water can be applied daily or alternate day on either side of the sub main depending upon the irrigation interval fixed for various treatments. After installation, trial run was conducted to assess mean emitter discharge and uniformity coefficient. This was taken into account for fixing the irrigation water application time. During the irrigation period an average co-efficient of 90 to 95 per cent was maintained.

OBSERVATION RECORDED

Growth parameters

The following growth parameters were recorded during the crop period

1. The height of the plant from the base to the tip of the main stem was measured at 30, 60, 90 DAP and at final picking and expressed in centimeters.
2. Stem girth was measured at the final picking and expressed in centimeters.
3. The sampled plants at 30, 60, 90, 120 DAP and at final picking were dried in hot air oven at 65 ± 5°C till it reached a constant weight. The total dry matter production was calculated and expressed in kg ha^{-1}.

Yield and yield parameters

The following yield parameters were recorded during the growth period

1. Length of the fruit was measured in the tagged plants at random from the calyx end to the tip of the fruit in all treatments and the mean was expressed in cm.

2. The girth of fruit was measured at the broadest point and expressed in centimeter.
3. The fruits harvested from five randomly selected plants over all harvests were weighed; the mean was worked out and expressed in grams.
4. The green chilli yield per plot was weighed and summed to arrive total green chilli yield per net plot which was converted and expressed in tonnes ha^{-1}.

Water use studies

Water use efficiency (WUE) is the amount of yield that can be produced from a given quantity of water. It was worked out by using the following formula and expressed as kg ha^{-1} mm^{-1}.

$$\text{WUE} = \frac{\text{Green chilli yield (kg ha}^{-1}\text{)}}{\text{Total water used (mm)}}$$

Soil moisture distribution

Soil moisture content was estimated by gravimetric method through soil samples taken before irrigation and 30 minutes after irrigation at the emitter and at a radial distance (horizontal) of 15, 30 and 45 cm from the emitter and at depths of 0 - 15, 15 - 30 and 30 -45 cm from the dripper for studying soil moisture distribution pattern in each treatment. This observation was done at 14 continuous irrigation cycles during non-rainy days, throughout the crop growth period. The mean values were calculated and expressed in per cent of soil moisture. The soil moisture distribution pattern in each treatment was plotted using the software "SURFER 7.0".

Economics

The benefit cost ratio (BCR) was worked out by using the formula suggested by Palaniappan (1985).

$$\text{BCR} = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

The cost of drip system for one hectare was worked out based on current market rates. The life of the drip system was assumed to be 6 years. Prevailing market price of drip components from a standard firm was used. Interest on capital investment was taken as 8.0 per cent per annum.

RESULTS AND DISCUSSION

Growth parameters

At the final picking the tallest plants (75.98 and 76.13 cm for low fertility and high fertility areas respectively) were produced with site specific drip fertigation providing daily drip irrigation. This was comparable to recommended doze drip fertigation with daily drip irrigation, in case of high fertility area. The shorter plants were recorded under manual application of fertilizer at all growth stages for both fertility areas.

The highest values of stem girth for low fertility area were 7.97 cm and 7.64 cm for site specific drip fertigation with daily drip irrigation and alternate day drip irrigation respectively. There was significant difference between the stem girth for recommended dose drip fertigation and site specific drip fertigation in low fertility area. In the high fertility area, highest values of stem girth were on par (7.98 and 7.97 cm) in treatments with recommended dose drip fertigation and site specific drip fertigation with daily drip irrigation.

The dry matter production (DMP) was affected by both irrigation interval and fertilizer levels. Site specific drip fertigation with daily drip irrigation produced the highest quantity of dry matter, ranging from 71.17 Kg/ha at 30 DAP to 5330.25 Kg/ha at final picking in the low fertility area. The values of DMP were lowest for manual fertilizer application with alternate day drip irrigation (66.64 Kg/ha to 5152.50 Kg/ha). In case of high fertility area, there was no significant difference between the highest DMP value at final picking between the treatments with recommended dose drip fertigation and site specific drip fertigation (5306.50 Kg/ha and 5284.25 Kg/ha).

Yield and yield parameters

Fruit length increased with increased rate of fertigation in the low fertility area, whereas no significant increase in fruit length was observed with increased rate of fertilizer application in high fertility area. Highest fruit length of 16.52 cm was recorded for the treatment site specific drip fertigation and daily drip irrigation in case of low fertility area followed by 15.93 cm for site specific drip fertigation with alternate day drip irrigation. The lowest fruit length was observed for the treatment with manual fertilizer application and alternate day drip irrigation.

In case of low fertility area, the highest fruit girth was recorded under the treatment site specific drip fertigation providing daily drip irrigation and was 5.27 cm and the lowest value was 4.19 cm for the treatment with manual fertilizer application and alternate day drip irrigation. In case of high fertility area there was no significant difference in fruit girth along with variation in dose of applied fertilizer. Highest fruit girth was noted for the treatment with site specific drip fertigation providing daily drip irrigation through drip.

Weight of fruit varied directly with the rate of fertilizer applied in case of low fertility area, whereas there was no significant effect of applied fertilizer on fruit weight in case of high fertility area. The method of fertilizer application had significant effect on fruit weight in high fertility area. The total green fruit yield plant^{-1} recorded with site specific drip fertigation along with daily drip irrigation for low fertility area was 1183.619 g plant^{-1}, which was comparable with that for site specific drip fertigation and recommended dose drip fertigation providing daily drip irrigation for high fertility area (1191.380 and 1191.936 g plant^{-1} respectively).

There was a significant difference in total green fruit yield owing to different moisture regimes by different intervals of drip irrigation in both fertility areas. The highest total green fruit yield (25.493 t/ ha) was recorded under the treatment site specific drip fertigation with daily drip irrigation for low fertility area, whereas there was no significant difference between the total yield under the treatments *viz.* site specific drip fertigation and recommended dose drip fertigation along with daily drip irrigation for high fertility area (25.66 and 25.672 t/ha respectively).

Water use studies

Though the water use efficiency values were generally high for high fertility area, the highest water use efficiency was obtained under the treatment site specific drip fertigation with daily drip irrigation under low fertility area (60.35 Kg/ha/mm), followed by site specific drip fertigation with alternate day drip irrigation (55.75 Kg/ha/mm). The increase in water use efficiency with fertilizer applied in the low fertility area might be attributed to effective utilization of fertilizer along with water. The water use efficiency values for high fertility area varied from 55.69 to 50.04 Kg/ha/mm for recommended dose drip fertigation with daily drip irrigation and manual fertilizer application with alternate day drip irrigation respectively. The results indicated that the water use efficiency varied with fertilizer applied and irrigation interval in case of low fertility area, whereas it varied with irrigation interval in high fertility area. The increase in water use efficiency with fertilizer applied in the low fertility area might be attributed to effective utilization of fertilizer along with water.

Soil moisture distribution

Soil moisture content estimated by gravimetric method before irrigation and 30 minutes after irrigation for both the test plots are given in Table 2 to 5. This observation was done at 14 continuous irrigation cycles during non-rainy days, throughout the crop growth period. The mean values were calculated and expressed in per cent of soil moisture. The soil moisture distribution pattern for each treatment was plotted using the software "SURFER 7.0" and from the results it was seen that moisture distribution pattern was similar, in both the fertility areas.

The moisture content before irrigation increased from 0 – 15 depth to 15 – 30 cm depth, whereas the same was reduced with the radial distance from the emitter, in all the treatments. This is due to the reason that as time passes on after irrigation, the amount of water evaporated from the surface and the amount of water percolated down to the root zone increases. The values of moisture content for treatments with alternate day drip irrigation were less than that for treatments with daily drip irrigation. This is due to the reason that when irrigation is given once in 2 days, more moisture is depleted from the soil before next irrigation, whereas in other treatments daily drip irrigation was given. The moisture content values for high fertility area were slightly lesser than that of low fertility area in all the treatments. This may be due to the reason that the high fertility area has a field capacity value slightly less than the low fertility area.

Table 2. Moisture distribution (%) in the low fertility area before irrigation

Depth (cm)	0 - 15				15 - 30				30 - 45			
Distance from emitter (cm)	0	15	30	45	0	15	30	45	0	15	30	45
T1	22.71	22.28	21.68	20.81	22.57	22.61	22.74	21.04	22.32	21.71	21.08	20.62
T2	22.36	21.96	21.12	20.61	22.47	22.29	21.39	20.72	22.02	21.41	20.75	20.27
T3	22.76	22.21	21.61	20.85	22.52	22.65	22.79	21.09	22.38	21.79	21.01	20.68
T4	22.27	21.84	21.25	20.72	22.54	22.34	21.49	20.81	22.15	21.52	20.93	20.34
T5	22.70	22.21	21.61	20.76	22.45	22.54	22.65	21.06	22.27	21.64	21.05	20.64
T6	22.20	21.81	21.22	20.70	22.51	22.32	21.45	20.80	22.12	21.51	20.89	20.36

Table 3. Moisture distribution (%) in the low fertility area 30 minutes after irrigation

Depth (cm)	0 - 15				15 - 30				30 - 45			
Distance from emitter (cm)	0	15	30	45	0	15	30	45	0	15	30	45
T1	23.01	22.58	22.06	21.98	23.07	23.04	22.52	22.43	21.79	21.68	21.43	21.32
T2	23.13	22.70	22.18	22.10	23.19	23.16	22.64	22.55	21.91	21.80	21.55	21.44
T3	23.09	22.52	22.09	21.94	23.09	23.08	22.56	22.47	21.72	21.65	21.48	21.36
T4	23.16	22.72	22.15	22.14	23.15	23.19	22.68	22.58	21.94	21.83	21.58	21.47
T5	22.98	22.58	22.01	21.90	23.01	23.09	22.48	22.49	21.81	21.72	21.47	21.38
T6	23.10	22.68	22.11	22.19	23.13	23.12	22.65	22.61	21.97	21.86	21.51	21.49

Table 4. Moisture distribution (%) in the high fertility area before irrigation

Depth (cm)	0 - 15				15 - 30				30 - 45			
Distance from emitter (cm)	0	15	30	45	0	15	30	45	0	15	30	45
T1	22.37	21.94	21.34	20.47	22.23	22.27	22.40	20.70	21.98	21.37	20.74	20.28
T2	22.02	21.62	20.78	20.27	22.13	21.95	21.05	20.38	21.68	21.07	20.41	19.93
T3	22.42	21.87	21.27	20.51	22.18	22.31	22.45	20.75	22.04	21.45	20.67	20.34
T4	21.93	21.50	20.91	20.38	22.20	22.00	21.15	20.47	21.81	21.18	20.59	20.00
T5	22.47	21.92	21.32	20.56	22.23	22.34	22.49	20.78	22.09	21.48	20.69	20.38
T6	22.13	21.72	21.10	20.56	22.41	22.22	21.37	20.69	22.03	21.36	20.76	20.22

Table 5. Moisture distribution (%) in the high fertility area 30 minutes after irrigation

Depth (cm)	0 - 15				15 - 30				30 - 45			
Distance from emitter (cm)	0	15	30	45	0	15	30	45	0	15	30	45
T1	22.67	22.24	21.72	21.64	22.73	22.70	22.18	22.09	21.45	21.34	21.09	20.98
T2	22.78	22.35	21.83	21.75	22.84	22.81	22.29	22.20	21.56	21.45	21.20	21.09
T3	22.76	22.19	21.76	21.61	22.76	22.75	22.23	22.14	21.39	21.32	21.15	21.03
T4	22.81	22.37	21.80	21.79	22.80	22.84	22.33	22.23	21.59	21.48	21.23	21.12
T5	22.65	22.25	21.68	21.57	22.68	22.76	22.15	22.16	21.48	21.39	21.14	21.05
T6	22.76	22.34	21.77	21.85	22.79	22.78	22.31	22.27	21.63	21.52	21.17	21.15

The soil moisture content was always higher below the soil depth of 15 – 30 cm, which may be due to the reason that, the root spread might have been restricted up to 30 cm depth for extracting its moisture requirement.

Economics

The Data on the economics of drip irrigation for chilli in one hectare are presented in Table 6 and 7. The life span of drip system varies from 6 to 10 years depending upon quality and maintenance of drip system. Hence a normal life span of 6 years was considered for computation.

Table 6. Cost Economics of site specific drip fertigation for chilli in 1 ha for low fertility area

Sl. No.	Description	Treatments					
		T1	T2	T3	T4	T5	T6
1	Fixed cost (Rs) Life (Years) Annual cost (Rs) Interest @ 8% (Rs) Repair and maintenance (Rs) Total Cost (Rs) **(A)**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**
2	Cost of cultivation, (Rs/ha) **(B)**	61005	60505	61243	60743	61805	61305
3	Seasonal total cost (Rs) **(C = A+B)**	**84784**	**84284**	**85022**	**84522**	**85584**	**85084**
4	Yield produced (t/ha)	22.859	21.902	25.709	23.750	20.861	20.277
5	Selling price (Rs/t)	8000	8000	8000	8000	8000	8000
6	Income from produce (Rs) **(D)**	**182872**	**175216**	**205672**	**190000**	**166888**	**162216**
7	Net seasonal income (Rs) **E = (D – C)**	98088	90932	120650	105478	81304	77132
8	Benefit – Cost ratio **F = (D/C)**	**2.16**	**2.08**	**2.42**	**2.25**	**1.95**	**1.91**

The Benefit – Cost Ratio (BCR) values worked for various treatments show that in case of low fertility area, highest BCR was recorded with the treatment site specific drip fertigation and daily drip irrigation (2.42) followed by the treatment with site specific drip fertigation and alternate day drip irrigation (2.25). The lowest BCR was recorded under the treatment with manual application of fertilizer and alternate day drip irrigation (1.91).

Table 7. Cost Economics of site specific drip fertigation for chilli in 1 ha for high fertility area

Sl. No.	Description	Treatments					
		T1	T2	T3	T4	T5	T6
1	Fixed cost (Rs) Life (Years) Annual cost (Rs) Interest @ 8% (Rs) Repair and maintenance (Rs) Total Cost (Rs) **(A)**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**	90788 6 15131 7263 1385 **23779**
2	Cost of cultivation, (Rs/ha) **(B)**	61005	60505	59212	58712	61805	61305
3	Seasonal total cost (Rs) **(C = A+B)**	**84784**	**84284**	**82991**	**82491**	**85584**	**85084**
4	Yield produced (t/ha)	25.672	24.993	25.660	24.980	23.772	23.068
5	Selling price (Rs/t)	8000	8000	8000	8000	8000	8000
6	Income from produce (Rs) **(D)**	**205376**	**199944**	**205280**	**199840**	**190176**	**184544**
7	Net seasonal income (Rs) **E = (D – C)**	120592	115660	122289	117349	104592	99460
8	Benefit – Cost ratio **F = (D/C)**	**2.42**	**2.37**	**2.47**	**2.43**	**2.22**	**2.17**

In case of high fertility area, corresponding values of BCR were 2.47. 2.43 and 2. 17 respectively. In low fertility area, though there was an additional cost of Rs.238.00/ha for fertilizer in the treatment with site specific drip fertigation and daily drip irrigation when compared with recommended dose drip fertigation and daily drip irrigation, there was an additional return of Rs. 22800.00/ha by way of increased yield due to site specific drip fertigation. In high fertility area, the impact of site specific drip fertigation was by way of savings in fertilizer cost. In the present experiment it was observed that an amount of Rs. 1793.00/ha could be saved due to fertilizer saving in the treatment with site specific drip fertigation and daily drip irrigation, when compared with the treatment recommended dose drip fertigation and daily drip irrigation, though the difference in yield among these two treatments were only Rs.96.00/ha.

CONCLUSION

Fertilizer recommendations are to be made based on the existing fertility status of the fields, rather than going for blanket recommendations for all the fields. Adoption of site specific drip fertigation with daily drip irrigation in hybrid chilli is a viable proposition for the farmers who aim for greater income benefits utilizing optimal inputs. Site specific drip fertigation with daily drip irrigation would be an ideal practice to achieve greater income from unit land area. Site specific drip fertigation with daily drip irrigation would be an ideal practice to achieve greater yield, greater net income and higher benefit – cost ratio from unit land, compared to recommended dose drip fertigation, irrespective of the fertility status of the field.

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Effect of Various Riser Heights and Pressures on the Performance of Raingun Irrigation System

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ABSTRACT

Efficient utilization of the water resources is need of the time. Numbers of advanced irrigation technologies areused in the field according to various crops and soils. Raingun is one of the best irrigation technique for different crops viz. cereals, pulses, fodder, sugarcane and landscape gardening. Besides irrigation, it is used for dust suppression and fire protection.The medium range rain gun having operating pressure 1to3 kg.cm^{-2}, radius of throw 15to20 m and discharge of 1to3 LPS was tested for various riser heights and pressures.The pressure discharge relation revealed the raingun exponent of 0.44 having turbulent flow. The discharge of raingun varied between 0.81to1.23 LPS as pressure increased from 1to3per centkg. cm^{-2}.The maximum uniformity coefficient was 80.5 percent at pressure of 3 kg. cm^{-2}and riser height of 2.5m. The minimum uniformity coefficient was 66per cent at pressure of 1.5 kg. cm^{-2}and riser height of2.0m.Distribution uniformity was maximumat 1.5kg.cm^{-2}pressure followed by 2 kg.cm^{-2}. The minimum DU was in 3 kg.cm^{-}2pressure.Maximum Distribution characteristic value of 27 percent was under 3 kg.cm^{-2} pressure, 2.5 m riser height and minimum of 25 per cent at 1.5 mriser height respectively.The maximum radius of coverage was18.5 mat riser height of 2.5m and pressure of 3kg.cm^{-2}. The minimum radius of coverage of raingun was 7.2 m found at riser height of 2.0m and pressure of 1.5kg.cm^{-2}. There was no considerable increase in the radius of coverage beyond 3 kg.cm^{-2}pressure.

INTRODUCTION

Swing arm (impact type) and water turbine (gear type) raingunsare getting popularity among the farmers. They are usually mounted on three to four-leg stands, sledges or wheeled carriages, which can be adapted to suit the various furrow and row spacing and crop heights.Being the new irrigation technology, it was essential to evaluate the pressure –discharge relationship, radius of coverage, application rate, uniformitycoefficient, distribution uniformity and distribution characteristic regarding the raingun.Now days advanced crops, soils, irrigation and fertigation management techniques were developed today. Large as well asmarginal farmers were shifting their mindset for cultivating different crops like close growing vegetables, cash crops, plantation crops, orchards&gardening on raingun.So that it was need of time to study different parameters regarding raingun system and recommend them to farmers for efficient usages.The study shows crop yield of wheat under raingun sprinkler irrigation was 27 percent higher as compared to the border irrigation method in addition to water saving of 41per cent. The benefit cost ratio was found to be 1.98*(Anwar et. al.2004)***.**The flexibility of present-day sprinkle equipment and its efficient control of water application makethe method's usefulness on most topographic conditionssubject to limitations imposed by land use capability and economics.

MATERIAL AND METHODS

The experiment was carried out at the Instructional Farm, Department of the Irrigation and Drainage Engineering, C.A.E.T., Dapoli. The medium range raingun having operating pressure 1to3 kg.cm-^{2}, radius of throw 15 to 20 m and discharge of 1 to 3 LPS was mounted on the 4-leg stand.The nozzle size used for study was 8mm diameter. Pressure gauge was installed to measure the inlet pressure. Central pivot G.I pipe of stand was movable to adjust the height of the raingun. Catch cans of 1 liter capacity were used for determining precipitation rate. Required discharge and pressure was developed by using electric pump of 5 H.P.The experimental set up consist of source of water, filtering unit, flow control valve, non-return valve, Air release valve, pipe line and other accessories.

Pressure discharge relationship

The raingun was operated at 1.5, 2.0, 2.5 and 3.0 kg.cm-2 pressure and discharge at each pressure was recorded. The pressure discharge relation revealed(table1) the raingun exponent of 0.44 having turbulent flow. The discharge of raingun varied between 0.81 to 1.23 LPS as pressure increased from 1 to 3per centkg. cm^{-2}

Uniformity coefficient

The catch cans were placed in square grid pattern at spacing 2 m x 2m over the area covered by the raingun. The system was operated for half an hour and collected water was measured by using measuring cylinder. The equation given by Christiansen (1942) was used for determination uniformity coefficient.

$$Cu = 100\left(1 - \frac{\Sigma X}{nm}\right) \qquad (1)$$

Where,

Cu = Uniformity coefficient, per cent

m = Average value of all observation, mm

n = Number of observations,

X = Deviation of individual observations from mean

Distribution uniformity

It indicates the degree to which water is applied uniformlyover the field. The following was relationship used.

$$DU = \frac{\text{Average low quarter discharge of water caught}}{\text{Average discharge of water caught}} \qquad (2)$$

Distribution characteristics

The distribution characteristics explain the amount of area getting irrigation more than average depth. It might tend to over irrigation of certain area.

$$DC = \frac{\text{Area receiving more than average depth}}{\text{Total wetted area}} \qquad (3)$$

Radius of coverage

The theoretical radius of coverage was determined by using Cavaza's equation. The radius of coverage for different pressures and riser heights were measured by using measuring tape

$$R = 1.35\sqrt{dh} \qquad (4)$$

Where,

R = radius of coverage, m

d = diameter of nozzle, mm

h = operating head,m

Discharge of raingun

The discharge for different pressures and riser heights were measured by using Hose pipe attached to the nozzle of the raingun.

RESULTS AND DISCUSSION

Pressure- Discharge Relationship

Raingun was operated at different pressures viz., 1.5, 2.0, 2.5, 3.0 kg.cm-^{2}and corresponding discharge through raingun were measured to develop the pressure- discharge relationship. The observed discharges at different pressures are given in Table 1. The discharge through raingun increases with increase in pressure.

Table 1. Pressure-Discharge relationship for medium range raingun

Operating pressure kg.cm-2	Average observed discharge, lit.sec-1	Given exponent	Observed exponent
1.5	0.81	0.50	0.44
2.0	0.90		
2.5	0.95		
3.0	1.23		

The pressure and discharge relationship was linear showing increase in pressure increases the discharge of raingun. The discharge coefficient was found to be 24.11 and exponent was 0.44 indicating turbulent flow in the system. The developed equation is as fallows

$$y = 24.111x^{0.44} \quad (5)$$

Where,

y = Discharge,lit. sec^{-1} (Ranjha A.Y.,1988)

x = Head, m

Uniformity coefficient for medium range raingun

Uniformity coefficient is the measurable index to measure the degree of the uniformity of any sprinkler. The uniformity coefficient was determined from volume of water collected into catch cans atdifferent pressures. Christensen's equationwas used to compute the uniformity coefficient. The uniformity coefficient values for raingun at different pressures are presented in Table 2.

Table 2. Uniformity coefficient for medium range raingun

Operating pressure, kg.cm-2	Average uniformity coefficient at various riser height, per cent		
	1.5m	2.0m	2.5m
1.5	66.0	70.0	76.50
2	70.0	73.33	79.0
2.5	72.0	75.0	80.0
3	73.0	75.2	80.5

The uniformity coefficient values for medium range raingunat different pressures and riser heights were observed in range of 66to 80.5per cent.(*Ahmad et.al.,1992*) The results revealed that the uniformity coefficient increases up to 3.0kg.cm^{-2}and reduces beyond. Similarly, the uniformity reduces beyond 2.5 m riser height. The maximum uniformity coefficient was 80.5 at 3.0kg.cm^{-2}and riser height of 2.5m pressure and minimum was 66.00per cent at 1.5kg.cm^{-2}pressures*(Li.j.,et.al.,2001)* respectively.

Distribution uniformity (DU)

Distribution uniformity with an increased operating pressure was calculated by equation 2. The average distribution uniformity for medium range raingunwasshown in Table 3. Distribution uniformity was maximum at 1.5kg.cm^{-2}pressure followed by 2 kg.cm^{-2}. The minimum DU was in 3 kg.cm^{-2}pressure. The distribution uniformity at riser height 1.5m indicates 16.0 per cent area was getting irrigation up to average depth and remaining84.0 per cent was getting less than average (Irrigation Equipment.,1991). Similarly, under riser height 2.5 m and pressure of 3.0kg.cm$^{-2,}$64.25 per cent area was getting irrigation up to average depth and remaining 35.75 per cent was getting less than average. It indicates area to be irrigated up to average depth. It will help to adjust irrigation time, so that all area can be irrigated up to average depth.The increase in the pressure and riser height increases the distribution uniformity.

Table 3. Distribution uniformity for medium range raingun

Operating pressure, kg.cm-2	**Average Distribution uniformity at various riser height, per cent**		
	1.5m	**2.0m**	**2.5m**
1.5	84.0	37.0	35.75
2	50.0	76.0	46.74
2.5	60.0	77.0	74.0
3	50.0	72.0	35.75

Distribution Characteristic (DC)

The data regarding distribution characteristic was collected and analyzed by equation3 is represented in Table 4. The results show that distribution characteristic increases with increase in pressure marginally. It indicates the area receiving more than average depth of irrigation increases with pressure up to 3.0.kg.cm^{-2}and riser height up to 2.5m respectively. Table 4 shows maximum DC value of 27 per cent was under 3 kg.cm^{-2} pressure, 2.5 m riser height and minimum of 25 per cent at 1.5 mriser height respectively.

Table 4. Distribution characteristic for medium range raingun

Operating pressure, kg.cm^{-2}	**Average Distribution characteristic at various riser height, per cent**		
	1.5m	**2.0m**	**2.5m**
1.5	25.0	26.0	25.0
2	25.10	26.10	26.0
2.5	25.99	26.51	26.50
3	26.0	26.90	27.0

Radius of coverage

The radius covered by raingun at various pressures and riser heights were presented in table 5. The results show that the increase in the pressure increases radius up to 2.5 kg.cm^{-2}and reduces beyond 3kg.cm^{-2}. The radius of coverage increases with increase in the riser height. The maximum coverage of 18.5m was found at3 kg.cm^{-2} pressure and riser height of 2.5m. The minimum was at 1.5 kg.cm-2pressure and riser height of 1.5m. Theresult shows that the increase in the pressure and riser height increases the radius of coverage.

Table 5. Radius of coverage for medium range raingun

Operating pressure, kg.cm^{-2}	**Radius of coverage at various riser height, per cent**		
	1.5m	**2.0m**	**2.5m**
3	15.6	16.9	18.5
2.5	14.5	15.8	17.5
2.0	13.8	15.3	17.0
1.5	12.1	15.0	16.0

CONCLUSIONS

- The pressure of 3 kg.cm^{-2} and riser height of 2.5m gives maximum uniformity coefficient for medium range raingun.
- The distribution uniformity reduces with increase in pressure and riser height.
- The distribution characteristic was nearly same throughout study.
- The study concludes that operating medium range raingun at 3kg.cm^{-2}and riser height of 2.5m was most efficient combination for good performance.

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Effect of different Irrigation Methods and Fertigation Levels on Growth and Quality Attributes of Sweet Orange (*Citrus Sinesis*)

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ABSTRACT

The quality aspects studied under the field experiment on sweet orange under different irrigation methods and fertigation levels carried out at All India Co-ordinated Research Project on Water Management, V.N.M.K.V. Parbhani during the period of 21st June 2011 to 15th May 2012,. The main treatments were three irrigation levels viz. Online double lateral drip irrigation system (I_1), Inline lateral ring drip irrigation system (I_2) and Online double lateral drip irrigation system supported by check basin irrigation system (I_3) and four sub treatment viz. 100% recommended dose of fertilizer through drip (F_1), 75% recommended dose of fertilizer through drip (F_2), 50% recommended dose of fertilizer through drip (F_3), and 100% recommended dose of fertilizer through soil application (F_4). Irrigation water was applied through drip irrigation system on the basis Class A pan evaporation data (100% ET). From the results, it was revealed I_2F_1 recorded highest length/ breadth ratio (1.00 to 1.022) and yield of sweet orange. The treatment I_2F_2 recorded maximum weight and average volume of fruit followed by treatment I_2F_4. Amongst the irrigation treatment maximum total soluble solid and ascorbic acid was recorded in treatment I_3 followed by I_2, whereas the fertigation treatments F_1 recorded the significantly superior total dissolved solids in the fruit (8.60 brix$^{\circ}$) followed by treatment F_4. It was revealed that treatment (I_2F_1) was found superior over all other treatment combinations.

Keywords: Water use efficiency, Fertigation use efficiency, Total dissolved solid, Ascorbic acid.

INTRODUCTION

Sweet orange is one of the most important commercial fruit crops in Maharashtra. It is scientifically known as *Citrus Sinesis*. It is most delicious and important fruit of trade and export due to its juice and medicinal value. Sweet orange of Maharashtra is famous throughout the country and even abroad. India total area, production of sweet orange (Mosambi) during the period of 2012-13 was 323000 ha, 3520000 Mt respectively. The total fruit area of sweet orange is 5.5% to total fruit area of India (Anonymous 2012-13). In India Sweet orange cultivation leading state is Maharashtra followed by Andhra Pradesh, Punjab, and Karnataka.Micro-irrigation systems are commonly used in citrus orchards throughout the world. There is now a gradual shift in method of irrigation from furrow irrigation–overhead sprinkler irrigation systems to under-tree sprinkling systems like micro-jets (Shirgure *et al.*, 2004). Micro-irrigation systems, viz., drip irrigation, under-tree sprinklers, micro-sprinklers, and micro-jets have been reported to be highly effective in commercial citrus cultivars like Valencia orange (Azzena *et al.*, 1988), Navel orange (Fouche and Bester, 1986), Hamlin orange (Marler and Davis, 1990),. Earlier studies in India comparing drip with flood irrigation in Nagpur mandarin (Shirgure *et al.*, 2003a; Shirgure *et al.*, 2003), sweet orange (Kumar and Bhojappa, 1994), and acid lime (Shirgure *et al.*, 2001c; 2001d and 2003) showed better performance using drip irrigation.Citrus is considered a crop sensitive to water stress, the flowering and fruit-set periods being the most critical phases (Doorembos and Kassam 1979).Domestically sweet orange is widely used for juice consumption. Sweet Orange juice is rich in vitamin C or ascorbic acid. It contains not only appreciable amount of vitamin C but also is good source of vitamin A and B. The juice contains fruit sugars, fruit acid, minerals like calcium, phosphorus, iron and alkaline salt which play role as health promoting ingredients in human diet. The sweet orange crop requires the balanced fertilizers and regular irrigations throughout the year for the high yield and quality fruits. The application of fertilizers (within root zone of soil) into number of split doses is a basic requirement of crop. It is only possible through drip irrigation systems, which will increases the fertilizer use efficiency.

MATERIALS AND METHODS

A field experiment was conducted at field of All India Co-ordinated Research Project on Water Management, V.N.M.K.V. Parbhani during the period of 21st June 2011 to 15th May 2012. The experiment was laid out in split plot design with four replication. The main plot treatments three and subplot treatment four shown in table 2. Under agro climatic conditions of India, Sweet orange blooms twice in year which is termed as Ambia and Mrig bahar. The Mrig bahar of Sweet orange was taken for the study. The soil type of experimental site is fairly uniform, medium black cotton with uniform texture and well drained. The soil moisture constant of experimental plot presented in table 1. The details of the experimental layout presented in table 2 and depicted in figure 1. Drip irrigated treatments were irrigated on alternate day basis considering previous two days evaporation. Irrigation scheduling was performed on 100 % crop evapotranspiration for drip irrigated trees. Irrigation scheduling for surface irrigated trees, plots were irrigated on basis of IW/CPE ratio equals to one. The value of crop coefficient for sweet orange crop was taken as 0.65 during mid-season of February and in late season 0.50 from March to May during investigation period. The value of pan coefficient was taken as 0.7 based on wind velocity, humidity and pan location for Parbhani. Quantity of water required for sweet orange tree in liters per day per tree is calculated using following equation.(Michael1978)

$$Q = \frac{A \times B \times C \times D}{E_u} \tag{1}$$

In which,

Q = Quantity of water required for sweet orange lpd/tree

A = Previous two days evaporation (mm)

B = Crop factor

C = Pan Coefficient (0.7)

D = Gross area per tree, m^2.

E_u = Emission uniformity of drip irrigation system

Table 1. Soil moisture constants of experimental plot

Sr. No.	Particulars	Observation for (0-60) cm depth
1.	Field capacity	34.0 %
2.	Permanent wilting point	16.2 %
3.	Apparent specific gravity	1.31 gram/cc

Table 2. Details of layout

Sr. No.	Particulars	Perticulars Details.
1.	Crop	Sweet orange
2.	Scientific name	citrus sinesis
3.	Variety	Nucellar
4.	Tree to tree spacing	5 m x 5 m
5.	Statistical design	Split plot design
6.	Main treatments	Three
7.	Sub treatments	Four
8.	Number of replications	Three
9.	Total number of trees	276
10	No. of trees under each treatment combination	23
11	Recommended dose of fertilizers (RDF)	800:400:400 gm/tree (NPK)

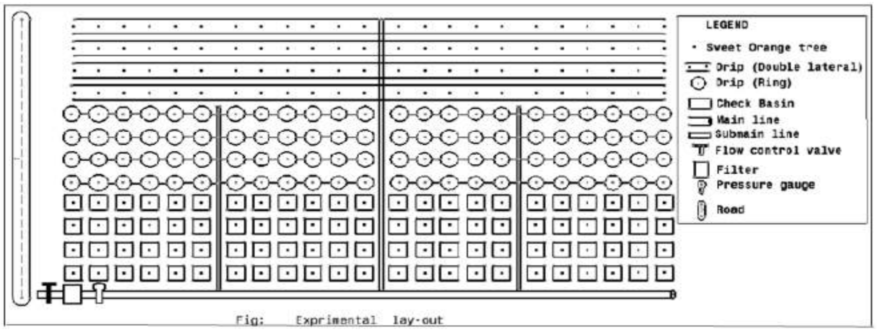

Figure 1. Layout of sweet orange tree

Biometric Observations

Following observations were recorded.

Height : Height measured from soil surface to top of tree.

Spread : Spread was measured in North-South and East-West.

Canopy : Canopy of tree was calculated by using the following equation (Watson, 1952).

$$\text{Canopy} = \left(\frac{H}{4}\right)^3 \tag{2}$$

Where,

H = EW + NS, m

EW = East-West spread of tree, m

NS = North-South spread of tree,

Irrigation water use efficiency: Irrigation water use efficiency is the ratio of crop yield to the amount of irrigation water applied to the tree. It is computed by using the following equation (Michael 1978).

$$E_{UI} = \frac{Y}{WR} \tag{3}$$

In which,

E_{UI} = Irrigation water use efficiency, q/ha-cm

Y = crop yield, q

WR = Water requirement, ha-cm

Fertilizer use efficiency

Fertilizer use efficiency is the ratio of crop yield to the amount of fertilizer applied to the trees. It is computed by using the following equation (Michael 1978).

$$E_{Uf} = \frac{Y}{FR} \tag{4}$$

In which,

E_{uf} = Fertilizer use efficiency, q/ha

Y = crop yield, q

FR = Fertilizer requirement, q/ha

RESULTS AND DISCUSSION

It was revealed that irrigation method I_2 recorded maximum average tree height (4.05 m), canopy (8.45 m^3), average number of fruits (543) and yield (117.56 kg per tree) represented in table 3. The interaction effect was found that treatment combination I_2F_1 recorded significantly maximum tree height (4.5 m), canopy (9.24 m^3), average number of fruits (828.00) and yield of sweet orange (174 kg per tree). In quality aspect of sweet orange revealed that irrigation method I_2 recorded maximum average no of fruits (543) , weight of fruit (224.21 kg per tree) , yield of sweet orange (117 kg per tree), volume of fruit (260.42 ml) , length and breadth of fruit (8.015), total soluble solid (8.25 brixs°) and ascorbic acid (44.96 mm per 100 gm). Whereas fertigation treatment F_1 recorded maximum average no of fruits (735), yield of sweet orange (146.42 kg per tree) , length and breadth of fruit (1.022 mm), total soluble solid (8.60 brixs°) and ascorbic acid (44.96 mm per 100 gm). Fertigation treatment F_2 recorded maximum average weight of fruit (225.05 kg per tree), volume of fruit (249.90 ml) and ascorbic acid (46.50 mm per 100 gm). In the treatment combination I_2F_1 recorded maximum no of fruits (828.00) and yield (174 kg per tree) followed by I_1F_1, I_2F_1. In the treatment combination I_2F_4 recorded maximum no weight of fruit (240) and volume of fruit (320 ml) followed by I_1F_2. Length breadth ratio of sweet orange as influenced by different treatment combination was recorded maximum in I_2F_1 (1.04) followed by I_3F_1, I_2F_1. Total soluble solids was highest amongst the treatment combination I_3F_1 (9.0 °brixs) followed by I_3F_4 (8.7 brixs°), I_2F_1 (8.5° brixs). Whereas ascorbic acid content recorded maximum in treatment combination I_1F_1 (48.4 mg per 100 gm.) followed by I_1F_2 (48.2 mg per 100 gm), I_1F_4 (.47.8 mg per 100 gm.).

Table 3. Physical and quality characteristic of Sweet Orange

Irrigation Treatment	Height (m)	Canopy (m^3)	Avg. no of fruits per tree	Weight of fruit (gm)	L/B ratio	Vol. of fruit (cc)	TSS (brix°)	Ascorbic acid content of Sweet orange (mg/100 gm)	Yield of sweet orange (kg/tree)
I_1	3.88	7.87	475	211.24	8.012	260.11	7.77	47.42	94.00
I_2	4.05	8.45	543	224.21	8.015	260.42	8.25	44.96	117.56
I_3	4.05	8.07	432	212.34	8.014	230.80	8.45	44.12	88.25
S.E. ±	0.146	0.22	42.31	4.76	0.0044	7.85	0.16	0.25	8.79
C.D. at 5%	0.404	0.63				21.73	0.46	0.70	
F test	NS	Sig	NS	NS	NS	Sig.	Sig.	Sig.	N.sig.
Fetigation									
F_1	4.40	8.66	735	203.47	1.022	238.77	8.60	45.70	146.42
F_2	4.02	8.24	548	225.05	1.019	249.90	8.13	46.50	116.17
F_3	3.70	8.02	336	219.07	1.011	251.71	7.62	43.46	69.75
F_4	3.86	7.80	313	216.12	1.000	261.40	8.26	46.26	67.41
S.E. ±	0.168	0.26	48.45	5.49	0.005	9.06	0.19	0.29	10.15
C.D. at 5%	0.466	0.73	135.00		0.014		0.53	0.81	28.10
F test	Sig.	Sig	Sig.	NS	Sig.	NS	Sig.	Sig.	Sig.
I×F									
S.E. ±	0.292	0.459	84.62	9.52	0.008	15.70	0.33	0.51	17.51
C.D.at 5%	0.808	1.27		26.34		43.47			
F test	Sig.	N.S.	N.sig.	Sig.	NS	Sig.	N.S.	NS	NS
C.V.	14.60	7.87	15.00	8.81	8.73	8.25	8.25		15.20

Water use efficiency*:* The water use efficiency using equation 3 and result are tabulated as given below in figure 2. It was revealed that the irrigation treatment I_2 recorded the highest water use efficiency followed I_1 and I_3.

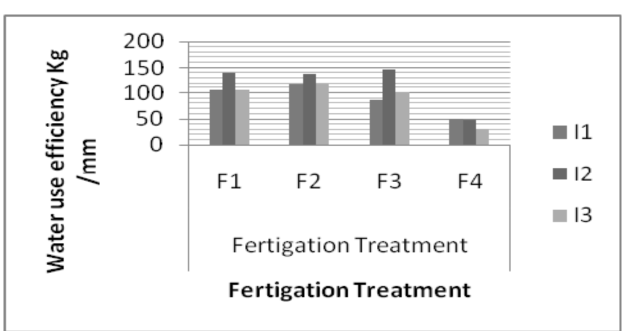

Figure 2. Water use efficiencies (Kg/mm water use)

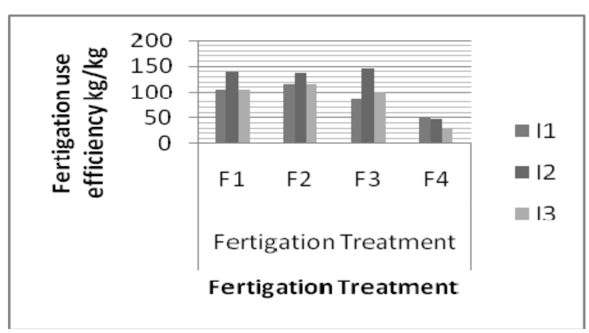

Figure 3. Fertilizer use efficiencies (Kg/Kg)

Fertilizer use efficiency: The fertilizer use efficiency of different treatments using equation 4, the results are presented in figure 3.

SUMMARY AND CONCLUSION

Highest yield recorded under inline lateral ring drip irrigation system, quality of fruit, highest water use efficiency, fertilizer use efficiency. It is also advocated to the farmers that to irrigate the sweet orange trees for getting quality fruits and highest yield, use Inline lateral ring drip irrigation system (4lph emitters placed at a distance of 60 cm with ring of three meter periphery) on the basis of 100 % ET, and apply the fertilizer dose of 100 % per cent of RDF through drip irrigation system for highest benefit.

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Study on Soil Moisture Distribution Pattern under Online Double Lateral and Inline Lateral Ring Drip Irrigation System of Sweet Orange

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ABSTRACT

An experiment on sweet orange under different irrigation methods and fertigation levels was conducted at field of All India Co-ordinated Research Project on Water Management, V.N.M.K.V. Parbhani during the period of 21st June 2011 to 15th May 2012. The main treatments were three irrigation levels viz. Online double lateral drip irrigation system (I_1), Inline lateral ring drip irrigation system (I_2) and Online double lateral drip irrigation system supported by check basin irrigation system (I_3). The overall moisture extraction after 24 hrs of irrigation was recorded 1.27 to 2.96 %, 1.28 to 3.4% and 1.79 to 4.93 % from the depth of soil layer 15, 30, and 45 cm respectively. It was revealed that Inline lateral ring moisture extraction percentage was 2.73 to 3.75 %, 2.4 to 4.46 % & 3.1 to 6.99 % from the soil layer of 15 cm, 30 cm and 45 cm from ground surface. Under inline lateral ring drip irrigation system at a distance of 30 cm to 90 cm distance from tree trunk, the uniform moisture was found to the tune of 32 to 35 % at a depth of 15 cm and 29 to 31 % at 30 cm soil layer depth and 28 to 29 % at 45 cm soil layer depth in circular manner around the tree.

Keywords: Moisture content (%), Online double lateral, Inline lateral ring, 8 and 4 lph emitter.

INTRODUCTION

Sweet orange is one of the most important commercial fruit crops in Maharashtra. It is scientifically known as *Citrus Sinesis*. It is most delicious and important fruit of trade and export due to its juice and medicinal value. Sweet orange of Maharashtra is famous throughout the country and even abroad. India total area, production of sweet orange (Mosambi) during the period of 2012-13 was 323000 ha, 3520000 Mt respectively. The total fruit area of sweet orange is 5.5% to total fruit area of India (Anonymous 2012-13). In India Sweet orange cultivation leading state is Maharashtra followed by Andhra Pradesh, Punjab, and Karnataka. The effect of different discharge rates of drippers on moisture distribution in soil. The soil moisture contours in terms of per cent moisture content for horizontal and vertical movement of water was drawn. They concluded that the water at higher discharge saturate the soil near the dripper. Lower application rate penetrated at higher depth due to more availability of time for infiltration (Goel *et. al.,* (1993)). The relationship between infiltration rate and some textural soil properties. Among the structural variable effective porosity shows strong highly significant correlation with infiltration rate (Helalia *et.al.,* (1993)). The soil moisture is directly effects on the crop growth and crop yield which respond to extent of wetted root zone, control of salinity and weed growth. It also determines the horizontal as well as vertical movement of water from point source of application at various locations around the root zone of crop. The wetting pattern of a loamy soil under trickle irrigation with different discharge. They found that in region where drip irrigation is recently used in field crop, wetting front advance knowledge is very important. It helps to design the drip irrigation system network wetted radius and width useful for optimum line spacing and dripper spacing whereas vertical wetting front advance was useful to determine calculation of optimum time application to prevent deep percolation of water and fertilizers (Thaber and Zayani (2008)). The growth and yield of sweet orange is greatly influenced by available soil moisture, nutrients, environmental condition and management practices. The location specific information is needed to enhance the productivity of crop. Therefore, it is the need of the day to provide information on choice of proper geometry of drip irrigation method. It has great importance to choose the combination of proper drip irrigation system with appropriate fertilizer level which attains the optimum water and fertilizer use efficiency.

MATERIALS AND METHODS

A field experiment was conducted at field of All India Co-ordinated Research Project on Water Management, V.N.M.K.V. Parbhani during the period of 21^{st} June 2011 to 15^{th} May 2012. The experiment was laid out in split plot design with four replication. The main plot treatments three and subplot treatment four shown in table 2. Under agro climatic conditions of India, Sweet orange blooms twice in year which is termed as Ambia and Mrigbahar. The Mrigbahar of Sweet orange was taken for the study. The soil type of experimental site is fairly uniform, medium black cotton with uniform texture and well drained. The soil moisture constant of experimental plot presented in table 1. The details of the experimental layout presented in table 2 and depicted in fig 1. Drip irrigated treatments were irrigated on alternate day basis considering previous two days evaporation.

Table 1. Soil moisture constants of experimental plot

Sr. No.	Particulars	Observation for (0-60) cm depth
1.	Field capacity	34.0 %
2.	Permanent wilting point	16.2 %
3.	Apparent specific gravity	1.31 gram/cc

Table 2. Details of layout

Sr. No.	Particulars	Particulars Details.
1.	Crop	Sweet orange
2.	Scientific name	*citrus sinesis*
3.	Variety	Nucellar
4.	Tree to tree spacing	5 m x 5 m
5.	Statistical design	Split plot design
6.	Main treatments	Three
7.	Sub treatments	Four
8.	Number of replications	Three
9.	Total number of trees	276
10	No. of trees under each treatment combination	23
11	Recommended dose of fertilizers (RDF)	800:400:400 gm/tree (NPK)

Irrigation scheduling was performed on 100 % crop evapotranspiration for drip irrigated trees. Irrigation scheduling for surface irrigated trees, plots were irrigated on basis of IW/CPE ratio equals to one.

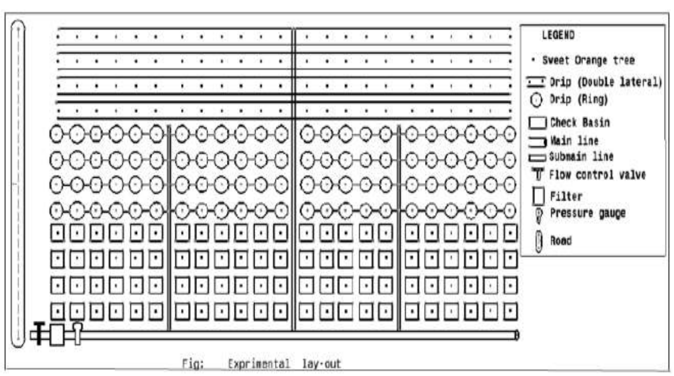

Figure 1. Layout of sweet orange tree

The soil moisture distribution pattern was studied to find out the vertical and horizontal moisture advance with respect to water emission point around the root spread area of trees. Accordingly soil samples were collected by screw augur after 24 hours and 48 hours (i.e. before irrigation of next cycle) in three consecutive irrigation cycle of online double lateral and inline lateral ring drip irrigation System. Soil moisture content was determined by gravimetric method on dry weight basis. The soil moisture contours were drawn by using Surfer, 10 software for interpretation of collected moisture distribution data at depth of 15 cm, 30cm and 45 cm soil layer.

RESULTS AND DISCUSSION

Inline lateral ring moisture distribution pattern: Soil samples collected after 24 hrs of irrigation and 48 hrs of irrigation (i.e. before next irrigation cycle), the average of three soil moisture reading was derived from the data obtain during three consecutive irrigation cycle and depicted in fig. 2, 3, 4, 5, 6 and 7. From figures, it was observed that average soil moisture under inline lateral ring drip irrigation system at depth of 15 cm was recorded in the ranges of 24.70 to 36.15 % where as it was 22.20 to 33.80 % and 20.43 to 31.95 at depth of soil layer 30 cm and 45 cm respectively. Under inline lateral ring drip irrigation system at a distance of 30 cm to 90 cm distance from tree trunk, the uniform moisture was found to the tune of 32 to 35 % at depth of 15 cm and 29 to 31 % at 30 cm soil layer depth and 28 to 29 % at 45 cm soil layer depth in circular manner around the tree. A circular band of 60 cm wide and 45 cm deep was found with the average soil moisture content 28 to 35 %, which is more and uniform wetted zone as compared to online double lateral drip irrigation system. The average soil moisture content recorded after 48 hrs of irrigation is depicted in fig 4, 5 and 6. From the fig, it is observed that after 48 hrs of irrigation (i.e. before start of next irrigation cycle), the soil moisture was found to the range of 21.97 to 32.37 %, 19.80 to 29.34 % and 17.33 to 24.96 % at a depth of soil layer 15, 30 and 45 cm respectively. The moisture extraction percentage was 2.73 to 3.75 %, 2.4 to 4.46 & 3.1 to 6.99 % from the soil layer of 15 cm, 30cm and 45 cm from ground surface. From this, it is revealed that a depth of root zone increase the soil moisture extraction was also more, which was recorded to the tune of 2.73 to 6.99 % with respective the depth.

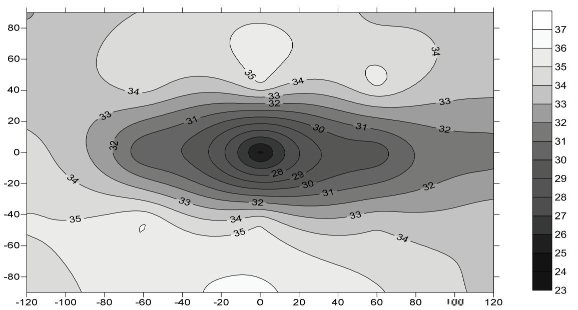

Figure 2. Depth at 15 cm after 24 hrs.

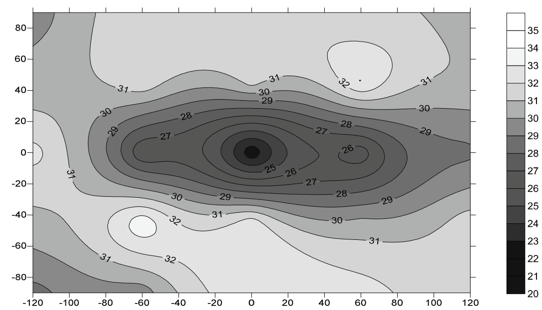

Figure 3. Depth at 30 cm after 24 hrs.

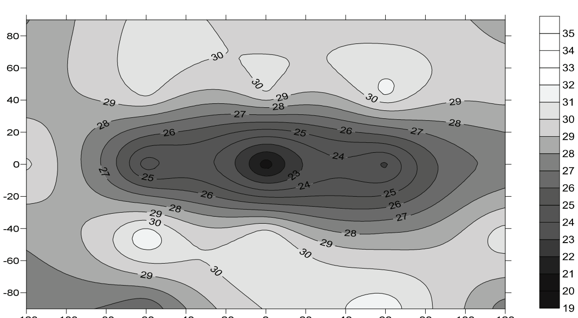

Figure 4. Depth at 45 cm after 24 hrs.

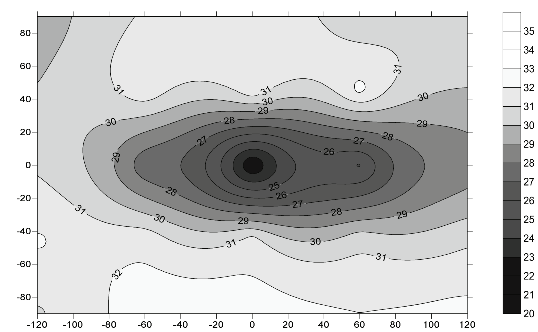

Figure 5. Depth at 15 cm after 48 hrs.

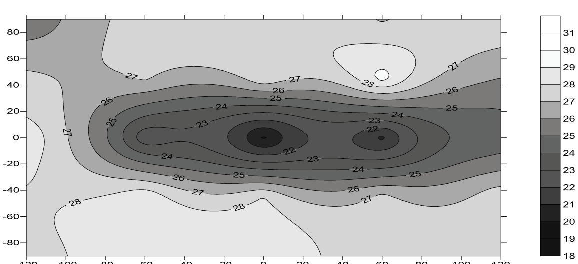

Figure 6. Depth at 30 cm after 48 hrs.

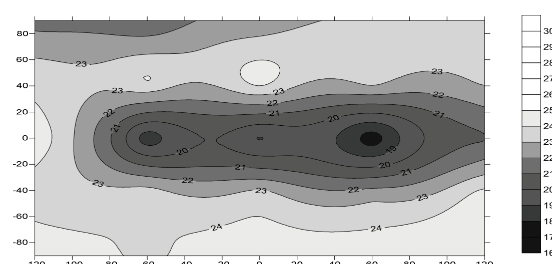

Figure 7. Depth at 45 cm after 48 hrs.

Online double lateral moisture distribution pattern: The laterals of 16 mm diameter were placed on both side of tree at a distance of 60 cm from tree trunk and pressure compensating emitters of 8 lph discharges were placed at a distance of 90 cm on lateral. The 1 kg/cm^2 operating pressure was maintained and pressure and discharge of the system was recorded within allowable limit, the soil samples were collected for recording moisture content along and across the dripper from both the side of lateral . From figure. 8 to 13, it was revealed that the average soil moisture under double lateral drip irrigation system at a depth of 15 cm was recorded to the tune of 22.10 to 34.47 %. From the graph, it is clearly observed that the moisture content decrease away from the dripper. Around the tree trunk, less moisture was recorded up to average distance of 30 cm (grid point 12 to 15), whereas moisture distribution pattern at 15, 30, 45 cm depth was recorded after 24 hrs of irrigation to the tune of 34.47 % to 22.10 %, 30.99 % to 19.80 % and 28.50 % to 18.82 % and after 48 hrs of irrigation to the tune 31.51 % to 23.37 %, 27.59 % to 18.82 % and 23.57 % to 17.03 % which is decreased with respect to increased depth and presented in fig. 1 to 6. At a depth of 45 cm the recorded average minimum moisture was to 50 % moisture depletion to field capacity of soil at effective root network.

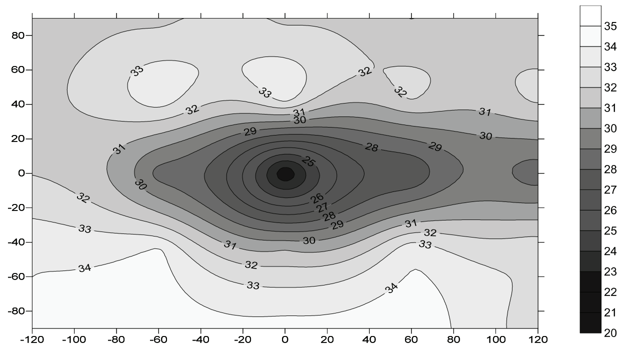

Figure 8. Depth at 15 cm after 24hrs.

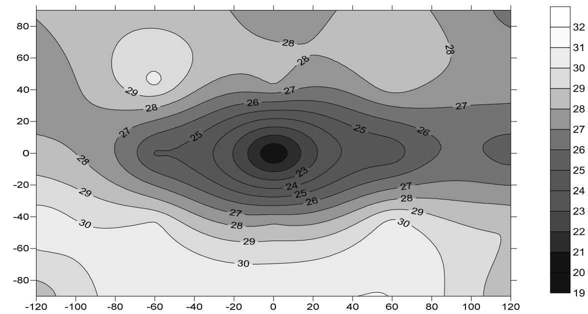

Figure 9. Depth at 30 cm after 24hrs.

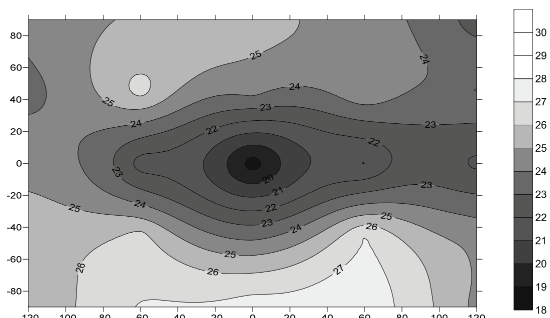

Figure 10. Depth at 45 cm after 24hrs.

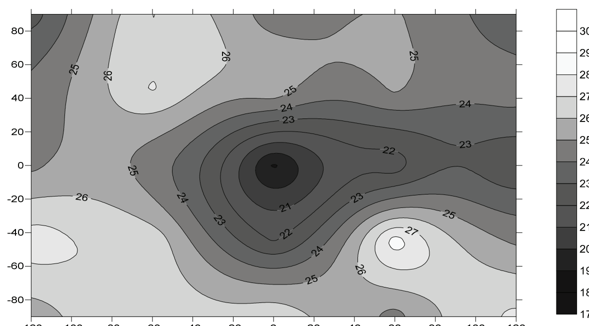

Figure 11. Depth at 15 cm after 48hrs.

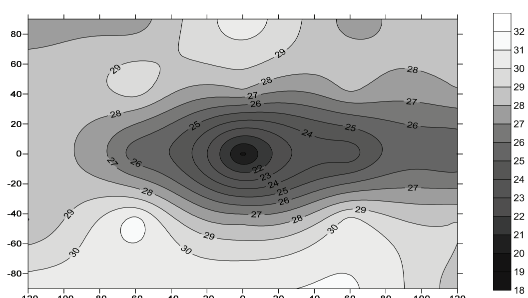

Figure 12. Depth at 30 cm after 48hrs.

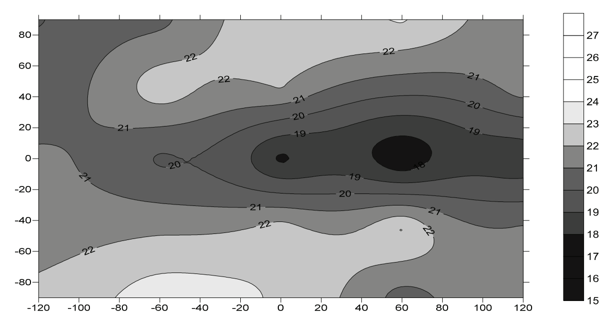

Figure 13. Depth at 45 cm after 48 hrs.

SUMMARY AND CONCLUSION

It is found that uniform moisture was recorded under inline lateral ring drip irrigation system as compared to double lateral drip irrigation system. The soil layer between two laterals (grid plot. 12 to 14) was comparatively less wetted (19.80 to 24.86 %) under double lateral drip irrigation system as compared to inline lateral ring drip irrigation system. The uniform moisture distribution was observed around the tree trunk (28 to 35 %) under inline lateral ring drip irrigation system.

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The Bio-Digester Recycling System: Application of Model Bio-Filter

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ABSTRACT

Microbial communities with a history of being previously exposed to organic matter contamination exhibit a higher potential of biodegradation than communities with no history of such exposure. The process of getting organisms to be adapted to organic matter pollutants includes selective environment. Such treatment encourages the organic matter utilizing organisms and the buildup of their proportion in the methanogenic community. Previous researches in the area of Biotiolets gave 82% efficiency with respect to Odor, COD and MPN. However, we demonstrate that using small-scale bio-filter model a maximum efficiency i.e. 90 -100% achieved with respect to various parameters including MPN for fecal coli forms.

INTRODUCTION

The quest for pure and palatable water, from time immemorial has been the persistent pursuit of humanity. Even though the criteria governing the purity of water have become more and more complex and rigid the underlined principles, methods and materials remained the same from the earliest known recorded data of 2000 B.C down to the present century. Evidences of water purification efforts dates back to thousands of years and great strides in the art have been made since then. But it's only in the beginning of 19^{th} century that this particular art of water purification on a community basis assumed a form as found today. More practically, if the world's water supply is 100 liters, usable supply of fresh water would be only about 0.003 liters (one half tea spoon). This makes water a precious resource. Burning problem that is being faced today in most of the major metropolitan cities is water scarcity. Almost 4% of water in metropolitan cities is used in toilets. In order to overcome the water scarcity problem we have taken up a research work on bio-toilet effluent water, which can be recycled, conserved and reused for flushing and gardening. India accounts for 58% of the world's population of open defecators. With the current rate of progress the nation is feared to miss the sanitation target by 32 years. The Indian Minister for Rural Development and Drinking Water Supply and Sanitation too says, "Sanitation is the biggest blot on the human development portfolio in India, as the sanitation situation is disastrous." Further, the nation is paying the cost for not spending on drinking water and sanitation in the form of loss of working days, expenditure on healthcare, school drop outs, malnutrition, anemia, and infant/child mortality. According to the WHO/UNICEF Joint Monitoring Programme, India has provided sanitation cover to over 200 million people between 1995 and 2008. However, the progress has been rated as highly inequitable as it displays exclusion of certain caste and communities. A research by Water Aid illustrates that the Scheduled Castes in particular are denied access to water facilities. Even the children from scheduled caste communities are not allowed to drink water from common water sources in schools or use the toilet facility if available. To draw the attention of the government towards this crisis, Water Aid has joined hands with End Water Poverty Campaign (a campaign involving 190 organizations all across the globe to end the water and sanitation crisis).

OBJECTIVE

The primary objective of the present work is to know the values of physical, chemical and microbial parameters of the samples that are collected from bio-toilets so as to design a bio-filter to treat the bio-toilet water and bring them to the desirable limits for flushing, gardening etc.

MATERIALS AND METHODS

Bio-filter Model 1: Bleaching power + Sand: 6 inches; anthracite + saw dust: 6 inches

Bio-filter Model 2: CaO + saw dust: 6 inches; bleaching powder + sand: 6 inches

In order to recycle the water, a small scale bio-filter model is designed and samples are filtered through the media and analyzed for physical, chemical and microbial parameters. These values are taken on hourly basis and these values are plotted on a graph (data not shown except for MPN of coli forms).

RESULTS AND DISCUSSION

Despite the fact that raw wastewater carries large quantities and a wide variety of fecal micro-organisms (including pathogens for humans), a significant reduction of bacteriological pollution observed upon passing through bio-filter.

Analysis of Water Sample for Portable Purpose: Coli forms MPN/ml (Set target <10 CFU/ml)

Coli forms (MPN/ml)	**Bio-filter 1**		**Bio-filter 2**	
	Before	**After**	**Before**	**After**
	350	Nil	300	30

CONCLUSIONS

1. In the above bacteriological examination, the presence/absence of coli form organisms detected by MPN determines the quality of water with a set target <10 CFU/ml.
2. Bio-filter 1 is the most efficient (eliminates MPN by 100%) as compared to Bio-filter 2 which eliminates MPN by 90% suggesting the importance of biofilter in eliminating coli forms from biotoilet water and their by enhancing the water recycling.

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Response of Tomato to Different Irrigation Treatments

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ABSTRACT

A field experiment was conducted to study the effect of mulching on growth and yield response of tomato under drip fertigation at research farm of Department of Irrigation and Drainage Engineering, Dr. PDKV, Akola during October 2014 to March 2015. Total water requirement of tomato was found to be highest (128.41 lit/plant) under irrigation scheduling at 100% ET_c level (T_4 and T_5). It was found to be lowest (59.46 lit/plant) under irrigation scheduling at 40% ET_clevel (T_1). Hence, highest saving of water over control treatment was achieved in T_1 (53.71%), followed by T_2 (35.77%) and T_3 (18.36%). The study indicated higher plant growth, more number of fruits per plant and enhancement in the yield under all levels of drip irrigation with mulch. Yield of tomato was maximum in the treatment of drip irrigation at 80% ET with mulching (186.48 q/ha). Minimum yield of tomato was found in the control treatment of 100% ET without mulch (64.41 q/ ha).

Keywords: tomato, polyethylene mulch, drip irrigation, evapotranspiration.

INTRODUCTION

Water supply is limited worldwide and there is an increasing necessity to reduce the quantity of water used during the irrigation practices. Tomato has the highest acreage of any vegetable crop in the world, therefore adoption of deficit irrigation could make substantial contribution to save water. Deficit irrigation is useful not only in reducing production costs, but also in preserving water consumption and minimizing leaching of nutrients and pesticides into groundwater. Furthermore, water deficit and poor water quality are the main factors affecting yield and tomato quality in terms of nutritional value and food safety (Fabio, 2009). Mulch regulates soil temperature, creates suitable condition for germination, improves soil moisture, suppresses weed growth, saves labour cost and improves soil physical conditions by enhancing biological activity of soil fauna and thus increases soil fertility, which ultimately increases the yield of tomato. In addition, mulching has the unique character of reducing the maximum soil temperature and increasing the minimum temperature (Kayum, 2008).

MATERIAL AND METHODS

Experimental site

The experiment was conducted during winter season of 2014- 2015 at the field of the Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh KrishiVidyapeeth, Akola, Maharashtra, India. The experimental site was fairly uniform and leveled.

Location

Akola is situated in Western Vidarbha region of Maharashtra state and comes under sub tropical zone. It is situated at an altitude of 307.415 m above mean sea level (MSL) at the intersection of $20^0 40'$ north latitude and $77^0 02'$ east longitude. Average annual precipitation is 760 mm, out of which approximately 86 per cent is received during June to September.

Experimental design

The experimental design is randomized block design (RBD). The field plot was divided into five treatments with each treatment having four replications. The plastic mulch film (silver up and black down) of 50 µm thickness were used to cover four treatments, and control treatment was kept uncovered with plastic mulch.

Details of treatments

Sr. No.	Treatment	Specification
1	T_1	40 % ET_c with Polyethylene mulch
2	T_2	60 %ET_c with Polyethylene mulch
3	T_3	80 % ET_c with Polyethylene mulch
4	T_4	100 % ET_c with Polyethylene mulch
5	T_5	100 % ET_c without Polyethylene mulch (control)

Water requirement of tomato crop

Before transplanting, common irrigation was applied on 16th October 2014 to the field for better survival.

Quantity of water to be applied per treatment was calculated by the following equation (Dick Krupp's Formula) and sample calculations are shown in Annexure-II.

$$Q = A \times B \times C \times D \quad (1)$$

In Which,

Q = Water requirement per plant (lit/plant)

$A = ET_o = E_{pan} \times K_p$

$B = K_c$

C = Canopy factor

D = Area allotted per plant (m^2)

Irrigation scheduling

The irrigation was scheduled to alternate days for tomato crop. The water requirement of tomato crop was worked out on the basis of class 'A' open pan evaporation.

Biometric observations

Five plants were selected at random from each plot to measure plant height, to countthe number of branches per plant, to measure leaf area index. In order to study the growth parameter, randomly five plants per plot were selected and tagged. Plant height and number of branches was measured at 30, 60, 90, and 120 days after transplanting. Then mean height was expressed in cm.

Leaf area index was taken three times (30 DAT, 60 DAT, and 90 DAT) during the growth period of crop. Three plants from each plot were selected. Three leaves of different sizes (small, medium, big) were selected from individual plant. LAI was traced on a sheet of graph paper with the help of pencil. The area of these three leaves was found out by counting the number of boxes in the graph paper.

Let the area of three leaves be A_1, A_2, A_3 on a given plant, the number of leaves, each of area nearly equal to A_1, A_2 and A_3 were counted. Let the number of leaves counted be N_1, N_2, and N_3. From these the leaf area of plant was calculated as $N_1A_1 + N_2A_2 + N_3A_3$.

Total LA_I of one plant was determined as

LA_I = Total leaf area (m^2)/ground area (m^2)

Yield parameters

The same five plantswere used to measure the fruit set percentage, fruit yield per plot, average fruit weight. The fruit set percentage per plant was then estimated by dividing fruits per cluster per plant by flowers per cluster per plant.Weight of individual fruit of the observation plants from each treatment was taken and the mean weight in grams was calculated. This mean is considered as the average weight of fruit for a particular treatment. The fruit yield from the observation plants in every treatment was pooled separately and the average yield per plant was worked out. The total yield of the ripe fruit harvested from net plot was recorded and expressed in kg per plot.

Quality parameter

Polar as well as equator diameter of fully developed, red coloured tomato were recorded using vernier calipers. This quality parameter also calculated separately for each and every treatment and average was expressed in millimeters.

REASULTS AND DISCUSSIONS

Crop water requirement

The estimation of crop water requirement is one of the basic needs for crop planning on the farm. It is observed that the amount of water applied, through drip irrigation at 40% ET_c with polyethylene mulching, drip irrigation at 60% ET_c with polyethylene mulching, drip irrigation at 80% ET_c with polyethylene mulching, drip irrigation at 100% ET_c with polyethylene mulching, and drip irrigation at 100% ET_cwithout polyethylene mulching were 13.21 ha-cm, 18.33 ha-cm, 23.30 ha-cm, 28.54 ha-cm, and 28.54 ha-cm, respectively.

Biometric characters

The highest plant height (75.25 cm) was observed 120 DAT for the treatment T_3 (80% ET_c with PM). Also the lowest plant height (43 cm) was observed for T_5 (100 % ET_c without mulch, control) 120 DAT respectively. The treatments T_3 and T_4 were at par and were significantly superior over T_1, T_2, and $T_{5.}$

The maximum number of branches (17) were oseerved in treatment T_3 followed by treatment T_4 (16). The minimun number of brances (10) were observed in control treatment T_5 (100% ET_cwithout PM).The treatments T_3 and T_4 were statistically at par.Treatments T_1, and T_2 were statistically at par.

The higher value of LAI is for T_3 (2.0) 90 DAT. Also the lower value of LAI is for T_5 (0.80 90 DAT). The treatments T_3 and T_4 were at par and also the treatments T_2 and T_1 are statistically at par. The treatment T_3 (80% ET_c with PM) is significantly superior over T_1, T_2 and T_5.

Yield parameters

It is revealed that under drip irrigation and plastic mulch the higher number of flowers (289) and fruits (288) were observed for the treatment T_3 (80% $ET_c$with PM). The lowest number of flowers (24) and fruits (14) is for control treatment. The highest fruit set per cent is observed for T_3 (99.65%) followed by T_4 (98.58%), T_2 (97.30%), T_1 (95.88%) and the lowest value was recorded for the treatment T_5 (72.09%).

