Proceedings of

4th National Conference on Water, Environment & Society

(NCWES - 2017)

16th-18th March, 2017

at JNTUH, Hyderabad, India

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Organized by

Centre for Water Resources

Institute of Science and Technology

Jawaharlal Nehru Technological University Hyderabad

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Preface

Water is an integral part of a society's development and a backbone for human health, livelihoods and poverty reduction. Without water, survival is not possible. The human right to access to clean water, the need for all people to be able to enjoy adequate water and sanitation services, is well established. Water is also an economic good and as such a driver for economic growth and development.

Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself. It is vital for reducing the global burden of disease and improving the health, welfare and productivity of populations. It is central to the production and preservation of a host of benefits and services for people. Water is also at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society and the environment.

In this context and backdrop that the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad felt the need to organize a three day 4th National Conference on Water, Environment and Society (NCWES-2017) to take stock of the current status of applications in water resources development and management. Further to identify areas most relevant to ensure sustainable development of water resources and environment to benefit the society at large.

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. The conference is expected to recommend suitable strategies and policy guidelines to operationalize the initiatives and dovetail them into various watershed development programmes appropriately. 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 three 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. Urbanisation, Bio-diversity and EIA and Human Health
4. Groundwater Exploration, Development, Recharge, Modeling and Quality
5. Water quality, Water treatment, Pollution and Society
6. Water Conservation and Irrigation management
7. Water Management, Rainfall and Rainwater Harvesting
8. Geospatial Applications in Water resources

More than 150 delegates and about 90 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.

I wish and expect that the participants will find this conference useful and give their total participation to make it a grand success.

It is with this great pleasure; I extend a warm welcome to all the delegates, speakers and participants to NCWES- 2017.

Dr. M.V. S.S Giridhar
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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

Prof. A. Venugopal Reddy M.Tech. Ph.D.
Vice-Chancellor

MESSAGE

The convener 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 a three day 4th National Conference on "***Water, Environment and Society - NCWES 2017***" during 16th -18th March 2017.

India is bequeathed with a rich and vast diversity of natural resources, water being one of them. It is one of the controlling factors for biodiversity and the distribution of ecosystems, communities of animals, plants, and microorganisms and their interrelated physical and chemical environments. However, misdemeanors of man and seldom mischief of nature are putting tremendous pressure on water and environmental health.

Water is an essential resource for all life on the planet. Water, once an abundant natural resource, is becoming a more valuable commodity due to droughts and overuse. To ensure adequate supply of water to our future generation every individual should feel responsible to conserve, manage and distribute. In situations where we trust we can contribute straight forwardly, I hope that this 4th National Conference on NCWES will be immense use for delivering measures of water management.

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 convener and committee members of this conference for taking up this topic and wish them all success.

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MESSAGE

It gives me immense pleasure to know that " Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a three day 4th National Conference on " ***Water, Environment and Society-NCWES 2017***" during 16th -18th March 2017.

It is evidently clear that water is one of the prime elements responsible for life on earth. As population increases and the impacts of climate change continue to constrain the availability of water, measuring and managing our environmental impact is most essential for the society. One of our most critical environmental impacts of all is on water.

A conference on such topic is appropriate to spread the message across all the section of the society. I believe that collaboration with others through this National conference would help us to learn, define and share best practices on the way to achieve our goals.

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

N. V. Ramana Rao

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MESSAGE

I am glad to know that "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a three day 4th National Conference on "***Water, Environment and Society-NCWES 2017***" during 16th - 18th March 2017.

Due to increase in population there is scarcity and exploitation of water. Many people around the world do not have access to clean water supplies. Although water is a renewable resource, it becomes difficult and expensive to reuse if it gets polluted. On this note I would like to say we can contribute, in our small way, towards water conservation by implementing rainwater harvesting structures in our homes. I would like to appreciate centre for Water Resources for their continuous efforts on creating public awareness about rainwater harvesting structures in JNTUH.

I hope this conference provides a platform for the researchers, engineers, managers, policy makers and the academicians to discuss about the advancement in the field of water resources and environment and bring 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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MESSAGE

It is a delight to know that "`Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a three day 4th National Conference on "***Water, Environment and Society-NCWES 2017***" during 16th - 18th March 2017.

Water is a cradle of life which helps to facilitate life's essential process. With the misuse of water resource, it is getting depleted. With climate change, the water cycle is expected to undergo significant change. Water is a precious resource to us and to our future generations. We must all use this resource more carefully and efficiently. Conservation will not only save our water supply, but also save money.

The theme of the conference being a thrust area in the society, I hope that the participants will be greatly benefited to enhance their technical knowledge and contribute to water resources and environmental engineering.

I wish the conference a grand success.

B.N Bhandari

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MESSAGE

I am very delighted to note that " Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing its 4th National Conference on " ***Water, Environment and Society-NCWES 2017*** " during 16th - 18th March 2017 with a mission to improve science and art of natural resource conservation.

Climate change is a global reality caused mainly by economic activities. Climate change has direct impacts on natural resources, ecosystems and societies, with water being particularly affected. In wake of increasing awareness on vulnerability of water and environment fostering their protection and conservation gained paramount importance.

This conference explores diverse interests on environment, ecosystem and hydrology and probe alternatives and innovations that can lead to greater water use efficiency and environment conservation.

I hope the conference will provide participants with information about innovative ways to protect water in environment and the associated environmental concerns and promote knowledge that can help us, as individuals and as a society, protect and manage our precious water resources wisely. I congratulate the convener and wish the program a grand success.

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MESSAGE

I am very pleased to note that " Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing its 4th National Conference on " ***Water, Environment and Society-NCWES 2017*** " during 16th - 18th March 2017 .

Despite water being an existential need for humans, it's also one of the most under prioritized but over abused commodity. Water being a central disposition in our lives has not been the central point of focus in our planning while we rapidly evolve into an urban society. It is reality from which there is no escape in which it should be monitored and assessed to alleviate it.

In this perspective this conference recognizes the need for inclusive and environmentally sustained growth or shared prosperity and directed accordingly.

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

Dr. A. JAYA SHREE

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MESSAGE

I am indeed privileged and delighted to host three day 4th National Conference on "***Water, Environment and Society-NCWES 2017***" during 16-18, March 2017. Three years ago ***NCWES 2014*** was the first National Conference to bring together researchers and practitioners with a shared interest. Since then there has been a huge support for the NCWES national conference.

One of the most compelling reasons to study environment management is the fact that we are facing the both environment crisis. Awareness to this crisis has been given most prominence importance as there has been wide range of environment problems. The main feature for these environmental crises as we know is climate change which should be given an utmost importance in environment management practices.

Apart from environment, water is also facing a huge challenge. The water crisis facing by the country is not due to water scarcity but due to mismanagement of water resources. The need to manage water resources in a scientific manner has been recognized and hence a lot of emphasis has been given to sustainable exploitation of water.

I hope the 4th National Conference will bring out such issues we are facing and hope to find productive measures in water and environment management practices.

We centre for water resources extend our warm welcome to all the participants across the India regardless of discipline and states.

I hope this National Conference will be a great success.

Dr. M.V.S.S.Giridhar

Acknowledgements

The organization of a conference is always an adventure because of all the very small things and all the very important issues that have to be planned and managed. The 4^{th} National Conference on Water, Environment and Society NCWES-2017 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 ***Prof. A. Venugopal Reddy***, Vice-Chancellor, Jawaharlal Nehru Technological University Hyderabad and Chief patron of the conference for his constant encouragement valuable guidance in organizing the conference in most efficient way.

I am very thankful to ***Dr. N.V. Ramana Rao***, Rector, Jawaharlal Nehru Technological University Hyderabad for his precious support as Patron of this conference.

My sincere and special thanks to ***Dr. N Yadaiah***, Registrar, Jawaharlal Nehru Technological University Hyderabad as the Chairman of the conference for his cordial, time to time permissions and support.

I am deeply indebted to ***Dr. A. Jaya Shree***, Director, IST, JNTUH and Co-Chairperson of this conference for having taken every responsibility for completing this task through various stages.

I would like to extend my grateful thanks to ***Dr. B. Venkateswara Rao, Dr. K. Rammohan Reddy*** and ***Dr. C. Sarla***, professors, Centre for Water Resources for their valuable support throughout the conference.

My sincere thanks to the officials of Technical Education Quality Improvement Program, Phase-II, IST, JNTUH, Science and Engineering Research Board (SERB), National Bank for Agriculture and Rural Development (NABARD), Council of Scientific & Industrial Research (CSIR) and Ministry of Earth Sciences (MoES), Telangana State Council of Science and Technology (TSCOST), Telangana State Pollution Control Board (TSPCB). M/s Swan Scientific LLP and Tencate Geosynthetics Private Limited for sponsoring this event. Without their help organization of this conference would not have been possible.

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.

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 my students Smt. P. Sowmya, Research Scholar, Ms. Shyama Mohan, Mr. G. Kishore and Ms. D. Sindhu who stood as a pillar to organize 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

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THEME – I

HYDROLOGIC PARAMETER ESTIMATION AND MODELLING

Estimation of Peak Discharge in an Ungauged Watershed using GIUH, SCS-CN and SNYDER Models with Supported GIS and RS

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ABSTRACT

Watershed in most parts of the world is either partially gauged or completely ungauged. Estimation of hydrological parameters in ungauged watershed is very difficult and also time consuming. Hydrological modelling is the tool which simulates the catchment behaviour by solving the equations that govern the physical processes occurring within the catchment hydrologic models. The main objective of this paper is, to estimate the peak discharge using the models, namely GIUH, SCS-CN and SBYDER model for ungauged watershed. Error analysis and correlation statistics for obtaining most suitable model for Peak discharge simulation in ungauged watershed. The peak discharge estimation is done for the period of 2009-2013 an event based approach. Remote sensing and GIS techniques have been used as a tool to develop the thematic maps of the ungauged watershed, which were used as input for GIUH, SCS-CN and SNYDER model. The obtained results were compared with recorded peak discharge in hydro observation site of watershed.

Keywords: Rainfall-runoff; Ungauged watershed; GIUH; SCS-CN; SNYDER.

INTRODUCTION

The water on earth is not stagnant. It continuously moves from one place to another or one form to another. The continuous movement of water on, above and under the surface of the Earth can be explained through a cycle known as the hydrologic cycle. The various aspects of water related to the earth can be explained in terms of this cycle (Chow *et al*., 1988; Subramanya, 2008). Hydrologic cycle is a very vast and complex cycle in which a large number of paths are there with varying time scale. The various processes involved in this cycle are evaporation, interception, transpiration, surface runoff, infiltration and percolation. A drainage watershed, which has insufficient records of various hydrological observations in terms of both quantity and quality for analysis at the appropriate spatial and temporal scales and up to a good level of accuracy for application in practical fields is known as ungauged watersheds (Sivapalan *et al.,* 2003). If the parameter of interest is not available for the required period of time for prediction or modeling, that watershed is an ungauged watershed with respect to that variable., Variables of interest can be rainfall, runoff, erosion rates etc. so every watershed is - ungauged in some respect. The aim of modelling is to reduce the uncertainty in hydrological predictions. Prediction of runoff water in an ungauged catchment area is vital for various practical applications such as the design of drainage structure and flood defences, runoff forecasting and for catchment management tasks such as water allocation and climate impact analysis.

Sherman, (1932), considered many factors affecting the shape of a hydrograph and in many cases relevant to the physical attributes of a drainage basin such as area, shape and slope, which were constant and found that the hydrograph shape must be the same for storms with similar attributes. Measurements carried out by the soil conservation service (SCS) of the United States presented dimensionless hydrograph in different drainage basins, (Mockus, 1957). The problems of geomorphologic instantaneous unit hydrograph (GIUH) were demonstrated in 1979 by Rodriguez- Iturbe. Recent progress in finding run off topographic was made by the aid of geomorphologic instantaneous unit hydrograph (GIUH). In the past two decades, using drainage basin attribute geomorphology in run off simulations interested many hydrologists (e.g. Gupta *et al*., 1980; Rodriguez- Iturbe *et al*., 1982; Krishen and Bars, 1983; Troutman and Karlinger 1985; Agnese *et al*., 1988; Chutha and Dooge, 1990; Yen and Lee, 1997; Olivera and Maidment, 1999; Berod *et al*., 1999). In Horton laws, construction and structure of drainage basins, engineering of stream networks and the results of geomorphologic response have been described as geomorphologic instantaneous unit hydrograph (Karvonen *et al*., 1999). The results showed that since run-off primarily occurs in low portions of a watershed near streams, a precipitation- run-off model that considers only the surface run-off is recognized as being inadequate. It was further demonstrated that with correction of GIUH, better results can be derived.

Study Area

The area of investigation in this research study is the major part covers Naidupeta and remaining area covers Venkatagiri, sullurupeta in Nellore district, Andhra Pradesh. It is located 13°90' and 14° 25' N and 79° 89' and 80° 12' E and covering an area of 957.92 sq.km. The Study area falls under Palar Sub-basin the area was delineated from India Water Resources Information System (IWRIS) C18PAL41. The study area it is a part of east flowing river between pennar and caurey basin and the river draining into the bay of Bengal. In the study area main river is Swarnamukhi and the length of the river as 56.90 km. In the study area has one hydro observation station and 11 rain gauge stations are located. The hydro observation site is located in naidupeta in Nellore district.

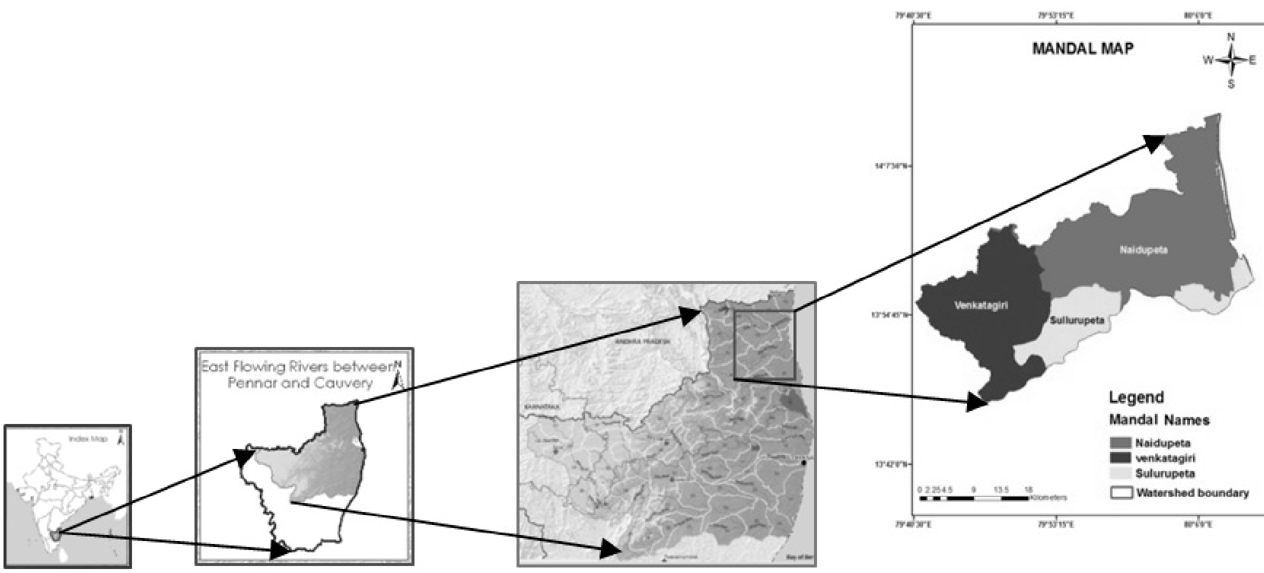

Figure 1 Location Map of the Study Area

Methodology

The current section describes the various methodologies and theoretical background that are required for the analysis within this study. They include GIUH and SCS-CN Models.

GIUH Model

Geomorphologic instantaneous unit hydrograph (GIUH), a pioneering concept linking quantitative geomorphology with the watershed hydrologic characteristics was introduced by Rodriguez-Iturbe and Valdes (1979).

$$q_p = 1.31 \times R_L^{0.43} \times \frac{V}{L_\Omega} \qquad \text{-------- (1)}$$

where, q_p = peak flow per unit time *(hr^{-1})*, $R_L = \frac{L_i}{L_{i-1}}$, V = Flow Velocity (m/s), L_i = average length of stream of i^{th} order, L_Ω = Length of the highest order stream in the basin (km) **;**

The following formula is used to estimate the peak discharge in GIUH Model as:

$$Q_p = t_r \times q_p \times \left(1 - t_r \times \frac{q_p}{4}\right) \times Q_e \qquad \text{--------- (2)}$$

where, Q_p = Peak discharge (m^3/s), Time of effective rainfall, $t_r = 0.133 \times t_c$ (hr),

q_p = peak flow per unit time *(hr^{-1})*, Effective discharge, $Q_e = i_r \times A$ (m^3/s),

Rainfall intensity $i_r = \frac{p}{t}$ (cm/hr), A= Area of the watershed (sq.km).

SCS-CN Model

SCS-CN method, developed by soil conservation services (SCS) of USA in 1969. It is simple, can predict accurately, and a stable conceptual method for estimation of direct runoff depth based on rainfall depth. It depends on only one parameter, CN. Losses are defined as the interception and infiltration rate in the watershed to indicate rainfall loss in surface runoff simulation

$$S = \frac{25400}{CN} - 254 \qquad \text{----------- (3)}$$

where, S = Losses, CN = Curve number

The runoff Q can be estimated for the SCS-CN Model using the following formula,

$$Q = \frac{(P-0.2\times S)^2}{(P-0.8\times S)} \qquad \text{----------- (4)}$$

Where, Q = Runoff in mm, P = Precipitation in mm, S = Losses, CN = Curve Number.

The following formula is used to estimate the Peak discharge for an ungauged watershed in SCS-CN Model:

$$Q_p = \frac{(2.083\times A\times Q)}{t_p} \qquad \text{----------- (5)}$$

Where, Q_p= Peak discharge (m^3/s), A=Watershed area (Km^2), Q = Runoff (mm), t_p= Time to peak (sec).

SNYDER Model

The following formula is used to estimate the Peak discharge for an ungauged watershed in SNYDER Model

$$Q_p = \frac{2.78\times C_p\times A}{t_p} \qquad \text{----------- (6)}$$

Where, Q_p = Peak discharge (m^3/s), C_p = Storage coefficient (m), A = watershed area (Km^2), t_p = Time to peak (hours),

Error analysis

The following models were taken for the validations

1. Nash-Sutcliffe Efficiency model

$$NSE=1-[\frac{\sum_{i=1}^{n}(y_i^{obs}-y_i^{sim})^2}{\sum_{i=1}^{n}(y_i^{obs}-y^{mean})^2}] \qquad \text{---------- (7)}$$

Where Y_i obs is the i^{th} observation for the constituent being evaluated, Y_i sim is the i^{th} simulated value for the constituent being evaluated, Y mean is the mean of observed data for the constituent being evaluated, and *n* is the total number of observations.

2. RSM (root mean square error of the observations standard deviation ratio) Model.

$$RSR=\frac{RMSE}{S\ TDEVobs} = \frac{\sqrt{\sum_{i=1}^{n}(y_i^{obs}-y_i^{sim})^2}}{\sqrt{\sum_{i=1}^{n}(y_i^{obs}-y^{mean})^2}} \qquad \text{---------- (8)}$$

3. Statistical errors

Statistical errors such as Relative Mean Error (RME), Root Mean Square Error (RMSE) are determined by using the following equations

$$1.\ RME=\sum_{i=0}^{n}[\frac{y_{obs}-y_{sim}}{y_{obs}}]\times 100 \qquad \text{--------- (9)}$$

$$2.\ RMSE=\sqrt{\frac{1}{n}\{\sum_{i=0}^{n}[\frac{y_{obs}-y_{sim}}{y_{obs}}]^2\}} \qquad \text{---------- (10)}$$

Where, y_{obs} = observed past data, y_{sim}= simulated or predicted data;

n = total number of observed data.

RESULTS AND DISCUSSION

This chapter describes the peak discharge is obtained from rainfall-runoff modelling using GIUH, SCS-CN and SNYDER models. By using these three models is estimated on an event based approach. Peak discharge is estimated on an event based approach during the period of 2009 - 2013. Total ' 10 ' events are considered.

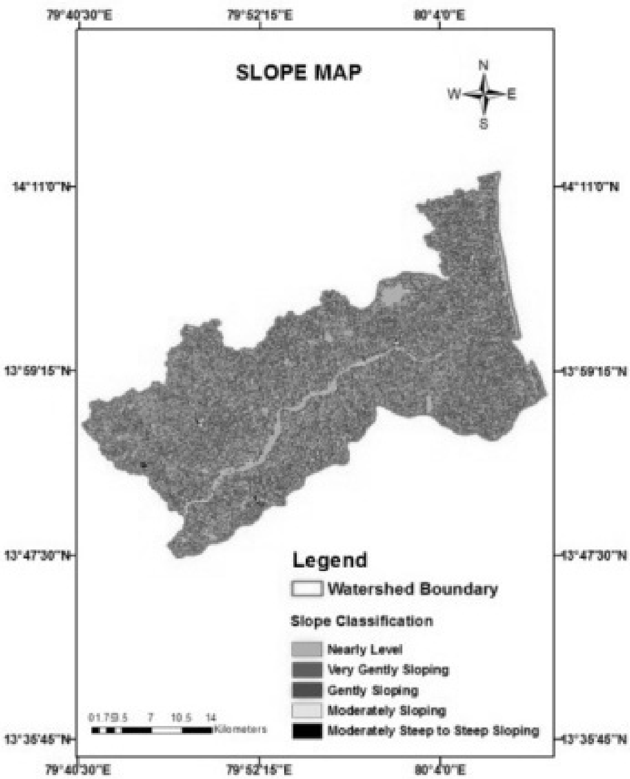

Figure 2 Slope Map

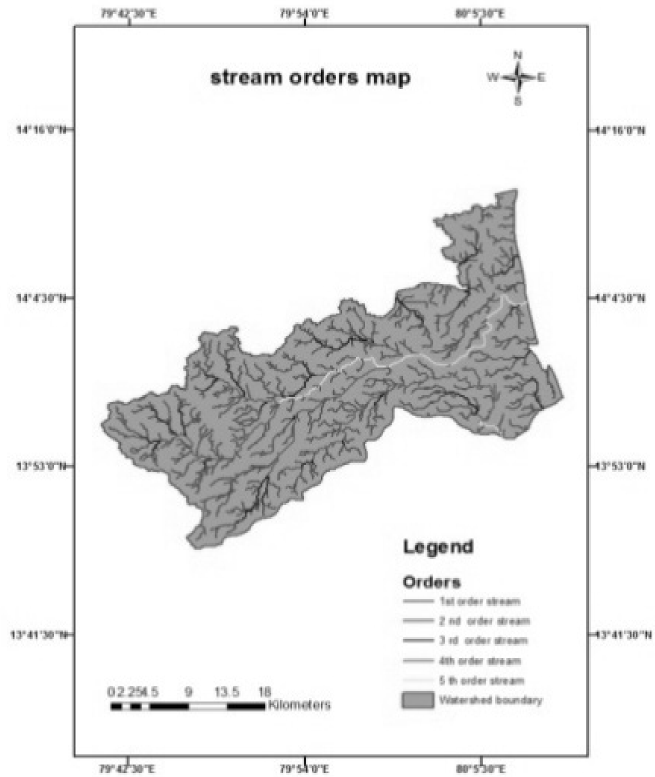

Figure 3 Stream Orders Map

Table 1 Geomorphological Parameters in the watershed

Stream Order	Number of Streams	Length of Streams (km)	Mean Length of Streams (km)	Length Ratio $R_L=L_u/L_{u-1}$	Average Length Ratio of a Watershed
1	452	590.71	1.30	1.30	
2	96	260.415	2.71	2.07	
3	25	95.023	3.80	1.40	2.289
4	5	105.926	21.18	5.57	
5	2	46.256	23.12	1.09	

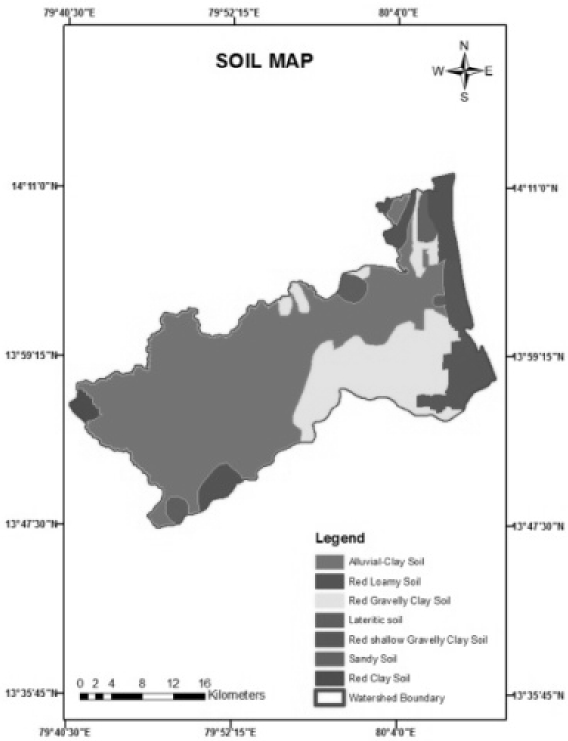

Figure 4 Soil Map of the study area

Land use Land cover Maps

The following maps are prepared in Arc GIS on each event, it has each satellite image on the particular day based and calculated the areas changes on one event to another event how it will be varies.