The highest value of fruit weight was recorded in T_3 (91.92 gm) followed by T_4 (82 gm), T_2 (73.75 gm), T_1 (66.75 gm) and the lowest value of fruit weight was observed for the treatment T_5 (53.40 gm). Treatment T_3 was significantly superior over all other the treatments. Treatments T_1 and T_2, treatments T_2 and T_4 were statistically at par.

It is revealed that treatment T_3 (80%ET_c with plastic mulch) with a yield of 186.48 q/ha was found significantly superior over all other treatments. Treatment T_1 and T_2 are at par. The lowest yield was observed under control treatment T_5 (64.405 q/ha). The per cent increase in yield due to mulching in 100% ET_clevel was found to be 136.00% and the treatment T_3 (80% $ET_c$with PM) recorded 189.54% more yield over treatment T_5 (control).

Quality parameter

It is revealed that the polar diameter was observed higher for T_3 (63.00 mm), followed by T_4 (62.15 mm), T_2 (52.48 mm), T_5 (47.35 mm), and T_1 (63.15 mm). Also the highest equator diameter was observed for T_3 (56.73 mm) followed by T_4 (52.18 mm), T_2 (49.48 mm), T_1 (48.08 mm) and the lowest value was recorded for the treatment T_5 (44.50 mm). It is also seen that in case of polar diameter T3 and T4 were at par and treatments T_1, T_2 and T_5 are at par. But for equator diameter, T_3 and T_4 were at par. Also the treatments T_4 and T_2, T_2 and T_1 were found to be statistically at par.

CONCLUSION

On the basis of above results it is concluded that if water is not the limitation, tomato should be grown under plastic mulch condition irrigated with drip at 80 per cent replenishment of evapotranspiration. If water is the constraint, then tomato should be grown under polyethylene mulch with drip irrigation having irrigation scheduling at 40 percent of ET_c.

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Effect of Split Application of Nutrients through Fertigation on Soil Moisture Distribution, Nutrient Dynamics and Yield of BT Cotton

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ABSTRACT

A field experiment was conducted during the year 2011-12 and 2012-2013 at Department of Agronomy, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola to study the soil moisture movement, nitrogen and potassium distribution and seed cotton yield due to split application of N and K fertilizers compared to conventional soil application of fertilizers in Bt cotton. The results indicated that soil moisture content was higher in soil layer of 0-30 cm vertically and it decreased with the increase in lateral distance from the emitter. Similarly it was higher in the surface layer (0-15 cm) and followed a decreasing trend with increase in depth. The mobility of nutrients was observed more in drip fertigation than conventional soil application method. The available nitrogen and potassium under drip fertigation levels showed increased concentrations as per the increment in the fertilizers doses from 50 to 125 per cent given through fertigation. There was a decrease in available N from dripper point both horizontally and vertically and highest available N was noticed at 125 per cent fertigation level at dripper point. The soil available K content was higher in the surface soil than in the subsoil. Drip fertigation at 125 per cent RDNK ha^{-1} had recorded higher seed cotton yield of 3680 Kg ha^{-1} and 3326 Kg ha^{-1}during 2011-12 and 2012-13 respectively. Drip fertigation at 75 per cent RDNK ha^{-1} recorded comparable yield with 100 per cent recommended dose of fertilizers applied through soil by conventional method during both the years of study indicating 25 per cent fertilizer saving through fertigation when compared to conventional soil application of fertilizers.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) as a white gold and king of fibre is the nature's gift to mankind and is mainly cultivated for its lint from time immemorial and also aptly called as **"white gold"**. India is one of the major producers of cotton in the world with largest acreage of 9.59 M ha., but productivity as low as 505 Kg lint ha^{-1} as compared to global average of 735 Kg lint ha^{-1} (Nasarabad *et al*. 2013). Bt cotton hybrids now constitute about 90 per cent of the cotton area sown in the country. Water and nutrients are the two most important critical inputs for producing vigorous healthy plants and improving the yield of any crop. Among the different strategies of increasing agricultural productivity and increasing the water and nutrient use efficiency, drip irrigation and split application of nutrients through fertigation method gaining the importance nowadays. Drip fertigation provides an efficient method of fertilizer delivery and the availability of soil moisture and nutrients at root zone of the crops influences the uptake and yield of the crop. Deficit fertilizer supply has the major influence on production of fruiting sites on a cotton plant. Fruit retention is strongly dependent on the supply of N and K to the developing fruit. Method of fertilizer application along with appropriate schedule is one of the several factors that affect fertilizer use efficiency. Application of water soluble fertilizers through drip irrigation has gained widespread popularity as an efficient method for fertilizer application (Mmolawa and Or, 2000).The roots are developed extensively in a restricted volume of soil wetted by drip fertigation. Thus, drip fertigation system can place nutrients efficiently in wetted zone and are used by the plant from soil easily. It helps in achieving higher productivity and enhancing the quality of crop. However several basic principles must be followed in applying nutrients through irrigation system in order to place the fertilizer correctly with suitable movements in soil, decrease potential nutrient losses, avoid excessive fertilizer application and ultimately higher seed cotton yield of Bt cotton. In view of the above, it was felt appropriate to study the effect of split application of nutrients on nutrient dynamics and yield of Bt cotton.

MATERIALS AND METHODS

A field experiment was conducted during 2011-12 and 2012-13 at Department of Agronomy, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) to study the effect of split application of N and K fertilizers on growth, yield attributes, soil moisture distribution and nutrient dynamics in Bt cotton and to economize the fertilizer requirement for Bt cotton under fertigation. The experiment was laid out in randomized block design with four replications. There were five treatments having four different levels of drip fertigation in five splits at 50 per cent, 75 per cent, 100 per cent and 125 per cent of recommended dose of N and K of fertilizers given through fertigation and P as basal compared with 100 per cent soil application of fertilizers.

The soil of experimental plot was clayey in texture, low in organic carbon, slightly alkaline in reaction, low in available nitrogen and phosphorus and fairly high in available potassium. Cropping history of the experimental plot was almost practically uniform before conducting the experiment. Total rainfall during crop growth period was 481.3 mm in 36 rainy days during the year 2011-12 and it was 722.5 mm in 56 rainy days during the second year of study (2012-13).The experimental site was established with inline drip irrigation system (16 mm) lateral laid out at 120 cm with 60 cm dripper spacing. The recommended dose of fertilizers (N and K) was applied as per the treatments through fertigation tank of 90 lit. capacity. Phosphorus was applied as basal and N and K as urea and murate of potash respectively through drip irrigation in five splits as per the treatments and growth stages of cotton and onion crop. In conventional soil application method half nitrogen and full dose of P and K were applied as basal at sowing and remaining half dose of N was top dressed at 30 DAS and 60 DAS. Irrigation water was applied through drip irrigation on alternate day at the rate of 100 per cent crop evapotranspiration level. The total water used by cotton through drip (including effective rainfall) was 469.32 mm and 622.3 mm during the year 2011-12 and 2012-13 respectively. The Bt cotton variety MRC-7326 was used for experimentation. The recommended dose of fertilizers was 100:50:50 NPK Kg ha^{-1}.The soil moisture content was estimated at 0,15,30 cm distance from the dripper point and to a depth of 0-15,15-30 and 30-45 cm below dripper to evaluate the vertical and horizontal uniformity of water spreading from the emitter in the crop root zone. Immediately after sowing, irrigation was given upto soaking of entire bed and subsequent irrigations were scheduled once in two days. For drip fertigation system the operating pressure was maintained at 1.0 kg cm^2. Drip irrigation was given as per the schedule once in two days based on cumulative pan evaporation. The volume of irrigation water to be applied per plant was determined by the following formula.

$$V(lpd) = (ET_o \times K_c \times A \times W_p) - (RE)$$

Where,

V - Volume of water applied (liter/day/plant)

ET_o - Reference evapotranspiration(mm/day)

K_c - Crop factor

A - Area under crop (m^2)

(Plant to plant spacing)x(Row to row spacing)

W_p - Wetted area fraction

RE - Effective rainfall in mm

The net depth of water to be applied in drip irrigation of alternate day was determined by the following formula-

$$D = (ET_o \times K_c) - RE$$

Where,

D - Net depth of water to be required (mm)

ET_o - Reference evapotranspiration (mm/day)

RE - Effective rainfall (mm)

Soil moisture content was estimated by gravimetric method. Soil samples were taken at a distance of 0, 15, 30 from dripper point (horizontal) and 0-15, 15-30 and 30-45 cm depth (vertical) for studying soil moisture irrigation regime during two consecutive irrigation cycles. This observation was done in rain free period. The values were expressed in per cent soil moisture by weight. The soil samples taken for moisture content were utilized for analysis.

RESULTS AND DISCUSSION

Soil moisture distribution

The data on soil moisture movement is given in Table 1. Adequate soil moisture availability ensures successful cotton production under any type of soil cultivation. The rate of applying water in drip irrigation is an important factor which governs moisture distribution in soil profile. The soil moisture distribution data given in Table 1 indicated that, below the dripper point, the moisture content 24 hrs. after drip irrigation showed higher soil moisture content in the top layer and progressively declined vertically in the bottom layer (30-45 cm).Similarly ,the moisture content also decreased horizontally from 0-30 cm. The higher moisture content of 32.9, 31.1, and 29.5 per cent was recorded near emitter point at 0-15 cm, 15-30 cm and 30-45 cm vertical depth respectively during the first year of study. Similarly, at 48 hrs. after drip irrigation as indicated in Table ,soil moisture content showed progressive decrease in moisture content both horizontally and vertically from the emitter location but slightly lower moisture percentage was noticed 48 hrs. after drip irrigation compared to 24 hrs. after drip irrigation. The same trend of soil moisture distribution was observed during both years of investigation.

The results of present investigation indicates that uniform soil moisture distribution due to increased frequency of irrigation at once in two days led to higher and constant moisture availability nearer to field capacity. The slow and frequent application of predetermined rate of water application could provide constant soil moisture availability to the crop in drip fertigation. Data on soil moisture content showed that in general, the moisture content was higher in soil layer of 0-30 cm vertically and it decreased with the increase in lateral distance from the emitter. Similarly it was higher in the surface layer (0-15 cm) and followed a decreasing trend with increase in depth (Fig a.). This uniform soil water distribution represented soil water nearing field capacity. This indicated optimum soil moisture availability conditions for the crop. It implies that drip system could maintain an ideal moisture regime for optimum crop growth condition and thus ensures water saving. The crop was irrigated with drip and experienced full irrigation without any stress period, due to which roots extracted adequate moisture and nutrients efficiently without any leaching loss. This might have increased the crop growth as well as yield of the crop. Similar results in respect of soil moisture distribution have been reported by Suganya *et al*.(2007) and Gokila (2012) in drip irrigation.

Table 1. Soil moisture distribution (%) at 100 percent pan evaporation in cotton (2011-12 and 2012-13)

Vertical Depth from soil surface (cm)	Horizontal distance from emitter (cm)	Soil moisture distribution 24 hrs after drip irrigation (%)		Soil moisture distribution 48 hrs after drip irrigation (%)	
		2011-12	2012-13	2011-12	2012-13
0-15	0	32.9	32.7	30.9	30.8
	15	30.7	30.5	29.1	29.6
	30	28.4	28.3	26.2	26.1
15-30	0	31.1	31.1	29.2	29.1
	15	29.9	29.8	28.2	28.4
	30	28.1	28.0	26.0	25.9
30-45	0	29.5	29.6	27.7	27.5
	15	28.3	28.2	26.6	26.3
	30	26.1	26.4	25.3	25.4

Effect of drip fertigation on nutrient dynamics in soil

(i) Available nitrogen dynamics under fertigation

The available nitrogen under fertigation levels showed increased concentrations as per the increment in the fertilizers doses from 50 to 125 per cent applied through fertigation as indicated in Table 2 and graphically depicted in Fig. B (i and ii). The available N at 50 per cent level of fertigation was comparatively more in the top layer at the dripper point and decreased horizontally upto 30 cm from dripper. Similarly, the available N slightly decreases as the depth increases from top layer (0-15 cm) to bottom layer (30-45 cm) as indicated in Table 2.However N concentration increased at 30 cm horizontal distance as the vertical depth increased. At 75 and 100 per cent fertigation of RDNK ha^{-1} also the same trend of decrease in available N from dripper point both horizontally and vertically was observed. At 125 per cent fertigation level, the available N was (234.9 and 239.5 kg ha^{-1} during 2011-12 and 2012-13 respectively) at dripper point and reduced horizontally upto 30 cm in bottom layer of 30-45 cm depth. The similar trend was observed during both the years of study in respect of available nitrogen under different levels of fertigation. The mobility of nutrients was well proven under drip fertigation system. An understanding of such transformation on nutrient mobility is very important in elucidating the soil fertility interactions. The recommended level of N and K was fertigated through urea and muriate of potash in the present study. The available N from the urea application decrease progressively from top layer and the increasing distance from the dripper point horizontally upto 30 cm. The top layer showed the higher value of 202.8, 213.7, 230.9, and 234.9 kg ha^{-1} at the dripper point while it was 200.2, 208.6,228.2,233 kg ha^{-1} in the bottom layer (30-45 cm) below the dripper during first year of study.

The nitrogen concentration 30 cm away from emitter increased as the vertical depth increased from 0-15 cm to 30-45 cm and then concentration was in the increasing trend at 30 cm horizontal distance at all the vertical depth and it was higher at 30-45 cm vertical depth. Urea is relatively mobile in soil and it is not strongly absorbed by soil colloids. It tends to be more evenly distributed down the soil profile below the emitter and had moved laterally in the profile to 15 cm radius from the emitter (Haynes, 1990). The more availability of N in the soil near the emitter is the result of adequate quantum of water available just beneath the drippers, which increased the nitrogen availability. These results are in accordance with the results of Bangar and Chaudhari (2004), Gokila (2012) and Pawar *et al*.(2013).

(ii) Available potassium dynamics under fertigation

The data on available potassium as influenced by different treatments are presented in Table 3 and graphically illustrated in Fig.C (i and ii) The potassium distribution below the emitter showed progressive increased concentration as per the increment in the fertigation from 50 per cent to 125 per cent levels of fertigation and the availability of K decreased at vertical depth from 0-15 cm to 30-45 cm and also decreased as the horizontal distance was increased from emitter from 0-30 cm. Maximum K distribution was observed at 125 per cent fertigation level during both the years of study. The level of soil solution K will depends upon equilibrium and kinetic reactions that occur between different forms of soil potassium, the soil moisture content and concentration of bivalent cations in solution and exchange phage Potassium is less mobile than nitrate, but distribution in the wetted volume may be uniform due to interactions with binding sites (Kafkafi *et al.*,1988).After the fertigation the highest K concentration was found in 0-15 cm soil depth than at the lower layer i.e.15-30 cm and 30-45 cm depth. The peak quantity of K was recorded in 0-15 cm depth under the emitter .

In the present study, soil available K content was higher in the surface soil than in the sub soil. This might be due to the majority of applied K was held up in the surface soil besides lesser downward movement. Slower downward movement of applied K may be partially attributed to net upward flux of soil water in the soil profile as a result of high evapotranspiration. This is in line with the findings of Zeng *et al*.(2000).Mmolawa and Or (2000) also reported that potassium (K) distribution in the soil profile is characterized by decreasing soil K content with depth. Suganya *et al*.(2007) inferred that the available K content was higher in the surface layer due to entrance of K ions in soil exchange complex resulting in very small movement to depth layer. Gokila (2012) and Pawar *et al*.(2013) also reported the maximum K availability at 125 per cent fertigation and decreased K availability with decreasing level of fertigation and also reported the availability of more K near the upper surface than the deeper soil layer.

(iii) Available nutrients (N and K) under soil application method

The data on available N and K as affected by soil application method are presented in Table 4 revealed that in soil application of 100 per cent RDNK ha^{-1}, the availability of N and K was decreased as the depth increased from 0-15 cm to 30-45 cm. The availability of N and K was less than all the fertigation treatments during both the years of investigation. The availability of low N and K might be due to leaching and volatilization losses of nutrients when applied by conventional method and the fertilizers may spread far away from the active root zone of crop. The decrease in available N concentration might be due volatilization losses and trapping of $NH4^{+}$ ion in clay crystal micelle. However, depletion in available K might be due to its fixation.

Table 2. Available –N (kg ha^{-1}) distribution in soil as affected by fertigation treatments in cotton (2011-12 and 2012-13)

Depth (cm)	Horizontal distance(cm)	2011-12				2012-13			
		T2 (50%RDNK fertigation)	T3 (75%RDNK fertigation)	T4 (100% RDNK fertigation)	T5 (125% RDNK fertigation)	T2 (50%RDNK fertigation)	T3 (75%RDNK fertigation)	T4 (100% RDNK fertigation)	T5 (125% RDNK fertigation)
0-15	**0**	202.8	213.7	230.9	234.9	205.8	217.9	235.7	239.5
	15	201.2	211.6	229.7	234.4	205.1	215.8	234.8	239.4
	30	196.3	204.1	225.6	229.8	199.3	208.3	230.0	236.8
15-30	**0**	201.2	212.4	230.4	234.1	205.6	216.6	235.5	239.1
	15	200.6	210.3	229.4	233.9	201.3	214.5	234.6	238.7
	30	198.5	206.8	227.7	231.1	202.4	210.8	232.8	237.7
30-45	**0**	200.6	210.4	230.0	233.7	203.5	214.6	235.0	238.5
	15	199.8	209.2	229.1	233.3	202.3	213.4	234.1	237.5
	30	200.2	208.6	228.2	233.0	202.1	212.6	233.9	238.9

Table 3. Available –K (kg ha^{-1}) distribution in soil as affected by fertigation treatments in cotton (2011-12 and 2012-13)

Depth (cm)	Horizontal distance(cm)	2011-12				2012-13			
		T2 (50%RDNK fertigation)	T3 (75%RDNK fertigation)	T4 (100%RDNK fertigation)	T5 (125% RDNK fertigation)	T2 (50%RDNK fertigation)	T3 (75%RDNK fertigation)	T4 (100%RDNK fertigation)	T5 (125% RDNK fertigation)
0-15	**0**	371.2	378.1	385.4	393.0	377.2	385.2	393.55	400.4
	15	367.8	374.8	381.2	388.6	373.8	381.9	389.35	396.0
	30	365.5	370.9	379.6	386.7	371.5	378.0	387.75	394.1
15-30	**0**	368.6	375.6	383.7	390.8	374.6	382.7	391.85	398.2
	15	364.4	373.8	379.3	387.0	370.4	380.9	387.45	394.4
	30	361.7	370.0	376.8	383.8	367.7	377.1	384.95	391.2
30-45	**0**	366.5	374.3	380.1	387.8	372.5	381.4	388.25	395.2
	15	361.8	371.9	376.7	383.6	367.8	379.0	384.85	391.0
	30	360.5	367.6	373.3	380.3	366.5	374.7	381.45	387.7

Table 4. Available nitrogen and potassium (kgha^{-1}) distribution in soil under soil application of fertilizers through drip irrigation (T_1)

Depth (cm)	2011-12		2012-13	
	Nitrogen	**Potassium**	**Nitrogen**	**Potassium**
0-15	194.9	362.2	197.2	372.8
15-30	190.4	356.5	193.6	368.9
30-45	186.2	354.9	188.2	368.2

Seed cotton yield of BT Cotton

Drip fertigation levels had marked and favourable influence on seed cotton yield due to various treatments.(Table 5). Drip fertigation at 125 per cent RDNK ha^{-1} has recorded significantly higher seed cotton yield (3680 kg ha^{-1} and 3326 kg ha^{-1}) during 2011-12 and 2012-13 respectively and followed by drip fertigation at 100 per cent RDNK ha^{-1} which registered next higher seed cotton yield of 3362 kg ha^{-1} and 3030 kg ha^{-1} respectively during first and second year of study. There was a significant response to fertigation of 125 per cent RDNKha^{-1} through drip in five splits than other lower level of fertigation (50,75 and 100 per cent).Drip fertigation at 75 per cent RDNK ha^{-1} registered significantly comparable yield with 100 per cent RDNK ha^{-1} applied through soil by conventional method during both the years of study and pooled of two years also show the similar trend indicating 25 per cent fertilizer saving through fertigation when compared to conventional method of fertilizer application. The saving of fertilizers might be due to reduction in losses of nutrients through volatilization and leaching and better movement of nutrients under drip fertigation as against soil application of fertilizers as reported by Bharambe *et al*.(1997), Kadam (1997) and Pawar *et al*.(2013).Increased nutrient availability and absorption by the crop at the optimum moisture supply coupled with frequent and higher nutrient supply by fertigation and consequent better formation and translocation of assimilates from source to sink might have increased seed cotton yield under fertigation.

Table 5. Seed cotton yield (kg ha^{-1}) as influenced by different treatments in cotton

Treatments	Seed cotton yield (kg ha^{-1})		
	2011-12	2012-13	Pooled
T_1: DI +100% RDNK soil application	2740	2519	2629
T_2: DF+ 50% RDNK	2350	2212	2281
T_3: DF+ 75 % RDNK	2894	2620	2757
T_4: DF+ 100 % RDNK	3362	3030	3196
T_5: DF+ 125 % RDNK	3680	3326	3503
S. E. (m) ±	102	95	93
C. D. at 5%	315	294	287
GM	3005	2742	2874

The seed cotton yield under drip irrigation with soil application of recommended dose of N and K was significantly lower and inferior over higher-level of drip fertigation. Soil application of fertilizers under drip irrigation might have restricted the mineralization of nutrients and enhanced the losses due to volatilization and this might be the probable reason for the lower yield under drip irrigation with soil application of nutrients. Nalayani *et al*. (2012),Singh *et al*.(2012) and Ayyadurai *et al*.(2014) also reported that drip fertigation had greater advantages and increased seed cotton yield as compared to broadcast application of fertilizer nutrients.

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Modelling Crop Coefficients of Wheat based on Multispectral Vegetation Indices

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ABSTRACT

Crop water requirement are determined as the product of crop coefficients and reference evapotranspiration. The crop coefficients for different stages of crops are given in tabular form in FAO publications. These crop coefficients are time based and lack spatial dimension. Therefore, this study was conducted to study the multi temporal spectral behavior of remotely sensed Vegetation Indices (VIs) of wheat and investigate their relationships with the corresponding crop coefficients in the form of models and selecting best performing model. Utilizing the best performing model for crop coefficients, spatial water requirement of wheat can be easily estimated. The study area consisted of wheat growing five districts situated in central Maharashtra. Images of IRS-P6, AWiFS sensor were used to generate multi-temporal vegetation indices RVI, NDVI, TNDVI, SAVI and MSAVI2. It was observed that all the vegetation indices in the study follow the same pattern as that of crop coefficients throughout the growing period indicating possibility for modelling. The week-wise VIs were correlated with week-wise crop coefficients of wheat recommended by MPKV Rahuri, which resulted in five models. Simple linear regression analysis showed NDVI-Kc model as a superior model for predicting crop coefficients of wheat. This model showed highest R^2 and D values of 0.895 and 0.980 with lowest values of SE, RMSE and PD of 0.120, 0.113 and 4.64 respectively. RVI-Kc model showed poor performance as compared to other four models.

INTRODUCTION

For accurate scheduling of irrigation, it is most essential to know the correct water requirement of the crops grown in the area. The crop water requirements are commonly determined in terms of crop evapotranspiration (ETc) which is expressed as the product of crop coefficients (Kc) and reference evapotranspiration (ETo). Crop coefficients represent the special characteristics of the crop grown. FAO have proposed tabulated average Kc values of major crops cultivated worldwide (FAO-24) according to growth stage of crops such as Kc initial, Kc,mid and .Kc end. These tabulated values are proposed for standard conditions and are time based. For spatial variation of crop field to field and during non standard conditions, it becomes cumbersome to select proper Kc value. Thus the estimated crop evapotranspiration by this method may vary from the actual evapotranspiration. These limitations can be overcome by adopting advanced technologies such as satellite remote sensing. Many studies have shown that satellite derived vegetation indices (VIs) can be used for estimating spatial Kc, considering similarity between the growth pattern of VIs and Kc. Different researchers have used VIs for estimation of crop coefficients. (Bashir *et al.* 2006, Rahiman *et. al.* 2011 and Farg *et al.*2012) and for estimating crop water requirement at different scales (Jayanthi *et al.*2000, Gontia and Tiwari 2010 and Ozcan *et al.* 2014). Wheat (*Triticum aestivum* L.) is the most important food crop of the world. It is grown under different soil and climatic conditions. In India it is second most important food crop. Since wheat is grown mostly in irrigated conditions, comprehensive knowledge of water requirement (crop evapotranspiration, ETc) of the wheat crop is necessary for appropriate irrigation scheduling. Therefore, this study was conducted to study the multi temporal spectral behavior of remotely sensed Vegetation Indices (VIs) of wheat and to investigate their relationships with the corresponding crop coefficients in the form of models for selecting best performing model. Utilizing the best performing model for crop coefficients, spatial water requirement of wheat can be easily estimated by combining this Kc with ETo estimated from meteorological data.

MATERIAL AND METHODS

Study Area

The study was conducted in five districts of central Maharashtra *i.e*. Pune, Solapur, Ahmednagar, Beed and Osmanabad where spatially, extensive and contiguous sites of wheat crop are found in *rabi* season (Fig. 1). It covers an area of approximately 65,716 Km^2. It is located between 73°17'19"E to 76°47'42"E longitudes and 19°58'57" N to 17°03'56"N latitudes. Most parts of the districts under study are falling in water scarcity zone with average annual rainfall between 500-700 mm with uncertainty and ill distribution.

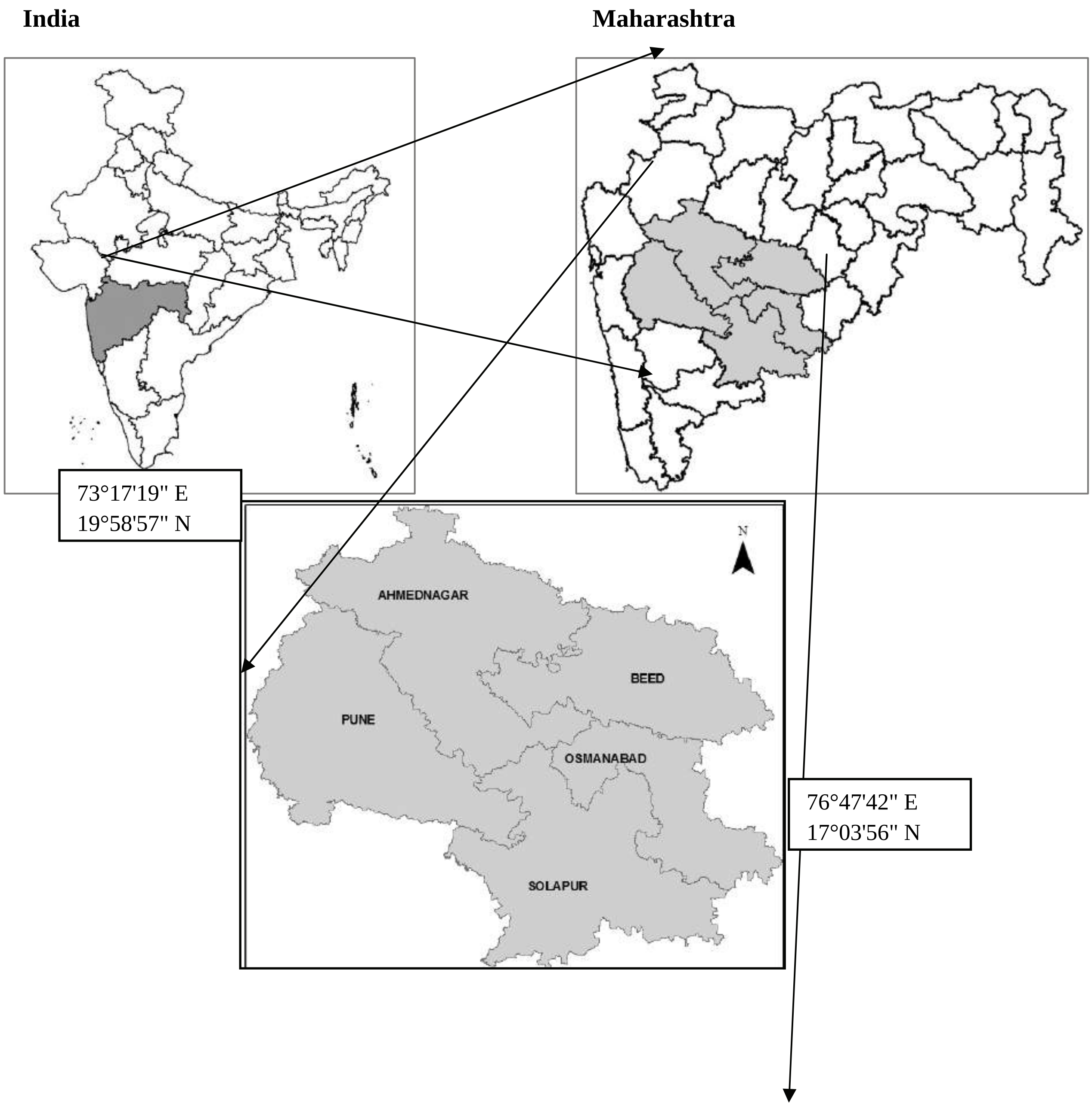

Figure 1. Study area location

Remote Sensing data

Satellite images of IRS- P6, AWiFS (Advanced Wide Field Sensor) for five consecutive months of rabi season (October -February) of the year 2012-13 were used for this study (Table 1). Subsets of these images which include the study area were obtained using ERDAS Imagine. These subsets were processed to generate five most commonly used vegetation indices (VIs) i.e. Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Transformed Normalized Difference Vegetation Index (TNDVI), Soil Adjusted Vegetation Index (SAVI) and Modified Soil Adjusted Vegetation Index (MSAVI2) on all the dates of satellite pass. (Table 2). Eight images of each vegetation index were stacked together to get a stack layer. (Total 5 stacks containing 8 images each were obtained).

Ground truth data

Ground truth work was carried out in first week of December 2012, coinciding with the season of wheat crop in the study area. Field data were collected from 17 sites of wheat crop, distributed properly in all the districts of the study area. The equipments like handheld GPS, geotagged camera and a mobile with LOCATE software were used to obtain the locations and elevations of the sites. At the different locations of wheat fields visited, wheat crop was at different stages. The information regarding the age was obtained by interviewing the farmers and by using criteria suggested by Feekes scale of wheat development (Herbek J and Lee C , 2009). The information obtained from each site was recorded in ground truth proforma sheets. The ground truth of other coexisting crops like rabi sorghum, chickpea, sugarcane etc was also collected from other 65 locations of fields.

Table 1. Multi-date IRS-P6 AWiFS data used for the study

Sr No	Satellite	Sensor	Path	Row	Date of Pass
1	IRS-P6	AWiFS	097	058	19-10-2012
2	IRS-P6	AWiFS	098	059	11-11-2012
3	IRS-P6	AWiFS	098	059	29-11-2012
4	IRS-P6	AWiFS	098	059	11-12-2012
5	IRS-P6	AWiFS	098	062	27-12-2012
6	IRS-P6	AWiFS	097	059	11-01-2013
7	IRS-P6	AWiFS	097	058	23-01-2013
8	IRS-P6	AWiFS	097	059	04-02-2013

Table 2. Vegetation Indices (VIs) used for study

S. No.	Indices	Equation	Reference
1.	RVI	NIR/RED	Jordan (1969)
2.	NDVI	(NIR-R) / (NIR+R)	Rouse *et al.* (1973)
3.	TNDVI	[(NIR - RED)/(NIR + RED) + 0.5]^(1/2)	Tucker (1979)
4.	SAVI	[(NIR - RED) / (NIR + RED + L)] * (1 + L)	Huete (1988)
5.	MSAVI2	$[2*NIR+1-\sqrt{(2*NIR+1)^2 - 8*(NIR-R)}] / 2$	Qi *et al.* (1994)

Image processing

Wheat polygon vector layer of wheat fields was prepared based on the ground truth using ArcGIS. Pure wheat polygon multidate VIs were extracted by overlaying the wheat polygon vector layer on the stack layer images using signature editor function. These VI values were arranged were exported to Excel and arranged weekwise considering the age of wheat crop at different locations in terms of week and dates of images (dates of pass).

Formulation of VI-K_c Models

The empirical relationships between weekly wheat crop coefficients (Kc) recommended by Mahatma Phule Krishi Vidyapeeth Rahuri (MPKV, 2012) and vegetation indices (VIs) were obtained by using linear regression analysis resulting in linear models. The models thus obtained were evaluated by means of statistical parameters such as coefficient of determination (R^2), root mean square error (RMSE), Willmott Index of agreement (D) and percent deviation (PD). Based on the results of statistical analysis best performing model was selected.

RESULTS AND DISCSSION

VI-K_c Models

The average weekly values of vegetation indices i.e. RVI, NDVI, TNDVI, SAVI and MSAVI2 for wheat obtained by image processing are depicted in Table 3. These weekly values of VI's were plotted against weekly crop coefficients (K_c) recommended by MPKV Rahuri (based on Penman-Monteith method of calculation of reference evapotranspiration, ET_o). Simple linear regression analysis was carried out to investigate the relation between the vegetation indices and crop coefficients. It was observed that fairly good linear relationship exists between these vegetation indices with crop coefficients. Figure 2 shows relationships of the vegetation indices RVI, NDVI, TNDVI, SAVI and MSAVI2 respectively with the recommended weekly crop coefficients of wheat crop. From the regression analysis prediction models (linear relations) were obtained as follows:

$$K_c = 1.650\ RVI - 2.366 \quad (1)$$

$$K_c = 6.461\ NDVI - 1.157 \quad (2)$$

$$K_c = 12.99\ TNDVI - 10.85 \quad (3)$$

$$K_c = 4.899\ SAVI - 1.437 \quad (4)$$

$$K_c = 6.626\ MSAVI2 - 2.101 \quad (5)$$

Models generated were statistically evaluated by most frequently used statistical parameters such as R^2, RMSE, PD and D. The results of statistical analysis are presented in Table 4.

It is found that all the vegetation indices have good correlation with wheat crop coefficients with reasonably high R^2 values. However, NDVI-K_c model showed highest R^2 and D values of 0.895 and 0.980 respectively with lowest values of SE, RMSE and PD of 0.120, 0.113 and 4.64 respectively. This confirms the excellent performance of NDVI-K_c model. SAVI-K_c model showed reasonable results after NDVI-K_c model with R^2 value 0.75 with SE, RMSE, PD and D values of 0.185, 0.174, 7.07 and 0.950 respectively. Whereas TNDVI-K_c and MSAVI2-K_c models showed nearly similar trend with comparatively lower R^2 value. On the other hand RVI –K_c model showed poor performance as compared to other four models indicating less accuracy for forming linear relationship. The vegetation indices are function of greenness and leaf area index. Wheat crop is mostly grown in irrigated conditions having dense plant population. As a result canopy always covers maximum surface of soil very fast after crop emergence.

Table 3. Week-wise averaged values of vegetation indices of wheat

Weeks past sowing	Vegetation Indices				
	RVI	NDVI	TNDVI	SAVI	MSAVI2
1	2.0727	0.2714	0.9204	0.5053	0.5136
2	2.0937	0.3241	0.9263	0.5338	0.525
3	2.0117	0.3142	0.9147	0.5077	0.5035
4	2.1404	0.3620	0.9285	0.5442	0.5297
5	2.1463	0.3576	0.9255	0.5362	0.5248
6	2.2692	0.3926	0.9391	0.5733	0.5506
7	2.1620	0.3705	0.9203	0.5213	0.5130
8	2.3654	0.4224	0.9463	0.5937	0.5649
9	2.2019	0.3871	0.9266	0.5391	0.5246
10	2.0547	0.3533	0.9178	0.5117	0.5080
11	2.1289	0.3770	0.9228	0.5284	0.5185
12	1.9619	0.3311	0.8984	0.4617	0.4674
13	1.9232	0.3394	0.9070	0.4850	0.4868
14	1.8506	0.3014	0.8908	0.4404	0.4524
15	1.7160	0.2615	0.8718	0.3903	0.4113
16	1.7150	0.2590	0.8700	0.3850	0.4060
17	1.7270	0.2400	0.8710	0.388	0.4110

Table 4. Results of statistical analysis of VI-Kc models of wheat crop

Model	Intercept	Coefficient	S.E.	R^2	RMSE	PD	D
RVI- Kc	-1.340	1.173	0.234	0.601	0.220	13.82	0.914
NDVI - Kc	-1.157	6.461	0.120	0.895	0.113	4.64	0.980
TNDVI- Kc	-10.850	12.990	0.195	0.722	0.184	7.56	0.944
SAVI – Kc	-1.437	4.889	0.185	0.750	0.174	7.07	0.950
MSAVI2 - Kc	-2.101	6.626	0.195	0.721	0.184	7.52	0.943

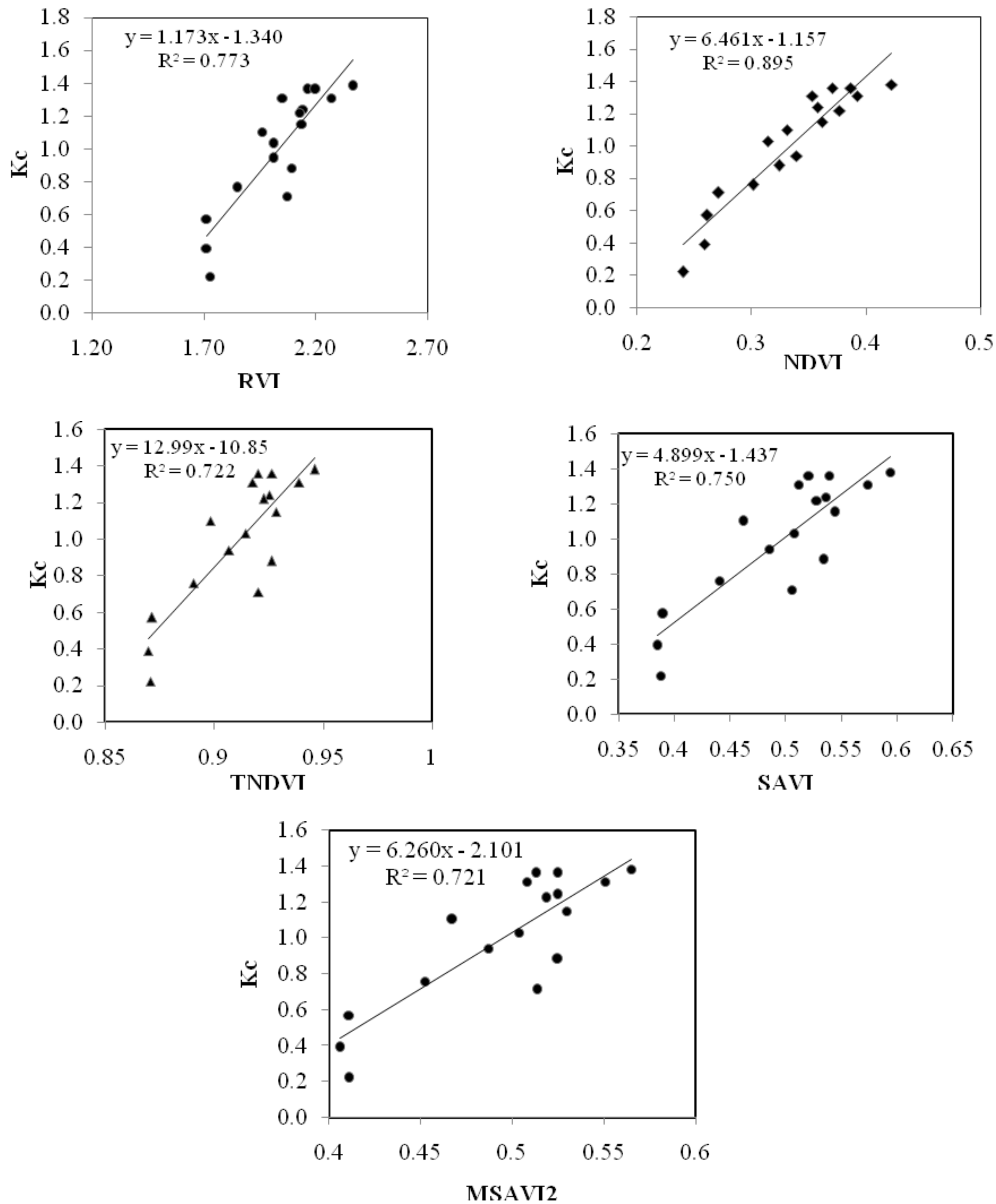

Figure 2. Relationship of crop coefficients(Kc) with vegetation indices (VIs) for wheat

Therefore soil background does not significantly affect the vegetation indices. Study conducted by Gontia and Tiwari (2010) in TSMC command, West Bengal for comparison of NDVI and SAVI showed higher significance (R^2) in case of SAVI. This may be due to use of coarse spatial and low temporal resolution data. However the study indicated usefulness of both the vegetation indices in calculating ET for wheat crop. The findings showing superiority of NDVI for predicting wheat crop coefficients were obtained by Calera and Gonzalez (2007) in Spain as well as Lei and Yang (2014) in China.

CONCLUSIONS

The study demonstrated the ability of remotely sensed vegetation indices to predict spatial and temporal crop coefficients of wheat crop. The study revealed that NDVI-Kc model gives more accurate results than other VI-Kc models. Utilization of this methodology can be successfully made to estimate temporal and spatial water requirement of wheat crop which can help in proper planning of available water. This will save considerable amount of water.

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Enhancement in the Productivity of *Rabi* Sorghum under Dry Land Condition by Adopting *in-situ* Moisture Conservation Practices – a Case Study of Maniknal Watershed

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ABSTRACT

The Operational Research project is functioning at Zonal Agricultural Research Station, Solapur and implemented its different activities in the adopted Maniknal watershed, Tal. Jat, Dist. Sangli (M.S.) during the period 2010-2014. One of the objective of the project was to demonstrate the impact of *in-situ* moisture conservation technique recommended by research station i. e., opening of ridges and furrow after first shower of rains during *kharif* season followed by *rabi* sorghum under farmers management condition and secondly to popularize the productive technology amongst farmers. The *in-situ* moisture conservation technique viz ridges and furrows was demonstrated on 46 farmers field in three years having plot size 0.20 ha. Each treatments during *kharif* and *rabi* sorghum (M-35.1) was grown as test crop following all recommended practices. The observations revealed that the average grain and fodder yields of sorghum were higher in ridges and furrow (12.08 and 31.12 q ha^{-1} respectively) treatment than farmers practice of two harrowings (10.18 and 26.19 q ha^{-1}respectively). The overall per cent increase in mean grain and fodder yields under ridges and furrow treatment was to tune of 19.71 and 19.46 per cent respectively over farmers practice. Also the ridges and furrow method of *in-situ* moisture conservation showed higher B:C ratio (2.15) than farmers practice of two harrowing (1.48).

Keywords: *In-situ* moisture conservation, rabi sorghum, ridges and furrow.

INTRODUCTION

Dryland agriculture is a dynamic and highly complex system with the limitation of water for food and fibre production. Dryland agriculture is practiced in arid and semi-arid regions where the water deficiency results due to low and erratic rainfall, it is inadequate storage as soil water and absence of other sources of water for irrigation. Effective rainwater management as *in-situ* moisture conservation plays vital role to increase and stabilize the yields. Soil and water conservation measures help to improve moisture availability in soil profile for plant growth (Mallappa, et. al. 1990 and Singh et. al. 1990). Moisture being the most limiting input for growth and development in these lands needs to be conserved to the best advantage of crop plants. This is possible through appropriate *in-situ* moisture conservation techniques to capture and harness the rainwater by reducing runoff and soil loss (Sinha et al., 2005). Rabi sorghum (Sorghum bicolor L.) is the staple food crop of the scarcity zone of Maharashtra. It constitutes about 36 to 38 per cent of total area in the country and 56 per cent in Maharashtra. During the year 2012-13 area, production and productivity of *rabi* sorghum was 22.78 thousand ha, 978 thousand metric ton and 429 kg ha^{-1} respectively in scarcity zone of Maharashtra. The rainfall in these areas is inadequate and distribution is erratic, hence the rain water conservation is a crucial factor in stabilizing and stepping up the productivity of dryland crops. Before inception of the project, the farmers were not adopting the *in-situ* moisture conservation practices for *rabi* sorghum. Monocropping of *rabi* sorghum was the common practice in medium to deep soils. The farmers were harrowing the land twice before sowing of the *rabi* sorghum. In view of the above facts, to test and popularize the *in-situ* moisture conservation technique on farmers fields for enhancing the productivity of *rabi* sorghum verification cum demonstration trials were conducted at Operational Research Project village Maniknal, Tal. Jat, Dist. Sangli during 2010-11 to 2013-14.

MATERIALS AND METHODS

The verification cum demonstration trials on *in-situ* moisture conservation practices i.e., ridges and furrow method was assessed for verification and demonstration on farmers field at Maniknal watershed during the year 2010-2014. The Maniknal watershed is located on Umadi – Bijapur Road in Jat tehsil of Sangli district (Maharashtra state). The watershed is located between $17^0$38' N Latitude and $73^0$41'E Longitude.

The field trials treating individual farmer as a replication with two treatments viz., ridges and furrows and farmers practice (two harrowing) were conducted on forty six farmers fields. The trials were conducted on 0.20 ha. area under each treatment. The soils of the experimental plots were medium deep i.e., 60 to 90 cm soil depth, clay to clay loam in texture, slightly alkaline in reaction, low to medium in available P and high in available potassium. The treatment i.e., opening of ridges and furrows was carried out after first shower of monsoon. The ridges and furrows were opened with the help of *Baliram* plough having 45 cm distance between two furrows and height of ridges 25 cm. In case of farmers practice, two harrowings were given before sowing of *rabi* sorghum. The sowing of *rabi* sorghum was done on receding soil moisture in *rabi* season by harrowing the fields.

The *rabi* sorghum cultivar M.35-1 was used as a test crop. The sorghum crop was sown in second fortnight of September in every year with all recommended practices viz., seed treatment with azotobactor, recommended fertilizer dose of 50 kg N + 25 kg P_2O_5 per ha at the time of sowing, sowing with two bowl ferti-seed drill, spacing - 45 x 20 cm, seed rate – 10 kg per ha, three hoeings at 3rd , 5th and 8th week after sowing. The yield data of rabi sorghum was record at harvest and presented in table 1.

RESULTS AND DISCUSSION

The results obtained revealed that the average grain and fodder yields of sorghum (12.08 and 31.12 q ha^{-1} respectively) were higher in ridges and furrow treatment than farmers practice i.e two harrowings (10.18 and 26.19 q ha^{-1}respectively). The overall per cent increase in grain and fodder yields under ridges and furrow treatment was in the tune of 19.71 and 19.46 per cent respectively, over farmers practice. The ridges and furrow method of *in-situ* moisture conservation showedh more B:C ratio (2.15) than farmers practice (1.48) i.e only harrowing. (Table 1). The increase in grain and fodder yield was due to more soil moisture conservation and more moisture availability during the critical crop growth stages under the ridges and furrow method than the farmers practice. Ridges and furrow method of *in-situ* moisture conservation also helped in avoiding terminal moisture stress to some extent than farmers method. In case of farmers practice i.e., harrowing, showed problems of soil erosion and formation of gully at high rainfall intensity. Thus the preparation of ridges and furrows for *in-situ* moisture conservation proved to be better for increasing the crop productivity of *rabi* sorghum under dryland condition. The areas where *kharif* fallow and *rabi* sorghum (mono cropping) is the practice, the ridges and furrows should be prepared on the contour before onset of monsoon to enhance the entry of rain water into the soil profile during rainy season which will be beneficial for raising post monsoon *rabi* sorghum on the conserved soil moisture.

Surkod and Itnal (1998) have observed higher soil moisture content due to compartment bunding, while Selvaraju et al. (1999) reported similar views due to adoption of tied ridges and furrows and compartment bunding as compared to flat bed method. In an investigation by Muthamilselvan et al. (2006), it is reported that compartmental bunding increases the grain and fodder production of rabi sorghum by 38 and 50 per cent respectively. Allolli et al. (2008 a) found that, the Ridge and furrows along with mulch enhanced the vigour of the crop as manifested in higher plant height, leaf area and dry matter production. Further moisture conservation practices (ridges and furrow + mulch) helped to promote the productivity of cluster bean as evident in significantly higher yield per unit area. Also, moisture conservation practices (ridges and furrow + mulch) helped to promote the productivity of chilli (Allolli et al., 2008 b). The results of Upadhye et al. (2010) revealed that, the average grain yield of sorghum on farmers field at Sarole watershed of Solapur district was highest in ridges and furrow (9.64 q ha^{-1}), compartmental bunding (8.24 q ha^{-1})as compared to farmers practice i.e., two harrowing. The percent increase in grain yield was 17 per cent in ridges and furrow over compartmental bunding and 54 per cent over farmers practice. Similar trend was also noticed in case of fodder yield of *rabi* sorghum. Adoption in the domain area of scarcity zone of Maharashtra is 65% with availability of *Baliram* Plough. If adoption on 50,000 ha area there would be increase of yield by 1.5 lakh ton and income by 30 crores.

CONCLUSIONS

The preparation of ridges and furrows for *in-situ* moisture conservation proved to be better for increasing the crop productivity of *rabi* sorghum, under dryland condition. The ridges and furrow method of in situ moisture conservation recorded 19.71per cent more grain yield than farmers practice i.e., two harrowings under farmers management condition in Maniknal watershed. The areas where *kharif* fallow and *rabi* sorghum (mono cropping) is the practice, the ridges and furrows should be prepared on the contour after first shower of rainfall to enhance the entry of rain water into the soil profile during rainy season which will be beneficial for raising post monsoon *rabi* sorghum on the conserved soil moisture. If this technology will diffuse on large scale through RKVY/MGNREGA/IWMP, which will upgrade the livelihood of the farmers of scarcity zone of Maharashtra.

Table 1. Yield and economics of *in-situ* moisture conservation techniques on farmers field at Maniknal watershed.

Year	Yield (q ha^{-1})							
	Farmers practice (Two Harrowing)		Ridges & Furrows		% increase over farmers practice		B : C ratio	
	Grain	Fodder	Grain	Fodder	Grain	Fodder	Farmers practice	Ridges and furrow
2010-11 (Mean of 6 farmers)	9.80	28.13	11.76	31.93	20.00	13.50	1.54	1.68
2012-13 (Mean of 20 farmers)	11.93	27.58	13.00	31.84	8.96	15.44	1.59	2.58
2013-14 (Mean of 20 farmers)	8.82	22.87	11.48	29.60	30.18	29.43	1.30	2.20
Mean	**10.18**	**26.19**	**12.08**	**31.12**	**19.71**	**19.46**	**1.48**	**2.15**

Note: 2011-12 – Drought year

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Investigation of Pressures on Spillways by Providing Air Vents

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ABSTRACT

The Spillway of Nagarjuna Sagar dam across Krishna River was severely eroded during the floods of 2009 due to cavitation which was resulted from the negative pressures developed over the spillway. On further investigation of the problem, it was found that there was a large deviation of the existed profile of the spillway from the design profile, which actually led to the development of negative pressures in such a magnitude that could create the problem. In the present study area, attempt has been made on Nagarjuna sagar Dam for investigation of pressures on spillway using air vents; study has been carried out by providing air vents of 0.01 m and 0.02 m at desired elevations for free and gated conditions in vents 1, 2 and 3 for various discharge conditions. The negative pressures obtained in different pressure levels of vent numbers has been determined and the results show that negative pressures are observed in vent 2 and 3 at different pressure points.

Keywords: Spillway, Floods, Nagarjuna Sagar Dam, Negative Pressures, Discharge conditions.

INTRODUCTION

In the science of hydraulics, many basic flow equations are available to predict the behavior of the flow of fluids but while deriving them many assumptions are made, making it an ideal situation, which limits their application to only for certain simple situations. In the analysis of more complicated cases of turbulent flow, the difficulties and short comings connected with theoretical solutions are further increased and a mathematical treatment, if at all possible may be extremely laborious and produce results which can only be used safely after verification by experiments and experience. The engineers associated with the design, construction and efficient working of the various types of hydraulic structures (such as dams, spillways etc.,) usually try to find out, in advance, how the structure would behave when it is actually constructed. For this purpose the engineers have to resort to experimental investigation. Such experiments are also necessitated in the case of the problems which cannot be solved completely simply by theoretical analysis. Obviously the experiments cannot be carried out on the full size hydraulic structures, which are proposed to be erected. It is then essential to construct a small scale replica of the structure and the tests are performed on it to obtain the desired information. The small scale replica of the structure is known as its model while the actual structure is called prototype. Mostly the models are much smaller than the corresponding prototypes, but in some cases the models may be larger than the prototypes. On the basis of final results obtained, the pressures on the vents at different pressure points have been determined.

STUDY AREA

The Nandikonda project, renamed as the Nagarjuna Sagar project, under the name of that great Buddhist Savant, Acharya Nagarjuna, is a mammoth irrigation project comprises a 124.7 m (409 ft) high masonry dam with total volume of 199 million cu ft. built at 2.4 km downstream of Nandikonda village of Miryalaguda taluk of Nalgonda District in Telangana State. It is located at 79°18' 47" E longitude and 16°34'23" N latitude.

Review of Literature

The case study of Hoover Dam is taken up where cavitation damage was occurred and spillways were repaired successfully. Hoover Dam is a part of the Boulder Canyon Project. It is located on the Colorado River about 58Km from Las Vegas, Nevada. The purpose of the project is to: provide river regulation, flood control, storage for irrigation, and power generation. The spillway tunnels operated for the first time in the winter of 1941. The Arizona spillway operated for 116.5 days at an average flow of 366 m^3/s with a maximum flow of 1076m^3/s. The Nevada spillway operated for only 19.5 hours at an average flow of 227m^3/s and a maximum flow of 407m^3/s. At the conclusion of the spill, the Arizona spillway had suffered severe damage, but the Newada spillway was essentially undamaged. Figure 2.5 shows the damage to the Arizona spillway consisting of a hole 35m long, 9m wide and 13.7 m deep. Evidently, the damage was caused by a misalignment in the tunnel invert. However, in the Nevada tunnel the damage was on the verge of becoming severe. The cause of this damage was a relatively insignificant pop out. The damage index, at the station where the damage began, is 6900 for a 10mm sudden offset. This value compares favorably with the recommended range of design values for the description of damage. Since damage occurred in both tunnels even with exceptionally smooth surfaces-aeration devices were designed for each spillway. Each aerator consisted of a ramp and a downstream offset. The ramp is 900 mm high on the invert and feathers to zero height at 35o on each side of the tunnel crown. The offset is concentric with the original tunnel diameter. The 1500 mm offset transitions back to original diameter in 7620 mm. Each aerator is located about 78m below the inlet to the tunnel. The installation of both aerators was completed in June 1987.

METHODOLOGY

The methodology of physical model study studies involves two parts:

Construction of Model: →Selection of the type of model (2D or 3D) based on the type of the problem to be handled. → Selection of the scale ratio for the model based on the discharge available at the site of model relative to prototype. →If the depth of the water available at the model is in such a way that it has a significant effect on the velocities measured, then the model has to be distorted. → Selection of the material for the construction of the different components of the structure so that the component serves the purpose assigned to it.

Experiments: Experiments were conducted to measure the pressure points at all the points of observation in vent no. 1, 2 and 3 duly provided air vents of diameter 0.01 m and 0.02 m and checked whether they are positive or negative. The experiments were carried out by keeping all the vents of the dam fully open i.e. Free Flow condition and Gated condition for various discharge conditions.

Providing Air Vent of 0.01 m dia: The experiments were carried out by providing an air vent of size 0.01 m dia at elevations of +75.864 m and +123.38 m in the model at various discharge conditions

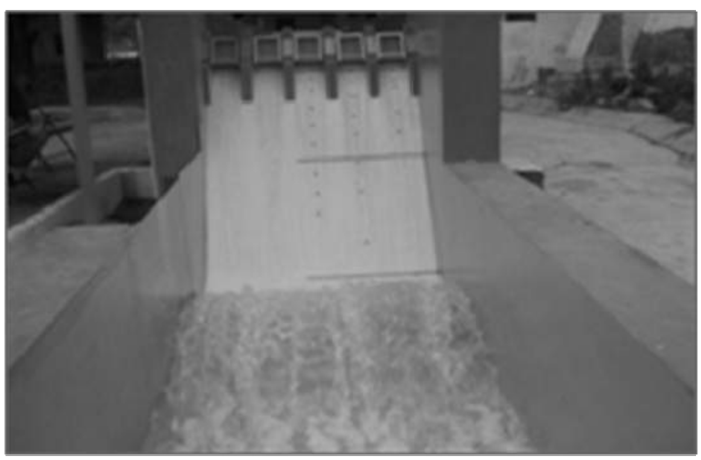

Figure 1. Photograph of Provision of Air Vent of dia 0.01 m

Free flow condition: The experiments were carried out by keeping all the vents of the dam fully open i.e., Free flow condition for various discharge conditions like Maximum Flood Discharge, 3/4th of Maximum Flood Discharge,1/2 of Maximum Flood Discharge & ¼ th of Maximum Flood Discharge.

Maximum Flood discharge: Initially a discharge corresponding to maximum flood discharge (Q_m= 3.0858 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 2 locations i.e., P2=-0.01& P3=-0.04 and negative pressures were observed on vent no 3 at 2 locations i.e., P1=-0.02 & P2=-0.04.

Three fourth of maximum flood discharge: In this condition, three fourth of maximum flood discharge (Q_m= 2.3145 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 2 locations i.e., P3=-0.01& P9=-0.004 and negative pressures were observed on vent no 3 at 1 location i.e., P9=-0.002.

Half of maximum flood discharge: In this condition, half of maximum flood discharge (Qm= 1.5429 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 1 location i.e., P3=-0.01 and negative pressures were observed on vent no 3 at 1 location i.e., P9=-0.002.

One fourth of maximum flood discharge: In this condition, one fourth of maximum flood discharge (Q_m= 0.7713Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 2 locations i.e.,P3=-0.003 & P=-0.005 and negative pressures were observed on vent no 3 at 1 location i.e., P9=-0.002.

Gated Condition (GC): In this condition of the experiments, discharge is varied and gates are operated by maintaining Full Reservoir Level (FRL).

One fourth of maximum flood discharge: In this condition, one fourth of maximum flood discharge (Q_m= 0.7713 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1 , negative pressures were observed on vent no 2 at 3 locations i.e.P1= -0.02,P2=- 0.018 & P3=-0.017 and negative pressures were observed on vent no 3 at 1 location i.e., P1=-0.002.

Half of maximum flood discharge: In this condition, half of maximum flood discharge (Qm= 1.5429 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 3 locations i.e. P2= -0.021, P3=- 0.023& P4=-0.004 and negative pressures were observed on vent no 3 at 2 locations i.e., P1=-0.006 & P9= -0.003.

Three fourth of maximum flood discharge: In this condition, three fourth of maximum flood discharge (Q_m= 2.3145 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 3 locations i.e. P2= -0.015, P3=-0.022 & P9=-0.03 & P9=-0.002 and negative pressures were observed on vent no 3 at 1 location i.e., P1=-0.003.

Maximum Flood Discharge: In this condition, discharge corresponding to Maximum Flood discharge (Q_m= 3.0858 Cusecs) was allowed into the model. The pressure points at all the points of observations in Vent Nos 1, 2 &3 were noted. In this discharge condition, no negative pressures were observed on vent no.1, 2 & 3.

Providing air vent of 0.02 m dia: The experiments were carried out by providing an air vent of size 0.01 m dia at elevations of +75.864 m and +123.38 m in the model at various discharge conditions.

Figure 2. Photograph of Provision of air vent of dia 0.02 m

Free Flow condition: The experiments were carried out by keeping all the vents of the dam fully open i.e., Free flow condition for various discharge conditions like Maximum Flood Discharge, $3/4^{th}$ of Maximum Flood Discharge,1/2 of Maximum Flood Discharge & ¼ th of Maximum Flood Discharge.

Maximum Flood discharge: Initially a discharge corresponding to Maximum Flood discharge (Q_m= 3.0858 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 2 locations i.e., P2=-0.0145& P3=-0.023 and negative pressures were observed on vent no 3 at 2 locations i.e., P1=-0.006 & P2=-0.005.

Three fourth of maximum flood discharge: In this condition, three fourth of maximum flood discharge (Q_m= 2.3145 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 2 locations i.e., P3=-0.015& P9=-0.001 and negative pressures were observed on vent no 3 at 1 location i.e., P9=-0.002.

*Half of maximum flood discharge: I*n this condition, half of maximum flood discharge (Qm= 1.5429 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 1 location i.e., P3=-0.009 and negative pressures were observed on vent no 3 at 1 location i.e., P9=-0.003.

One fourth of maximum flood discharge: **I**n this condition, one fourth of maximum flood discharge (Q_m= 0.7713 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 1 location i.e., P3=-0.01 and negative pressures were observed on vent no 3 at 2 locations i.e., P2=-0.003 & P9=-0.002.

Gated Condition (GC): In this condition of the experiments, discharge is varied and gates are operated by maintaining Full Reservoir Level (FRL).

One fourth of maximum flood discharge: In this condition, one fourth of maximum flood discharge (Q_m= 0.7713 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 3 locations i.e.P1= -0.004,P2=- 0.01 & P3=-0.02 and negative pressures were observed on vent no 3 at 3 locations i.e., P1=-0.026,P2=-0.001 & P9=-0.006.

Half of maximum flood discharge: In this condition, half of maximum flood discharge (Qm= 1.5429 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 3 locations i.e. P2= -0.012,P3=- 0.025& P4=-0.001 and negative pressures were observed on vent no 3 at 3 locations i.e., P1=-0.01,P2=-0.005 & P9= -0.003.

Three fourth of maximum flood discharge: In this condition, three fourth of maximum flood discharge (Q_m= 2.3145 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, negative pressures were observed on vent no 2 at 3 locations i.e. P2= -0.004, P3=-0.008 & P9=-0.001 and negative pressures were observed on vent no 3 at 2 locations i.e., P2=-0.005 & P9=-0.002.

Maximum Flood Discharge: In this condition, discharge corresponding to Maximum Flood discharge (Q_m= 3.0858 Cusecs) was allowed into the model. In this discharge condition, no negative pressures were observed on vent no.1, 2 & 3.

RESULTS AND DISCUSSIONS

The following are the Negative pressures observed at pressure tube points along the spillway under free flow condition and gated condition.

Providing 0.01m dia of air vent:

Free Flow Condition: Under free flow condition following results were obtained

- Under maximum flood discharge, negative pressures were observed at pressure tube points P2, &P3 in vent no 2 and P1& P2 in vent no.3. No negative pressures were observed in vent no1.
- Negative pressures under three fourth of maximum flood discharge condition, were observed at P3&P9 in vent no 2 and P9 in vent no.3. No negative pressures were observed in vent no1.
- From the experiments, it was found that under half of maximum flood discharge condition, negative pressures were occurring at P3 in vent no 2 & P9 in vent no 3. No negative pressures were observed in vent no1.
- Under one fourth of maximum flood discharge condition, negative pressures were observed at pressure tube points at P3 & P4 in vent no 2 and P9 in vent no 3. No negative pressures were observed in vent no1.

Table 1. Negative pressures in vent no's 1, 2 &3 for Free flow condition (0.01 m dia of air vent)

Discharge Condition	**Discharge in cusecs**	**Negative pressures observed at pressure tube points along the spillway in mts**		
		Vent No 1	Vent No 2	Vent No 3
MFD	3.0858	No Negative Pressures	P2 = - 0.01 P3=-0.02	P1=-0.01 P2= -0.01
3/4th of MFD	2.3145	No Negative Pressures	P3 = - 0.041 P9 = - 0.004	P9=-0.002
½ of MFD	1.5429	No Negative Pressures	P3=-0.007	P9 = - 0.002
1/4th of MFD	0.7713	No Negative Pressures	P3= -0.003 P4 = - 0.005	P9 = - 0.002

Gated Condition: Under Gated condition following results were obtained

- Under maximum flood discharge, no negative pressures were observed at pressure tube points P1, P2, &P3.
- Negative pressures under three fourth of maximum flood discharge condition, were observed at P2, P3&P9 in vent no 2 and P1 & P9 in vent no.3. No negative pressures were observed in vent no1.
- From the experiments, it was found that under half of maximum flood discharge condition, negative pressures were occurring at P2, P3 &P4 in vent no 2 and P1&P9 in vent no 3. No negative pressures were observed in vent no1.
- Under one fourth of maximum flood discharge condition, negative pressures were observed at pressure tube points at P1, P2& P3 in vent no 2 and P1 in vent no 3. No negative pressures were observed in vent no1.

Table 2. Negative pressures in vent no's 1, 2 &3 for Gated condition (0.01 m dia of air vent)

Discharge Condition	**Discharge in cusecs**	**Negative pressures observed at pressure tube points along the spillway in mts**		
		Vent No 1	Vent No 2	Vent No 3
3/4th of MFD	2.3145	No Negative Pressures	P2 = - 0.015 P3 = - 0.022 P9=-0.002	P1=-0.003 P9=-0.002
½ of MFD	1.5429	No Negative Pressures	P2=-0.021 P3=-0.023 P4=-0.004	P1=-0.006 P9=-0.003
1/4th of MFD	0.7713	No Negative Pressures	P1= -0.002 P2 = - 0.018 P3=-0.017	P1 = - 0.002

Providing 0.02m dia of air vent

Free Flow Condition: Under free flow condition following results were obtained

- Under maximum flood discharge, negative pressures were observed at pressure tube points P2, &P3 in vent no 2 and P1& P2 in vent no.3. No negative pressures were observed in vent no1.
- Negative pressures under three fourth of maximum flood discharge condition, were observed at P3&P9 in vent no 2 and P9 in vent no.3. No negative pressures were observed in vent no1.
- From the experiments, it was found that under half of maximum flood discharge condition, negative pressures were occurring at P3 in vent no 2 & P9 in vent no 3. No negative pressures were observed in vent no1.
- Under one fourth of maximum flood discharge condition, negative pressures were observed at pressure tube points at P3 in vent no 2 and P2 & P9 in vent no 3. No negative pressures were observed in vent no1.

Table 3. Negative pressures in vent no's 1, 2 &3 for Free flow condition (0.02 m dia of air vent)

Discharge Condition	Discharge in cusecs	Negative pressures observed at pressure tube points along the spillway in mts		
		Vent No 1	Vent No 2	Vent No 3
MFD	3.0858	No Negative Pressures	P2 = - 0.0145 P3=-0.023	P1=-0.006 P2= -0.005
3/4th of MFD	2.3145	No Negative Pressures	P3 = - 0.015 P9 = -0.001	P9=-0.002
½ of MFD	1.5429	No Negative Pressures	P3=-0.009	P9 = - 0.003
1/4th of MFD	0.7713	No Negative Pressures	P3= -0.01	P2=-0.003 P9 = - 0.009

Gated Condition: Under Gated condition following results were obtained

- Under maximum flood discharge, no negative pressures were observed at pressure tube points P1, P2, & P3.
- Negative pressures under three fourth of maximum flood discharge condition, were observed at P2, P3&P9 in vent no 2 and P2 & P9 in vent no.3. No negative pressures were observed in vent no1.
- From the experiments, it was found that under half of maximum flood discharge condition, negative pressures were occurring at P2, P3 &P4 in vent no 2 and P1,P2 &P9 in vent no 3. No negative pressures were observed in vent no1.
- Under one fourth of maximum flood discharge conditions, negative pressures were observed at pressure tube points at P1, P2 & P3 in vent no 2 and P1, P2 & P9 in vent no 3. No negative pressures were observed in vent no1.

Table 4. Negative pressures in vent no's 1, 2 &3 for Gated condition (0.02 m Dia of air vent)

Discharge Condition	Discharge in cusecs	Negative pressures observed at pressure tube points along the spillway in mts		
		Vent No 1	Vent No 2	Vent No 3
3/4th of MFD	2.3145	No Negative Pressures	P2 = - 0.02 P3 = - 0.004 P9=-0.008	P2=-0.005 P9=-0.002
½ of MFD	1.5429	No Negative Pressures	P2=-0.012 P3=-0.025 P4=-0.001	P1=-0.01 P2=-0.005 P9=-0.003
1/4th of MFD	0.7713	No Negative Pressures	P1= -0.004 P2 = - 0.01 P3=-0.02	P1=-0.026 P2=-0.001 P9=-0.006

CONCLUSIONS

The spillway of Nagarjuna Sagar dam across River Krishna was severely eroded during the floods of 2009 due to cavitation which was resulted from negative pressures developed over the spillway. The model was run under gated as well as under free flow conditions allowing one-fourth of MFD, half of MFD, three-fourth of MFD and full discharges. No negative pressures observed at pressure tube points in vent no 1 duly provided an air vent of 0.01 m and 0.02 mm dia for both free flow condition and gated condition. The maximum negative pressures observed at pressure tube points in vent no 2 duly providing an air vent of 0.01m dia is 0.025 at P3 for free flow conditions at maximum flood discharge. The maximum negative pressures observed at pressure tube points in vent no 3 duly providing an air vent of 0.01m dia is 0.01 at P1 for free flow conditions at maximum flood discharge. The increase in size of the Air vent i.e. from 0.01 m to 0.02 m does not make much difference in the reduction of negative pressures. However the magnitude of negative pressures at some pressure point elevations are reduced and at some elevations increased.

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THEME VII

Farm Management and Rainwater Harvesting

Integrated Nutrient Management with
Water Soluble Foliar Grade Fertilizers in Summer Groundnut.