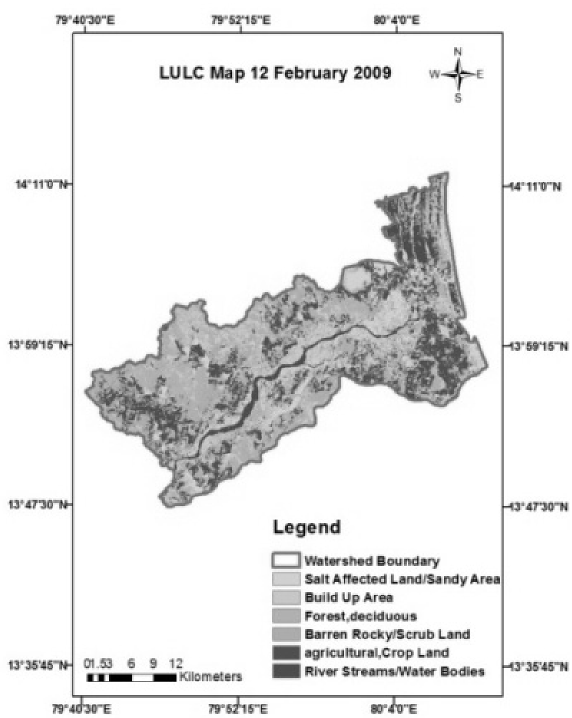

Figure 5 LULC Map on 12 February 2009

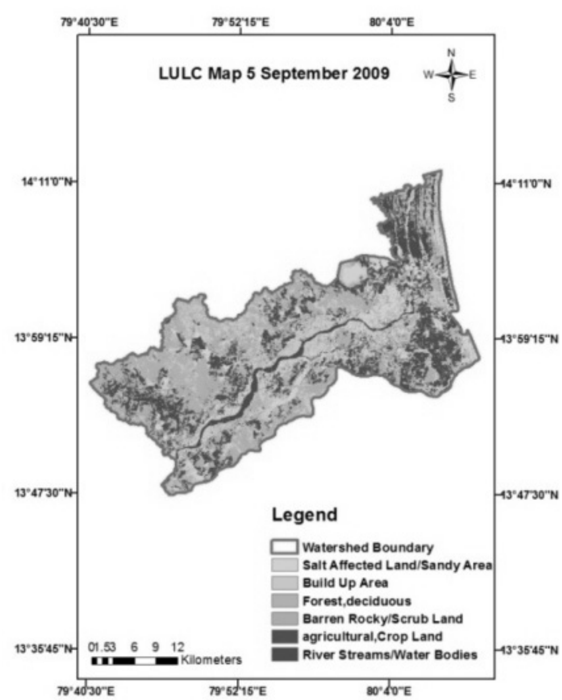

Figure 6 LULC Map on 5 September 2009

Table 2 LULC Classification on 12 February 2009

S. No	LULC Classification	AREA in sq. km	Percentage Area
1	Salt Affected Land/Sandy Area	58.17	6.07
2	Agricultural Land	193.18	20.16
3	River Stream/ Water Bodies	58.93	6.15
4	Barren Rocky/ Open Scrub Land	148.62	15.51
5	Forest Area	254.10	26.52
6	Build up Area	244.91	25.56
	Total	957.92	100

Table 3 LULC Classification on 5 September 2009

S. No	LULC Classification	AREA in sq.km	Percentage Area
1	Salt Affected Land/Sandy Area	56.37	5.86
2	Agricultural Land	143.29	14.94
3	River Stream/ Water Bodies	83.97	8.79
4	Barren Rocky/ Open Scrub Land	173.62	18.12
5	Forest Area	254.42	26.53
6	Build up Area	246.12	25.77
	Total	957.92	100

The remaining LULC Maps and classification in event based are done in above procedure. We can download the landsat images and import the GIS and prepare the LULC Maps. Totally 10 LULC Maps are prepared in event based.

Table 4 Comparison between observed and calculated peak discharges on three models

EVENTS	DATES	$Q_{(observed)}$	$Q_{(calculated)}$ (m^3/s)		
			GIUH	SCS-CN	SNYDER
1	12-February-2009	11.18	8.36	6.92	3.09
2	5,6 -September-2009	17.32	15.31	14.02	13.18
3	13,14-March-2010	7.85	7.09	6.83	4.32
4	28,29,30,31-October-2010	145.72	140.11	132.79	103.75
5	22,23-February-2011	37.41	34.21	29.38	18.01
6	22,23,24-August-2011	104.84	99.81	90.81	80.55
7	04-January-2012	13.10	12.41	9.36	4.05
8	3,4,5-November-2012	126.63	125.62	116.92	93.75
9	19,20-March-2013	69.22	64.01	58.02	49.88
10	19,20,21,22,23-October-2013	145.57	138.32	129.36	106.66

Table 5 Performance evaluation indices on the three Models

S. No	Models	RME	RMSE	NSE	RSR
1	GIUH	8.06	0.39	0.89	0.61
2	SCS-CN	12.55	1.23	1.09	0.81
3	SNYDER	19.1	1.6	1.41	1.09

CONCLUSIONS

The Peak discharge has been estimated in an ungauged watershed using GIUH, SCS - CN and SNYDER Model on an event based method. It shown that GIUH Model gives best estimation for ungauged watershed as as compared with observed data. It is recommended that GIUH Model is the best method in order to find out peak discharge estimation in an ungauged watershed. Statistical Analysis has been done to know the performance evaluation of the model. These models can also be applied for small, medium, and large watershed with proper modification in the input parameters.

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Estimation of Turbulence Properties of Accoustic Doppler Velocimetry Data Contaminated with Spikes

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ABSTRACT

Experimental investigations have been carried out to despiking ADV data in non-uniform sand bed channels with and without seepage. Turbulent analysis of velocity signals recorded by acoustic Doppler velocimetry (ADV) and contaminated with spikes remains an interesting task. In this paper, we recommend a new method for restructuring contaminated time series which is modification of code given by Islam and Zhu (2013) for detecting and replacing spikes. The accuracy of the new method is estimated by applying it to classify and remove spikes and restructure the spectra of unfiltered data sets which are preciously contaminated with arbitrary spikes. The method is also useful to reconstruct the velocity and Reynolds shear stress profile obtained from purposely contaminated ADV measurements. The results show that the power spectra of the reconstructed time series followed the universal -5/3 law in the inertial sub range. Even for a severely contaminated time series, the proposed method can accurately recover the velocity and Reynolds shear stress profile for both no seepage and seepage runs. Measures of turbulent statistics such as velocity, Reynolds shear stresses, thickness of roughness sub layer and shear velocities were found increasing with seepage.

Keywords: ADV, Seepage, Channels.

INTRODUCTION

Acoustic Doppler Velocimeter (ADV) has been used widely in experimental flume and in fields as well. Main advantages in using ADV are its three dimensional instantaneous measurement and its robustness. Major concern in ADV measurements is the presence of contaminants which generally occur in form of spikes in time-series representation of the data. Contaminants are generally caused by presence of free shear layer, boundary interferences, signal aliasing and doppler noising (Yafei, 2015; Islam and Zhu,2013). Various techniques have been developed to remove spikes from time series. Nikora and Goring (1998) have used various thresholding methods to discriminate spurious data from the acceptable ones. Universal threshold parameter and standard deviation had been used to define the size of the ellipsoid, containing the most of the part of cluster and points lying outside the ellipsoid are labelled as spikes (Goring and Nikora, 2002). Wahl(2003) improved this approach by using MAD(Median of Absolute Deviations) instead of standard deviation to determine the scale quantity. Wahl (2003) found more number of spikes for the same time series and he removed the associated data from all the velocity series. Cea*et al.* (2007)took a different approach and plotted three components of velocity in 3-D space. This method is also iterative and uses universal threshold as a cut off. Parsheh*et al.*(2010) applied a preconditioning to the PST method of Goring and Nikora (2002) which uses a robust statistics to calculate the dimensions of ellipsoid.All of the above mentioned methods take up an iterative approach for spike detection. Islam and Zhu (2013) applied above mentioned methods to investigate the experimental data from a wall jet test which contained a lot of contaminants in time series and they found that previously mentioned methods proves ineffective at many places with 40% of contaminated data. To improve despiking in such cases of high contamination, Islam and Zhu (2013) used Kernel density function to separate the spikes from the cluster. One of the minor disadvantages of code developed by Islam and Zhu (2013) is that it will give filtered time averaged velocity data at a single depth of flow once at a time. For various depth of flow at a particular section, process will be repeated until filtered time averaged velocity for full depth of flow is achieved. Thus a code developed by them is suitable and practically applicable for despiking ADV data but the process is highly time consuming. Since riverbeds are usually composed of non-uniform sediment mixture and the important hydraulic nature of sand bed is that it provokes lateral flow as seepage. we have slightly modified in MATLAB codes developed by Islam and Zhu (2013) for purpose of despiking ADV data in the seepage affected alluvial channel. Experiments were conducted for free-surface flows subjected to downward seepage from the boundary. The present study also investigates the effect of seepage on turbulence parameters of flow.

Experimental setup and program

In the present work, experiment was conducted in a large tilting flume with dimensions of 17.24 m in length, 1m in width, and 0.72m in deep at a bed slope (S) of 0.1%. The flume is having seepage chamber of 15.2 m long, 1m wide and 0.22 m deep located at 2 m from the upstream end of the flume that collects water and allows free passage of water through the sand bed. Non-Uniform river sand of particle sizes d_{50} = 0.5 mm was used as bed material in the experiments. The seepage flow rate that was measured by an electromagnetic flow meter (accuracy of ±0.5%) could be controlled by a valve which is installed at the downstream end of the flume. The flow depth in the channel was measured with digital point gauge attached to a moving trolley. Main Flow discharge in channel was measured by using the flow depth over the rectangular notch at the downstream collection tank. Non-uniformity in the particle size distribution for the sand was confirmed with the value of geometric standard deviation (σ_g) greater than 1.4 (Marsh *et al.,* 2004). The characteristics of sediment mixture and flow parameters used in study are shown in Table 1.

Table 1 Details of sediment mixture and flow parameters

Sand size d_{50} (mm)	Standard deviation σ_g	Flow depth y m	Discharge, Q m^3/s	Seepage discharge. q_s (%Q)
0.50	1.65	0.116	0.0402	10%

Instantaneous velocity measurements were captured with the help of 4-beam down looking acoustic Doppler probe manufactured by Nortek. Data was collected at the center line of the channel cross section at a distance of 8m from the downstream end of the flume.

Post Processing of ADV data

The data measured from the vectrino contained spikes so, in the present study, we have taken a further step in applying despike ADV and have used the consequent time series to get the velocity profile and Reynolds shear stressat centre position of a vertical section. For despiking ADV data, we have slightly modified in the matlab code developed by Islam and Zhu(2013). The advantage of using modified code is that it will give filtered value of velocity and Reynolds shear stress for full depth profile of a particular section once at a single time. Data recorded from the ADV is in .vno format. Using ExploreV, utility software provided along with the ADV instrumentation, a set of different file formats is extracted from the .vno files. Of these various file formats, we can get the records for the velocity time series in .dat files. The .dat files have been imported to Matlab for further operations. The .dat files stores the data in a matrix of 'N' rows and 19 columns. N is number of the data recorded in a particular time series. Since the data was recorded at a frequency of 200 Hz for a time period of five minutes, N is approximately equal to 40000 for each observation. First column of the .dat file contains the time at which the data has been recorded whereas the second column represents the sample number. There are total 19 data recorded in all different 19 columns, the columns of our interest are columns D, E, F and G representing *u, v, w1* and *w2* respectively, where *u* is the velocity in longitudinal direction, *v* is transverse velocity in vertical direction and *w*1 and *w*2 are velocity components in horizontal transverse directions. Columns D and F are imported to the Matlab workspace and are further used as input arguments to despike ADV functions to get filtered *u* and *w* velocity time-series respectively. Figure 3 shows the unfiltered and filtered velocity time series in stream wise and vertical direction respectively. Figure 1 indicates that unfiltered velocity time series is having highly unrealistic values due to the presence of intermittent spikes contaminating time series measured by acoustic Doppler velocimetry (ADV) while filtered velocity time series contained the very smooth value because of spike removal with the modified code. Apart from the plotting of the velocity time series for *u* and *w*, we have also plotted the power spectral density estimate for a point of observation in the particular section. Power spectral density represents distribution of power over frequency. An inbuilt MATLAB function pwelch() has been used to obtain power spectra. Power spectral density has been plotted for u and w components of the velocity. Pwelch function uses Welch's averaged, periodogram method (also known as Bartlett's method) to return the power spectral density (PSD) estimate of a discrete time-signal. Pwelch makes use of window functions in estimating the PSD. Basic operation that pwelch performs are: multiplication of the time series with a chosen window and Fast Fourier Transformation of the multiplied time series. By default in pwelch, time series is divided into 8 segments with 50% overlap and each segment is then windowed using a Hamming window. There are various types of window functions available, which can directly be used in pwelch. Type of window, length of window, extent of overlapping and sampling frequency can also be set by user.

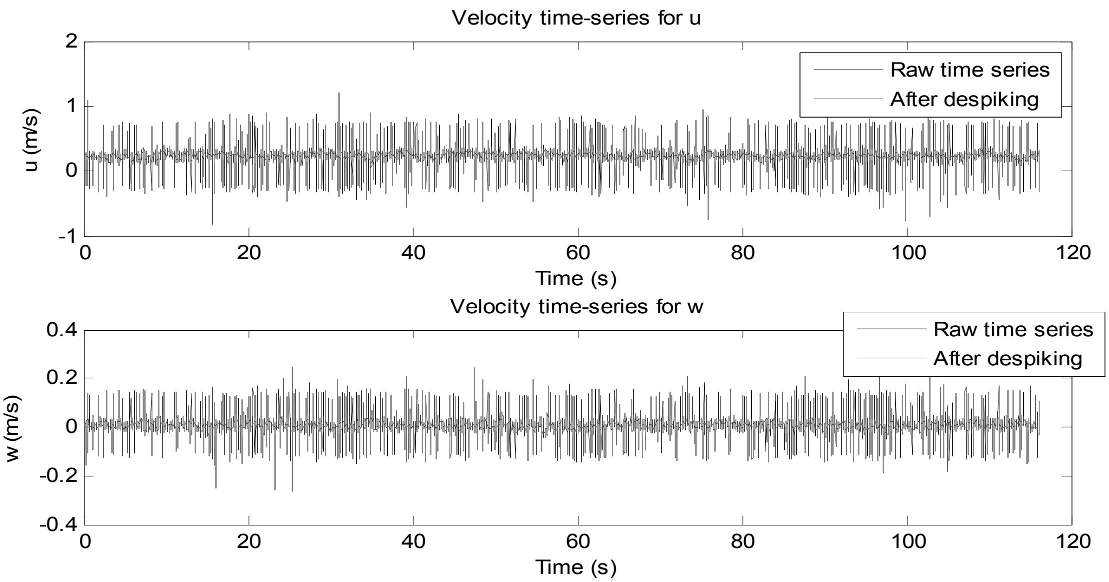
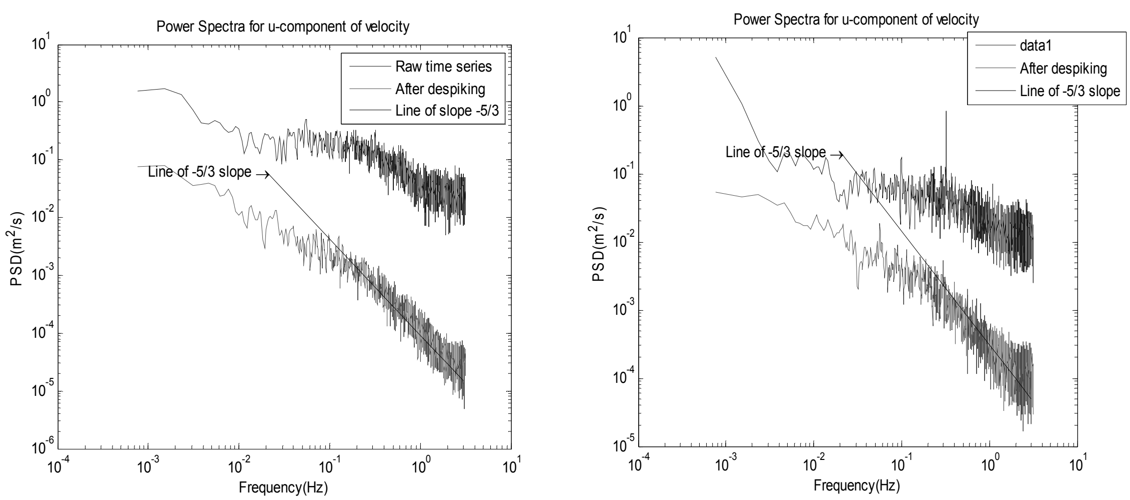


Figure 1 Velocity time series for stream-wise velocity *u* and vertical velocity *w*



(a) (b)

Figure 2 Power spectral density of stream-wise velocity- *u* for (a) 10% seepage and (b) no seepage

There are various input argument and different options available for declaration of pwelch function, based on which there are multiple possible syntaxes of pwelch function. Most general of these syntaxes is:

[pxx,f] = pwelch(x,window,noverlap,f,fs)

Here, all input arguments are optional except x where x is the signal or time-series, window can be any positive integer or a vector. If window is an integer then the windows created is of length window and if window is an vector then the window created is of same length as of vector, noverlap is the length of overlapping between two consecutive segments, it must be a positive integer smaller than the length of window vector or smaller than window in case window is an integer. Power spectral density (PSD) at z=2.34 cm for no seepage and seepage are displayed in the Figure 2where z is flow depth from bed surface. For this particular location, contamination was found to be 54.37 and 52.88% of the total time series for 10% seepage and no seepage conditions. It is observed from Figure 2 that for both no seepage and seepage case, velocity power spectra for filtered data is in good agreement with the Kolmogorov's −5/3 law in the inertial sub range.

Filtered Reynolds Shear stress

Reynolds shear stress (τ_{uw}) was calculated as:

$$\left.\begin{aligned} \tau_{uw} &= -\rho_w \overline{u'w'} \\ \overline{u'w'} &= \frac{1}{n}\sum_{i=1}^{n}\left(U_i - u\right)\left(W_i - w\right) \end{aligned}\right\} \quad (1)$$

Where, Where, U_i and W_i are the instantaneous velocities in the stream wise and vertical directions respectively and n is the number of samples. ρ_w is the density of water, u' and w' are the fluctuating components of velocities in the stream wise and vertical directions, respectively. Figures 3 show the vertical variations of Reynolds shear stress (RSS) in flows subjected to no seepage and seepage runs where the vertical ordinate (z) has been made non-dimensional with the flow depth (y). The shear velocity u_* [$=\left(\tau_0/\rho\right)^{0.5}$] where τ_0=boundary shear stress that are used to normalise the flow and turbulence quantities has been evaluated by the linear projection of the RSS profile on the channel bed which is $\tau_0 = \left(\tau_{uw}\right)_{z=0}$ as given by Nezu (1977). It can be seen from Figure 3that RSS increases along the channel bed are associated with the provided momentum from the main flow to maintain sediment particle motion overcoming the bed resistance and then again decrease towards the boundary because of the presence of a roughness sub layer in the near bed region. In the present experiments, the profiles of Reynolds shear stress distribution were found to be similar for both no seepage and seepage runs but the magnitude is higher in inner layer and lower in outer layer with the application of seepage.

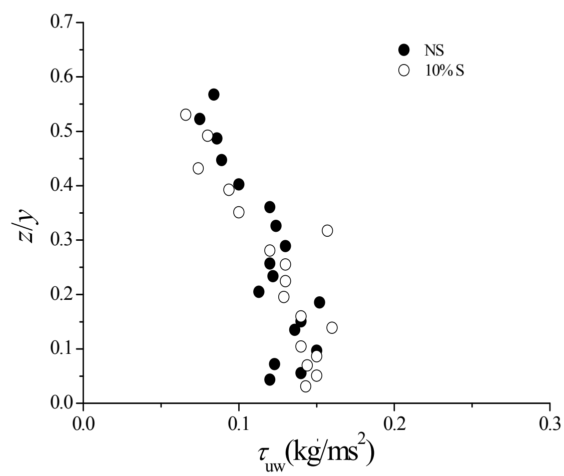


Figure 3 vertical profiles of filtered Reynolds Shear stress in flows

Filtered Time averaged velocity

Time averaged stream wise (u) and vertical (w) velocities were calculated as:

$$\left.\begin{aligned} u &= \frac{1}{n}\sum_{i=1}^{n} U_i \\ w &= \frac{1}{n}\sum_{i=1}^{n} W_i \end{aligned}\right\} \quad (2)$$

Figure 4 shows the variations of time averaged stream wise velocity u with normalised vertical distance (=z/y) in flows subjected to no seepage and seepage for 10%. It is interesting to note in Figure 4(a) that the velocity increased with the application of downward seepage as compared to no seepage for a particular discharge.Experimental data has fitted to theDeshpande and Kumar (2016) log law as expressed in following non-dimensional form.

$$\frac{\overline{U}}{u_*} = \frac{1}{k}\ln\left(z^+ + \Delta z^+\right) - \frac{1}{k}\ln\left(\varepsilon^+\right) \tag{3}$$

Where, $z^+=z/d_{50}$, $\Delta z^+= \Delta z/d_{50}$, Δz is depth of virtual bed level from the bed surface, $\varepsilon^+= z_0/d_{50}$, z_0 is zero velocity level, k is von Karman constant. Average values of the von Karman's constant, depth of the virtual bed level and the zero velocity level are tabulated in Table 2. Value of the k for no seepage condition has been observed to be slightly lower than the universal value (0.41).The downward seepage influenced the bed particles start to move rapidly and value of k drastically decreased to 0.362 with 10% S. Further, from the regression equation shown in Figure 4(b), it is observed that with the application of seepage, the depth of virtual bed level and the zero velocity level from the bed surface increased suggesting an exposure of increased velocity component in the stream wise direction to the particles on the bed surface.

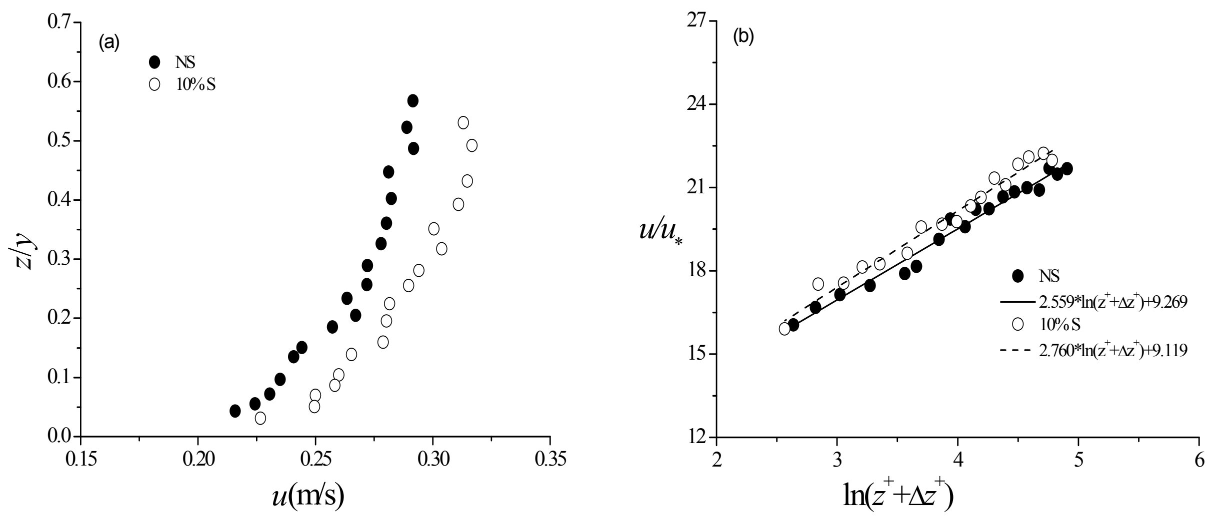


Figure 4 (a) Profile of mean stream wise velocity and **(b)** Velocity logarithmic law

Table 2 Coefficient value observed from log law equation

Flow Condition	u_**(mm/s)*	k	Δz(mm)	z_0 (mm)
NS	13.45	0.390	2.00	0.0134
10% S	14.24	0.362	3.20	0.0184

CONCLUSIONS

An experimental study has been carried out to observe changes in the turbulent characteristics of flow when downward seepage was applied to an alluvial channel composing of non-uniform sediment mixture. At the point of maximum Reynold's shear stress, the measurements are seen to have the most number of contaminants which is evident from the data of the experimental setup used in current study. For some locations contaminants are as high as 54.88% and still the filtered shows good agreement with Kolmogrov's -5/3 law. Therefore, it can be concluded that bivariate kernel-density based despiking is a robust method. The variations of stream wise velocity with vertical distance in flows with downward seepage in the near bed region are greater than no seepage flow. This increase in stream wise velocities was sufficient for increased rate of sediment transport with seepage. The profiles of Reynolds shear stress is slightly scattered in general and increased with seepage which signifies the greater momentum transfer towards the boundary. The distribution of Reynolds shear stress undergoes a damping due to a decreasing level of turbulence fluctuation within the wall shear layer. The thickness of roughness sub layer and shear velocities were increased with the application of downward seepage. The reduced value of von Karman's constant corresponds to increase in the bed load transport with seepage.

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Location Specific Constants in IFD Equation for Solapur Region in Scarcity Zone of Maharashtra

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ABSTRACT

Rainfall intensity- frequency-duration equations are required for design of soil and water conservation and runoff disposal structures and for planning flood control projects. The rainfall intensity-duration-return period relationship as $I = (KT^a) / (t+b)^d$ has been developed for Solapur region under scarcity zone of Maharashtra. The constants K, a, b and d in this equation are location specific. The values of parameters a and b were determined by using graphical method and the values of K and d by least square method. The daily automatic rain gauge charts of Solapur were analyzed in the form of annual maximum series of various durations viz. 5, 10, 15, 30 minutes, 1, 3, 6, 12 and 24 hours. The constants K, a, b and d for Solapur were found as 11.08 0.1892, 1.01 and 1.2066 respectively by analyzing 17 years daily automatic rain gauge charts of Solapur (Barai, 2004). These constants K, a, b and d were now modified to 6.96, 0.2313, 1.00 and 1.1081 respectively by analyzing 28 years daily automatic rain gauge charts.

Keywords: Rainfall intensity-frequency-duration relationship, IFD, Rainfall intensity).

INTRODUCTION

The hydrologic phenomena which directly influence the interest of an engineer are rainfall, runoff, flood and drought. The characteristics of rainfall which are of importance for a design engineer are those which are responsible for producing runoff. These characteristics are intensity, duration, frequency of rainfall, time distribution and geographical distribution. It is not possible to predict accurately the future occurrences of these events from given facts and data in a mathematical manner due to complex nature of hydrologic cycle. Rainfall is one of the most important factors responsible for soil erosion. The characteristics of rainfall viz., amount, intensity and duration play an important role in determining the rate of soil erosion. Greater the intensity of rainfall, greater is the kinetic energy it possesses. The kinetic energy of rainfall dislodges soil particles and splashes them. Among other factors, the amount of runoff is determined by rainfall intensity, duration and rainfall amount. The rainfall of longer duration reduces the infiltration capacity of soil as result produces considerable runoff regardless of its intensity. The capacity of runoff conveyance system is usually based on certain depth of rainfall to be expected during a selected period of time. Farm terraces, culverts, bridges and flood control structures are thus designed on the basis of safely conveying runoff expected from rain storms of specified frequency, intensity and duration.

The significance of rainfall intensity-duration-return period analysis is also important from economic considerations. An overdesigned structure involves excessive cost and underdesigned structure will be unsafe and also involve high recurring expenditure on repair, maintenance and replacement. An appropriate design would provide a structure with reasonable initial and maintenance cost. In order to have optimization in hydraulic design of any structure, the peak rate of runoff expected during the recurrence interval should be correct. This necessitates the knowledge of rainfall intensity-frequency – duration relationship for a particular location.

The rational formula, which is one of the extensively used empirical formula due to its simplicity, for estimating runoff to be expected from small drainage areas. In USA the generalized charts of rainfall intensity-frequency-duration, developed earlier by Yarnell (1935) and now revised by US Weather Bureau (Hershfield, 1961) are being used for obtaining the value of rainfall intensity 'I' in the Rational formula (Ram Babu *et al.* 1979). Since such generalized charts are not available in our country because of insufficient density of automatic raingauge stations, some empirical assumed values of 'I' are used for estimating runoff which needs improvement. Rainfall intensity-duration-return period equations on regional basis are required in the country for design of soil conservation and runoff disposal structures and for planning flood control projects. Such relationships and nomographs have been developed at a few stations scattered over the country (Gupta *et al.*, 1968; Raghunath *et al.*, 1969; Khuller *et al.*, 1975 and Senapati *et al.*, 1976). Nemec (1973) developed the general form of the rainfall intensity- duration- return period equation.

Selection of data

Jarvis (1936) stated that use of annual maximum value is the most practical rain independent events, which are essential in hydrologic frequency analysis. Beard (1974) has shown that the relationship between annual series and partial duration series, flood peak varies throughout the U.S. and recommends the use of empirically derived, regionalized relationship. Raghunath *et al.* (1969), Patel *et al.* (1969), Kharche (1970), Ram Babu *et al.* (1979) and Ranade & Gupta (1988) used the annual duration series method for frequency analysis.

Adequacy of length of record

While analyzing the rainfall data, the adequacy of the length of available record must be ensured for reliable results. Mockus (1960) gave the equation for finding the minimum acceptable years. The values for minimum acceptable years for this study were found less than 28 years for all durations.

Method for frequency analysis

Dalrymple (1960) suggested that for the period of record more than 30 years, the use of mathematical model may be advisable, while for short period of record the graphical method should be preferred.

Probability Paper

In order to linearise the frequency distribution, use of probability paper is made. Hazen (1914) suggested the use of probability paper for linearization of normal distribution. The linearization makes the extrapolation or comparison easy. Ram Babu *et al.* (1979) and Ranade and Gupta (1988) used the log normal probability paper for frequency analysis.

Curve Plotting

Ogrosky and Mockus (1957) developed the 'computing method' for plotting the frequency line by computation of plotted points, which was used by Gupta *et al.* (1968), Handa and Misra (1968), Raghunath *et al.* (1969), Singh *et al.* (1971), Sharma (1973) and Ranade and Gupta (1988).

Analytical Procedure

Various equations that were found to represent the rainfall intensity-duration-return period relationship in India and abroad are summarized and discussed by Raghunath *et al.* (1969). However, the most satisfactory general equation is of the form as given in equation (I).

$$I = \frac{KT^a}{(t+b)^d} \qquad \text{------- (1)}$$

Where,

I = Rainfall intensity, cm/hr

T = Return period, yr.

K, b = Derived constants

a, d = Derived exponents

MATERIALS AND METHODS

Ram Babu *et al.* (1979) has already worked out intensity – duration-return period equations and developed nomographs for the whole country using the relevant data from a large number of raingauge stations. The relationship was developed for Central Zone of India as a whole, which covers a large area. It is necessary to develop such relations which are site specific. In central zone of India the place Solapur is not included. In Maharashtra the values have been determined for Aurangabad, Mahabaleshwar, Mumbai, Nandurbar, Nagpur and Vengurla stations by Ram Babu *et al.* (1979). Since the relationship between rainfall intensity duration and return period is specific for a particular location and mainly depend upon the physical characteristics of rainfall, the relationship developed for one particular location cannot be superimposed on the other. It is necessary to determine the values of constants K, a, b and d for as many locations as possible. Hence, it is necessary to develop such relationship for small units in order that their reliability and applicability will have greater practical significance. Hence, Barai (2004) analyzed 17 years rainfall data of Solapur upto year 2003 and found the values of constants K, a, b and d as 11.08, 0.1892, 1.01 and 1.1081 respectively. Now, the paper is an effort to modify these constants for Solapur region in the scarcity zone of Maharashtra by analyzing 28 years data upto year 2011.

a. Location and climate

The latitude and longitude of Solapur are 17^0 4'N and 75^0 54'E, respectively. The altitude of raingauge station at Solapur is 483.63 m above mean sea level. The climate is usually hot and pan evaporation (PE) far exceeds the precipitation and climatically the area falls under scarcity zone. The annual average rainfall is 723.4 mm. The rainfall is scanty, erratic and ill distributed. The September rains are more assured with relatively high intensity which are responsible for severe soil erosion.

b. Data Acquisition (Automatic raingauge charts)

The daily automatic rain gauge charts of Solapur for the period 1970 to 2011 (except 1973, 1978, 1983-1988, 1992-2000) (total 28 years) were obtained from the observatory of National Agricultural Research Project (NARP), Solapur and analyzed.

c. Collection and preparation of data for analysis

The daily automatic raingauge charts were analyzed in the form of annual maximum series of various durations viz. 5, 10, 15, 30 minutes, 1, 3, 6, 12 and 24 hours.

d. Plotting positions for development of frequency line

The plotting positions were obtained by using the 'computing method' suggested by Ogrosky and Mockus (1957). The values of antilog of mean, antilog of mean plus and antilog of mean minus are the plotting positions corresponding to 50 per cent, 15.9 per cent and 84.1 per cent of abscissa, respectively (Table 1).

Table 1 Plotting positions for development of frequency lines of rainfall intensities of selected durations

Duration, h	Rainfall intensity, mm/h		
	50 % chance line	15.9% chance line	84.1% chance line
0.08	86.90	130.11	58.04
0.16	73.23	111.99	47.89
0.25	66.49	101.64	43.50
0.50	49.45	74.99	32.60
1.0	35.53	57.57	21.93
3.0	16.03	24.45	10.51
6.0	9.00	13.19	6.13
12.0	4.88	7.36	3.24
24.0	2.59	3.81	1.76

e. Development of frequency line

The rainfall intensities were plotted on log-normal probability paper, with rainfall intensities on log scale and per cent chance of occurrence on probability scale. A straight line passing through all the three points was extended so that it intersected with ordinate (Fig.1). This line is called as frequency line of rainfall intensity. The frequency lines were drawn for nine durations and are designated as $I_{0.08}$, $I_{0.16}$, …… and I_{24} for 0.08, 0.16, ……. and 24.0 h durations, respectively. The rainfall intensities for each duration against selected per cent chance (1 %, 2 %, 4 %, 10 %, 25 % and 50 %) were obtained. Return period in years was obtained with the help of following equation,

$$T = \frac{100}{PC} \qquad \text{-------- (2)}$$

Where, T = Return period, year and PC = Per cent chance.

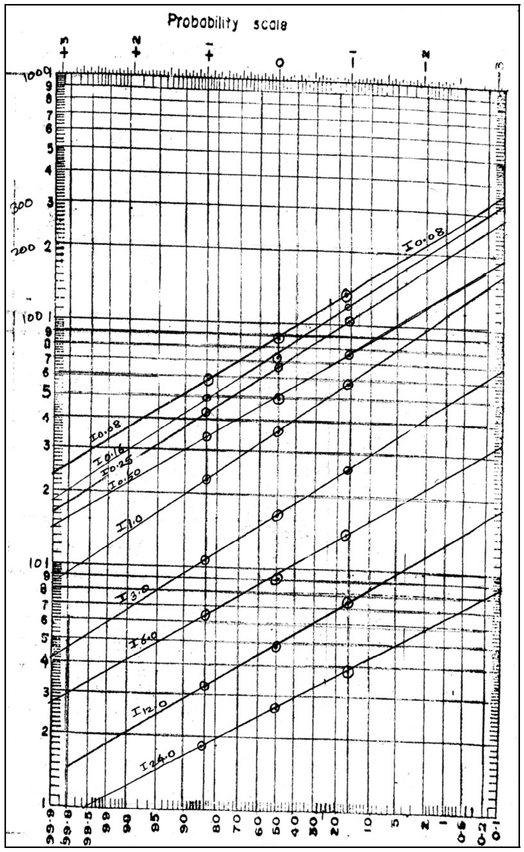

Figure 1 Frequency distribution of rainfall intensities for various durations at Solapur.
(log scale = rainfall intensity, mm/hr, (probability scale = percent chance of occurrence)

The rainfall intensities for selected frequencies and return period for selected durations are given in Table 2.

Table 2 Rainfall intensities for different return period and selected durations

Duration, h	**Per cent frequency**					
	1%	**2%**	**4%**	**10%**	**25%**	**50%**
	Return period, year					
	100	**50**	**25**	**10**	**4**	**2**
	Rainfall intensity, mm/h					
0.08	250.0	230.0	190.0	155.0	120.0	90.0
0.16	240.0	200.0	170.0	140.0	105.0	74.0
0.25	195.0	170.0	150.0	120.0	90.0	66.0
0.50	140.0	120.0	110.0	88.0	68.0	50.0
1.0	120.0	96.0	85.0	79.0	50.0	36.0
3.0	48.0	42.0	35.0	30.0	22.0	16.0
6.0	25.0	22.0	19.5	16.0	12.5	9.6
12.0	13.0	12.0	10.5	8.4	6.6	5.0
24.0	6.7	5.8	5.2	4.3	3.5	2.6

f. Testing for adequacy of length of record

The minimum acceptable years of record were determined by using the equation suggested by Mockus (1960). The test works in terms of numbers of years of record used, that is, in terms of sample size. This method is represented by following equation :

$$Y = (4.30 \ t \log_{10}R)^2 + 6 \qquad \text{------------------ (3)}$$

Where, Y = minimum acceptable years of record

t = Student's 't' at 10 per cent level of significance

R = Ratio of magnitude of the 100 year event to the 2 year event

The values of R and Y were calculated for all the nine durations and tabulated in table 3.

Table 3 Computation of minimum acceptable years of record.
(t_{10}=1.7171 at 22 (n-6=28-6=22) d.f.)

Duration, h	**Rainfall Intensity, mm/hr**		**R = (2)/(3)**	**$\log_{10}$R**	**$Y = (4.30\ t \log_{10}R)^2 + 6$**
	100 year event	**2 year event**			
(1)	(2)	(3)	(4)	(5)	(6)
0.08	250	90	2.78	0.44	16.75
0.16	240	74	3.24	0.51	20.21
0.25	195	66	2.95	0.47	18.03
0.5	140	50	2.80	0.45	16.90
1	120	36	3.33	0.52	20.88
3	48	16	3.00	0.48	18.41
6	25	9.6	2.60	0.42	15.39
12	13	5	2.60	0.41	15.39
24	6.7	2.6	2.58	0.41	15.24

The values of 'Y' for all durations obtained from the test of the length of record are found less than 28 years (Table 3). The data analyzed for the present study are of 28 years, hence the length of record considered was found adequate.

In order to evaluate the coefficients K, a, b and d for frequency curves, the following steps are involved (Ram Babu *et al.* 1979).

g. Geometric mean slope

The values of rainfall intensities from table 2 for all durations were plotted on Y-axis and values of return period on X-axis on log-log paper (Fig. 2). All the points connected by a thin dotted line giving more weightage to points from 10 year to 100 years return period. The dotted line was extended to cut the Y-axis against 1-year return period. The scale distance of all slope lines was measured from X-axis. The slope of the individual dotted lines for each duration was determined. The geometric mean slope ($\bar{m}$) for the entire set of lines was determined. The geometric mean slope of the lines represents the exponent 'a' in the equation and found as 0.2313. The detailed procedure is given in Table 4.

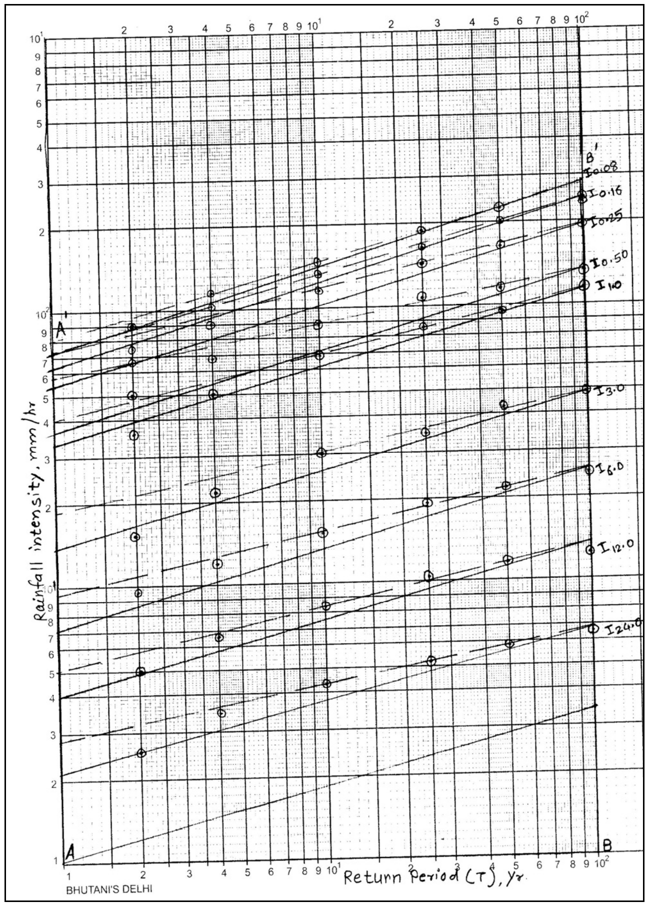

Figure 2 Rainfall intensities for selected durations and return period at Solapur.

Table 4 Determination of geometric mean slope of frequency lines or the value of exponent 'a' in the formula, $I = K\,T^{a} / (t+b)^{d}$ at Solapur.

Frequency line	**Scale distance (cm) from x-axis**		**Difference (col.2-col.3)**	**length of Line AB**	**Slope = Col 4 / Col 5**	**Logarithmic value of col. 6**
	B1	**A1**				
1	2	3	4	5	6	7
$I^{0.08}$	18.5	14.1	4.4	14.9	0.2953	-0.530
$I^{0.16}$	17.6	13.5	4.1	14.9	0.2752	-0.560
$I^{0.25}$	17	12.9	4.1	14.9	0.2752	-0.560
$I^{0.50}$	15.7	12.1	3.6	14.9	0.2416	-0.617
$I^{1.0}$	15.2	12	3.2	14.9	0.2148	-0.668
$I^{3.0}$	12.4	9.5	2.9	14.9	0.1946	-0.711
$I^{6.0}$	10.4	7.2	3.2	14.9	0.2148	-0.668
$I^{12.0}$	8.4	5.3	3.1	14.9	0.2081	-0.682
$I^{24.0}$	6.1	3.3	2.8	14.9	0.1879	-0.726
			Sum			-5.722
			Mean			-0.636
			Antilog (Mean)			0.2313
			Geometric mean slope			0.2313
			Hence the **factor a**			**0.2313**
			Factor T^{a}			$T^{0.2313}$

h. Rainfall intensity of one year return period

A line representing the geometric mean slope was drawn at the base through origin as shown in Fig. 2. The solid lines parallel to this slope line were drawn by cutting the y-axis against 1-year return period. The rainfall intensities against 1-year return period for the corresponding durations are presented in Table 5. The old and new plotting positions are shown in Fig. 2.

i. Estimation of constant ‘b’

The values of rainfall intensities of one year return period on Y-axis and selected durations on X-axis plotted on log-log paper (Fig. 3). The points so plotted do not fall in a straight line. To make the points aligned into a straight line, suitable constant ‘b’ is needed. After adding this constant in the values of durations the points were aligned into a straight line. The estimated value of ‘b’ for Solapur was found as 1.0.

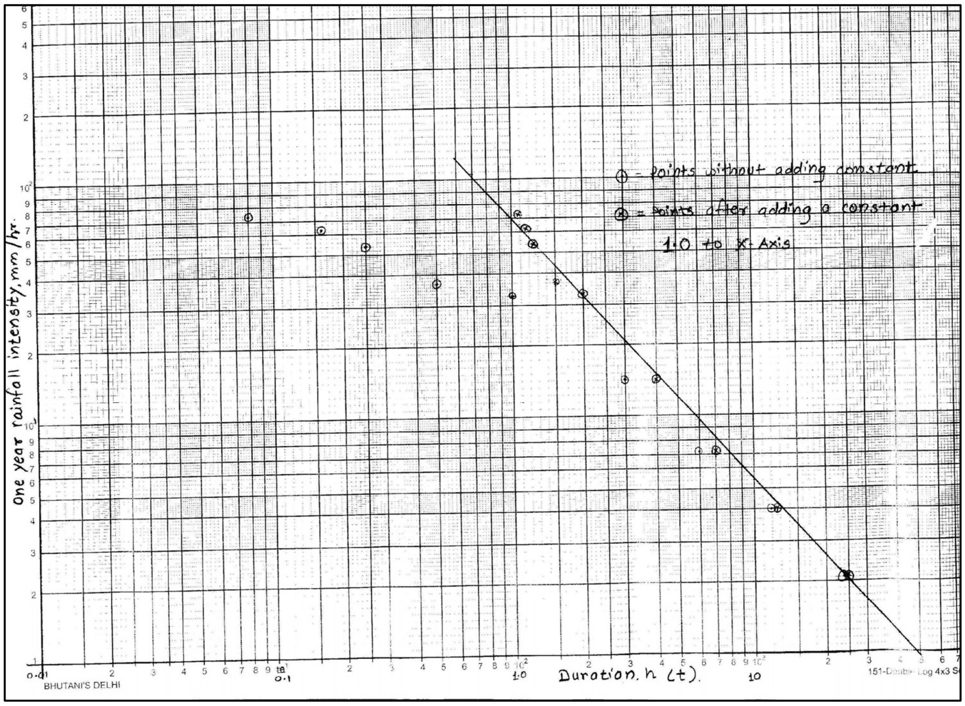

Figure 3 Fitting of constant ‘b’ in the equation at Solapur.

j. Estimation of constants ‘K’ and ‘d’

The constants ‘K’ and‘d’ are solved by least square method. In this method the values of one year (T=1 year) rainfall intensities for selected durations and the values of ‘K’ and ‘d’ were determined by solving the following equation.

$$I = (K) / (t + 1.0)^d \qquad \text{--------- (4)}$$

The equation in its logarithmic form can be written as, log I= logK- d log (t + 1.0), which is in a straight line form. The constants ‘K’ and‘d’ are then solved by least square method by solving the following equations.

$$\log K = \frac{\sum \log I . \sum \left[\log(t+b)^2 - \sum \left[\log I . \log(t+b) \right] \sum \log(t+b) \right]}{n \sum \left[\log(t+b) \right]^2 - \left[\sum \log(t+b) \right]^2} \qquad \text{-------- (5)}$$

$$d = \frac{\sum \log I . \log(t+b) - n \sum \log I . \log(t+b)}{n \sum \left[\log(t+b) \right]^2 - \left[\sum \log(t+b) \right]^2} \qquad \text{--------- (6)}$$

By solving above equations, the values of K and d are K= 6.96, d = 1.1081

At this stage, the frequency factor, $T^{0.2313}$ as obtained, is included to give the rainfall intensity-duration-return period relationship

$$I = \frac{6.96\ T^{0.2313}}{(t + 1.00)^{1.1081}}\ cm/h \qquad \text{--------- (7)}$$

RESULTS AND DISCUSSION

The constants K, a, b and d in the rainfall intensity-frequency-duration equation developed by Barai (2004) by analyzing 17 years daily automatic raingauge charts for Solapur were 11.08, 0.1892, 1.01 and 1.2066 respectively. These constants were modified to 6.96, 0.2313, 1.00 and 1.1081, respectively by analyzing 28 years daily automatic raingauge charts for Solapur. The equation for intensity of rainfall (cm/h) based on duration (h) and frequency (year) for Solapur station with modified constants becomes

$$I = \frac{6.96\ T^{0.2313}}{(t + 1.00)^{1.1081}}\ cm/h \qquad \text{--------- (8)}$$

By using above equation, the intensity of rainfall for any duration, t upto 24 hours and any return period T upto 100 years can be determined.

CONCLUSION

The location specific constants K, a, b and d for Solapur region in the scarcity zone of Western Maharashtra were modified to 6.96, 0.2313, 1.00 and 1.1081, respectively.

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Drainage Line Treatments for Sustainable Crop Production in Vidarbha Region of Maharashtra

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Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.)

ABSTRACT

During drought years, supplemental irrigations at critical stages may be essential not only to prevent mortality of crops but also to maintain a required vigor for normal productivity. This can be achieved through drainage line treatment in which judicious mix of ancient knowledge, modern technology, public and private investment and above all, people's participation will go a long way in reviving and strengthening water harvesting practices throughout the country. Availability and storage of water in reservoirs and lakes depends ultimately on yearly rainfall. Natural conservation of water and efficient use of this natural storage and at the same time making arrangements for additional recharge of groundwater aquifer by one way or other, to replenish the used groundwater becomes our responsibility. Thus on drainage line networks the rainwater harvesting is possible by constructing suitable structures. The project CRP on Water was initiated at Kajaleshwar - Warkhed watershed which is situated in Barshitakli taluka of Akola district in Maharashtra. The work of nala widening and deepening has been done under this project and the existing CNB was repaired. The rainwater was harvested in the nala and was used in *kharif* for soybean crop during the one month dry spell from 13th August to 13th September 2016 at which the soybean is at pod filling stage. This dry spell of one month severely affected the soybean pod filling resulting into very poor yields of soybean in dryland conditions. One protective irrigation during this dry spell from stored water resulted in significant increase in yield as compared to rained condition i.e without irrigation. Overall 31-40% increase in yield was observed due to protective irrigation provided during the critical growth stage of pod filling to soybean crop.