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ABSTRACT

A field experiment entitled "Integrated nutrient management with water soluble foliar grade fertilizer in summer groundnut" was conducted at Oilseed Research Unit Dr.PDKV, Akola during summer season 2011-2012. Eight treatments were compared which are as under T_1 (Absolute control), T_2 (100% RDF 25:75:25 NPK kg per ha), T_3 **(**Foliar application of starter dose (11:36:24 NPK + trace element) + foliar application of Booster dose(8:16:39 NPK + trace elements), T_4 **(**100 % RDNPK + T_3**)**, T_5 (FYM @ 7.5 t ha^{-1} + 100%RDNPK), T_6 (FYM @ 7.5 t ha^{-1} + 100%RDNPK + T_3), T_7 (FYM @ 7.5 t ha^{-1} + 85% RDNPK), T_8 (FYM @ 7.5 t ha^{-1} + 85% RDNPK + T3). Treatments compared to evaluate the effect of different combination of organic, inorganic and foliar grade fertilizer on growth and yield of groundnut. Experiment results revealed that the growth and yield attributes are enhanced significantly with combination of organic, inorganic and foliar grade fertilizers. The results revealed that plant growth characters, yield and benefit: cost ratio were significantly superior with application of FYM @ 7.5 t ha^{-1}+100% RDF 25:75:25 NPK kg per ha), Foliar application of starter dose (11:36:24 NPK + trace element) + foliar application of Booster dose (8:16:39 NPK + trace elements). This treatment recorded highest pod yield (28.90 q. ha^{-1}), net monetary return (84263 Rs.ha^{-1}) and Benefit: cost ratio (2.84). it was closely followed by treatment FYM @ 7.5 t ha^{-1}+100%RDNPK recorded significant pod yield (27.18 q ha^{-1}), net monetary return (79464 Rs. ha^{-1}) and benefit: cost ratio (2.77). However, integration of inorganic and foliar grade fertilizers is better option against the application of only inorganic fertilizers for better yield benefit: cost ratio. Substitutes of inorganic fertilizers through organic fertilizer and foliar grade fertilizers were found to be beneficial for harvesting excellent yield. Beneficial effect of FYM and foliar grade fertilizers was observed on crop yield.

Keywords: organic, inorganic, foliar grade fertilizers, Groundnut.

INTRODUCTION

Groundnut or peanut is commonly called the poor man's nut. It is an important oilseed and food crop, native to South America and has never been found uncultivated. The botanical name for groundnut, *Arachis hypogaea* Linn., is derived from two Greek words, *Arachis* meaning a legume and *hypogaea* meaning below ground. Groundnut (*Arachis hypogaea* L.) is grown in majority of countries in the world and plays an important role in world economy. Groundnut is known by several vernaculars as peanut, monkey-nut or goober nut etc. (Reddy, 1988). The oil content of the groundnut seed varies from 44 to 50 per cent depending on the varieties and agronomic practices. The cake is utilized for making reconstituted food because of its high protein content. It is also good organic manure and nutritious cattle feed. (Nagraj, 1995). Their calorific value is 349 per 100 g. The residual oil cake contains 7 to 8 percent of N, 1.5 percent of P_2O_5 and 1.2 per cent of K_2O and is used as a fertilizer. it can synthesise atmospheric nitrogen and therefore improve soil fertility. (Anonymous, 2013) In India, groundnut is grown over an area of 58.56 lakh ha with production of 84.54 lakh million tonnes and average productivity of 1411 kg ha^{-1} (Anonymous, 2013.) In *kharif*, total area under groundnut crop is 49.77 lakh ha with production of 66.42 lakh million tonnes and in *rabi* and summer area under groundnut crop is 8.78 lakh ha with production 16.22 lakh million tones.

MATERIAL AND METHODS

The experiment was conducted on wheat at farm of Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* 2011. The experimental soil was medium black having initial status of 190.15 kg N ha^{-1}, 16.72 kg P ha^{-1} and 310.22 kg K ha^{-1}. The experiment was laid out in a Randomized Block Design with Eight treatments replicated three times three replications. The Treatments details are T_{1-}Absolute control, T_{2-} 100% RDF(25:75:25 NPK kg per ha) ,T_{3-} Foliar application of starter dose + foliar application of Booster dose T_{4-} 100 %

RDNPK + T3, T_5 - FYM @ 7.5 t ha^{-1} + 100%RDNPK, T_6- FYM @ 7.5 t ha^{-1} + 100%RDNPK + T3, T_7- FYM @ 7.5 t ha^{-1} + 85% RDNPK, T_8 - FYM @ 7.5 t ha^{-1} + 85% RDNPK + T3. Starter Dose: 11:36:24 + trace elements soluble grade fertilizers used as starter dose @2% as foliar application at 30 DAS. Booster dose: 8:16:39 + trace elements soluble grade fertilizers used as starter dose @2% as foliar application at 45 and 60 DAS. The crop was subjected to recommended package of agronomic and plant protection practices to obtain a healthy crop.

RESULTS AND DISCUSSIONS

Plant height

The mean plant height at harvest was 13.47 cm.At harvest in as affected by various treatments are presented in Table No.1. At harvest, application of FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose (T_6) recorded significantly maximum plant height (15.07 cm) and found significantly superior over the treatments T_5, T_2, T_3, T_8, T_4 and T_1 . However, it was at par T_7 (FYM @ 7.5 t ha^{-1}+ 85% RDNPK). The lowest plant height was recorded with treatment T_1 (12.09 cm). The increase in plant height with integration of organic, inorganic and foliar grade fertilizers might be due to availability of balanced nutrition throughout plant growth Application of FYM attributed to better supply of nutrients resulted in enhanced crop growth by cell enlargement in meristematic region and there by more plant growth. The above results are supported by the findings of Thorave and Dhonde (2007) and Sonawane *et al.* (2010).

Number of nodule per plant

At harvest treatment T_6 (FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose) showed maximum number of root nodules per plant which were significantly superior over the treatments, T_8, T_3, T_4, T_2 and T_1. However, it was comparable with T_7 (FYM @ 7.5 t ha^{-1}+ 85% RDNPK) and T_5 (FYM @ 7.5 t ha^{-1}+ 100%RDNPK). Among all the treatment T_1 (control) recorded minimum number of nodule per plant at harvest. Application of FYM influenced better root development and plant vigour which has enhanced the nitrogen fixing power of the plant by increasing the activity of nodulating bacteria and resulting in more number of nodules $plant^{-1}$. Above results are in the agreement with findings of Deshmukh *et al.* (1995), Borse *et al.* (2008) and Kausale *et al.* (2009).

Number of developed pods per plant

Various treatments showed significant differences in the number of developed pods. Treatments T_6 (FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose) recorded higher number of developed pods (21.20) and found statistically superior over all the treatments. Treatment T_1 (control) recorded lowest number of developed pods (14.33).

Yield of dry pods

The Table No.1. Include the data regarding yield of dry pods per plant, per plot and per hectare as influenced by various treatment**.** It revealed that, the dry pod yield of summer groundnut was influenced significantly due to various treatments and mean dry pod yield was recorded 2381 kg ha^{-1}.

Pod yield obtained with application of FYM @ 7.5 t ha^{-1} + 100 % RDNPK + foliar application of starter dose and Booster dose (T_6) was significantly superior over rest of treatments. However, treatment T_6 found comparable with treatment T_5 (FYM @ 7.5 t ha^{-1}+ 100%RDNPK) and significantly superior over the remaining treatments i.e.T_2, T_8, T_7, T_3 and T_1. These treatments were also significantly different from each other. Treatment T_4 i.e. 100% RDF + foliar application of starter dose + Booster dose also recorded significantly superior dry pod yield ha^{-1} over the treatments T_8, T_7, T_3 and T_1. Treatment (T_2) i.e. 100% RDF recorded (2605.78 kg ha^{-1}) pod yield ha^{-1}. Application FYM @ 7.5 t ha^{-1} + 100 % RDNPK + Foliar application of starter dose and Booster dose (T_6) yield was (39%) more as compared to the control treatment. It indicates that if the application of recommended dose of 25 kg N + 75 kg P+ 25 kg k it applied through inorganic fertilizer with FYM and foliar application of starter dose and Booster dose, a high yield of summer groundnut can be harvested. 60% more as compared to the control treatment. Pod yield increased might be due to application of recommended dose of fertilizer along with water soluble foliar grade fertilizer and FYM influenced the yield attributes through more photosynthesis and their by increased pod yield.These findings were supported by Shinde *et al.* (2000), Shankhe *et al.* (2004), Thorave and Dhonde (2007), Chandrasekaran *et al.* (2008).

Biological yield per hectare

Table No.1 indicated that the biological yield was influenced significantly due to different treatment and mean biological yield was 6279.73 kg ha^{-1}.Treatment T_6 recorded significantly higher biological yield as compared to all other treatments. The maximum biological yield was recorded with application of FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose (8166.62 kg ha^{-1}); whereas lowest yield was obtained with the control treatment T_1 (4595.21kg ha^{-1}).

Oil content and Oil yield per hectare

While in case of oil content, treatment T_6 (FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose) recorded highest oil content (51.60 %) and significantly superior over the treatments T_7, T_5, T_2, T_4, T_3 and T_1. Lowest oil content was observed in control treatment T_1 (48.98).

Similar, results were also reported by Ananda *et al*. (2004) and Chandrasekaran *et al.* (2008) .Oil yield found significantly different in all the treatments. The application of FYM @ t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose (T_6) recorded oil yield of 10.37 q ha^{-1} was found to be significantly superior over all the treatments. Also treatment T_5 recorded best oil yield of (9.19 q ha^{-1}) after $T_{6.}$ These treatment differences effect significantly in respect of oil yield per hectare. However, the lowest oil yield (5.65 q ha^{-1}) was obtained with control treatment $T_{1.}$ Similar, results confirmed with Borse *et al.* (2008).

Studies on Economics

The data on the response of groundnut to different in term of yield and the economics of their use are presented in Table 1.

Table 1. Effect of Integrated Nutrient Management With Water Soluble Foliar Grade Fertilizer In Summer Groundnut

Treatment	Final plant stand	Plant height (cm)(At Harvest)	Number of root nodules per plant (At Harvest)	Number of developed pods	Pod yield (kg ha^{-1})	Oil %	Oil yield (q ha^{-1})	Biological yield (kg ha^{-1})	Net return	Cost benefit ratio
T_1- Absolute control	256	12.09	25.57	14.33	1732.78	48.98	5.65	4595.21	28953	1.78
T_2- 100 % RDF	259	13.53	27.50	17.53	2605.78	49.94	9.07	6440.44	68914	2.61
T_3 - Foliar application of starter dose and booster dose	257	13.20	26.43	17.60	1984.10	49.39	6.84	5440.45	57376	2.40
T_4- 100 % RDF NPK+T3	260	12.53	26.63	18.30	2658.69	49.60	8.52	6619.01	75937	2.73
T_5- FYM @7.5 t ha^{-1} + 100 % RDNPK	262	13.62	28.44	19.30	2718.22	49.73	9.19	7333.30	79464	2.77
T_6- FYM @7.5 t ha^{-1} + 100 % RDNPK+ T_3	264	15.07	30.43	21.20	2890.17	51.60	10.37	8166.62	84263	2.84
T_7- FYM @7.5 t ha^{-1} + 85 % RDNPK	257	15.00	28.60	17.80	2195.74	50.20	7.8	5749.97	68149	2.52
T_8- FYM @7.5 t ha^{-1} + 85 % RDNPK+ T_3	258	12.77	27.23	17.00	2262.65	50.61	7.6	5892.83	69582	2.52
S.E.(M) ±	8.99	0.44	0.87	0.61	80.10	0.41	0.26	208.57	2365.51	-
C.D. at 5%	NS	1.36	2.61	1.85	242.97	1.24	0.81	632.65	7175.06	-
GM	259.13	13.47	27.60	17.88	2381.02	50.00	8.13	6279.73	66579.75	2.52

The highest benefit: cost ratio of 2:84 and net monetary return (84263 Rs ha^{-1}) was obtained when the crop of groundnut was applied with FYM @ 7.5 t ha^{-1}+ 100 % RDNPK + foliar application of starter dose and Booster dose (T_6) and it was closely followed by the treatment T_5 (FYM @ 7.5 t ha^{-1}+ 100%RDNPK). Treatment T_5 recorded B: C ratio to the extent of 2.77 showing these treatments to be most economic. The B: C ratio as low as 1.74 was recorded in control treatment T_1.

Similar results were reported by Halepyati (2001), Madhiyazhagan *et al.* (2002), Pareek and poonia (2011) and Virida *et al.* (2011).

CONCLUSIONS

1. Application of inorganic fertilizers (100 % RDNPK) combined with organic manure and foliar grade fertilizer favorably improved growth, yield contributing character, yield
2. Combined application of inorganic fertilizer (100 % RDNPK) and FYM in groundnut was more beneficial than recommended dose of fertilizer alone
3. Integration of organic (7.5 t ha^{-1}), inorganic fertilizer (100% RDF) and foliar grade fertilizer was found superior than the application of RDF only. This treatment recorded highest pod yield (28.90 q ha^{-1}) net monetary return (84263 Rs. ha^{-1}) and Benefit: cost ratio (2.84)

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Waste Plastic Material based Mulching: An Alternative to the Conventional Mulching System in Vegetable Crop

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ABSTRACT

A field experiment was conducted at Faculty of Agricultural Engineering, IGKV, Raipur to analyze the effect of different type of mulches on soil temperature, soil moisture depletion for growing cherry tomato (Pimpinelifolium L.) in Alfisol. Different mulches such as black polythene mulch (BPM), paddy straw mulch (PSM), waste plastic mulch (WPM - plastic bag, fertilizer bag etc.) was used and irrigation was done through drip system at 100% crop water requirement. Each experiment was replicated four times. Soil temperature was recorded at 7.00 AM and 2.00 PM at 5 cm and 10 cm depth. Moisture content and soil moisture depletion at 12cm and 20 cm depth of soil was worked out by Time Domen Reflectometer. The soil temperature (in morning) was found maximum in 10 cm depth compared to 5 cm depth under BPM, followed by WPM, PSM and WM. Similarly, in the afternoon the soil temperature was found maximum in 5 cm depth compared to 10 cm depth under BPM, followed by WPM, WM and PSM. Similarly, maximum soil moisture content and minimum soil moisture depletion were obtained under BPM, WPM, than under PSM and WM at 12 cm and 20 cm soil depth. In view of yield attributes such as length of plant: 1.5 m under BPM and WPM, more than PSM 1.23 m and WM 80 cm, number of fruits per plant BPM and WPM (231.57) is more as compared to PSM and WM, the yield of cherry tomato is 1.5, 2, 2.1 times higher than the without mulch respectively PSM, WPM, BPM. Result shows that increase in yield with BPM and WPM is at par. However, availability of BPM is a constraint for the poor farmer in remote areas. On the other side waste plastic are readily available and can be utilized as mulching material with some efforts.

Keywords: Mulches, Drip Irrigation, Soil Temperature, Soil Moisture Depletion.

INTRODUCTION

Mulching is the process of covering the soil surface around the plants to create congenial conditions for the crop growth. This may include moisture and soil conservation, temperature moderation, salinity and weed control etc. It exerts a decisive affect on earliness, yield and quality of the crop. Mulches are used for various reasons but water conservation and erosion control are the most important objects in agriculture in dry regions. Mulches when property managed definitely aid wind and water erosion control. The effect of mulch upon soil moisture content is complex. Mulch forms a layer between the soil and the atmosphere which prevents sunlight from reaching the soil surface, thus reducing evaporation. However, mulch can also prevent water from reaching the soil by absorbing or blocking water from light rains.Other reason for high mulching is followed includes soil temperature modification soil conservation nutrient addition, improvement in soil structure weed control and crop quality control. Continuous use of mulches is helpful in improving the organic matter content of soil which in turn improves the water holding capacity of the soil. There are two basic kinds of mulch: organic and inorganic. Organic mulches include formerly living material such as chopped leaves, straw, grass clippings, compost, wood chips, shredded bark, sawdust, pine needles, and even paper. Inorganic mulches include gravel, stones, black plastic, and geotextiles (landscape fabrics). Both types discourage weeds, but organic mulches also improve the soil as they decompose. Inorganic mulches don't break down and enrich the soil, but under certain circumstances they're the mulch of choice.

Mulches break the force of rain and irrigation water thereby preventing erosion, soil compaction and crusting. Mulched soils absorb water faster. Mulches prevent splashing of mud and certain plant disease organisms onto plants and flowers during rain or overhead irrigation. The mulch covering excludes light which prevents germination of many weed seeds. Fewer weeds provide less competition for available moisture and nutrients. Using mulches to control weeds is safer than applying herbicides or cultivating which can damage tender, newly formed roots. Mulches also add attractive features to landscape.

Drip irrigation system along with mulching is most suitable approach for cultivation of cherry tomato (*Pimpilenifolium L.*). Drip irrigation is an efficient method of providing irrigation water directly in to soil at the root zone of plant and it permits the irrigation to limit the watering closely to the consumptive use of plants. Thus, micro runoff and soil evaporation. It also permits the utilization of fertilizer, pesticides and other water-soluble chemicals along with the irrigation water with better crop response.

Cherry tomato (pimpinelifolium L) is a popular type of a table tomato with small fruits and the demand for cherry tomato has increased in the market, chiefly due to the recognition of their high quality and good taste (Kobryn and Hallmam, 2005). These small tomatoes often have a sweeter taste than full-size tomatoes and offer several nutritional benefits. The cherry tomato is also beneficial to human health because of its high water of antioxidant and photochemical compounds, including lycopene, ß-carotene flavonoids, vitamin C and many essential nutrients (Rosales et al., 2011). Cherry tomatoes are miniature versions of traditional beefsteak tomatoes, but they are equally as nutritious. In addition to the 1.3 grams of protein, 1.8 grams of fiber and 20 milligrams of vitamin C in 1 cup of cherry tomatoes, you also get a healthy dose of other vitamins and minerals essential for good health.

MATERIALS AND METHODS

Experimental Site

Field experiments were carried out during the year 2014-15 at Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), located in the central part of Chhattisgarh at Longitude 81.360 E, Latitude 21.160 N and at an Altitude of 289.56 meters above the mean sea level.

Experimental Design and Treatments

The experiments were laid out in a having four replications. In this experiment, different mulches such as black polythene mulch (BPM), paddy straw mulch (PSM), waste plastic mulch (WPM - plastic bag, fertilizer bag etc.) and without mulch were used and irrigation was done through drip system at 100% crop water requirement. Each experiment was replicated four times Drip irrigation system consists of drip tubing placed in each row of plant. During irrigation, water pressure in the system was maintained at 1.2 kg/cm2. The cherry tomato plants were spaced at 1m x 1m and the polythene mulch of 25 micron thickness, used plastic and paddy straw mulches applied during the study period.

Measurement of Soil Temperature

Temperature of soil was taken during the experiment with the help of digital soil thermometer. Soil temperature was taken at 5 and 10 cm depth by inserting sensor rod of digital soil thermometer below the soil surface. Soil temperature was taken from the plot covered with different mulches as black polythene mulch (25μ), use plastic mulch, paddy straw mulch and without mulch. Observation was recorded to know the effect of different mulches on soil temperature which indirectly affect the crop production. The daily records of soil temperature were taken at 7:30 am and 2:00 pm.

Soil Moisture Measurement

Moisture of soil was taken during the experiment with the help of Time Domen Reflectometer. Soil moisture was taken at 12 and 20 cm depth by inserting sensor rod of digital time domen reflectometer below the soil surface. Soil moisture was taken from the plot covered with different mulches as black polythene mulch (25μ), used plastic mulch, paddy straw mulch and without mulch. Observation was recorded to know the effect of different mulches on soil moisture which indirectly affect the crop production. The daily records of soil moisture.

Soil moisture depletion (mm)

$$= \frac{(\text{F.C.} - \text{M.C.}) \times \text{Root zone depth} \times \text{B. D.}}{100}$$

Where,

F.C. = Field capacity (%),

M.C. = Moisture content (%),

B.D. = Bulk density (g/cc).

Plant height (m)

The plant height of Capsicum plant was measured from the ground level to the tip of the tree canopy by using measuring tape and average was calculated.

Number of fruits

The number of fruits was counted from each plant at an average was calculated.

Fruit yield

Total yield per plant was calculated by weighing the fruits after harvesting.

RESULTS AND DISCUSSION

Effect of different type of mulches (black plastic, used plastic, paddy straw and without mulch) on soil temperature, soil moisture content, soil moisture depletion and yield of crop under different level of irrigation were recorded and are presented in the form of tables.

Effect of Different Type of Mulches on Soil Temperature

Soil temperature was recorded at 7:00 AM and 2:00 PM from 15 January to 5 March (Fig. 1 to 5). The weekly average of daily recorded soil temperature at 5 and 10 cm depth is presented in Table 1.

Table 1. Weekly average of daily recorded soil temperature under BPM and WPM of mulches

Black plastic mulch				Waste plastic mulch			
7.00AM		2.00PM		7.00AM		2.00PM	
5cm	10cm	5cm	10cm	5cm	10cm	5cm	10cm
15.97	18.44	25	22.764	15.23	17	24.87	21.86
16.83	19.475	27	24.33	15.96	17.96	26.55	23.24
16.98	19.357	26.485	25	16.22	18.67	25.13	24.46
17.5	19.757	26.671	25.157	16.87	18.25	25.135	24.97
18.45	20.571	28.2	26.2	17.96	19.59	27.531	25.78
21.67	23.6	31.75	28.95	20.5	22.4	29.86	27.25
19.35	20.55	28.02	25.93	18.67	19.93	26.78	24.55
Mean							
18.107	20.250	27.591	25.47	17.34	19.13	26.78	24.507

Table 2. Weekly average of daily recorded soil temperature under PSM and WM of mulches

Paddy straw mulch				Without mulch			
7.00AM		2.00PM		7.00AM		2.00PM	
5cm	10cm	5cm	10cm	5cm	10cm	5cm	10cm
14.57	16.5	23.5	22.5	13.89	15.87	20	19
15.93	17.33	23.57	22.57	14.96	16.55	22.7	21.71
15.5	17.671	21.87	19.62	15.37	16.6	23.72	21.15
16.32	18.27	23.198	21.41	14.95	16.78	24.1	23.14
16.2	18.64	23.314	22.07	15.42	16.82	25.9	23.75
20	21.78	25.24	23.92	17.67	19.54	28.47	26.97
19.5	21.8	23.43	21.92	20.7	22.2	25.95	23.79
Mean							
16.86	18.859	23.44	22	16.137	17.765	24.35	22.699

From table it can be seen that at 7:30 AM the average soil temperature at 10cm depth is higher as compared to 5 cm depth under all four type of mulches. At the same time soil temperature has been found maximum under black plastic mulch followed by waste plastic mulch, paddy straw mulch and without mulch at 5 and 10 cm depth. The result revealed that during forenoon soil temperature increases with increasing depth. Increasing and decreasing trend of soil temperature under black plastic mulch depends on daily atmospheric temperature. Similar trend fallows in the case of waste plastic mulch, paddy straw and without mulch. The result concluded that at 7:00 AM the average soil temperature under BPM is 0.767, 1.247 and 1.97°C higher than under WPM, PSM and WM at 5 cm depth respectively. Similarly, at 10 cm depth soil temperature under BPM is 0.811, 4.151 and 3.241°C higher than under WPM, PSM and WM respectively. At the same time the average soil temperature under WPM is 0.48and 1.21°C higher than under PSM and WM at 5 cm depth respectively. Similarly, at 10 cm depth soil temperature under WPM is 3.34 and 2.43°C higher than under PSM and WM. At the same time the average soil temperature under PSM is 1.025 and 0.723 °C higher than under WM at 5 and 10 cm depth respectively

Based on the recorded data at 2:00 PM the average soil temperature at 10cm depth is lower compared to 5 cm depth under all four types of mulches. At the same time soil temperature has been found maximum under black plastic mulch followed by waste plastic mulch, without mulch and paddy straw mulch at 5 and 10 cm depth. The result revealed that at afternoon soil temperature decreases with increasing depth. At 2:00 PM the average soil temperature under BPM is 0.811, 4.151 and 3.241°C higher than under WPM, PSM and WM at 5 cm depth respectively. Similarly at 10 cm depth soil temperature under BPM are 0.963, 2.77 and 3.47 °C more than under WPM,WM and PSM respectively. At the same time the average soil temperature under WPM is 2.41and 3.32°C higher than under WM and PSM at 5 cm depth respectively. Similarly, at 10 cm depth soil temperature under WPM is 2.587 and 1.888°C higher than under PSM and WM. At the same time the average soil temperature under WM is 0.699and 0.91 °C higher than under PSM at 5 and 10 cm depth respectively.. The result revealed that soil temperature variation is low under paddy straw mulch and high under without mulch at 5 and 10 cm depth. The results are in conformity with the findings of Singh and Kamal (2012), El- Shaikh and Fouda (2008), Ramakrishna *et al.*, (2006), Mbagwu (1991) and Lee and Yoon (1975).

Effect of Different Mulches on Soil Moisture Content and Soil Moisture Depletion

Average soil moisture content and soil moisture depletion with different mulches were measured at 12 cm and 20 cm soil depth and is presented in Table 3.

Table 3. Soil moisture content and soil moisture depletion under different mulches

MULCHES	12 cm depth		20 cm depth	
	M.C.%	**SMD(mm)**	**M.C.%**	**SMD(mm)**
BPM	27.3	1.53	25.6	3.53
WPM	26.2	2.84	24.5	4.81
PSM	25.4	3.29	23.8	4.92
WM	21.2	6.48	23.74	4.30

From table it can be seen that at the 12 cm depth soil moisture content (27.3, 26.2, 22.54,25.4 and 21.2%) and soil moisture depletion (1.53, 2.84, 3.29 and 6.48 mm) were found under BPM, WPM, PSM and WM respectively. Similarly, at 20 cm depth soil moisture content (25.6, 24.5, 23.8 and 23.74%) and soil moisture depletion (3.53, 4.82, 4.92 and 4.39 mm) was found under BPM respectively. From table 3 it can be seen that maximum soil moisture content (27.3% and 25.6%) and minimum soil moisture depletion (1.53mm and 3.53mm) were found under the 100 % of CWR with BPM at 12 and 20 cm depth of soil respectively. Similarly, minimum soil moisture content and maximum soil moisture depletion were found under control WM at 12 and 20 cm depth of soil.

Maximum soil moisture content and minimum soil moisture depletion have been found under BPM followed by WPM, PSM and WM. Based on experimental records it is concluded that soil moisture content was found maximum at 12 cm depth compared to 20 cm depth in case of BPM,WPM and PSM, but in case of WM soil moisture content was found less at 12 cm depth than at 20 cm depth. Similarly, soil moisture depletion was found maximum at 12 cm depth compared to 20 cm in case of BPM, WPM, and PSM, but in case of without mulch soil moisture depletion was found minimum at 20 cm depth compared to 12 cm depth. The results are in conformity with the finding of Singh and Kamal (2012), Al-Rawahy *et al.*, (2011), Ramakrishna *et al.*, (2006) and Mbagwu (1991).

Effect of Different Type of Mulches in the Growth characters of cherry tomato

Table 4. Growth characters of cherry tomato in different mulches

Mulches	Plant height	No. of fruit/plant	Yield (q/h)
BPM	1.68	231.57	185
WPM	1.6	220.42	175.62
PSM	1.4	180.97	143.72
WM	1.1	167.86	125

From table it can be seen that the plant height, primary branches secondary branches, number of fruit per plant and yield significantly effected by different mulches. The data reveals that significantly maximum plant height was recorded with BPM (1.68m) followed by WPM (1.6m), PSM (1.32m) and WM (90 cm). The numbers of fruits have been found under different mulches. The BPM (231.57) is maximum compared to WPM (220.42), PSM (180.97) and WM (167.86). The yield of crop was recorded with different mulches. Due to effect of different type of mulches, significantly maximum yield (q/ha) was recorded under the BPM (185 q/ha) followed by WPM (175.62 q/ha), PSM (143.75q/ha) and WM (125q/ha) respectively.

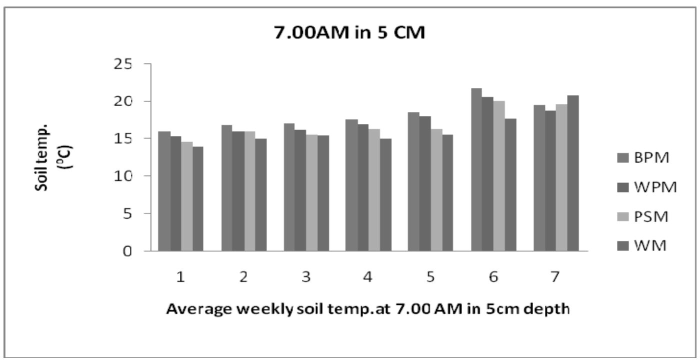

Figure 1. Average weekly soil temperature at 7:00 AM in 5 cm depth

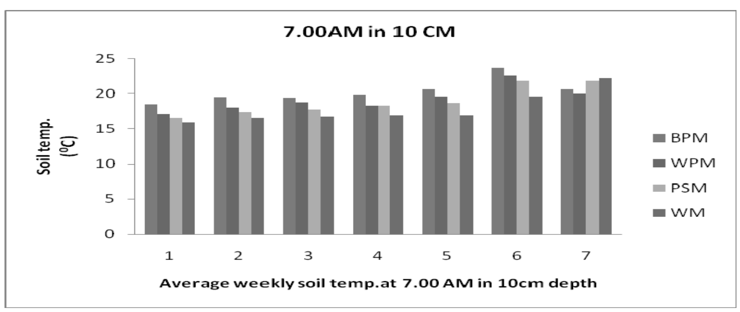

Figure 2. Average weekly soil temperature at 7:00 AM in 10cm depth

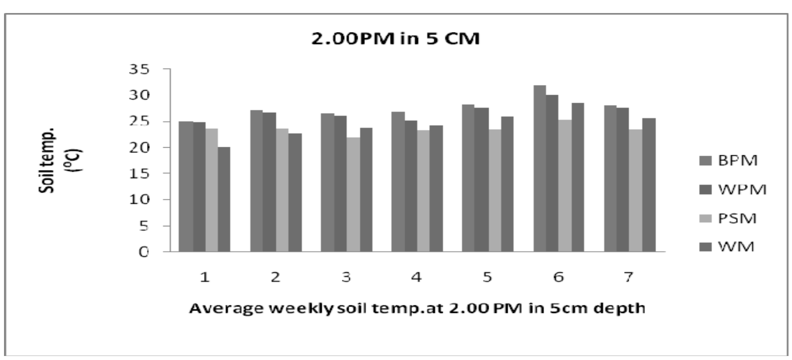

Figure 3. Average weekly soil temperature at 2:00 PM in 5 cm depth

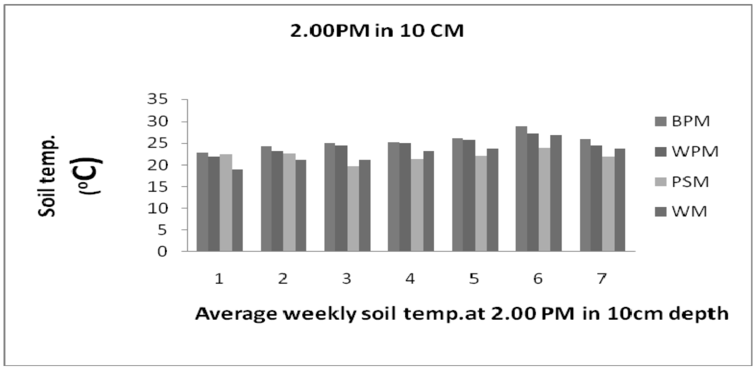

Figure 4. Average weekly soil temperature at 2:00 PM in 10 cm depth

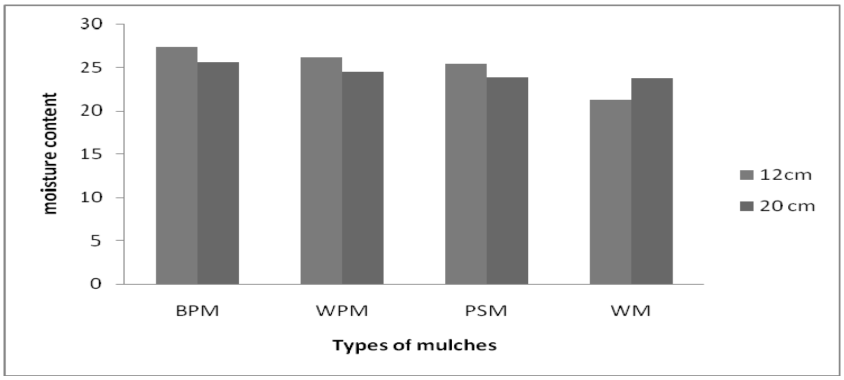

Figure 5. Soil moisture under different mulches at 12 cm and 20cm depth

CONCLUSION

Use of different type of mulches with 100 % level of irrigation is helpful for providing adequate amount of moisture and temperature which directly help in to increase production of crop.

ACKNOWLWDGEMENT

The authors thankfully acknowledge the help received during the course of investigation from Faculty of Agricultural Engineering, IGKV, Raipur.

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Summer Maize: An Alternative to Summer Paddy

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ABSTRACT

In Chhattisgarh, maize occupies an area of 102.70 thousand ha with an annual production of about 185.8.0 thousand tonnes and an average productivity of 1809 kg ha^{-1} (Anonymous, 2010). Maize is grown throughout the year in India. It is predominantly a kharif crop with 85 per cent of the area under cultivation in the season. Maize is the third most important cereal crop in India after rice and wheat. It accounts for ~9 per cent of total food grain production in the country. Maize production in India has grown at a CAGR of 5.5 per cent over the last ten years from 14 Mn MT in 2004-05 to 23 Mn MT in 2013-14. (Anonymous, 2014). Chhattisgarh is dominated by monocropping of rice in *kharif* season and cropping intensity varies from 130-137 per cent. The climate of the region is sub humid with an average annual rainfall of 1200-1400 mm. The investigated area was conducted during the *summer* season of 2012 and 2013 at Kotela village in Charama cluster, Raipur, Chhattisgarh. In Kotela village, rice, maize and ladyfinger was grown side by side fields and yield and water use was recorded. The results of this site is revealed that all the parameters like Water requirement of rice was 2772 mm whereas 733 mm and 1650 mm water was required respectively in maize and ladyfinger. Water use efficiency was 1.7 kg ha^{-1} cm of rice. It was 7.8 and 18.7 kg ha^{-1}-mm respectively in maize and ladyfinger and crops yield 24.4 q rice from 0.50 ha while 217 q maize and 517 q ladyfinger can be harvested respectively from 3.78 ha and 1.68 ha. Maize will give 6 times more net return than summer rice while net returns from ladyfinger will be 13 times higher than rice.

INTRODUCTION

In India, summer rice is grown in 4.83 million ha with average productivity of 3174 kg/ha (2010-11). In Chhattisgarh, area under Rabi crops is 1.707 million ha. During Rabi season irrigation is available to 0.361 million ha, in which, share of summer rice is 45% (0.164 million ha) with average yield of 1941 kg/ha. Get water and overuse it, seems to be the rule under canal command for rice cultivation. In head reach of canal command of major and medium irrigation projects, irrigation is being given for summer rice in the state. Field to field irrigation is common practice in canal command where rice is grown. Improper irrigation methods and misconceptions are the stated reasons for the high wastage of a scare resource. Large amount of water is lost in seepage and percolation (S&P) and also overflows though streams in canal command. Loss from S&P is estimated at 50 per cent in heavy textured clay soils and about 85 per cent in light textured loamy sands and laterite soils.

Maize is grown throughout the year in India. It is predominantly a kharif crop with 85 per cent of the area under cultivation in the season. Maize is the third most important cereal crop in India after rice and wheat. It accounts for ~9 per cent of total food grain production in the country. Maize production in India has grown at a CAGR of 5.5 per cent over the last ten years from 14 Mn MT in 2004-05 to 23 Mn MT in 2013-14. (Anonymous, 2014). Maize (*Zea mays* L.) belongs to family Poaceae is one of the most important cereal crops of the world, after wheat and rice, and has great importance in the world agricultural economy both as a food and fodder crop. Maize grains are used for human consumption, feed for poultry and livestock, extraction of edible oil and also for starch and glucose industry. Corn oil is becoming popular due to its non-cholesterol character. In addition, its products like corn starch, corn flakes, gluten germ cake, lactic-acid, alcohol and acetone are either directly consumed as food or used by various industries like paper, textile, foundry and fermentation (Nazir *et al*., 1994). Maize crop has multiple uses. The kernel contains about 77 per cent starch, 2 per cent sugar, 9 per cent protein, 2 per cent ash on water free basis. Maize oil has higher poly unsaturated fatty acid content and low in linoleic acid (0.7%) and contains high level of natural flavour. It is a miracle crop with very high yield potential. Due to its tremendous yield potential and wider adaptability, in India, it is also known as 'Queen of cereals.

In India, maize is grown over an area of 8.67 million ha with an annual production of about 21.60 million tonnes and an average productivity of about 2492 kg ha^{-1} (Anonymous, 2012). In Chhattisgarh, maize occupies an area of 102.70 thousand ha with an annual production of about 185.8.0 thousand tonnes and an average productivity of 1809 kg ha^{-1} (Anonymous, 2010). Maize being a C_4 plant has tremendous yield potential and responded well to applied inputs. However, its yield potential could not be explored fully due to uneven and erratic rainfall pattern leading to severe water stress and weed competition. Chhattisgarh is dominated by monocropping of rice in *kharif* season and cropping intensity varies from 130-137 per cent. The irrigation facility in the state is very meager and it is hardly more than 30 per cent which is mainly available as protective irrigation for rice. In order to feed the growing population, there is urgent need to increase the productivity per unit area per unit time which can be increased by increasing the cropping intensity especially under irrigated area to fulfill the food requirement of the country.

At present, the dominant cropping system in Chhattisgarh plain is rice followed by wheat/chickpea/safflower, *etc*. but the productivity of these crops are very less because the farmers generally grow medium to late duration rice varieties like Swarna which is harvested in late November and lifting of harvest and preparation of land for *rabi* cultivation delayed the planting of wheat/chickpea under normal situation. However, in some part of Chhattisgarh farmers keep their land fallow in *kharif* season due to submergence of field in low lying areas and utilize the land for cultivation after receed of water from the field. They generally grow vegetable/pulse crops in *rabi* and summer season. In such cases, summer maize is one, which can be adjusted successfully under assured irrigation system. Now days, hybrid varieties of maize with different durations are available, but their performance is varying in different soil-plant-climate management complex. It is well known fact that high temperature at initial stage of maize is not congenial for the proper growth and further at tasseling and silking stages the rains also affect the fertilization of cobs. Considering those factors there is needed to identify suitable agro-management practices for maximizing maize production specially in the *summer season*.

In the background of shrinking water resources and competition from other sectors, the share of water allocated to irrigation is likely to decrease by 10 to 15 per cent in the next two decades. One of the ways of alleviating water scarcity is by enhancing its use efficiency or productivity. Improving WUE in agriculture will require an increase in crop water productivity (an increase in marketable crop yield per unit of water used by plant) and reduction in water losses from the crop root zone. Improving water use efficiency by 40% on rainfed and irrigated lands would be required to counterbalance the need for additional withdrawals for irrigation over the next 25 years to meet the additional demand for food. Growing more crops per drop of water use is the key to mitigating the water crisis, and this is a big challenge to many countries. Among the irrigation system, drip irrigation helps in maintaining the optimum soil moisture in soil root zone with increased yield and water use efficiency. Efficient use of water is highly critical to sustain agricultural production, more particularly in the context of declining per capita land and water availability. The utilization of water by crop varies with different irrigation levels, methods and season of cultivation. Optimum irrigation levels with suitable method of planting would help in enhancing the yield of corn apart from higher water use efficiency in *summer* planted maize crop.

In order to harness hand some yields from *summer* maize, the biggest productivity constraints is water. The availability of water during summer season is very meager. Judicious use of available water through drip irrigation in wider spaced crop like maize can be better option in *summer* season. There is need to grow more profitable crop like maize in *summer* season which can give more remuneration than existing pulses and oilseeds. It is a well established fact that for attaining higher crop production, the soil moisture supply should be adequate throughout the growth period. In general, the importance of water for plant growth is very well documented. However, with regard to the effect of irrigation levels on *summer* maize requires attention under different farming situations of Chhattisgarh plains. Therefore, detailed study is warranted to identify the appropriate irrigation level for summer maize taking to the good profitability of summer maize in the state.

In Chhattisgarh, the average annual rainfall is 1400 mm, which is mainly congenial for rice cultivation. As regards to soil type, rice is mainly cultivated in *Matasi* (Inceptisol), *Dorsa* (Alfisol) and *Kanhar* (Vertisol), which represents 45.5 %, 10 % and 25 % of total net cultivated area, respectively. In Chhattisgarh, the upland unbunded bharri (*Kanhar*) occupies 10 % (3.4 lakh ha) area. Out of 10 lakhs ha area under upland in Chhattisgarh, 30 % area in under heavy soil and 70 % is under light soil. In upland heavy soil, maize has gained popularity among the farmers. Maize can prove to be the best option for crop diversification in upland and mid land terrains of Chhattisgarh. Till date, much emphasis in Chhattisgarh has been given to realize maximum production by mainly single crop *i.e.* rice but concerted efforts are now needed for tapping the untapped productivity of cropping system. Therefore, the situation calls for the use of dynamic and innovative approaches to get maximum productivity from every unit of land. *Summer* maize in Chhattisgarh is a better option for providing higher productivity and overall profitability through increased cropping intensity. Farmers of Chhattisgarh are well aware with cultivation of rice. Therefore, with availability of water farmer prefer to grow summer rice. Enterprising farmer may grow vegetable for higher return. In Chhattisgarh, farmers grow summer rice both in canal and tube well commands. Tube well irrigation in summer rice is highly injudicious because of high use of energy in lifting of groundwater which is scarce resource in the state. However, yield of summer is higher than wet season crop but area of potential rabi crops can be increased substantially by substituting summer rice to earn more, than rice. But farmers are well aware with cultivation of rice and don't interested to grown other equally remunerative rabi crops. Looking to above problems associated with summer rice investigations were conducted with the objectives (i) to compare productivity and income of maize and vegetable over summer rice and (ii) to optimize use of ground water resource for enhancing irrigation efficiency in summer crop production.

MATERIALS AND METHODS

The investigated area was conducted during the *summer* season of 2012-13 and 2013-14 at Kotela village in Charama block of Kanker district, Chhattisgarh. The Kotela village was nearly 120 km from Raipur, the state capital. The soil was clay loam, low in available nitrogen and phosphorus and rich in potash with neutral in reaction (pH 6.2). Six replications on six fields of farmers (6 acre land) were taken to conduct the trails. Each field was divided into three equal parts for growing summer rice, maize and lady finger. There were two tube wells with the farmers for sharing water to irrigate rice, maize and ladyfinger. Rice variety MTU1010 was grown by transplanting seedlings in 3rd week of January and at the same time hybrid maize and ladyfinger was sown following recommended agronomic package of practices.

RESULTS AND DISCUSSION

Water discharge: Discharge of tube well was 21 m^3 $hour^{-1}$. This was 1764 m^3 $week^{-1}$ while tube well runs for 12 hours daily for 7 days. Daily irrigation was given to rice and twice a week in maize.

No. of irrigation: Daily irrigation applied in rice filed while every three days interval irrigations were given in a week in ladyfinger. In maize irrigation applied every six days in a week. Total no. of irrigation applied in rice was 111 and 17 in maize and 32 in ladyfinger. So that the total water applied in 555 cm in rice while 119 cm in maize and 225.17 cm in ladyfinger. Duration of rice, maize and ladyfinger was 111, 102 and 96.5 days respectively.

Water use (mm): Watering was withheld 10 days before harvest of all the crops. With this water requirement a tube well can irrigate 5500 mm water for rice whereas 1167 mm water in maize and 2217 mm water in lady finger during 2012-13 can be grown under tube well command. During 2013-14 average water requirement of rice was 5550 mm whereas 1190 mm and 2252 mm water was required respectively in maize and ladyfinger.

Water use efficiency:- WUE (kg ha^{-1} mm^{-1}) was calculated as the ratio of Crop yield to water requirement (mm) of crop.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Crop yield (kg ha}^{-1})}{\text{Water requirement (mm)}}$$

During 2012-13 water use efficiency was 1.13 kg ha^{-1} mm^{-1} of rice. It was 0.20 and 0.07 kg ha^{-1}-mm^{-1} respectively in maize and ladyfinger. In 2013-14, average water use efficiency was 1.22 kg ha^{-1} mm^{-1} of rice while 0.20 of maize and 0.07 kg ha^{-1}-mm^{-1} ladyfinger respectively.

Yield (q/ha): Based on current tube well discharge and water requirement of the crops, during 2012-13 yield of rice is 48.5 qha^{-1} and 57.5 q ha^{-1} maize and 308.1 q ha^{-1} ladyfinger harvested. During 2013-14 it is possible to harvest average yield 45.7q ha^{-1} rice while 60.07q ha^{-1} maize and 320.35q ha^{-1} ladyfinger can be harvested respectively.

Economics: Growing of maize will give Rs. 48572 more net return than summer rice (Rs. 33619) while net returns from ladyfinger will be Rs. 156710.

Estimated command area: Rice equivalent yield (q) based on production from estimated tube well command area will increases from 120.2 to 132.5 of maize and 184.9 to 203.8 of ladyfinger.

Estimated production: Based on current tube well discharge and water requirement of the crops, it is possible to harvest estimated production of rice is 24.4 while, 164.6 of maize and 463.9 of ladyfinger obtained during 2013-14.

Estimated income: Estimated increase in net income over summer rice (times) was maize from 581 to 684 and from 998 to 1166 of ladyfinger.

Table 1 Detail of irrigation and estimated summer rice, maize and ladyfinger area commanded by tube well during summer season at kotela village, Charama block, district Kanker, Chhattisgarh

Particulars	2012-13			2013-14			Average		
	Rice	Maize	Ladyfinger	Rice	Maize	ladyfinger	Rice	Maize	ladyfinger
Growing period of crop	110	100	95	112	104	98	111	102	96.5
Irrigation interval (days)	Daily	6	3	Daily	6	3	Daily	6	3
No. of irrigations applied	110	17	32	112	17	33	111	17	32
Average depth of irrigation (cm)	5	7	7	5	7	7	5	7	7
Total irrigation water applied (ha- cm)	550.0	116.7	221.7	560.0	121.3	228.7	555	119	225.17
Tube well discharge (m^3 $hour^{-1}$)	21.00	21.00	21.00	23.73	23.73	23.73	22.37	22.37	22.37
Estimate of water availability (ha-cm), if tube well operated for 12 hour daily for the crop growing period-110 days	277.2	277.2	277.2	318.9	318.9	318.9	298.1	298.1	298.0
Estimated command area of tube well(ha)	0.50	2.38	1.25	0.57	2.63	1.39	0.54	2.50	1.32

Table 2 Yield and economic returns from summer rice, maize and lady finger on farmers field

Particulars	2012-13			2013-14			Average		
	Rice	Maize	Lady finger	Rice	Maize	Lady finger	Rice	Maize	Lady finger
Yield harvested (q/ha)	48.5	57.5	308.1	42.89	62.63	332.6	45.70	60.07	320.35
Water use (mm)	5500	1167	2217	5600	1213	2287	5550	1190	2252
Water use efficiency (kg ha^{-1}-mm)	1.13	0.20	0.07	1.31	0.19	0.07	1.22	0.20	0.07
Gross return(Rs./ha)	60625	63250	184860	53613	68893	199560	57119	66072	192210
Net return(Rs./ha)	37125	45750	149360	30113	51393	164060	33619	48572	156710
Estimated production from estimated tube well command(q)	24.4	136.6	385.3	24.4	164.6	463.9	24.44	150.62	424.59
Gross return(Rs.) from estimated tube well command	30555	150282	231172	30533	181089	278335	30544	165685	254754
Net return(Rs.) from estimated tube well command	18711	108702	186779	17150	135089	228822	17930	121896	207800
Rice equivalent yield (q) based on production from estimated tube well command	24.4	120.2	184.9	24.4	144.9	222.7	24.4	132.5	203.8
Estimated increase in net income over summer rice(times)	100	581	998	100	788	1334	100	684	1166

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Performance of Different Grasses in Mango based Horti-Pastoral Agroforestry System

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ABSTRACT

A field experiment was conducted during years 2012 to 2015 at the experimental farm of All India Coordinated Research Project (AICRP) on Agroforestry at Central Experimental Station Dr Balasahwb Sawant Konkan Krishi Vidyapeeth, Dapoli (MS). Mango based horti-pastoral agroforestry system consisting of mango as tree species planted in Kharif-2012 at spacing of 10m X 10m. Total six types of rainfed grasses were planted in this experiment in the month of July/August, 2012, namely, Ber *(Ischaemum indicum*), Setaria grass (*Setaria* spp.), Guinea grass (*Panicum maximum*), Marvel (*Dicanthium annulatum*), Moshi (*Iseilema laxum*), Fulgavat (*Themeda triandra*). Data recorded on height, DBH and canopy diameter of mango and yield of grasses. Data recorded on height, DBH and canopy diameter of mango were statistically non significant. The height and DBH of mango were ranged from 1.23 to 1.54 m. and 1.94 to 3.02 cm, respectively. Similarly, the East-West and North-South canopy spread of mango were varied from 41.25 to 70.52 and 39.79 to 70.00 cm, respectively. Treatment (Mango + Setaria grass) was recorded highest yield of 16.80 ton/ha, on dry weight basis followed by marvel (5.88 ton/ ha). Setaria grass Proved its superiority over other grasses in terms of yield with mango in combination, therefore *Mangifera indica* with *Setaria* spp. (Mango + Setaria grass) based horti- pastoral system of agroforestry may be preferred under rainfed condition in Konkan region.

Keywords: Horti-pastoral system, Mango, Grasses, Yield.

INTRODUCTION

In Konkan region most of the farmers were interested in planting more fruit trees on their farms, cash generation was a major reason for their interest. Preferred species were generally adapted exotics. Preference was in the order of *Mangifera indica, Anacardium occidentale* L, *Cocus nucifera*, Annona spp. and *Garcinia indica.* Mango is generally a spreading type of trees crop and requires lot of space for its canopy spread. When the planting is recommended at a spacing of 10m X 10m, the plants take minimum 6-7 years to cover the entire allotted space in the initial years such space can be made use of for planting suitable intercrops which would help in generation of additional income, conservation of soil and moisture and utilization of space and other natural resources more effectively in the juvenile stage of orchard life. Initially intercropping received little attention in the mango but inter-cropping has become popular with the systematic establishment of large-scale orchards. Selection of a suitable crop for mixed cropping or intercropping is very important since intercrop should not compete with the main crop for any of the natural resources. Mango is a sun loving crop plant and requires maximum solar energy for better yield. Therefore the crops which grow to the height of mango canopy or more will not be suitable intercrops. Intercropping is practiced in the first few years (6 to 7 years) when there is sufficient space between crop rows with the main objectives of deriving some income until mango starts giving economic returns. The prime aim of raising any tree crop under field condition is generally to make profit on capital investment (Rawat, 1989). The overall goal of raising tree crops along with agricultural crops in farm lands is to increase production, to generate a sustained agricultural product base, to reduce environmental damage, and to raise the standard of living of the farmer (Betters, 1988). Economic analysis helps a farmer to make decisions about allocation of scarce resources in a rational way in order to meet the targeted objectives (Hoekstra, 1990). Horti-pastoral system is one form of agroforestry where the tree component is a fruit tree. Agroforestry systems in India contribute variously to environmental, social and economic benefits. Environment benefits includes, reduction of pressure on forest, better protection of ecological systems, reduction of surface run-off, nutrient leaching and soil erosion through impending effect of tree roots and stems of these processes, reduction of evaporation of soil moisture through a combination of mulching and shading, Improvement of soil structure through the constant addition of organic matter decomposed litter. Horti-pastoral systems are definitely the most prominent agroforestry practice. System of rainfed grasses and mango have determined their potential of being a better economic investment of land use than producing solely fruits and timber or grazing livestock in open pastures. Depending on soil and climatic conditions and local situations rainfed grasses like Ber *(Ischaemum indicum*), Setaria grass (*Setaria* spp.), Guinea grass (*Panicum maximum*), Marvel (*Dicanthium annulatum*), Moshi (*Iseilema laxum*), Fulgavat (*Themeda triandra*), those are locally cultivated are selected for intercropping .

MATERIALS AND METHODS

The present experiment on study of performance different grasses in Mango based horti-pastoral agroforesty system was carried out at the experimental farm of All India Coordinated Research Project (AICRP) on Agroforestry at Central Experimental Station, Dr B.S. Konkan Krishi Vidyapeeth, Wakavali, Dapoli, during years 2012 to 2015 Mango based horti-pastoral agroforestry system consisting of mango as tree species planted in Kharif-2012 at spacing of 10m X 10m. Total six types of rainfed grasses were planted as inter crop in mango plantation in this experiment in the month of July/August, 2012, viz., Ber *(Ischaemum indicum*), Setaria grass (*Setaria* spp.), Guinea grass (*Panicum maximum*), Marvel (*Dicanthium annulatum*), Moshi (*Iseilema laxum*), Fulgavat (*Themeda triandra*), with the spacing of 45cm X 45cm. All grasses have established well. One to two cuttings was undertaken as per growth performance of every grass species. The experiment was laid out in Randomized Block Design (RBD) with four replications and seven treatments. A farm yard manure (FYM) and fertilizer doses for particular crops was given as per the university recommendations. The growth parameters like height, diameter, canopy east-west and north-south sides were recorded and analyzed as per the procedure described for RBD (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSIOINS

Perusal data of (Table 1) third year after plantation are reported and analyzed for growth attributes of mango and yield of grasses.

Table 1. Height and canopy diameter of Mango and yield of grasses grown in mango Plantation

Treatments	Mango				No. of cuttings	Grass yield ton/ha. (Dry basis)
	Height (m)	DBH (cm)	Canopy East-West (cm)	Canopy North-South (cm)		
T_1 Mango + *Ischaemum indicum*	1.31	2.57	70.52	43.65	1	2.10
T_2 Mango + *Setaria* spp.	1.54	1.94	54.38	51.98	4	16.80
T_3 Mango +Natural grass	1.30	2.51	51.88	47.19	2	3.50
T_4 Mango + *Panicum maximum*	1.30	3.02	55.31	48.51	4	4.06
T_5 Mango + *Dicanthium annulatum*	1.35	3.00	63.44	70.00	4	5.88
T_6 Mango + *Iseilema laxum*	1.27	2.11	41.25	39.79	1	0.22
T_7 Mango + *Themeda triandra*	1.23	2.11	61.77	53.85	4	4.40
SE. $\pm$	**0.11**	**0.46**	**10.16**	**10.50**		0.122
CD at 5%	**NS**	**NS**	**NS**	**NS**		0.364

***EW=East –West, **NS=North-South**

The height and DBH of mango were ranged from 1.23 to 1.54 m. and 1.94 to 3.02 cm, respectively. Similarly, the East-West and North-South canopy spread of mango were varied from 41.25 to 70.52 and 39.79 to 70.00 cm, respectively. Data recorded in respect of height, DBH and canopy diameter East-West and North-South of mango were statistically non significant. This may attributed that the tree species were not influenced by any particular intercrop tried. Similar findings have been reported in Rhodes grass intercropped with three specie, viz., *Acacia nilotica Dalbergia sissoo* and *Casuarina equisetifolia* (Batra and Kumar, 1994). Bean (*Phaseolus vulgaris*) raised in *Eucalyptus grandis* also studied by Couto and Gomes (1995) and Castor (*Ricinus communis*) and green gram (*Vigna radiate*) grown under three agroforestry tree species like *Emblica officinalis*, *Tamarindus indica* and *A. senegal* such experiment conducted by Korwar *et al*., 2006. There were statistically significant differences among the treatment for grass yield (ton/ha). The maximum four cutting during the period of 4 months (June to September) were given by *Setaria* spp., *Panicum maximum*, *Dicanthium annulatum* and *Themeda triandra*, where as Natural grass cut two times and *Ischaemum indicum* and *Iseilema laxum* recorded two cuttings. Treatment

Mangifera indica with *Setaria* spp. was recorded highest yield of 16.80 ton/ha, on dry weight basis followed by *Dicanthium annulatum* 5.88 ton/ ha.

CONCLUSION

The treatment number two *Mangifera indica* + *Setaria* spp. performed better in mango cultivation. Wheras, *Setaria* spp. highly proved its superiority over all the other grasses in terms of yield with mango in combination, therefore *Mangifera indica* with *Setaria* spp. based horti-pastoral system of agroforestry may be preferred beneficial under rainfed condition in Konkan region. This result should be confirmed by continuing experiment to three years more and on pooled data basis, it might be desirable and feasible over juvenile period of mango plantation.

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Rain Water Harvesting - Are We Going the Right Way

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ABSTRACT

The Rain Water Harvesting was promoted to utilize the non committed monsoon run off and to mitigate the water requirement. Many of the states have included rain water harvesting in the urban building bye-laws making it mandatory for the new infrastructure to adopt it. Depending upon the hydrogeology and geomorphology, a number of rain water harvesting structures have been constructed with different designs. The conventional recharge structures, although take care of part of the suspended load by constructing a desilting chamber and inverted filter consisting of different grades of sand and gravels before entering into the aquifer system through a recharge well but the maintenance of these structures have been a key concern. National Green Tribunal observed that most of the rain water harvesting structures are not maintained in the NCR region and so levied penalty on faulters. It is thus evident that rain water harvesting is not serving the purpose to recharge the aquifers but rather it is polluting the un-confined aquifers. In most of the cases, it is observed that the design is defected for desilting through the inverted filters as the very fine particles enters the recharge well causing clogging and this is the main cause for their non-maintenance regularly. The inverted filter used at present for removing the suspended load in storm water need to be replaced with the Geo-textile with opening matching with the size of the clay particles and with an additional arrangement to remove the colloidal particles. Another key problem is the process for granting the permission to make the recharge structures in the areas categorized as over exploited. The paper discusses in detail the various constraints in implementing rain water harvesting and the possible solutions thereof.

INTRODUCTION

Rain Water harvesting was a national programme after it was inaugurated by Prime Minister in 1999. In order to guide the rain water harvesting structure, CGWB brought out guidelines in manual on this subject. Central Ground Water Board (CGWB) prepared a “National Perspective Plan for Recharge to Ground Water by utilizing Surplus Monsoon Run-off” in 1996 to calculate the river basin which has surplus or deficient (CGWB, 2013). It was estimated that 232 BCM can be stored in aquifer zones of different basin. The plan presented a conceptual framework for utilization of surplus monsoon run-off for artificial recharge of ground water.

CGWB had prepared a Master Plan for Artificial Recharge to Ground Water earlier in the year 2002. The Master Plan envisaged the number of artificial recharge and water conservation structures in the country as 39 lakh at an estimated cost of Rs. 24,500 crores. Based on the recommendations of the Committee in 2008, the present revised Master Plan is prepared on the basis of hydrogeological parameters and hydrological data base available for each State (CGWB, 2013). The identification of feasible areas for artificial recharge to ground water was made on the basis of depth and declining trend of ground water levels.

Artificial Recharge Techniques

Wide spectrums of techniques are available to recharge ground water reservoirs. Techniques used for artificial recharge to ground water broadly fall under the following categories as shown in Figure 1. In the urban areas, roof top rain water harvesting and the paved areas are considered as the runoff area. Based on these catchment areas, total potential of rain water runoff and the rechargeable potential are computed. The guidelines specify that the recharge well should be constructed up to a depth 1 m below the water table. In rural areas, suitable structures like percolation tanks, check dams, nala bunds, gully plugs, gabion structures etc. and sub-surface techniques of recharge shaft, well recharge etc. have been recommended.

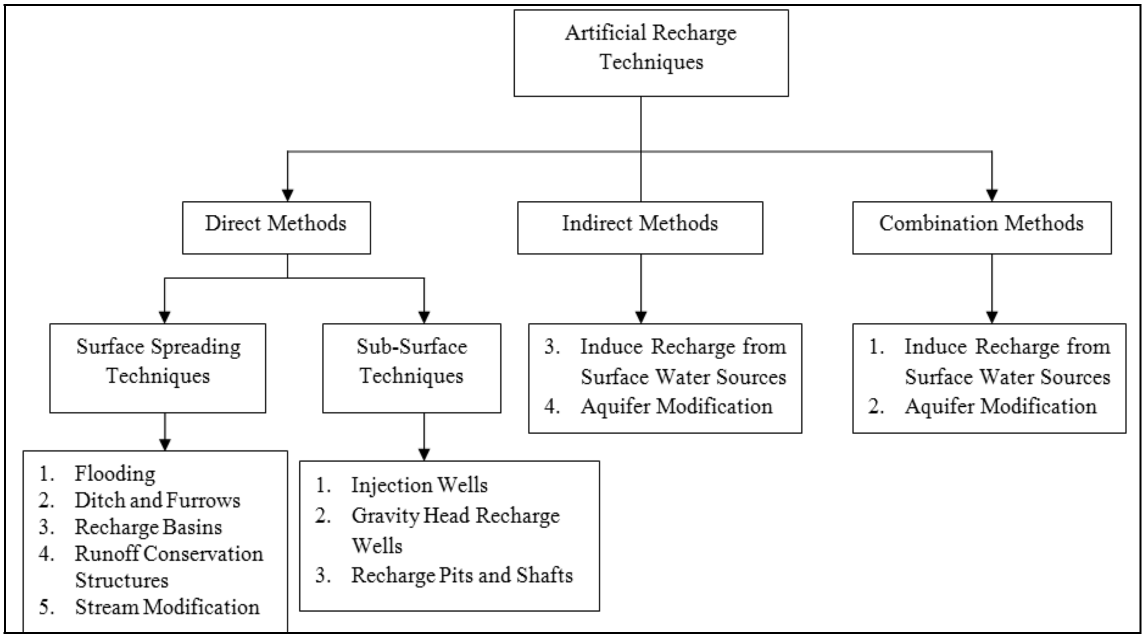

Figure 1. Artificial Recharge Techniques (Source: CGWB, 2007)

Rain Water Harvesting Structures in Brief

Percolation Tanks: A percolation pond/tank is generally constructed in low-level wasteland or a small drain. It has well defined catchment and spillover is diverted to a nearby natural drain. It consists of earthen embankment and an overflow type masonry waste weir. Permeable formation in the reservoir bed is an essential requirement of percolation tank.

Check Dams: Check Dams (Figure 2) are constructed across small streams having gentle slope and are feasible both in hard rock as well as alluvial formation. Check dams have been constructed in many areas without consideration to the watershed and the total quantum of water which can be stored. Check dams have been constructed across the river flow without considering the height of the check dam in respect of the check dam area (CGWB, 2007).

Figure 2. Check Dam

Sub-Surface Dykes: These are basically ground water conservation structures and are effective to provide sustainability to ground water structures by arresting sub surface flow. Sub-Surface dykes (Figure 3) are sub surface barriers across stream which retards the natural ground water flow of the system and stores water below ground surface to meet the demands during the period of need.

Figure 3. Sub-surface Dyke

Roof Top Rain Water Harvesting: In Urban areas, the roof top rain water harvesting (Figure 4) can be used for recharge of ground water. This approach requires connecting the outlet pipe from rooftop to divert the water to existing recharge wells/tube wells/bore wells or specially designed wells.

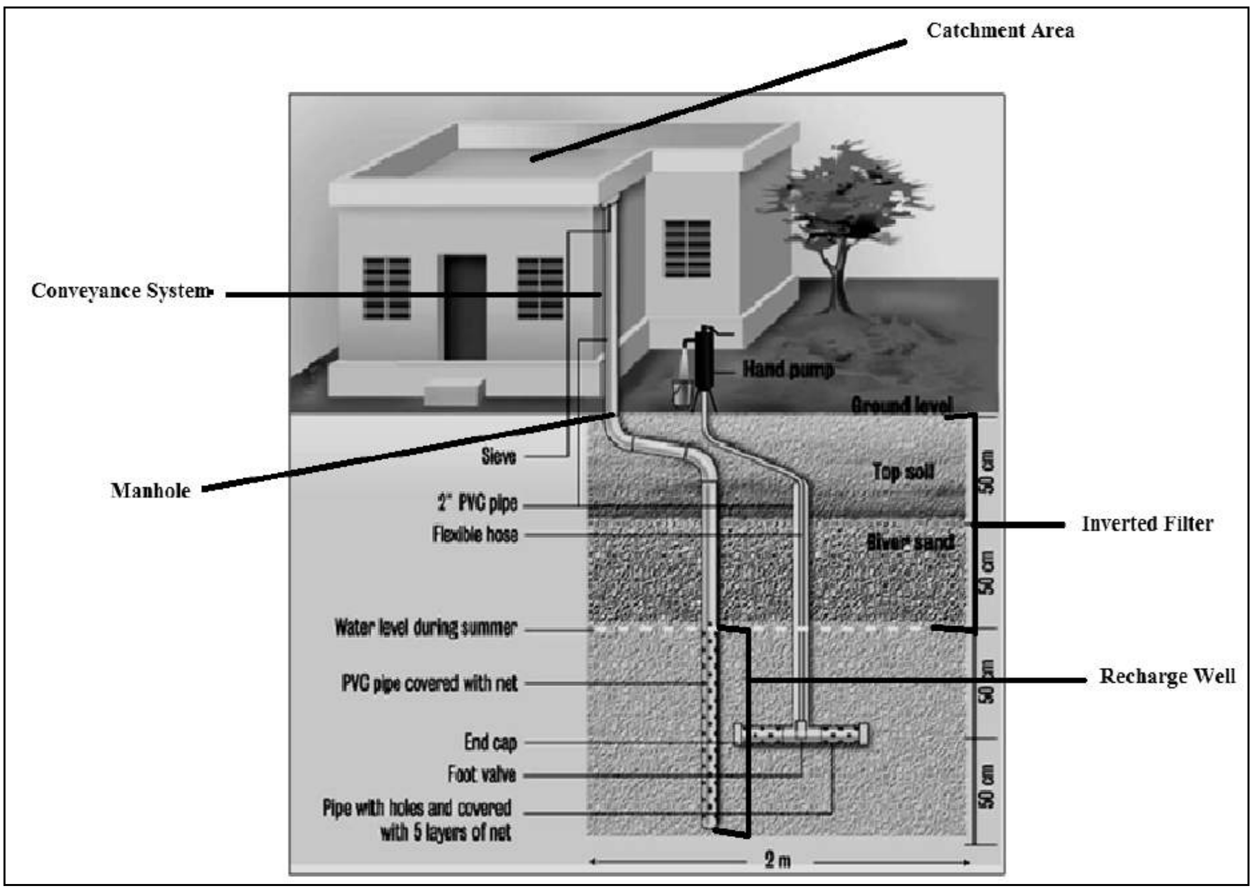

Figure 4. Roof Top Rain Water Harvesting and Recharge to Ground Water

Components of Artificial Recharge Structures

The design for artificial recharge structure by CGWB is given in Figure 5.

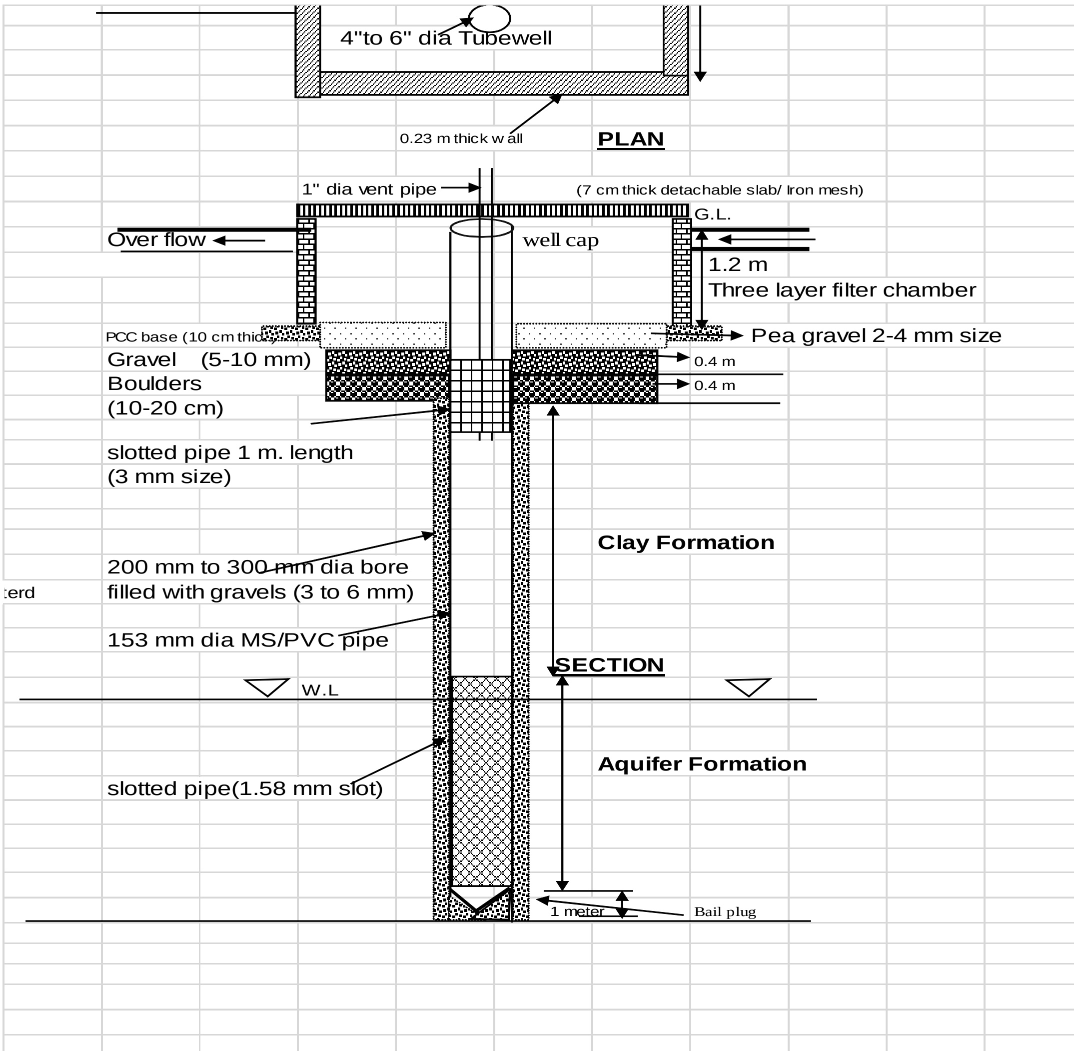

Figure 5. Design for Artificial Recharge Structure by CGWB

The various components of artificial recharge structure are as follows:

Catchment Areas: The catchment of a rain water harvesting system is the surface which directly receives the rainfall and provides water to the system.

Conveyance System: In flat roof, the down pipes are the common source to bring the rainwater up to ground level. Normally manhole is provided at the bottom of each down pipe. The water from the manholes is carried to the recharge structure either through the pipe or by channel/drains.

Man Holes: The roof top rain water is brought to ground through a series of down pipes into the man holes which are then interconnected to channel to carry the water to de-silting chamber.

De-Silting Chamber: De-silting chamber with baffle wall is to allow deposition of the silt at bottom. The break in velocity will deposit the silt at bottom which should be cleaned once in a year just before monsoon.

Filtration Media: Normally a filtration media known as "Inverted Filter" is provided before the water is injected to recharge through tube well, shaft etc. The filter media is generally comprises of pebbles as base material, the thickness of which varies from 40 to 75 cm. A layer of gravel ranging in thickness of 50-80 cm is placed above the pebbles followed by a layer of coarse sand of 50-80 cm thick.

Recharge structures- Tube well, recharge shaft: These are the structures through which the water is actually recharged to ground water. Clogging and subsequent destruction of recharge tube well/shaft may take place due to silt in the water inspite of all precaution of de-silting and removal of silt through filtration. Thus it advisable to develop the well at regular intervals, which may be once in year or once in two to three years to maintain their efficiency of recharge.

Rain Water Harvesting-NCT Delhi

Urban building bye-laws, 2001, made water harvesting mandatory through storing of rain water runoff in all new buildings of residential character, group housing & plotted development as plots of about 1000 m^2 & above.

The depth to water level ranges from 0.96 to 66.45 m bgl (May, 2012). Water with desirable quality is found mostly in East, parts of North, North East, and South Districts. The unsuitable saline water is scattered throughout the state, South West, West and parts of North West districts are more affected.

Delhi Jal Board design recharge structure with recharge well up to the depth of 10 m for Andhra Education Society, B-3B Block, Janakpuri, as shown in Figure 6. Depth to Water Level is 20 – 30 m, depth to fresh/saline water interface is <30 m, and the EC value is lying between 11,000-5,800 micromhos/cm and lithology is given in Table 1. The design has many constraints, the main being the depth of the recharge well. The recharge well terminates in the silty clay strata, and the water table is at 26 m bgl.

On Rain Water Harvesting in Gurgaon Urban area, the design given is to construct the pit of the dimensions: diameter- 1.20 m, vertical height- 0.50 m, RCC cover – 75 mm thick, de-silting chamber depth- 1.5 m as shown in Figure 7. One fails to understand is how such a structure will recharge the ground water or its conservation.

Table 1. Lithology of District Park, B-Block, Janakpuri

Depth (m)		Thickness	Resistivity	Description
From	To	(m)	(Ohm-m)	
0	6.66	6.66	17	Top soil
6.66	13.33	6.67	10	Silty clay
13.33	66.66	53.33	3	Silty clay
66.66	80	13.34	13	Silt Clay with kankar
80	86.66	6.66	3	Silty clay
86.66	93.33	6.67	2	Silty clay
93.33	106.66	13.33	14	Silt Clay with kankar
106.66	110	3.34	2	Silty clay

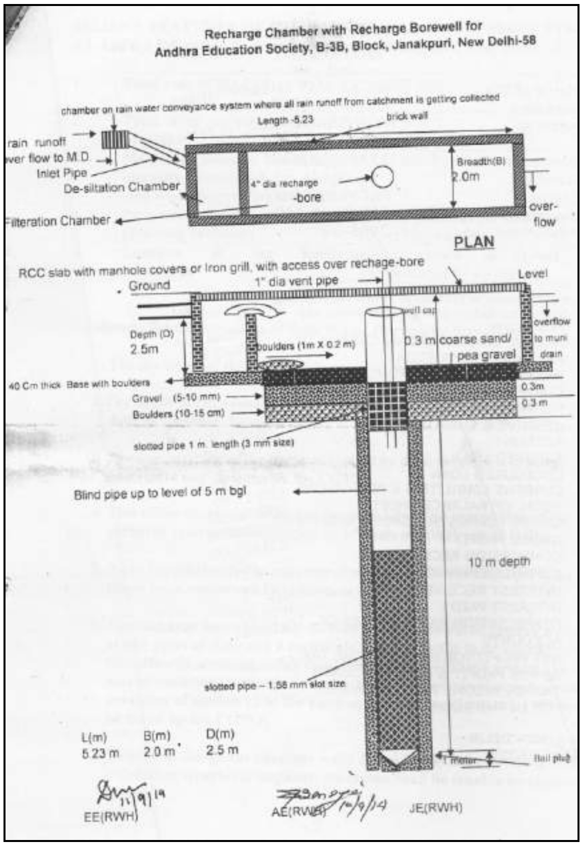

Figure 6. Recharge structure with Recharge well with 10 m depth below water level

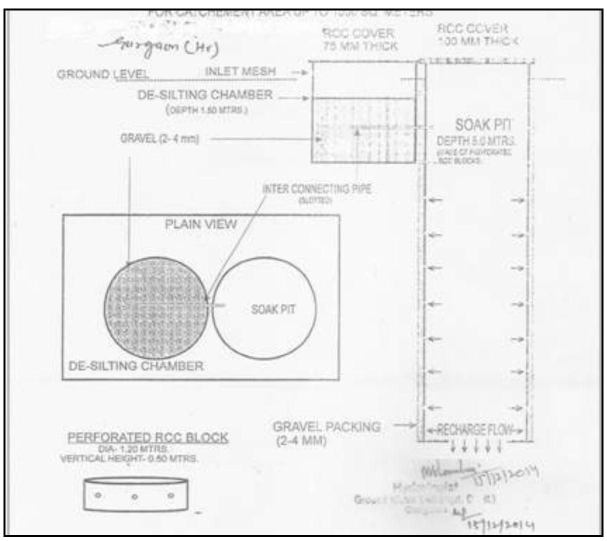

Figure 7. Design of Rain Water Harvesting Structure for Gurgaon Urban Area

The above designs serve no purpose. The clay formation will get saturated with the recharge water making it vulnerable during seismic activity. The saturated clay/silt will get liquefied and the building may collapse. Who will be responsible if rain water harvesting with these structures continue. The Rain Water Harvesting from roof top as the catchment should adhere to the design which gives the recharge well 6 m below the water table.

The Rain Water Harvesting structures are being taken in a very casual manner not adhering to the technical details of the de-silting and the recharge structures. Design given by the consult department (DJB) has many lacunas. The present designs with inverted filter have the perpetual problem of maintenance and clogging over the years. For non-maintenance and not having the rain water harvesting system installed within the premises, National Green Tribunal have levied penalty on these two accounts.

Considering the twin problem of maintenance and clogging and improper depth of the recharge well, we have modified the design to overcome these problems. Instant of using the inverted filter, the design includes the use of geo-textile for preventing the fine particles entering into the recharge well (Figure 8). In many cases, it was observed that the colloidal particles in storm water enter the recharge well. This problem has also been considered while making the new design.

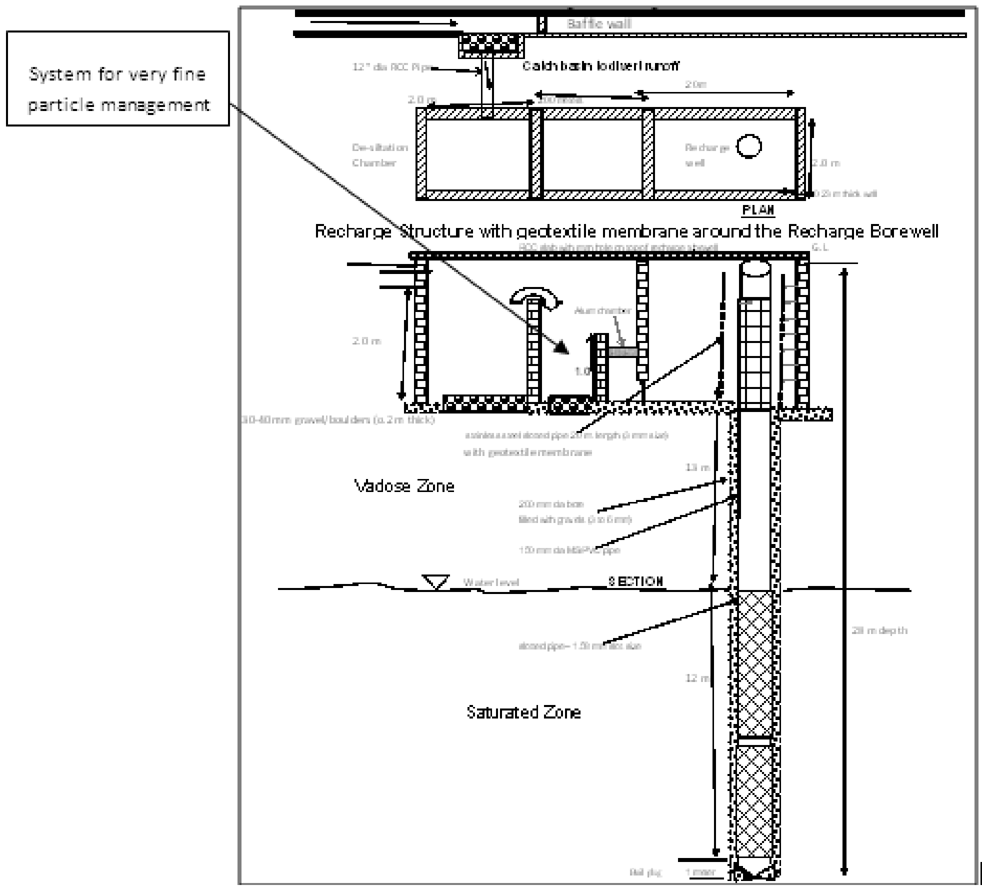

Figure 8. Design for Recharge Structure with 28 m depth below water level

There is a need to undertake R & D on the Rain Water Harvesting structures to make them adaptable system during monsoon.

CONCLUSION

1. Based on the monitoring of different recharge structures, it is recommended that urban bye laws for rain water harvesting should be modified and these structures should only be constructed in the multi-storey buildings, star hotels, hospitals and educational institutions.
2. The training and capacity building program should be carried out regularly in different areas to motivate the stakeholders for adopting rain water harvesting structures.
3. A National Level Institutions may be open and the rain water harvesting structures should be web based for easy access to the design of rain water harvesting structures.

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Roof Top Rain Water Harvesting: A Case Study in B.I.E.T.

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ABSTRACT

The population is now concentrating in few places like multi-storied buildings, etc., depending on mostly ground water. But looking at the ground water status it is getting depleted rapidly due to over drawing and fewer areas are left for recharge. The cities are almost becoming concrete jungles. Therefore the |Government is very much encouraging people to go for rain water harvesting structures. These are of two kinds one is public recharge structures and the second one is private recharge structures. These recharge structures are necessary in cities to regulate flooding situation whenever rainfall of higher intensities occur. This is because most of the lakes in urban areas got converted into habitation areas. These tanks used to regulate the flood as they act as detention reservoirs. Hence in our institution we have taken a case study to project the design of the Roof top water harvesting structures. Our campus is located at a higher elevated area and rocky area spots. Supplementation of water requirements during deficient period will to be done by purchasing tanker water which may be costly. For this we propose to harvest and collect the Rooftop water of our BIET MAIN BLOCK. The roof area of the block is 599.64square meters (L=44.65m, B=13.43m), from the dimensions we can infer that the block is rectangular in shape.

The following ancillaries are:

1. There are four drain holes each of 9cm diameter, to collect rooftop water and convey it to the connectors.
2. There is a Reverse Osmosis plant of area 20.59square meters, which is taken care separately as its water is taken by the separate drainpipes and connects it to the main drainpipe.
3. The water collected from the roof top will be diverted to a **soak pit** of dimensions 10*8*4=320cubic meter.
4. Mean annual rainfall for Hyderabad city is 850mm.
5. Calculating the volume of water with above rainfall data it would be approximately 509.64cubic meters. 20% of total volume water collected is deducted towards evaporation and splash i.e.407.7cubic meter.

The collected water will be used for avenue plantation, gardening and landscaping etc. In this process rain water is not wasted and not only disturbing aquifer but also recharging ground water.

ESTIMATION OF COST FOR STORAGE TANK

Harvested Rain water using for other purposes in BIET Campus

Design of storage tank

Size of Storage Tank is based on the area of the roof top considered, Per capita water requirement, No. of days of rain fall.

Water available from Roof: Annual rainfall (in mm) x roof area (in sq. m) x co-efficient of run off for roof co-efficient of run off

co-efficient of run off	
GI sheet	0.9
Asbestos	0.8
Tiled	0.75
Plaster on bricks/ Concrete	0.7

Water available from roof top 0.85*599.64*0.8=407.7 cum per annum

Size of Tank = 3m length, 2m breadth, 1.35m height

No. of Tanks = 1

Volume of Tank =3*2*1.35 =8.1cum= 8100 liters

Daily discharge expected

Roof area = 599.64 sq.m (approx 600 sq.m)

Volume of rainfall assumed = 0.017*600*0.075=7.65 cum =7650liters

Cost of Material for Storage Tank

Excavation	1 day	500
Concrete	3.25cum*4500.00	14625
Cement	1/2 bag*Rs. 350.00	175
Sand	1 bag *Rs250	250
PVC pipe	63mm dia.*10M	200
Steel 6mm dia	6rods*Rs100	600
Mason/ Labor charges		1000
Transportation		500
Total		**17850 .00**

So, the project cost is Rs 17850.00 for storing of about 8100 liters

1. RAIN WATER HARVESTING

The human civilization, entirely depend upon rivers, lakes and ground water to fulfill their water demands. However rain is the ultimate source that feeds all these sources. The implication of rainwater harvesting is to make optimum use of rainwater at the place where it falls i.e. to conserve it without allowing it to drain away. Rainwater harvesting is an ancient technique enjoying a revival in popularity due to the inherent quality of rainwater. Rainwater is valued for its purity and softness. It has a nearly neutral pH, and is free from impurities such as salts, minerals, and other natural and man-made contaminants. Archeological evidence attests to the capture of rainwater as far back as 4,000 years ago. The concept of rainwater harvesting in China is as old as 6,000 years. Ruins of cisterns built as early as 2000 B.C. for storing runoff from hillsides for agricultural and domestic purposes are still standing in Israel. Rooftop rainwater harvesting (RTRWH) is the most common technique of rainwater (RWH) for domestic consumption. In rural areas, this is most often done at small-scale. It is a simple, low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Rainwater is collected on the roof and transported with gutters to a storage reservoir, where it provides water at the point of consumption or can be used for recharging a well or the aquifer. Rainwater harvesting can supplement water sources when they become scarce or are of low quality like brackish groundwater or polluted surface water in the rainy season. However, rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter. Therefore regular maintenance (cleaning, repairs, etc.) as well as a treatment before water consumption (e.g. filtration or/and disinfection) are very important. Rainwater harvesting (RWH) is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. For drinking water purposes in rural areas, the most common technique is small-scale rooftop rainwater harvesting: rainwater is collected on the roof and transported with gutters to a storage reservoir, where it provides water. at the point of consumption (for rainwater harvesting for agricultural use see also bunds, field trenches, planting pits, micro-basins, retention basins, sand dams, conjunctive use, plug, controlled or fog drip). Collected rainwater can supplement other water sources when they become scarce or are of low quality like brackish groundwater or polluted water in the rainy season. It also provides a good alternative and replacement in times of drought or when the water table drops and wells go dry. The technology is flexible and adaptable to a very wide variety of conditions. It is used in the richest and the poorest societies, as well as in the wettest and the driest regions on our planet (HATUM & WORM 2006) (see also precipitation harvesting for a general overview on RWH).

2.1 STUDY AREA: A CASE STUDY IN B.I.E.T.

We have taken a case study in Bharat Institute of Engineering and Technology which is situated in Mangalpally village, Ibrahimpatnam mandal, and Ranga Reddy district. Ranga Reddy district is located in the western part of Andhra Pradesh with its Headquarters located at Hyderabad. The district lies between North latitudes 16° 54'- 17°48' and between East longitudes 77° 21'- 78°51'. The district is divided into three revenue divisions, 37mandals and 870 revenue villages. The district is bounded in the north by Medak district, in the east by Nalgonda district, in the south by Mahabubnagar district and on the west by Karnataka state (Fig.1). The geographical area of the district is 7493 sq.km with a population (2011) of 52, 96,396 lakhs. The population density which was 54 persons per sq.km during 1901 has risen to 707 persons per sq.km. Out of the total geographical area of 7, 49,300 ha, 73,075 ha of land is covered by forests. Similarly, barren and uncultivable land is 27,084 ha and land put to nonagricultural use is 1, 49,181 ha. The total net area sown is 2, 34,557 ha. As the institute has been situated in the higher elevation and to make the ground water sustainable in this campus Rooftop rainwater harvesting system has been proposed. The latitude and longitude of Ibrahimpatnam is 17.19515 and 78.656242 respectively. Ibrahimpatnam Mandal Headquarters is Ibrahimpatnam town. It belongs to Telangana State. It is located 68KM towards east from District head quarters Hyderabad. Ibrahimpatnam Mandal is bounded by Manchal Mandal towards East, Hayathnagar Mandal towards North, Yacharam Mandal towards south, Saroornagar Mandal towards West.

2.2 RAINFALL AND CLIMATE

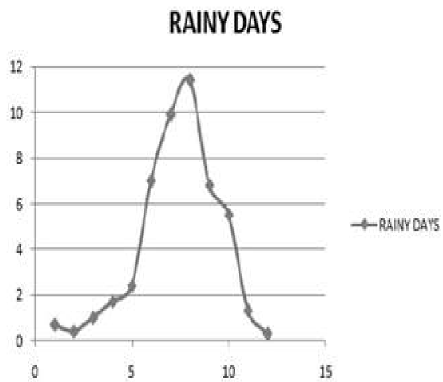
The average annual rainfall of the district is 833 mm, which ranges from nil rainfall in January and December to 190 mm in July. July is the wettest months of the year. Themean seasonal rainfall distribution is 652 mm in southwest monsoon (June-September), 114 mm in northeast monsoon (Oct-Dec), 4 mm rainfall in Winter (Jan-Feb) and 63 mm in summer(March – May). The percentage distribution of rainfall, season-wise, is 78.3% in southwest monsoon, 13.7 % in northeast monsoon, 0.5 percentage in winter and 7.6 % in summer.. The annual Rainfall ranges from 516 mm in 2011 to 1110 mm in 2010. The annual rainfall departure ranges from -38 % in 2011 to 33 % in 2010. The southwest monsoon rainfall contributes about 78 % of annual rainfall. It ranges from 428 mm in 2002 to 927 mm in 2010. The year 2002 and 2011Experienced drought conditions in the district as the annual rainfall recorded in these two years is27 % and 38% less than the long period average (LPA) respectively. It indicates that, the rainfall departure as on2011 is negative i.e. -64%, showing rainfall deficit. The peak temperature recorded in the year2010 was 40.9o C in the month of and 85% was observed in April and September respectively. The annual rainfall during 2012 is 988 mm.

Table 1. Rainfall distribution in Ranga Reddy district

Sl.no	District	Year	Annual	SMW	NEM	Winter	Summer	SMW%	NEM%	Winter%	Summer%	DEP from LPA
1		1999	632	505	38	3	86	79.91	6.01	0.47	13.61	-24
2		2000	906	780	36	20	70	86.09	3.97	2.21	7.73	9
3		2001	787.2	538	189.2	8	52	68.34	24.03	1.02	6.61	-5
4		2002	609.9	428.2	124	11.7	46	70.21	20.33	1.92	7.54	-27
5		2003	801.7	677.7	83	2	39	84.53	10.35	0.25	4.86	-4
6		2004	729.1	496.9	103.7	29.6	98.9	68.15	14.22	4.06	13.56	-12
7	Ranga Reddy	2005	1101.3	832.8	162.3	25.9	80.3	75.62	14.74	2.35	7.29	32
8		2006	776.8	533.1	44.1	0	199.6	68.63	5.68	0	25.7	-7
9		2007	664.4	554.8	60.2	0.1	49.3	83.5	9.06	0.02	7.42	-20
10		2008	844.1	627.7	49	27.8	179.6	71	5.54	3.14	20.31	6
11		2009	778.8	608.2	114.2	0	56.4	78.09	14.66	0	7.24	-7
12		2010	1110.4	926.6	135.9	12.8	35.1	83.45	12.24	1.15	3.16	33
13		2011	516.1	430.2	22.6	6.9	56.4	83.36	4.38	1.34	10.93	-38
Long Period Average	832.6	651.9	113.8	4	62.9	78.3	13.66	0.48	7.56			

Table 2. Avg annual rainfall per day of 25years from 1981-2005

Months	Avg.Annual Rainfall(mm)	Rainy days
January	10.9	0.7
February	8.2	0.4
March	18.9	1
April	20.9	1.7
May	31.6	2.4
June	116.3	7
July	170.6	9.9
August	190.4	11.4
September	114.1	6.8
October	108.5	5.5
November	26.1	1.3
December	5.3	0.3
Total	821.7	48.6



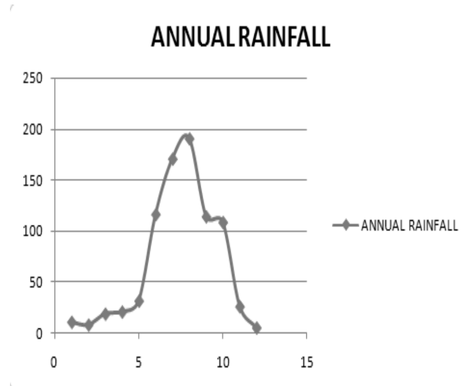


Figure. 1(a) Number of rainy days for avg annual rainfall per day for 25years.

Figure. 1(b) Avg Annual rainfall.

3 GEOLOGY

The district is underlain by various geological formations like Archaean granites and Gneisses, Proterozoic Bhima series and the younger Deccan traps. The Archaean crystalline rocks occupy nearly three fourths of the district comprising older metamorphic rocks, peninsular gneissic complex (migmatites) and younger intrusive rocks. Intrusive of dolerite dyke are common in the area. The upper pretoerozoic sediments of Bhima group comprising of limestones and shale’s occur in the western most corner of the district, NW of Kotepally. The shale beds show Intercalations of limestone. The basaltic flows of the Deccan Traps cover either the Bhimasediments or the granitoids around Vikarabad, Tandur and Parigi. The thickness of each flow The upper pretoerozoic sediments of Bhima group comprising of limestones and shale’s occur in the western most corner of the district, NW of Kotepally. The shale beds showIntercalations of limestone. The basaltic flows of the Deccan Traps cover either the Bhimasediments or the granitoids around Vikarabad, Tandur and Parigi. The thickness of each flowvaries from 15 to 20 m. Intra-trappean beds are thin and comprise conglomerates, chert and Sandstone. The thickness of infra-trappeans varies from 0.5 to 8 m and these are fossiliferous. A series of WNW – ESE trending faults are seen in the southeastern part of the area

4. HYDROGEOLOGY

The map depicting hydro geological conditions in the district is presented in Fig the depth and yield ranges of wells constructed by CGWB in basalts and granitic formations from the Table-3

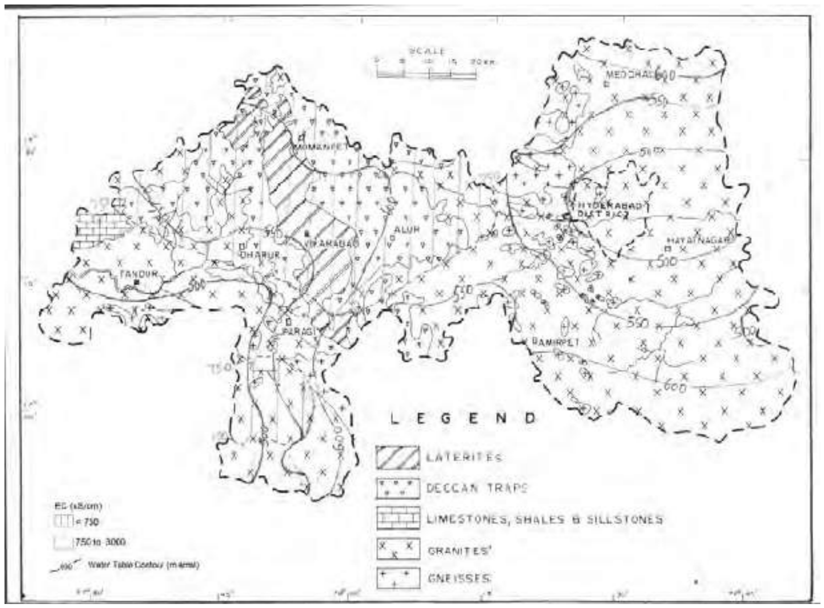


Figure 2. Hydrogeology of Ranga Reddy district, TELANGANA

Table 3. Depth range and yield ranges in basalts and granitic terrain

Depth Range (m)	No. of EW Yield	
	Basalts	Granites
20-30	0	1
30-40	1	20
40-50	2	15
50-60	4	4
60-70	6	2
70-100	14	2
100-150	5	1
150-200	2	0
3-Jan	8	18
5-Mar	1	2
>5	4	2

5. GROUND WATER RESOURCES

Based on the Ground Water Estimation Committee (GEC 97) norms, ground water assessment was done in 2008-09. The total ground water resources available in the district are 62,199 Ham. The ground water annual draft is 46,136 Ham and the balance ground water resource available for irrigation being 17195 Ham. The overall stage of ground water development in the district is 74%, and falls under safe category. Based on the ground water resource estimation, 1mandal has been classified as Over-Exploited (OE), 4 mandals as Semi Critical and rest of mandals as Safe. The Mandal wise categorization in respect of ground water development is presented in the Fig.3

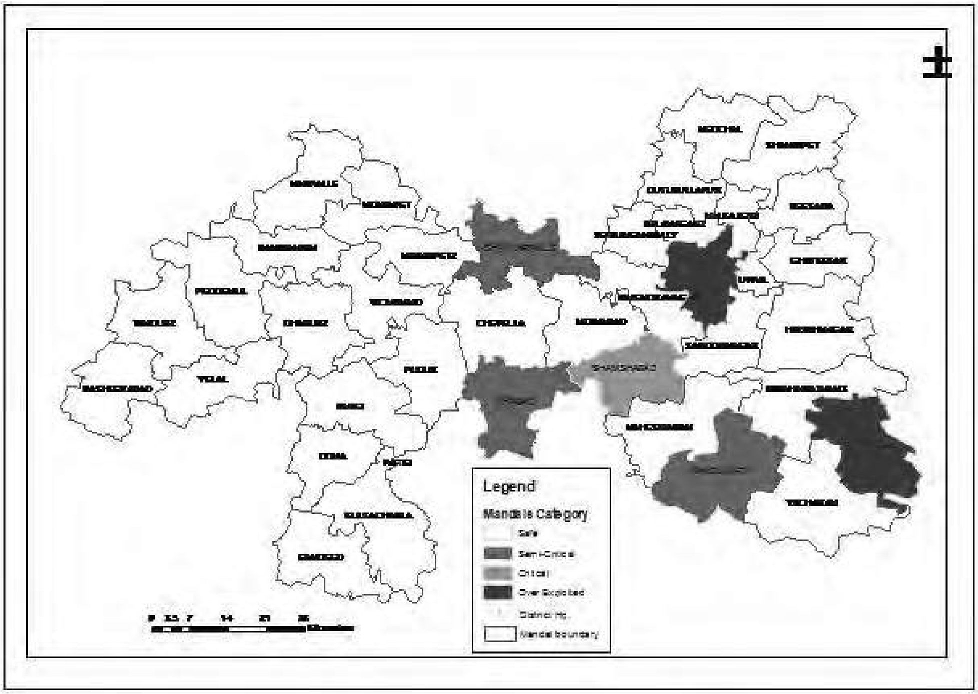


Figure 3. Mandal- wise categorization in respect of ground water development

6. METHODOLOGY

The method we adopted in the field of BIET is Rooftop rain water harvesting. Rainwater collection depends on the rooftop area, the size of the tank and the rainfall at that place. For example in a place where it rains 500 mm and the roof area is 100 square meters, the rainwater falling on the roof is 50,000 liters. Some amount of it will be absorbed by the roof and some amount will be lost in the collection process. If we assume 80% can be collected then 40,000 liters of rainwater is available for collection. Depending on the size of the rainwater tank and the distribution of rainfall even a 3000 liter tank may be sufficient to collect all this 40,000 liters of rainwater.

7. SYSTEM COMPONENTS

The parts of the roof top parts of the roof top rainwater harvesting system are as follow

Roof, PVC Gutters, Downpipes, First rain separator, Filter, Storage tank, Overflow pipe, Tap, water quality check, Transportation, First flash.

The rooftop area of **BIET MAIN BLOCK** has been calculated as the estimation of the size of the water tanks to fulfill drinking and cooking water demand @ 8.00 LPCD & their costs required to fulfill the annual drinking water demand through RWH from rooftop of BIET are done. A general mathematical equation expressing the relationship between the size and cost of water tank and rooftop areas of BIET is developed.

Roof of BIET Main block

BIET Main block,

Proposed site for the construction of storage tank in BIET

8. CONCLUSIONS

8.1 ESTIMATION OF COST FOR STORAGE TANK

Harvested Rain water using for other purposes in BIET Campus. The size of the storage tank is Design is based on area of the roof to considered, Per capita water requirement, no. of days of rain fall.

Water available from Roof: Annual rainfall (in mm) x roof area (in sq. m) x co-efficient of run off for roof

co-efficient of run off	
GI sheet	0.9
Asbestos	0.8
Tiled	0.75
Plaster on bricks/ Concrete	0.7

Water available from roof top 0.85*599.64*0.8=407.7 cum per annum

Size of Tank: 3m length, 2m breadth, 1.35m height, no. of Tanks: 1

Volume of Tank:-3*2*1.35 =8.1cum= 8100 liters

Daily discharge expected:

Roof area: 599.64 sq.m (approx 600 sq.m),

Volume of rainfall assumed = 0.017*600*0.075=7.65 cum =7650liters.

Cost of material for storage tank

1.Excavation	1 day	500
2.Concrete	3.25cum*4500.00	14625
1no. Cement	1/2 bag*Rs. 350.00	175
2 no. Sand	1 bag *Rs250	250
3 no.PVC pipe	63mm dia.*10M	200
4 no. Steel 6mm dia	6rods*Rs100	600
5 no. Mason/ Labor charges		1000
6.Transportation		500
Total		**17850 .00**

So, the project cost is Rs 17850.00, for storing of about 8100 liters. By implementing this project we can minimize usage of ground water. This provides a sustainable quantity of water in B.I.E.T.Campus.By this method we can arrest the rain water.

9. RECOMMANDATIONS

We can also recommend storage tank for drinking purpose and also for recharging of bore wells.

Material	Quantity in no	Amount in RS.
P/fabricated cement rings	5*Rs. 40.00	200
Cement	2 bags*Rs. 140.00	280
Sand	2 bags	50
Grit	4 bags	50
Charcoal	20 Kg*Rs. 8.00	160
Sand for Plastering	4 bags	100
Mason/ Labor	2	500
White washing	1kg	40
Transportation	Auto Charge	50

The cost for construction of storage tank used for drinking purpose is 1430Rs.

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Effect of Phosphorus, Vermicompost and PSB on yield and Quality of Blackgram (*Vigna Mungo*)

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ABSTRACT

A field experiment was conducted to study the effect of phosphorus, vermicompost and PSB inoculation on growth, yield and quality of black gram during *Kharif* 2011 on the farm of Agronomy department, at college of Agriculture, Latur. The maximum value of yield attributes, seed yield and protein content of black gram was obtained with the application of 75 kg P_2O_5 ha^{-1}. A significant increase in seed yield was recorded with the application of vermicompost @ 2.5 tonne ha^{-1} combined with PSB inoculation. The higher protein content was recorded with the higher level of phosphorus and combined treatment of vermicompost and PSB inoculation.

INTRODUCTION

Blackgram (*Vigna mungo* L.) is one of the important pulse crops grown in India. Pulses are the cheapest source of quality protein for human being. Black is also grown as a cover crop as well as catch crop due to short duration.The role legume in improving soil fertility by fixing atmospheric nitrogen in soil. The importance of phosphorus application to black gram crop has been recognised since long (Patil and jadhav 1994). Application of phosphorus plays an important role in growth, development and maturity of crop. Phosphorus helps to increase grain yield, seed quality, regulate the photosynthesis, govern physico- bio chemical process and also in development of roots and nodulation. Therefore application of phosphorus is must incentive coupled with increased use of phosphorus with organic manure (Vermicompost) and bio fertilizers PSB. To compensate the short supply and price hike of chemical fertilizers, use of indigenous sourses like vermicompost has to be encouraged as it supplies essential plant nutrients and improves physical, chemical and biological conditions of the soil, soil microbial activities, soil structure, water holding capacity and thereby increase the fertility and productivity of soil. Vermicompost is a potential source due to the presence of available plant nutrients, growth enhancing substances like nitrogen fixing, phosphorus solubilising and cellulose decomposing organism. Many investigators reported that crop utilizes only 15- 20 % of the applied phosphorus and rest is retained in the form which is not readily available to the crop. The PSB like *Pseudomonas* and *Bacillus* also enhance the availability of phosphorus to plant by converting insoluble phosphorus from the soil into soluble form. Hence the present investigation was undertaken to study the effects of judicious use of inorganic phosphorus , organic vermicompost, and biofertilizer PSB on yield attributes, seed yield and quality of black gram.

MATERIALS AND METHODS

The present field experiment was conducted during *Kharif* 2012-13 at the Experimental Farm, Agronomy Section, College of Agriculture, Latur (Maharashtra).The soil of the experimental site was clayey in texture, low in available nitrogen (193.5 kg ha^{-1}), medium in available phosphorus (11.82 kg ha^{-1}), and high in potash (433.78 kg ha^{-1}).The soil was slightly alkaline in reaction (8.27 p^H). The experiment was laid out in Factorial Randomised Block Design (FRBD) with three replications.The treatments were comprised of three levels of phosphorus *viz*, namely P_1: 25 kg P_2O_5 ha^{-1}, P_2: 50 kg P_2O_5 ha^{-1}, P_3: 75 kg P_2O_5 $ha^{-1}$and the treatments of vermicompost and PSB *viz.* V_1: Vermicompost @ 2.5 tone ha^{-1}, V_2: PSB inoculation @ 250 gms/10 kg seed and V_3: Vermicompost and PSB inoculation. The gross and net plot size was 5.4mx4.2m and 4.8mx3.0m respectively. The precipitation received during crop growth season was 526.1mm and distributed over 34 rainy days during the course of experimentation. The sowing of black gram seed (BDU-1) was done on 1^{st} july 2012 by dibbling two seeds per hill at a distance of 30 x10 cm at about 2.5 cm depth. The complete dose of phosphorus and nitrogen as per treatments was drilled at the time of sowing uniformly in the plot. Application of Vermicompost and PSB seed inoculation was done as per treatments before sowing.

RESULTS AND DISCUSSIONS

The results obtained from the present investigation have been presented under following heads

Yield attributes

Effect of phosphoruslevels:

Data in Table 1 revealed that yield attributes *viz* , dry matter plant^{-1}, no. of pods plant^{-1}, pod yield (g) plant^{-1}, seed yield (g) plant^{-1}, and test weight (g) were significantly influenced by the different levels of phosphorus. Maximum Dry matter production plant^{-1}, no. of pods plant^{-1}, pod yield (g) plant^{-1}, seed yield (g) plant^{-1}, and test weight (g) were observed with the application of 75 kg P_2O_5ha^{-1}but was found to be at par with 50 kg P_2O_5 ha^{-1}. This might be due to the higher dose of phosphorus resulted in producing large productive parts (Sarkar and Banik 1991, Rathor *et al* 2010)

Table 1. Dry matter plant^{-1}, No. of pods plant^{-1}, Pod yield (g) plant^{-1}and seed yield (g) plant^{-1}, Test weight (g) as influenced by various treatments

Treatments	Dry matter plant^{-1}	No. of pods plant^{-1}	Pod yield (g) plant^{-1}	Seed yield (g) plant^{-1}	Test wt. (g)
Levels of phosphorus (P)					
P_1 - 25 kg P_2O_5ha^{-1}	20.27	17.88	4.93	3.57	45.74
P_2 - 50 kg P_2O_5 ha^{-1}	22.18	19.80	5.53	4.48	47.47
P_3 - 75 kg P_2O_5 ha^{-1}	22.73	20.40	6.21	5.10	48.39
SE ±	0.53	0.57	0.19	0.15	1.24
CD at 5%	1.58	1.70	0.57	0.45	NS
Vermicompost and PSB (V)					
V_1 – Vermicompost @ 2.5 tonnes ha^{-1}	20.20	17.57	4.94	3.81	46.10
V_2 - PSB inoculation @ 250g ha^{-1}	22.14	19.56	5.57	4.46	47.07
V_3-Vermicompost and PSB inoculation	22.83	20.96	6.61	4.89	48.43
SE ±	0.53	0.57	0.19	0.15	1.24
CD at 5%	1.58	1.70	0.57	0.45	NS
Interactions (P x V)					
SE ±	0.91	0.98	0.33	0.27	2.14
CD at 5%	N.S	NS	NS	NS	NS
General Mean	**21.72**	**19.36**	**5.56**	**4.38**	**47.20**

Effect levels of Vermicompost and PSB inoculation:

The maximum dry matter plant^{-1}, no. of pods plant^{-1}, pod yield (g) plant^{-1}, seed yield (g) plant^{-1}, and test weight (g) was recorded when Vermicompost 2.5 tonnes ha^{-1} incorporated with the PSB seed inoculation. But was found at par with PSB seed inoculation. Alone Vermicompost application was not found significantly beneficial. Higher values in respect of yield attributes may be due to efficient photosynthesis and produces high carbohydrate (Rajkhowa *et al* 2000)

Seed and biological yield

Effect of phosphorus levels:

The results indicated that various phosphorus levels significantly affected the seed, straw and biological yield (kg ha^{-1}) of black gram. The significantly protein of 75 kg P_2O_5 ha^{-1} which was found to be at par with 50 kg P_2O_5 ha^{-1} and significantly superior over 25 kg P_2O_5 ha^{-1} (Table 2). The higher harvest index was observed with the higher levels of phosphorus. It may be due to vigorous start to plant and strengthen straw by the higher dose of phosphorus application. (Singh and Sharma 2001)

Table 2. Mean seed yield, straw yield, biological yield (kg ha^{-1}), harvest index (%) asinfluenced by various treatments

Treatments	Seed yield	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Levels of phosphorus (P)				
P_1 - 25 kg P_2O_5ha^{-1}	1014	1610	2624	38.64
P_2 - 50 kg P_2O_5 ha^{-1}	1264	1720	2984	42.35
P_3 - 75 kg P_2O_5 ha^{-1}	1319	1718	3037	43.43
SE $\pm$	40	64	114	-
CD at 5%	120	NS	342	-
Vermicompost and PSB (V)				
V_1 - Vermicompost @ 2.5 tonnes ha^{-1}	1055	1574	2690	39.22
V_2 - PSB inoculation @ 250g ha^{-1}	1229	1755	2984	41.18
V_3Vermicompost and PSB inoculation	1305	1727	3034	43.01
SE $\pm$	40	64	114	-
CD at 5%	120	192	342	-
Interactions (P x V)				
SE $\pm$	69	111	198	35.07
CD at 5%	NS	NS	NS	NS
General Mean	**1194**	**1679**	**2883**	**41.41**

Effect of Vermicompost and PSB inoculation

Application of Vermicompost 2.5 tonnes ha^{-1} along with seed inoculation of PSB enhance the seed, straw and biological yield of black gram. PSB inoculation with Vermicompost application and alone PSB seed inoculation was at par with each other and found significantly superior over Vermicompost application alone.

Quality Attributes

Effect of phosphoruslevels:

Data in Table 3 revealed that thehigher protein content in black gram seed was recorded with the application of 75 kg P_2O_5 ha^{-1} but did not differs significantly whereas significantly higher protein yield was obtained with75 kg $P_2O_5ha^{-1}$was at par with 50 kg P_2O_5 ha^{-1} (Shukla and Dixit 1996)

Effect of Vermicompost and PSB inoculation

The seed protein content was not significantly influenced by the application of Vermicompost and PSB inoculation. Where as protein yield was significantly affected. The higher protein content and protein yield was obtained with the combined application of Vermicompost and PSB inoculation. (Vasanti, D. and Subramanian, S 2004)

Interaction (P x V):

Interaction effect of fertilizer levels and Vermicompost alone and with PSB did not show any significant effect on yield and quality attributes.

Table 3. Protein content (%) and protein yield (kg ha^{-1}) as influenced by different treatments

Treatments	**Seed yield (kg ha^{-1})**	**Protein content (%)**	**Protein yield (kg ha^{-1})**
Levels of phosphorus (P)			
P_1 - 25 kg $P_2O_5ha^{-1}$	1014	22.80	231
P_2 - 50 kg P_2O_5 ha^{-1}	1264	23.06	291
P_3 - 75 kg P_2O_5 ha^{-1}	1319	23.39	309
SE $\pm$	40	0.48	9.02
CD at 5%	120	NS	27.77
Vermicompost and PSB (V)			
V_1 - Vermicompost @ 2.5 tonnes ha^{-1}	1055	22.67	239
V_2 - PSB inoculation @ 250g ha^{-1}	1229	23.11	284
V_3-Vermicompost and PSB inoculation	1305	23.47	306
SE $\pm$	40	0.48	9.02
CD at 5%	120	NS	27.77
Interactions (P x V)			
SE $\pm$	69	0.82	0.023
CD at 5%	NS	NS	NS
General Mean	**1194**	**23.08**	**276**

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Rainwater Harvesting and its Scenario

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ABSTRACT

Rainwater harvesting provides an independent water supply in the developed countries and is often used to supplement the main supply. It provides water when there is a drought, can help mitigate flooding of low-lying areas and reduces demand on wells which may enable ground water levels to be sustained. It also helps in the availability of potable water as rainwater is substantially free of salinity and other harmful salts. Improved water quality can be obtained by using a Pre-filtration which is a common practice used in the domestic / industry sectors to ensure that the water entering the tank is free of large sediment. Pre-filtration is important to keep the system healthy. The main purpose of the rain water harvesting is to utilize the locally available rain water to meet water requirements throughout the year without the need of huge capital expenditure. This would facilitate availability of uncontaminated water for domestic, industrial and irrigation needs. Soil and water conservation as well as water harvesting will go a long way towards reducing misuse of government funds.

INTRODUCTION

Around the 3rd century BC, the farming communities in Baluchistan (now located in Pakistan, Afghanistan and Iran) and India used rainwater harvesting for irrigation. In ancient Tamil Nadu (India), rainwater harvesting was done by Chola kings. During the later Chola period, the tanks were built in Cuddalore district of Tamil Nadu to store water for drinking and irrigation purposes. For eg. Viranam is a 16 km long tank with a storage capacity of 1,465,000,000 cubic feet (41,500,000 m^3). Rainwater harvesting was also carried out in the states of Madhya Pradesh, Maharashtra, and Chhattisgarh in the olden days. Ratanpur, in the state of Chhattisgarh, had around 150 ponds. Most of the tanks or ponds were utilised in agriculture works.

CASE STUDY

Hussainsagar was a drinking water source from 1884 to 1930. The Hussainsagar lake of Hyderabad in Telangana is now a stinking stretch of polluted water. The lake, which was once received unpolluted water from the upper regions of the river Musi, now receives domestic sewage and toxic chemicals from different industries. A few industrial units which are located in and around Hussainsagar lake viz. Sanathnagar, Balanagar, Kukatpally, Jeedimetla etc drain untreated and partially treated wastes into the lake. In addition, the domestic sewage received from Picket, Kukatpally, Banjara Hills areas account for a daily flow of 28,190 cum per day of waste into Hussainsagar. Presently, the lake is saturated with phenols, benzenes, cyanides and toxic metals. Groundwater pollution along the Hussainsagar watershed poses serious health hazards. Nitrate concentration in the groundwater around the lake is reportedly high, ranging from 0-400 ppm (parts per million), several-fold higher than the permissible World Health Organization (who) standard of 10 ppm. A study in 1993 revealed high concentration of toxic heavy metals in groundwater samples along the radius of 0-800 metres around the lake. The concentrations of lead were in the range of 1-25 microgram/litre (µg/l), and cadmium concentrations ranged from 1-27 µg/l. These are significantly higher than the permissible levels of 10 µg/l of lead and 5 µg/l of cadmium recommended by agencies such as the Indian Council of Medical Research and the WHO. India –which has 16 percent of the world's population, 2.45 percent of the world's land area and 4 per cent of the world's water resources already has a grave drinking water crisis.

The reservoir of underground water, estimated presently at 432 billion cubic meters has been declining at a rapid rate of 20 cms annually in as many as fifteen States with major metropolitan cities due to over-exploitation and misuse. India's rainfall is temporal (with as much as 70 per cent rainfall occurring in four months) and the rain is also unevenly distributed. Refer Table-1.

Table 1. Distribution of Annual Rainfall by Seasons in India

S.No	Rainfall	Duration	% of annual rainfall
1	Pre-monsoon	March–May	10.4
2	South-west monsoon	June–September	73.7
3	Post-monsoon	October–December	13.3
4	Winter/north-east monsoon	January–February	2.6
	Total	Annual	100.0

*Source: Meteorological Department of India, Pune, Maharashtra State.

Under the present circumstances, the only method is to adopt and implement the Rainwater harvesting technology. Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops or the land surfaces using simple techniques such as pits/drums. Commonly used systems are constructed of three principal components namely the catchment area, the collection device and the conveyance system.

Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site rather than allowing it to run off. Its uses include water for garden, for livestock, for irrigation, for domestic use with proper treatment etc.. In many places the water collected is just redirected to a deep pit with percolation. The harvested water can be used as drinking water as well as for storage and other purpose like irrigation.

Rainwater harvesting provides an independent water supply in the developed countries and is often used to supplement the main supply. It provides water when there is a drought, can help mitigate flooding of low-lying areas and reduces demand on wells which may enable ground water levels to be sustained. It also helps in the availability of potable water as rainwater is substantially free of salinity and other harmful salts.

Improved water quality can be obtained by using a Pre-filtration which is a common practice used in the domestic / industry sectors to ensure that the water entering the tank is free of large sediment. Pre-filtration is important to keep the system healthy. The main purpose of the rain water harvesting is to utilize the locally available rain water to meet water requirements throughout the year without the need of huge capital expenditure. This would facilitate availability of uncontaminated water for domestic, industrial and irrigation needs.

On account of inadequate awareness or planning, excess rainfall water has been getting discharged into the oceans after coursing its way through the drains and rivers. In effect, it is possible to prevent this wastage of water by storing it during the rainy season for allowing it to seep underground in the dry areas as a measure of maintaining adequate levels of ground water. This water can subsequently be ‘recharged’ or pumped up for irrigational or drinking water purposes.

There are different ways in which rainwater can be harvested. There is a method of what is known as ‘rooftop harvesting’ in which the rainwater is allowed to get collected in built-up tanks. This water can be used for direct consumption as also for recharging groundwater through simple filtration devices. Water can also be collected in tanks that have cement slabs built at their base to prevent the water from seeping underground. This method is usually employed in the desert areas of Rajasthan which often face drinking water problem.

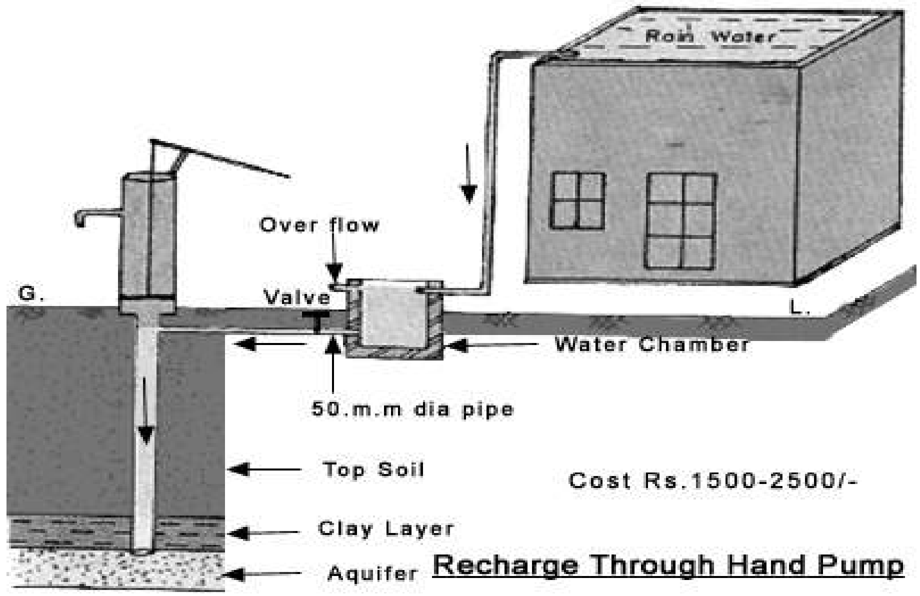

Figure 1. A simple rainwater harvesting structure

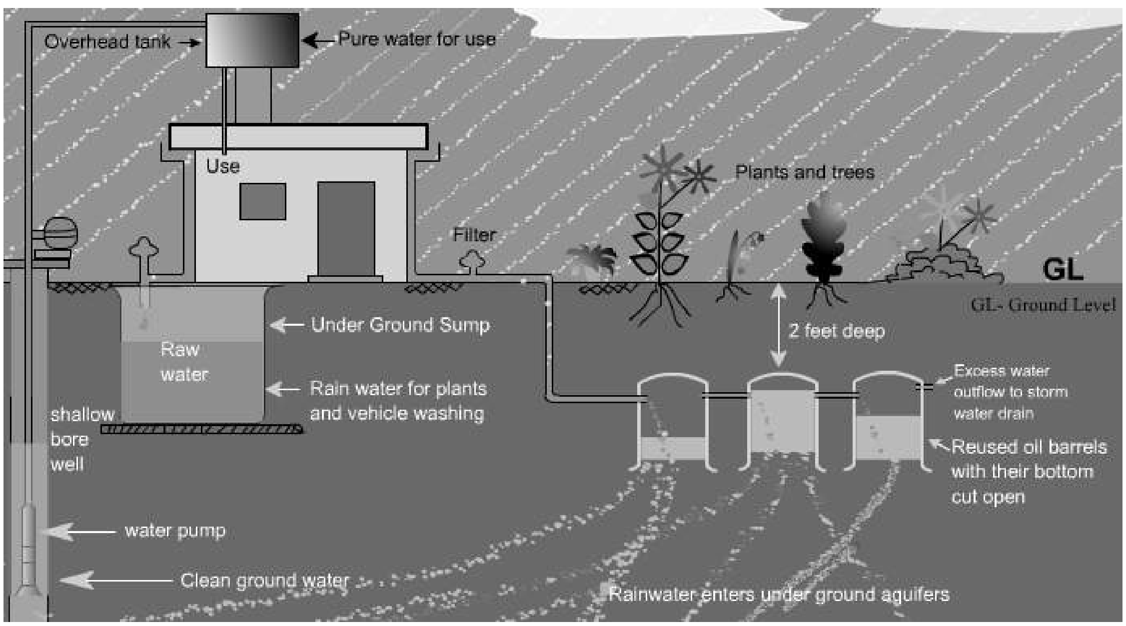

Figure 2. A rainwater harvesting structure depicts the distribution of rainwater into the ground

Concept and Technology of Rainwater Harvesting

Area of plot	= 100 sq.m.	= 120 sq. yd
Height of rainfall	= 0.6 m	= 600 mm or 24 inches
Volume of rainfall	= Area of plot x Height of rainfall over the plot	
	= 100 sq.m. x 0.6 m	
	= 60 cu.m.	= 60,000 litres

Assuming that only 60% of the total rainfall is effectively harvested, then the

Volume of water harvested = 60,000 litres x 0.6 = 36,000 litres

This volume is about twice the annual drinking water requirement of a 5-member family. The average daily drinking water requirement per person is 10 litres.

Rainwater Harvesting Advantages

- Makes use of a natural resource and reduces flooding, runoff, erosion, and contamination of surface water with pesticides, sediment, metals, and fertilizers.
- Reduces the need for imported water.
- Excellent source of water for landscape irrigation, with no chemicals such as fluoride and chlorine, and no dissolved salts and minerals from the soil.
- Home systems can be relatively simple to install and operate may reduce the water bill.
- Promotes both water and energy conservation.

Rainwater Harvesting Disadvantages

- Limited and uncertain local rainfall.
- Can be costly to install - rainwater storage and delivery systems can cost between 10000 to 20,000 depending on the size and sophistication of the system.
- Requires some technical skills to install and provide regular maintenance.
- If not installed correctly, may attract mosquitoes (eg: West Nile Disease and other waterborne illnesses).
- Certain roof types may seep chemicals, pesticides, and other pollutants into the water that can harm the plants.

CONCLUSIONS

It is very important to make water everybody's need. Every household and community has to become involved in the provision of water and in protection of water resources. Make water the subject of a people's movement. Further involving people will give the ownership over watershed development. Soil and water conservation as well as water harvesting will go a long way towards reducing misuse of government funds. In this way it is possible to solve water problems facing the country in the 21st century.

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Part of the text and images used in this paper are taken from the book "Amruthavarshini – A guide for Rainwater Harvesting" published by Karnataka State Council for Science and Technology.

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Impact of Polyethylene Mulch on Yield of Bitter Gourd

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ABSTRACT

A field experiment framed in RBD was conducted to check impact of polyethylene mulch on yield of bitter gourd at research farm of Dept. of IDE, Dr. P.D.K.V, Akola during Nov. 2014 to March 2015. The experiment comprised of seven irrigation/mulch treatments with four replication. Seasonal water requirement of bitter gourd was found to be highest (334.64 mm) under polyethylene mulch with irrigation scheduling at 100% ETo (T_5 and T_6), followed by T_7 (328.44 mm), T_3 and T_4 (275.92 mm), and T_1 and T_2 (217.19 mm). It was found lowest under irrigation scheduling at 60% crop evapotranspiration under polyethylene mulch with drip irrigation. Treatment T_4 (drip + black mulch, irrigation scheduling @ 80% of ETc) recorded highest water use efficiency (2.77) followed by treatment T_6, T_3, T_5, T_7, T_2 and T_1.

Keywords: bitter gourd, mulch, drip irrigation, water use efficiency.

INTRODUCTION

Bitter gourd (*Momordica charantia L.*) is one of the most popular vegetable in South East Asia. It is a member of cucurbit family along with cucumber, squash, watermelon, and muskmelon. Depending on location, bitter gourd is also known as bitter melon, karella, or balsam pear. The medicinal value of the gourd in the treatment of infectious diseases and diabetes is attracting the attention of scientists worldwide (Palada and Chang, 2003). Bitter gourd has been used for centuries in the ancient traditional medicine of India, China, Africa, and Latin America. Crop productivity enhanced with use of mulches (Jayasinghe and Goonasekera *et al.* 1993; Tiwari *et al*. 2003; Diaz-Parez *et al*. 2010). Use of mulch has many benefits like increase in soil temperature especially in early spring, reduction in weeds, moisture conservation and higher crop yields (Rajablariani, 2012; Patil *et al.*2013). Colour of Mulch affects the micro-environment surrounding the plants. The experiment was carried out at Research Farm of Department of Irrigation and Drainage Engineering, Dr. PDKV, Akola during the year 2014-15.

MATERIAL AND METHODS

The experiment consists of seven treatments with four replications. Treatment T_1 and T_2 is irrigation scheduling based on 60% crop evapotranspiration under silver and black polyethylene mulch with drip irrigation respectively. Treatment T_3 and T_4 is irrigation scheduling based on 80% crop evapotranspiration under silver and black polyethylene mulch with drip irrigation respectively. Treatment T_5 and T_6 is irrigation scheduling based on 100% crop evapotranspiration under silver and black polyethylene mulch with drip irrigation respectively. Treatment T_7 is irrigation scheduling based on 100% crop evapotranspiration with drip irrigation. The amount of irrigation water required for all treatments to bring soil to the field capacity was calculated by using equation of Michael, (1978). Irrigation water requirements for treatments based on irrigation scheduling at 60%, 80% and 100% reference evapotranspiration was calculated by equation $ET_C = E_P \times K_C \times K_P$ where ETc - Crop evapotranspiration, mmday^{-1}, Kc - Crop coefficient, Kp - Pan coefficient, E_P - Pan evaporation, mmday^{-1}. The volume of water to be applied per treatment was calculated by using equation $V = ETc \times A \times N$ where, V -Volume of water per treatment, lit, ETc - Crop evapotranspiration, mmday^{-1}, A - Area of one plot, m^2, N - Number of plots.

RESULTS AND DISCUSSIONS

Crop growth stage wise water requirement of bitter gourd

Irrigation water applied during different growth stages and rainfall received during these stages summed up to determine the crop growth stage wise water requirement of bitter gourd as influenced in different irrigation schedules and presented in Table 1.

Table 1. Crop growth stage wise water requirement

Sr. No	Crop growth stage	Water requirement under different treatments, mm						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
1	Before sowing common irrigation	41	41	41	41	41	41	41
2	Initial	19.07	19.07	25.42	25.42	31.78	31.78	31.78
3	Crop development	48.82	48.82	65.09	65.09	81.37	81.37	75.16
4	Mid season	67.94	67.94	90.59	90.59	113.24	113.24	113.24
5	Late season	40.36	40.36	53.81	53.81	67.26	67.26	67.26
	Seasonal water requirement	**217.19**	**217.19**	**275.92**	**275.92**	**334.64**	**334.64**	**328.44**

(Rainfall received during the crop season - 37.5mm on 01.01.2015; 12.4mm on 02.01.2015; 1.5mm on 03.01.2015)

Performance of Bitter Gourd under Different Irrigation and Polyethylene Mulch Treatments

In order to observe growth and yield of bitter gourd as affected by different irrigation mulch treatments, biometric observation were recorded. The statistical analysis of recorded biometric observations was carried out and presented in Table 2.

Table 2. Statistical analysis of biometric observation

Treatment	Plant height at 90 DAS, cm	Average No. of branches for15, 30, 45, 60, 75 and 90 DAS	Average length of bitter gourd, cm	Average weight of bitter gourd, gm	Yield qha^{-1}
T_1	133.08	12.02	18.55	21.39	19.70
T_2	133.01	12.16	18.95	21.95	23.57
T_3	156.19	14.85	22.14	25.16	48.20
T_4	209.18	19.62	25.19	27.75	76.37
T_5	168.21	16.20	23.22	24.80	53.65
T_6	175.61	17.33	22.27	25.05	60.86
T_7	112.36	11.14	16.45	19.71	47.13
Mean	155.38	14.61	20.96	23.53	46.99
F test	Sig.	Sig.	Sig.	Sig.	Sig.
SE	3.02	0.294	0.943	0.803	2.28
CD at 5%	8.99	0.876	2.803	2.387	6.78
CV (%)	3.895	4.036	9.00	6.825	9.70

Plant height for treatments T_4 is significantly highest, while plant height for treatments T_7 is significantly lowest as compared to all other treatments. Similar results are observed for number of branches, length, weight and yield of bitter gourd. Treatment T_4 showed significantly highest yield as compared to all other treatment.

Water Use Efficiency

Bitter gourd yield and water use efficiency as influenced by different irrigation/mulch treatments are presented in Table 3.

Table 3. Bitter gourd yield and water use efficiency

Treatment	Consumptive use/ha ha-cm	Yield/ha Q	Water use efficiency $q.ha^{-}1.cm^{-1}$
T_1	21.72	19.71	0.91
T_2	21.72	23.58	1.09
T_3	27.59	48.21	1.75
T_4	27.59	76.38	2.77
T_5	33.46	53.66	1.60
T_6	33.46	60.87	1.82
T_7	32.84	47.13	1.43

It cleared that the treatment T_1 with silver polyethylene mulch with irrigation scheduling at 60 percent crop evapotranspiration resulted in lowest water use efficiency. From Table 3 it is cleared that the treatment T_4 (drip + black mulch, with irrigation scheduling @80 percent of ETc) recorded highest water use efficiency followed by treatment T_6, $T_{3,}$ T_5, T_7 and T_2.

CONCLUSION

Bitter gourd should be grown under black polyethylene mulch with drip irrigation at 80 per cent replenishment of crop evapotranspiration for higher water productivity and more returns.

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Techniques and Strategies for Maximization of Water use Efficiency in Agriculture

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ABSTRACT

Shortage and scarcity of water and as well as the increasing global demand for water in many sectors including agriculture, has become an important global concern. The rapid growing population of the world and adverse effects of climate change has led to increasing competition for water use by industrial and urban uses for agricultural to secure enough food production. Increasing water use efficiency in agricultural will require an increase in crop water productivity and reduction in water losses from the crop root zone. At present there are many ways of enhancing water use efficiency and productivity of agricultural produce by maximum utilization of water. These include mainly agronomic practices *viz.,* Crop selection, Selection of variety, Sowing time, Sowing and planting method, seed rate, intercultural operations, use of improved irrigation methods (Sprinkler and drip), Adoption of Intercropping, soil moisture conservation practices such as spraying of antitranspirants, mulching, use of vegetative barriers and New concepts such as Integrated Farming System, Agro forestry.

Keywords: Agriculture, Water, Water use efficiency.

INTRODUCTION

Water is the most crucial input for agricultural production. Globally, agriculture accounts for more than 80% of all freshwater used by humans, most of that is for crop production (Morison *et al.*, 2008). The Food and Agriculture Organization has predicted a net expansion of irrigated land of about 45 million hectares in 93 developing countries (for a total of 242 million hectares in 2030) and projected that water withdrawals by the agriculture sector will increase by about 14% during 2000 – 2030 to meet food demand (FAO, 2006). Agriculture sector in India has been and is likely to remain the major consumer of water but the share of water allocated to irrigation is likely to decrease by 10-15 per cent in the next two decades. Current use efficiency or productivity of irrigation water is so low that most, if not all, of our future water needs could be met by increased productivity or efficiency alone, without development of additional water resources. Improving water use efficiency by 40% on rainfed and irrigated lands would be required to counter- balance the need for additional withdrawals for irrigation over the next 25 years to meet the additional demand for food. Growing more crop per drop of water use is the key to mitigating the water crisis, and this is a big challenge to many countries. Vagaries of monsoon and declining water table due to over exploitation have resulted in shortage of fresh water supplies for agricultural use, which calls for an efficient use of this resource. Strategies for efficient management of water for agricultural use involves conservation of water, integrated water use, optimal allocation of water and enhancing water use efficiency by crops.

Crop and varietal Selection

The prime most important strategy under the water scarce condition is the proper crop selection and its varieties to be cultivated in the season. The amount of rainfall (Rainy season) and crop growing season should be matched, so as the crop selected would be able to utilize the maximum amount of water received in that particular time. Escaping drought, in this plant completes its life cycle and matures before the shortage of water ceases in is termed as ephemerals. For major field crops, there are many examples where the use of early maturing (or early flowering) cultivars increased and stabilized grain yield, especially in conditions of 521 terminal drought (Fereres *et al.*, 1998). Improved varieties well adapted to specific conditions can improve soil water use and increase yield. These varieties should be tolerant to abiotic stresses such as cold, drought and heat, and biotic stresses such as diseases and insects (Dakheel *et al.*, 1993). Shivani *et al.* (2003) reported that wheat cultivars HUW 234 and Lok 1 had higher water use efficiency.

Sowing/ Planting time and method

Sowing time is the non-monetary input in factors of production which not only ensures higher yields but also the maximum utilization of the applied inputs and resources. Sowing and Planting time is a vital factor for achieving higher yield and maximum utilization of available resources. As an example, attempts made to persuade farmers to move from spring to winter sowing of chickpea gave 30-70% yield increases (Erskine and Malhotra, 1997). Grain yield increase of 20-25% was obtained by sowing lentil in mid-November instead of early January (Pala and Mazid, 1992b). Planting pattern has a direct effect on yield, solar energy capture and soil water evaporation and thus an indirect effect on water use efficiency. The correct method of planting according to the site moisture availability or other factors can help to increase the yield or reduce the total irrigation water to be applied to crop without affecting the yield of crop. Gill *et al.*, (2006) reported that better water use efficiency and water productivity were observed in direct seeded rice.

Plant density

Establishment of an optimum plant density per unit area is a non-monetary input factor for getting higher production. There is a considerable scope for increasing yield by proper adjustment of spacing (Balyan and Mehta, 1985). This can be done by adjusting both inter row as well as intra row spacing. Plant population and yield of crop are the important factors which are interdependent to each other. The number of plants per unit area forms a base of yield triangle. More than optimum plants ha^{-1} tends to enhance total yield, but $plant^{-1}$ yield reduces substantially. On the contrary, lesser plants $unit^{-1}$ area than the optimum, tend to produce higher $plant^{-1}$ yield, but plants number being suboptimal which reduce the yield ha^{-1}. Soil water evaporation is reduced with higher planting density. In humid regions where rainfall exceeds evapotranspiration, plant densities can be increased with a concomitant increase in yield. However, in semi-arid areas where soil moisture is deficit the thicker stand are avoided. The desirable plant density which could be supported by available moisture up to production of economic part and not initial biomass only is recommended for these situations. Karrou (1998) observed that the lower seed rate of 200 kernals/m^2 gave the highest grain yield and WUE of durum wheat, which was statistically at par with 300 kernals/m^2 but significantly better than 400 kernals/m^2.

Nutritient management

Good yield can be achieved by balanced nutrition along with nitrogen and adequate supply of phosphate and potash is highly important. Fertilizer is an important input for successful crop production. Fertilizer use can also have a very marked effect on crop yield and water use efficiency. Nitrogen, phosphorus, combination of chemical fertilizer with organic fertilizer or chemical fertilizer with biofertilizer has been shown to increase growth and development in both dry and irrigated areas. Patil and Sheelavantar (2000) reported that application of nitrogen increased the yield, water use efficiency and yield component of sorghum. Ghosh *et al.* (2003) reported that application of 75% NPK and poultry manure 1.5 t/ha recorded the highest water use efficiency of rainfed sorghum.

Irrigation

The artificial supplementation of water to the crop during water deficit and critical growth stages is known as irrigation. Irrigation scheduling can be used to improve WUE, and various strategies may be adopted depending on the crop response to water stress, water holding capacity of the soil, the availability of irrigation water and the irrigation system used. Nadeem *et al.* (2007) reported that maximum water use efficiency of wheat was recorded at IW: CPE ratio 1.25, which was statistically on a par with that at IW: CPE ratio 1.0. Ghadage *et al.* (2005) reported that the water use efficiency of cotton was higher due to each row and alternate row irrigation. This might be due to the significantly same seed cotton yield produced by irrigation techniques. However, Nalayini *et al.* (2006) reported that water use efficiency of cotton was highest with drip irrigation as than conventional irrigation during winter season.

Intercropping

Growing two or more crops simultaneously on the same piece of land with a definite row arrangement is called as intercropping. The main objective of intercropping is to get higher productivity per unit area in addition to stability production. Intercropping utilizes resources efficiently. Efficient intercrops are cowpea, greengram, blackgram, soybean, etc. Inter and mixed cropping is a practice to have an opportunity to diversify cropping system by making the multiple land use possible utilizes water and other resources more effectively and also provides a cover against the failure of one crop particularly under the rainfed situations. Any factor that increases yield will increase water use efficiency. Higher water use efficiency has been reported for Maize + potato (Bharati *et al.,* 2007), pearlmillet + greengramand pearlmillet + cowpea (Goswami *et al.,* 2002) intercrops in relation to their respective monocrops.

Soil moisture conservation practices

Soil moisture is the most limiting factor in dryland agriculture. About 60-75% of the rainfall is lost through evaporation. Such losses can be reduced by mulches, antitransoirants, wind breaks. Agronomic measures of soil moisture conservation include strip cropping, vegetative barriers. These measures help in greater intake rate of water by the soil due to imporove in organic matter and soil structure. There is better interception of rain water and hence reduction in splash erosion. Antitranspirants are the materials which are applied to transpiring plant surfaces to reduce water loss from the plant. E.g.:Stomata closing type (Phenyl mercuric acetate), Film forimg type (Mobileaf), Reflecting type (Kaolin). Moisture conservation practices have been widely practiced as a mean of improving yields in water limited environment. Continuous cover crops can reduce on- farm erosion nutrient leaching and grain losses due to pest attacks and build soil organic matter and improve the water balance, leading to higher yields (Oliver *et al.,* 2010). Awasthi *et al.* (2007) reported that water use efficiency of Indian mustard was highest with the weeding, hoeing and paddy straw mulch at 20 days after sowing followed by weeding, hoeing and grass mulch at 20 days after sowing, weeding and hoeing at 20 days after sowing and control. Vegetative barriers; dense vegetation is raised across the slope for making the live bunds. The vegetative barier helps to reduce the length of field slope, check the run off velocity, improve the soil moisture. Chand and Bhan, 2002 reported that water use efficiency of sorghum was appreciably improved due to different vegetative barriers over control. The maximum water use efficiency was recorded under *Sesbaniasesban* followed by *Leucaenaleucocephala* and *Cajanuscajan* barriers. Minimizing water use efficiency was observed under the control crop. The increase in the water use efficiency may be attributed to appreciable increase in grain yield which was in much greater proportion than the water use under different vegetative barriers.

Integrated farming systems

An integrated farming system is a holistic production system which combines the sectors such as agriculture, horticulture, dairy, fishery, sericulture etc which ensures growth and stability in overall productivity and profititability. Comparing the different combination of farm enterprises, crop + fishery system gives more profit per unit of water followed by crop + dairy combination. The water productivity has increased considerably where allied enterprises involved along with crops. Among the allied enterprises, dairy component requires minimum water which in turn produced maximum water productivity per unit of water (Palanisami and Ramesh, 2009).

CONCLUSION AND REMARK

Water is utmost requirement of any living being around the globe. As far as plants are concerned water use efficiency is an important physiological characteristics which is related to ability of crop to cope with the water stress condition. It can be manipulated and enhanced by selection of proper crops in a respective season, timely sowing, maintaining an optimum population, supply of optimal nutrition and irrigation, adoption of intercropping, use of newer techniques such as mulching, spray of antitranspirants, vegetative barriers and last but certainly not the least integrated farming system.