Keywords: Crop, CNB, nala, yield.

INTRODUCTION

In recent years, decline and deterioration of natural resources (NRs) has emerged as a serious concern for sustainable food production in our country. Optimization of NRs, inputs, and diversification/intensification of cropping system through optimized use of lands are the major issues for sustainable agriculture development. Many regions in the country are characterized by variable and low rainfall and the soils have low productivity. The fragile ecosystems in the dry areas are prone to degradation. Groundwater is one of the major resources necessary for the overall socio-economic development and management of any area and it requires careful development and proper investigation of groundwater level. Groundwater resources evaluation in many areas of the country is important for the developmental strategies of integrated watershed development and management. The extensive spatial-temporal changes in the occurrence of ground water resources warrant scientific exploration to locate best sites for tapping this valuable resource. It has many other advantages over surface water. Fast industrial growth, urbanization and rise in agricultural manufacture have led to freshwater lacks in many parts of the world. For suitable supply of water for various purposes like agronomic, domestic and industrial, a greater importance is being laid for a planned and optimal utilization of water resources. The water intake for agriculture, municipal and industries is higher than the yearly recharge. This may lead to reduction of ground water (Magesh et al., 2011; Thomas et al., 2012; Selvam et. al. 2012, Rangarajan 2009). The remote sensing technology can be combined within a GIS environment for a successful description and management of watershed functions and conditions (Khadri and Kanak Moharir 2015 and Khadri and Chaitanya Pande 2016). Minor et. al. (1994) has developed an integrated analysis plan to describe groundwater resources and groundwater management for monitoring and identification of observation well locations in Ghana with the help of remote sensing, GPS and GIS technology. With increased population and higher water demand for industrialization, water availability becomes a major constraint to agriculture including aquaculture and animal husbandry. The further scarcity of water for different agricultural production systems should be checked for sustaining the food security through efficient water conservation and management practices. There is a need for adoption of advanced agricultural and water management practices to produce more per drop of water. Moreover, the policy decisions on water management are more important for water resource development and effective adoption of water efficient techniques in country level.

Study Area

The Kajaleshwar and Warkhed watershed is situated in Barshitakali Taluka, Akola district of Maharashtra between 20°13′59” N latitude and 77° 13’23’’ E longitude and at an altitude of 337m above M.S.L. with an average annual rainfall of 845mm. The important aquifers in the area are basalt rock. Basalt, when weathered and fractured contain considerable amount of groundwater. Location of Kajaleshwar - Warkhed watershed is depicted in Fig 1.

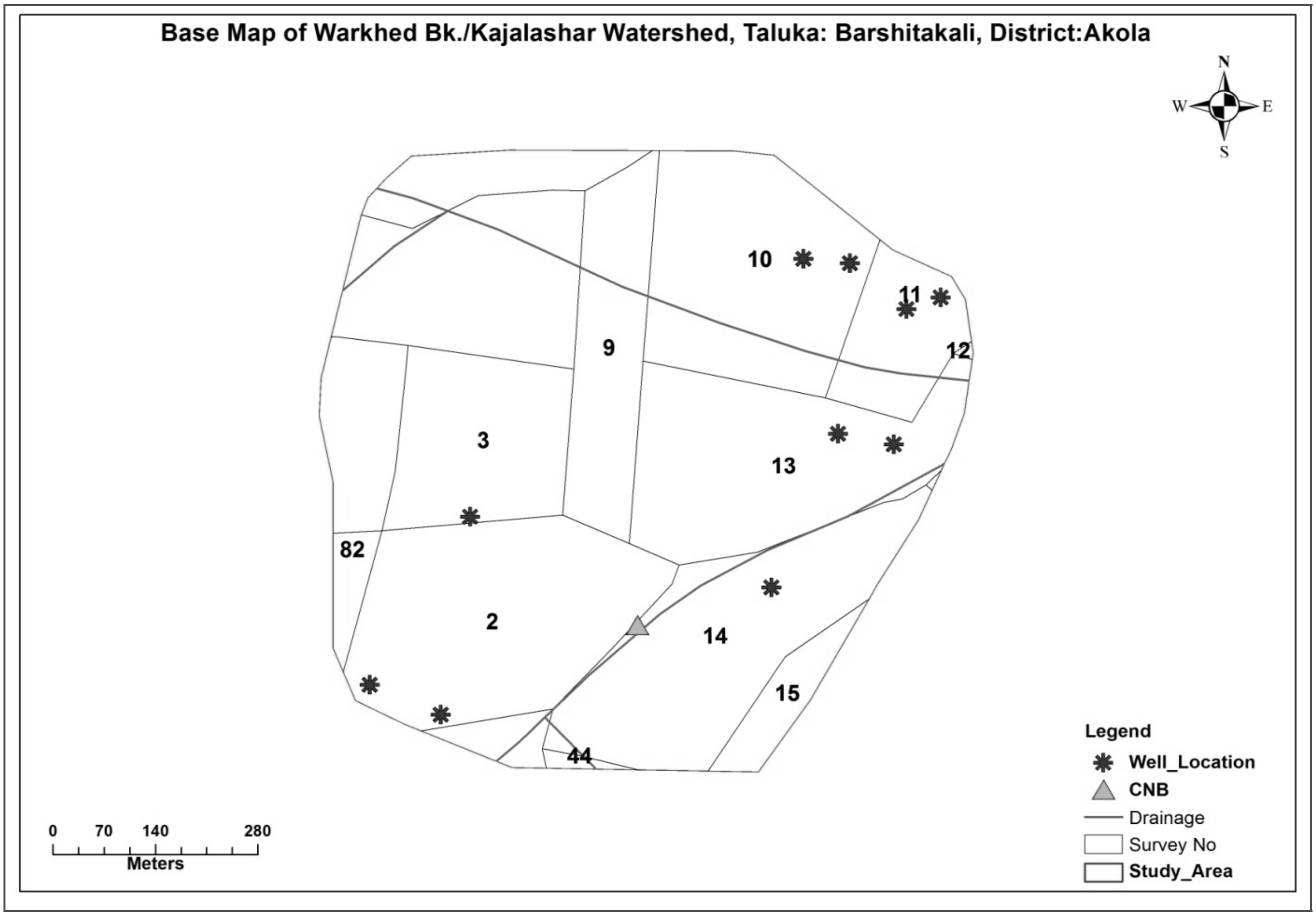

Figure 1 Location map of Kajaleshwar -Warkhed Watershed

The SRTM (30m) data set of Space Shuttle Endeavor satellite has been used to create Digital Elevation Model. The DEM data is very effective tool for terrain analysis, many terrain attributes (such as slope, aspect, relief, and watershed hill shade and flow direction) can be used for location of rain water structure. The following methodology has been used to derive the contour maps from the said dataset, which are used as layers in GIS domain for further analysis. The one meter interval contour map was generated from digital elevation model using surface analysis tools in Arc GIS software 10.1. The contour map is very useful for survey of rain water harvesting structure work. In demonstration site topographic analysis is most important for suitable location of artificial recharge work and also the lowest and highest elevation ranges was observed such as 325 to 337 meters (Fig. 2). The contour map of the area is given in Fig.3.

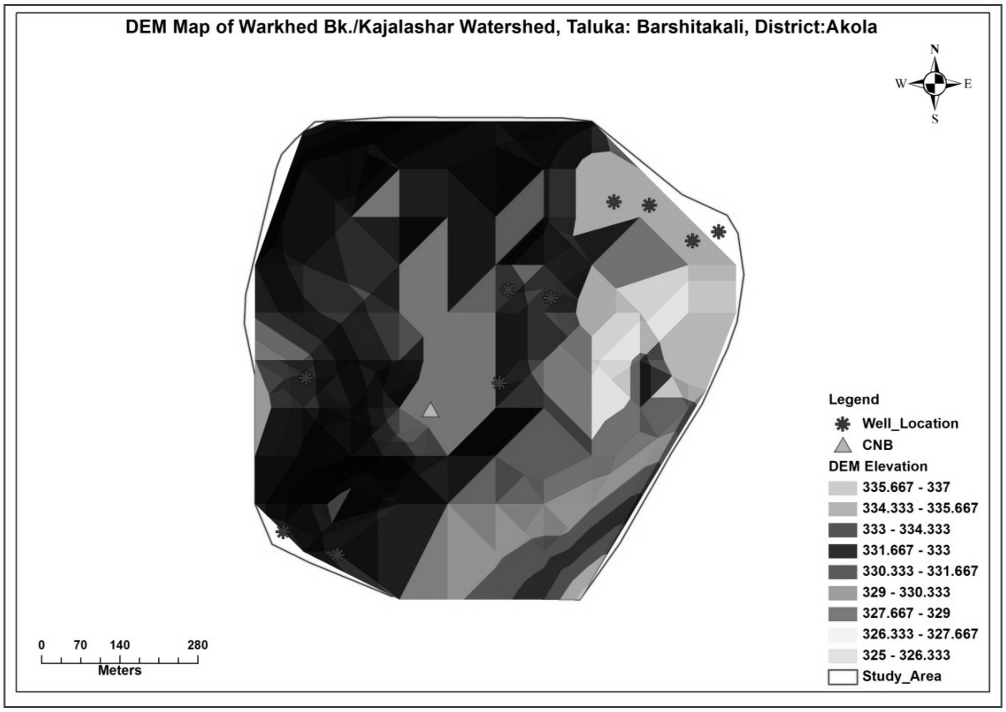

Figure 2 Digital Elevation Model map of Kajaleshwar -Warkhed Watershed

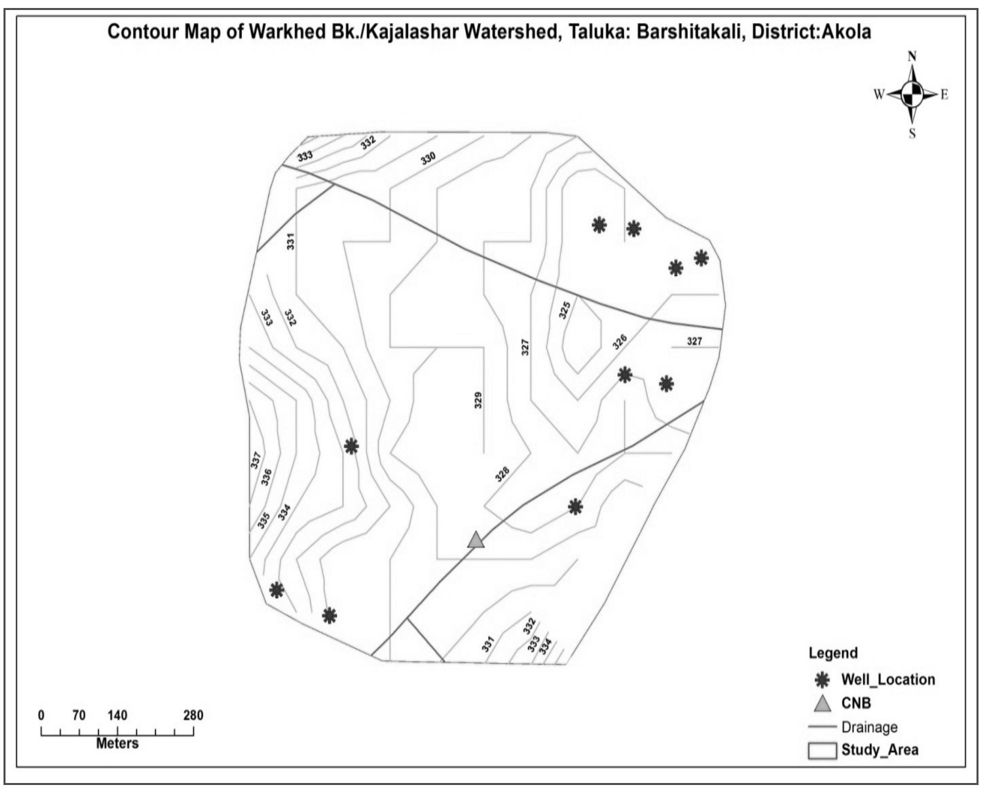

Figure 3 Contour map of Kajaleshwar - Warkhed Watershed

Soil slope is considered as an important factor in soil genesis and land use. In demonstration site soil slope ranges of 1-3% and 3-5% was observed with the help of multispectral satellite image. The soil slope map is prepared from LISS-III satellite images and ground checking with the help of visual interpretation techniques in GIS environment software and is depicted in Fig.4.

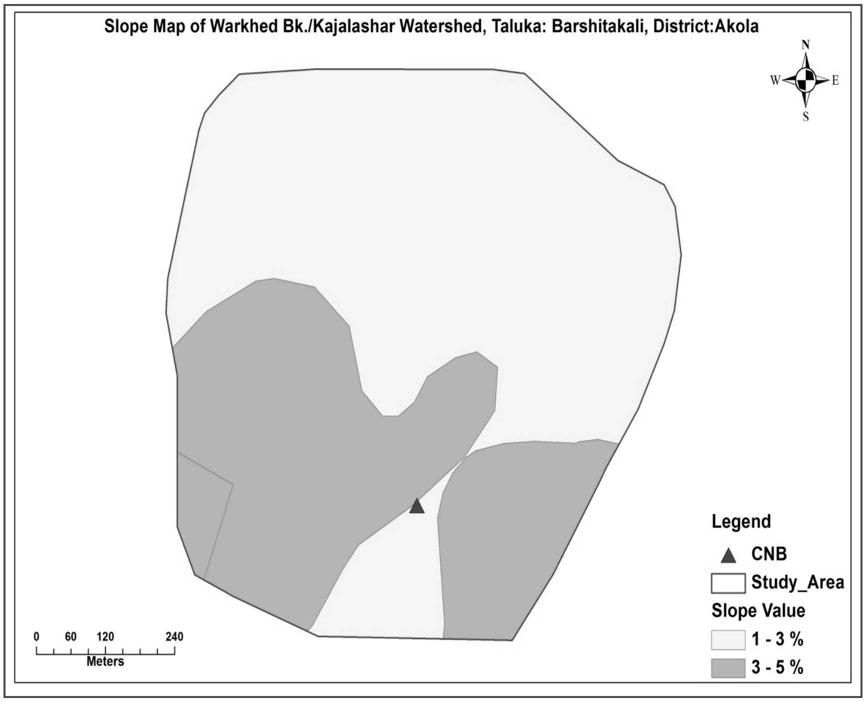

Figure 4 Soil slope map of Kajaleshwar -Warkhed Watershed

Land Use Land Cover Mapping

By applying visual interpretation techniques in Arc GIS 10.1 software the analysis of land use land cover mapping was done by using LISS-III satellite images(23.5m resolution) and LANDSAT ETM satellite images(30m resolution) for the year 2015 and 2016. In the demonstration site the land was categorized into two land classes of agricultural land and waste land. The land use land cover maps for the year 2015 and 2016 are depicted in Fig. 5 and 6 respectively. It was observed that after implementation of the project the major part of the waste land has been converted into Agricultural land and it can be seen from above mapping.

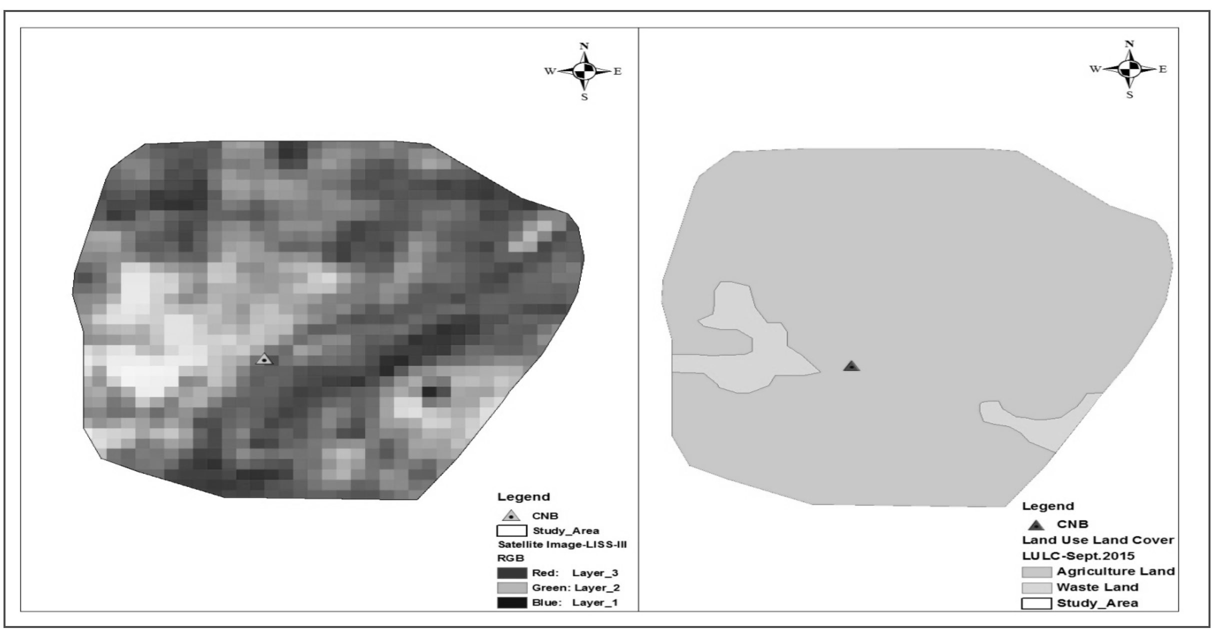

Figure 5 Satellite Image and Land Use and Land Cover map of Sept. 2015

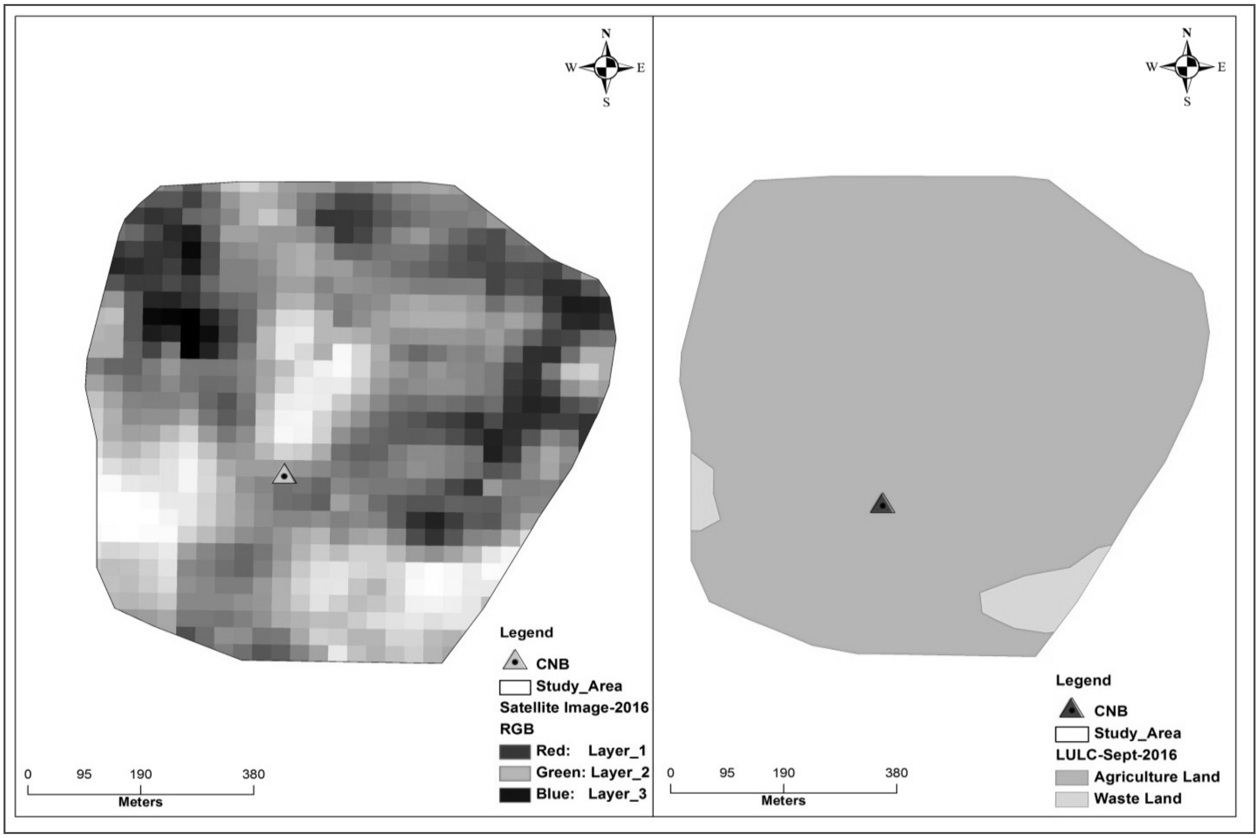

Figure 6 Satellite Image and Land Use and Land Cover map of Sept. 2016

Rainwater Harvesting and Impact Analysis

The work of nala widening and deepening has been done under this project and the existing CNB was repaired. Due to this work the rainwater was stored in the nala and the stored water was used in *kharif* for soybean crop and will be utilized in *rabi* season for gram. In the vicinity of the deepened and widened nala / CNB ten wells have been monitored for ground water levels. During *kharif* season the stored water was used for soybean crop during the one month dry spell from 13th august to 13th September 2016 at which the soybean is at pod filling stage. This dry spell of one month severely affected the soybean pod filling resulting into very poor yields of soybean in dryland conditions. One protective irrigation during this dry spell from harvested water in the widened and deepened nala / CNB resulted in significant increase in yield as compared to the dryland condition i.e without irrigation. 31-40% increase in yield was observed due to protective irrigation provided during the critical growth stage of pod filling from the data recorded from farmers as per the Table 1.

Table 1 Yield of soybean crop during *kharif* 2016

S. No.	Name of farmer	Yield of soybean qt/ha (without irrigation)	Yield of soybean Q/ha (One protective irrigation at pod filling stage from water stored in widened and deepened nala/CNB)	% increase in yield.
1	Beneficiary-1	9.37	12.40	32.33
2	Beneficiary-2	8.50	11.10	30.50
3	Beneficiary-3	11.60	15.25	31.40
4	Beneficiary-4	6.25	8.75	40.00

Deepened and widened nala and CNB at Kajaleshewar

CONCLUSION

During *rabi* 2016 the harvested water in the CNB was utilized for gram and it was observed that due to availability of water the farmers could provide the protective irrigation to the gram and thus the single cropping pattern changes to double crops and due to yield increase income generation for the farmers is possible. Based on the pre and post project implementation data regarding, water storage, reuse of stored water, yield economics, increase in groundwater levels, availability of water in the surrounding wells, cropping pattern it can be recommended to undertake the deepening and widening of existing drainage line network along with construction or repairing of the permanent structure and reuse of harvested water through micro-irrigation in the entire Vidarbha region of Maharashtra for sustainable crop production and water resources development.

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Strategies for Development and Management of Water Resources in Rainfed Area

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ABSTRACT

Water resources can be developed by adopting the concept of catchment management. Strategies of water conservation and management in rainfed areas should be planned and adopted. On arable cropped lands with very shallow, shallow medium deep and deep soil cover; contour cultivation is recommended to achieve higher crop yield and *in-situ* rainwater and soil conservation. The fields having the slope in one direction at least the sowing and cultivation across the slope needs to be adopted. Development of good perennial vegetation systems on degraded lands is possible with CCT's layout. Adoption of CCT layout at 5-6 m horizontal interval (H.I.) resulted in 97 per cent *in -situ* rainwater conservation. The farm pond technology for rainwater harvesting and its reuse should be adopted by constructing farm ponds / dug-outs at suitable locations. After adoption of proper *in-situ* conservation techniques and construction of suitable harvesting structures, the work of drainage line treatments should be undertaken to harvest the water which otherwise flow into the river. For this purpose suitable drainage line structures like CNB should be constructed and the stored water can be used for supplemental irrigation purpose depending upon the crop requirement. Also due to water storage in the structures for longer time the groundwater recharge will be more and the surrounding wells around these structures will be having maximum gain in water levels and thereby overall increase in the water table of the area could be possible. With these techniques the maximum amount of rainwater will be recharged into the ground and ultimately the water resources development and management is possible which ultimately useful for sustainable crop production in rainfed area.

Keywords: *In-situ*, rainwater, water resources, CCT, CNB, groundwater.