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THEME - VIII

Geospatial Applications in Water Resources

Development of an Automatic Algorithm for Extraction of Waterlogged Areas using Geospatial Techniques

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ABSTRACT

The automatic extraction of features of land using time series data has become reliable and time saving as the conventional remote sensing techniques are tedious. As multispectral and multi temporal remote sensing plays an important role in assessing waterlogged areas, Resourcesat-1 AWiFS datasets (spatial resolution of 56m) of 2004 to 2013 of parts of Haryana are used. The advantages of automation over conventional methods are allowed to make low cost assessments of the value of larger investments in extraction technology. The land degradation process is water logging and at present this problem is addressed to resolve the standing water and surface wetness using satellite data. The primary goal of present study is to develop an automatic algorithm to extract waterlogged areas using remote sensing data. Two spectral indices were used for extracting waterlogged areas in parts of Haryana, India, which have rainfall variability ranked topmost in climate related risks. The rule based automatic algorithm was developed using MATLAB and waterlogged areas were mapped for Resourcesat-1 AWiFS datasets. Waterlogged area features were more enhanced by including indices in the algorithm and the values of indices were positive for water features mixed with vegetation. The algorithm is validated using error matrix method and it is found that the algorithm is working satisfactorily. The results indicate that the overall accuracy of waterlogged areas extracted from the automatic algorithm figures for AWiFS is 90%.

Keywords: Remote sensing, Spectral Indices, Waterlogged areas, AWiFS and MATLAB.

1.0 INTRODUCTION

Water logging is a land degradation process and at present this problem is addressed to resolve the standing water and surface wetness using satellite data. The water logged areas appear in dark bluish shades to light bluish shades with smooth textures on the satellite data due to absorption of radiation in all spectral regions of electromagnetic spectrum. An automatic hierarchical multi criterion modeling approach has been developed to extract various features such as glacier using reflectance and indices derived from IRS Advanced Wide Field of view Sensor (AWiFS) (Praveen et al. 2011). This approach clearly discriminates between lake ice, water, wet snow and glacial ice. With minor feature based analysis and corrections, the same model can be applied to other sensors having similar spectral bands (Praveen et al. 2011). The identification and delineation of waterlogged areas using remote sensing is mainly based on characteristic spectral response from the soils. Remote sensing often requires other kinds of ancillary data to achieve both its greatest value and the highest levels of accuracy as a data and information production technology (Munyati, C., 2000). Remote sensing (RS) and geographical information system (GIS) offers convenient solutions to map the extent and severity of water logging, particularly in large areas. Rationed images are often useful to discriminate spectral variations in the images from individual spectral bands.After 2005, the second approach involved the use of band-ratio approach using two multispectral bands. One band, taken from visible wavelengths, is divided by the other band usually from near infrared (NIR) wavelengths (Xu, H., 2006_). By using this band ratio approach, the areas inundated with water are enhanced but vegetation and land features are suppressed (Xu, H.,2007). The water features from satellite imageries have been extracted using various indices like Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) (Lira,J.,2006 and Merot, Ph., 1995). Several studies have shown that MNDWI gives better results for extracting water featured from Landsat, SPOT, ASTER and MODIS imagery (Kaiser et al 2013 and Kaul, H.A, 2011) but there are very few studies in which NDWI and MNDWI have been compared for extracting water features using coarse and fine resolution imageries from Indian Remote Sensing satellites (Panigrahy, S. 2012). Several approaches used to distinguish positional waterlogging from other types of waterlogging (Merot, Ph., 1995). Dennison. 2005, found that NDWI is less sensitive to vegetation containing large amount of water. There is a need for further investigation whether NDWI and MNDWI can be used for extracting water features mixed with vegetation. Mapping of waterlogging was approached using digital classification with NDWI and MNDWI followed by online visual interpretation. The NDWI was developed by Mc Feeters for extracting waterlogged areas (McFeeters, S., 1996) NDWI is defined as NDWI = (Green-NIR) / (Green+ NIR) where Green is a green band (Resourcesat-2 AWiFS band 2) and NIR is the near infrared band (AWiFS band 4). The value of NDWI ranges from -1 to +1. The reflectance of water is higher in green band and lower in NIR band, but the reflectance of vegetation is higher in NIR band than green band. The subtraction of NIR band from green band in the numerator of NDWI will result in positive values of water features and negative values of vegetation. It has been found that water features may not be accurately extracted using NDWI due to spectral confusion of built-up land with water bodies because built up land may also have positive values in the NDWI derived image (Lillesand, T. M., 1994).The value of MNDWI also ranges from -1 to +1.Thehigher reflectance of builtup and lower reflectance of water in SWIR band result in negative values of built-up and positive values of water features in the MNDWI derived image.

2.0 STUDY AREA AND DATASETS

The present study focused on extraction of waterlogged areas automatically in the part of Haryana especially, Rohtak and Jajjhar. The extent of study area is 3731.22 km^2. The study area located between latitudes of 28^o 46’ to 29^o 67’N and longitudes of 75^o 35’ to 76^{o}51’E.

2.1 Remote Sensing Data

IRS-P6 AwiFS sensor is highly preferable for the reason that it contains the SWIR band which gives dynamic moderate resolution data. It ensures continuity of medium and high resolution data supply. AWiFS Datasets of 2005, 2006 with 56m resolution are used for the presentstudy. LISS- III data of the year 2005 with 23.5 m resolution is also used for validation.

2.2 Ancillary Data

Survey of India topographical maps 1:50,000 and 1:250,000 scales were used for identification of cultural features (settlements& roads etc) and preparation of base map. Available thematic maps of Land Use/Land Cover, wastelands and land degradation were used in identification of waterlogged areas for extracting digital signatures from the satellite data. These maps also used for accuracy assessment.

3.0 METHODOLOGY

Automated feature extraction can be defined as the identification of geographic features and their outlines in remote-sensing imagery through post-processing technology that improves feature definition, either by increasing feature-to- background contrast or by the usage of pattern recognition software. To develop an automatic extraction algorithm the following were employed.

3.1 Geo-referenced AWiFS data

In the data acquisition, the satellite image was used as the main source of the data. This IRS-P6 satellite data was clipped to the desired area. The data was in IMG format were exported into ERDAS Imagine and converted to TIFF format. AWiFS images are reprojected to Geographic (Lat/Long) Projection using WGS84 Datum.

3.2 Generation of indices

Two indices namely,Normalized Difference Water Index (NDWI),Modified Normalized Difference Water Index (MNDWI) are shortlisted for development of an algorithm.

3.2.1 NDWI

(Normalized Difference Water Index): In 1996, McFeeters [24] expressed normalized difference water index as follows:

$$NDWI= (GREEN-NIR)/ (GREEN+ NIR) \quad (1)$$

Where, Green is a green band, and NIR is a near infrared band

3.2.2 MNDWI

(Modified normalized Difference Water Index): The modified NDWI (MNDWI) can be expressed as follows:

MNDWI= (GREEN-MIR)/ (GREEN + MIR) (2)

Where, MIR is a middle infrared band.

3.3 ALGORITHM IMPLEMENTATION

Geo-referenced temporal AWiFS data set was used as input to an algorithm and after processing, it generates the extracted output. The output of an algorithm was waterlogged areas.

3.3.1 Architecture of the Automated Algorithm Development

Geo-referenced temporal AWiFS data sets were used as input. Steps involved in the process of an algorithm are as follows:

Step-1: Defining training areas using AWiFS datasets.

Step-2: Computation of NDWI and MNDWI

Step-3: Computational formula for NDWI= (GREEN-NIR)/(GREEN+NIR)

Step-4: Computational formula for MNDWI= (GREEN-MIR)/(GREEN+MIR)

Step-5: Accuracy assessment (Threshold is 225)

3.3.2 Code implementation using MATLAB

Using MATLAB 2013, Image processing tool box implementation of an algorithm is given below.

```
clear all;
clc;
[A,R] = geotiffread('haryana_October2004.tif');
P=single(A);
img_size = size(A);
x_max = img_size(1);
y_max = img_size(2);
fori=1: x_max
for j=1: y_max
B(i,j)=P(i,j,1);
C(i,j) = P(i,j,3);
D (i,j) = P(i,j,4);
I(i,j)=P(i,j,1);
J(i,j)=P(i,j,1);
L(i,j)=A(i,j,1);
M(i,j)=A(i,j,1);
N(i,j)=A(i,j,1);
O(i,j)=A(i,j,1);
end
end
E=B-C; F=B+C; G=B-D; H=B+D;
fori=1: x_max
for j=1: y_max
if F(i,j) ~= 0
I(i,j)= E(i,j)/F(i,j);
```

```
else I(i,j)= 0;
end
end
end
fori=1: x_max
for j=1: y_max
if H(i,j) ~= 0
J(i,j)= G(i,j)/H(i,j);
else J(i,j)= 0;
end
end
end
I_max = max(I);
I_max1 = max(I_max);
I_min = min(I);
I_min1 = min(I_min);
minout = 0;
maxout = 255;
J_max = max(J);
J_max1 = max(J_max);
J_min = min(J);
J_min1 = min(J_min);
fori=1: x_max
for j=1: y_max
 L(i,j) = ( (I(i,j) - I_min1)*( maxout - minout ) )/( I_max1 - I_min1 ) + minout ;
end
end
fori=1: x_max
for j=1: y_max
M(i,j) = (J(i,j) - J_min1)*( maxout - minout )/( J_max1 - J_min1 ) + minout ;
end
end
N=L+M;
fori=1: x_max
for j=1: y_max
if N(i,j) > 225
O(i,j)=1;
else O(i,j)=0;
end
end
end
```

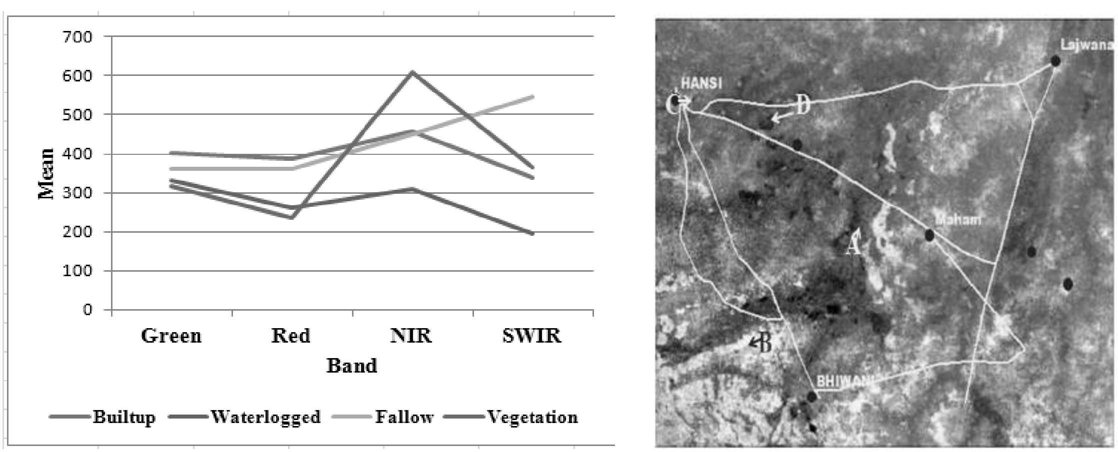
```
P = uint8(O);
geotiffwrite('hary04.tif',N,R);
geotiffwrite('haryana2004.tif',P,R);
```

4.0 RESULTS AND DISCUSSIONS

The results obtained from the present study to extract information on waterlogging were arranged as utility of spectral feature parameters, implementation of automatic extraction algorithm and accuracy assessment with validation for the two data sets i.e. AWiFS and LISS-III.

4.1 Spectral feature parameters

Figure 1(a) shows the standard FCC of central part of Haryana. Spectral signatures of different features (including builtup area & fallow land) were analyzed (as shown in Figure 1) to identify unique pattern in each land cover to develop spectral indices. Spectral signatures analysis of various land covers showing better separation of these classes in band 4 compared to others. The waterlogged areas and FCC images are seen in dark or light white with smooth texture (class ‘D’).along the irrigated canal network. The other broad landuse classes are crops (class ‘A’), fallow lands (class ‘B’), and built-up (class ‘C’). Separability of these classes is shown in figure 1(b). For these major classes, this is keen in the analysis of satellite image, longer visible wavelengths and near infrared radiation is absorbed more by water than by the visible wavelengths. Thus water looks blue or blue green due to stronger reflectance at these shorter wavelengths and darker if viewed at red or near infrared wavelengths. Results showed that the reflectance pattern of built-up (class ‘C’) in the green band and NIR band was similar with that of waterlogged area (class ‘D’), i.e. they both reflect green light more than they reflect near infrared light. The SWIR (short wave infrared) band is particularly significant because of its strong relation with the water content in the vegetation canopy cover. It was observed that a large amount of absorption by leaf water occurred in the wavelength region of 1.4–2.5 m and therefore SWIR reflectance was negatively related to leaf water content while NIR is almost independent of the variation in water content. SWIR band is sensitive to the amount of water in the plants. Band 4 has separated waterlogged (dark tone) from fallow lands. In these spectral profiles, unique patterns have been identified in waterlogged and built-up area spectral signatures, and bands combinations in which these two land covers have almost similar reflectance with minute differences, are used to develop two indices.



A: Crops; B: Fallow land; C: Builtup; D: Waterlogged 1 (b) Spectral reflectance patterns of various classes

Legend:

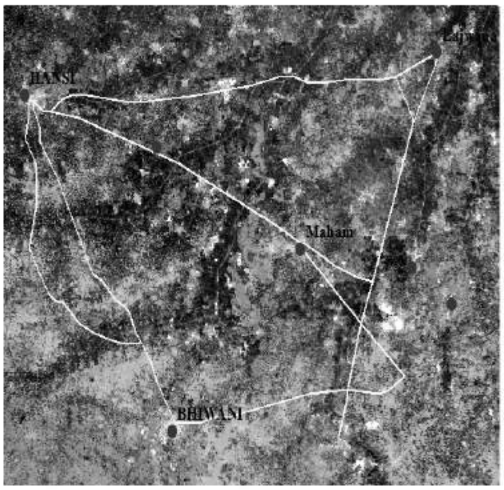
● **Settlement**

Roads

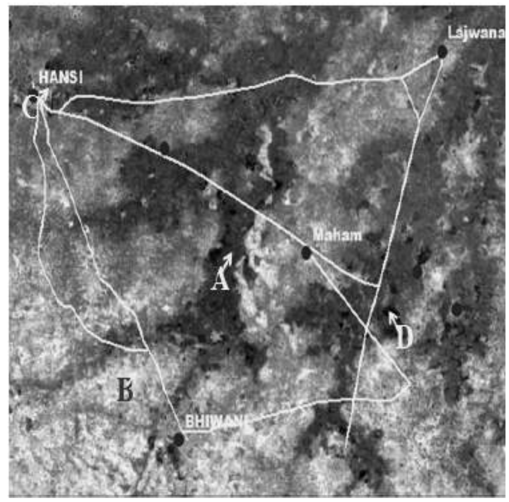
Figure 1. Spectral profile of major land covers

Spectral indices for extraction of waterlogged areas:

The spectral indices derived by using Green, NIR, and SWIR bands namely Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) are useful in the extraction of waterlogged area automatically. The results obtained with reference to NDWI are discussed below. As the land/water demarcation is confusing in a single NIR band, and hence, two band data such as G & NIR bands can be used in such situations. Thus rationing of the two bands takes advantage of the different wavelengths in enhancing a particular feature from the satellite data. Hence, in the present study, the Normalized Difference Water Index (NDWI) developed and used for delineation of waterlogged areas and to enhance their presence in remotely sensed digital imagery while simultaneously eliminating soil and terrestrial vegetation features. The NDWI values for waterlogged areas identification in the satellite images of October 2004 are fixed. FCC and NDWI of the study area in 2005 are presented in figure 2(a) and figure 2(b).



2(a) FCC of study area, October, 2005



2(b) NDWI of study area, October, 2005

Legend:
● **Settlement**
Roads

Legend:
● **Settlement**
Roads

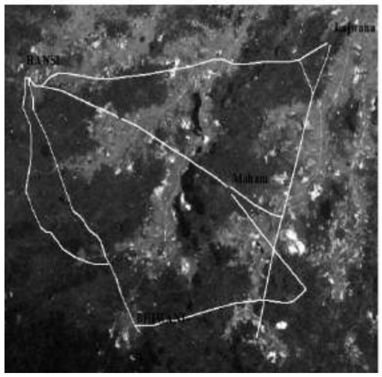
A: Crops; B: Fallow land; C: Builtup; D: Waterlogged area

Figure 2. NDWI image of study area

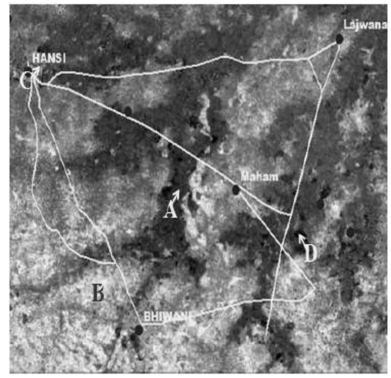
In the NDWI image the waterlogged areas (class 'D') are seen as bright white irregular shape smooth patches very distinctly as compared to other landuse classes in the study area.The NDWI image resulted in similar reflectance pattern for water and built-up in the green band and NIR band. The range of NDWI image is -0.5 to 1.The reflectance of built-up and waterlogged areas were similar (-0.14 for water -0.17 for built-up).The negative values of NDWI for mixed water pixels comprising 70% of water fraction, 5% of soil fraction, 25% vegetation fraction.From the NDWI image it is derived that, the value of NDWI for water is either equal to or greater than 0.32 and the values ranges from -0.34 to + 0.59 represents some of the water logged areas.NDWI image resulted in similar reflectance pattern of water and built-up in the green band and NIR band. The built-up was present in a medium grey tone in the NDWI image. The NDWI of built-up and water features were similar (-0.14 for water and -0.17 for built-up). Both bands in built-up and water features reflect green light approximately similar than they reflect near infrared light. Consequently, the contrast value between the built-up and water was only 0.03. A low contrast value with water features caused the presence of built-up as a noise in the NDWI image.The MNDWI is more suitable for enhancing and extracting water information for a water region with a background dominated by built-up areas because of its advantage in reducing and even removing built-up land noise over the NDWI.

FCC and MNDWI of the study area in 2005 are presented in figure 3(a) and figure 3(b). The result of MNDWI image showed that, this image enhanced the water features and removed the noise from built-up features because it absorbs more light in the SWIR region than in NIR region range of MNDWI is -0.51 to 1.The MNDWI for water is

0.04 and -0.12 for built-up. MNDWI can enhance the contrast between the water and built-up land features because of their reflectance in the MIR band. The range of MNDWI is lies between -0.512 to 1. Here these values greater than 0.03 represent waterlogged areas. It can quickly and accurately discriminate waterlogged areas from non-water feature. In the implemented algorithm the two indices are added then waterlogged areas (class'D') are easily picked.



3(a) FCC of study area, October, 2005



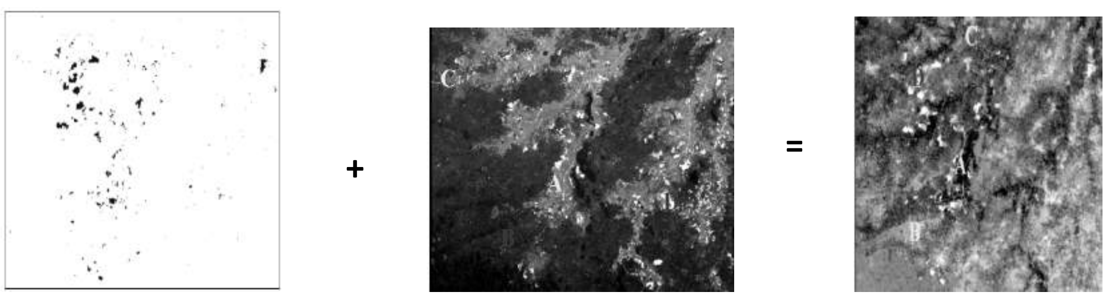
3(b) MNDWI of study area, October, 2005

Legend:
Settlement
Roads

Legend:
Settlement
Roads

A: Crops; B: Fallow land; C: Builtup; D: Waterlogged area

Figure 3. MNDWI image of study area



NDWI MNDWI Extracted output, October, 2004

A: Crops; B: Fallow land; C: Builtup; D: Waterlogged area

Figure 4. Waterlogged area extracted by an algorithm

To enhance the accuracy of extracted pixels of waterlogged areas in the NDWI image, the two thematic layers are combined. In an output image the reflection of waterlogged areas is more and easy to discriminate between water bodies and non water features.

4.3 Accuracy Assessment

The accuracy analysis of an automated algorithm for waterlogged area extraction from AWiFS data has been carried out using error matrix method. For accuracy assessment land degradation map of Haryana has been used as reference map. Figure 5 shows the land degradation map with waterlogged area features. The accuracy was usually assessed by comparing the extracted output with some reference data that is believed to accurately reflect the true land-cover. Sources of reference data include ground truth, higher resolution satellite images and maps derived from aerial photo interpretation. Accuracy report from error matrix method for extracted output images have been carried out.

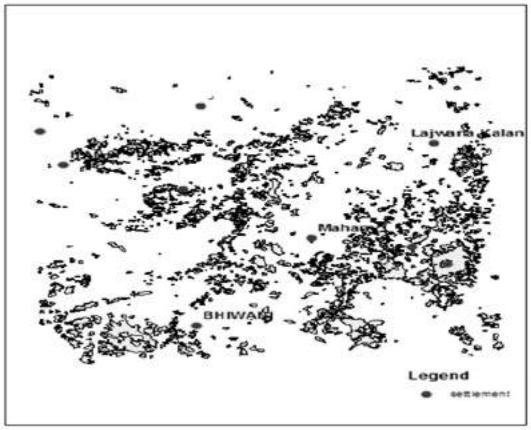


Figure 5. Land Degradation map of the study area

The results of accuracy assessment in respect to IRS_P6 Resourcesat-1 AWiFS image, October 2005 and LISS-III image October 2005 are presented in Table 1& Table2 .Results showed that an overall accuracy 93.3% by LISS-III and 90% by AWiFS dataset used for estimation of waterlogged area in the study site.

Table 1. Error matrix for AWiFS image -Accuracy Totals

Classified Data	Unclassified	Waterlogged	Number Correct	Producer's accuracy	User's accuracy
Unclassified	11	10	9		
Waterlogged	19	20	18	94.74%	90.00%
Column Total	30	30	27		

Overall Classification Accuracy = 90.00%

KAPPA (K^) Statistics:

Overall Kappa Statistics = 0.7805

Conditional Kappa for each category:

Class Name	Kappa
Unclassified	0.8421
Waterlogged	0.7273

Classification Accuracy Assessment Report of IRS_P6 Resourcesat-1 LISS-III Image, October 2005.

Table 2. Error matrix for LISS-III image-Accuracy Totals

Classified Data	Unclassified	Waterlogged	Number Correct	Producer's accuracy	User's accuracy
Unclassified	12	10	10		
Waterlogged	18	20	18	100.00%	90.00%
Column Total	30	30	28		

Overall Classification Accuracy = 93.33%

KAPPA (K^) Statistics:

Overall Kappa Statistics = 0.8571

Conditional Kappa for each category:

Class Name	Kappa
Unclassified	1.0000
Waterlogged	0.7500

The commonly used accuracy parameters or indices derived from the error matrix are the overall accuracy and the user's and the producer's accuracies and Kappa coefficient. From the accuracy assessment reports it is found that, Table 1 and Table 2 shows the information class waterlogged and another is unclassified. The "overall accuracy" provides the probability of the correctness in the classified image. The overall accuracy is 93%, which can be interpreted as 93% of the area is correctly classified using LISS-III and 90% of the area is correctly classified using AWiFS. The user's and the Producer's accuracy provide impressions of the commission and omission errors respectively for each class in the classified image. The user accuracy for LISS-III and AWiFS was 90% and producer accuracy for LISS-III and AWiFS image are 100% and 94% respectively.

Table 3. Accuracy estimates of waterlogged areas in AWiFS and LISS-III sensors

Sensor	Overall accuracy	Kappa efficient
LISS-III	93.33	0.8571
AWiFS	90.00	0.7805

From the above table 3, the conditional kappa coefficients for LISS-III and AWiFS were 0.85 and 0.78 respectively, which shows the algorithm is resulting satisfactorily. The accuracy evaluation carried out using different methods showed that the automated extraction algorithm for waterlogged areas provides accuracy greater than 90% for both classification accuracy and waterlogged area estimation for water bodies .The reduction in the accuracy in the area estimate is essentially due to the increased number of water pixels. The above analysis shows the suitability of the algorithm for regular generation of waterlogged area from AWiFS image data for operational activities related to monitoring and management of water resource.

5.0 CONCLUSIONS

An automated algorithm for the extraction of waterlogged areas was developed for the central part of Haryana in India using AWiFS data and the automatically extracted results showed the algorithm is working satisfactorily. The summary of the conclusion is as follows:

1. The use of spectral indices namely NDWI, MNDWI derived from spectral bands Green, NIR, SWIR from IRS sensors were found to be useful in extraction of waterlogged areas with high degree of accuracy.
2. An automatic algorithm was found to be extracting waterlogged areas from AWiFS and LISS-III data with an overall accuracy of 90% and 93% respectively.

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Evaluation of NDWI and MNDWI for Intra-Annual and Inter Annual Assessment of Waterlogged Areas using Satellite Data - A Case Study

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ABSTRACT

Waterlogging is one of the major land degradation process that restricts the economic and efficient utilization of soil and land resources in command areas. Remotely sensed data from satellite can be used to derive information on waterlogged areas due to its repetitive nature with multi spectral bands and large area coverage. Indian Remote Sensing (IRS- P6) Advanced Wide Field Sensor (AWiFS) digital data for the years of 2004, 2005, 2006, 2008,2010,2012,2013 were used for extracting information on waterlogged areas. The imagery has four spectral bands [band-2 (VIS), band-3 (VIS), band-4 (NIR) and band-5 (SWIR) with wavelength ranges 0.52–0.59, 0.62–0.68, 0.77–0.86 and 1.55–1.7 μm, respectively. The water logged areas appear in dark bluish shades to light bluish shades with smooth textures on the satellite data due to absorption of radiation in all spectral regions of electromagnetic spectrum. Rohtak and Jajjhar Districts of Haryana, India experiencing heavy rainfalls is selected as study area. Hence, inter and intra annual changes in waterlogged areas pertaining to Haryana state are assessed using Resourcesat-1 AWiFS datasets and two spectral indices NDWI and MNDWI. The waterlogged area extracted using satellite data estimates 4.5% of total geographical area of study area in 2010 and decreases to 1.4% due to less rainfall in 2012. It has been ascertained from the results obtained using satellite data that the waterlogging is not constant and varies with time and rainfall variations.

Keywords: waterlogged areas, NDWI, MNDWI, multispectral multi-temporal data, inter and intra annual changes.

1.0 INTRODUCTION

Ministry of Water Resources (1991) considered water table within 2m of land surface that comes under waterlogged area. Diagnosis and mapping of waterlogged in irrigation command areas is a pre-requisite for management of valuable land resources. The National Commission on Agriculture (1976) reported that an area of about 6.0 Mha was under waterlogged condition in the country. Out of this, an area of 3.4 Mha was estimated to be under surface water stagnation and 2.6 Mha through rise in water table. The Ministry of Water Resources (1991) estimated an area of 2.46 Mha suffered from the problem of waterlogging under irrigation command areas. According to the national wasteland change analysis, spatial extent of different classes of waterlogged area were 5526.68 and 8703.39 sq.km respectively in the year 2005-06 and 2008-09.This represents an increase of 3952.09 sq.km area under waterlogged marshy (seasonal) land. The waterlogging problem in command areas is dynamic. It can be seasonal or permanent. Several automated algorithms have been developed for feature extraction. Researchers from 1991-2000 proposed that automatic feature extraction also can be done by using data fusion in remote sensing *(Paul S. Schenker, 1991).* A semi automated procedure integrated thresholding, region growing and edge detection techniques for feature extraction in remotely sensed imagery. An interface has been developed to provide an interactive platform of the procedure. Thresholding technique is employed to sample object of interest. Estimated properties (i.e., mean and variance) of the sample are applied for feature extraction using region growing. Since the derived object is subject to the sample and initial conditions, edge detection is incorporated to calibrate initial parameters by examining how the derived object matches the local edges inherent in the imagery (*Quanfa Zhanga, b., et. al., 2005)*. Spectral indices based automated extraction of water bodies has been attempted and these methods have limitation due to interference from cloud shadows and urban areas etc. *(Ouma, Y.O., 2006)*. Some methods for automatic extraction are implemented in MATLAB environment. Very high resolution satellite imagery like IKONOS and Worldview satellite datasets are used to test the algorithms *(Lillesand, T. M.,1994).* A novel approach for the automatic extraction of trees from co-registered

DSMs and color-infrared imagery was implemented The results are promising as long as the ground resolution of the DSM is high enough, while coarser input data leads to a deterioration of the quality *(Dennison, P., et.al., 2005)*. Under Indo-Dutch Network Project, a study was taken up to map salinity and waterlogging using visual interpretation in a part of the Nagarjuna Sagar Project (NSP) right canal command area using satellite data *(Panigrahy, S.,2012)*.The problem of waterlogging in terms of surface ponding under NSP right canal command area was limited to a few pockets. Remotely sensed data enabled to identify such areas on the FCC print. An area of 50 ha was found under this category. Remote sensing often requires other kinds of ancillary data to achieve both its greatest value and the highest levels of accuracy as a data and information production technology *(Munyati, C., 2000)*. The four channel Multispectral Scanner System (MSS) aboard Landsat-1, with spectral measurements made in the narrow and discrete bands of the electromagnetic spectrum, provided a synoptic view of the Earth's surface every 18 days. Such data enabled soil scientists to delineate and monitor the temporal behavior of waterlogged areas *(Singh, J., 2006)*, to a degree adequate for planning reclamation programmes. Mapping of waterlogging was approached using digital classification with NDWI and MNDWI followed by online visual interpretation. The NDWI was developed by *Mc Feeters, 1996*, for extracting waterlogged areas. NDWI is defined as NDWI = (Green-NIR) / (Green+ NIR) where Green is a green band (Resourcesat-2 AWiFS band 2) and NIR is the near infrared band (AWiFS band 4). The water features from satellite imageries have been extracted using various indices like Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) *(Lira, J., 2006 and Merot, Ph., 1995)*. There are very few studies in which NDWI and MNDWI have been compared for extracting water features using coarse and fine resolution imageries from Indian Remote Sensing satellites *(Panigrahy, S.,2012)*.The delineation of waterlogging areas can also be inferred by analyzing the topography. In general, low lying areas are more prone to waterlogging than the upland areas. The interface of flood water with the terrain can be better visualized with the digital elevation model(DEM)which may help in better understanding of spatial distribution of waterlogging *(Lillesand, T. M.,2000)*.

2.0 STUDY AREA

The location of the study area is part of Haryana state shown in Figure 1.The extent of study area is 3731.22 km^2. The study area is located between latitudes of 28^o 46' to 29^o 67'N and longitudes of 75^o 35' to 76 51'E. the rainfall variability is ranked topmost in climate related risks. The Jajjhar district receives surface runoff from Rajasthan through the Sahibi and other rivers in the south. The surface runoff in the command area is received from the north in the Rohtak district.

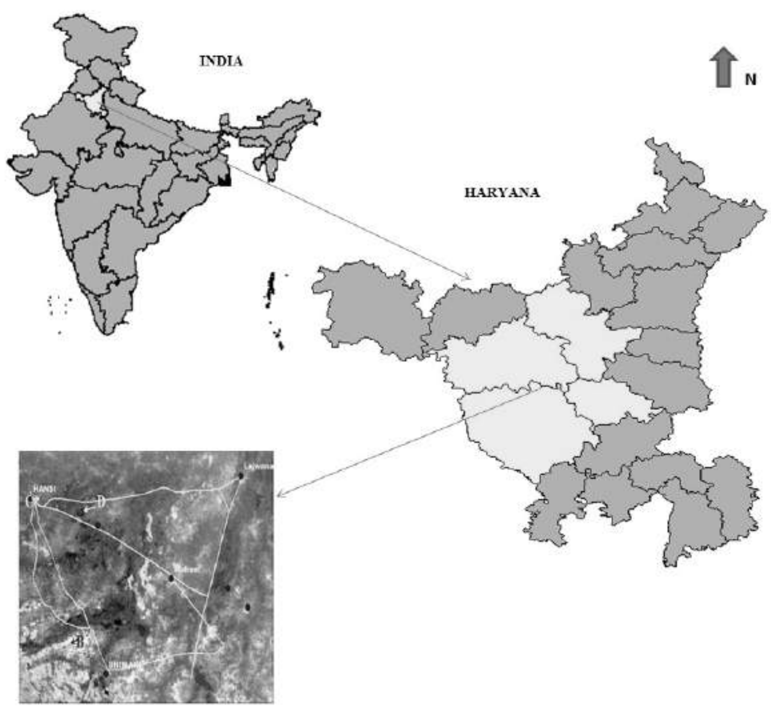


Figure 1. Location map of the study area

2.1 Data Used

IRS-P6 AWiFS sensor is highly preferable for the reason that it contains the SWIR band which gives dynamic moderate resolution data. It ensures continuity of medium and high resolution data supply. The high-resolution data is useful for applications such as urban planning and mapping, while the average resolution is used for vegetation discrimination, land mapping and natural resources management. Datasets used for the study are listed in table 1.

Table 1. Details of satellite data used in the study

SI No	Sensor	Spatial Resolution	Date of Acquisition	Path/ Row	Type of Satellite
1	AWiFS	56m	October,2004 October,2005 October,2006 October,2008 October,2010 October,2012 February,2013 March,2013 October,2013	95/53	Resourcesat-I

3.0 METHODOLOGY

The flowchart for the method is shown in figure 2.

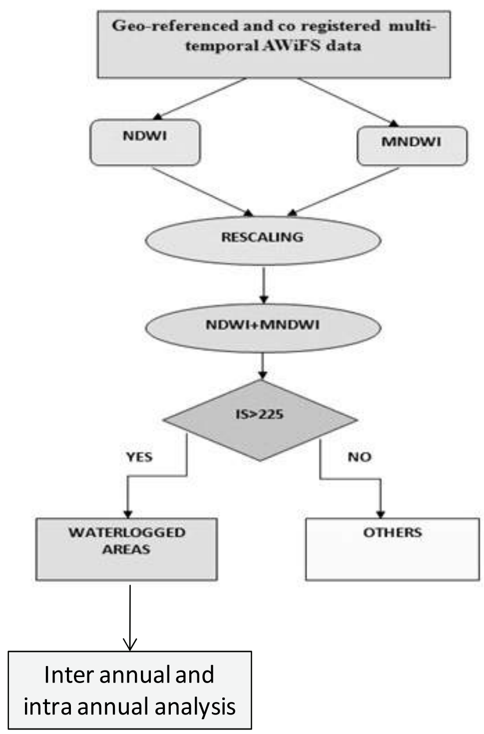


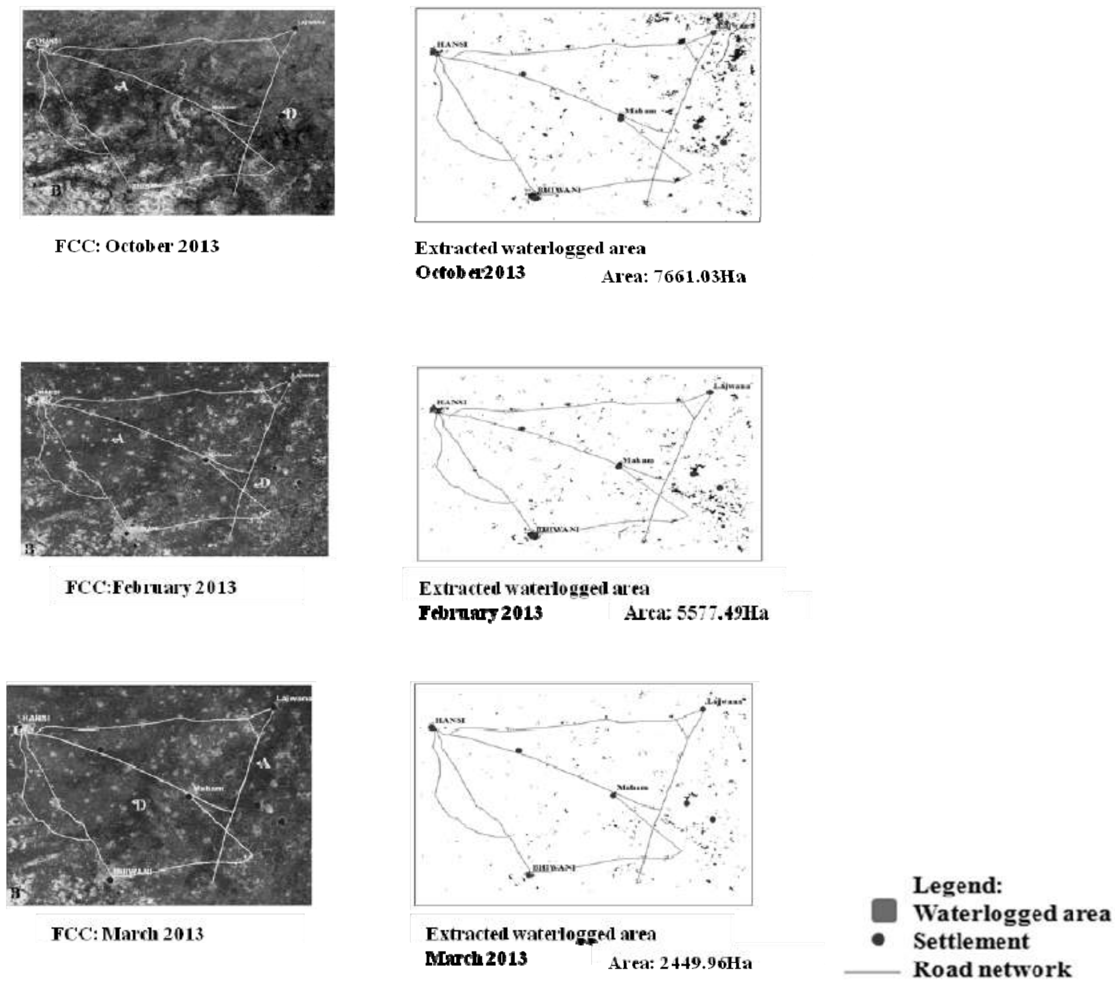
Figure 2. Methodology flow chart

An automatic algorithm is developed for the extraction of NDWI and MNDWI. By processing the algorithm according to the flowchart , the waterlogged areas were extracted for all the datasets for the study area. The observations are as follows: (1) The output image was overlaid on the FCC image and checked for the accuracy of an algorithm. (2) Threshold value for waterlogged area is season dependant but for same season across years it is constant. The developed automated algorithm was tested with AWiFS data of different months and also with different years. The intra and inter annual variations of waterlogged areas has been evaluated. Validation of algorithm has been carried out in parts of Uttar Pradesh.

4.0 RESULTS AND DISCUSSIONS

The implemented algorithm was tested for extraction of waterlogged area in the study area using February, March, October using AWiFS 2013 data. Figure 3 shows the AWiFS FCC image of the different months along with the extracted waterlogged area for the respected months. The testing and evaluation of the algorithm has been carried out to verify its scene and season independent extraction of waterlogged areas as this is one of the most important requirement for automated technique. Towards this an images of AWiFS covering the study area acquired over the year and the waterlogged area extraction has been carried out using the algorithm (Figure 3).

4.1 Intra Annual Assessment for the Year 2013



A: Crops; B: Fallow land; C: Builtup; D: Waterlogged area

Figure 3. Intra annual variations of waterlogged areas

Intra annual variation in the waterlogged area is useful for planning the water resource management plans well in advance immediately after the end of monsoon period. The comparative analysis of the waterlogged area can be very useful to detect the reduction amount of available water for use during the crop year and up to the next monsoon period. It provides suitable advice to the formers to opt the type of crop that can be cultivated for optimal utilization of water resource. Further the area of waterlogging in small and medium water bodies can be related to the rainfall in the local area and to the climate. In case of large waterlogged areas, the onsite measurements of the water availability have been regularly made, but in case of small and medium size waterlogged areas no information available about the water during different months across the year. The satellite based measurements can provide reliable information on the water resources in such cases. Figure 3 shows the waterlogging in the different months of the year 2013 that is extracted from the AWiFS images of central part of Haryana using automated algorithm. The water levels at all the waterlogged areas were maximum for that year. It reduces every month during the post monsoon period and reaches their minimum in the summer months of March.

4.2 Inter Annual Assessment

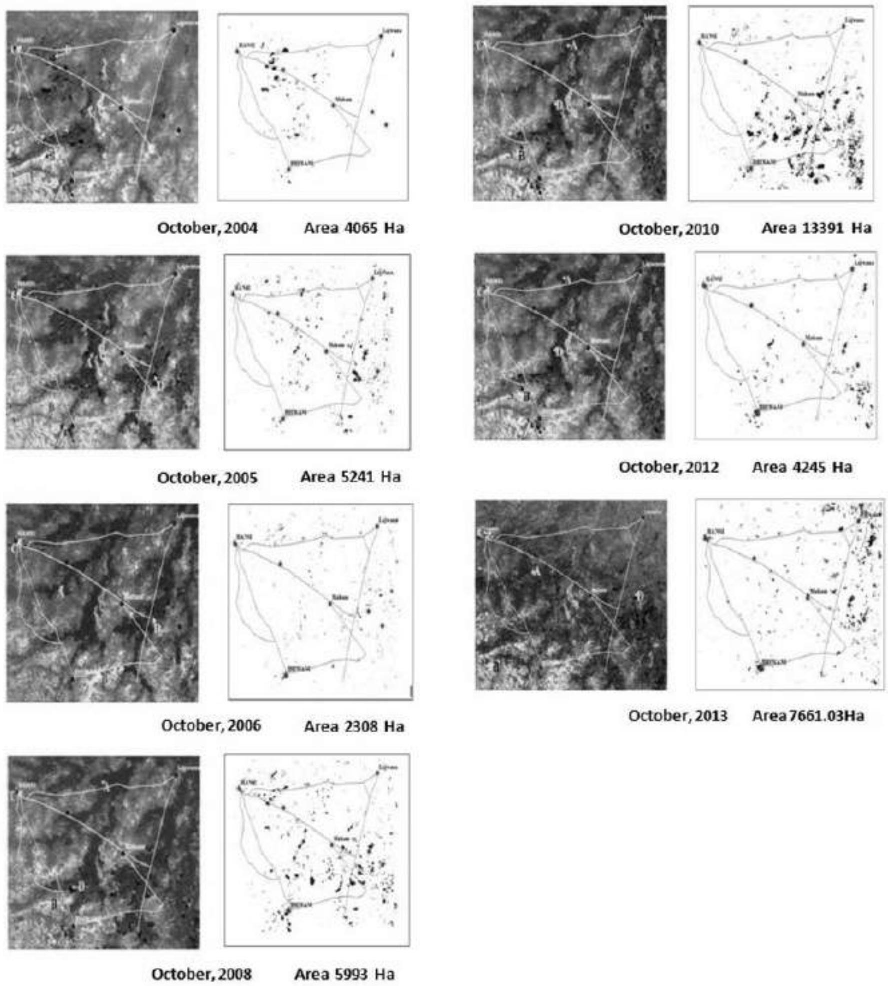


Figure 4. Intra annual variations of waterlogged areas

The automatic algorithm was also tested using AWIFS data for central part of Haryana using October month data of different years 2004, 2005, 2006, 2008, 2010, 2012 and 2013. The FCC image of the October month of the study area along with the extracted output is shown in Figure 4. The NDWI, MNDWI of different years has been generated and the threshold value (225) was finalized for waterlogged areas extraction using an automated algorithm. In view of the above analysis of waterlogged area variation over multiple years has been attempted. Results showed that the spatial distribution of waterlogged areas in the AWiFS images of the year's 2004 to 2013 that was extracted using the automated algorithm. The intra annual changes are shown in Table 2.

Table 2. Waterlogged area extracted from satellite data

Satellite imagery	Area under waterlogging in Hectares
October 2004	4065.81
October 2005	5241.53
October 2006	2308.41
October 2008	5993.88
October 2010	13391.37
October 2012	4245.21
February 2013	5577.49
March 2013	2449.96
October 2013	7661.03

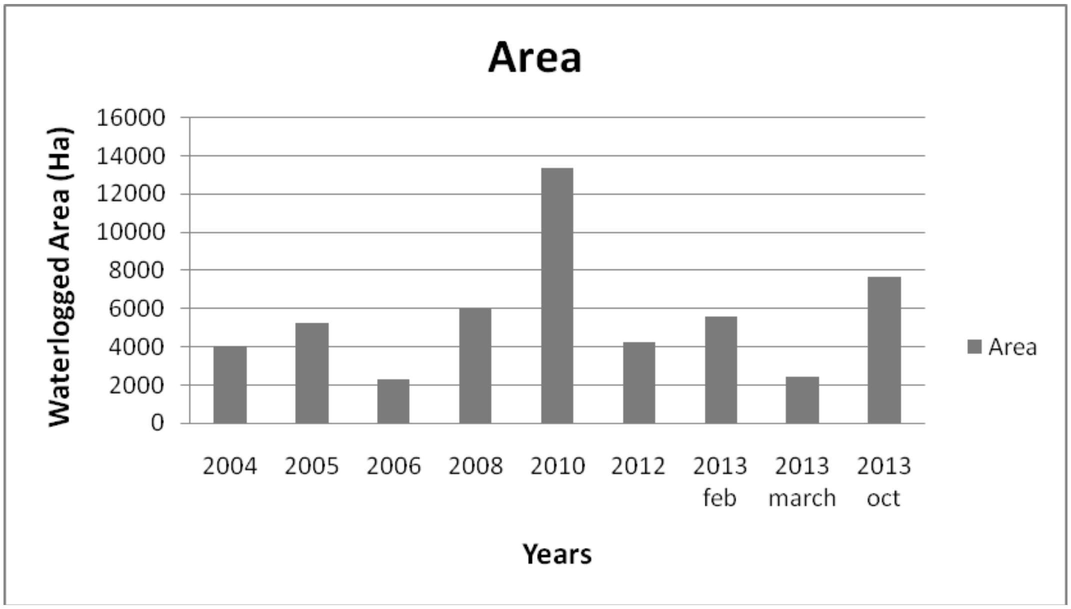


Figure 5. Plot of Waterlogged Area showing the change dynamics

The statistics showed that, in 2010 waterlogging was more compared to other years, which was 4.5% of total study area. Due to heavy rainfall and flooding in the month of October in 2010 the area was waterlogged heavily. In 2013, in the month of February waterlogging was more when comparing with March and October. The statistics which was observed from an automated algorithm results are shown in the Table 2 and graph has been plotted for the same, shown in the figure 5.

5.0 CONCLUSIONS

The waterlogging is increased drastically from 2004 to 2010. In 2010 it was 4.5% of total geographical area of study area. In 2012, the extent was decreased to 1.4% due to less rainfall. The waterlogging is not constant and regularly it was changing in the geographic area of study area. Area calculated from the automated algorithm for waterlogged areas of various years are shown the table 2. Plot of Waterlogged Area showing the change dynamics is presented in the figure 5.

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Forecasting Inflow of Srisailam Dam using Artificial Neural Networks

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ABSTRACT

Hydrologic forecasting plays an ever increasing role in water resource management. Engineers are required to make component forecasts of natural inflows to reservoirs for numerous purposes. Resulting forecast techniques vary with the system purpose, physical characteristics, and availability of data. As most hydrological parameters are subjected to the uncertainty, a proper forecasting method is of interest of experts to overcome the uncertainty. This project presented an Artificial Neural Network (ANN) approach for forecasting of daily reservoir inflow using available data. A Levenberg-Marquardt Back Propagation (LMBP) algorithm has been used to develop the ANN models. Perceived strengths of the ANN model are the capability for representing complex and non-linear relationships as well as being able to include more information in the model easily. Although the results obtained may not be universal, they are expected to reveal some possible problems in ANN models and provide some helpful insights in the development and application of ANN models in the field of hydrology and water resources. In developing the ANN models, different networks with different number of neurons in hidden layer were evaluated. Srisailam Dam was considered as a case study for this project. A total 16 years of historical data (1984-2000) were used to train and test the networks. The optimum ANN network with Three Inputs, eight neurons in hidden layer and one output (3-8-1) was selected. To evaluate the accuracy of the proposed model, the Correlation Coefficient (CC) was employed**.** Training and testing process showed the correlation coefficient of 0.98 and 0.96 respectively.

1. INTRODUCTION

The rapid growth of the population in India with both arid and semi-arid climate has increased the water need much more than ever. The precipitation distribution is erratic in space and time in the country. This irregularity in precipitation further increases the severity of the existing water shortage for agriculture and other purposes especially during drought periods. Therefore, effective use of water resources is an essential task for the countries like India having arid or semi-arid climate. As relationship between available water resources and its need are often incompatible for countries in arid and semi arid climate. This irregularity may commonly be overcome by construction of water reservoirs and their effective operation, which is equally important as that of reservoir construction. Therefore, effective reservoir operation has become a major focus for water resource management in recent decades. In reservoir operation, there is a need to find an optimal solution to release water downstream simultaneously keeping maximum storage within the reservoir with no or minimum downstream damage during flood. This problem can be overcome by obtaining reliable information of inflow to a reservoir.

In most cases, historical records of water inflow to the reservoir are often unavailable, and in situation where these data are available, the records are too short to give any statistically significant meaning. In such cases, the lack of data is obviated by generating synthetic data and stochastic models can be utilized in forecasting. Sharma et al. [1] suggested the importance of generating synthetic streamflow sequences to analyze alternative designs, operation policies, and rules for water resources systems. Abrahamsson and Hakanson [2] stated that it was very difficult to give a reliable prediction of the streamflow for a specific river at a given time so that river discharge has a high degree of variability among years for a given river and depends on some stochastic processes.

A major goal of stochastic hydrology is to generate synthetic streamflow sequences that are statistically similar to observed streamflow sequences. Statistical similarity implies sequences that have statistics and dependence properties similar to those of the historical record. These sequences represent plausible future streamflow scenarios under the assumption that the future will be similar to the past [3]. Therefore, the choice of a model for streamflow simulation involves the choice of the statistical properties that are to be preserved. Stochastic streamflows are neither historical flows nor predictions of future flows, but they are representative of possible future flows in a statistical sense. A stochastic process can either be linear or nonlinear. If there is a linearly dependent between the values of the stochastic process, the correlation between the values may be taken as dependence criterion [4].

Traditionally, statistical models have been used for hydrologic data forecasting based on time series methods. Regression and Autoregressive Integrated Moving Average (ARIMA) are common models among statistical time series approaches for forecasting. Characteristic of many types of hydrologic time series has periodically varying components. Data of this type may be modeled using a linear stochastic model that is commonly referred to as ARIMA model [5]. The assumption about the stationary of data by these models does not allow them to capture non-stationary and non-linearity in the hydrologic series. Therefore, it is very important for decision-makers to focus on alternative models when non-stationary and non-linearity play a significant role in the forecasting.

In recent years, artificial neural networks (ANNs) has been extensively used in modeling nonlinear and non-stationary time series in hydrology [6–12] and found performing well in comparison to other statistical models. Results from different studies suggest an encouraging performance by ANNs in comparison to other statistical models. Keeping this in view the better performance of ANNs for different studies, this study is designed to predict the daily reservoir inflow to Srisailam reservoir in Andhra Pradesh, India, by using ANNs.

2. METHODOLOGY

Artificial Neural Networks (ANN)

A Neural network comprises a large number of simple processing elements linked to each other by weighted connections according to a specified architecture. These networks learn from the training data by adjusting the connection weights. There is a range of artificial neural network architectures designed and used in various fields. In this study, a feed-forward neural network with back-propagation learning algorithm was used. Artificial Neural Network is an information processing system that tries to replicate the behavior of a human brain by emulating the operations and connectivity of biological neurons. The basic structure of an ANN model, usually, consists of three distinctive layers, the input layer, where the data are introduced to the ANN, the hidden layer or layers, where data are processed, and the output layer, where the results of ANN are produced.

The basic element of a back-propagation neural network is the processing node. Each processing node behaves like a biological neuron and performs two functions. First, it sums the values of its inputs multiplied by the weight associated with each interconnection. This sum is then passed through an activation function to generate an output as shown in Fig.1. All processing nodes are arranged into layers, each fully interconnected to the following layer. There is no interconnection between the nodes of the same layer. In a back-propagation neural network, generally there is an input layer that acts as a distribution structure for the data being presented to the network. This layer is not used for any type of processing. After this layer, one or more processing layers, called the hidden layers, follow. The final processing layer is called the output layer. All the interconnections between each node have an associated weight. The values of the interconnecting weights are determined by the network during the training process, starting with randomly assigned initial weights as shown in Fig.2. There are a number of algorithms that can be used to adjust the interconnecting weights to achieve minimal overall training error in multi-layer networks. The goal of training is to minimize the overall difference (error) between the desired output and the actual output of the network. The process of training begins with the entry of the training data to the network. These data flow forward through the network to the output units. At this stage, the network error, which is the difference between the desired output and the actual network output, is computed. This error is then fed backward through the network towards the input layer with the weights connecting the units being changed in relation to the magnitude of the error. This process is repeated until the error rate is minimized or reaches an acceptable level, or until a specified number of iterations has been accomplished.

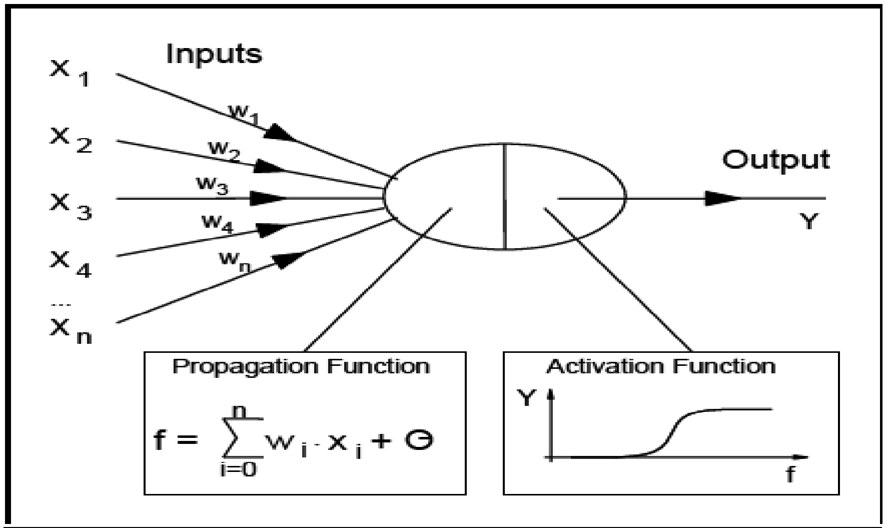

Figure 1. Processing Element of ANN

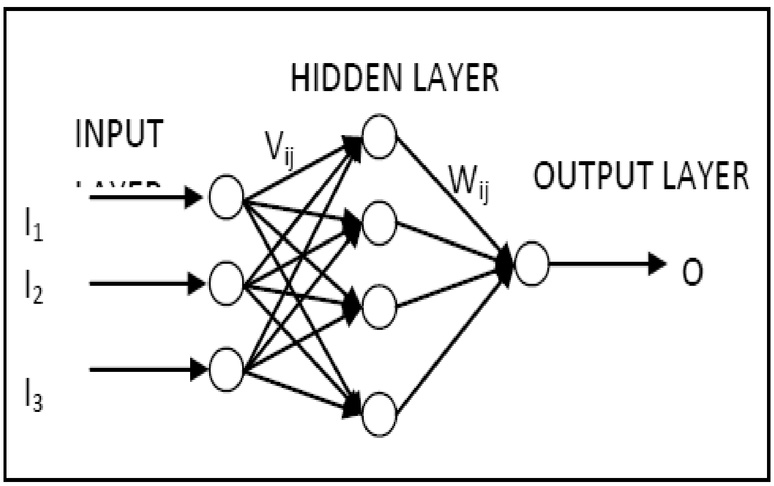

Figure 2. A Typical Three-Layer Feed Forward ANN (ASCE, 2000a)

3. STUDY AREA AND DATA USED

The Srisailam Reservoir is a dam constructed across the Krishna River in the border of Mahabubnagar District, Telangana(Left bank) and Kurnool district, Andhra Pradesh (Right bank) in India and is the 3rd largest capacity hydroelectric project in the country. The Srisailam project is falling in K7 namely, lower Krishna sub-basin. Lower Krishna sub-basin lies between north latitudes of $15^0$42’0” and $17^0$16’22” and east longitudes of $77^0$0’0” and $81^0$9’8”. It has a catchment area of 36125 km^2 and forms 13.95% of the Krishna basin. The catchment area of the sub-basin lies in the States Karnataka and Andhra Pradesh.

From Fig.3 the dam was constructed in a deep gorge in the Nallamala Hills in between Mahabubnagar and Kurnool districts, 300 m (980 ft) above sea level. It is 512 m (1,680 ft) long, 269.748 meters (885.00 ft) high and has 12 radial crest gates. It has a reservoir of 800 square kilometers (310 sq mi). Project has an estimated live capacity to hold 216 *Tmcft*. The left bank power station houses 6 × 150 megawatts (200,000 hp) reversible Francis-pump turbines (for pumped-storage) and the right bank contains 7 × 110 megawatts (150,000 hp) Francis-turbine generators.

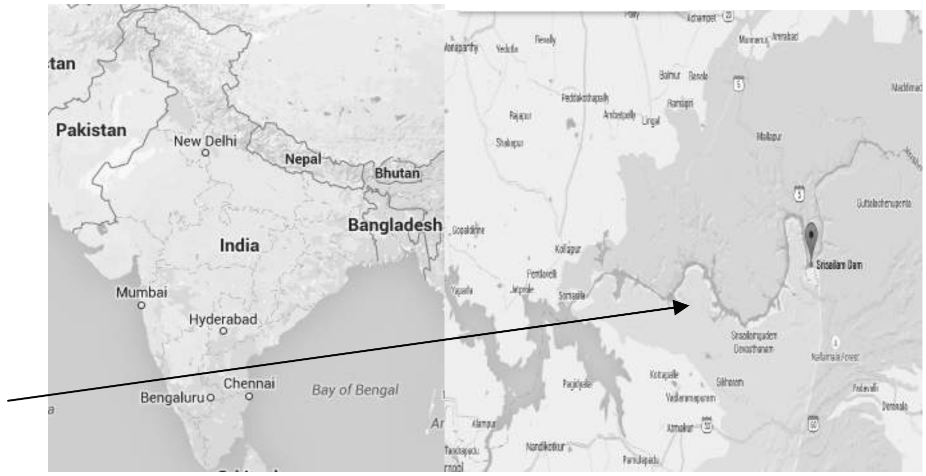

Figure 3. Location map of Srisailam Reservoir.

For this study the daily inflow data into the reservoir between years 1984–2000 was used. Time series plot of Srisailam Reservoir for above said period is shown in Fig.4.Statistical parameters of daily inflow to Srisailam dam for whole period (from 07 June 1984 to 30 April 2000) are presented in Table 1. A total of 5442 inflow data between a period of 07 June 1984 to 30 April 2000 was used to Neural network model in predicting inflow rate in Srisailam reservoir. To remove any bias in using same dataset for training and testing, total dataset was divided in two part in a way that a total of 3830 daily inflow data (i.e. between 07 June 1984 and 01 Dec 1995) was considered for model training and the remaining 1612 data (between 02 Dec 1995 and 30 April 2000) was used for testing the models. For both neural networks, hyperbolic tangent activation function was used. The purpose of this study is to predict inflow (Qt+1) at the time (t + 1). In order to predict the inflow at time (t + 1), inflow values up to a lag time of 7 days was used with both neural networks. Therefore, the input layer of network will consist of inflow values up to a lag period of 3 days (i.e. Q(t), Q(t - 1), and Q(t- 2) values) and output layer will consist of the inflow values Qt+1.

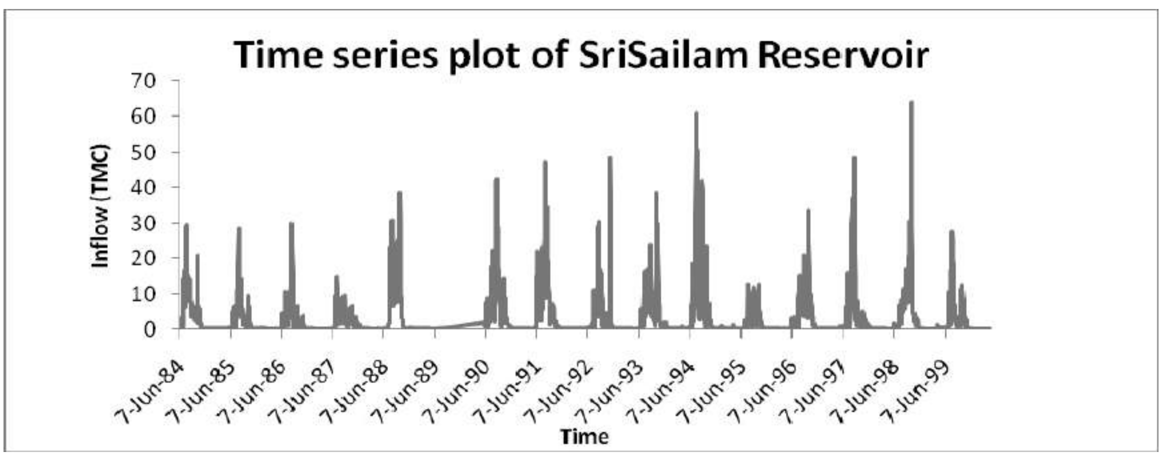

Figure 4. Time series plot of Srisailam Reservoir

Table 1. Inflow statistics of Srisailam reservoir. (All units are in TMC).

Minimum	0.000
Maximum	63.978
Mean	3.160
Std.deviation	6.611
Skewness	3.693
Kurtosis	17.296

4. ANALYSIS, RESULTS AND DISCUSSION

To find the correlation between inflow at time (t + 1) and the inflows up to the lag time of 3 days, correlation coefficient values were obtained with test data sets and provided in Table 2. As can be seen from the Table 2, inflow to reservoir at the (t + 1) time period has a good correlation with inflows at the time (t) and up to the lag time of (t _ 2). As increasing the lag times increases the complexity of both neural networks therefore, only 3 inputs consisting of the inflow from time t to (t - 2) lag times were considered to predict the inflow at time (t + 1) for this study.

Table 3 shows the results of correlation coefficients for different ANN Architectures by modifying the number of Hidden Neurons in Hidden layer. A higher correlation coefficient R value 0.98 obtained by ANN (3-8-1) Model. The Fig.5 provides a scatter plot between actual and predicted inflow values by ANN (architecture 3-8-1) for test dataset. Fig. 6 provides a plot of actual and predicted inflow values with data number by ANN (architecture 3-8-1) for test dataset. The Fig.6 shows that this model predicts low values accurately, whereas it under predicts discharge values exceeding 1.5 hm3. A major reason of this variation in performance with low and high discharge values may be due to large difference in minimum and maximum discharge values. Table 4 shows the Statistics of observed Inflows v's Forecasted Inflows by using ANN (3-8-1) for Test data Set. From the table observe that the statistical properties of ANN Model are similar to those of the historical record. The correlation coefficient between observed and forecasted inflows for Test data set from ANN model is 0.96.

Table 2. Auto correlation coefficients between inflows at lag times.

	Q(t+1)	Q(t)	Q(t-1)	Q(t-2)
Q(t+1)	1	0.96	0.90	0.84
Q(t)	0.96	1	0.9	0.9
Q(t-1)	0.90	0.96	1	0.96
Q(t-2)	0.84	0.9	0.84	1

Table 3. Correlation coefficient values by different ANN models (Training).

ANN Model	R value
3--2--1	0.92
3--4--1	0.94
3--6--1	0.95
3--8--1	0.98

Table 4. Statistics of observed Inflows vs Forecasted Inflows by using ANN (3-8-1) for Test data Set. (All units are in TMC)

Mean	2.926	2.942
Std.Dev	6.568	6.277
Skewness	3.836	3.782
Kurtosis	18.569	17.877

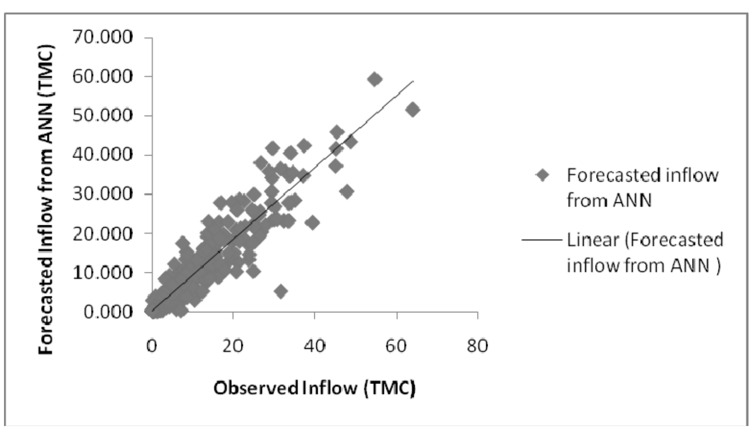

Figure 5. Scatter plot between observed inflow and forecasted inflow by ANN.

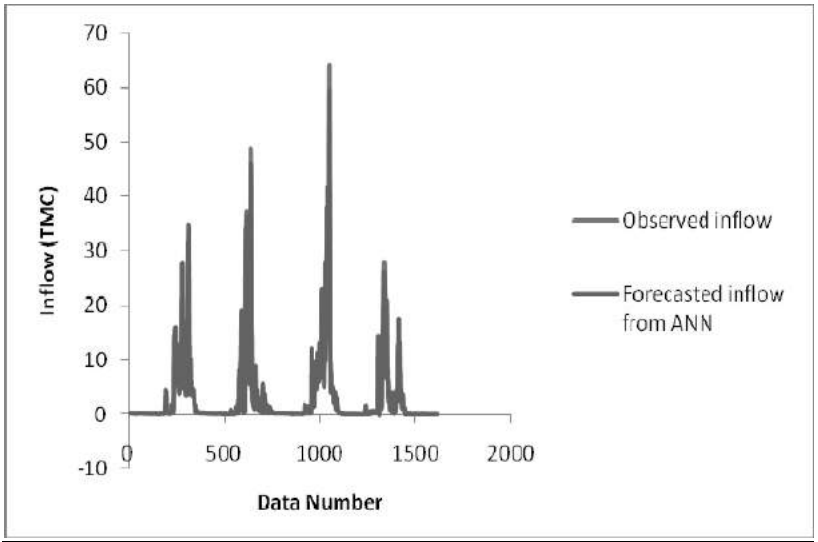

Figure 6. Plot of actual & Forecasted inflows with Data Number from ANN (3-8-1) Using Test data set.

5. CONCLUSIONS

Artificial Neural Networks with Multi Layer Perceptron (MLP) approaches were used for modeling the daily inflow into Srisailam reservoir. Some major conclusions of this study are summarized below:

1. The ANN (3-8-1) Model having eight neurons in hidden layer provide the best performance out of the three models with different memory structure in forecasting daily inflow to Srisailam reservoir.
2. The proposed model work well with low inflow values but fail to forecast high inflows due to the large variation in inflow values may be the reason of poor performance.

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Satellite based Assessment of Soil and Water Characteristics

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ABSTRACT

As the conventional ground based surveys to acquire the natural resources information are time consuming and expensive the advent of remote sensing technology has paved ways for preparing the base line data of these resources on time in cost effective mode. Remote Sensing technology coupled with the geographic information system is a proven approach for preparing the resource base. The space based satellite Remote Sensing due to its synoptic, repetitive and multi-spectral coverage will facilitate techniques of mapping, analysis, drawing inferences and management of natural resources information on vegetation, hydro-geomorphology and soils, which are prerequisite in any developmental planning. For this purpose Champawat district, Utharkhand, India is selected as study area. Using Advanced Wide Field Sensor (AWiFs), a high resolution multispectral data as input the thematic layers will be generated for the study area. An attempt has been made to generate a GIS based maps like hydro-geomorphology and soils for the assessment of spatial distribution of runoff for the Mahakali river in Utharkhand, India. The GIS layers of the study area were generated in ArcGIS using stream layers.\

Keywords: GIS, Remote Sensing, Soil characteristics, AWiFS

1. INTRODUCTION

The GIS and Remote Sensing technology have opened new paths in natural resources studies. The GIS and Remote Sensing techniques together have been considered as an efficient tool, which provides quick and useful information on the parameters like geomorphology, soil profiles etc., Wright & Morrice **(**1988) examined the use of multitemporal Landsat satellite radiance values to classify the potato crop. The study also integrates the spatial distribution database with soil and potential water deficit data to generate statistical information on the proportion of the potato crop growing on drought susceptible soils. Sharma, Saxena R. K. & Verma K. S (2000) used Multidate, high resolution,IRS-LISS II, geocoded FCC images on 1550 000 scale used for integrating visual image interpretation, physiographic analysis, ground data and laboratory analysis of soil samples.Mohamed E. Hereher & Khaled H. El-Ezaby (2012**)** reports an assessment of the soil and water in the coastal strip between Marsa Alam and Shalateen at the southern part of the Red Sea coast of Egypt. The FAO soil map of the world shows that the Eastern Desert of Egypt belongs mostly to the lithosols (soils of rocky origin) .Johansson & Stromquist (2008) examined the detailed maps of geomorphology and vegetation have been produced by interpretation of LANDSAT satellite images from a semi-arid area in central Tanzania. The methods of analysis are discussed with reference to land forms, geomorphological process activity, soils, and vegetation. A correlation between the grey tones (on band 5) and their associated vegetation types, soils, and geomorphology is established. The study by Mahmoud A. Abdelfattah & Shabbir A. Shahid (2007) aims at characterizing and classifying the soils that occur in the arid conditions of Abu Dhabi Emirate. Using Landsat-7 ETM image (Enhanced Thematic Mapper) acquired in 2002 and Geographic Information Systems for the compilation and production of maps. In order to evaluate the potentials of IRS-1A Linear Imaging Self-scanning Sensor (LISS-I) data for geological and geomorphological applications and also to compare the IRS-1A LISS-I data with Landsat Thematic Mapper (TM) data, a study has been attempted for parts of Uttar Pradesh and Madhya Pradesh in Northern India by Krishnamurthy(1991). The first four spectral bands of Landsat TM sensor data which are similar and close to IRS-1A LISS-I senor have been utilised for the comparative evaluation. Quan Quan , Bing Shen , Jianchang Xie , Wan Luo & Wenyan Wang (2012) studied a method to accurately model soil salinity using statistical tools. The method integrates field data, geographic information systems, remote sensing, and spatial modeling. Hence in the present study using recent satellite data AWiFs the soil and water characteristics are assessed and hydro-geomorphological map is generated.