INTRODUCTION

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. 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. The country is already experiencing water shortage and the problem become very acute in the near future unless preventive measures are taken on substantial scale. India possesses 4% of the total average annual run off in the rivers of the world. The per capita water availability of natural run off is at least 1100 cubic meters/yr. The utilisable surface water potential of India has been estimated to be 1869 cubic kms but the amount of water that can actually be to put to beneficial use is much less due to severe limitations imposed by physiographic, topographic, interstate issues and the present technology to harness water resources economically. The recent estimates made by the Central Water Commission indicate that the water resources utilisable through surface structures is about 690 cubic kms only (about 36% of the total). Ground water is another important source of water. Of the total 329 M-ha of land, it is estimated that only 266 M-ha possess potential for production. Of this, 143 M-ha is agricultural land. It is estimated that 85 M-ha of land suffers from varying degrees of soil degradation. Of the remaining 123 M-ha, 40 Mha is completely unproductive. The balance 83 M-ha is classified as forest land, of which over half is denuded to various degrees. It is alarming to note that the per capita availability of land is half of what it used to be same 35 years ago. This would further reduce as our country's population continuous to grow. At present 141 M-ha of land is being used for cultivation purposes. Between 1970-71 and 1987-88 the average net sown area has been 140.4 M-ha. The need for production of food, fodder, fibre, fuel in the crop growing areas have to compete with the growing space require for of inadequate planning and inefficient management of water resources projects will severely constrain the growth of net sown area in the future.

Our country is of diverse agro-ecosystems and cropping preferences. Indian agriculture is being dominated by rainfed agriculture that accounts 68 per cent of the total net sown area (136.8 million hectare) spread over 177 districts. The great challenge of the agricultural sector is to produce more food from less water. With rapidly growing population, the pressure on limited fresh water resources increases. Due to erratic nature of rainfall, irrigation become a mean to counteract the effect of climate change beside other advantages as increase in crop yield, protection from famine, cultivation of superior crops, elimination of mixed cropping and economic development. Therefore understanding the soil water regime of rainfed regions is important for efficient rainwater conservation for its optimum uses for practical soil water management and thus water resources development is very essential in rainfed area of the country.

Management practices in rainfed area

In rainfed agriculture, scarcity of water is the main problem. Apart from the low and erratic behavior of rainfall, high evaporative demand and limited water holding capacity of the soil constitute the principle constraint in the crop production in dryland areas. Yield fluctuations are high mainly due to vagaries of weather, often much behind the risk bearing capacity of the farmers. It is surprising to a layman that even humid areas with 2000 mm of annual rainfall not only suffer from moisture stress, but also face drinking water scarcity. Monsoon starts in the month of June and ends in last week of September or sometimes in the first week of October. Most of the rainfall is received during this period. With undulating topography and low moisture retention capacity of the soil, major portion of the rainwater is lost through runoff, causing erosion and adding to the water logging of low lying areas. After the rain stops, very little moisture is left in the profile to support plant growth and grain production. In dryland area deficiency and uncertainty in rainfall of high intensity causes excessive loss of soil through erosion which leaves the soil infertile. Owing to erratic behavior and improper distribution of rainfall, agriculture is risky, farmers lack resources, tools become inefficient and ultimately productivity is low. The problems can be solved by adopting the following improved technologies,

- Crop planning
- Planning for aberrant weather
- Crop substitution / Cropping system
- Rainwater management
- Water-shed approach
- Resource improvement and utilization
- Alternate land use system

Strategies of Water Conservation in Arable Lands

A) ***Preventive measures***

Water conservation through soil management: Mulch farming, conservation tillage, rough seed bed, contour cultivation, ridge furrow system of planting, formation of tie ridges and soil conservation systems

B) ***Control measures***

a. ***Slope management through***

(i) Terracing
(ii) Contour bunds

b. ***Runoff management through***

(i) Surplus water disposal structures
(ii) Grassed Waterways
(iii) Soil Conservation structures
(iv) Rainwater harvesting

Results and Recommendations

At the experimental farm of AICRPDA, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Agricultural University) the various research experiments of *in-situ* rainwater conservation and water resource management had been conducted. Based on the results of some of these experiments, following recommendations has been made. These recommendations are useful for water resources development in rainfed area.

A. Rainwater management

1. *In-situ* moisture conservation through toposequence based cropping in Vidarbha region

On sloppy fields (up to 3% slope), cotton (Rajat) in the lower toposequence covering about 30% area is replaced by soybean (PKV-1) - chickpea (ICCV-2) sequence cropping instead of cotton. For demarcation of such area, Vetiver keyline is established in the beginning of the system which also helps in moisture conservation.

The yields of soybean (915kg ha^{-1}) and chickpea (410kg ha^{-1}) are significantly higher under lower toposequence compared to sole cotton (498kg seed cotton ha^{-1}). Monetary returns from this toposequence based cropping are 40% higher over the farmers practice of sole cotton in entire field. This improved system, reduced the runoff and soil loss to an extent of 24 and 20%, respectively. This improved system besides providing higher monetary returns also reduces soil loss and runoff due to canopy architecture of soybean.

2. Vegetative barriers for reducing runoff and soil loss and increasing crop productivity

For reducing runoff and soil loss and increasing crop productivity, vegetative keyline of vetiver or Leucaena should be developed on contours and cultivation should be done along the vegetative key lines on contour.

The reduction in runoff was observed to be in the tune of 40-50% whereas, the reduction in soil loss was observed to be 70-75% in case of vegetative barriers as compare to across the slope sowing. Uniform moisture distribution due to contour cultivation gave higher productivity in case of test crops i.e. sorghum and cotton to the extent of 15 and 20%, respectively.

B. Alternate land management

Continuous Contour Trenches for perennial plantations

As per requirement contour lines are demarcated on selected plot and lines are drawn parallel to these guide lines with 5-6m row spacing of desired plantation. On these lines a continuous contour trenches of 60 x 30cm are excavated such that the upper fertile soil is collected on upstream side and below murum is spread at downstream side in the form of bund with suitable berm. Then the fertile soil is used to fill mound in the trench on desired distance as per plant to plant spacing. The mound is used for plantation and remaining trench is left for rainwater conservation.

Figure 1 Continuous Contour Trenches

- There was no surface runoff in the CCT treated catchment as compare to untreated catchment *i.e.* the runoff in CCT treated catchment (100%) was recharged in the soil.
- The highest yield of pod and grain of greengram was observed in the treatment of CCT treated catchment (271.75 and 170.48kg ha^{-1}) as against untreated catchment (162.45 and 106.84kg ha^{-1}).
- The soil moisture status in CCT treated catchment was observed to be better as compared to the untreated catchment at 0-15, 15-30 and 30-45cm depth in every recorded month.
- On an average during the nine months (2013-14) the ground water recharge in the CCT treated catchment was more by 17.74 % compared to the non treated catchment.

Impact: The CCTs are useful in order to increase infiltration into soil, to control damaging excess runoff and to manage and utilize runoff for groundwater recharge. The *in-situ* conservation of rainfall takes place in CCT treated catchment. The prolonged moisture in the CCT treated catchment will enhance the growth of perennial plantation. The groundwater recharge in the CCT treated catchment was more.

C. Rainwater Harvesting

Rainwater harvesting in farm pond and its reuse

The *in-situ* moisture conservation practices are necessary to harvest rainwater for augmenting of crop yield through protective irrigation. Nevertheless the practice is not being adopted by the farmers on large scale. Also while constructing the farm pond the site specifications viz. catchment area and the rainfall-runoff relationship are not considered. Therefore the farm ponds are not being constructed with proper design and at proper location. Thus the rain water harvesting is not at desired level and the chance of failure and under utilization of water becomes the hassle in adoption. Three different catchments were considered at the experimental field of All India Co-ordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Based on the rainfall-runoff relationship from three catchments, the capacity of the farm pond has been designed considering the location specific parameters.

Dimensions of farm pond

Table 1

Catchment no./Farm pond no.	Catchment area (ha)	Runoff from the catchment (cu m)	Capacity (cum)	Top dimensions (m x m)	Depth (m)	Side slopes
1	3.5	4154	2753	45 x 27	3.0	1.5:1
2	5.0	4748	4265	60 x 30	3.0	1.5:1
3	2.0	1582	370	18 x 11	3.0	1:1

Average annual rainfall = 791.28mm

Expected area which can be provided protective irrigation

Depending upon the amount of rainfall and the intensity of rainfall, the runoff from the catchments can be accumulated in the farm ponds. On the basis of availability of water in the farm ponds and as per need the protective irrigation can be given to the crops in *Kharif* , *Rabi* season as well as to different vegetables.

Table 2

Depth of water in the farm pond (m)	Availability of water in the farm ponds (cu m)			Expected area which can be provided protective irrigation from the available pond water considering 10 % losses (ha)		
	Farm pond 1	Farm pond 2	Farm pond 3	Farm pond 1	Farm pond 2	Farm pond 3
Full	2753	4265	370	4.95	7.68	0.66
2.5	2294	3554	307	4.13	6.40	0.55
2.0	1836	2844	246	3.30	5.12	0.44
1.5	1377	2133	184	2.48	3.84	0.33
1.0	918	1422	123	1.65	2.56	0.22
0.5	459	711	61.5	0.83	1.28	0.11

It is observed that one protective irrigation for soybean during *kharif* resulted in yield increase of 23.78% over rainfed crop. Similarly during *rabi* the increase in yield of chickpea over rainfed crop was 45.44%. The farm pond water was used for irrigation to different vegetables by using micro-irrigation systems. It was found that in the vegetable like Okra, Cluster Bean, Brinjal, Sponge Guard, Bitter Guard, Fenugreek, Spinach, Corriander, Carrot, Radish, and Tinda the water use efficiency was in the range of 1.05 - 4.50 kg/m^3. The total income from these small vegetables plots during the season 2015-16 is Rs.7868. Computed total income from these vegetables is Rs.73395/ha.

D. Rainwater Harvesting Structures on Drainage line

The work of nala widening and deepening has been done alongwith repair of the existing CNB. The rainwater was harvested in the nala and was used in *kharif* for soybean crop during the one month dry spell from 13th August to 13th September 2016 at which the soybean is at pod filling stage. This dry spell of one month severely affected the soybean pod filling resulting into very poor yields of soybean in dryland conditions. One protective irrigation during this dry spell from stored water resulted in significant increase in yield as compared to rained condition i.e without irrigation. Overall 31-40% increase in yield was observed due to protective irrigation provided during the critical growth stage of pod filling to soybean crop. Based on the pre and post project implementation data regarding, water storage, reuse of stored water, yield economics, increase in groundwater levels, availability of water in the surrounding wells, cropping pattern it can be recommended to undertake the deepening and widening of existing drainage line network along with construction or repairing of the permanent structure and reuse of harvested water through micro-irrigation in the entire Vidarbha region of Maharashtra for sustainable crop production and water resources development.

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Flood Inundation Mapping and 1-D Hydrodynamic Modelling using SWAT and GIS

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ABSTRACT

Extreme events like floods and droughts are of concern for any country in the context of the damage caused to life as well as property. This situation calls for adequate management measures such as flood plain mapping, in order to minimize the extent of damage. ASTER (Advance Space Borne Thermal Emission and Reflection Radiometer) DEM (Digital Elevation Model) along with gridded precipitation, temperature, land use and soils data used for the basin. A distributed hydrologic model, SWAT (Soil and Water Assessment Tool) was used to quantify the land management practices in watershed. Log Pearson Type-III distribution was used to find the flow magnitudes correspond to various recurrence intervals. Flood is a spatial phenomenon, which could be best presented using a geospatial tool like GIS (Geographic Information System). In order to determine the extent of inundation, a 1-D model, HEC-RAS (Hydraulic Engineering Center-River Analysis System) was used. HEC-GeoRAS with Arc GIS was used for creating maps of flood inundation depth and extent. Therefore, this study demonstrated the usefulness of these models as exploratory tools for identifying critical sections of the reach for detailed analysis.

Keywords: ASTER, Floods, DEM, HECRAS.

INTRODUCTION

Flood is one of the most common hydrologic extremes frequently experienced by any country. The rainfall received in India is not uniformly distributed both in time and space. According to government of India flood statistics, about 4,00,000 km^2 [9] of area is getting inundated due to floods every year. Tamil Nadu has been frequently affected by severe floods and has suffered from many flood disasters in terms of the population affected, frequency, extent of inundation and socio-economic costs. According to Rashtriya Barh Ayog, the area of flooding extent in Tamil Nadu is 4,500 km^2. The state of Tamil Nadu has 17 river basins [6] among which Thamiraparani is the second largest basin. Most of the Thamiraparani catchment area lies in the Western Ghats; hence, the river is benefited by both the South-West and North-East monsoons which make the river perennial. The river is prone to heavy floods, especially during the North-East monsoon season (October to December) and occasionally due to thunderstorms. Due to rapid land use changes, encroachment and sedimentation, the rivers may not be able to carry the excessive runoff resulting from heavy rains of high intensity. As a result the river overflows and water enters the flood plain. Flood water surface elevation information is important to know the depth of the flooding. Accurate water surface elevations can be computed using a hydraulic model. Long-term continuous discharge measurements are available only in few locations across the Indian River basins. Since the current study is agricultural watershed, so the flow values at these locations can be simulated using hydrologic model, SWAT [2] based on landuse practices, crop management, irrigation scheduling and reservoir operation. The datasets used in the current study include the following:

- ASTER DEM of 30m resolution
- Land use data based on LANDSAT imagery.
- Soils data obtained from the Tamil Nadu agricultural university.
- High resolution (0.5° × 0.5°) daily gridded rainfall data (1971-2005) developed by India Meteorological Department (IMD) [15].
- 1ºX1º daily temperature data from IMD (1969 to 2007).

Methodology

SWAT is a complex physically based distributed parameter hydrologic model developed by the United States Department of Agriculture (USDA), which operates on a daily time step [3] and [4]. In SWAT surface runoff is estimated using the SCS curve number procedures from the daily rainfall data. Based on the annual maxima of discharge predicted by SWAT at different reach segments, flood frequency analysis was carried out to predict the flood magnitudes of various recurrence intervals. Log-Pearson Type III distribution is often the preferred statistical technique for flood frequency analysis. The flow values for different recurrence intervals from this technique is given as input into a hydraulic model, HEC-RAS to estimate the water surface profiles. Flood inundation map is generated using HEC GeoRAS by comparing water surface TIN (Triangulated Irregular Network) with DEM, to compute the water surface elevation in the channel and flood plain. The overall modeling sequence is shown in figure 1.

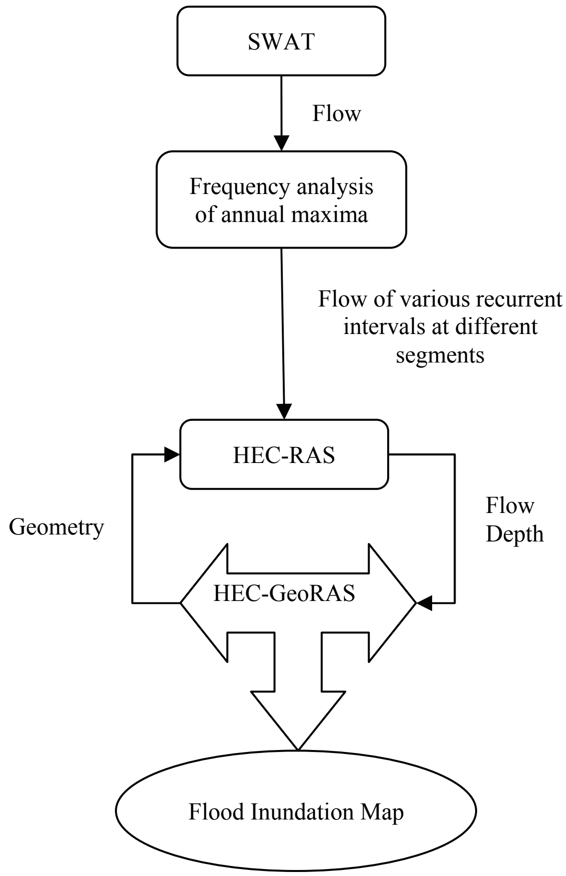

Figure 1 Overall Methodology

Model setup

Hydrologic modeling was carried out by using a distributed hydrological model SWAT. The data required to setup SWAT include topography, land use, soil, weather and land management practices. Accordingly, the ArcGIS SWAT model setup involves five major processes: 1) Watershed delineation 2) Landuse and Soil setup 3) Hydrologic Response Unit (HRU) definition 4) Weather data and 5) Land management information. Watershed delineation is the process of identifying the natural drainage pattern in the river basin for delineating the streams, demarking the contributing watershed area and subdividing a large river basin into small subunits called sub basins. ASTER DEM at 30m resolution is used to perform watershed delineation. For identifying the actual stream network in the river basin, the images from Google earth (around 700) were georeferenced and mosaiced in ArcGIS software. From these mosaiced images, the actual stream network was manually digitized in the vector format. Using ArcSWAT, the digitized vector stream network was burnt into the DEM thus forcing delineated stream network to follow the actual stream network as visible in the Google Earth imagery. The manually added outlet points for this delineation was based on eight stream gauges (PWD) and six reservoirs present in the watershed. Based on these manually added outlets and the natural topography, the watershed was divided into 139 sub basins as shown in Figure 2.

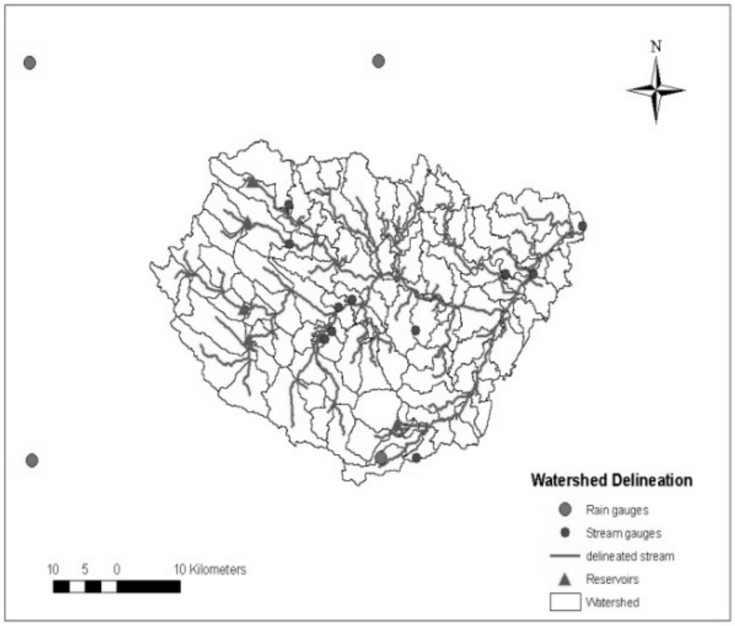

Figure 2 Watershed Delineation

The landuse data for the Thamiraparani study area was developed by using image classification techniques on landsat 2006 imagery. The accuracy of the image classification based on field survey is about 93%, shown in figure 3.1. The GIS data on soils were obtained from the Soil and Crop Science Department, Tamil Nadu Agricultural University (TNAU). The soils in the watershed are equally distributed between hydrologic groups as shown in figure 3.2. Based on the unique land use and soil type combination, the sub basins were further subdivided into HRU's (Hydrologic Response Unit) for hydrologic simulation

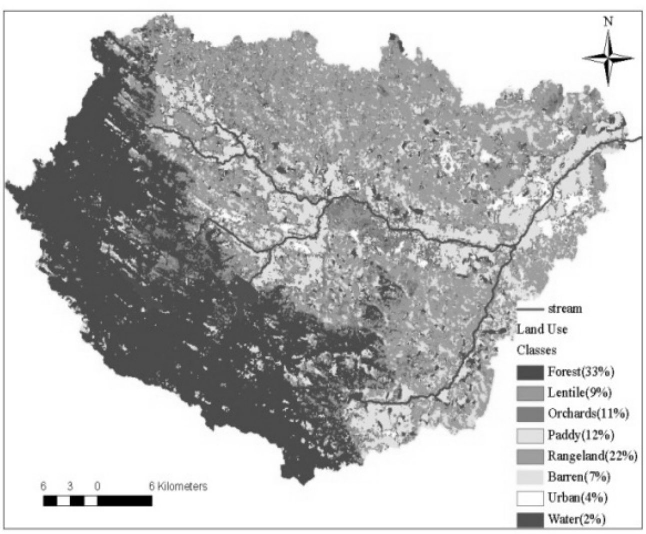

Figure 3.1 Land Use Classification

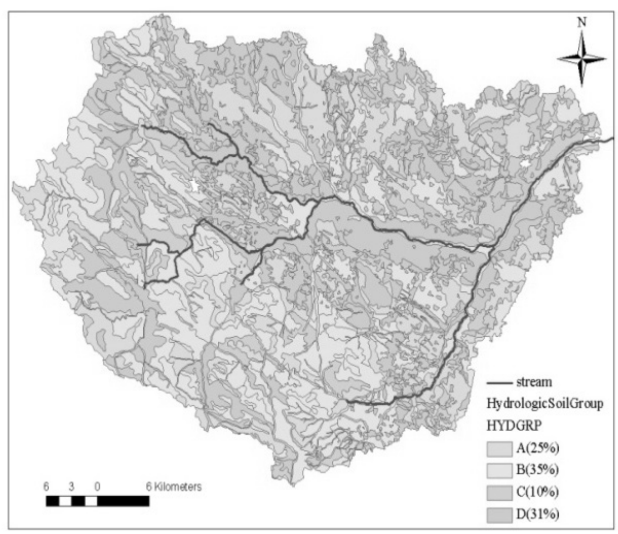

Figure 3.2 Soil Classification

Based on the unique land use and soil type combination, the sub basins were further subdivided into HRU's (Hydrologic Response Unit) for hydrologic simulation. HRU represent a patch of land within the sub basin with similar land use and soil. 2,022 HRUs were identified based on the threshold criteria for simulation. The simulated flows were summed at HRU level to sub watershed level and then routed through the stream system using hydrologic routing (variable-storage method).

SWAT needs daily rainfall, maximum and minimum temperature, solar radiation, relative humidity and wind speed etc. for hydrologic simulation. The high resolution gridded precipitation data viz., 0.5º×0.5º, maximum and minimum temperature developed by the India Meteorological Department (IMD) and the solar radiation, relative humidity and wind speed data is used as weather database for this model. Four rain gauge stations are falling in the study area is shown in figure 4. These four stations daily rainfall values are used to generate flow values.

Quality controlled rainfall data from more than 6,000 rain gauge stations all over India for the period 1971-2005 [16]. Daily rainfall data for the four grid points within the study area were used for hydrologic simulation. The monthly average rainfall values for each grid points are shown in Figure 4.

Considering the limited rainfall data of IMD stations over study region, suitability of another resource of satellite data namely Tropical Rainfall Measuring Mission (TRMM) which is a joint mission of NASA and Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rain fall. This IMD annual average rainfall data is compared with TRMM (Tropical Rainfall Measuring Mission) 15 years annual average rainfall data and presented in the Table No:1.

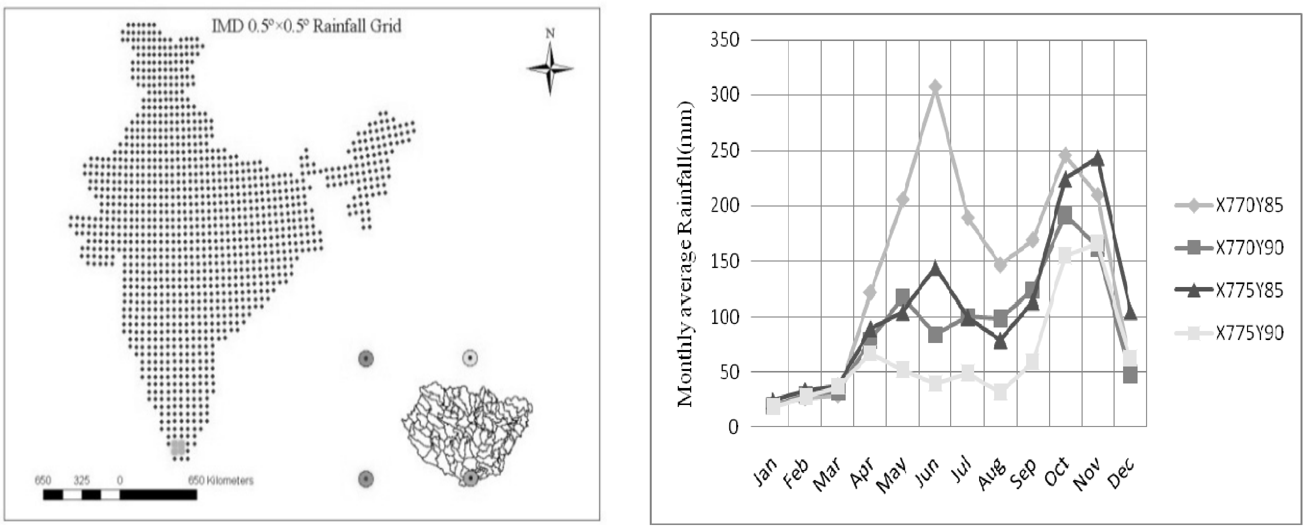

Figure 4 Locations of IMD Rain gauge Data Considered for SWAT Model and Montly rainfall variation

The difference may be attributed to differences in rain fall monitoring technology and duration of data which are in acceptable level for this hydrological modeling. For accurate hydrologic simulation, land management information such as crop type, general crop plan and irrigation (quantity and schedule) is important. In the current study, it is noticed that flooding in the downstream reaches is significantly influenced by the reservoirs located upstream. The flood releases and storage in reservoirs depend on the status of reservoir storage during the flood event and the quantity of water released for irrigation during the cropping season respectively.