2. STUDY AREA

The district of Champawat constituted in the year 1997 is situated between $29^0$5' and $29^0$30' northern latitude and $79^0$59' and $80^0$3' at the center of eastern longitude. The geographical coverage of Champawat is about 1613 sq. km. It includes two Tahsils, four development blocks and 691 revenue villages. Champawat district is located in the south eastern part of Utharkhand, India. Major part of the district is covered by high hill ranges, varying in altitude from about 300m to about 2100m above msl. Southern part of the district is occupied by plains of Sarada river.

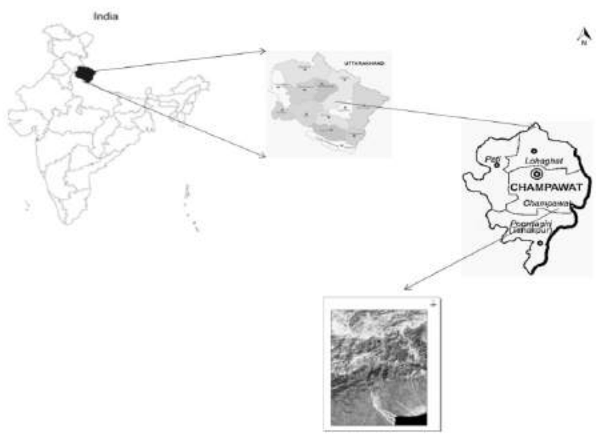

Figure 1. Location Map of Study Area

3. DATA PRODUCTS

The high resolution satellite imageries of Resource-Sat P6 AWiFs are procured from NRSC and the associated topo sheets from Survey of India at 1:25,000 scale. The hydro-geomorphological maps have been prepared by using satellite remote sensing techniques with limited field check. Soil survey is carried on at an interval of 200-500 metres interval based on soil variability covering all villages, of the Champawat District. The soil profile data is presented in table.3

Table 1. Description of the Satellite Data

Specifications	AWiFs
No. of Bands	4
Spectral Bands (μ)	B2 0.52 – 0.59 B3 0.62 – 0.68 B4 0.77 – 0.86 B5 1.55 – 1.70
Resolution (m)	56
Swath (Km)	740
Path/row	98/50, 98/51

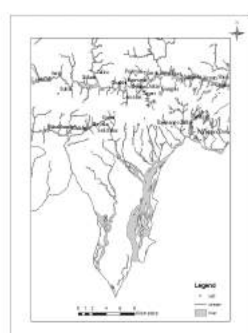

Figure 2. Satellite image_AWiFs **Figure 3.** Base Map _Part of Champawat District

4. METHODOLOGY

A detailed study is carried out using high resolution IRS multispectral and multi temporal images in GIS environment for the Champawet District, Uttarakhand. SOI toposheets of 1:250,000 scale are referred for generation of maps for forest and steep hilly areas and 1:50,000 scale for agricultural areas and forestry/hilly terrain within a time frame of 18 months.

The base map of the study area was prepared from the topographic maps of the SOI toposheets. The SOI toposheets were first rectified and georeferenced to the geographical coordinate system. Then the georeferenced SOI toposheets were mosaiced to form a single image of topomap for delineating the study area. The mosiaced toposheet was further georeferenced, then considered for digitization of contours and the study area has been delineated correspondingly. The Fig No.3 refers water bodies, rock/soil profiles, settlement, and river/streams. The data of hydro-geomorphological map in the form of spatial information and statistical data is vital for spatial planning, management and utilization of land for agriculture, forestry, pasture, urban, industrial, environmental studies, economic production etc.,Therefore, hydro-geomorphological map (Fig. No.7) for the study area is prepared by using the AWiFs satellite imagery with the help of ARCGIS software. The soil map of the study area is supported by the corresponding soil profile map (Fig No.5 & 6), which in turn useful for the estimation of runoff. Different types of soils pertaining to the study area include clay, silty clay, sandy silty clay, sand and gravel.

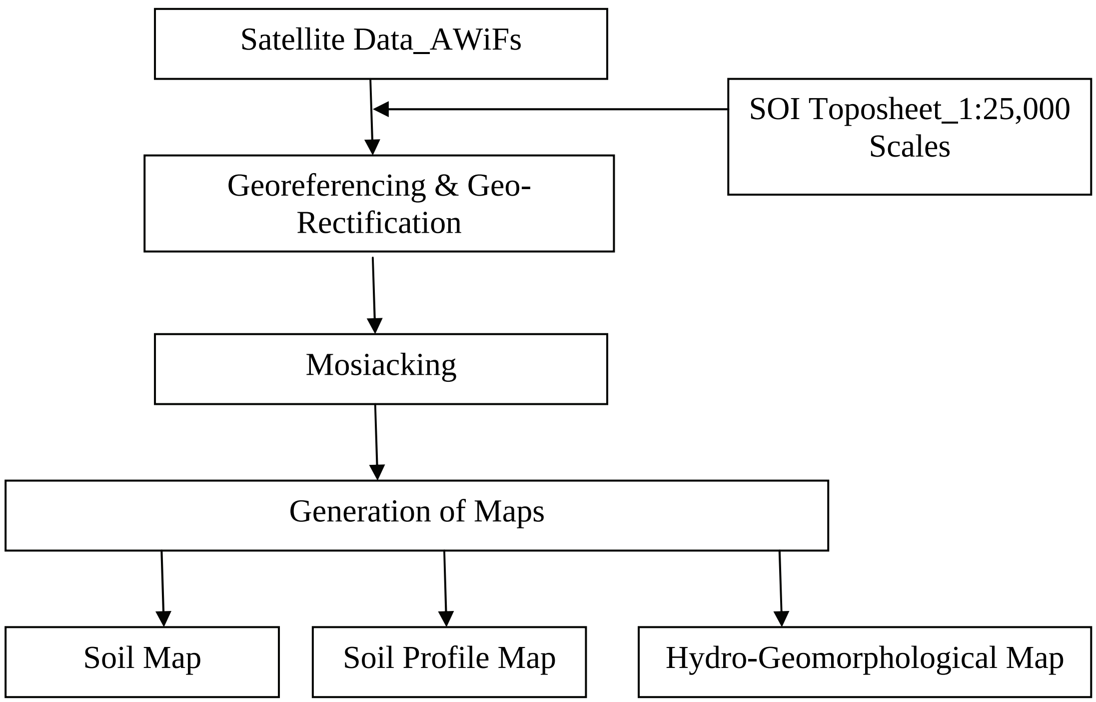

Figure 4. Methodology of Champawat District

5. RESULTS AND DISCUSSIONS

5.1 Soil

With the detailed soil survey and mapping works at the Champawat district, one or more soil series formed on two different physio-graphic units were identified and mapped in more than 27 mapping units. Limitations such as salinity, sodicity and surface fragments(rocks and stones) were determined in the study area. The base saturation percentage was high and often close to 100 % with the Calcium and Magnesium. The soil properties for the upper part of more than 30 cm of soil layer are given in Tables 2 and 3. Soil profiles investigated in the area have ochric and mollic surface horizons and some of them have cambic horizon as a sub-surface horizon (FAO/UNESEQ Legend).

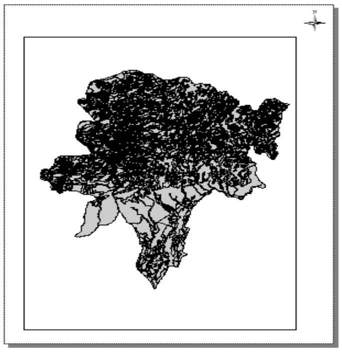

Figure 5. Soil Map of Champawat district

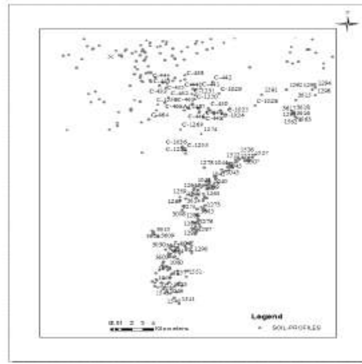

Figure 6. Soil Profiles of Champawat district

Table 2. Soil units of study area

FID	Shape *	UNITS	S_NO
0	Polygon	A4D4C	1
1	Polygon	A4D5C	2
2	Polygon	A5D4F	5
3	Polygon	A5D4M	6
4	Polygon	F3D5M	19
5	Polygon	F4D4M	22
6	Polygon	LAKE	25
7	Polygon	A4D5MF	3
8	Polygon	A4D5MF	3
9	Polygon	A5D4C	4
10	Polygon	A5D4C	4
11	Polygon	A5D4C	4
12	Polygon	A5D5C	7
13	Polygon	A5D5C	7
14	Polygon	A5D5C	7
15	Polygon	A5D5C	7
16	Polygon	A5D5C	7
17	Polygon	A5D5C	7
18	Polygon	A5D5C	7
19	Polygon	A5D5C	7
20	Polygon	A5D5C	7
21	Polygon	A5D5C	7
22	Polygon	A5D5C	7

Table 3. Soil Profiles units of Champawat District

FID	Shape *	PROFILE_	VILLAGE	X	Y
1756	Point	C-201	Chakku	80.08458	29.34397
1757	Point	C-50	Chakku	80.08356	29.34711
1758	Point	C-10	Chakku	80.08342	29.34056
1759	Point	C-208	Champawat	80.09164	29.33317
1760	Point	C-311	Champawat	80.09744	29.33764
1761	Point	C-17	Chatar	80.09808	29.34625
1762	Point	C-18	Chaukhuni bora	80.11261	29.31289
1763	Point	C-210	Cheura Khark	80.05961	29.33272
1764	Point	C-119	Chura	80.11833	29.35639
1765	Point	C-120	Chura	80.11778	29.36
1766	Point	C-11	Dakhna	80.08044	29.34447
1767	Point	C-12	Dakhna	80.07722	29.34753
1768	Point	C-101	Dakhna	80.07972	29.34278
1769	Point	C-6	Dara	80.09139	29.34361
1770	Point	C-7	Dara	80.08933	29.34683
1771	Point	C-9	Dara	80.09436	29.34436
1772	Point	C-312	Devraj tok	80.10039	29.32014
1773	Point	C-102	Dewal nad	80.07583	29.34417
1774	Point	C-59	Dhami son	80.04139	29.35417
1775	Point	C-19	Dhon	80.09686	29.26831
1776	Point	C-206	Jada	80.13425	29.34825
1777	Point	C-20	Jhop	80.10314	29.329
1778	Point	C-209	Kaflang	80.111	29.32006

5.2 Hydro-Geomorphology

Champawat district is located in the south eastern part of Uttarakhand. Major part of the district is covered by high hill ranges, varying in altitude from about 300m to about 2100m above msl. Southern part of the district is occupied by plains of Sarada river. Ladhiya r0iver flows easterly across the State in the central part and joins Kali river which in turn joins the Sardariver.Structural hills, formed by the rising Himalayas and associated compression which are divided into high structural hills and low structural hills occupy large part of the district. High structural hills are found in the north central part of the district as distinct areas. They are surrounded on all sites by the low structural hills.The structural hills in general are moderately dissected with steep slopes. Around Champawat and Lohaghat, there are areas with gently sloping topography within the structural hills (both high and low) and they are extensively used for agriculture and habitation.A number of small patches of gently sloping areas are seen in both high and low structural hills which are also used for agriculture.Southern tip of the district is covered by the alluvial plains of Sarada river. Different types of fluvial landforms have been identified and delineated. They include, channel bars, (active and stabilized) point bars, flood plain and alluvial plain (older floodplain).A number of terraces are marked on either side of Ladhiya river and its major tributaries.In between the low structural hills and the alluvial plains there is a piedmont zone with gentler slope mostly consisting of colluvial material.

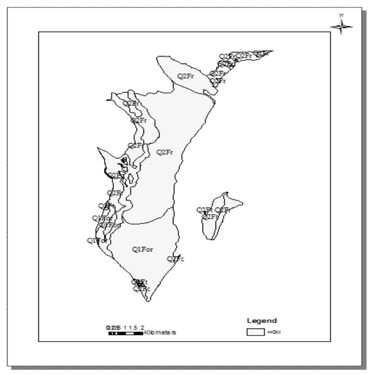

Figure 7. Hydro- Geomorphology Map of champawat district

Table.4 Hydro-Geomorphological units of Champawet District

FID	Shape *	AREA	PERIMETE	GEO_UNIT	GEOLOGY	GEOM_UN	GEOMORPHOL	GEO_GEO	GEO_GEOM	GW_PROSPE
633	Polygon	2284291	8517.452	Q2Ft	Fine to medium graine	FP	Flood Plain	FP - Q2Ft	Flood Plain - Fine to medium grair	Very Good
634	Polygon	1402213	8865.562	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
635	Polygon	26335.94	742.369	Q2Ft	Fine to medium graine	SCB	Stabilized Channel	SCB - Q2F	Stabilised Channel Bar - Fine to m	Very Good
636	Polygon	16637594	19828.08	Q1For	Sand, clay and silt	AP	Alluvial Plain	AP - Q1Fo	Alluvial Plain - Sand, clay and silt	Very Good
637	Polygon	403302.4	4283.506	Q1For	Sand, clay and silt	AP	Alluvial Plain	AP - Q1Fo	Alluvial Plain - Sand, clay and silt	Very Good
638	Polygon	14823.26	506.241	Q2Ft	Fine to medium graine	SCB	Stabilized Channel	SCB - Q2F	Stabilised Channel Bar - Fine to m	Very Good
639	Polygon	585094.9	5189.831	Q1For	Sand, clay and silt	AP	Alluvial Plain	AP - Q1Fo	Alluvial Plain - Sand, clay and silt	Very Good
640	Polygon	49886.51	1483.059	Q1For	Sand, clay and silt	AP	Alluvial Plain	AP - Q1Fo	Alluvial Plain - Sand, clay and silt	Very Good
641	Polygon	99634.92	1817.069	Q2Fc	Talus of unsorted grave	FP	Flood Plain	FP - Q2Fc	Flood Plain - Talus of unsorted gra	Very Good
642	Polygon	351696.3	6133.931	Q2Fc	Talus of unsorted grave	FP	Flood Plain	FP - Q2Fc	Flood Plain - Talus of unsorted gra	Very Good
643	Polygon	24052.33	696.146	Q2Ft	Fine to medium graine	CB	Channel Bar	CB - Q2Ft	Channel Bar - Fine to medium grai	Very Good
644	Polygon	24518.47	707	Q2Ft	Fine to medium graine	CB	Channel Bar	CB - Q2Ft	Channel Bar - Fine to medium grai	Very Good
645	Polygon	33731.73	916.622	Q2Ft	Fine to medium graine	CB	Channel Bar	CB - Q2Ft	Channel Bar - Fine to medium grai	Very Good
646	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	FP	Flood Plain	FP - Q2Fr	Flood Plain - Gravel sorted and un	Very Good
647	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	FP	Flood Plain	FP - Q2Fr	Flood Plain - Gravel sorted and un	Very Good
648	Polygon	4698937	18121.68	Q2Fr	Gravel sorted and unso	FP	Floodl Plain	FP - Q2Fr	Floodl Plain - Gravel sorted and ur	Very Good
649	Polygon	4698937	18121.68	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
650	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
651	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	FP	Flood Plain	FP - Q2Fr	Flood Plain - Gravel sorted and un	Very Good
652	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	FP	Flood Plain	FP - Q2Fr	Flood Plain - Gravel sorted and un	Very Good
653	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
654	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
655	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
656	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
657	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
658	Polygon	41709688	54453.73	Q2Fr	Gravel sorted and unso	FP	Flood Plain	FP - Q2Fr	Flood Plain - Gravel sorted and un	Very Good
659	Polygon	1290488	6591.584	Q2Fr	Gravel sorted and unso	AP	Alluvial Plain	AP - Q2Fr	Alluvial Plain - Gravel sorted and u	Very Good
660	Polygon	6912351	44711.37	Q2Fc	Talus of unsorted grave	FP	Flood Plain	FP - Q2Fc	Flood Plain - Talus of unsorted gra	Very Good

6. CONCLUSIONS

By using the Indian Remote Sensing satellite (IRS P6 AWiFS) data with a spatial resolution of 56 m the expansion of settlements and drainage network is updated (Fig.3). The code given in the soil profile for champawat district is C-208, C-311 and the soil units are A4DAC etc.,.The area of $4.1x10^7$ sq kms is under flood plains and alluvial plains which covers gravel sorted and unsorted, inter layered sand, silt and clay capped by fine silt and sand .The area of 1.6 $x10^7$ sq kms is .under stabilized channel bar which covers sand, clay and silt .The area of 0.2 $x10^7$ sq kms is under flood plains which covers fine to medium grained sand and silt . The area of 0.9 $x10^5$ sq kms is under flood plains which covers talus of unsorted gravels, boulders, pebbles, sand and silt. The area of 0.24 $x10^3$ sq kms is under channel bar which covers fine to medium grained sand and silt. The ground water status is very good for all the covered areas (Table.4). Based on visual interpretation of satellite imagery a number of major and minor liniments have been delineated.

ACKNOWLEDGEMENTS

The authors are extremely thankful to, NRSC, Hyderabad, for providing Satellite data and Centre for Spatial information technology, Institute of Science and Technology, Jawaharlal Nehru Technological University, Kukatpally, Hyderabad-500085, India for the facilities provided.\

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Estimation of Sediment Retained in Sriramsagar Reservoir using Artificial Neural Network Technique and Conventional Method

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ABSTRACT

All the reservoirs experience the sedimentation problem, even though the intensity may be varying. Thus reservoir sedimentation becomes a significant problem as the main purpose of construction of the reservoir is not met . Because of complicated and nonlinear process of sediment retained in the reservoir, and the lack of data in hydrological stations, it is difficult to measure exact sediment retained in the reservoir. In this study an artificial neural network (ANN) model and conventional method were used to estimate the volume of sediment retained in the reservoir. The ANN model has been developed using Matlab for prediction of the sediment volume retained (S_v) in the reservoir. One of the largest reservoir in Telangana State , Sriramsagar reservoir has been taken as a case study. The input parameters are annual rainfall, annual inflow, and annual outflow of the reservoir. Twenty three years of data pertaining to Sri Ram Sagar Reservoir on the Godavari river in India, were used in this study. Seventeen years data is used for training and six years of data is used for testing and validation of the model. The pattern of the sediment volume retained in this reservoir was well captured by the ANN model using the back propagation algorithm. A conventional regression analysis was conducted, relating the output parameter (S_v) to the input parameters (R_a, I_a, and O_a), using Regression analysis and Excel add-in that performs multivariate descriptive data analysis and multiple linear regression analysis. Based on several performance indices, it was found that the ANN model estimated the volume of sediment retained in the reservoir with better accuracy and less effort as compared to the conventional method.

Keywords: Reservoir sedimentation, Artificial Neural network, Conventional method.

1. INTRODUCTION

Most parts of India are dependent for water on rainfall during the monsoon months which exist for a period of 3 to 4 months. For the non monsoon period, the requirements are met from the reservoirs which are created to store water. The reservoirs receive silt along with the water of the rivers and a significant proportion of the silt settles down in the reservoir, thus reducing the space available for storage of water. Siltation results in reduction in benefits from the projects constructed at huge costs to the nation. Siltation of reservoirs can also have a number of other impacts, including increased evaporation losses, increased backwater flooding and also could damage the power house turbines. Gregory Morris,(1995) stated that, “Planned Obsolescence due to sedimentation affects most reservoirs and will render many of them unusable in the foreseeable future. Dams are uniquely different from engineering infrastructure such as roads, harbours, and cities, and which can be reconstructed on the same site occupied by obsolete infrastructure. Dams cannot be reconstructed at the same site once the reservoir has filled with sediment. The sediment must either be removed or the site abandoned. The cost of sediment removal at a large reservoir can easily exceed the original dam construction cost by an order of magnitude.” Globally, the overall annual rate of loss of reservoir storage capacity due to sedimentation is estimated as 1 to 2 per cent of the total storage capacity (Yang, 2003; Campos, 2001;V.Jyoti Prakash et al., 2008). Some reservoirs are filled very rapidly, while others are hardly affected by sedimentation. In India, many reservoirs have been subjected to reduction in their storage capacities due to sedimentation. Analysis of sedimentation survey details in respect of 43 major, medium and minor reservoirs in the country indicated that the sedimentation rate varies between 0.34 to 27.85 ha m/100 km^2/ year for major reservoirs, 0.15 to 10.65 ha m/ 100 km^2/ year for medium reservoirs and 1.0 to 2.3 ha m/ 100 km^2/ year for minor reservoirs (Shangle,1991 and V.Jyoti Prakash et al., 2008).

2. OVERVIEW

For a long time, various empirical formulae have been used for estimating the sedimentation in reservoirs which is not a simple task as it involves simultaneous processes of sediment erosion, transportation and deposition. Although in some empirical methods, catchment area, sedimentation rate and reservoir capacity parameters are used for sediment rate estimation, it is seen that there is no clear relationship among these parameters (V.Jyoti Prakash et al., 2008). Neural Networks models have proved useful for better definition of the relationship between hydrologic parameters and sediment concentration (Morris , 2010).The Neural Networks model is essentially a nonlinear black box that correlates outputs to inputs by training its internal algorithms and their weighting schemes against a calibration data set. It is a highly nonlinear tool that can capture complex interactions among the input and output variables without any prior knowledge about the nature of these interactions (Hammerstrom, 1993). In comparison to conventional methods, ANNs can tolerate imprecise or incomplete data, approximate information, and presence of outliers and are well suited to this problem (Haykin, 1999).

It is observed from the literature that limited studies have been conducted for estimating reservoir sedimentation using ANNs. Cigizoglu (2002a) used ANNs to forecast and estimate sediment concentration values, and Cigizoglu (2002b) compared ANN and sediment rating curves for two rivers with very similar catchment areas and characteristics in north England and also highlighted the potential advantages of ANNs in sediment concentration and flux estimation. It was also found that in particular, an ANN approach can give information about the structure of events (e.g., hysteresis in the sediment concentration , water discharge relationship, and the effect of antecedent conditions) which is impossible to achieve with sediment rating curves (Cigizoglu, 2002b). Agarwal et al. (2005) developed feed-forward error BP ANN and linear-transfer-function-sediment-yield models for the Vamsadhara River basin. Cigizoglu and Alp (2006) developed an ANN model for river sediment yield using a generalized regression algorithm. Such generalized regression neural networks do not require an iterative training procedure as in the conventional BP method. It was found that the conventional techniques sometimes underestimate or overestimate actual values and need modifications (Jothiprakash and Garg, 2008). Lee et al. (2006) conducted quantitative estimation of reservoir sedimentation for Shihmen Reservoir watershed in Taiwan.

In this study, an ANN model has been developed using Matlab and the available measurements for the estimation of the sediment volume retained (S_v) in a large reservoir, Sriramsagar reservoir in India. The input parameters such as annual inflow(I_a) , annual outflow(O_a) and annual rainfall (R_a) were decided on basis of their influence in the sedimentation process, and sediment volume retained (S_v) was regarded as an output parameter. The time series plot of this data in the figure 1 shows the relationship of the input parameters I_a, O_a and R_a with the output parameter S_v of the reservoir.

3. STUDY AREA DESCRIPTION AND DATA ANALYSIS

The Sri Ram Sagar Project (SRSP), formerly known as the Pochampadu irrigation project has been built on Godavari river. The Godavari river is one of the major peninsular rivers in southern India. This irrigation project is located at Pochampadu village (18° 58' N Latitude and 78° 20' E Longitudes) in Nizamabad district of Telangana State (TS) of southern India at a distance of about 200Km from Hyderabad. This project has been built to utilize Godavari river water for irrigation and drinking purposes in Telangana state. The regions such as Nizamabad, Adilabad, Karimnagar, and Warangal districts of Telangana state are covered under this project. The Sri Ram Sagar reservoir is a major irrigation project built across the river Godavari at its 637th Km intended to create irrigation facilities to about 4.0 lakhs hectares in addition to generate power up to 36 M.W. Construction of the project was taken up in 1964, with an elevation up to 322.48 m. In the year 1970, the irrigation benefits started, when the first impounding of the reservoir took place. Subsequently after the Godavari Water Dispute Tribunal Award, the gates on the reservoir were provided and the full reservoir level was raised to 332.537 m . Full benefits of this project were achieved by 1984 after the water was stored up to 332.537 m. The estimated capacity of reservoir at FRL +332.537m is given as 3,172 Mcum. As a result of sedimentation, the live storage capacity reduced to 2166.10 Mcum. The Minimum Draw Down Level (MDDL) storage capacity of the reservoir is about 10.10 Mcum. A flood flow canal has been built to utilize flood water and this water is stored in the Lower Manair Reservoir (LMR) which is situated at a chainage of 146 km from the SRSP.

A provision for silting made at the time of construction was based on Khosla’s formula for evaluation of sediment inflow at the rate of 3.57 H m/100 SqKm/year of catchment area and assuming the life of the reservoir as 100 years, a provision of dead storage to an extent of 849 Mcum (30 TMC) corresponding to E.L +324.307m was made in the original proposal. This has been revised taking the recommended silt rate of 1.20 Acres ft/Sq mile/year by the Central Water Commission. Based on this it is expected that 35 TMC silt gets deposited in the first 50 years and 65 TMC in next 100 years. Hydro graphic surveys in Sriramsagar reservoir were conducted by A.P. Engineering Research Labs(A.P.E.R.L), during December 1979, November 1981 and January 1983 when the water level in the reservoir was at E.L. +321.554 m ,+322.478 m and + 325.135 m respectively to measure the actual sediment deposited in the reservoir . Table 1 shows the rate of siltation of the reservoir with reference to full reservoir capacity as per the surveys carried out by A.P.E.R.L. This 3.172 BCM gross storage reservoir capacity lost 25% of its capacity (779 Mcum) in just 14 years of its impoundment in 1970. The data of the annual inflows into and the annual outflows from the reservoir has been acquired from the Sriramsagar Reservoir Camp Office(SRSP-I).

Table 1. Annual rate of siltation of Sri Ram Sagar reservoir

Year	Water level in reservoir (m)	Original capacity at given w.r.l (Mcum)	Capacity as per survey (Mcum)	Total volume of sediment retained (Mcum)	Annual volume of sediment retained (Mcum)	Annual rate of siltation(%)
1970 - 1979	322.478	606.451	380.56	226	22.6	0.71
1980 - 1981	322.478	606.451	338.0	268.451	22.37	0.7
1982 - 1983	326.136	1184.59	942.36	242.23	17.3	0.545
1984 - 1984	332.537	3172	2377.37	794.63	52.97	1.67
1985 - 1994	332.537	3172	2557.25	614.75	25.61	0.807
1995 - 2006	332.537	3172	2264.15	907.84	25.21	0.79

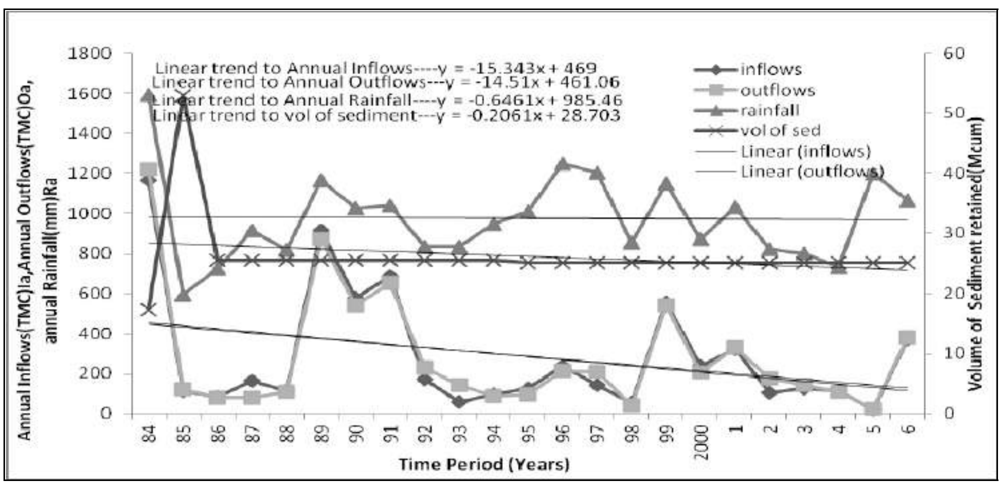


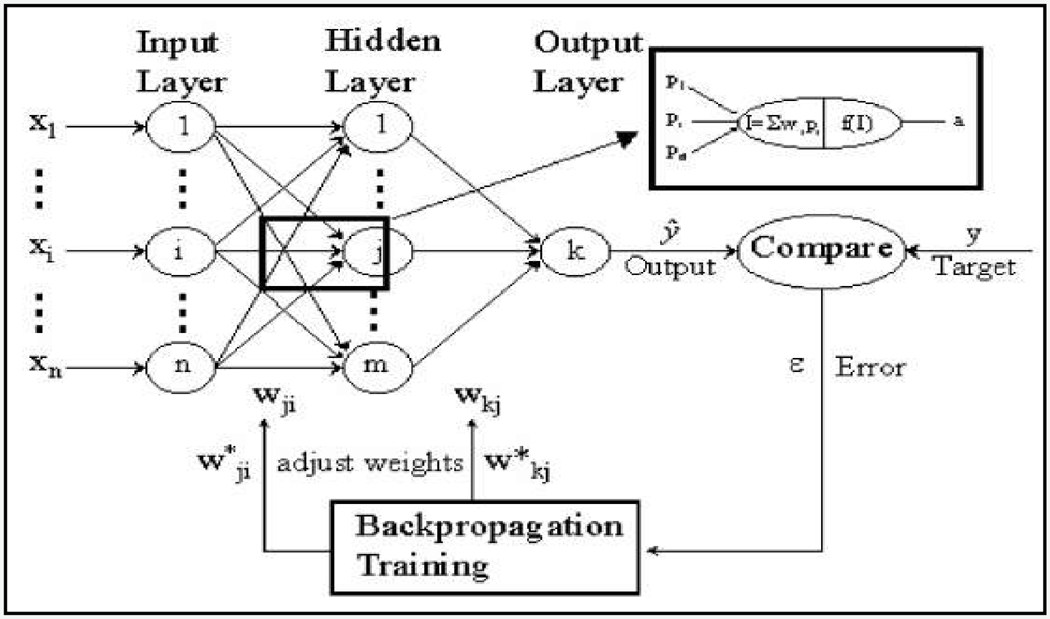
Figure 1. Time Series Plot of Annual Inflows, Outflows, Rainfall and Volume of Sediment

4. METHODOLOGY AND MODEL DEVELOPMENT

Artificial Neural Network(ANN) is widely applied in the forecasting of hydrology and water resource variables. In ANN, BP network models are common to engineers, which is the feed-forward artificial neural network structure and a back-propagation algorithm (BP). It has proved that BP network model with three-layer is satisfied for the forecasting and simulating as a general approximator (Hornik et al., 1989). Thus, a three layer BP network model trained by Levenberg Marquardt optimization algorithm is chosen for this study.

4.1 Artificial neural networks

A neural network architecture used for prediction of volume of sediment retained in the reservoir is shown in the figure 2. A three-layered feed forward neural networks (FFNNs), which have been usually used in forecasting hydrologic time series, provide a general framework for representing nonlinear functional mapping between a set of input variables and the output. Three-layered FFNNs are based on a linear combination of the input variables, which are transformed by a nonlinear activation function. In the figure 2 i, j and k denote input layer, hidden layer and output layer neurons, respectively and w is the applied weight of the neuron. The term “feed-forward” means that a neuron connection only exists from a neuron in the input layer to other neurons in the hidden layer or from a neuron in the hidden layer to neurons in the output layer and the neurons within a layer are not interconnected to each other.



Source: (Jothiprakash and Garg, 2008)

Figure 2. Neural network architecture used for prediction of volume of sediment retained in the reservoir.

The sedimentation data for 23 years period from 1984 to 2006 have been used to carry out the current study along with annual inflow, annual outflow and annual rainfall data. The data is divided into three sets: the first set of data of about 70% of total data were used for training, and the second 30% of the total data were used for validation and model testing. The ANN model requires the normalization of the data . The data used is normalized between 0 and 1 using the equation 1.

$$r_i = \frac{R_i - R_{min}}{R_{max} - R_{min}} \quad (1)$$

where r_i is the respective normalized value, R_i is the actual value, R_{min} and R_{max} are the minimum and maximum of the total values of the data.

4.2 Development of the Model

There are no fixed rules for developing an ANN model, even though a general framework can be followed based on previous successful applications in engineering. In the present study, MLP ANN model architectures to estimate volume of sediment retained in the reservoir were developed as shown in Figure 2 . Using available data of the study area, a trial and error approach was employed in the present analysis to select the appropriate ANN architecture. The number of input parameters in the ANN was determined on basis of parameters causing and affecting the underlying process and which are also easily measurable at the reservoir site. The number of hidden layers and the number of nodes in each hidden layer were also determined by a trial-and-error procedure. The number of nodes in the hidden layer plays a significant role in ANN model performance. The Sigmoid and Hyperbolic Tangent (tanh) transfer functions corresponding to a single (S_v) output were used to select the best ANN architecture.

4.3 Training and Validation of Networks

In a MLP ANN, connections exist between nodes of different layers, while no such connections exist between nodes within the same layer. The inputs are presented to a network at the input layer, and are acted upon by transformations to produce an output (Haykin 1999). The neural network learns by adjusting the weights and biases of such connections. Before training, the initial network biases and weights were assigned small random values. The split sample approach was applied, in which part of the available data from a site is used to develop a predictive relationship and then tested with the remaining data. For training purpose, BP training algorithm was used along with resilient propagation (RP), gradient descent with momentum (GDM), gradient descent with adaptive learning (GDA), combination of GDM and GDA, one step secant, and Levenberg-Marquardt as training algorithms. The learning process was terminated when an optimum prediction statistics with respect to epoch size and validation results were obtained. Once the training process was satisfactorily completed, the network was saved, the test and validation data sets recalled, and values predicted by the model were compared with the observed values. When the prediction error statistics for these data sets were acceptable, then the neural network structure was considered to perform well for predicting S_v with different sets of data. The networks were trained with various available input and output parameters. The statistical indicators used to test the performance of the model such as coefficient of correlation (R), square of coefficient of correlation (R^2), mean-square-error (MSE), root-mean-square error (RMSE) are shown in the table 3. A conventional regression analysis was conducted, relating the output parameter (S_v) to the input parameters (R_a, I_a, and O_a), using RegressIt an Excel add-in that performs multivariate descriptive data analysis and multiple linear regression analysis.

5. RESULTS AND DISCUSSIONS

The observed values of the sediment, the predicted values of the sediment by using ANN model and the estimated values of the sediment by the regression method are shown in the table 2. The volume of sediment retained in the reservoir is very well predicted by the ANN model which is seen from the figure 3 and the figure 4 which depicts the comparison of the observed , predicted and the estimated volume of sediment. The figure 5 shows the plot of the cumulative sediment retained in the reservoir for the observed data, predicted data as well as the estimated data which shows that the predicted data by ANN model follows the trend of the observed data very well. The values of the statistical parameters for the two methods i.e. the ANN model and the conventional regression method are shown in the table 3, which shows that the performance of the ANN model is better than the conventional regression method.

Table 2. Observed, Predicted(ANN Model) and the Estimated(Regression Method) values of Sediment retained in the reservoir.

Year	Observed Volume of sediment Retained (Mcum)	Predicted Volume of sediment Retained (Mcum) by ANN Model	Estimated Volume of sediment Retained (Mcum) by Conventional Regression Method
1983-1984	17.3	17.29	17.82
1984-1985	52.97	52.86	32.40
1985-1986	25.61	24.84	30.06
1986-1987	25.61	24.88	27.20
1987-1988	25.61	24.86	28.54
1988-1989	25.61	25.68	24.78
1989-1990	25.61	24.89	26.25
1990-1991	25.61	26.04	26.34
1991-1992	25.61	25.03	28.30
1992-1993	25.61	25.03	27.89
1993-1994	25.61	25.00	26.25
1994-1995	25.21	25.84	25.32
1995-1996	25.21	25.14	21.45
1996-1997	25.21	24.03	21.79
1997-1998	25.21	25.74	27.78
1998-1999	25.21	25.20	23.99
1999-2000	25.21	25.75	28.02
2000-2001	25.21	25.53	25.40
2001-2002	25.21	25.87	28.25
2002-2003	25.21	25.75	28.86
2003-2004	25.21	25.88	30.01
2004-2005	25.21	25.31	21.65

Contd…

Year	Observed Volume of sediment Retained (Mcum)	Predicted Volume of sediment Retained (Mcum) by ANN Model	Estimated Volume of sediment Retained (Mcum) by Conventional Regression Method
2005-2006	25.21	25.31	24.92
2006-2007	-	24.59	27.92
2007-2008	-	28.59	26.06
2008-2009	-	26.99	30.83
2009-2010	-	49.62	21.82
2010-2011	-	24.26	26.61
2011-2012	-	26.11	28.27
2012-2013	-	39.36	19.25

Table 3. Comparison of Performance Statistics of ANN Model and Conventional Regression Method

Statistical Parameter	ANN Model	Conventional Regression Method
R	0.99966	0.545
R^2	0.99932	0.298
MSE	2.3431×10^{-5}	5.473
RMSE	4.840×10^{-3}	2.339

Predicted $\mathbf{S_v}$ from regression method = $42.463 + (0.005025 \times I_a) - (0.002235 \times O_a) - (0.017 \times R_a)$ (2)

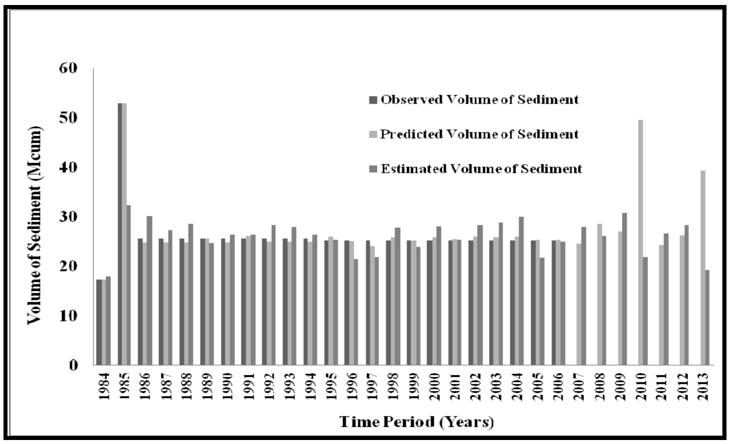


Figure 3. Comparison of Observed ,Predicted (developed ANN model) and Estimated(Regression Method) Sediment data

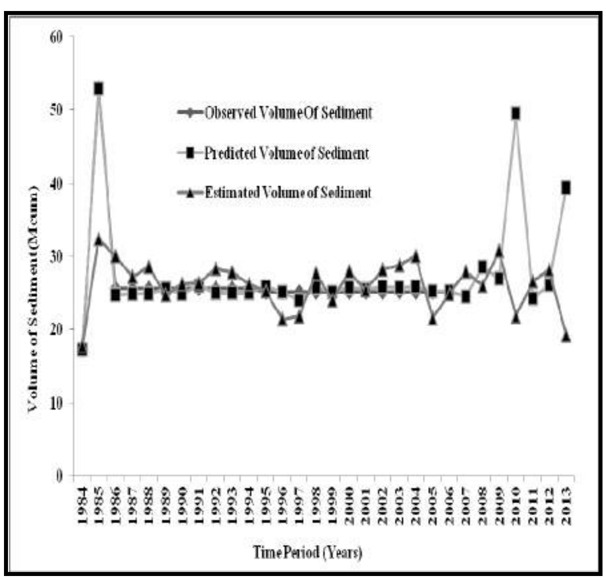


Figure 4. Comparison of Observed , Predicted(ANN Model) and Estimated (Regression Method) Sediment data.

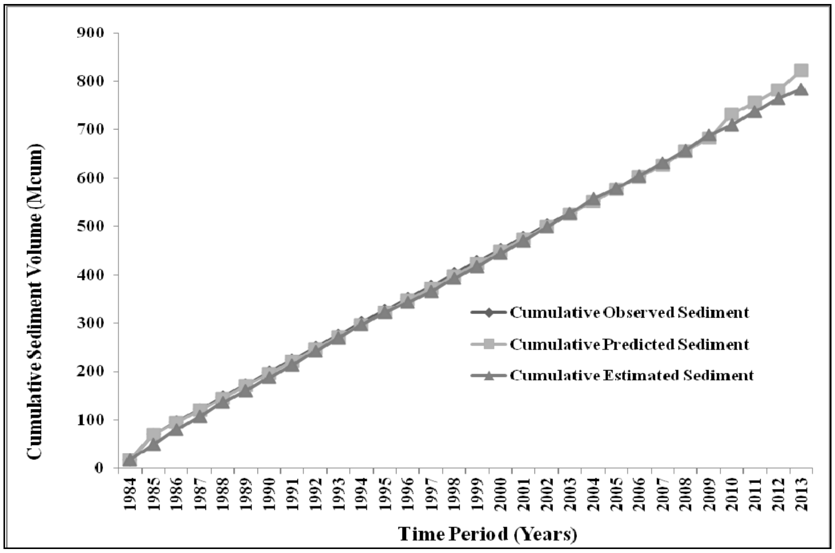


Figure 5. Comparison of the Cumulative Observed , Predicted and Estimated Sediment.

6. CONCLUSIONS

In the present study, the ANN approach and conventional regression method is employed for the estimation of the sediment in Sriramsagar reservoir on a yearly basis. It is found that the developed ANN model captured the trend of retained sediment volume well as compared to the traditional regression approach, which is seen from the trend of the curves in the figure 3, figure 4 and figure 5 and also the values of the statistical parameters shown in the table 3. From the present study it is also seen that there is a need for large databases in India for improving ANN models for estimating the sediment retained in the reservoir.

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Watershed Planning and Impact Assessment – using Satellite Data

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ABSTRACT

Change detection is the measure of the distinct data framework and thematic change information that can lead to more tangible insights into underlying process involving land cover and land use changes than the information obtained from continuous change. This involved development of spatial and temporal database and analysis techniques. Integrated use of GIS, Remote Sensing and Image processing technologies enable us to cope with the objectives of change detection. A common observation is that most of the changes of ecosystems happens on earth is in close proximity of human inhabitations. The ability to model hydrologic processes with greater accuracy and at finer spatial and temporal resolution will continue to improve with the use of remotely sensed data, improvements in GIS and database management systems. The geo-hydrology model helps to identify potential sites for appropriate soil and water conservation measures through identifying suitable sites for water harvesting. The watershed protection approach could prove to be a strategy for effectively protecting and restoring aquatic ecosystem and hence protecting human health. The region geographically lying between 25°25’30” N to 25°32’30” N Latitude and 74°27’00” E to 74°35’00” E Longitude is selected as study area. It is covered by Survey of India Toposheets Nos. 45 K/6, 45 K/7, 45K/10 and 45K/11 west of scale 1:50000 and IRS P6 LISS IV images. The base map is generated at 1:25,000 scale from the SOI Toposheet. The thematic layers like LULC, hydro geomorphology, soil, slope etc. are generated using the satellite data IRS P6 LISS IV images and Cartosat-I Data. The rainfall, temperature and other collateral data of the study area are collected and are integrated in the GIS domain. The DEM (Digital Elevation Model) is generated from the SRTM data. A scheme for thematic data integration and recommendation for various combinations of land parameters was evolved by observations in the field of study area. Change detection analysis was carried out with the help of Change Detection Matrix provided with ERDAS imagine.

Keywords: Land Use Planning, classification, NDVI, Change Detection, Ground Water.

1.0 INTRODUCTION

Soil, water, flora and fauna are the important land resources which together influence in the survival of human beings by supporting food production and providing a congenial living environment. Land resources are being exploited faster than they are renewed, as a result ecosystems are degraded, life support processes are threatened and biodiversity, being the key factor in maintaining biospheric resilience is decreasing at an alarming rate. Watershed is defined as a natural unit of land upon which water from direct precipitation, snowmelt and other storage collects in a channel and flows downhill to a common outlet at which the water enters another water body such as stream, river, wetland, lake or the ocean(Samuels, 2001).Watershed management is defined as the analysis, protection, repair, utilization and maintenance of drainage basin for optimum control and conservation of water with due regard to other resources(S.TimandS.Mallavaram,2003).Watershed development is carried out to rehabilitate the watershed though proper land use and conservation measures in order to minimize erosion and reduce the damage caused by sedimentation to the multipurpose reservoir. It also develops the watershed’s crop, livestock, forestry, fish culture and recreational activities so as to ensure that the watershed provides water of the highest quality and manage the watershed in order to minimize natural disasters such as floods, drought and landslides, etc. The objectives of watershed development can be achieved through a well-defined planning process. Planning is a means of making decisions concerning future action. When the action is targeted on the land use or management, it is referred to a geo-spatial planning. The geo-spatial planning is needed from national level to the grass root level. The inventory of land resources to evaluate the watershed for its potentials and problems is a pre-requisite for watershed planning. The remote sensing technology has immense potential to meet the challenges of land resource management which is evident from the improved capabilities of the current satellite sensors and more so from the future missions. It is necessary to periodically evaluate the current status of application in all spheres so as to apprise the users about the potentials, and at the same time, provide a feed back to the sensor designers about the gaps in meeting the user demands. Information about change is necessary for updating land cover maps and the management of natural resources. The information may be obtained by visiting sites on the ground and/ or extracting it from remotely sensed data. For many of the physical and cultural features on the landscape there are optimal time periods during which these features may best be observed. Remotely sensed data acquired at the fixed time interval becomes an important factor. Change detected from different temporal images usually reflect natural and human activity impact each other and then can be used to study how to form the regional geographic feature. Integrated use of GIS, Remote Sensing and Image processing technologies enable us to cope with the objectives of change detection to study the impact of watershed programmes on the environment.

2.0 STUDY AREA AND DATASETS

The study area comprises, Mahendragarhwatershed of Bhilwara district, Rajasthan, which spreads over an area of 7500 ha. These area lies geographically between the25°25'30" N to 25 °32'30" N Latitude and 74 °27'00" E to 74 °35'00" E Longitude and falls in Survey of India Toposheets Nos. 45 K/6, 45 K/7, 45K/10 and 45K/11 West scale 1:50000 published in 1971. IRS P6 LISS IV and Cartosat-I, SRTM, rainfall and temperature data and other collateral data were used for the study.

3.0 METHODOLOGY

The following methodology is adopted in the present study to meet the above mentioned objectives. The base map is generated at 1:25,000 scale from the SOI Toposheet.The thematic layers like LULC, hydro geomorphology, soil, slope etc. are generated using the IRS P6 LISS IV images and Cartosat-I Data. Taking the SOI Toposheets as source, the thematic layers like drainage and contours are prepared at 1:25,000 scales. The slope map is derived using Survey of India topographical sheets at 1:25000 scale with 10 meter contour interval. The rainfall and temperature data and other collateral data of the study area are collected and are integrated in the GIS domain. The DEM (Digital Elevation Model)is generated from the SRTM data (Garbrecht and Martz, 2001). Digital Elevation Model (DEM) of the catchment was extracted from Shuttle Radar Topographic Mission (SRTM) (Prafull Singh, AnkitGupta and Madhulika Singh 2014) data .The SRTM DEM was utilized to prepare topographic, slope and delineation of drainage map of the basin Using Spatial Analyst tool of ARCGIS 10. All the extracted parameters from satellite images and SRTM DEM such as the number and lengths of streams of each different order; drainage area, basin perimeter and total basin length, and width were calculated using ARC GIS software, drainage density, drainage frequency, shape, form factor, circulatory ratio, and elongation ratio, etc., were calculated from these parameters. The soil map is taken as the base for integration. A scheme for thematic data integration and recommendation for various combinations of land parameters was evolved by observations in the field. Following the scheme of data integration, action plan maps were generated giving suitable site - specific recommendations for alternate Land Use and water conservation measures. To study the impact of the watershed programme change detection was carried out for different temporal data sets to analyze the extent and density and type of vegetation and the vegetation growth, the integrated use of GIS and Remote Sensing and Digital Image Processing techniques were used for the study. The study was carried out specifically for the years, 2001,2003,2005,2006 and 2007.

3.1 Raster Theme Weightages

Weightages are given to significant units (on priority basis) in various thematic layers such as hydro geomorphology, slope, drainage, soils and Land Use/Land Cover in raster form in order to prioritize locations for structures suggesting appropriate recharge.

3.2 Conversion of Thematic layers to Raster Format

All the thematic layers were converted to raster form in Arc Map using convert features to raster option to assign weightages, since the analysis should be performed in raster mode. Assigning weightages to different units in various thematic layers is purely dependent up on the priority. In drainage raster 4th order streams can be given high first priority, 3rd order streams can be given moderate second priority and least third priority to2nd&1st order streams. These themes can be evaluated using raster calculator in spatial analyst based on the weightage decided. The formula for this raster calculation is

$$(\text{Drainage})*0.4 \quad (1)$$

A drainage raster indicating high and low priority locations will be generated by evaluating this equation. Based on this location priority raster various water harvesting structures can be suggested at appropriate locations (Berhanu, 2012).

3.3 Proposed Structures in the Watershed

Based on this location of priority raster and field checking various water harvesting structures have been suggested at appropriate locations. Seven locations for constructing check dams, and sixteen locations for moisture conservation pits, and rain water harvesting units were identified. It will be very useful for the development of water resources of the watershed.

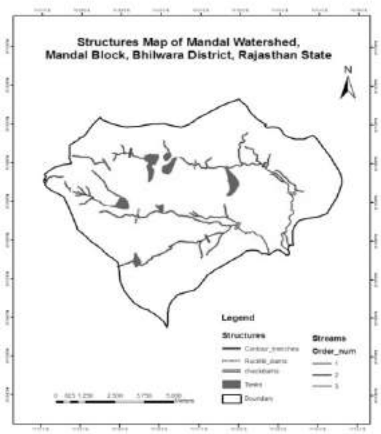


Figure 1. Structures map of mandal watershed

3.4 Land Use/Land Cover Classification

Thematic land classes were derived digitally by grouping pixels that have similar spectral signatures from the measurements of individual bands throughout the spectrum. Usually this classification is made with visible, near-infrared, and middle infrared part of the spectrum. Image interpretation was carried out with the help of nine elements of interpretation key (Prakasam, 2010).

3.5 Normalized Difference Vegetation Index (NDVI)

$$NDVI = NIR - Red / NIR + Red \quad (2)$$

NDVI values lies between -1and +1. Vegetation in good condition shows higher NDVI values. This is used to eliminate the seasonal sun angle difference and minimize atmospheric effects. Higher values indicate more density and vigor of the vegetation. NDVI is extensively used to detectseasonal variations among vegetation (Vikram and Bhamar, 2012).

3.6 Change Detection

Change detection analysis was carried out with the help of Change Detection Matrix provided with ERDAS imagine. By giving classified image of two different periods as input, the model automatically generates the area where changes are happened. For knowing changes happened in which type of land use classes statistical analysis were also carried out. To get an idea about vegetation, terrain, people and climate, a preliminary field visit was carried out in the early periods of study and necessary literatures and statistical information such as rainfall, temperature, agriculture were collected and incorporated with further studies (Coppin and Marvin, 1996).

4.0 RESULTS AND DISCUSSION

Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations. Today, watershed modelers have been able to capture the key hydrological behaviors of many watershed systems. The study is envisaged to prepare a comprehensive watershed management plan and to assess the impact of the watershed programme on the improvement of the environmental aspect of the watershed. Based on careful integration of information on soil, Land Use/ Land Cover, ground water potential and slope, the following action plan have been formulated in development of land, soil and water conservation. An attempt is also made using change detection studies to see the impact of these activities on the vegetation and the environmental aspects related to the watershed.

4.1 Land Use Land Cover map

The knowledge of spatial distribution of Land Cover/Land Use of large area is of great importance to regional planners and administrators. The Land Use / Land Cover categories was obtained from the remotely sensed data include level I classes of land use classification system such as water bodies, forest, grass land, agricultural land, barren land, and scrub land. The Spatial Distribution of the various Land Use Land Cover classes found in the study is calculated in GIS environment. The Land Use Land Cover maps were generated for the years 2001 to 2007 to study the impact of the watershed programme in the study area.

4.1.1 Land Use Land Cover Map of Sept.2001

In 2001, Land Use Land Cover map shows the dominance of crop land and it is clearly seen by the percentage (50%). The scrub land covers near about 25.1% area of the watershed which is second dominant class. Waterbody covers 2.8% of total area where as open land and temporary fallow land covers 3.6% and 18.5% respectively

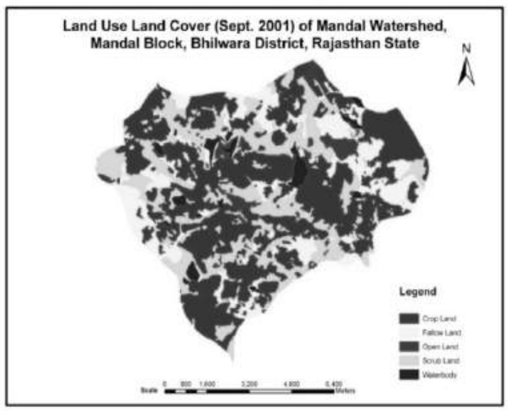


Figure 2. Land Use Land Cover Map of Sept. 2001

4.1.2 Land Use Land Cover Map of Sept. 2003

In 2003, Land Use Land Cover map shows the dominance of crop land and it is clearly seen by the percentage (51.1%). The scrub land covers near about 27.7% area of the watershed which is second dominant class. Water body covers 2.7% of total area where as Open Land and Temporary fallow land covers.6.5%and 12% respectively.

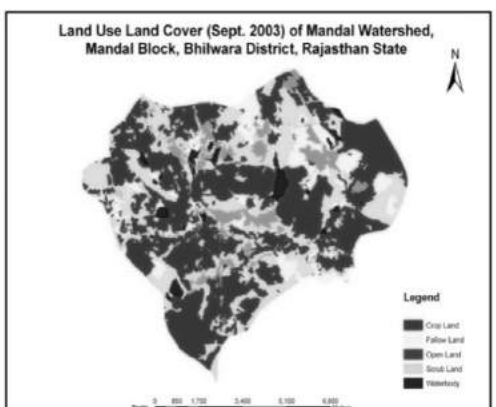


Figure 3. Land Use Land Cover Map of Sept. 2003

4.1.3 Land Use Land Cover Map of Sept. 2005

In 2005, Land Use Land Cover Map shows the **dominance of Crop Land and it is clearly seen** by the percentage (47.5%). The Scrub land covers near about 19.3% area of the watershed which is second dominant class. Waterbody covers 3.3% of total area where as Open Land and Temporary fallow land covers 11.4% and 18.50% respectively.

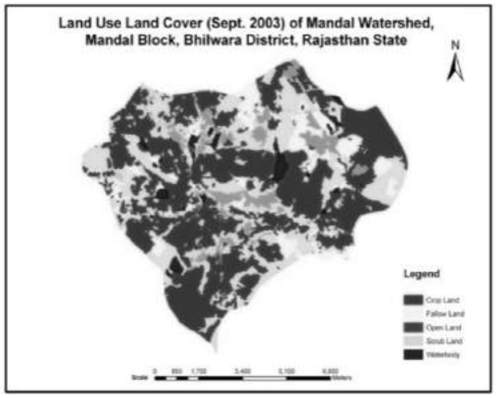


Figure 4. Land Use Land Cover Map of Sept. 2005

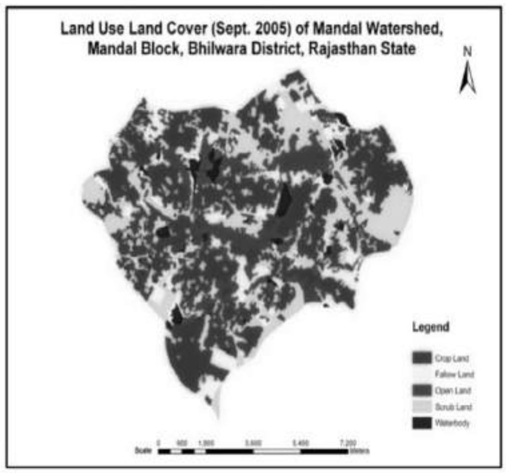


Figure 5. Land Use Land Cover Map of Sept. 2006

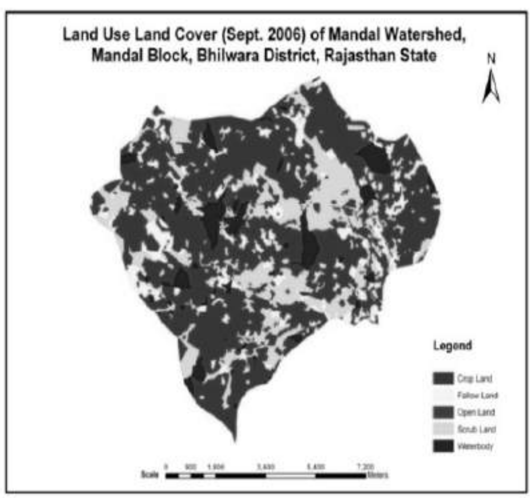


Figure 6. Land Use Land Cover Map of Sept. 2007

4.1.4 Land Use Land Cover Map of Sept. 2006

In 2006, Land Use Land Cover Map shows the dominance of Crop Land and it is clearly seen by the percentage (61.47%). The Scrub land covers near about 19.87% area of the watershed which is second dominant class. Waterbody covers 6.9% of total area where as Open Land and Temporary fallow land covers 0.98% and 10.78% respectively.

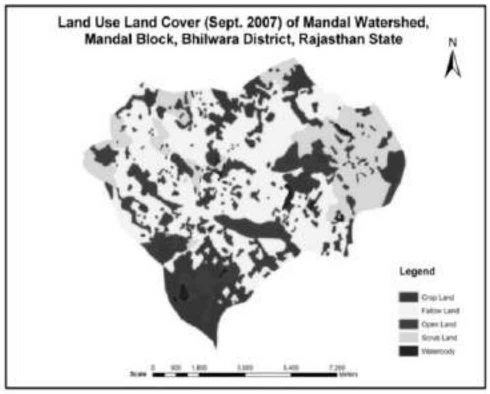


Figure 7. Hydrogeomorphology map

4.1.5 Land Use Land Cover Map of Sept. 2007

In 2007, Land Use Land Cover Map shows the dominance of Fallow Land and it is clearly seen by the percentage (44.30%). The Crop land covers near about 23% area of the watershed which is second dominant class. Waterbody covers 1.10% of total area where as Open Land and Scrub Land covers 13.6% and18% respectively

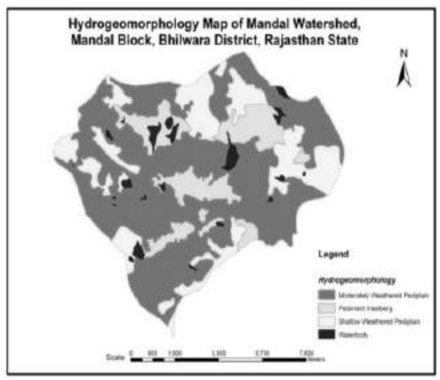


Figure 8. Ground water potential map

4.2 Hydrogeomorphology

Hydrogeomorphology deals with the study of landform in relation to groundwater occurrence and availability. It is manifested at the surface, mainly by geology, geomorphology, structure and recharge conditions. All the four parameters were studied and integrated to arrive at the groundwater prospects under each geomorphic cum lithologic unit, designated as hydrogeomorphic unit. The following geomorphic units are mapped in the Watershed area at 1:10, 000 scale.

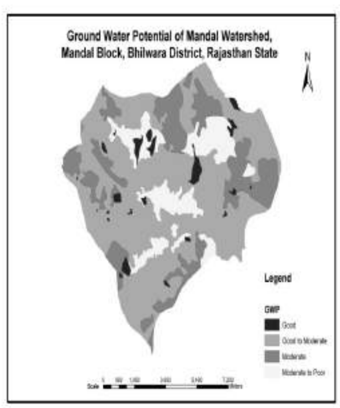


Figure 9. Soil map

4.3 Ground Water Potential

Ground water potential maps are prepared by integrating information on geomorphology, slope, lithology, structural features and the precipitation. Ground water recharge depends on favorable slope, permeability and degree of compactness of the rocks. On the basis of ground water availability major categories has been identified, high, moderate, low and very low ground water potential zone. An areaof250 ha under watershed area falls under Alluvial Plain and 200 ha of are under Floodplain which has very good ground water potential and it is nearly about 2% of the total study area. Denudation hill, Linear Ridges, Mesa, Pediment Plain and Structures hill have poor ground water potential and which covers near about 5000ha under the watershed which is 18% of the study area. Moderate weathered and shallow weathered pediplain have moderate ground water potential and is more than 50% of the study area**.**

4.4 Soils

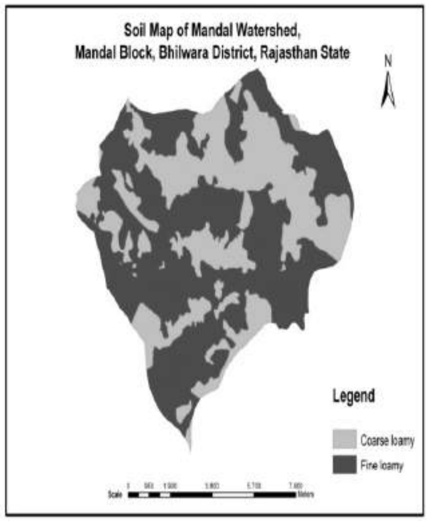


Figure 10. Change Matrix between 2001 and 2006

For optimal utilisation of available land and water resources, information on soil with respect to nature, physico-chemical characteristics, potential and inherent limitations are pre-requisite. The soils are directly related to the geomorphology or physiography of the area. Geomorphology is the study of the processes involved in formation of a landscape and those processes are indirectly related to the developmental process involved in soil formation. Hence, by integrating those processes the soils are mapped. The land units thus mapped include the external and internal characteristics of the landforms. Thus similar land units will have similar soils. This approach has been adopted in mapping of soils, of course more detailed investigations has been done during the field work by digging profiles at closer intervals. Deep, well drained, loamy, calcareous soil on very gently sloping plane soil with gently or moderate erosion covers near about 1000 ha area. Slightly deep well drained fine calcareous soil on very gently sloping land with moderate erosion covers near about 1500 ha area. Very shallow excessively drained, loamy calcareous soil gently sloping undulating lands with severe erosion covers near about 1700 ha area. Slightly deep, excessively drained, loamy soil on gently sloping undulating land with moderate and severe erosion covers near about 2100 ha area. Slightly deep well drained fine moderately calcareous soil on very gently sloppy lands with moderate erosion covers near about 1300 ha area. Shallow, well drained, clayey, calcareous Soil on gently sloping land with moderate erosion covers near about 900 ha area .For running the hydrology model these soils were regrouped into two classes clay loamy and fine loamy soils for assigning the weightages.

4.5 Change Detection

Change detection is used to highlight or identify significant differences in imagery acquired at different times. The matrix operation from the GIS Analysis menu allows two thematic images or vector files of different years to be compared. By comparing two classified or vector sets of data, the false positives due to radiometric differences can be eliminated. The matrix operation compares all the classes of image with all classes of another image and shows the change from one class to another class. The changes between 2001 and 2006 were presented in figure 10, table1 and figure 11as well as the changes between 2001 and 2006 were presented in figure 12, table2 and figure 13.

4.5.1 Change analysis between 2001 and 2006

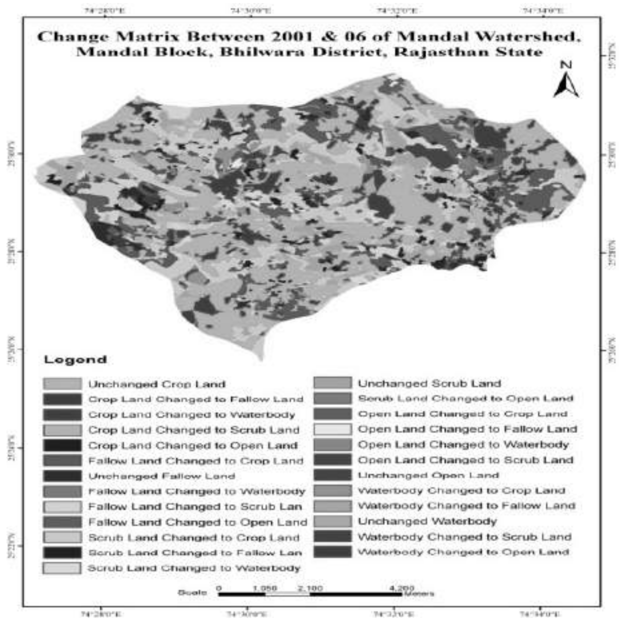


Figure 11. Changes in 2001 and 2006 image.

Table 1. Changes in study area (All Area are in ha)

Classes	Crop Land	Fallow Land	Open Land	Scrub Land	WaterBody
Crop Land	**2230.20**	417.08	45.16	698.63	335.72
Fallow Land	890.62	**177.76**	6.16	253.11	65.32
Open Land	125.00	29.61	**9.74**	92.39	13.80
Scrub Land	1216.78	174.79	5.94	**409.98**	80.33
Waterbody	127.85	12.78	7.78	42.50	**23.51**

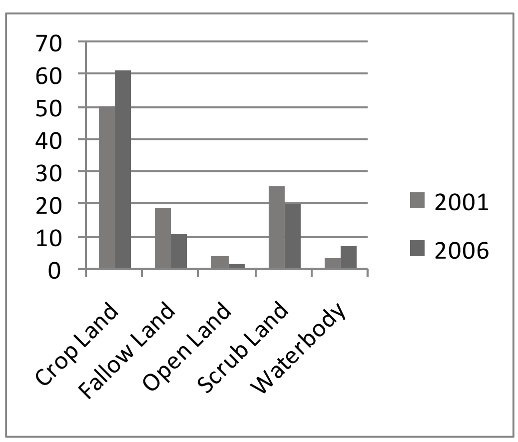


Figure 12. Change Matrix between 2001 and 2007

4.5.2 Change analysis between 2001 and 2007

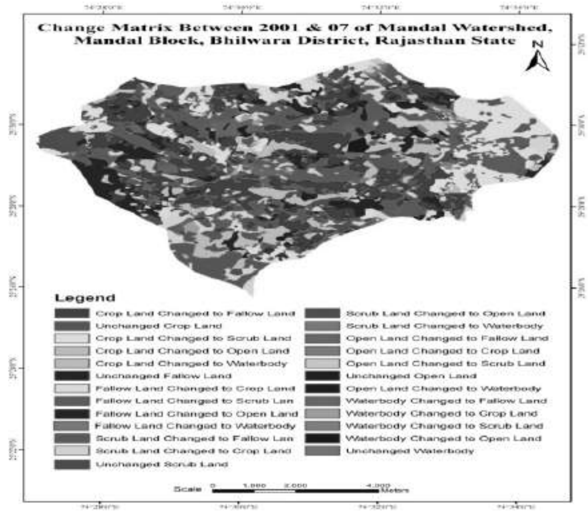
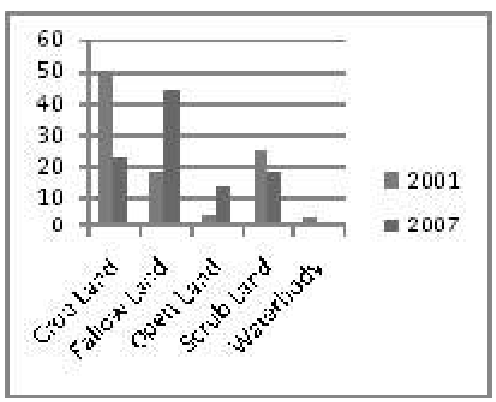


Figure 13. changes in 2001 and 2007 image.

Table 2. Changes in study area (All Area are in ha)

Classes	Crop Land	Fallow Land	Open Land	Scrub Land	Waterbody
Crop Land	**894.63**	1524.36	529.94	707.06	70.77
Fallow Land	311.74	**515.91**	220.39	342.77	2.14
Open Land	41.03	111.55	**36.57**	81.39	0.00
Scrub Land	41.03	1028.97	206.19	**200.30**	10.50
Waterbody	35.12	130.11	33.22	15.70	**0.27**



4.6 NDVI Classification

From the NDVI analysis it was observed that in the year 2001, 2523.14 ha of area was under high density vegetation, 1567.35 ha of area was under Moderate Vegetation, 1903.78ha of area is under low vegetation,1265.18 ha of area is under barren land and 223.54ha is under water bodies. In the year 2006, 2395.42ha of area was under high density vegetation, 1373.10 ha of area was under Moderate Vegetation, 1938.25 ha of area is under low vegetation,1219.87 ha of area is under barren land and 455.90 ha is under water bodies.

5.0 CONCLUSIONS

The watershed planning is carried out at different spatial levels to meet the requirement of the hierarchy of decision makers and implementing agencies. Remote sensing is being applied in different stages of the planning process for integrated watershed development. At a time, when new satellite data products are generated, it is imperative that the technology in the application aspect is updated with due consideration to the users requirements. It is with this background, a study was taken up with an aim to apply remote sensing for tactical and operational planning and prepare a perspective plan for watershed development. It is being felt that field information is required to support structures proposed based on hydrology modeling. For instance ground water potential can be estimated only from intensive filed observations of water table at least during two seasons i.e., pre and post monsoon periods. Similarly, for proposing structures the following parameters like soil depth, texture, terrain conditions and slope all along the gullies at micro-level (on large scale) are required. In order to identify suitable satellite data and the scale of mapping for different levels of planning in the process of watershed development, LISS-III, IV and PAN data and Cartosat-I data were used for the natural resource inventory. Initially, the natural resources inventory of the study area was carried out using LISS-IV data at 1:25,000 scale. The data on hydrogeomorphology, soils, land use/land cover and slope was generated following the technical guidelines by the National Remote Sensing Agency, with necessary modifications in few aspects.