Table 1 Comparison of IMD Data with TRMM Data

X-Longitude Y-Lattitude	IMD Annual Average Rainfall (mm)	TRMM Annual Average Rainfall (mm)	Difference (%)
X775Y90	795	1236	38.6
X775Y85	1295	1175	9.27
X770Y90	1050	1979	46.9
X770Y85	1782	1785	0.16

The storage and discharge specifications for these six reservoirs were obtained from. The area which reservoir should support for irrigation is calculated by using a thumb rule that one cubic meter of water is needed to irrigate 11,646 ha of paddy crop [7]. Considering this as preliminary information the cropping pattern is simulated in canal and the well irrigated area. Based on the reservoir area for each crop, the sub basins coming under the command of each reservoir were assigned as shown in the figure 5.

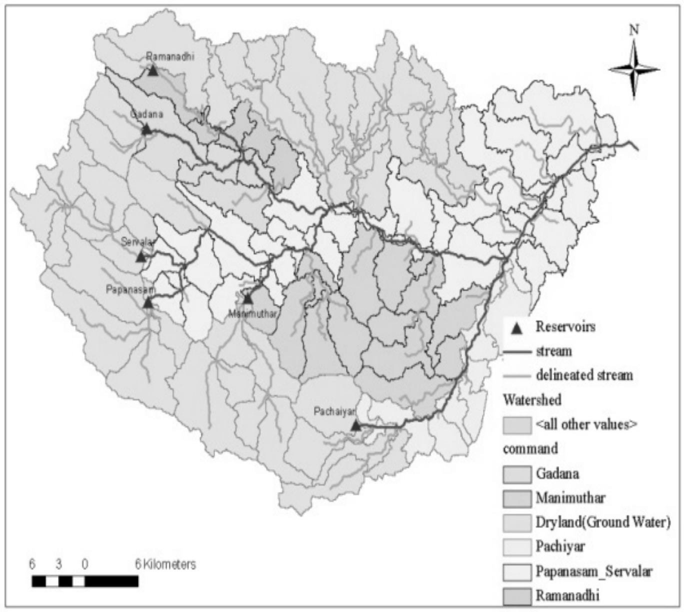

Figure 5 Reservoir command area for irrigation

Planting, irrigation, and harvesting are the three important agricultural operations simulated by the model. Simulation of irrigation water on crop land can be simulated on the basis of five alternative sources: stream, reservoir, shallow aquifer, deep aquifer and external source. The irrigation source was assigned based on the available water from different sources. Based on the flow available in each reservoir, area to be irrigated and irrigation operations, single cropping and double cropping patterns are assigned. The result from this base simulation (with default parameters) is subsequently used in flood frequency analysis.

Among many SWAT parameters, the five critical parameters which affect the runoff volume are ESCO (Soil Evaporation Compensation factor), CN (Curve Number), K_{sat} (Saturated Hydraulic Conductivity), SURLAG (Surface Runoff Lag) and AWHC (Available Water Holding Capacity). As the flow values predicted by SWAT could not be calibrated or validated due to lack of measured data, the flow values simulated by SWAT are taken as primarily data based on default parameter values. Hence, a sensitivity analysis on flood plain mapping is performed on SWAT parameters that would increase the flow to a maximum, another combination of parameters that would reduce the flow to a minimum.

RESULTS AND DISCUSSIONS

Four scenarios were run with SWAT to study the impact of flow simulation on flood inundation. The scenarios include virgin flow simulation (without any reservoirs) and flow simulation for the current hydrologic condition (with reservoirs). Further, with the present hydrologic setting, to study the effect of model parameters, critical SWAT parameters were changed within a reasonable range. SWAT model is simulated for flows with default model parameters (DEFAULT), parameter combinations that would increase the flow (MAX) and parameter combinations that would decrease the flow (MIN). The cumulative flow plots shown in figure 7, clearly demonstrates that, as expected, the volume of flow and the flow magnitudes predicted without the reservoirs will be higher than with the reservoirs. Flood frequency analysis is carried out for these four simulations of the daily flow values. The frequency plots for the different SWAT simulations are plotted for upstream Reach 1 and downstream Reach 9 as shown in figure 6.1 and figure 6.2 respectively.

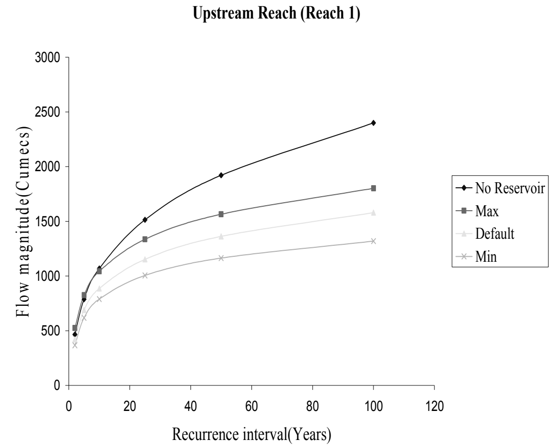

Figure 6.1 Frequency Analysis for the Upstream of the reach

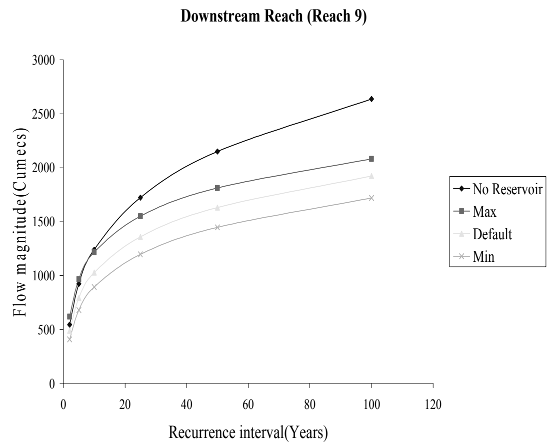

Figure 6.2 Frequency Analysis for the Downstream of the reach

Flood Inundation Mapping

Flood inundation mapping was done for the four model scenarios. For illustration purpose the inundation maps of only the DEFAULT scenario of 2 year and 100 year flood for one critical section is shown in figure 7.

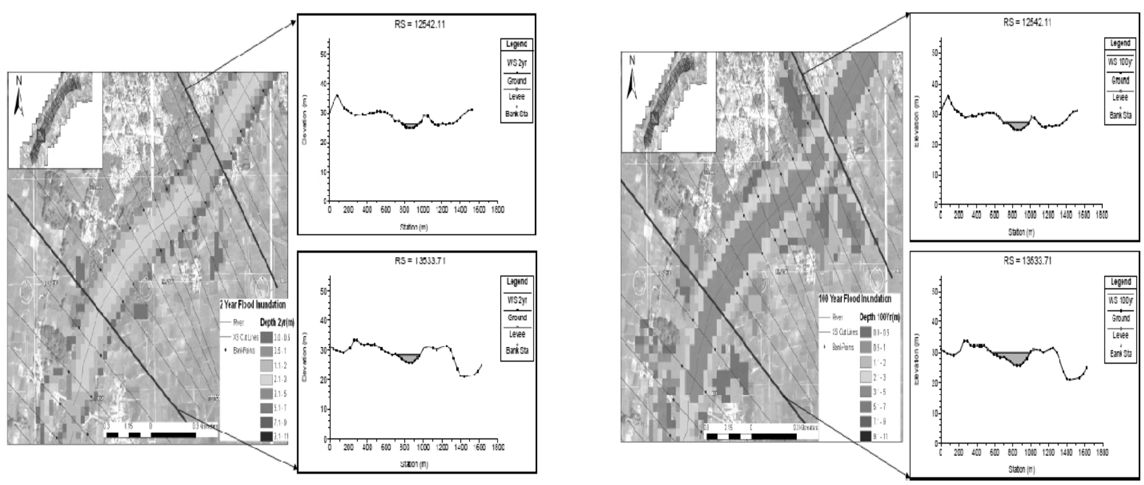

Figure 7 Two year and 100 year Flood Inundation Map with Water Surface Profiles at two Cross Sections as Part of Thamiraparani River Basin

CONCLUSION

With the increasing availability of GIS data, the combination of SWAT, HEC-RAS and GIS models provides a method for modelling and visualizing the spatial distribution of the catchment response for a given storm event in terms of flood inundation area. It is confirmed that, TRMM data may also be applied for such hydrological studies data in the absence of ground based rain gauge data. The hydrologic analysis from this study shows that SWAT model could be used to get a reasonable estimate of the hydrology with minimal calibration. The results of the model could be further improved if dense network of weather stations are available along with a good network of stream gauge data.High resolution digital elevation model or detailed channel cross section is not available for this study. In spite of this, the study demonstrates that ASTER DEM of 30 m resolution with artificially burned streams could be used for exploratory flood plain study of large watersheds. Future studies could focus on how this limitation could be overcome with the model.

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Application of Swat Model for Watershed Prioritization

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ABSTRACT

A few areas of the watershed are critical and responsible for high amount of soil erosion. Implementation of best management practices is required in those critical erosion prone areas of the watershed for controlling the soil erosion. Identification of these critical areas is essential for the effective and efficient implementation of watershed management programmes. In this study, Soil and Water Assessment Tool (SWAT) model for a small watershed (Dudhi) is used for identification and prioritization of critical sub-watersheds to develop an effective management plan. A GIS based distributed approach using MUSLE formulations is used for soil erosion assessment. Daily rainfall, Maximum and minimum temperature data of six years (1997-20002) are used in the study. Besides these data, the soil, landuse, DEM, and drainage map of study area are used in the study. A geographical information system is used for generating the watershed and sub-watershed boundaries, drainage networks, and soil series. Supervised classification method is used for landuse/cover classification from satellite imageries. The weighted average value of parameters such as runoff curve number, surface slope, channel length, average slope length, channel width, soil erodibility factor and other soil layer data are taken for each sub-watershed (HRU) to verify the model. Critical Sub-watersheds are identified on the basis of average annual sediment yield. The erosion rates and their classes are used as a criterion for identifying the critical sub watersheds. Out of the 33 HRU, six fell under high soil loss group, six HRU fell under very high soil loss group, five fell under severe soil loss group and five HRU fell under very severe soil loss group. Remaining HRU fell under slight soil loss group. The region prone to high rate of soil erosion associated with scarce irrigation facilities or scarcity of water are identified and considered for the study purpose. Dudhi watershed experiencing heavy rainfall accompanied with high intensity rains having excessive runoff and soil erosion are considered for study purpose.

Keywords: Hydrological Modeling, SWAT, Watershed, Erosion. Runoff, HRU.

INTRODUCTION

The Resource considerations for implementation of watershed management programmes or various other reasons related to administration or even political considerations may limit the implementation of management programmes to a few sub-watersheds only. Even otherwise, it is always better to start management measures from the most critical sub-watershed, which makes it mandatory to prioritise the sub-watershed available. Watershed prioritization is thus the ranking of different critical sub-watersheds of a watershed according to the order in which they have to be taken up for treatment and soil conservation measures. The intensive study of individual watersheds is necessary to enable management plans to be developed and also to apply the results of one watershed, to another with similar characteristics. Effective control of soil and nutrient losses requires implementation of best management practices in critical erosion prone areas of the watershed. It can be enhanced by the use of physically based distributed parameter models, remote sensing technique and geographic information system that can assist management agencies in both identifying most vulnerable erosion prone areas and selecting appropriate management practices. The current study is undertaken with the use of a validated model i.e. SWAT to identify the critical sub-watersheds on the basis of estimated sediment yield of a small watershed for the purpose of developing effective management plan.

MATERIALS AND METHODS

Study Area and Data Collection

In the present study, the study area is taken as Dudhi micro-watershed of Madhya Pradesh state (Figure 1). Dudhi micro-watershed is a treated watershed where intervention activities had been undertaken by Regional Research Laboratory (RRL), Bhopal as a Project Implementing Agency (PIA) under the project Rajiv Gandhi Watershed Mission (RGWSM) of the Madhya Pradesh (MP) state government.

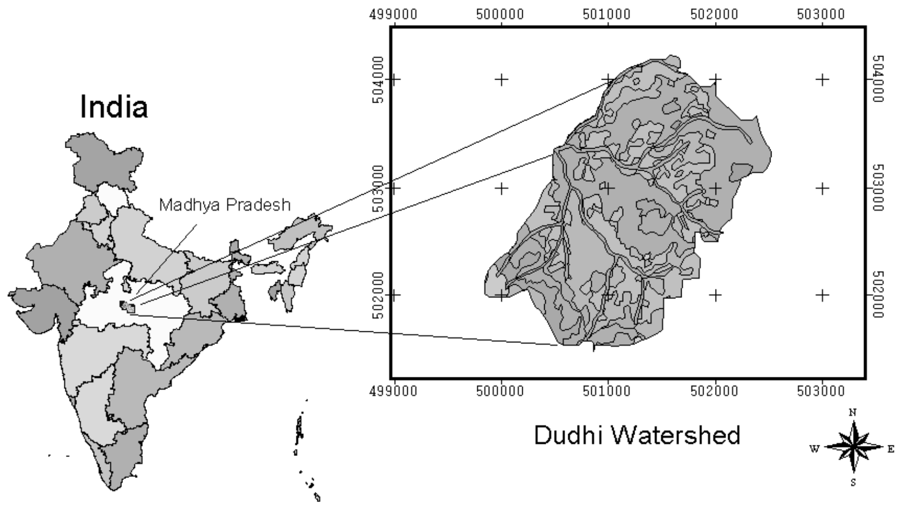

Figure 1 Location of the Dudhi micro-watershed in Madhya Pradesh, India

The study area is located at about 100 km away from Raisen town towards the north-east, and is bounded by north latitudes 23°24’ to 23°26’ and east longitudes 78°31’ to 78°33’ and lies on Survey of India (SoI) topographical map SOIT No. 55 I/11. The area is characterised by undulating topography with steep valley and flat plateau tops. The altitude of area is ranging from 585 m to 710 m above MSL. Dudhi micro-watershed covers approximately 405 ha of land area. Several streams originate from the hilly region yielding high amount of runoff causing erosion in hilly slopes and adjoining agricultural fields. Various thematic maps, namely contour, drainage, landuse/land cover, and soil maps have been generated from the IRS-1B (LISS II) satellite data on 1:12500 scale for the study of watershed. Daily rainfall, minimum and maximum temperature, and annual values of relative humidity and wind speed data of the rain gauge station at Dabri and Imaliya for six years (1997-2002), were collected from, Raisen District; Madhya Pradesh has been used in the study. Based on available rainfall data, the average yearly rainfall for the present study area is computed as about 1240 mm.

Extraction of Watershed parameters for the model

The watershed and HRU boundaries and drainage networks maps are generated using ArcView GIS software. The automatically delineated watershed is used for study. Since SWAT works on sub-watersheds basis, the delineated watershed is subdivided into 33 HRU on the basis of topography. In this study each HRU is coded as 1 to 33. The curve numbers (CN) for average antecedent moisture condition (II) are obtained by combining the two raster coverages of hydrological soil groups and landuse based on the SCS (1972) look up table (Table 4.1). Thus, the runoff computation by SCS curve number method requires two attributes to be stored for each grid viz., the hydrologic soil type and land use. Other input parameters for each HRUs, such as overland and channel slope, channel length and average slope length are extracted using the various maps including sub-watershed map, contour map and drainage map. Supervised Land use classification method is used for land use/land cover classification. The identified land use classes are Degraded Forest, open Forest, Dence Forest, Single Crop, Double Crop, Culturable Waste Land, Water Body, river, Stony Waste Land, and Settlements. There are three soil types found in study area. In this study landuse classes and soil classes are coded as shown in Table 2.

Table 1 Soil Properties under Different Soil Series of Dudhi Watershed

Soil Series	Code	Depth (mm)	Bulk Density (g/cm3)	Available Water Capacity	Organic Carbon %	Sand %	Silt %	Clay %	Rock %
Vertic ustochrepts	MPS 1	150	1.59	0.08	0.20	76.00	4.80	19.20	2.00
Lithic ustorthents	MPS 2	180	1.65	0.08	0.69	22.80	29.40	47.80	0.00
		430	1.66	0.38	0.34	20.80	33.40	45.80	0.00

		780	1.69	0.26	0.24	24.80	33.40	41.80	0.00
		1010	1.72	0.20	0.14	22.80	33.40	43.80	0.00
		1500	1.73	0.20	0.07	21.10	29.10	49.80	0.00
Typic	MPS	157	1.54	0.34	1.56	72.60	9.10	18.30	40.00

In the present study, the land use map of the watershed is used while assigning the C factor values to each land use category. Also while running SWAT model an average value of P-factor is considered and that is 1 for each HRU. It is observed that K-factor values for all the soil series, ranges from 0.2 to 0.3 in the study area.

Table 2 Landuse class coded in SWAT model

Landuse class	Code	C-Factor Values
Degraded Forest	FRDI	0.001
Open Forest	FRSD	0.001
Dence Forest	FRST	0.001
Single Crop	LENT	0.200
Culturable Wasteland	WSTI	0.001
Water body	WATR	0.000
Double crop	WWHT	0.030

Table 3 Soil class coded in SWAT model

Sr. No	Soil Series Type	Code	% Area	K-Factor
1	Vertic ustochrepts	MPS1	45.03	0.30
2	Lithic ustorthents	MPS2	23.71	0.30
3	Typic ustorthents	MPS3	31.26	0.30

Model Calibration and Validation

The model validation on the Dudhi micro watershed was carried out for year 2000 datasets (Dr.P.P.Lodha, 2006). An initial validation exercise was performed for the study watershed as a measure to ensure that SWAT could produce reasonable flow estimates using land use and soil data for the relatively small watershed. The validation was performed for the monsoon season of year 2000 using daily precipitation and temperature data obtained for Dudhi weather station located within the watershed. In this study, we have not calibrated and validated the model. We have used the data directly without calibration and validation. The results obtained are authentic. From the past study, it is confirmed that the Soil and Water Assessment Tool (SWAT) model can predict reasonable results without calibration.

Identification and Prioritization of critical sub-watersheds

In SWAT model we have given input data, and sediment yield in each HRU are obtained as output. The sediment yield in each HRU is summarized in Table 4.

The critical sub-watersheds were identified on the basis of average annual sediment and nutrient losses from the sub-watersheds during the period of 1996-1998. In this study, mean annual sediment yields are simulated for each HRU of Dudhi watershed using SWAT model. Priorities are fixed on the basis of ranks assigned to each critical HRU according to ranges of soil erosion classes described by Singh et al (1992) (Table 5). Soil loss values of identified critical HRU are compared with the average soil loss (16.35 t/ha/yr) of India (Dhruva Narayana, 1993) and prescribed permissible upper limit of soil loss (11.2 t/ha/yr) (Mannering, 1981).

Table 4 Area Under Different Classes of Soil Erosion By Water In India

Sr.No.	Soil Erosion Classes	Soil Erosion Range (t/ha/yr)	Area, km^2
1	Slight	0-5	801 350
2	Moderate	5-10	1405 640
3	High	10-20	805 030
4	Very high	20-40	160 050
5	Severe	40-80	83 300
6	Very severe	>80	31 895

Table 5 Soil Erosion and final priority For Each HRU in DM$_c$W

HRU	Soil Erosion (t/ha/year)	MUSLE Ranks	HRU	Soil Erosion (t/ha/year)	MUSLE Ranks
1	79.19	6	18	0.0	-
2	32.04	11	19	20.38	16
3	16.86	18	20	12.59	-
4	0.0	-	21	31.50	12
5	0.0	-	22	112.46	5
6	0.0	-	23	0.04	-
7	26.51	13	24	18.25	17
8	25.23	15	25	140.45	4
9	3.05	-	26	154.72	3
10	0.0	-	27	61.28	8
11	15.42	19	28	0.20	-
12	3.88	-	29	0.16	-
13	294.96	2	30	25.35	14
14	43.06	10	31	0.47	-
15	295.14	1	32	14.50	-
16	54.29	9	33	15.31	-
17	70.92	7			

Watershed Simulation

In the present study, The Dudhi micro-watershed, which is treated micro-watershed, has been simulated. The watershed intervention has been simulated using SWAT model. SWAT provides facility for generating various land-cover change scenarios. The average annual outputs in form of values of surface runoff, and sediment loading for virgin condition is presented in Table 5. The landuse data derived from the satellite imageries, IRS-1B (LISS II) has been used. The Land-cover scenarios have been simulated using SWAT model. The inputs were provided in the form of landuse layers created on Arc View GIS platform. Then various hydrological components such as surface runoff and total Sediment Loading are predicted.

Table 6 SWAT model average annual outputs for virgin conditions in DMcW

Hydrological components	Model output
Surface runoff (mm)	323.94
Sediment loading (t/ha)	48.551

Simulation for Critical HRUs

In this study, based on annual sediment loading, we have identified the critical HRUs. As stated earlier most of the critical HRUs fell under culturable wasteland. So we have created one scenario in which the landuse is changed from wasteland to dence forest. The results are shown below in Table 7.

Table 7 Average annual output for the critical HRUs scenarios

Components	Virgin Condition	Scenario for Critical HRUs
Surface runoff (mm)	323.94	260.00
Sediment loading (t/ha)	48.551	31.844

RESULTS AND DISCUSSION

Results show that none of the HRU fell under moderate erosion class. The HRU 13, 15, 22, 25, and 26 fell under Very severe soil erosion class. The maximum soil erosion is from HRU 13 and 15. There are many HRU in which soil erosion is more than average soil loss 16.35 t/ha/yr of India (Dhruva Narayana, 1993). The landuse classes falling under this category are wetlands and wasteland. Maximum plant cover and afforestation should be the basis for treating such severely eroded areas. From the analysis of K factor for each soil series of the watershed, it can be established that the soil series MPS1 and MPS2 are highly prone to erosion while series MPS3 is less prone to erosion. Table 8 can serve as the basis for choosing remedial measures on a priority basis for soil conservation. On the basis of annual sediment yield, the HRU 1,2,13,14,15,16,17,22,25,26 and 27 are found to be critical. After arranging the critical HRU in ascending order, considering the annual sediment yield from each HRU, priorities are fixed. The HRU that comes first is given the top priority for developing the management plans to reduce the soil erosion losses.

Table 8 Soil Erosion Class Group for Different HRU

Sr.No.	Soil Erosion Classes	Soil Erosion Range (t/ha/yr)	HRU
1	Slight	0-5	4,5,69,10,12,18,23,28,29,31
2	Moderate	5-10	-
3	High	10-20	3,11,20,24,32,33
4	Very high	20-40	2,7,8,19,21,30
5	Severe	40-80	1,14,16,17,27
6	Very severe	>80	13,15,22,25,26

Also from the watershed simulation, for the critical scenario Surface Runoff and Total Sediment loading is decrease and that is 24.60% & 52.45% respectively. The study revealed that afforestation is the measure for reduction of surface runoff and sediment loading. Below (Table 9) the results for the virgin condition and after changing the landcover for critical HRU are given for soil erosion in each HRU. As seen from the result due to afforestation, soil erosion is very much decreased. After changing the Landuse/cover for the critical HRUs, the soil erosion class groups have been decided. (Table 10) Due to Landcover change, most of the HRU fell under the Slight erosion class group. In the Rest of the HRUs, the soil loss is decreased.

Table 9 The Detail of Landcovercover change and Soil erosion in Virgin and Critical HRU condition for DMcW

HRU	Landcover in virgin condition	Landcover in Critical HRU condition	Soil erosion in virgin condition (t/ha/year)	Soil erosion in critical HRU condition (t/ha/year)	% Change
1	LENT	LENT	79.19	70.96	-10.39
2	WSTI	FRST	32.04	0.59	-98.15
3	WSTI	FRST	16.86	0.11	-99.35
4	WATR	WATR	0.0	0.0	-
6	WATR	WATR	0.0	0.0	-
7	WSTI	FRST	26.51	0.49	-98.15
8	WSTI	FRST	25.23	0.15	-99.40

Table 9 *Contd*...