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Use of WMS for Stormwater Management

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ABSTRACT

Warangal, being a big city, next to Hyderabad in Telangana State, is urbanising at a very rapid rate. Population rise due to commercialisation and growth of educational institutions have brought severe stress on the infrastructure development including stormwater conveyance systems, due to increase in impervious areas indiscriminately. Along with this, the insufficient drainage density, drains with inadequate capacity, and poor solid waste management, cause severe inconvenience to the people, by flooding especially the low-lying areas. Hence, stormwater management has to be taken up in all seriousness to reduce the effects of flood, pollution control and to increase the availability of water for human consumption. Bhavani Nagar of Hanamkonda is identified as a study area, due to its location in a low-lying area and poor drainage facilities and dense residential area. The IDF relationship for pre-determined return period is needed which is useful as an input is developed at NIT Warangal. Watershed Modelling System (WMS) is selected for the present study due to its capabilities, availability of trial version, and its strength in interfacing with GIS which greatly enhances its utility. Along with this IDF equation, the ArcGIS generated shape files forms the primary input to WMS. This modelling system is capable of computing most of the basin characteristics and design of open drains as well as closed conduits. Hydrographs at every outlet are generated and surcharges occurring at any location in the drainage network are also identified.

Keywords: Urban stormwater drainage, WMS, ArcGIS, IDF, simulation.

INTRODUCTION

Urban drainage is rapidly becoming a central issue in urban planning and management particularly in developing countries. Combined effects of urbanisation, industrialisation, and population growth affect natural landscapes and hydrological response of watersheds. Although many elements of the natural environment are affected by anthropogenic factors, the principal structure of the hydrological cycle remains unchanged in urban areas. However, the hydrologic cycle is greatly modified by urbanisation impacts on the environment like providing water services to the urban population, construction of drainages, wastewater collection and management. Thus, it can be noted that the hydrological cycle becomes more complex in urban areas, because of many anthropogenic influences and interventions. The resulting “urban” hydrological cycle is then called urban water cycle (UWC). Urban drainage is a part of this cycle and is related to urban hydrological system in a very complex way. One of the most important facilities in preserving and improving the urban water environment is to provide an adequate and properly functioning stormwater drainage system.

OBJECTIVES

The study is taken up to locate the areas of Hanamkonda region having low-elevation profile and inadequate drainage system., which are prone to possibility of inundation. In addition the objective of the work will also be to compute the hydrographs for the study area using an appropriate peak flow estimation method, and to plan, prepare and design stormwater drainage network for the selected part of Warangal city using WMS.

Limitations

Warangal city which is growing at a very rapid rate doesn’t have adequate drainage system and corresponding data for use in selected software, WMS. For the study, it is assumed that all the drains follow the road network, even if they don’t exist, and the areas adjacent to the study area are not considered for the contribution to runoff.

Rational Method

For hydraulic designs on very small watersheds, a complete hydrograph of runoff is not always required. The peak value of the hydrograph is sufficient for design of the drains. This method is still probably the most widely used method for design of storm sewers in urban areas. The rational method, because of its simplicity, is still in continued use for storm drain design for small urban and rural watersheds, when high accuracy of runoff rate is not essential. According to Ponce (1989), the rational method takes into account the following hydrologic characteristics or processes: (a) rainfall intensity, (b) rainfall duration, (c) rainfall frequency, (d) catchment area, (e) hydrologic abstractions, (f) runoff concentration, and (g) runoff diffusion. The rational method doesn't take into account the following characteristics or processes: (a) spatial or temporal variations in either total or effective rainfall, (b) concentration time much greater than rainfall duration, and (c) a significant portion of runoff occurring in the streamflow.

Watershed Models Available for Urban Flood Studies

Various watershed models available for urban flood studies are TR-20, TR-55, HEC-HMS (Hydrologic Engineering Centre-Hydrologic Modelling System), NFF, MODRAT, OC Rational, HSPF, HEC-RAS, SMPDBK, CE-QUAL-W2, GSSHA, HSPF, KINEROS2.

Watershed Modelling Systems Available for Urban Flood Studies

There are numerous watershed-scale hydrologic modelling systems available that utilise some of the models within one packaged system for watershed management (Daniel et al., 2011). These are AGWA, BASINS, MODFLOW-What, WISE, XP-STORM and WMS.

Selection of Watershed Modelling System (WMS) for the study

WMS, is a comprehensive environment for hydrologic analysis, developed by the Environmental Modelling Research Laboratory of Brigham Young University in cooperation with the U.S. Army Corps of Engineers Waterways Experiment Station. The software is currently being developed by Aquaveo LLC. WMS can harness the entire spectrum of watershed analysis through hydrologic and hydraulic solution with user friendly graphical interface to support modelling rainfall, losses, unit hydrographs, stream routing, lumped parameter, regression, and 2D hydrologic modelling of watersheds and can be used to model both water quantity and water quality.It can handle floodplain analysis of single events or long term studies with additional capabilities for groundwater modelling, contaminant transport, sediment transport, storm and tile drain modelling. It currently supports the models like HEC-1, HEC-RAS, HEC-HMS, TR-20, TR-55, National Streamflow Statistics (NFF), Rational, MODRAT, HSPF, EPA-SWMM, XP-SWMM, CE-QUAL-W2, GSSHA, SMPDBK, and Orange Country Rational and Unit Hydrograph method.

WMS offers state-of-the-art tools to perform automated basin delineation and to compute important basin parameters such as area, slope, overland flow length, stream channel length, flow accumulations, and flow directions (Erturk et al. 2006; Chu and Steinman. 2009; Tecle et al. 2012). It also serves as a graphical user interface for several hydraulic and hydrologic models. With its management of coordinate systems, WMS is capable of displaying and overlaying data in real world coordinates. The program also provides many display tools for viewing terrain surfaces and exporting images for reports and presentations (WMS, 2014). A storm drain network can be drawn or imported from ArcGIS. It can compute elevations, lengths, and slopes of pipes from underlying elevation data. It links the storm drain network to the hydrologic model data. The hydrologic model data and the storm drain network can be exported to EPA-SWMM or XP-SWMM and these files can be imported into WMS.

METHODOLOGY

The design of stormwater drain is a direct application of the principles from both hydraulics and hydrology. IDF curves are used to specify the rainfall intensities. Watershed characteristics are used to estimate the volume of flow, and rate of runoff for a given rainfall intensity. Flow equations are used to estimate pipe or channel sizes necessary to convey the calculated rates of flow.

Selection of study area

Keeping in mind the projected land use, due to rapid rate of urbanisation expected in the near future, an underground stormwater conveyance system is proposed for Bhavani Nagar of Hanamkonda region with a rough idea of location of inlets, man-holes and outfalls, to reduce the flooding and water-logging problem due to insufficient capacity of the existing open drains.

Planning of drainage network

A storm drainage network is planned by delineating the watershed with DEM as input by using hydrologic modelling wizard in WMS, to understand the flow accumulations and directions, and then the drainage lines are marked along the roads to create a drainage shape file of the study area.

Using WMS, the open drain network is designed by understanding the flow pattern and flow accumulation of the Bhavani Nagar study area using a 31m Cartosat DEM. Piped network is designed by using HYDRA program developed by the Federal Highway Administration (FHWA) which is inbuilt in WMS. Bhavani Nagar (Figure 1) having an area of 0.14 km^2(Source: Google Maps)is designed for underground piped network.

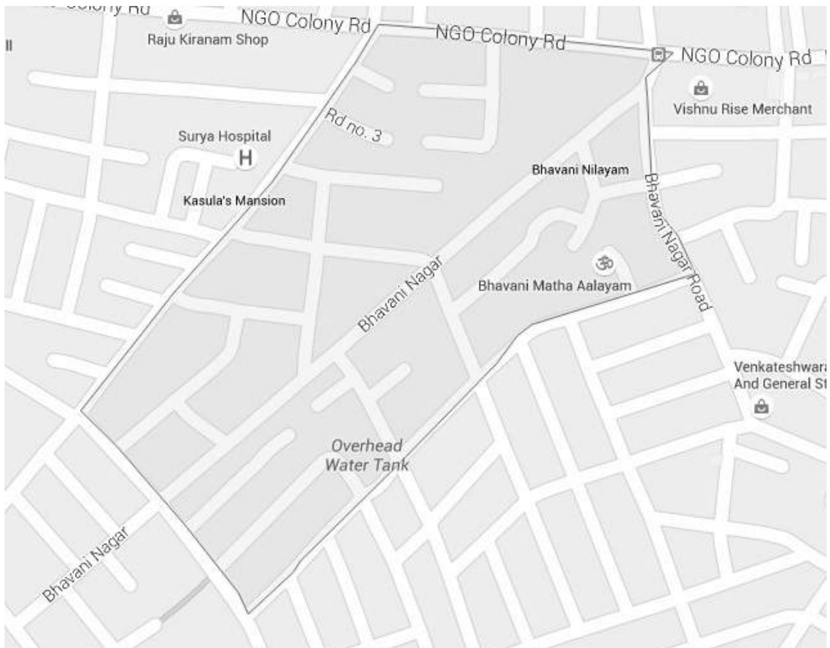

Figure 1. Bhavani Nagar

The IDF relationship developed for Warangal using 21 years of data by ButchiBabu (1997), is used to enter the intensity values for 5 year return period to design the storm drains as shown in the Equation 1.

$$I = \frac{18.31T^{0.321}}{(t_c)^{0.661}} \quad (1)$$

Where, I is Intensity (in/hr), T is Return period (years), and t_c is Time of concentration (min).

The time of concentration (Eq. 2) is taken equal to time of flow in drain (lag time), with no consideration of overland flow.

$$T_c = \frac{nL}{60.R^{2/3}S^{1/2}} \quad (2)$$

Where, L = Length of the channel or drain (m), R = Hydraulic Radius (m), S = Slope (m/m), n = Manning's constant for open channel flows, and T_c = Time of Concentration in min.

Data Preparation

Figure2(a) to Figure 2(d) shows Land use shape file, Runoff shape file, Drainage shape file, and Pipe network shape file for Bhavani Nagar study area (Figure 1) are prepared using ArcGIS.Even though the shape files can be prepared in WMS, a knowledge of ArcGIS is required for faster preparation of the same.

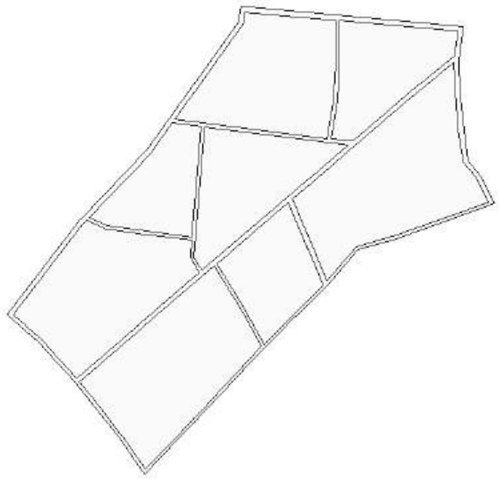

Figure 2(a). Land use shape file

Figure 2(b). Runoff (Drainage basin) shape file

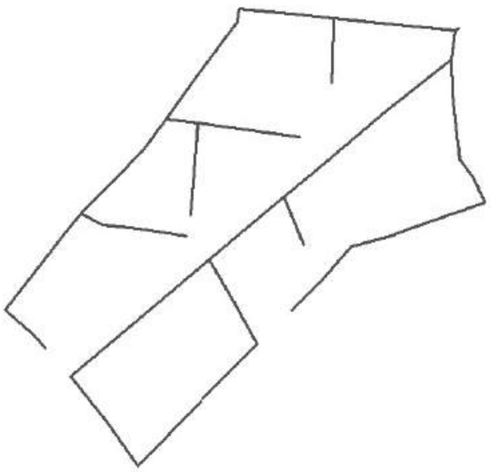

Figure 2(c). Drainage network shape file

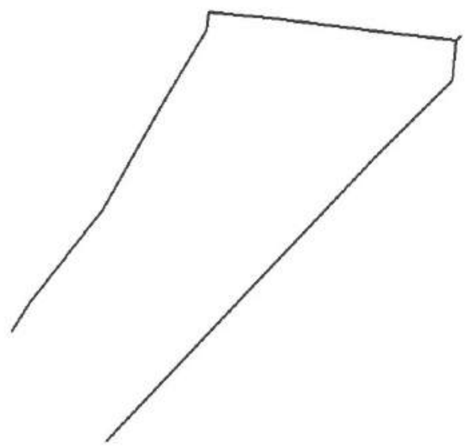

Figure 2(d). Pipe network shape file

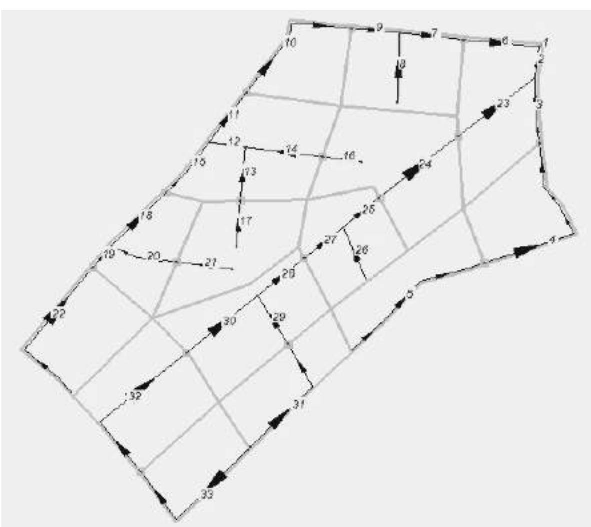

Figure 3. Time Computation Arcs

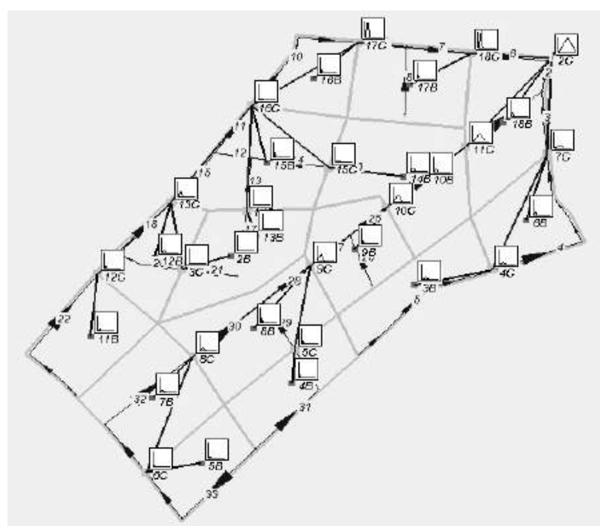

Figure 4. Hydrographs and outlets (yellow dots)

RESULTS AND DISCUSSIONS

Computing times of concentration

The time computation arcs as shown in the Figure 3, are prepared in the time computation coverage to compute times of concentration for all the drainage arcs using Rational Method. The outlet points can be seen in the Figure 4. The Manning's "n" for all the channels is taken as 0.017.

Hydrographs

Triangular hydrographs are produced for all the basins and at the basin outlets, can be seenin the Figure 4. WMS develops the hydrographs with labels in English units. Figure 5 shows a triangular hydrograph at the basin outlet 2C.

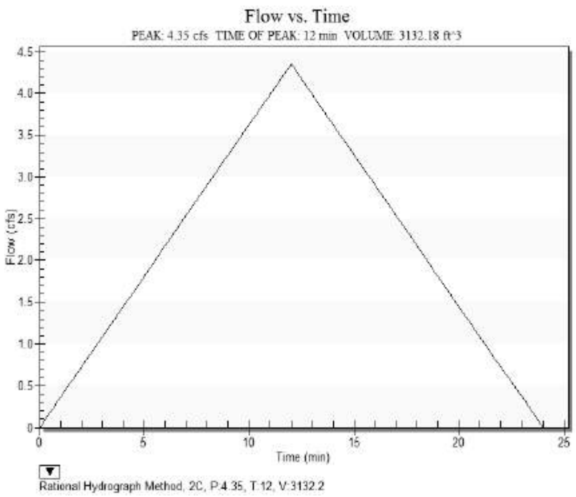

Figure 5. Rational Method Hydrograph at the outlet 2C.

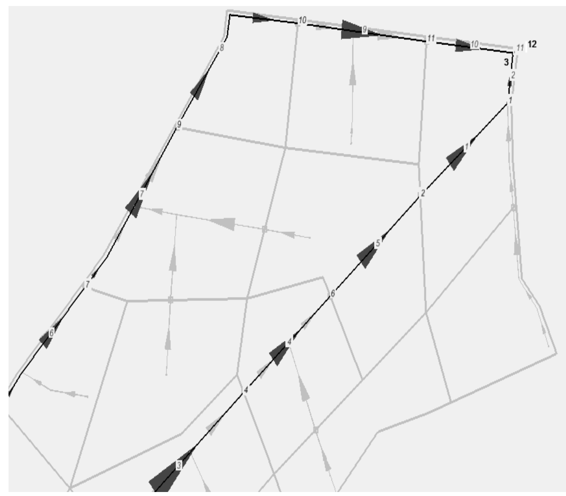

Figure 6. Pipe network and direction of flow in each link

Pipe Design

The study area is designed for 11 links of circular pipes for flow conveyance as shown in the Figure 6. Super-critical velocity is maintained in the system, which shows that it is more than self-cleansing velocity. The pipe sizes vary from 750 mm to 900 mm.

Estimated Link	Invert		Depth		Min. Velocity		Flow	
	Length (m)	Diam (mm)	Up/Dn (m)	Slope (m/m)	Up/Dn (m)	Cover (m)	Act/Full (m/s)	Act/Full (m^3/s)
1	152	750	198.518 197.455	0.007	1.113 3.605	0.300	0.920 2.284	0.022 1.009
2	98	750	197.455 196.967	0.005	3.605 3.463	2.650	0.951 1.930	0.035 0.853
3	101	750	196.967 196.359	0.006	3.463 3.961	2.650	1.056 2.115	0.041 0.934
4	97	750	196.359 195.779	0.006	3.961 4.621	3.149	1.014 2.115	0.035 0.934
5	33	750	195.779 195.615	0.005	4.621 2.315	1.503	0.925 1.930	0.033 0.853
Length = 480m Total Length = 480m								
6	106	750	197.687 197.049	0.006	1.113 2.861	0.300	0.789 2.115	0.015 0.934
7	131	750	197.049 196.265	0.006	2.861 4.275	2.048	0.915 2.115	0.025 0.934

8	147	750	196.265 195.239	0.007	4.275 4.141	3.329	1.125 2.284	0.041 1.009
9	112	750	195.239 194.569	0.006	4.141 2.931	2.119	1.063 2.115	0.042 0.934
Length = 495m Total Length = 495m								
10	75	750	194.569	0.005	2.931 3.737	2.119	1.047 1.930	0.049 0.853
11	5	900	194.193 194.143	0.010	3.737 3.547	2.572	1.499 3.083	0.077 1.962
Length = 576m Total Length = 1056m								

Hydraulic Gradeline Computations

Link	Down Stream node	Hydraulic Gradeline Elevation	Crown Elevation	Possible surcharge	Ground Elevation	Super critical	Man hole depth	Loss coefficient
3	4	197.541	198.217	N	201.060	Y	0.152	0.41
4	6	197.078	197.729	N	200.430	Y	0.170	0.12
5	2	196.478	197.121	N	200.320	Y	0.158	0.00
1	1	195.891	196.541	N	200.400	Y	0.149	0.59
2	3	195.722	196.377	N	197.390	Y	1.718	0.90
6	7	197.122	197.811	N	199.910	Y	0.133	0.44
7	9	196.359	197.027	N	200.540	Y	0.171	0.51
8	10	195.359	196.001	N	199.380	Y	0.171	0.41
9	11	194.690	195.331	N	197.500	Y	0.184	0.15
10	3	194.324	194.955	N	197.930	Y	1.718	0.72
11	12	195.779	195.032	Y	197.690	Y	1.636	0.00

In the link 11 it is found that there is a surcharge which must be taken care of. This can be done when the other areas in the neighbourhood of Bhavani Nagar are also analysed and surcharge, if any, from those areas also must be taken into account to take suitable remedial measures.

CONCLUSIONS

Based on the study carried out, the following conclusions can be arrived (a) a drainage system has been designed for a low-lying area, (b) the location of possible surcharges have been identified, (c) errors and capabilities have been identified, so that the system can be effectively used, and (d) WMS can be used in conjunction with other software and models.

DISCUSSIONS

This study requires the knowledge of ArcGIS and watershed hydrology. A DEM or a TIN is used to assign the ground elevations and to calculate pipe elevations. WMS has the following capabilities (a) Hydrographs are generated at every drainage basin outlet, (b) the generatedhydrographs are used to size the conveyance elements, (c) there is an option to choose both open channels of different cross-sections as well as closed conduits to transport the stormwater to the outlet, (d) the invert levels at top and bottom of a conveyance element are fixed by the WMS using the TIN files, (e) in WMS there is a provision for placing of manholes at the predetermined places by linking the storm drain inlets from the Drainage coverage to the nodes of pipe network in the Storm Drain coverage, (f) WMS automatically assigns pipe elevations based on an underlying TIN or DEM. WMS also has the following limitations (a) unexpected software crashes are experienced for some of the options related to hydrograph calculation in the Rational Method, (b) errors are encountered when multiple downstream nodes (storm drain inlets) are encountered, the streams form a closed loop, and the directions of stream arcs are in reverse order, (c) the lack of clear guidelines from the vendor of WMS, is making it difficult to learn the software and make it more readily applicable.

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Evaluation of Damping for Safety and Stability of Gravity Dams by Finite Element Analysis

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ABSTRACT

The Gravity dams are solid concrete structures resisting the pressure of impounded water through their own weight. Their failures can cause immense damage to society and loss of life. Since a concrete gravity dam is a plain concrete structure, the failure due to earth quake is resulting mainly from the occurrence and propagation of cracks in the dam body. Investigations of existing dam structures revealed that damping factor could vary between 1 to 7 percent. For the design of dams, it is necessary to assess the influence of damping factors on the stress levels. In the present study the entire range of damping factors available in the response spectrum given by IS 1893 is conducted on five different dam sections for no water and full reservoir conditions and their responses are evaluated with a special emphasis on dam – reservoir – foundation systems. A two dimensional Finite Element Modal is created using both triangular & quadrilateral elements to simulate dam with foundation. The dam has been idealized by considering a separate monolith under plane stress conditions. Westergaard's concept of the added mass is considered for the attachment of the reservoir-water with the upstream face of the dam. Five number of modes are considered to evaluate the response under different damping factors. It is observed that the dams are subjected to constant displacement at the crest for the condition of damping ratio exceeding 5%. It is also revealed that the variation of stress at heel and toe is changing from non linear to linear when the damping ratio exceeds 5%.

Keywords: Gravity dams , cracks , damping factor, finite elements, earthquakes.

1.0 INTRODUCTION

Gravity dams form a major role of a country economy and their failure will create huge loss of life and properties. The failure is mainly from propagation of cracks (Asteris P.G, 2003) in the dam body due to seismic forces. Hence, it is necessary to evaluate the safety of dams by study of the various aspects influencing the seismic response of a concrete gravity dam. The response of a dam subjected to seismic loading is a reasonably complex problem. An important aspect that influence the occurrence of cracks in dams under seismic loading is of damping characteristics. Also the response of a dam subjected to dynamic loading (Brijesh.S, 2009) exhibits a combined effect of the interaction among dam, reservoir and foundation systems. El-Aidi and Hall (1989) showed that damping characteristics have a large effect on crack propagation behavior and that the mass proportional parts in damping constitute a resisting force at the surfaces where cracks occur so that the stress release becomes insufficient. Bhattacharjee, S.S. (1993) also reported similar findings, and in general the crack localization phenomena can be indicated by using the initial stiffness to set proportional damping. Also Kimata.H, Fujita.Y (2008) evaluated the crack propagation behavior in dams by introducing a damage variable to vary the damping characteristics according to the amount of damage .Since these studies have shown that the damping characteristics have a significant effect on the occurrence and propagation of cracks in the bodies of concrete gravity dams. It has been shown that cracks become more dispersed and less liable to propagate as the damping increases, whereas cracks become localized and propagate more easily when the damping is small. While offering the inherent vibration characteristics, the work is carried by extending the natural vibration characteristic towards the pseudo-static response of the concrete dam-reservoir-foundation system.

2.0. GEOMETRY AND FINITE ELEMENT MODELS OF CONCRETE GRAVITY DAMS

A two dimensional conventional finite element model is created using both triangular & quadrilateral isoparametric elements. The dam has been idealized by considering a separate monolith under plane stress conditions. The parametric study is carried out for two different cases.

CASE 1: Dam super structure subjected to seismic forces and Case 2: Dam with foundation subjected to seismic forces.

2.1. Dam super structure subjected to seismic forces

Parametric investigation pertaining to the dam with triangular cross section is under taken for no water and full reservoir conditions carried in detail. The material properties considered in the analysis are modulus of elasticity E = 0.250 X 10^8 kN/m^2 & density ρ = 25.0 kN/m^3 respectively for all cases. Poisson's ratio γ = 0.15 considered. Five dam monoliths are analysed for different heights. The finite element idealization (Tepes Onea florin Yang Lu, Gelmaambet Sunai, 2010) details for the problems being investigated are shown in Figure.1 and their discretization numerical data is provided in Table.1

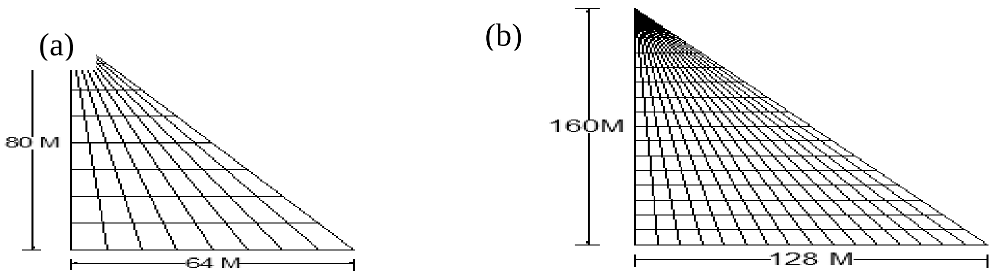


Figure 1. Details of studied gravity dam monoliths (a) Dam height 80.0 m.(b) Dam height 160.0m.

Table 1. Discretization of dam sections.

S. No	Dam height(m)	Down stream slopes	Nodes	Elements	Existing dams
1.	40.0	0.6:1	101	96	Lower Manair dam(A.P)
2.	80.0	0.6:1	201	192	Upper Bhavani dam(T.N)
3.	120.0	0.7:1	349	336	Ram Ganga(U.K)
4.	160.0	0.7:1	465	448	Srisailam dam(A.P)
5.	200.0	0.8:1	661	640	Lakhwar(U.K)

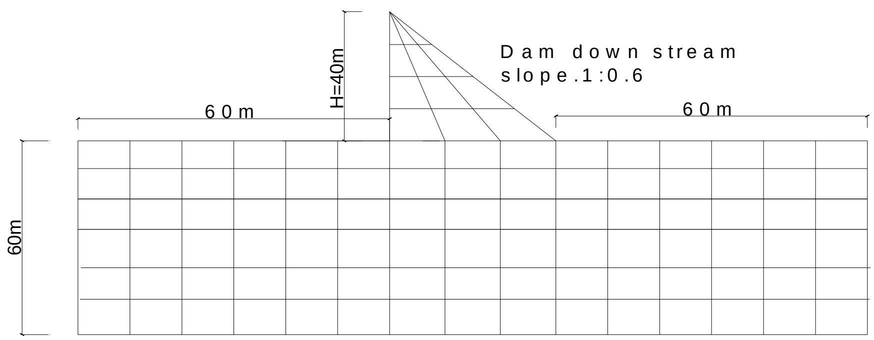
2.2 Dam with foundation subjected to seismic forces

Dam sections varying for three heights with foundations are considered and their numerical data is given in Table.2. Idealizations details are presented for 40.0 m and 80.0 m in Figures 2 & 3. The details of dam material properties considered in the analysis for the three cases are,

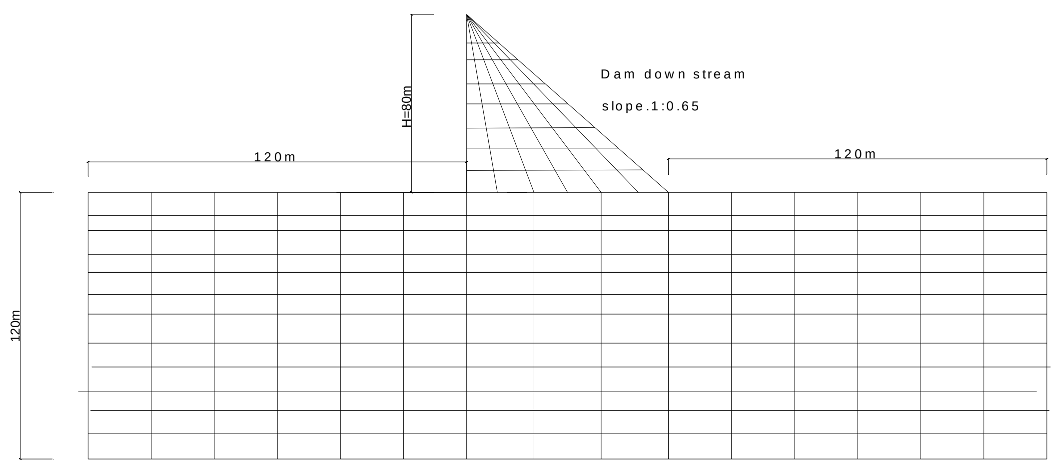
- ***Super structure material details***: Modulus of Elasticity E_d = 0.25 X 10^8 kN/m^2, Poisson's ratio γ = 0.15 and density ρ = 25.0 kN/m^3 are considered.
- ***Foundation material details:*** Modulus of Elasticity E_f value for the foundation material is considered with five different ratios (E_f / E_d) as shown in Table 3.

Table 2 Discretization of dam sections with foundation

	Dam height(m)	Down stream slopes	Nodes	Elements	Existing dams
1.	40.0	0.6:1	125	102	Lower Manair dam(A.P)
2.	80.0	0.65:1	453	408	Upper Bhavani dam(T.N)
3.	120.0	0.7:1	1015	948	Ram Ganga(U.K)



(a)



(b)

Figure 2. Idealization of dam monoliths (a) Dam height 40.0 m.(b) Dam height 80.0m.

Table 3. Modulus of elasticity for dam foundation

S.No	E_f / E_d	E_f in kN/m^2
1.	0.20	0.05 E+08.
2.	0.40	0.10 E+08.
3.	1.00	0.25 E+08.
4.	2.00	0.50 E+08.
5.	4.00	1.00 E+08.

3.0. METHODOLOGY

A pseudo static response analysis of dam reservoir foundation system provides the solution for preliminary design of the system with respect to earthquake shock. This involves considerations to the modal characteristics and participation factors coupled with the IS code recommended spectra. The uncertainty in this process exists in respect of the damping factor to be considered. In the present study the entire range of damping factors available in the response spectrum given by IS 1893 is conducted on five different dam sections for no water and full reservoir conditions and their responses are evaluated with a special emphasis on dam – reservoir – foundation systems(Gregory Fenves A.M, Anil K.Chopra.M, 1985) In the dam – reservoir interaction, while conducting pseudo static quake response analysis the codes recommended the use of concept of the added mass arising from the attachment of the reservoir-water with the upstream face of the dam. The added mass (Westergaard.H,1998) arises from the weight of the water contained within the hydrodynamic pressure. Hence the proposed work is carried in two phases namely (a) study of modal characteristics of dam and (b) pseudo static structural response for dam-reservoir and dam-foundation systems and is restricted to the first five modes.

3.1 Study of modal characteristics

Complete information regarding modal characteristics such as mode shapes and related natural frequencies are presented for the dams with and without foundation systems. The modal characteristics provided are for self weight of the structure. Yet same is bound to be useful while considering the influence of the reservoir loads. This is obvious because in the previous work by Sashikiran.K, Manjulavani.K (2015), it was established that the natural frequencies of the structure derived on self weight could be adopted for the cases in which the water load is also included. The results are shown below for dams with and without foundations.

Dam super structure without foundation:

The modal characteristics for the first five frequencies ω_1 to ω_5 of the dam with heights 80.0 m and 160.0 m are shown in figure.3 .Also the modal amplitudes for the upstream face of the dams are shown in Figure.4 .

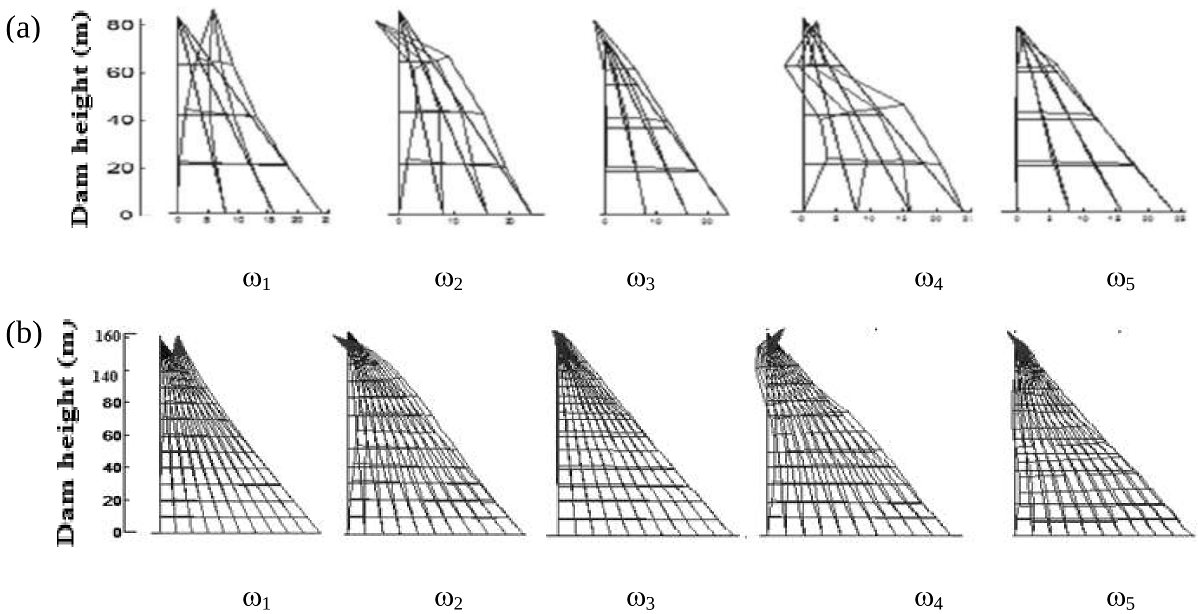


Figure 3. First five mode shapes of (a) Dam height 80.0 m.(b) Dam height 160.0m.

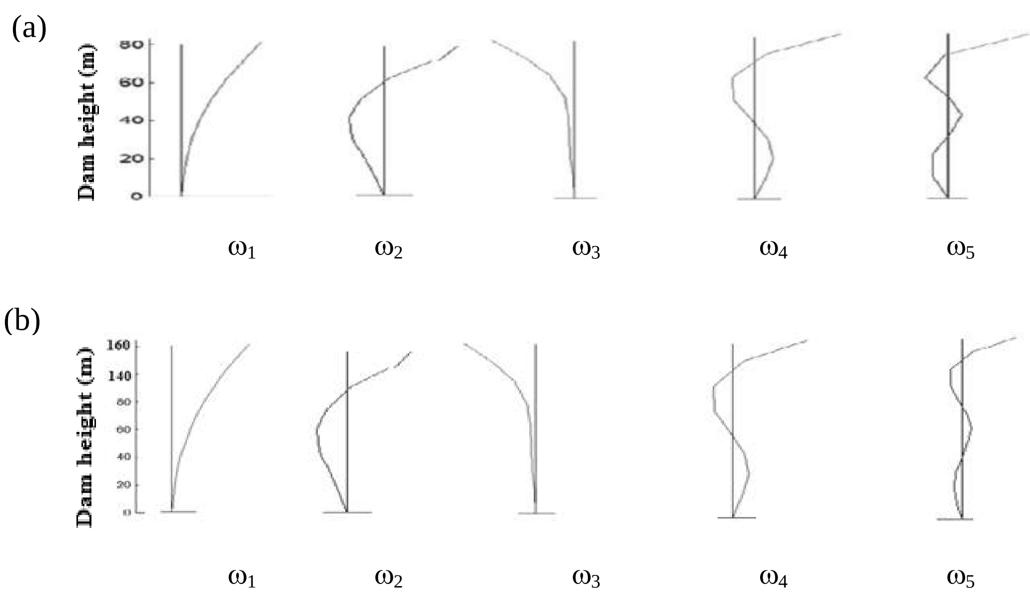


Figure 4. First five modal amplitudes (a) Dam height 80.0 m.(b) Dam height 160.0m.

Dam super structure with foundation: The modal amplitudes for the first five frequencies ω_1 to ω_5 for up stream face of the dams with heights 40.0 m and 80.0 m are shown in figure.5

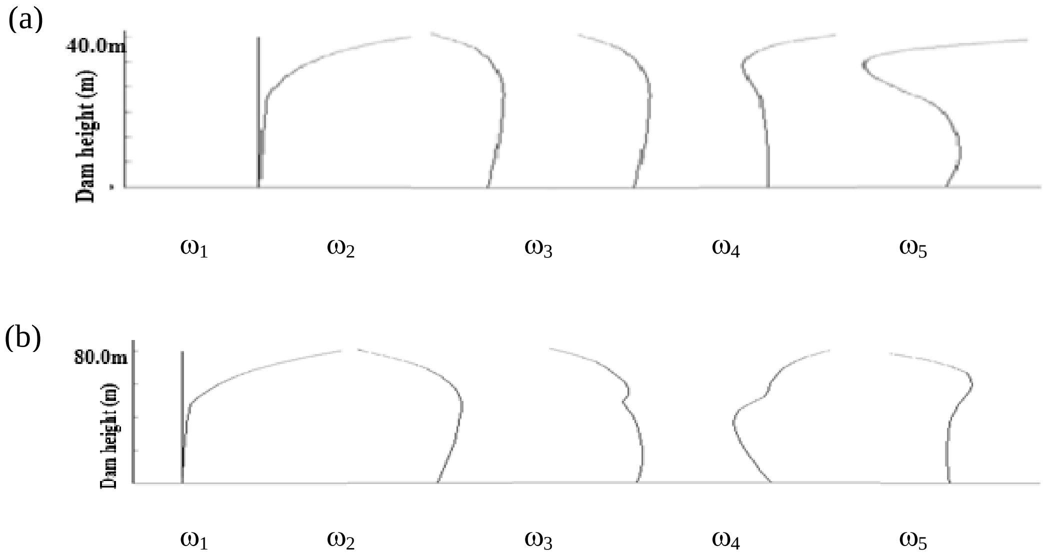


Figure 5. First five modal amplitudes (a) Dam height 40.0 m.(b) Dam height 80.0m.

3.2 Pseudo Static structural response of the systems-Damping ratio

The modal characteristics comprising mode shapes and corresponding natural frequencies could be utilized towards the development of pseudo static forces by employing the technique of modal participations. In this section the details are presented and discussed. The emphasis in this presentation is on the influence of damping factors mainly because the problem of damping is more often than not suffer from various uncertainties. The conventional practice is to choose the damping factor arbitrarily more or less based upon the past practice. In view of all these it was thought that considering the entire range of damping factors included in the earthquake response spectrum in IS: 1873 should be taken up and study the influence with a view to achieve a rational conclusion regarding the damping factors. The results aims for the response details such as horizontal deflection at the top of the dam and principal stress at the heel and toe of the dam for both reservoir empty and reservoir full conditions considering different heights of dam with and without foundations.

Dam super structure without foundation: Response details for both reservoir empty and full conditions, horizontal deflection at the top of the dam and principal stresses at the heel and toe in respect of the dam heights 80.0 m and 160.0 m are presented in figures 6, 7 & 8.

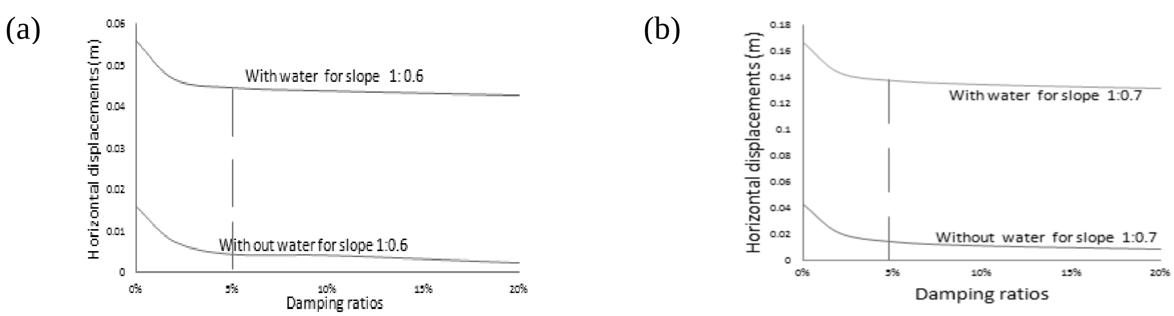


Figure 6. Crest displacement Vs Damping ratios for (a) Dam height 80.0 m with side slope 1:0.6
(b) Dam height 160.0m with side slope 1:0.7.

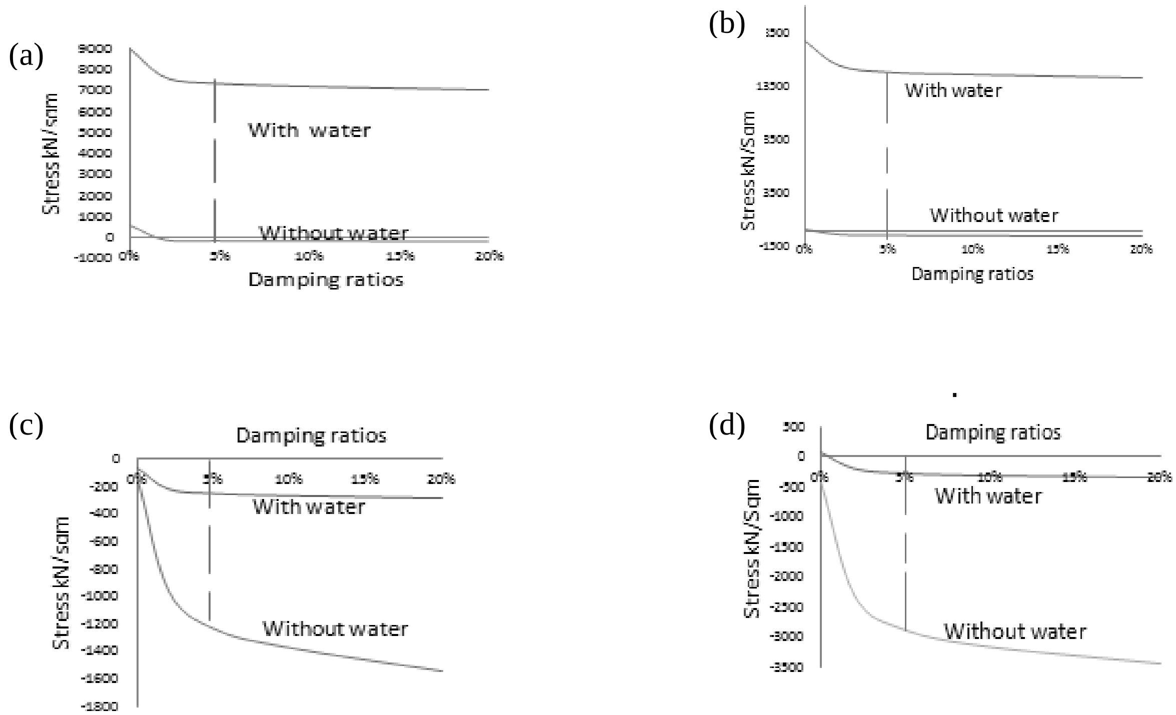


Figure 7. Principal stresses at Heel (a) Major principal stress for dam height 80.0 m (b) Major principal stress for dam height 160.0 m (c) Minor principal stress for dam height 80.0 m (d) Minor principal stress for dam height 160.0 m.

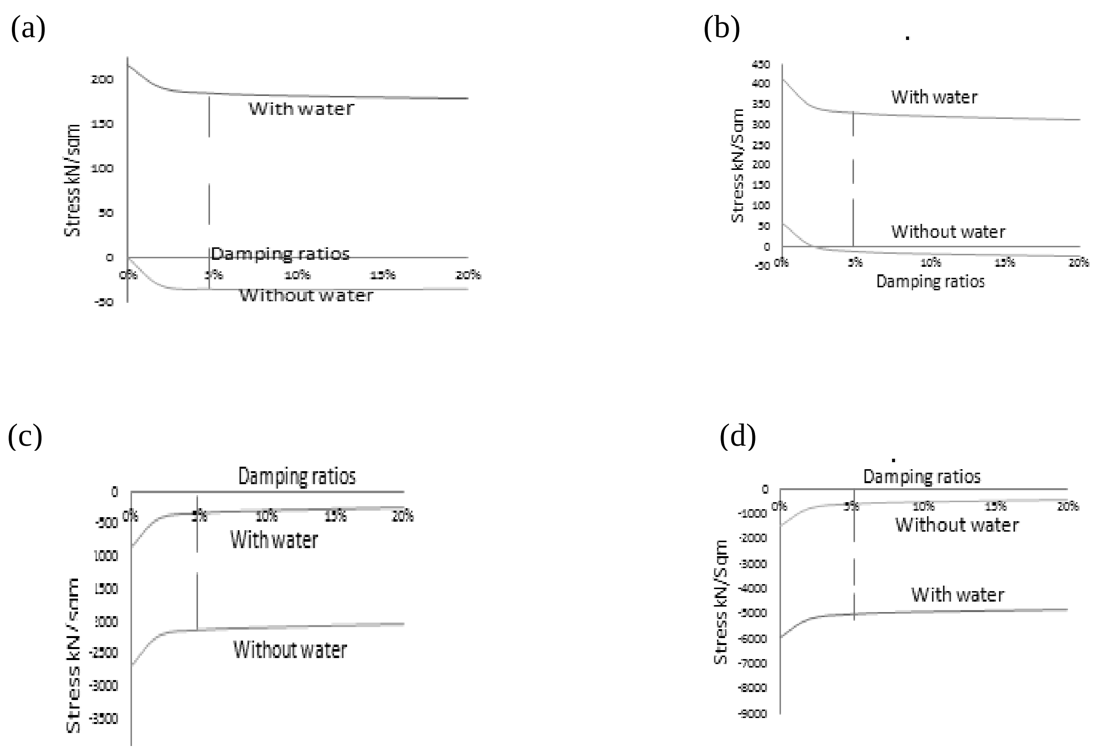


Figure 8. Principal stresses for Toe (a) Major principal stress for dam height 80.0 m (b) Major principal stress for dam height 160.0 m (c) Minor principal stress for dam height 80.0 m (d) Minor principal stress for dam height 160.0 m.

Dam structure with foundation

Crest deflection and principal stresses at the heel and toe of the dam with height 120.0 m and slope 0.7 in 1 with E_f /E_d = 0.2,0.4, 1, 2 & 4 are presented in figures 9, 10 & 11.

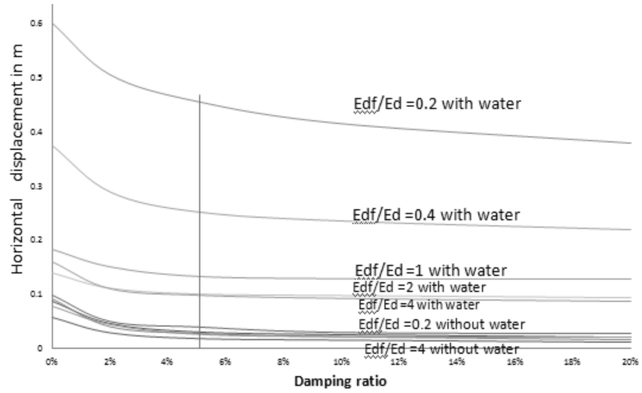


Figure 9. Crest displacement Vs Damping ratios for dam height 120.0 m.

(a) (b)

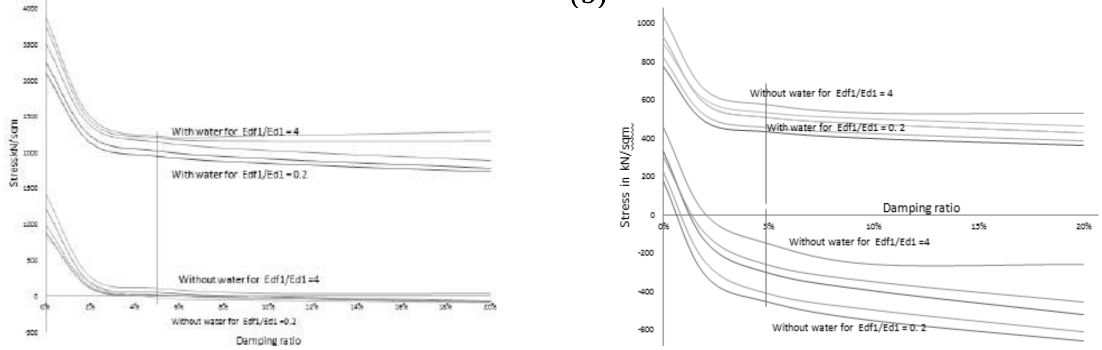


Figure 10. Principal stresses for Heel (a) Major principal stress for dam height 120.0 m
(b) Minor principal stress for dam height 120.0 m.

(a) (b)

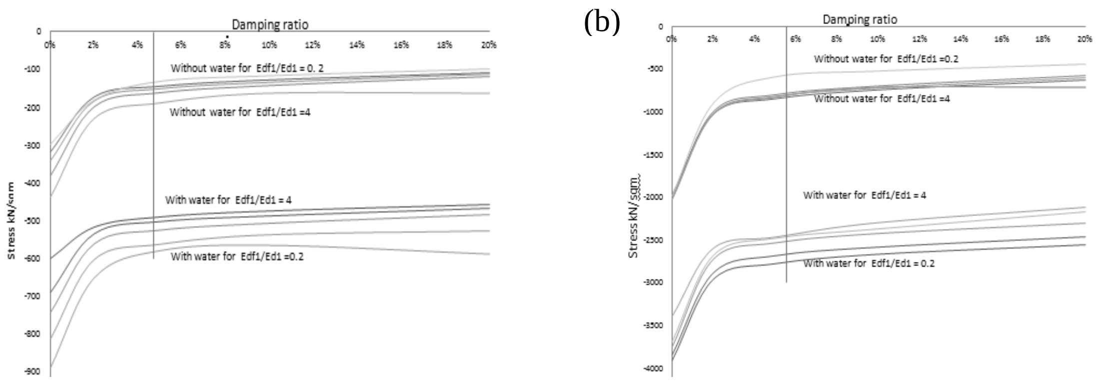


Figure 11. Principal stresses for Toe (a) Major principal stress for dam height 120.0 m
(b) Minor principal stress for dam height 120.0 m.

4.0 RESULTS AND DISCUSSION

The actual modal characteristics are supplemented with the amplitudes displayed by the vertical upstream edges for the dams presented in the figs 3,4 & 5. These are indicating mode shapes. It is observed that the maximum crest displacements and stresses at the heel and toe of the dams shown for heights 40.0 m, 80.0m are higher in the case of foundations considered. Also for the same dam sections the stresses at the heel are found to be compressive for both the reservoir empty and reservoir full conditions. It is evident from the figure.11 that, the magnitude of stresses at both toe and heel of the dam section are gradually reducing from 0 to 5 % damping. However beyond 5% damping, changes in the stress response are not evident .Therefore it is quite proper in order to assume 5% damping as the design parameter in the case of dams subjected to seismic forces.

5.0. CONCLUSIONS

The conclusions drawn from the above study are as follows.

(a) It is witnessed that the crest displacements for dams with foundation systems are higher than the crest displacements for dams with fixed base.

(b) The stresses at the heel of the dams are found to be compressive in all cases. However for the reservoir full conditions the stresses at the toe of the dam indicate marginal development of tensile stresses.

(c) It is observed that the dams are subjected to constant displacement at the crest for the condition of damping ratio exceeding 5%. It is also revealed that the variation of stress at heel and toe is changing from non linear to linear when the damping ratio exceeds 5%.

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Urban Growth Simulation: A Case Study

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ABSTRACT

In the present paper, LanduseSim 2.0 has been explored to simulate urban growth pattern in a stretch in Charminar, Hyderabad. The software is based on Cellular Automata (CA). The CA algorithm is used to simulate spatial-temporal patterns of great complexity. LanduseSim 2.0 is found to be useful for the chosen stretch and can be explored to simulate urban growth patterns of similar nature.

Keywords: Urban, Cellular Automata, LanduseSim 2.0.

INTRODUCTION

Urbanization has been increasing drastically from past decade throughout the World. People are migrating from villages to cities for livelihood, which is increasing the urban populationand is likely to increase in future. Over a period of time, the outskirts of the city are also transforming into urban areas. Accessibility and availability of resources also affect an area in transforming into urban creating major land transitions. But, the urban growth pattern has always been a complex phenomenon to town planners. It is difficult to predict the pattern of urban growth as it is affected by several factors which are difficult to model. In the present paper, LanduseSim 2.0 software has been explored to simulate urban growth patterns for a stretch covering the area from Umada Sagar to Durga Nagar, Charminar, Hyderabad. It comes under Zone 5 of Greater Hyderabad Municipal Corporation (GHMC). The subsequent sections describe the literature review, software, study area, results and discussion followed by conclusions.

LITERATURE REVIEW

Samat etal. (2011) integrated Geographical Information System (GIS) with markov-Cellular Automata (CA)to analyze and forecast land use pattern map of 2020 for the case study of Seberag Perai region, Penang State, Malaysia. They found that major urban development in 2020 was towards the southern districts. The heavy vegetation in Northern districts was the constraint to urban growth. Rajendran and Kaneda (2014) simulated land use/cover change maps for urbanization in Chennai, India. They used GIS and CA. They acquired land satellite data for three decades (1989, 2000, 2012) and digital elevation map for present with 30m resolution. They have classified maps using supervised classification for four land use classes. They created transition probability matrices for all three decades and compared them with each other. They found significant increase in urban area and decrease in barren land. Memarian etal. (2012) validated markov-CA for simulating land use and cover changes at Langat basin, Selangor, Malaysia. They performed the validation using metrics, allocation disagreement and quantity disagreement. They have used data from 1990-1997 for validation and concluded that performance of markov-CA is dependent on uncertainties in the source data. Clarke and Gaydos (2014) have applied GIS and CA to two urban areas, namely, San Fransicoand Washington.They analyzed results of both areas and observed that the model could generate long term land use pattern maps for both the areas for 2100. They found the predictions appeared useful for urban planning. Hedge etal.(2005) applied CA and Neural networks to carry out simulation for settlement growth in ahypothetical case study. They tried different sizes and shapes of neighborhood, land use parameters and carried out simulations using traditional CA and CA along with neural networks. It is concluded that CA with neural networks is more appropriate in predicting settlement growth compared to traditional CA.

LANDUSESIM 2.0

LanduseSim 2.0 has been developed by Department of Urban and Regional Planning, Sepuluh Nopember Institute of Technology, Indonesia (www.landusesim.com). The software does massive simulation for various land use classesand used to simulate spatial temporal patterns of urban growth. The software is based on CAalgorithm, which is in-built. It generates urban growth pattern in the form of maps for various time steps defined by the userand simulatesfor various land use classes like urban, vegetative, water bodies, barren and saturated areas. LanduseSim requires GIS software for initial data preparation. Brief discussion on cellular automata is as follows: The algorithm generates various patterns of a complex system using simple limited set of rules. A typical CA consists of four primary components: cells, status, neighborhood and transition rules.CA model assumes an action space (usually a grid), a set of initial conditions and a set of behavior rules. The rules are applied to the initial boundary conditions and iterations take place. Next generation is simulated from the present state of the complex system CA has been improved especially in expansion of transition rules (Wang,2012)

STUDY AREA

The study area chosen is stretch in Charminar, Hyderabad. It comes under zone 5 of GHMC. The area covers water bodies, namely, Umda sagar, Palle cheruvu, Yerra kunta lakes. The total area covered is 36 Km^2. The Google Earth Pro image of the study areais presented in Fig. 1.

Figure 1. Google pro image of study area
Source: Google Earth Pro

RESULTS AND DISCUSSION

Initial Data Preparation

The study area has been identified on Google Earth Pro by giving the latitudes and longitudes of desired locations. The latitudes and longitudes are saved to "my places" in Google Earth Pro. The map of the study area for the year 2014 has been downloaded and saved in jpeg format. The map is then fed into ArcGIS. The map is classified using supervised classification, among various classification options available (Fig. 2). The supervised classification has been performed with required number of classes defined by the user. The major road network in the study area has been identified and digitized in ArcGIS to create shape file of the road network. Settlement map has been developed by creating polygons of the urbanized residential and complex areas. Euclidean distance maps for roads (Fig. 3) and settlementmap(Fig. 4) are also generated. This information of road network is required as it is expected that further urbanization will take place near to the major road network due to the accessibility in the near future. Settlement map will enable to know the present urban area in the locality. All the maps are converted into raster format and clipped to an extent that the rows and columns are same. The land use map, Euclidean roads and Euclidean settlement are then converted to ASCII format. These ASCII files are inputs to LanduseSim 2.0 for carrying out simulations.

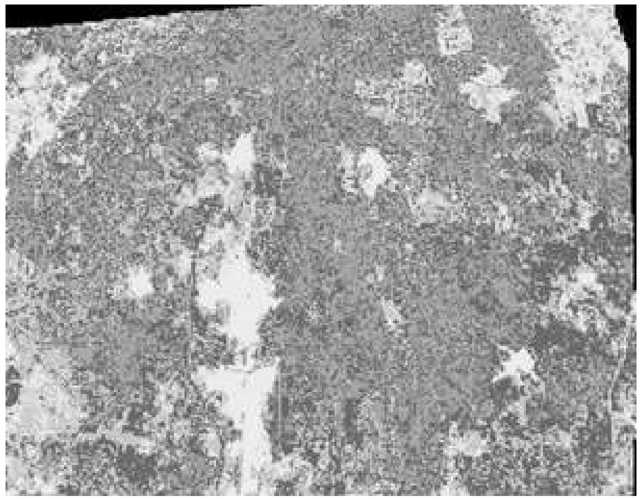

Figure 2. Classified map showing various land use classes.

Figure 3. Euclidean map for roads

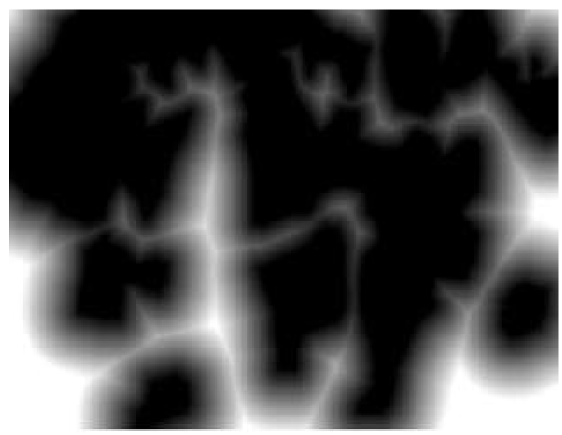

Figure 4. Euclidean map for settlements

Procedural Steps

The ESRI ASCII maps are imported into LanduseSim as image file (TIFF). The existing data are customized to Integer or Float format/decimal (choose float if not sure). Then, they are saved to TIFF format. The imported maps are checked using preview grid and number of grids are calculated in each land use map. The Euclidean distance data is then converted to fuzzy set memberships with a range of real numbers. In the next step, the land use maps of the potential expansion with overlaying fuzzy maps are given appropriate weights. Weights are given to various maps. This step is performed for each type of land use, to map the potential expansion of land use simulation. A Neighborhood filter 3×3, operates as a sum function, is used in the simulation. A probability matrix with null values is used. A conversion value of 150000 is given, that represents the possibility of a land use change into another land use. By providing conversion value, the value of the original adjacency will be distinguished by looking at land use changes before. After creating neighborhood filter, transition rules are prepared. The required input data are land use/code, growth, suitability map, dynamic constraints, and change conversion probability. The start and end year are used for simulation. Start date is used as the baseline for land use projections. Sequences of iterations are run and land use map of 2100 is produced. The final image can be viewed when the progress is 100% and map can be viewed in ArcGIS after processing. The difference between the original map and the simulated map can be identified clearly.

In the present study, only urban land use class is simulated. It can be inferred from the below original map of the year 2014 (Fig. 5), blue color indicates water bodies and white color indicates urban area (built-up area). The second image is the simulated image of LanduseSim 2.0 for the year 2100 (Fig. 6) where the white color indicates the built-up area. It can be visualizedfrom Fig. 6,that the water bodiesare decreasing and built-up areas are increasing. A null probability function was given to the vegetation and barren land, so they remained the same else they could have changed. This inference is based on the chosen input functions such as neighborhood filters, probability functions, transition rules, land use classes and their weights, and may vary for different input functions and various locations.

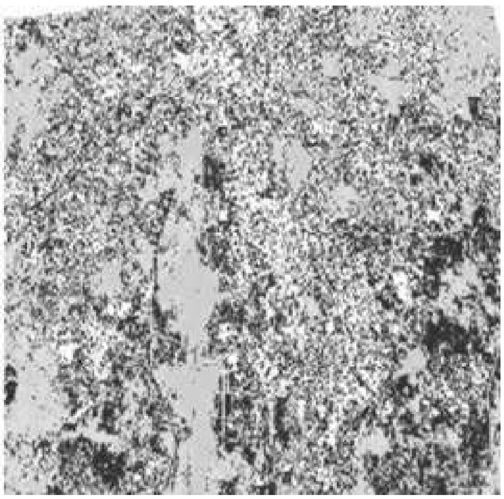

Figure 5. Land use map of 2014

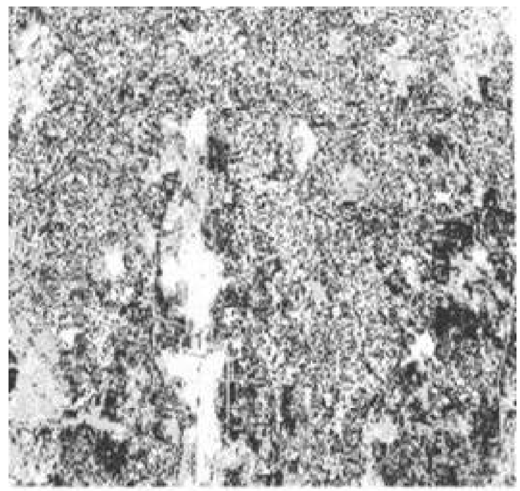

Figure 6. Land use map of 2100

CONCLUSIONS

The present study analyzes land use pattern for year 2014 and 2100. It is observed that built-up area is increasing which may create land transitions. It is relevant to note that the results emanated from the present paper are based on the chosen input functions such as neighborhood filters, probability functions, transition rules, land use classes and their weights, andmay vary for different input functions and various locations. However, methodology remains same which is the main focus of the present study.

ACKNOWLEDGEMENTS

This work is supported by Information Technology Research Academy (ITRA), Government of India under, ITRA-Water grant ITRA/15(68)/Water/IUFM/01 dated Sep 20, 2013, Integrated Urban Flood Management in India: Technology Driven Solutions. The first Author is thankful to Raya Budiarti, LanduseSim Representativefor clearing queries, whenever approached. Authors would also like to acknowledge "LanduseSim v.2.2" team for providing us with trial version of LanduseSim 2.0. We thank Google Earth Pro team for providing free access to the website.We are grateful to Ms. Sumasri, Mr Ravinder, Ms. Santoshi of GHMC, Hyderabad and Mr. Ravinder, Voyants Consultancy, Hyderabad for providing the valuable suggestions and all the necessary information.

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A Survey on Classification of SAR Images

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ABSTRACT

Optical remote sensing technology is used for mapping the earth surface. But it cannot map the earth surface in all weather conditions since optical bands cannot penetrate clouds, smog and haze. Microwave remote sensing technology is used as an alternative technology for mapping the earth surface features especially when optical data is not available. The classification is used to recognize the objects of the SAR image in exact positions. The method used for classification plays the critical role in object identification. This paper explores different classification methods for land use and land cover classification.

1. INTRODUCTION

Synthetic Aperture Radar (SAR) automatic sensors, first developed in the 1950's, have the ability to produce all weather, 24-hour a day, high-resolution images with quality quickly approaching that of optical imaging systems. SAR, an active sensor, transmits pulses of microwave and detects echo, which carries information about the surface. Due to relatively long wavelengths in microwave, radar signals are capable of penetrating clouds in the atmosphere and are independent of sunlight. The characterization and classification of land cover using SAR data has been extensively investigated and reported in recent few decades. Recently, imaging radar satellites have been introduced to map natural resources. With long wavelengths, radar's radiation is not reflected or absorbed by clouds or haze, thereby allowing more frequent and systematic assessments of land cover changes and deforestation. The same principle allows penetrating in the canopy to assess data on the trunks level, which increases the potential of distinction between different stages of regrowth. The recent progress in sensor and antenna construction enabled the remotely sensed satellite imagery to become widely available and to find its daily applications in fields such as: ecology, meteorology, oceanography, cartography, natural risk management and many others.

2. CLASSIFICATION MODELS

Remote sensing techniques aided with ground information provide a reliable source of classification in a cost and time-effective way. Radar sensors operating in different wavelengths and polarizations can be widely used for large-scale land cover mapping and monitoring using backscatter coefficients in different polarizations and wavelength bands. C-band space borne SAR is widely used for the classification of the vegetation type using techniques viz., texture measures, multi-sensor fusion, multi-polarization data, multi temporal data and polarimetric data. The following are different models that are used in the area of classification of radar data.

2.1. First order statistics based classification

To evaluate the effectiveness of different image processing techniques for extraction of landuse/land-cover information, it is necessary to classify the raw SAR images, filtered images and texture images. The radiometric distortions depend strongly on the terrain and increase significantly in mountainous areas, in which the distortions should be corrected by a backscatter model for better classification results. The back scattering coefficients have been calculated for the microwave image. Several thresholding levels have been applied to the sigma_o image to get classified image. By using signatures supervised classification has been done. The SAR backscattering coefficient of different classes were analyzed using the ground truth points; mean, standard deviation, variance and range of backscattering coefficient for each land cover class is calculated. The back scattering coefficient values of a class must be known before starting thresholding classification. Based upon these values, thresholdings of backscattering value for each land cover class is decided and applied on SAR images for classification.

2.2. Texture measures based classification

Various studies showed that texture is the most important source of information in an image, especially SAR image. Texture can be defined as the various measures of smoothness, mean, homogeneity, variance, contrast, dissimilarity, entropy, correlation, and coarseness of an image region. The popular grey level occurrence matrix and grey level co-occurrence matrix texture models have been widely used in remote sensing studies. Texture analysis in SAR data was considered the most important source of information and textural measures were considered for automated land cover classification.

2.3 Multi-sensor fusion based classification

The merging of microwave data with optical data has shown the improved capabilities of land use and land cover categories. Image fusion techniques deal with integration of complementary and redundant information from multiple images to create a composite image that contains a better description of the scene.

The fusion of two image sets can be done in order to achieve a merged image set with the qualities of both the microwave and optical. The low-resolution multispectral satellite imagery or optical image can be combined with the higher resolution SAR imagery by fusion technique to improve the interpretability of the merged image. The resultant data product has the advantages of high spatial resolution, structural information, and spectral resolution. Thus, the merged image provides faster interpretation and can help in extracting more features.

2.4. Polarimetric decompositions

Polarimetry is the measurement and interpretation of different polarizations of electro-magnetic waves. Due to its sensitivity to vegetation and various land-covers, SAR polarimetry has the potential for crop and land-cover classification. A polarimetric SAR system measures the electric field including its polarization state, backscattered by the scene. The interaction of the transmitted wave with a scattering object transforms its polarization. Therefore, the polarisation of the backscattered wave depends on the polarization of the transmitted wave as well as on the scattering properties of the imaged objects. As polarimetric image data contains different features and these features relate to physical properties of terrain in unique ways, a variety of classification algorithms have been developed that are optimized for use with polarimetric data.

2.5. Coherence based classification

SAR interferometry is based on a coherent combination of images acquired from the same orbit and the complex correlation between above said images is called interferometric coherence. In general, SAR interferometry processing includes an image co-registration, baseline estimation, interferogram formation, calculation of the interferometric coherence, adaptive filtering and coherence image generation.

2.6 Circular polarized based classification

The information that got with circular polarized imagery is generally more when compared to co or cross polarized waves. It had been proved already that the circular polarized waves are better to classify the land cover when compared to fully polarized waves. The $sigma_o$ images of RH and RV were calculated separately as mentioned earlier. These two images were added to get addition image. A false colour composite (FCC) image has been obtained by having RH with Red, RV with Green and addition image with Blue guns. The FCC image has been modified as supervised classified image by taking signatures from the imagery.

3. ACCURACY ASSESSMENT

To assess the quality of the image classifications, various measures including overall accuracy and Kappa coefficient of agreement (or Kappa) were analyzed to compare classification results with the validation or reference data in confusion matrices. Overall accuracy is the total number of correctly classified samples (diagonal cells in a confusion matrix) divided by the total number of reference pixels. Utilizing all elements from the confusion matrix, Kappa coefficient is a measure of the difference between the actual agreement between reference data and a classification and the change agreement between the reference data and a classification . Kappa takes into account both errors of commission and omission, and thus provides a more complete picture of the information comprising the confusion matrix than overall accuracy.

4. CONCLUSION

Threshold based or first order classification gives less accuracy and it is due blind selection of threshold. The better selection of texture gives better accuracy. Generally fusion classification gives better accuracy measurements after classification among all, because it has both spatial and spectral properties in it. Interferometry based classification needs base line information for SAR images. Polarimetric classification is only possible with latest versions of POLSAR-PRO software. The interferometric and polarimetric classification needs SLC data only. The classification accuracy depends on many factors like behavior of target with the sensor, incidence angle of the image, roughness of the target surface, distortions that are possible at target surface, wavelength of the sensor, etc.

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Morphometric Properties of Allagadda Area, Kurnool District, Andhra Pradesh, India. Using Cartosat-1 DEM with GIS.

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ABSTRACT

Remote sensing and GIS software have used for analysis of Morphometric properties of the drainage basin in Allagadda region. The study area has located in latitudes78^0.40' E and 78^0.70'E longitudes –15^0.40' N and 14^0.90'N. we were determined and computed; Stream network, flow direction, flow accumulation, slope, aspects and contour by using Arc GIS 9.3 with Cartosat-1 DEM. The catchment area has 6th order of basin and drainage pattern mainly sub dendritic and parallel type. Subdendritic drainage pattern has represented less structural control and parallel drainage pattern suggest that gentle slope and less resistant bed rock. One third areas have covered by moderately dissected hills in N-S trending mostly occupied in Eastern Part. The results indicated that drainage density (2.5), Stream Frequency (7.67), Form Factor (0.46), Elongated ratio (0.76) and Circularity ratio (0.53).Bifurcation ratio (2.25). Which are suggested that the circulation ratio value indicate that the watershed is elongated in shape and highly permeable. Bifurcation ratio value represented very hard surface and terrain, and different in geological composition which might increase the hazard of floods. The Relief ratio is 0.013 which indicate that the relief ratio is moderate and steep and moderate gentle slope the study reveals that this area is not suitable for construction dam and check dams because in rainy season more water comes from 1st order and 2nd order of streams those were occupied mostly in hilly terrain. So this area is a highly vulnerable Drought area.

Keywords: GIS, Cartosat-1 DEM, Morphometric analysis and Allagadda watershed area.

INTRODUCTION

Hydrological and geomorphological analysis using GIS had worked over 1960s onwards; it had developed many stages (Lo. Yeung, 2007). 1960-1975 was the "hydrological modeling" Era in which mathematical description of fluvial process were developed and incorporated into hydrological models. 1975-1985 was a "transport models" Era for predict water pollution, mid 1980s had a led to the Era of "spatial modeling" .Digital terrain data and remote sensing catchment charactering are considered as hydrological and water quality models. Miadment (1993) has well explained about Modern hydrological process using Gis .The comparison between topological based hydrological data and geomorphological models have excelling review watershed analysis (Moore et. al. 1991). They are many changes in geomorphological analysis over last decades for the development of physiographic methods to describe the evolution and behavior of drainage networks on the surface (Horton, 1945). Morphometric analysis of basin incorporates a quantitative description of drainage network which is important for prioritization of watershed (Strahler, 1964). They are many works done their work on identification of identification of morphmetric properties in different regions by using GIS and DEM data (Kuldeep Pareta, 2011; Praveen Raj Saxena. A, et.al. 2008; Babar, Md.2001; Pawar-Patil V.S, et al 2013, Hachem Aouragh Myet al 2014). Geographical information System has a powerful tool for analysis of watershed, various terrain conditions and manipulation of Morphometric parameters of catchment area. Gis data has perfect accuracy, fast and provide a flexible environment.

STUDY AREA

The Allagadda region drainage basin covers 1564Km^2 in Kurnool district, Andhra Pradesh, India.

The study area has situated in between latitudes 78^0.40□E and 78^0.70□E, longitudes -15^0.40□ N and 14^0.90□N (Fig: 1). Northeast side Nallamalla Hills occupied by Allagadda Reserve forest and Nandyal Reserve forest. Cartosat-1 DEM, ISO Top sheet 1:50000 scale (57I/5, 57I/6, 57I/7, 57I/11, 57I/14 and 57J/1), ARC GIS 9.3 were used for Geomorphological analysis. Arc GIS 9.3 was used to digitizing the DEM image data and manipulated, measuring and drawing the spatial data of the different analysis. Fill, Flow direction, Hill shade, Flow Accumulation, Basin, Aspects, Slope (fig: 2) and a stream network have been prepared using GIS.
been prepared using GIS.

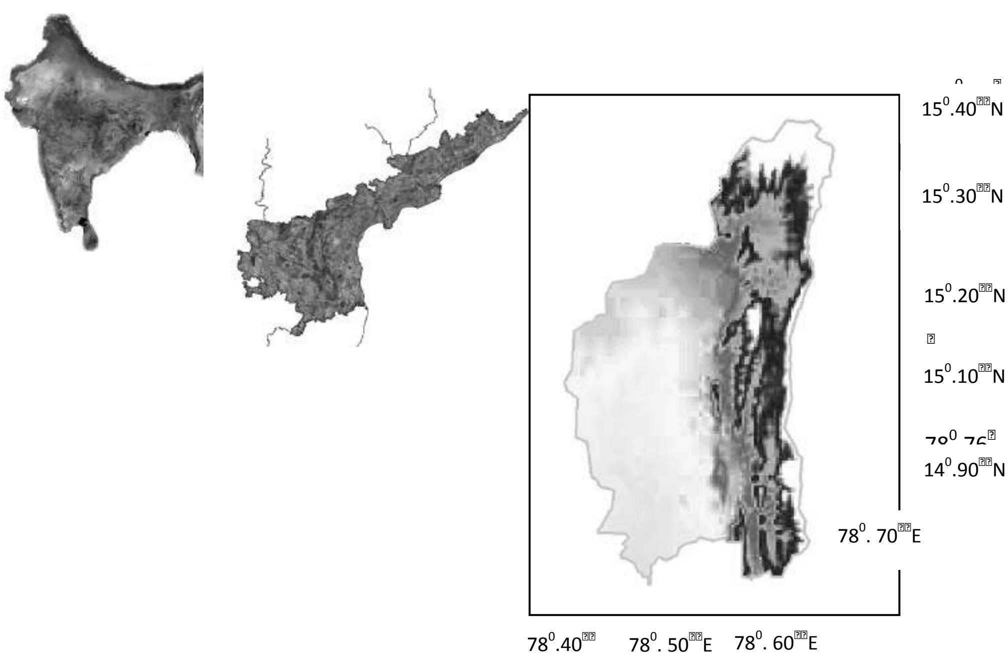

Figure 1. Location of the Study area

Geomorphology and Geology

The Allagadda region one third areas covered by moderately dissected hills and reserved forest. Nallamala hills have N-S trending mostly occupied in Eastern Part. The geomorphological areas of Allagadda have classified different units: moderate dissected Hills (200-904m msl). Lacustrine area (187 msl) and Pediment and pediplain complex elevation is 160-137m above mean sea level. Kunderu river form pediplain are in Northwestern. They are many tributaries such as bavanasi, Tundlavagu and Vakkileru flows and connected with Kunderu river. The drainage pattern of the Allagadda area is parallel and subdendritic- dendritic in nature.The geology of the study area is mostly occupied by Kurnool super group. Rock types are shale with Phyllite of Nanadyal formation (Upper proterozoic age), Limestone as Koilkuntla formation(Middle Proterozoic age) and Cuddapah Group of Nallamala formation rocks are Quartzite – Slate (Middle proterozoic age) Dolomite, red ochre rocks also occurs. (King, W. 1872).

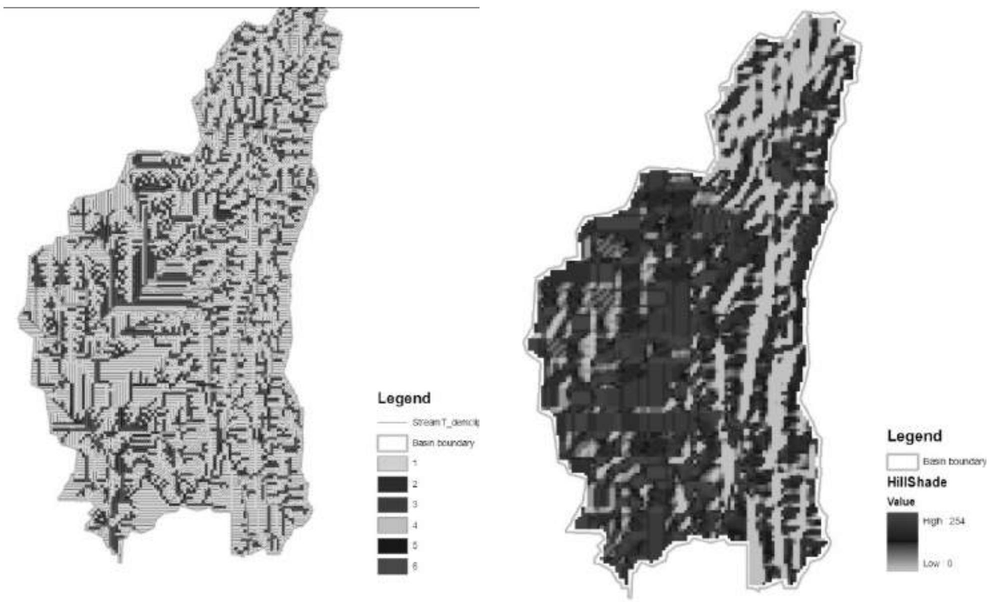

Figure 2. a. Stream network of the Study area b. Hill shade of the study area

METHODS AND MATERIALS

The following materials we were used for analysis of catchment area of Allagadda region.

1. Cartosat-1 DEM:

Cartosat-1 DEM has a good accuracy while comparison other DEMs like ASTER and SRTM (S. Muralikrishnan, 2011). It has a Pair of Panchromatic cameras for acquire stereo image data with a base-to-height (0.63 ratio). The Spatial Resolution is 2.5m in the horizontal plane. CartoDEM (30m, 90m) data was freely to download from BHUVAN website; ISRO (Indian Space Research Organization) has developed CartoDEM for Idenfication of terrain conditions, delineation of watershed and various scientific works.

2. Survey of India Toposheet (1: 50000)

Morphometric Properties of the Allagadda region Toposheets (57I/5, 57I/6, 57I/7, 57I/11 and 57J/1, 57i/14) were scanned and digitized in Arc Gis Software.

Stream Number (Nu)

The catchment area has number of streams, the order wise total number of streams is known as stream number the study area have 6 order of streams for DEM analysis were 1st order stream 7976, 2nd order stream 2191, 3rd order stream 919, 4th order stream 489, 5th order stream 263 and 6th order stream172. The relationship between stream order and a drainage basin. The important results were as stream order increases the number of stream decreases in an inverse geometric ratio (figure: 2).

Stream Order:

Horton (1945), Strahler (1957) has proposed stream ordering is the first step of analysis of watershed. Stream order determines the hierarchical position of a stream within drainage Basin. The primary rivers are order rivers, contact with two primary rivers and form the second order river, two second order river contact each other and form a third order river like that all 6 order rivers will form and it covers the size of the network of the river. The result is decreasing of stream frequency as the stream order increases.

Table 1 Linear Aspects of study area.

S.No	Stream Order	Stream Number	Bifurcation Ratio (Rb)	Stream Length (km)	Length /order	Length Ratio	No. of Stream length used in Ratio
1	1	7976	-	2662.26	2662.26		
2	2	2191	3.64	716.02	358.01	7.4	3378.28
3.	3	919	2.38	304.69	101.56	3.5	1020.71
4.	4	489	1.87	164.99	41.2	2.4	469.68
5.	5	263	1.85	89.97	17.9	2.3	254.96
6.	6	172	1.52	59.49	9.9	1.8	149.46
Total = 3997.42 Mean 2.25 3.46							

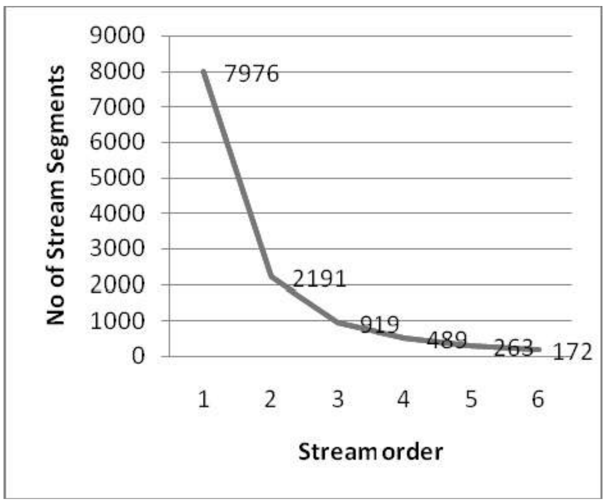

Figure 3. line graph for Stream Order verses no of Stream Segments

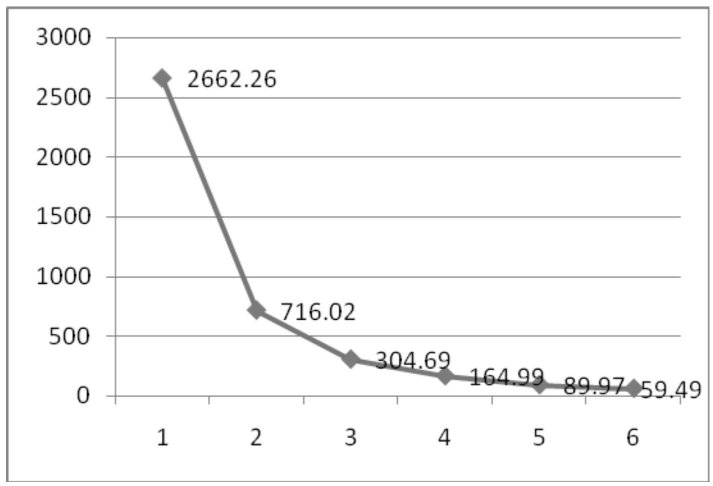

Figure 4. line graph for Stream order verses no of Stream Length

Stream Length (Lu)

The total stream lengths of the study area have various orders which have computed with the help of ArcGIS Hydro tool (Table: 1). Plot on the graph stream order verses stream length (figure: 4) showed stream lengths decreases in watershed of increasing order (Strahler, 1964). The linear pattern which indicates the homogenous rock material subjected to weathering-erosion characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography (S. A. Sharma, 2014).

Bifurcation Ratio (Rb)

The bifurcation ratio is represent the ratio of the number of the stream segments of given order to the number of streams in the next higher order (Schumm, 1956). Rb is not have same values in all Stream order. It is depends on the Topological, climatic conditions and lithology of the catchment area (Strahler 1952). Generally Rb value is indicate from 3.0-5.0 The lower values of Rb are characteristics of the watersheds, which have suffered less structural disturbances (Strahler 1964) then the present catchment area have less Rb value 2.25 (Table. 1)That means it is very hard surface and terrine, and different in geological composition which might increase the hazard of floods.

Aerial Aspects

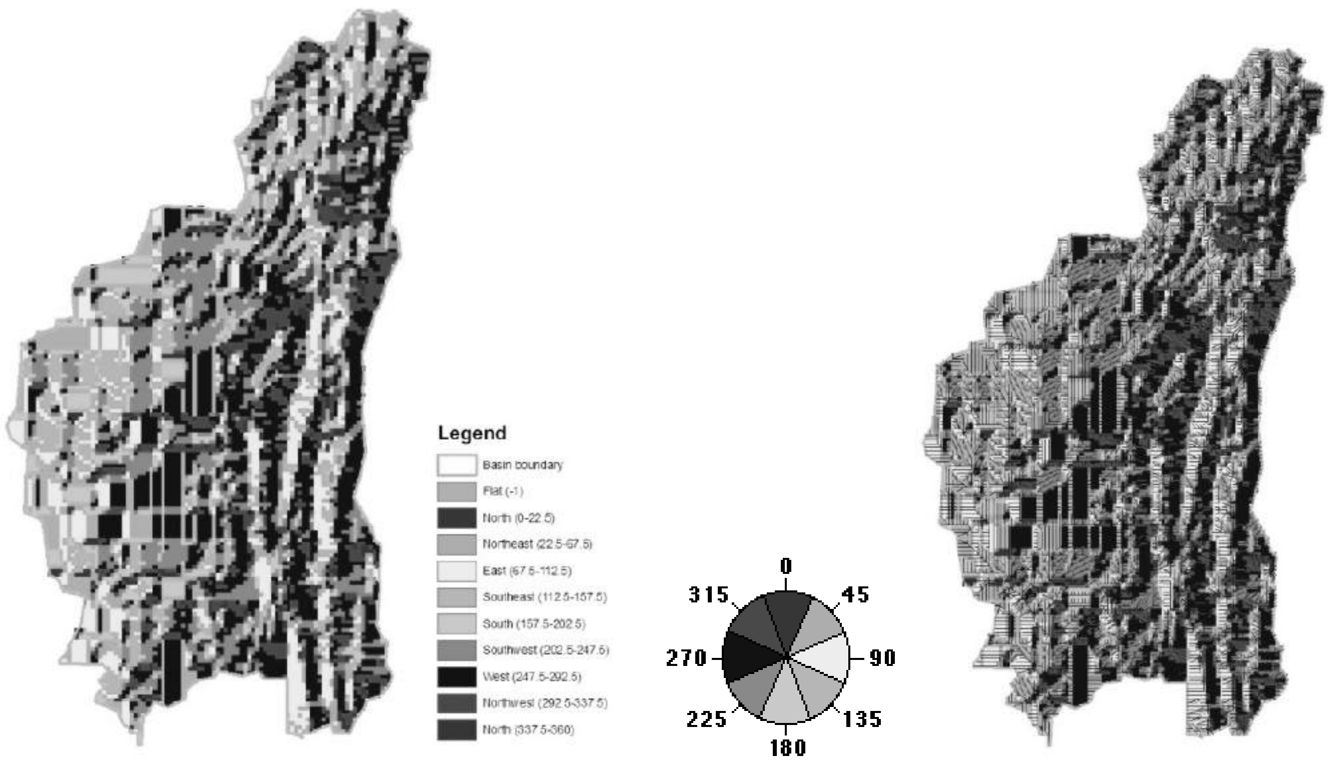

Figure 5. a. Aspect image of the study area b. Aspect directions

Aspect ratio represents the direction of the hill slope faces. The values of the study area will be the compass direction of the aspect (Burrough, P. A. 1998). The Aspect ratio image created from the Cartosat-1 DEM data is represented in eight directions (fig: 5). The flat surface identified in south west direction (Gray shade is a flat area).

Form Factor (Rf)

Form Factor is Represent the different basing shapes. Which is defined the basin area divided by square of the basin length (Horton1932). The ratio of the values indicates 0.1-0.8 (Thronbury 1966). Elongated basins have the small form factor values. The basins which have high values of form factor it indicates a high peak flows of shorter duration, whereas elongated drainage basin with low form factors have to flow of longer duration. The basin have form factor value is 0.3 which indicate elongated in shape and flow for long duration.

Elongated Ratio (Re)

Schumm (1956) represents the elongation ratio (Re) as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. The value of Re varies from 0 (highly elongated shape) to unity (circular shape). Thus the higher the value of elongation ratio the more circular shape of the basin and vice-versa. Where as those of (0.6 to 0.8) are usually associated with high relief and steep ground slope (S. Singh and P. Singh, 2011). The elongation ratio of Watershed is 0.76 which is defined as a less elongated and low relief of the terrain (Table: 2).

Circulation ratio (Rc):

Miller V. C. (1953) defined it as the ratio of the area of the basin to the area of the circle having same circumference as the basin perimeter. Miller has described circulation ratio values from 0.4-0.7 indicates strongly elongated and highly permeable homogeneous materials. The circulation ratio values 0.53 which indicate that the watershed is elongated in shape and highly permeably stara.

Table 2. Aerial Aspects of Study area

S.No	Morphometric Parameter	Results
1	Basin Area (A)	1564 k m^2
2	Perimeter (P)	191.2 km
3	Length of basin (L_b)	58
4	Width of basin(W_b)	32.7
5	Circularity ratio (Rc)	0.53
6	Elongated ratio(Re)	0.76
7	Form Factor (Rf)	0.46
8	Drainage Density (Dd)	2.5
9	Stream Frequency (Fs)	7.67

Drainage Density (Dd)

Drainage Density is the ratio of total length of all streams to the total area of the basin. Dd of any basin reveals the terrain configuration that a property of the rock of the area (N. S. Magesh et.al, 2013). It is indirectly help to the Idenfication of groundwater potential of an area due to its relation with surface runoff and permeability (Horton, 1932). The area Allagadda characterized according to the value to the obtained it's an area with a low density (2.5). It is suggested that sub soil, thick vegetation cover and low relief (Nag, 1998) Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.

Stream Frequency (Fs)

Horton (1945) suggested the stream frequency of the basin is the ration of total number of streams (Nu) of all orders to the Basin Area (A).It is a good indicator of drainage basin. It mainly depends on the lithology of the basin and reflects the texture of the drainage network. The stream frequency of the Kunderu river in Allagadda region is 7.67

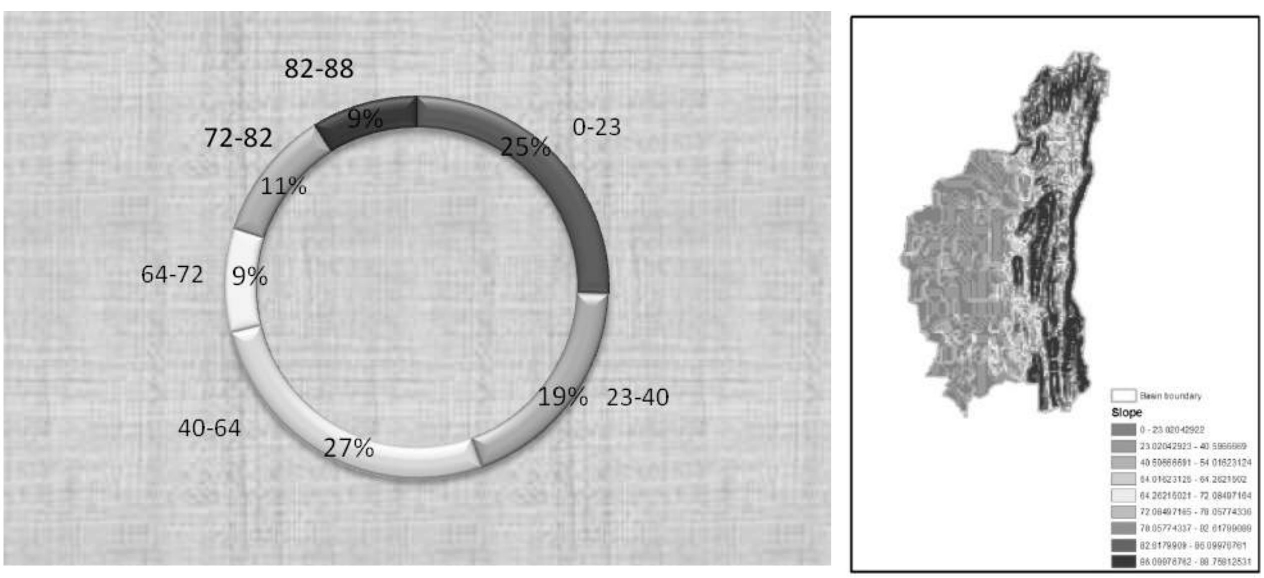

Figure 6. (a) Graphical represent of Slope of the area b) Slope map of the study area

Slope of the Area

Slope map prepared from CartoSat-1 DEM image in Arc GIS 9.3 software (ESIR, 2000). Gradient of the area broadly divided 6 types such as (fig: 6). Flat or leveling area (25%), Very gently slope (19%), Gently slope (27%), Moderately sloping (9%), Steeply sloping (11%), Very steeply sloping (9%). A Lower slope value is 25% which indicate flat terrain in South west side, near mouth of the Kunderu River. Higher values indicate very steep sloping

(9%) in northeastern side. The drainage of Allagadda region 44% of the area occupied by Nallamala Hills Hence the slope map can be used to identify areas with high runoff and high erosion rates.

Relief Aspects

Basin Area (A)

Area (A) and Perimeter (P) both are important parameter for Quantitative morphology of watershed. Basin area is the important aspect of hydrology which concern directly size of the storm hydrograph and mean runoff. The basin area computed using ARC GIS software which is 1564 Sq kms.

Basin Relief (H)

Relief is the vertical distance between point of maximum elevation and minimum elevation. The maximum elevation of the basin is 904m and minimum elevation is 136m. Relief ratio of the basin is 768m

Relief Ratio (Rr)

The relief ratio is defined as the Ratio between the total relief of a basin (H) and the maximum measured length of the drainage basin (Lb)" (Schumm, 1956). There is direct relationship between the relief and channel gradient and also a correlation between hydrological characteristics and the relief ratio of a drainage basin (Schumm, 1964). The value of the Relief ratio is 0.013 which indicate that the relief ratio is moderate and steep and moderate gentle slope, generally the low relief ratio indicates less resistant rocks of the area (Sudheer 1986).

CONCLUSION

The study of Morphometric analysis is more useful for rainwater harvesting, watershed management plans. The catchment area of Allagadda region has 6^{th} order drainage basin. The drainage pattern is parallel and dendritic pattern. Subdendritic drainage pattern has less structural control and parallel drainage pattern suggest that gentle slope and less resistant bed rock. While increase the stream order, number of stream segments decrease in the study area, 1^{st}, 2^{nd} order of streams situated in Nallamala hills and flows eastern to western direction due to slope. The drainage of Allagadda region 44% of the area occupied by Nallamala Hills Hence the slope map can be used to identify areas with high runoff and high erosion rates. The circulation ratio value (0.53) indicates that the watershed is elongated in shape and highly permeable. Bifurcation ratio value (2.25) represented very hard surface and terrain, and different in geological composition which might increase the hazard of floods. The Relief ratio is 0.013 which indicate that the relief ratio is moderate and steep and moderate gentle slope the study reveals that this area is not suitable for construction dam and check dams because in rainy season more water comes from 1^{st} order and 2^{nd} order of streams those were occupied mostly in hilly terrain. So this area is a highly vulnerable Drought area.

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Radial Basis Function Neural Network for Groundwater Level Forecasting in Raichur District, Karnataka

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ABSTRACT

Over exploitation of groundwater is emerging as an increasingly serious problem in many parts of the country hence the accurate forecasting of groundwater level is immense important for sustainable utilization and management of groundwater resources. In this study Radial Basis Function neural network (RBF) used for groundwater level forecasting. The Devasugur nala watershed was selected for the study. Inputs to the model were decided based on the auto correlation, partial auto correlation and cross correlation function. Number of neurons in the hidden layer was optimized by trial and error. The results revealed that RBF model with 3-2-1 network architecture provided the better prediction. Overall it was observed that the ANN based algorithm was a promising tool for the forecasting of groundwater level.

Keywords: Artificial neural network; Radial basis function neural network; Groundwater level forecasting

INTRODUCTION

Groundwater plays major role in meeting the demands of water for various sectors in India. Groundwater usage in India accounts over 65 percent for irrigation and around 85 percent for drinking water supplies. The rate of withdrawal of groundwater in the country has reached "unsafe" levels in 31 per cent of the districts, covering 33 per cent of the land area and 35 per cent of the population. As groundwater resources are more intensively used, there is an increasing need for monitoring of groundwater systems. In recent past, Artificial Neural Network (ANN) models are being applied increasingly to simulate the hydrological processes due to their better performance over the traditional modelling techniques. The Artificial Neural Network (ANN) is an alternative modelling and simulation tool, greatly suited to dynamic non-linear system modelling. ANNs are treated as universal approximators. The technique of ANN is quite appropriate for groundwater problems (Manisha *et al.*, 2008). Neural networks have previously been applied for groundwater level prediction (Coulibaly *et al.,* 2001a; Coppola *et al.,* 2003; Daliakopoulos *et al.,* 2005; Nayak *et al.,* 2006 and Krishna *et al.,* 2008).

METHODOLOGY

The statistical parameters such as Auto-Correlation Function (ACF), Partial Auto-Correlation Function (PACF) and Cross-Correlation Function (CCF) were used to find out the significant lag values of input variables. Usually, not all of the potential input variables will be equally informative, because some may be correlated, noisy or have no significant relationship with the output variable being modelled (Maier and Dandy, 2000). Many researchers successfully used correlation analysis for selection of input variables (Nayak *et al.,* 2006 and Sasmita *et al.,* 2013).

Radial Basis Function Neural Network

Radial basis function (RBF) networks are typically configured with a single hidden layer of units whose activation function is selected from a class of functions called basis functions. Similar to back propagation in many respects, radial basis function networks have several advantages. They usually train much faster than back propagation networks. The major difference between RBF networks and back propagation networks is the behavior of the single hidden layer. Rather than using the sigmoidal or S-shaped activation function as in back propagation, the hidden units in RBF networks use a Gaussian or some other basis kernel function. Each hidden unit acts as a locally tuned processor that computes a score for the match between the input vector and its connection weights or centers. In effect, the basis units are highly specialized pattern detectors. The weights connecting the basis units to the outputs are used to take linear combinations of the hidden units to product the final classification or output. The structure of an RBF networks in its most basic form involves three entirely different layers as shown in Figure 1

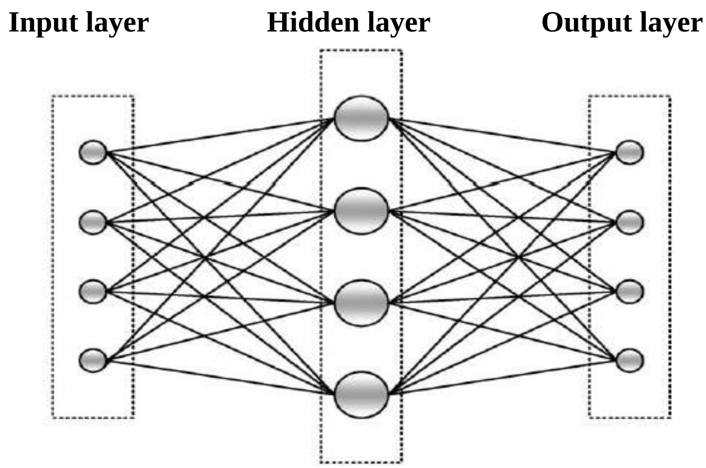


Figure 1. A typical radial basis function neural network.

The center of the basis function for a node *i* at the hidden layer is a vector C_i whose size is the as the input vector u and there is normally a different center for each unit in the network.

First, the radial distance d_i, between the input vector u and the center of the basis function C_i is computed for each unit *i* in the hidden layer as using the Euclidean distance.

$d_i = ||u - C_i||$

The output h_i of each hidden unit *i* is then computed by applying the basis function G to this distance

$h_i = G(d_i, \sigma_i)$

j^{th} output is computed as

$$X_j = f_j(u) = W_{oj} + \sum_{i-1}^{L} Wij\ hi$$

$$j = 1, 2, ..., M$$

In summary, the mathematical model of the RBF network can be expressed as

$$x = f(u),\ f{:}R^N \rightarrow R^M$$

$$X_j = f_j(|u|) = W_{oj} + \sum_{i-1}^{L} Wij\ G(||u - Ci||)$$

$$j = 1,2,.....,M$$

Training the ANN

Determining the best values of all the weights is called training the ANN. The main objective of training (calibrating) a neural network is to produce an output vector $Y = (y_1, y_2, ..., y_p)$ that is as close as possible to the target vector (variable of interest or forecast variable) $T = (t_1, t_2, ..., t_p)$ when an input vector $X = (x_1, x_2, ..., x_p)$ is fed to the ANN. In this process, weight matrices W and bias vectors V are determined by minimizing a predetermined error function as indicated as

$$E = \sum_{P} \sum_{p} (y_i - t_i)^2$$

Where, E is the error function; t_i is a component of the desired output T; y_i is the corresponding ANN output; p is the number of output nodes; and P is the number of training patterns.

Network Architecture

The network geometry is generally highly problem oriented in order to get optimal network geometry trial and error procedure is adopted. The numbers of nodes in the input layer were decided based on the inputs to the model. The number of hidden neurons in the network, which is responsible for capturing the dynamic and complex relationship between various input and output variables, was identified by various trial and error methods. The trial and error procedure started with one hidden neuron initially, and it has been increased up to 10 neurons. For each set of hidden neurons, the network was trained with input datasets in batch mode to minimize the mean square error at the output layer. MATLAB 2012a was used for analysis.

Performance evaluation of ANN Models

The whole data length is divided into two sets based on statistical properties of the time series such as mean and standard deviation, in that one is used for calibration (training) and another for validation of model. The performance of model was evaluated by using statistical parameters. They are Correlation coefficient (CC) Coefficient of Efficiency (CE), Root Mean Square Error (RMSE), Explained Variance (EV) and regression analysis. The correlation coefficient calculated by

$$CC = \frac{n(\sum XjYj) - (\sum Xj)(\sum Yj)}{\sqrt{[n\sum Xj^2 - (\sum Xj)^2]}[n\sum Yj^2 - (\sum Yj)^2]}$$

Coefficient of Efficiency calculated by

$$CE = \left\{1 - \frac{\text{residual variance}}{\text{initial variance}}\right\} == \left\{1 - \frac{\sum_{j=1}^{n}(Y_j - X_j)^2}{\sum_{j=1}^{n}(Y_j - \overline{Y})^2}\right\}$$

RMSE is expressed as:

$$RMSE = \sqrt{\frac{\text{residual variance}}{n}} = \sqrt{\sum_{j=1}^{n}\frac{(Y_j - X_j)^2}{n}}$$

Explained Variance given by.

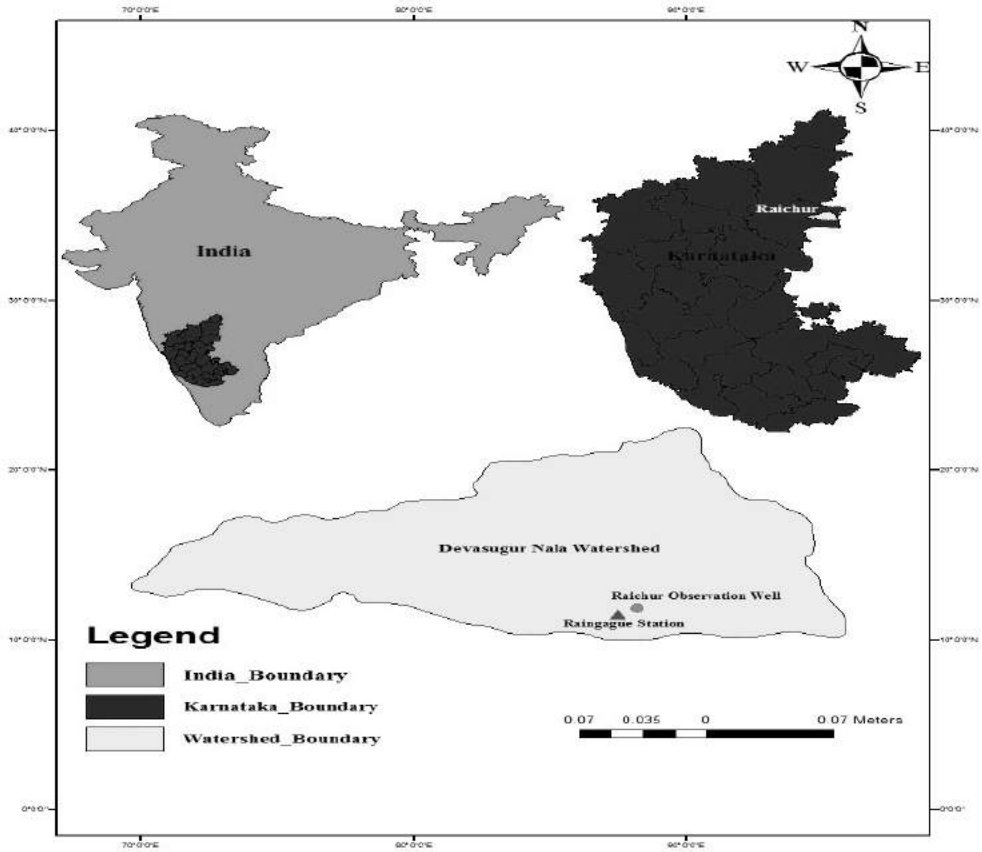
$$EV = \sqrt{\left(\frac{\sum(X_j - \overline{Y}_j)^2}{\sum(Y_j - \overline{X}_j)^2}\right)}$$

Where,

Yj = Observed water table depth, Xj = Predicted water table depth, n = Number of observations, $\overline{Y}$ j= Mean of observed water table depth, $\overline{X}$ j= Mean of predicted water table depth.

STUDY AREA

Devasugur nala watershed was selected for the study which is located at northern part of Raichur district Karnataka and comes under middle Krishna river basin which is covered in the Survey of India topographic sheets 56H/3, 56H/4, 56H/7 and 56H/8 on scale 1:50000. Raichur district falls in the northern maidan region, between 15º 33’ to 16º 34’ N latitudes and 76º 14’ to 77º 36’ E longitudes (Appendix 1). Granites, gneisses and dharwar schist’s, are the main rock formations in the Raichur district. The depth to water level in general varies from 0.65 meters below ground level (m.bgl) to10.70 m.bgl. The observation well is located at Dept. of Mines and Geology premises with the latitude and the longitude 16° 12' 30" N, 77° 21' 15" E. The monthly water table depth (below ground level) for 17 years *i.e.*, from January 1999 to March 2015 were collected from Department of Mines and Geology, Raichur, and used for analysis. The rainfall and meteorological data such as maximum and minimum temperature, relative humidity, wind speed and sunshine hour data were collected from Main Agricultural Research Station, Raichur, Karnataka and used for calculating the evapotranspiration using CROPWAT 8.0 which uses Penman-Monteith method.



Location map study area of devasugur nala watershed

EXPERIMENTAL RESULTS

The input vectors were selected by trial and error. The simple correlation between the dependent and independent variables helps in selection of significant input vector to the model. The correlation coefficients values between rainfall and groundwater level as well as between evapotranspiration and groundwater level were -0.03444 and 0.4528 respectively. It clearly indicated that the rainfall and evapotranspiration were not much correlated with water table depth for all the observation wells.

Hence ACF and PACF of groundwater level, the CCF between monthly mean evapotranspiration with monthly mean water table depth and the CCF between monthly total rainfalls with monthly mean water table depth were calculated and presented from Figure 2 to Figure 6.

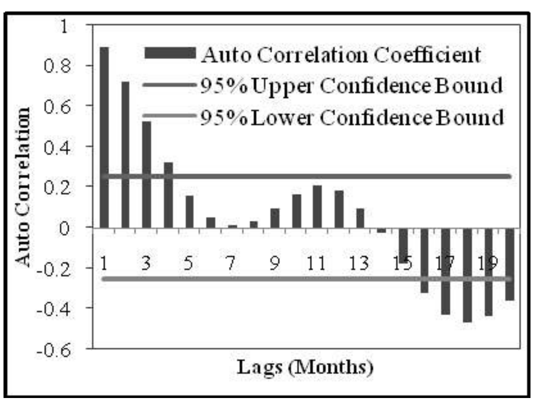


Figure 2. ACF of groundwater level

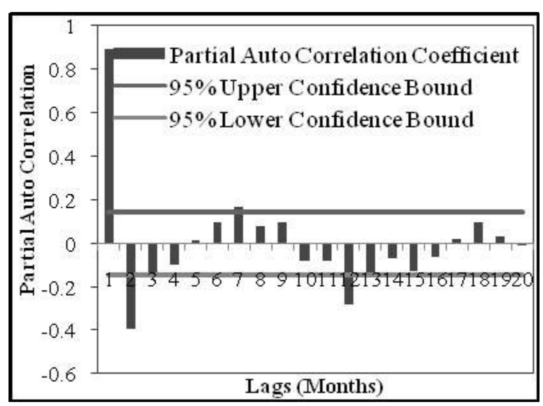


Figure 3. PACF of groundwater level

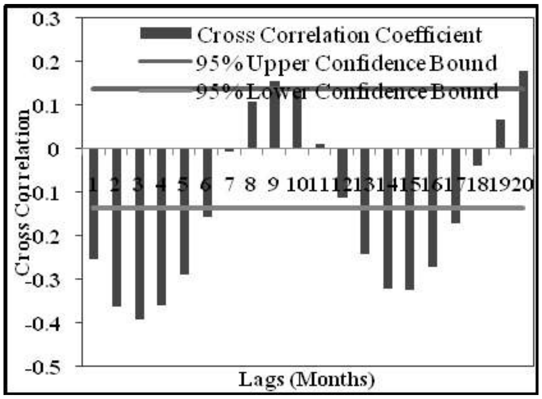


Figure 4. CCF between RF and GWL

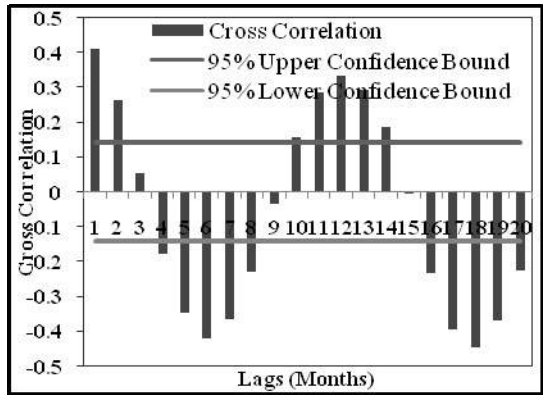


Figure 5. CCF between ET and GWL

The higher correlation values of ACF of Groundwater Level (GWL), PACF (GWL), CCF of Rainfall (RF) with (GWL) and the CCF of Evapotranspiration (ET) with (GWL) were 0.89 for one month lag time, 0.89 for one month lag time, -0.39 for three month lag time and 0.41 for three month lag time respectively.

The data from January-1999 to March-2015 (195 months) was considered for the development of the model. Out of 195 months dataset, 192 month dataset was available for analysis considering maximum of three month time lag for rainfall series. The whole dataset was divided into two sets for the calibration and validation of the ANN models.

The performance of the RBF model during calibration and validation with the input combination derived from statistical procedure were indicated (Table 1).

Table 1. Goodness of fit statistics of developed RBF models.

ANN model	Architecture	CC Cal	CC Val	CE Cal	CE Val	RMSE Cal	RMSE Val	EV Cal
RBF-1	3-1-1	0.8505	0.8601	0.7389	0.7279	1.1942	1.2353	0.8489
RBF-2	3-2-1	0.8599	0.8608	0.7394	0.7338	1.1986	1.2373	0.8599
RBF-3	3-3-1	0.8659	0.8471	0.7498	0.7169	1.1692	1.2918	0.8659
RBF-4	3-4-1	0.8644	0.8505	0.7472	0.7226	1.1710	1.2899	0.8644
RBF-5	3-5-1	0.8626	0.8544	0.7440	0.7279	1.1764	1.2806	0.8626
RBF-6	3-6-1	0.8615	0.8540	0.7442	0.7233	1.1922	1.2489	0.8615
RBF-7	3-7-1	0.8612	0.8514	0.7441	0.7116	1.1921	1.2523	0.8626
RBF-8	3-8-1	0.8605	0.8455	0.7465	0.6988	1.1822	1.2644	0.8640
RBF-9	3-9-1	0.8592	0.8393	0.7425	0.6857	1.1841	1.2771	0.8631
RBF-10	3-10-1	0.8590	0.8336	0.7418	0.6754	1.1800	1.2896	0.8659

The values of statistical parameters of different RBF models (Table 1) indicates that RBF-2 with 3-2-1 architecture is the best model among all other models with highest correlation coefficient, correlation efficiency and lowest RMSE value during the validation period. Even though all other models recorded highest correlation coefficient, correlation efficiency and lowest RMSE value during the calibration, the results during the validation is more important to decide the good architecture. From Fig. 7 indicated the comparison of actual and predicted water table depth computed by the RBF-2 models during the calibration and validation period and it was observed that the predicted water table depths followed the actual water table pattern.

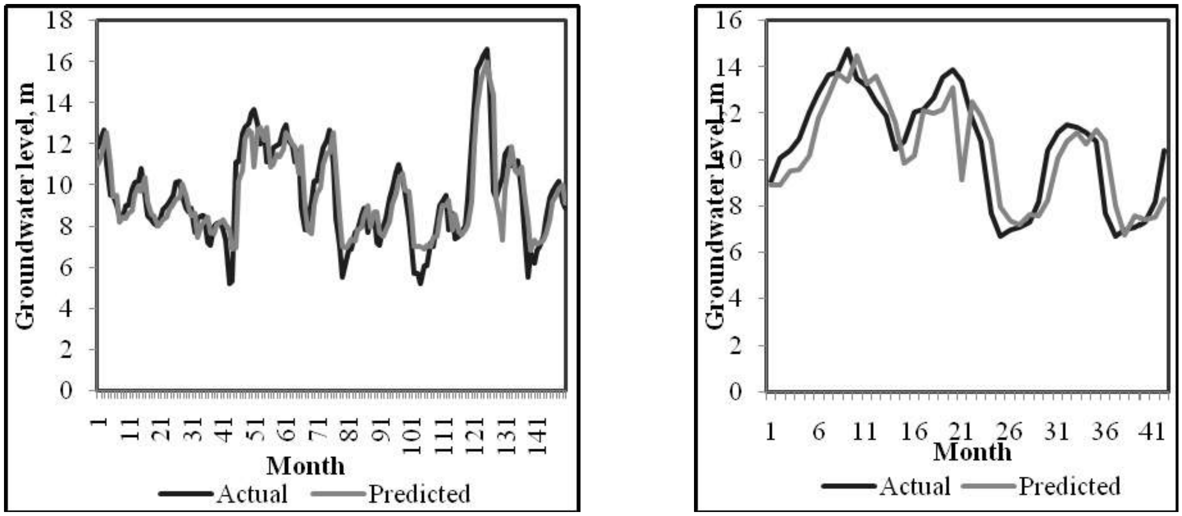


Figure 7. Comparison of actual and predicted water table depth for RBF model during calibration and validation period.

The regression analysis between actual and predicted groundwater level for RBF model was indicated in Figure 8

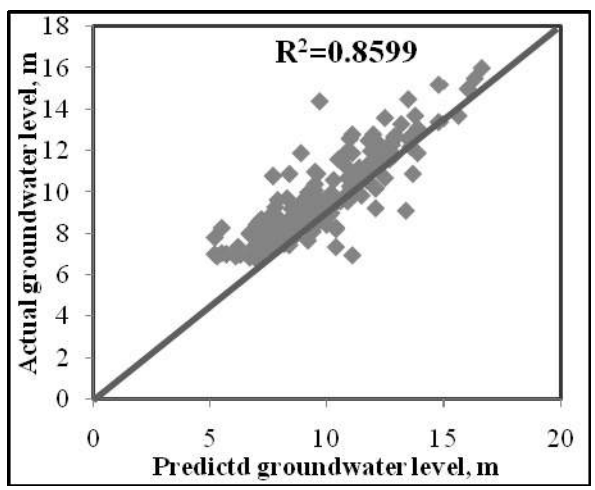


Figure 8. Regression graph for RBF model

From regression analysis it was observed that the actual and predicted groundwater level values lies near to the straight, Hence by analysis of all the figures and considering the all the goodness of fit statistics results RBF-2 model with 3-2-1 architecture was found as best for the groundwater level forecasting for observation well located at Raichur.

CONCLUSION

The optimum ANN based model proposed in this study shows very promising results. The RBF model was developed and the performance of the model for the study area was assessed using statistical indicators as well as visual comparison of observed and predicated groundwater level. The RBF model with 3-2-1 architecture found to be most efficient for monthly groundwater level forecasting for the study area. Overall it can be concluded that ANN technique can be used effectively for the prediction of groundwater level.

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Digital Elevation Model Generation using SRTM

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ABSTRACT

A digital elevation model (DEM) is the most basic and interesting geographical data type. Different techniques are used for acquisition of DEM source data: aerial and spatial photogrammetry, radargrammetry, SAR interferometry, airborne laser scanning (LIDAR), cartographic digitization of existing maps, traditional and modern surveying techniques. DEM generation by means of optical satellite images is become very advantageous method: it offers updated information, large area coverage, quick data access and it is very cost effective. In present study area for DEM generation, Kaddam watershed of Middle Godavari river basin has been selected. Using Shuttle Radar Topography Mission we can obtain DEM in 90m and 30m data. The article presents main sources of data for DEM generation, the interferometry processing steps for DEM generation based on the Shuttle Radar Topography Mission data/model and the crucial threshold values are tried to explain.

Keywords: Digital Elevation Model, Optical satellite images, Kaddam watershed, SRTM.

INTRODUCTION

The digital elevation model is simply a statistical representation of the continuous surface of the ground by a large number of selected points with known coordinates in an arbitrary coordinate field. The new techniques of data acquisition and processing have been developed and new types of digital terrain models have come into sight: from highway to railway design to agricultural management, flight simulation, flood monitoring and many more. DEM may be arranged in a raster or random form. Instead of the expression DEM also the term digital height model (DHM) is used. Digital Elevation Models do play a fundamental role in mapping. The digital description of the three dimensional surface is important for several applications. Today the most often used photogrammetric product are orthoimages generated by means of a single image and a DEM. The very high resolution space sensors are mainly operating in a single image mode; stereo pairs are not taken very often. A correct geo-referencing is only possible based on a DEM. But these DEMs have to be created. The existing and not classified world wide DEMs usually do not have a sufficient accuracy and reliability for more precise applications or they may be too expensive. Interferometry SAR (InSAR) is based on the processing of complex SAR images acquired from slightly different points of view. InSAR was proposed by Graham in 1974 and applied for the first time at JPL (Jet Propulsion Laboratory's) in 1986 using airborne data. Today, a large number of research groups are working on DEM generation with InSAR data coming from different airborne and space borne systems. The importance of InSAR is related to its high spatial resolution and good potential precision and to the highly automated DEM generation capabilities. Using Shuttle Radar Topography Mission, the digital elevation model for Kaddam watershed of Godavari river basin has been obtained.

STUDY AREA

The Godavari basin is situated between East longitudes 73˚ 21′ to 81˚ 09′ and North latitudes 16˚ 07′ to 22˚ 50′ in the Deccan plateau covering large areas in the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa, Karnataka, and Andhra Pradesh. Godavari catchment is divided into eight sub basins. The study area is a part of 'Middle Godavari' (G-5) sub basin of River Godavari which lies between latitudes 17˚ 04′ and 18˚ 30′ north and longitudes 77˚ 43′ and 79˚ 53′ east. The watershed spreads over twelve mandals which fall under Adilabad district. The total basin area and entirely lies in the state of Andhra Pradesh.

REVIEW OF LITERATURE

Shuttle Radar Topography Mission (SRTM) consists of a specially modified Synthetic Aperture Radar (SAR) system that flew onboard the Space Shuttle Endeavour which was launched into space on the 11th of February 2000, During an 11-day mission SRTM had the goal to obtain data in order to generate the most complete high-resolution digital topographic database of the Earth. SRTM InSAR was using two radar systems with different wavelengths. One was the C-band radar system operated by the USA having a wavelength λ=5.6cm and the other was the X-band radar system with λ=3cm operated by Germany and Italy. The radar Interferometry technique implies the acquirement of two radar images from slightly different locations in order to calculate the surface elevation. The two antenna systems of the SRTM which were separated by a fixed distance of 60 meters (the mast) were collecting two radar data sets. The main antenna was operated in active and passive mode because it transmitted and received signals while the outboard antenna was just passive. The main antenna illuminated a portion of the Earth´s surface with a pulse of 1/10 of a microsecond using a beam of radar waves. The X-band data set can be bought with a point spacing of 1 arc second (≈30m) while the C-band data are available free of charge with a reduced spacing of only 3 arc seconds (≈ 90m).

METHODOLOGY

DEM Generation: Shuttle Radar Topography Mission is a good source of DEM data for almost anywhere in the world. It is available at 90 meter and, since the end of 2014, 30 meter resolutions.

The first thing to do is to make a note of the Extend of the study area you want to model; the maximum and minimum latitudes and longitudes. If you have a longitude above 180°, subtract 360. Decimal degrees, rather than degrees, minutes and seconds, will be required for clipping later, so convert yours if necessary and make a note of them.

30m Data generation

To generate DEM data from SRTM we should register and logged on in earthexplorer to access and to download DEM data.

The step by step methodology used is as follows: Under *Coordinates*, select *Decimal* and click *Add Coordinates*. Enter the latitude and longitude of one of the 4 corners of the extent. Add the other 3 corners similarly. Then above *Enter Search Criteria* select the second tab, *Data Sets.*

Find *Digital Elevation*, click on the plus sign to expand and find *SRTM.* Expand that and check *SRTM 1 Arc-Second Global*. Then go straight to the fourth tab, *Results*

After a few seconds you should see the tiles you need listed. For each one, Click on *Download options*

(5th symbol) and then click *Download* beside *GeoTIFF.* Save the file, close the *Download Options* form, and repeat for each of your tiles. Note that the save form says the file is a zipped archive, but its extension is .tif and it is not zipped. Move the .tif files to the map folder.

RESULTS AND DISCUSSIONS

The acquired DEM data from SRTM 1 Arc-Second Global is used for generating watershed boundary for the study area. From the digital elevation model obtained, the file is opened in soil and water assessment tool, to create a watershed boundary.

In the large DEMs, the number of cells in a digital elevation model is probably the main factor influencing processing time; it is not the only one. DEM sizes are in millions of cells; for example the 100 million DEM has 10000 rows and 10000 columns.

The SRTM file which we obtained may be larger in size when compared with study area which we need to obtain the watershed boundary.

Figure 1. Digital Elevation Model of Middle Godavari G-5 Sub Basin

To extract the watershed from the digital elevation model, we need to add the watershed boundary in the Layers of SWAT model.

The procedure we follow to clip the watershed boundary from the digital elevation model, the following method is used: use Raster → Extraction → Clipper → select the clipping mode to mask layer → make sure the boundary shape file is selected → click OK to reproject → clear the completion message → Close the clipper form → remove the DEM file to check that we have DEM clipped to the shape.

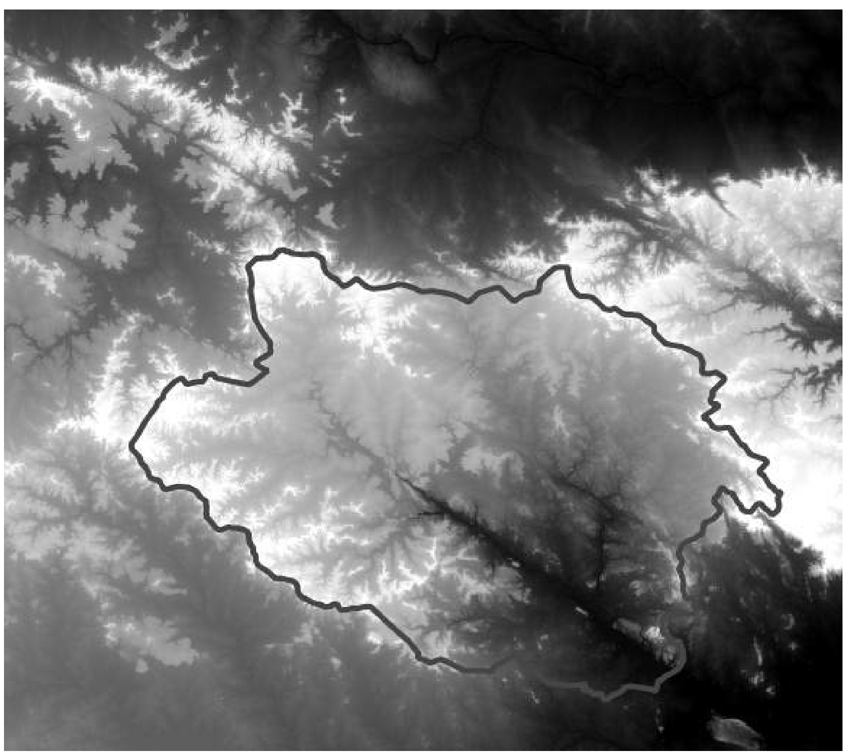

Figure 2. Digital Elevation Model with Kaddam Watershed Boundary

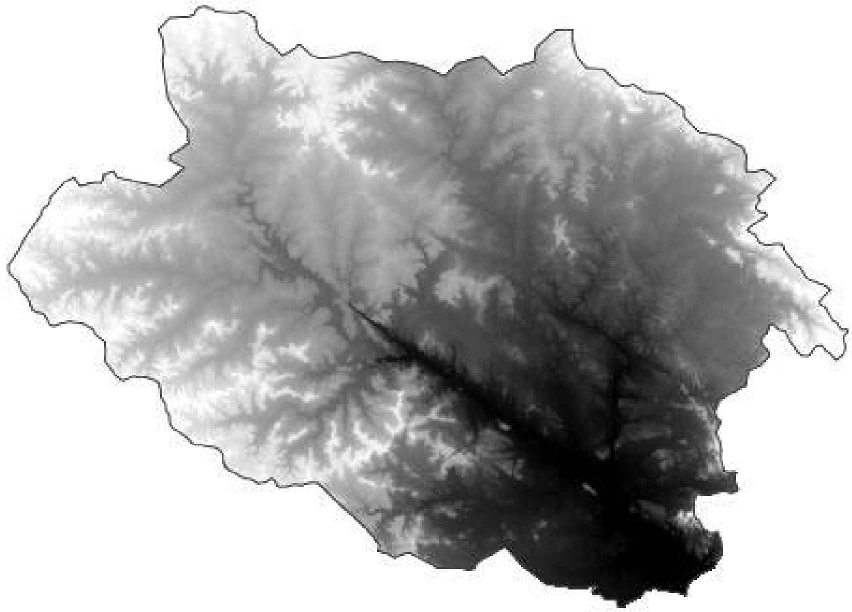

Figure 3. Kaddam watershed Digital Elevation Model

The above figure shows the study area (Kaddam Watershed) which is obtained from the digital elevation model.

CONCLUSIONS

With the rising number of high and very high resolution imaging satellites, with improved configurations and also by interferometry SAR, digital elevation models can be generated in any location with accuracy and with details which was not possible few years ago. For reaching satisfying results, images taken within the same orbit should be preferred. The generated digital surface models have to be reduced to digital elevation models. The project gives the ideal DEM of Kaddam watershed area and accuracy evolution from SRTM 1 Arc-Second Global. Further investigations analyzing the dependence on slope angles will be done.

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QSWAT Model Application in Watershed Delineation - A Case Study, Tirupathi

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ABSTRACT

Understanding and managing water resource problems involves complex processes and interactions within the watershed surface and subsurface. The development of hydrologic models to simulate the watershed has helped in generating the hydraulic response units of the watershed. As the demand for and development of watershed modeling capabilities have evolved, Soil and Water Assessment tool (SWAT) have played an essential role supporting in both data collection and analysis. In the present study area, Alipiri of Tirupathi is considered in generating the stream lines, subbasins, and watershed using quantum soil and water assessment tool. QSWAT is the interface for QGIS. From the results it is determined that soil and water assessment tool helps in knowing the total length of stream lines, areas of subbasins within the watershed area and development of water resources. Further study can be made on Hydraulics Response Units with respect to soil maps, land use land cover maps, and climatic data.

Keywords: Soil and Water Assessment Tool, Hydrologic Models, Simulation, Stream Lines, Subbasins, Watershed.

INTRODUCTION

Parameter specification and estimation are among the two most important activities in modeling. The challenge of catchment modeling lies in identifying, through a sensitivity analysis, which inputs and model parameters strongly affect system relevant outputs, and trying to define those inputs and model parameters in the most accurate way. But in delineating the watershed for a particular area requires the digital elevation model of that area using QSWAT. A watershed model simulates hydrologic processes in a more holistic approach, compared to many other models which primarily focus on individual processes or multiple processes within a water body without full incorporation of watershed area. Advancements in SWAT modeling have influenced the trend in watershed modeling. It has offered hydrologists by providing additional capabilities for reducing computation times, efficiently handling and analyzing large databases describing the heterogeneities in land surface characteristics, and improving display of model results.

STUDY AREA

The present study area, Alpiri situated between East longitudes 79° 24’ to 79° 23’ and North latitude 13° 38’ to 13°37’ in Tirupathi. Alpiri is situated at 673 ft above mean sea level. Because of its hill terrain, huge amount of rain water goes waste to downstream in the form of runoff, by using the soil and water assessment tool model, the stream lines and subbasin of the Alpiri region is delineated. A study is made to know the elevations of the stream lines and areas of subbasins to divert the runoff to the useful means.

REVIEW OF LITERATURE

Watershed models can be classified based on the spatial and/or temporal scale used, the methods adopted for solving the equations, and how the underlying hydrologic processes are represented (Meloneet al., 2005). The main features for distinguishing watershed modeling approaches are the algorithms (or solution methods) used, whether a stochastic or deterministic approach is taken to input or parameter specification, and whether the spatial representation is lumped or distributed. These classifications assist users in determining the applicability of a model to a given watershed. In India GIS based SWAT model has been widely tested and recognized as reliable tool for watershed management at watershed level (Gosain *et al,* 2004, Gosain *et al.,* 2005). However implementation of SWAT at micro watershed or filed level is not yet completely tested with greater degree of confidence. One of the widely used field scale model which simulate the water quality and quantity at plot level is APEX (Williams and Izaurralde, 2006). APEX model is now increasingly applied in different part of world to simulate the impact of different conservation practices at plot level (Wang *et al.,* 2006; Saleh *et al.,* 2007, Santhi *et al.,* 2008). But development in the modeling of Quantum Soil and Water Assessment Tool, it also became easy to implement in mini watersheds, in knowing the watershed area, subbasins, hydraulic response units, etc. with respect to the threshold/cell value which we give while creating steam lines, the following sections explains the methodology involved in delineating watershed and subbasins of particular study area.

MATERIAL AND METHODS

Modeling Tool: QSWAT Model: Just as ArcGIS interface of Arc SWAT, QGIS is Interface for Quantum SWAT. The QSWAT model is a basin-scale distributed hydrologic model. It is been developed to quantify the impact of land management practices in large, complex catchments. QSWAT is capable of accepting output data from other simulation models. QSWAT operates on a daily time step and allows a basin to be divided into subbasins based on topography to incorporate spatial details.

Depending on the threshold value which we give while creating stream lines, it generates the number of stream lines. Further in QSWAT we can add inlets, outlets, reservoir, point source values which helps in creating required watershed. Further QSWAT allows users to obtain large number of subbasins in a watershed. Each subbasin is further divided into hydrological response units (HRUs), which are unique combinations of soil and land cover. Individual HRUs are simulated independently, area weighted, and added for each subbasin and then routed through a stream network to the basin outlet.

Preprocessing: The following steps have been used in preprocessing

Watershed Delineation

To start automatic watershed delineation, click the Delineate Watershed button in QSWAT project. When the prompt box is opened browse to the data source in the dialogue box next to select DEM. The selected DEM will be copied to the projects source folder and if necessary converted to GeoTIFF format.

Creating stream networks

The threshold size for creating Subbasins is set next. It can be set by area, in various units such as sq km or hectares, or by number of cells. Click on Create Streams: the number of cells will be adjusted to the corresponding value.

We can add outlets, reservoirs, inlets, and point sources by selecting the Draw Inlets/Outlets option. Points need to be placed on the stream network, and may need to zoom in to place them precisely.

Only points within the snap threshold of a stream reach will be counted as points. Click OK to confirm and exit.

Adding Inlets/Outlets

If we have several points in inlets/outlets file we can use just a selection of them. To do this, choose the Select Inlet/Outlet option. Selected points will turn yellow, and a count will be shown at the bottom left of the main window.

Clicking Review snapped shows the snapped inlets/outlets, i.e. those within the defined threshold distance. Clicking on Create Watershed will create the watersheds after a few minutes.

Merging Subbasins:

In QSWAT we can select and merge subbasins. This is especially important in avoiding small Subbasins.

To merge Subbasins, select Subbasins under Merge sub basins. Selected Subbasins will turn yellow. When finished click on save. Click on Merge to perform the action.

After merging of Subbasins, click on OK. This causes Subbasins to be numbered. This step ends watershed delineation.

RESULTS AND DISCUSSIONS

In the present study Quantum Soil and Water Assessment Tool, helped in generating the number of stream lines which can be in study area depending upon the threshold number/cell size which we give to the digital elevation model during creating streams in QSWAT. It also made use in generating the subbasins and areas of subbasins in a watershed. In Figure 1, the black colored points at the end of stream lines are the inputs and outputs which we give in the watershed delineation in QSWAT model. The transparent layer in the figure is study area, SV Arts College play ground, Tirupathi. Though the study area is very small, from the direction of stream lines generated in a DEM are helpful in constructing a check dam to stop and storage the runoff. From the figure we observe that stream lines are in the direction of higher elevation to lower elevation, which covers the study area. Hence the runoff which flows waste can be diverted accordingly to the storage place.

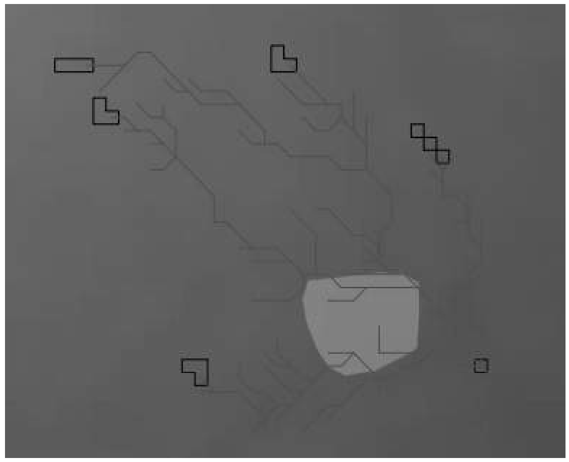

Figure 1. Representation of Stream Lines on Digital Elevation Model

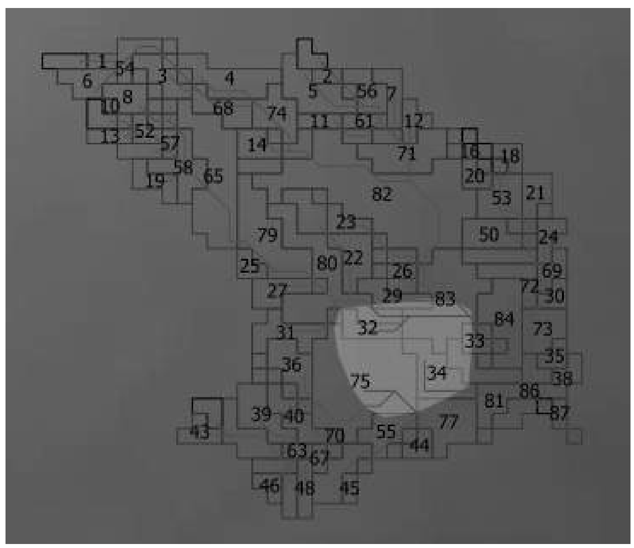

Figure 2. Representation of Number of Subbasins in the Watershed.

In Figure 2, along with the stream lines generated in the first step of QSWAT model, it also represents the subbasins which are generated after creating watershed; the process of generating subbasins is mentioned under *Adding Inlets/Outlets* section. DEM, Stream lines, inlet/outlet points are necessary steps in delineating a watershed. When we merge all the small subbasins into one, the complete watershed delineation process is said to be completed. This Model also helps users in generating the Hydraulic Response Units of particular study area depending on the soil and LU/LC maps. It also generates the all climatic data for simulation. After successful completion of watershed delineation, in step 2 of QSWAT Model, create HRU's is the command which automatically appears. The subbasin areas are shown in Table 1.

Table 1. Areas of Subbasins in Hectares

Subbasin Number	Areas of Subbasins in Hectares
1	1848.587
2	2772.881
3	5545.761
4	12015.82
5	10167.23
6	5545.761
7	4621.468
8	5545.761
9	2772.881
10	1848.587
11	4621.468
12	3697.174
13	2772.881
14	4621.468
15	2772.881
16	2772.881
17	2772.881
18	4621.468
19	3697.174
20	4621.468
21	12940.11
22	7394.348
23	3697.174
24	2772.881
25	2772.881
26	5545.761
27	2772.881
28	5545.761
29	2772.881
30	8318.642
31	4621.468
32	2772.881
33	10167.23
34	2772.881
35	7394.348
36	3697.174
37	4621.468
38	8318.642
39	7394.348
40	4621.468
41	3697.174
42	2772.881
43	2772.881
44	2772.881
45	2772.881
46	3697.174
47	7394.348
48	6470.055
49	7394.348
50	2772.881
51	7394.348
52	6470.055
53	6470.055
54	5545.761
55	1848.587
56	10167.23
57	1848.587
58	2772.881
59	2772.881
60	1848.587
61	1848.587
62	1848.587
63	23107.34
64	4621.468
65	1848.587
66	6470.055
67	3697.174
68	924.2936
69	11091.52
70	5545.761
71	7394.348
72	7394.348
73	37896.04
74	2772.881
75	12940.11
76	6470.055
77	17561.58
78	21258.75
79	5545.761
80	54533.32
81	24955.93
82	12015.82
83	6470.055
84	924.2936
85	2772.881

QSWAT Model automatically calculates the areas of subbasins in Hectares units. Model also helps in knowing the elevation difference of stream lines, length of the stream lines, hydraulic response units. The threshold size given in creating stream lines is 3 sq km per cell size. The threshold decides the number of stream lines in a watershed.

CONCLUSIONS

An essential element of watershed management is the utilization of watershed-scale modeling. The benefits of using these models include the ability to assist with a variety of applications, such as runoff, flood hazard mapping, and computing peak flows. QSWAT Model using DEM generates the stream lines, watershed delineation, hydraulic response units, climatic data simulations etc. QSWAT is the developing model which is useful for the user in large aspects. Future trends suggest that QSWAT will continue to influence watershed modeling by providing flexible platforms to support hybrid watershed modeling system development, real-time data collection and deployment of web based watershed modeling applications. Open-source QSWAT software appears to be leading this movement and it is showing great promise as a cost effective alternative to traditional commercial Arc SWAT. Results suggest that using QSWAT for considered study area, large amount of runoff which shows can be diverted to the storage points, and the runoff from the subbasins can be collected and utilized for various purposes.

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