HRU	Landcover in virgin	Landcover in Critical HRU	Soil erosion in virgin condition	Soil erosion in critical HRU	% Change
9	WSTI	FRST	3.05	0.02	-99.34
10	WATR	WATR	0.0	0.0	-
11	WSTI	FRST	15.42	0.09	-99.41
12	WSTI	FRST	3.88	0.03	-99.23
13	LENT	LENT	294.96	282.84	-4.11
14	WSTI	FRST	43.06	3.29	-92.36
15	LENT	LENT	295.14	282.91	-4.14
16	WSTI	FRST	54.29	0.32	-99.41
17	WSTI	FRST	70.92	0.42	-99.41
18	WATR	WATR	0.0	0.0	-
19	WWHT	WWHT	20.38	19.86	-2.55
20	WSTI	FRST	12.59	0.08	-99.36
21	WSTI	FRST	31.50	0.59	-98.13
22	WSTI	FRST	112.46	2.27	-97.98
23	FRSD	FRSD	0.04	0.04	-
24	LENT	LENT	18.25	11.09	-39.23
25	WWHT	WWHT	140.45	137.03	-2.43
26	WWHT	WWHT	154.72	157.76	+1.96
27	WWHT	WWHT	61.28	59.7	-2.58
28	FRSD	FRSD	0.20	0.24	+20.00
29	FRSD	FRSD	0.16	0.19	+18.75
30	LENT	LENT	25.35	20.79	-17.99
31	FRSD	FRSD	0.47	0.61	+29.78
32	WWHT	WWHT	14.50	14.82	+2.21
33	LENT	LENT	15.31	12.15	-20.64

Table 10 Soil Erosion Class Group for critical HRUs

Sr.No.	Soil Erosion	Soil Erosion Range	HRU
1	Slight	0-5	2,3,4,5,6,7,8,9,10,11,12,14,16,17
2	Moderate	5-10	-
3	High	10-20	19,24,32,33
4	Very high	20-40	30
5	Severe	40-80	1,27
6	Very severe	>80	13,15,25,26

CONCLUSIONS

This study demonstrates the integrated use of remote sensing, GIS and physically distributed model of SWAT for development of a watershed and for evaluation of its hydrologic response, to various land use and management changes. The spatial analysis of thematic information, which can be derived from remote sensing helps in the assessment of development plans before they are implemented in the field. This approach is thus an effective tool for selection of the best management plan to be implemented. ArcView GIS based interface for SWAT model has been used for the pre processing of the data and to delineate the watershed and sub-watersheds.

The GIS based distributed runoff model for the watershed is developed to estimate the runoff using SCS curve number procedure. The study shows that excessive runoff occur in the study area. Most of the HRU have Surface

Runoff more than 250 mm. The Modified universal soil loss equation used in the present study is helpful to evaluate the influence of different land cover and soil management factors in quantitative estimations of soil loss of the watershed. MUSLE uses runoff factor as a function for the prediction of average annual gross erosion, which improves the sediment yield prediction. Implementation of SWAT model using integration procedures of GIS enabled the prediction of soil loss rates. The mean soil loss rate is estimated to be 48.55 tones/ha/year.

The study confirmed that the Soil and Water Assessment Tool (SWAT) model could accurately simulate runoff, and sediment yield particularly from small agricultural watersheds. The SWAT model can successfully be used for prioritization of the critical sub-watersheds in order to develop multi-year management plan to reduce the runoff, and sediment losses from a small agricultural watershed.

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Estimation of Surface Runoff using Soil Conservation Services Curve Number Method and Geographical Information System - A Case Study

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ABSTRACT

With the increasing need for water due to industrialization, population growth and agricultural practices, it has become an essential task for water scientists to simulate and optimize the utilization of existing water resources. The Soil Conservation Service Curve Number (SCS-CN) method is widely used for predicting direct runoff volume. Runoff curve number is determined based on the factors of hydrological soil group, land-use, land cover and hydrologic conditions.. In the present study, GIS is used for quantitative measurements of watershed morphology; SCS-CN method is used to estimate the runoff for Ramagundam watershed located in Karimnagar district of Telangana state. Land use from LISS III image is used in the process of determining the spatial distributed runoff curve numbers and runoff depth are determined for the watershed for different land use classes. The estimated geographical area for watershed is 16633 ha and the average rainfall is 859 mm. The weighted curve number for the total Ramagundam watershed is obtained as 85. The results of the present study show that the promising results for all six years (2006 to 201) of estimated runoff depth and average volume of runoff for the study area in the monsoon season.

Keywords: Geographical Information System, Remote Sensing, Surface Runoff, Curve Number.

INTRODUCTION

Runoff is one of the most important hydrologic variables used in most of the water resources applications. Its occurrence and quality depends on the characteristics of rainfall event, i.e., the intensity, duration and distribution and also the other factors which have a direct effect on the occurrence and runoff volume. This includes soil type, vegetation cover and slope. The Soil Conservation Service Curve Number (SCS-CN) method is widely used for predicting direct runoff volume for a given rainfall event. This method was developed by the US Department of Agriculture. Being the simplest method, it became popular and is applied for wide range of problems in the stream of Hydrology specifically for small catchments. The main reasons for its success is that it accounts for many of the factors affecting runoff generation that which includes the type of the soil, land-use/land-cover, surface condition, and antecedent moisture condition. All these factors are well explained in a single parameter called Curve Number (CN)[1]. Moreover, it can also be concluded as the only methodology that features readily grasped and reasonably well documented environmental inputs and widely accepted for use in many countries.

On the other hand the other tool adopted for the present study is Remote Sensing which is more reliable, up-to-date, and faster than conventional techniques. It plays a vital role in acquisition of data in the different aspects of land use and soil cover, which are essential parameters in the field of watershed runoff estimation. GIS is capable of handling spatial and a spatial data when compared to conventional information system. It also identifies the spatial relationships between map features. The use of GIS technology as a spatial data management and an analysis tool provides an effective mechanism for hydrologic/ hydraulic studies. Thus the remote sensing along with GIS application aid to collect, analyze and interpret the data rapidly is very much helpful for watershed planning. For un-gauged watersheds accurate prediction of the quantity of runoff from land surface into rivers and streams requires much effort and time[2].

The ungaged sites occupies the important position in hydrological studies as there is every need for estimation of runoff from a watershed and also for which there is record of precipitation and no records of runoff. An approach to solution of this ungaged site is to compare runoff characteristics with those of watershed characteristics. Its scope was also expanded beyond the evaluation of storm runoff and it becomes an integral part of more complex and continuous hydrological simulation models[3]. Nowadays it has become more essential for the researchers to emphasize watershed-based water resources planning and development for successful management practices.

Remote Sensing (RS) techniques have been applied extensively and are recognized as powerful and effective tools for detecting land use changes. Remote sensing collects multi-spectral, multi-resolution, multi-temporal data, and converts the same to use friendly information. GIS technology creates a flexible environment for entering, analyzing, and displaying digital data from various sources, for identifying various urban features, their change, and thereby develops the databases. Much researches is been carried out to develop an integrated approach for combining RS and GIS techniques to elucidate the effects of land-use change on runoff using a simple Soil Conservation Service (SCS) model[4]. The role of remote sensing in runoff calculation is generally to provide a source of input data or as an aid for estimating equation coefficients and model parameters. The geographical information system provides efficient tools for data input into database retrieval of selected data items for further generation of modules which can analyze and manipulate the retrieved data in order to develop desired information on a specific project[5]. The present study is carried out initially by preparing a land use and land cover map of the Ramagundam Watershed using Arc-GIS Software. Secondly it continued with the estimate the weighted curve number for the total watershed. Thirdly, the process was extended to evaluate the surface runoff for the watershed using SCS Curve Number Method and thereby compare it with the observed data.

METHODOLOGY

SCS Runoff Curve Number

SCS-CN method developed by Soil Conservation Services (SCS) of USA in 1969 has become a simple, easily predictable conceptual method for estimation of direct runoff depth based on storm rainfall depth. It relies on only one parameter, CN and is based on the water balance equation and two fundamental hypotheses. The first hypothesis equates the ratio of the amount of direct surface runoff 'Q' to the total rainfall 'P' (or maximum potential surface to the runoff) with the ratio of the amount of infiltration 'F_c' and the amount of the potential maximum retention 'S'. The second potential hypothesis relates the amount of initial abstraction 'I_a' and the maximum retention[6].

Thus, the SCS-CN method consisted of the following equations.

a. First Hypothesis: Water balance equation:

$$P = I_a + F + Q \quad \textbf{(1)}$$

Proportional equality hypothesis

$$\frac{F}{S} = \frac{Q}{P - I_a} \quad \textbf{(2)}$$

b. Second Hypothesis: I_a – S

$$I_a = \lambda S \quad \textbf{(3)}$$

Where,

P is the total rainfall,

I_a the initial abstraction,

F the cumulative infiltration excluding I_a,

Q the direct runoff,

S the potential maximum retention or infiltration

λ the regional parameter dependent on geologic and climatic factors ($0.1 < \lambda < 0.3$).

Combining equations (2) and (3), and using (1)

$$Q = \frac{(P - I_a)^2}{P - I_a + S} = \frac{(P - \lambda S)^2}{P + (1 - \lambda)S} \quad \text{for } P > \lambda S \quad \textbf{(4)}$$

For use in Indian conditions λ = 0.1 and 0.3 subject to the constraints of soil type and Antecedent Moisture Condition (AMC) type as follows and developing the relation between I_a and S was developed by analyzing the rainfall and runoff data from experimental small watersheds and is expressed as $I_a = 0.3S$. Combining the water balance equation and proportional equality hypothesis, the SCS-CN method is represented as

$$Q = \frac{(P - 0.3)^2}{P + 0.7S} \quad (5)$$

Equation-5 is valid for Black soils under AMC type I and for all other soils having AMC of types I, II, and III. The potential maximum retention storage 'S' of watershed is related to a CN, which is a function of land use, land treatments, soil type and antecedent moisture condition of watershed. The CN is dimensionless and its value varies from 0 to 100.The S-value in mm can be obtained from CN by using the relationship

$$S = 254\left(\frac{100}{CN} - 1\right) \quad (6)$$

Study area

Ramagundam is a small town as shown in Figure-1 in Karimnagar district of Telangana state in the southern part of India. It is about 240 km north of the state capital of Hyderabad and is located on right bank of Godavari River. Ramagundam is located at 18.8N 79.45E. It has an average elevation of 179 meters. The town derives its name from an adjoining village by the same name and which now represents an urban agglomeration of several urban and rural settlements. The town receives copious rainfall of around 1200 mm/annum, primarily during south west monsoon in the months of June to October. The runoff volume for the Ramagundam watershed is estimated for the monsoon season in 2006, 2007, 2008, 2009, 2010, and 2011.

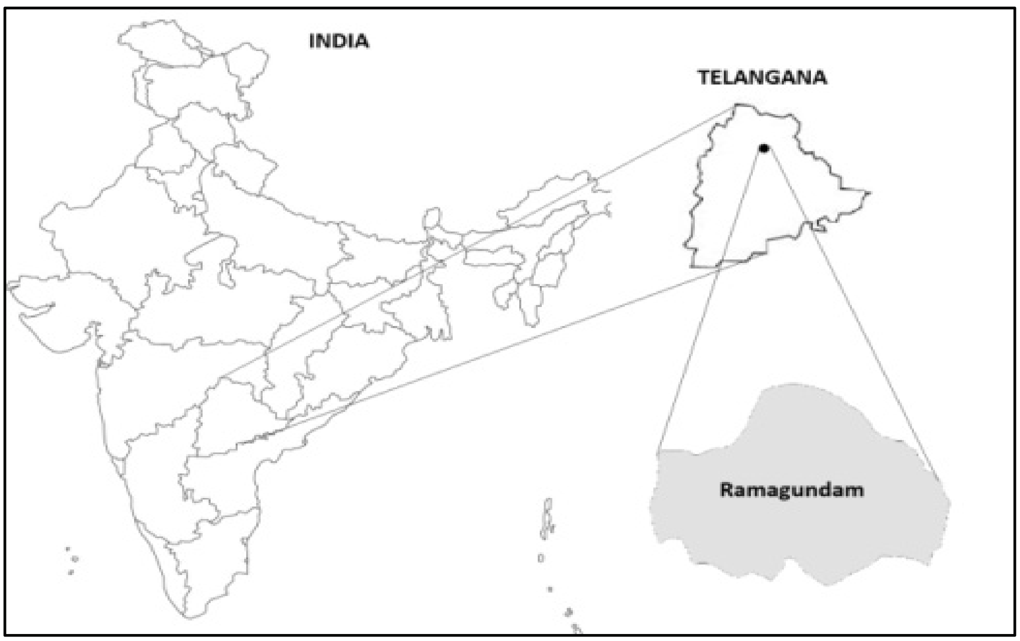

Figure 1 Location Map

RESULTS AND DISCUSSION

In the present study two different image processing classification methods were used i.e., Unsupervised and Supervised classification. The study area is broadly divided into six classes, mainly as forest, water bodies, agricultural land/vegetation, fallow land, waste land etc., and five land use and land cover parameters. The study area comprises of two hydrological soil groups namely Group-B and Group-D. Group-D has low infiltration capacity leading to high runoff potential as shown in Table-1. This data have been selected to develop land use and land cover map of Ramagundam watershed as shown in Figure-2. The soil map, DEM and slope maps as shown in Figure-3, Figure- 4 and Figure-5 respectively for the study area are also prepared by using the satellite imagery using Arc-GIS software considering the unsupervised classification.

Table 1 Class of Land Use and Land Cover

Land Use	Area (ha)	Percentage of area (%)	Hydrological Soil Group
Urban	3316	19.94	Group (D)
Agriculture	3800	22.85	Group (D)
Forest	2997	18.02	Group (B)
Waste land	4240	25.49	Group (B)
Water body	2280	13.71	Group (D)
SUM	16633	100	NIL

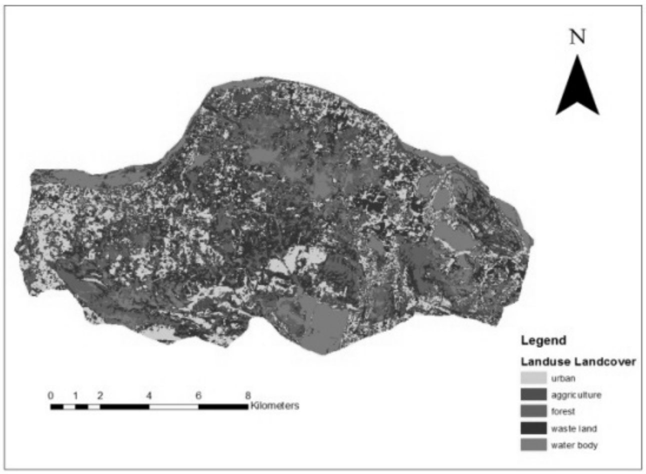

Figure 2 Land use and land cover map

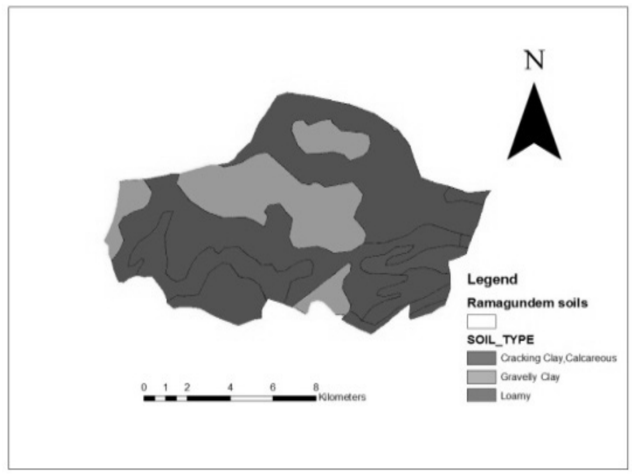

Figure 3 Soil map

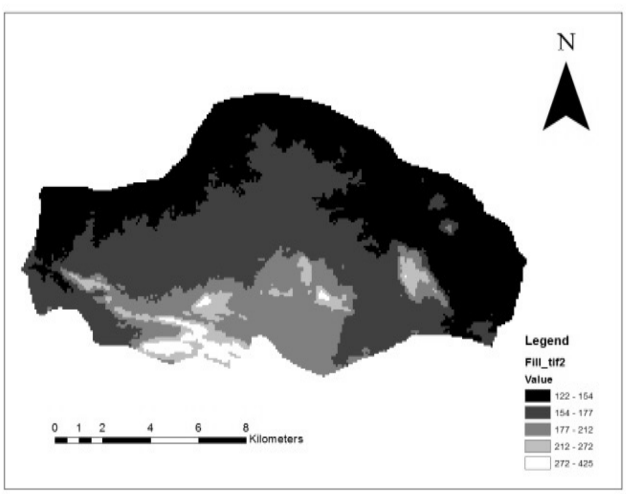

Figure 4 DEM Map

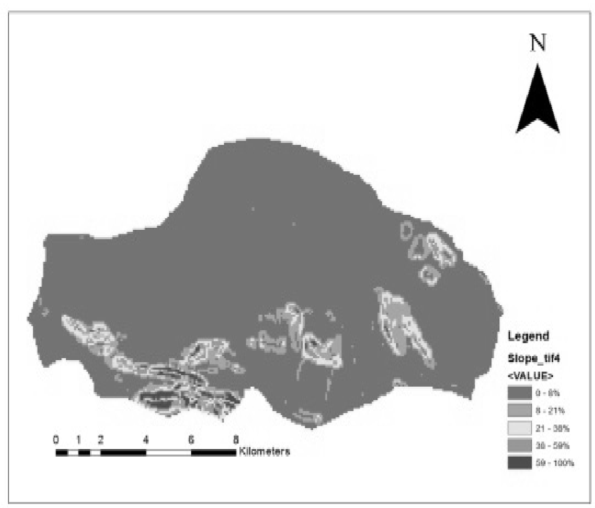

Figure 5 Slope map

The Curve Number values are evaluated for each land use/land cover as shown in the Table-2. For different AMC conditions, the corresponding weighted curve number, maximum retention capacity and the total precipitation for the whole watershed is calculated and is shown in Table 3.

Table 2 Values of Curve Number

Land Use	Hydrological soil group	CN
Urban	(D)	91
Agriculture	(D)	87
Forest	(B)	64
Waste land	(B)	88
Water body	(D)	95

Table 3 Hydrological Parameters

AMC	CN	S	P > 0.3S
I	71	103.75	31.125
II	85	44.82	13.446
III	93	19.12	5.74

The computations are further elaborated to estimation of runoff along with the Volume of runoff from the watershed and the Coefficient of Determination to show the adaptability of the method to the watershed for the years 2006-2011 and are tabulated in Table-4. The estimated runoff values are compared with the observed runoff values for all the six years. The comparison of runoff values along with the correlation graph are shown in Chart-1 and chart-2 respectively.

Table 4 Average Runoff Depth and Volume

Years	Total Rainfall (mm)	Total runoff (mm)	Runoff percentage	Volume (m³) Runoff*area	Coefficient Of Determination
2006	997	469.81	47.12	78143497	0.9368
2007	660.2	80.84	12.24	13446117	0.9049
2008	807.9	231.96	28.71	38581907	0.9836
2009	583.7	123.15	21.09	20483540	0.9629
2010	1465	658.66	44.95	109554918	0.9783
2011	639.4	75	11.73	12474750	0.9586
Average	859.00	273.24	27.64	45447455	

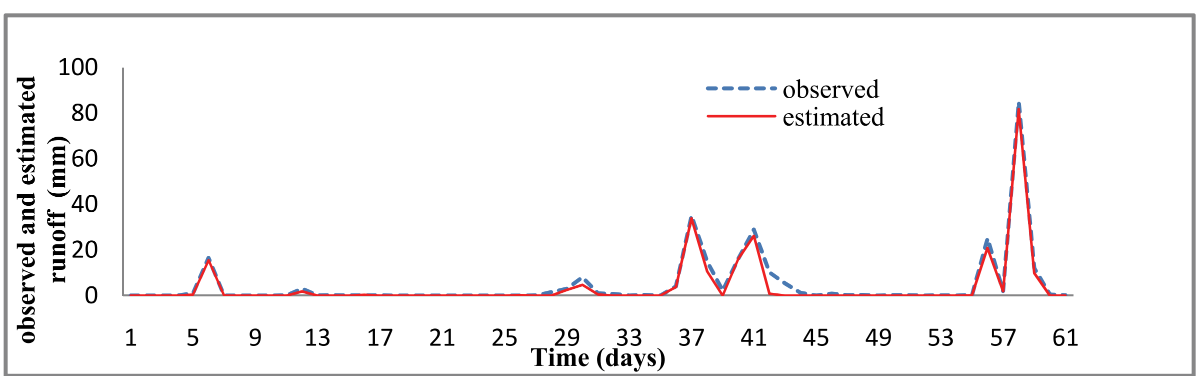

Chart 1 Observed and Estimated Runoff Values for the year 2008

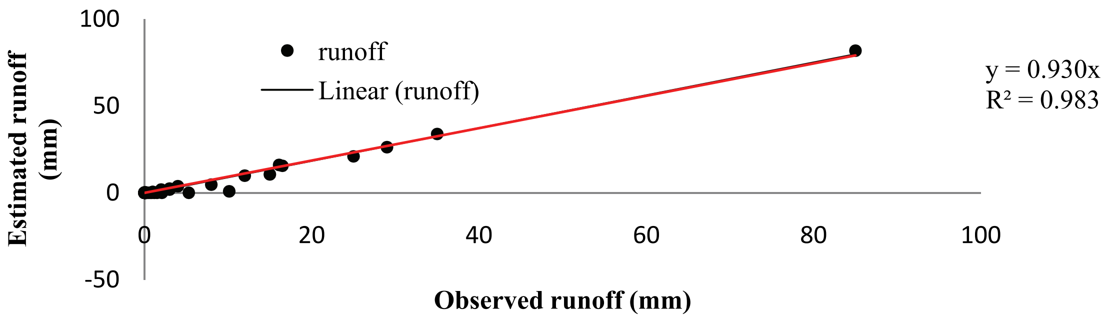

Chart 2 Observed Runoff versus Estimated Runoff Values for the Year 2008

CONCLUSIONS

The conventional hydrological data are inadequate for the purpose of design and operation of any Water Resources Projects. In such cases Remote Sensing data are of great use for the estimation of relevant hydrological parameters, and offers the potential to increase the degree of definition of spatial sub-units, in number and in descriptive detail. The conclusions that have been drawn from the present study are as follows:

- Land-use and land-cover for the present watershed using GIS is prepared for an area comprising of 16633 ha.
- From the GIS based analysis of soil map, the hydrological soil Group–D is found to have the highest percentage as 56.5% whereas the remaining portion of 43.5% is occupied by Group–B. The Weighted CN value is obtained as 85, 71 and 93 for AMC II, AMC I and AMC III conditions respectively.
- The runoff calculated show calculations that the minimum total runoff occurs in the year 2011as 75mm and maximum total runoff in the year 2010 as 658.66mm.
- The comparative plots of estimated and observed runoff depths for all the six years are near and comparable.
- The Coefficient of Determination for 6 years is well fitted and lies between 0 to 1.
- Based on the above analysis, it can be suggested that the SCS-CN curve number and GIS are very much suitable methods for estimation of runoff volume.

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Identification of Suitable Method for Estimation of Reference Evapotranspiration for Paleru Sub Basin of River Krishna

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ABSTRACT

Grass Reference evapotranspiration as ' the rate of evapotranspiration from a hypothetical reference crop with an assumed crop height of 0.12 m , a fixed surface resistance of 70 sec/m and an albedo of 0.23 closely resembling the evapotranspiration from an extensive surface of green grass of uniform height actively growing completely shading the ground and with adequate water'. Evapotranspiration is one of the major components of the hydrologic cycle. Accurate estimation of RET is essential in many environmental studies such as hydrologic water balance, irrigation scheduling, and efficient water resource planning and management. Different meteorological parameters such as Maximum and minimum temperature, Maximum and minimum relative humidity, wind speed, sunshine hours shall be collected in order to estimate RET. Various methods are available in the literature to determine Reference evapotranspiration based on temperature methods, radiation methods and combination methods. However, all the methods are not suitable for accurate estimation of RET for all the study areas, as RET methods are site specific. Keeping this in view, it is proposed to study and estimate daily, monthly and yearly reference evapotranspiration for the study area using the above methods. Paleru sub basin (K-11) of river Krishna, located in the Andhra Pradesh has been considered for the study area. Out of all the available methods, a suitable method for estimation of RET shall be identified pertaining to the study area.

Keywords: RET, Paleru sub basin, Evapotranspiration.

INTRODUCTION

Evaporation is one of the major processes in the hydrological cycle and it is a vital consideration in water resources planning and for effective management of water. Evapotranspiration constitutes the loss of water to the atmosphere by the combined process of evaporation from soil and plant surfaces and transpiration from plants. The accurate estimation of evapotranspiration is the requirement for many studies such as hydrologic water balance, irrigation system design and management, crop yield simulation, and water resources planning and management. Doorenbous and Pruitt (1977) defined the reference evapotranspiration rate as "the rate of evapotranspiration from an extensive surface of 8cm to 15cm tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water". Later Allen et al (1994) defined the grass reference evapotranspiration as "the rate of evapotranspiration from a hypothetical reference crop with an assumed crop height of 0.12m a fixed surface resistance of 70s m^{-1} and an albedo of 0.23 closely resembling the evapotranspiration from an extensive surface of green grass of uniform height actively growing completely shading the ground and with adequate water". The widely used reference equations for accurate estimation of ETO are of the combination type and the one recommended by FAO-56 is the Penman Monteith (PM) equation. Further, ET_O estimation methods other than PM method will continue to remain in practice owing to simplified data requirements. Evapotranspiration is a complex phenomenon as it depends on several climatological factors, such as temperature, humidity, wind speed, radiation and type and growth stage of the crop. ET can be either directly measured using Lysimeter or water balance approaches or estimated indirectly using climatological data.

Several methods have been developed to assess RET based on temperature, radiation and their combination. There are three general approaches to estimate reference crop evapotranspiration viz., temperature methods, radiation methods, and combination methods. However, in the present study, the ET_o program is used to calculate ET_o values by using various methods based on temperature radiation and their combination. Keeping these points in view, identification of suitable method of estimation of Reference Evapotranspiration is found essential and it is set as the objective of the present study. The objectivities of the present study are as follows

2. To arrive at the daily RET values at the given location by developing appropriate tools.
3. To compare the performance of different RET equations with FAO-56 Penman – Monteith method.
4. To identify the suitable method for estimation of Reference Evapotranspiration for the study area of Palleru sub basin of River Krishna.

REVIEW OF LITERATURE

Temperature Methods: Blaney Criddle (1950) developed a simplified formula for estimating consumptive use of crops for the arid western regions of the United States by correlating mean monthly temperature and daylight hours. Doorenbos and Pruitt (1977) presented the most fundamental revision of the Blaney Criddle method. Hargreaves and Samani (1985) proposed a method for estimating the reference ET that requires only maximum and minimum temperatures. Radiation Methods: Solar radiation provides the energy required for the phase change of water and often limits the ET process where water is readily available. A number of ET equation methods have been developed based on energy balance (Turc 1961; Priestley and Taylor 1972, Doorenbos and Pruitt 1977).

Combination Methods: The combination methods were developed by combining the energy balance, heat and mass transfer approaches. These methods attempted to combine fundamental physical principles and empirical concepts based on standard meteorological observations and have been widely used for estimation of ET from climatic data. Penman (1948) first derived the combination equation by combining components of energy balance and aerodynamics. The Priestly-Taylor model resulted as a modification of Penman's theoretical equation and used in areas of low moisture stress, the Priestly-Taylor and Penman-Monteith equations produced estimates within 5 % of each other.

FAO-56 Penman-Monteith method: Monteith (1965) further carried out modifications to the Penman method by way of incorporating stomatal resistance term specific to that particular type of crop in addition to the existing aerodynamic term and then, formulated the Penman-Monteith evapotranspiration model. Amatya. et al. (1995) employed six different methods for the calculation of ETo at three sites in eastern North Carolina. They are a) Penman-Monteith method b) Makkink method c) Priestly-Taylor method d) Turc method e) Hargreaves-Sanmani method and Thornthwaite method. Ahmed (1999) computed the RET in Central Sudan from the meteorological data. In this study he used four forms of Penman combination equations. The results were compared with measured data and observed that Penman-Monteith method gave good agreement with the measured data. The results of this study support that FAO-56 Penman-Monteith was the best method to calculate RET.

Shih et al. (1981) proved that Penman method is a good predictor of reference Evapotranspiration when compared to all the other methods. They concluded that Penman method is the best and reliable method for the purpose of calculation of RET. Sudheer Reddy (2001) calculated RET from three different methods mentioned above, i.e. temperature, radiation and combination methods. He found that temperature methods consistently overestimate ETo during summer months. He also observed that radiation methods provide a much more consistent estimate of ETo than temperature methods. However, ET_o is still underestimated during winter months compared to FAO Penman-Monteith method. The combination methods are fairly consistent throughout the year. He observed that out of all the above methods, FAO -56 Penman-Monteith method gave best results. Georg et al. (2002) developed decision support system for estimating RET. Temperature, radiation and combination methods were employed to develop the decision support system. Among all these methods, Penman-Monteith method is taken as standard method for comparison with other methods. Temperature related variables are found to be to be the most crucial inputs required to obtain ET_0 estimates which are comparable to those from the FAO-56 PM method across all the climates considered. Hence, from the above review of literature, it is clear that the FAO-56 Penman-Monteith method is the best method to calculate the RET for all climatic conditions.

STUDY AREA

The Krishna basin scenario along with its tributaries, Physiography, climatic parameters and basin rainfall were broadly outlined. The river Krishna is the second largest river in the peninsular India. The river basin extends over an area of 2,58,948 Km^2, which is 8% of the total geographical area of the country. The river Krishna is the second largest river in the peninsular India. The river basin extends over an area of 2,58,948 Km^2, which is 8% of the total geographical area of the country. There are 19 Indian Meteorological Department observatories and about 300 rain gauge stations maintained by various authorities in and around the basin. The climate of the catchment is characterized by Cold weather, Hot weather, South west monsoon and Post monsoon. The rainfall is the source of all water within the Krishna basin. The catchment mainly experiences the southwest monsoon. The rainfall in the non-monsoon period is not significant. The average annual rainfall in the basin is 784 mm. The climate of the sub-basin is characterized by a hot summer & mild winter. Daily data has been collected from the meteorological station located at Jagityal, Karimnagar district for the present study.

METHODOLOGY

The following methods were considered in the present study for the estimation of Evapotranspiration.

- Thornthwaite and Mather's (1955) method of estimating potential evapotranspiration (PET) is solely based on air temperature. PET estimates are based upon a 12-hour day (amount of daylight) and a 30-day month.

$$PET = 16\left(\frac{L}{12}\right)\left(\frac{N}{30}\right)\left(\frac{10T_a}{I}\right)^{\alpha} \quad .....(1)$$

- Modified Blaney-Criddle method presented by Allen et al. (1986) is considered in the present study.

$$ET_o = a_{bc} + b_{bc}\, f \quad .....(2)$$

- The Mc.Cloud method was developed to predict potential evapotranspiration from turf and golf courses (McCloud, 1955). The equation, based on daily temperature values, may be expressed as

$$ET_p = KW^{(T-32)} \quad .....(3)$$

- **Hargreaves method:** The Hargreaves method (Hargreaves and Samani, 1985) of computing daily grass reference evapotranspiration is another empirical approach that was used in cases where the availability of weather data is limited. The method was developed in Davis, California from a lysimeter study on Alta fescue grass. The original Hargreaves formula calculates reference evapotranspiration from solar radiation and temperature.

$$ET_O = 0.0135\frac{R_s}{\lambda}(T+17.8) \quad .....(4)$$

- **Turc Method:** The equation given by Turc is expressed as

$$ET_o = 0.013TM/(TM+15)\ (23.9\ R_s+50) \qquad \text{if } RH>50\%$$

$$ET_o = 0.013TM/(TM+15)\ (23.9\ R_s+50)\ (1+(50-RH)/70) \qquad \text{if } RH<50\%$$

- The radiation method is essentially an adoption of the Makkink formula (1957). This method is suggested for areas where available climatic data include measured air temperature and sunshine, cloudiness or radiation, but not measured wind and humidity. The relationship recommended in mm/day is expressed as

$$RET = c\ (W\ R_s) \quad .....(5)$$

- **Priestly – Taylor method:** Reference evapotranspiration (RET) can be estimated using the following equation.

$$ET_r = 1.26\frac{\Delta(R_n - G)}{\Delta + \gamma} \quad .....(6)$$

- **FAO 56 Penman - Monteith Equation:** The FAO-56 Penman-Monteith method to estimate reference crop evapotranspiration is as follows

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_d)}{\Delta + \gamma(1+0.34u_2)} \quad .....(7)$$

Daily meteorological parameters viz., maximum temperature, minimum temperature, minimum relative humidity, maximum relative humidity, wind speed, sun shine duration collected for a period of 2000 to 2013 from Jagityal meteorological station was processed and gaps were filled with the averages of previous and subsequent day. Total twelve internationally accepted RET equations were used for the calculation of daily RET out of which two methods are based on temperature, three methods are based on radiation, two methods are based on combination type and five methods are based on Pan evaporation. Generally, Mc.Cloud (W=1.07) gives high RET results when compared with FAO-56 PM. Therefore, in addition to the above mentioned equations, an attempt has been made to calculate RET by reducing the coefficient (W) by an interval of 0.005. In Mc.Cloud method, RET was calculated by varying the coefficient, i.e., W=1.07 to W=1.065, W=1.06, W=1.055 and W=1.05. Direct reading from the Pan was also taken as RET value for that day in the present study. Hence, it is also considered as Evaporation method for further analysis. A program has been developed in VC^{++} to calculate daily RET. Methodologies on crop water requirements were reviewed at international level to advice on the revision and update of procedures for estimating RET and the panel of experts recommended the adoption of the FAO-56 Penman - Monteith combination method as standard. Hence for the present study, the same method was chosen as the standard method against which performance evaluation of the other methods was carried out. The calculated daily values were converted to monthly and yearly values. The RET values estimated from different methods were compared with the standard method i.e, FAO-56PM. Performance evaluation was carried out between the values of RET estimated from standard FAO-56 PM and other methods.

ESTIMATION OF REFERENCE EVAPOTRANSPIRATION (RET)

RET is the loss of water from the land and water surfaces of catchment due to the combined processes of evaporation and transpiration. Daily meteorological parameters viz., maximum temperature, minimum temperature, minimum relative humidity, maximum relative humidity, wind speed, sun shine duration collected for a period of 2000 to 2013 from meteorological station located at Jagityal, Karimnagar district, A.P. This data was processed and gaps were filled with the average of previous and subsequent day. For the present study, RET was calculated from FAO-56 PM method. Daily RET was estimated from FAO-56 Penman-Monteith method. Daily RET was estimated from FAO-56 Penman-Monteith method using the following equation.

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{900}{T+273} u_2 (e_s - e_d)}{\Delta + \gamma(1 + 0.34 u_2)} \quad \text{.....(8)}$$

RESULTS AND DISCUSSIONS

Results pertaining to estimation of reference evapotranspiration from different methods and performance evaluation of reference evapotranspiration with the standard FAO-56 Penman method were analyzed. Daily meteorological parameters maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, wind speed and sun shine duration were collected for a duration of 2000 to 2013 for the estimation of RET. Generally, Mc.Cloud (W=1.07) gives high RET results when compared with FAO-56 PM. Therefore, in addition to the above mentioned equations, an attempt has been made to calculate RET by reducing the co efficient (W) by an interval of 0.005 i.e., W=1.07 to W=1.065, W=1.06, W=1.055 and W=1.05. Direct reading from the Pan for that day, was also considered for the estimation of RET in the present study. Hence it is also considered as another Evaporation method for further analysis.

From these tables, the average yearly values estimated using the twelve equations namely, Blaney-Criddle, Mc.Cloud equation with coefficients W as 1.05, 1.055, 1.06, 1.065 and 1.07, Priestly Taylor, Hargreaves, Turc, radiation method, evaporation method, were found to be 4545, 1051, 1342, 1712, 2186, 2790, 1988, 1886, 1646, 2121, and 1144 mm respectively. The average yearly RET estimated from the standard FAO-56 PM method is found to be 1492 mm. Blaney-Criddle method gave very high estimation of RET when compared with standard FAO-56 Penman-Monteith. All the temperatures methods estimated maximum RET in the year 2003 and minimum RET in the year 2000 in the entire duration of 2000 to 2013. All radiation methods and Priestly Taylor method estimated maximum RET for the year 1992 and minimum RET for the year 1990 for the duration of 2000 to 2013. Similarly, all five pan evaporation equations estimated maximum RET for the year 1996 and minimum RET for the year 2001 for the above duration. Yearly RET from Mc.Cloud method with coefficient W=1.055 is under estimated by 10% and with coefficient W=1.06 is over estimated by 15% when compared to the standard FAO-56 PM method.

Table 1 Yearly RET values in MM for the K-11 Sub-Basin

RET Method	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Hargreaves	1837	1855	1865	2015	1921	1929	1879	1906	1903	2229	1879	120003	1798	1828	1885
Turc (1961)	1654	1555	1606	172000	1696	1747	1626	1606	1619	1751	1624	1576	1596	1581	1647
Radiation	2170	1953	1952	2446	2136	2112	2109	2060	1981	2435	2228	2340	2268	1971	2122
FAO-56 PM	1591	1564	1587	1539	1558	1452	1516	1467	1446	1421	1429	1402	1398	1514	1492

RET estimated from Mc.Cloud equation with coefficient W=1.055 has shown7 -10.02% deviation when compared to FAO-56 Penman Monteith method. So, this method exhibited least deviation among all the temperature methods studied. Hence for the Palleru sub basin, Mc.Cloud equation is found to be suitable with the coefficient of W=1.055 instead normally adopted value of W=1.07. Turc (1961) equation gave 10.63 % deviation from FAO-56 PM method and the deviation is found to be least among all the radiation methods for the study area. Correlation coefficient (R^2) between the values of RET estimated using FAO-56 PM and each of the other methods has been calculated on daily and monthly basis. Out of all the temperature methods, Mc.Cloud with coefficient W=1.055 gave good correlation in case of daily and monthly RET values with correlation coefficient (R^2) 0.79 and 0.84 respectively. Correlation coefficients for daily and monthly RET values were found to be highest as 0.83 and 0.87 respectively through combination method i.e Priestly-Taylor method compared to all the methods under consideration in the present study. This is due to the fact that combination approach was developed by combining the energy balance, heat and mass transfer approaches. Of all the three radiation methods, Turc (1961) equation showed good correlation with R^2=0.82 for both daily and monthly RET values. Among all the methods of estimating RET, FAO-24 radiation method showed very low correlation.

The estimated RET from Blaney-Criddle method, Mc.Cloud method with coefficient W=1.06, W=1.065, W=1.07, Priestly– Taylor method, Hargreaves method, Turc method, Radiation method, resulted positive percentage of deviation as 190.34%, 14.83%, 46.55%, 87.07%, 13.40%, 26.68%, 10.63%, respectively when compared with FAO-56 Penman-Monteith method. Mc.Cloud method with coefficient W=1.05, W=1.055, reflected negative percentage of deviation as -29.48%, -10.02% respectively when compared with FAO-56 Penman-Monteith method. RET estimated from Mc.Cloud equation with coefficient W=1.055 resulted in -10.02% deviation when compared to FAO-56 PM method which was found to be least among all the temperature methods studied. Hence, it is concluded that, for the Palleru sub basin, Mc.Cloud equation is suitable with the coefficient of W=1.055 instead of normally adopted value of W=1.07. Of all the three radiation methods, Turc (1961) equation showed good correlation with R^2 = 0.82 for both daily and monthly RET values. RET estimated from Turc method resulted in 10.63% deviation when compared to FAO-56 PM method which was found to have least deviation among all the radiation methods in the present study. Hence, it is concluded that, for the Palleru sub basin, Turc (1961) equation is suitable among all the radiation methods.

Table 2 Percentage Deviation of RET Estimated With Different Methods Using FAO-56 Method.

Year	Blaneny cridle	Mc. Cloud W=1.05	Mc. Cloud W=1.055	Mc Cloud W=1.06	Mc. Cloud W=1.065	Mc. Cloud W=1.07	Priestly Taylor	Hargreaves	Turc 1961	Radiation Method	Evaporation
2000	225	-34.10	-15.97	7.16	36.67	74.30	3.51	15.39	4.02	36.26	42.9
2001	204	-35.53	-18.62	2.99	30.29	64.75	2.35	12.18	-0.56	18.47	24.8
2002	192	-33.71	-15.50	7.69	37.22	74.85	5.88	17.52	1.18	23.02	22.7
2003	210	-33.26	-14.84	8.56	38.36	76.44	14.34	30.60	16.27	58.96	33.0
2004	220	-29.77	-9.88	15.67	48.52	90.77	10.00	23.73	8.86	36.85	36.1
2005	172	-28.33	-8.41	17.12	49.86	91.2000	17.97	32.85	19.86	45.41	-72.8
2006	165	-26.37	-5.52	21.24	55.59	99.67	11.53	23.92	7.26	39.05	-83.2
2007	146	-23.11	-1.30	26.70	62.65	108.78	17.03	29.98	9.47	40.42	-69.3
2008	139	-27.83	-8.11	16.99	48.93	2000.59	18.47	31.62	11.97	37.02	-77.5
2009	163	-29.30	-10.18	14.18	45.20	84.76	27.00	44.82	24.98	66.65	-71.5

Table 2 Contd…

Year	Blaneny cridle	Mc. Cloud W=1.05	Mc. Cloud W=1.055	Mc Cloud W=1.06	Mc. Cloud W=1.065	Mc. Cloud W=1.07	Priestly Taylor	Hargreaves	Turc 1961	Radiation Method	Evaporation
2010	180	-27.32	-7.41	17.96	50.29	91.48	17.19	31.48	13.67	55.90	-78.0
2011	168	-34.23	-17.23	4.16	31.07	64.95	19.2000	35.04	19.51	59.90	-52.3
2012	174	-33.34	-15.91	6.11	33.92	69.06	15.56	28.62	14.21	62.26	-79.0
Average	181.	30.4	-32.8	30.9	43.73	23O.12	13.84	27.5	11.5	44.6	-32.6

CONCLUSIONS

RET estimated from Mc.Cloud equation with coefficient W=1.055 resulted in -10.02% deviation when compared to FAO-56 PM method and was found to be suitable among all the temperature methods studied. Of all the three radiation methods, Turc (1961) equation resulted in 10.63% least deviation when compared to FAO-56 PM method and for Palleru sub basin, Turc (1961) equation is suitable among all the radiation methods. The combination method of Priestly–Taylor equation resulted in 13.4% deviation from the FAO-56 PM equation and may be reliably adopted. Daily RET estimated was found to be maximum through Blaney-Cridle method compared to all other methods for the present study. The estimated RET values from Hargreaves method, Turc method, FAO-24 Radiation method resulted in positive percentage of deviation as 26.68%, 10.63% and 42.69% respectively when compared with FAO-56 Penman-Monteith method.

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Decision Support System for Optimization of Multi-Purpose Reservoir System Operations: A Review

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ABSTRACT

The multiplicity of demand for water for various purposes, viz, agriculture (irrigation and livestock), hydroelectric power, industry, domestic use, flood control and environmental concern calls for optimal utilization of available water in multipurpose reservoirs. World Commission on Dams (WCD) advocated for a more equitable distribution of the benefits to be gained from large dams and proposed the inclusion of all identified stakeholders in the planning and management of water resources stored in reservoirs. To achieve this the dam managers must take into account the water uses upstream and downstream of the dam and must also give consideration to political, organizational, social and environmental factors, not only biophysical constraints. Conventionally, the information required for this purpose has been generated by judicious audit of demand and inflow of water into the reservoirs. With the development of decision support systems (DSSs) the alternatives for judicious allocation of reservoir water for various purposes involving complicated hydrological, environmental and socio-economic constraints and conflicting management objectives became available in near-real time. Decision Support Systems (DSS) are computer-based tools having interactive, graphical and modelling characteristics to address specific problems and assist individuals in their study and search for a solution to their management problems. In this article we trace the history of the development of DSS for reservoir operations, provide the state-of-the-art and identify gap areas for further research.

Keywords: Optimal Utilization, Reservoirs, Decision Support System.

INTRODUCTION

The availability of quality water in adequate quantities for various purposes, namely flood control, hydropower generation, irrigation, industrial and domestic purposes is the major issue in water management. In this context, optimization of reservoir operations assumes greater significance. It involves determination of the optimal release volumes in the successive time periods so that the expected total rewards resulting from the operations are maximized. Furthermore, the deregulation of the power industry emphasizes the need for maximizing hydropower benefits. Reservoir managers must improve the management of existing resources and must adapt quickly to changing objectives and requirements. Despite several decades of intensive research on the application of optimization models to reservoir systems, a continuing gap between theoretical developments and real-world implementations has been noted (Yeh, 1985; and Wurbs, 1993). The disparity may be attributed, amongst other factors, to scepticism of most of reservoir system operators in adopting optimization models which are mathematically more complex than the existing simulation models, to replace their judgment, lack of the scope for incorporating the risk and uncertainty in optimization models, and wide range and varieties of optimization methods making the decision by the operators of the reservoir system very complex. Many of these hindrances to optimization in reservoir system management are being overcome through ascendancy of the concept of decision support systems and dramatic advances in the power and affordability of desktop computing hardware and software.

BACKGROUND

Decision support system (DSS) is primarily concerned with supporting decision-making in terms of problem identification and problem solving at all decision-making levels. A DSS provides support to the user and does not replace the individual. The emphasis is on the enhancement of a decision-making process by allowing use of quantitative models that are appropriate to the problem. The term system includes both, the user and the machine.

The machine is a computer that, for now, operates in interactive mode through an input/output terminal. System also implies availability of quantitative models and some type of database. In the framework of this definition, these elements are more providing service to the decision maker than directly delivering a decision. Integrating all previous comments and characteristics, the decision support system can be defined as "an interactive computer-based support system that helps decision makers utilize data and models to solve unstructured problems." (Sprague and Carlson, 1982). Key terms in this definition are: *interactive, data,* and *models*, which are a recurring theme among developers of water management DSSs. In the context of water resources management a DSS can be defined as "an integrated, interactive computer system, consisting of analytical tools and information management capabilities, designed to aid decision makers in solving relatively large, unstructured water resource management problems (McKinney,2004)

A Decision Support System allows decision-makers to combine personal judgment with computer output, in a user-machine interface, to produce meaningful information for support in a decision-making process. Such systems are capable of assisting in solution of all problems (structured, semi-structured and unstructured) using all information available on request. They use quantitative models and database elements for problem solving. They are an integral part of the decision-maker's approach to problem identification and solution (modified after Parker and Al-Utabi, 1986; and Simonovic and Savic, 1989.).

In the context of optimization of reservoir operations, decision makers are the planners and managers. The objective of these decision makers is, among others, to provide the reliable supply of water with a quality appropriate for its use, production of hydropower, protection from floods, and protection of ecosystems. Three main subsystems must be integrated in an interactive manner in a DSS : (1) a user-interface for dialog generation and managing the interface between the user and the system; (2) a model management subsystem; and (3) an information management subsystem. Considering this in more detail, DSS architecture consists of (i) Data collection, (ii) Data processing ,(iii) Analysis, (iv) Decision support, and (v) Decision implementation (Fig.-1).

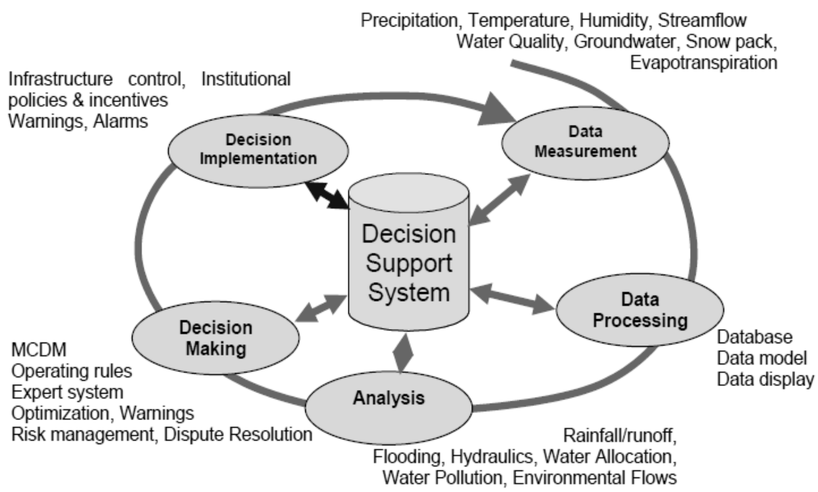

Figure 1 Schematic of a general framework for a water resources DSS (McKinney,2004).

Water Management Decisions

Although there are several areas of decision making in water resources management the focus is given here on two principal areas, namely (i) *Emergency water management* - involving floods or chemical spills; and (ii) *Water regulation and allocation* - involving water supply for municipalities, agriculture, industry, hydropower production, and environmental protection. Decision making regimes tend to be different for these two areas due to the difference in time available for making decisions- hours in former case and days to months in the latter.

Emergency Water Management

Early Warning Systems - Early warning systems for floods or accidental chemical spills are information systems designed to send automated hydrologic and water quality data regarding water-related disasters to river basin planners, who combine them with meteorological data and river basin models to disseminate hazard forecasts and formulate strategies to mitigate economic damage and loss of human life. Early warning systems are typically comprised of early warning subsystem, risk information subsystem, preparedness subsystem; and communication subsystem.

Accidental Chemical Spills

Accidental chemical spills are a major concern for areas that have vulnerable riverine ecosystems and cities with vulnerable drinking-water supplies and weak spill response capabilities. In order to provide emergency response capability to protect against accidental spills, studies are performed to determine travel times in river reaches. The results of these studies can be used to plan emergency responses to chemical spills into rivers, including guiding decisions regarding closing and reopening of intakes to drinking-water systems. A system for supporting response to accidental spills should include a database of potential spill sites and locations of agricultural chemicals, oil tanks, pesticides, and hazardous wastes stored on or near a river. The database should also include the bridges and rail lines which cross rivers and often serve as transport for hazardous materials. From the use of such a DSS tool, spill responders can quickly find directions to spill sites, emergency contacts and details about chemicals and how they react with the river under various conditions. Spill responders can also run simulation models of spills to practice their response and determine how long it takes for a spill to reach critical locations downstream.

Water Regulation and Allocation

Reservoir and Lake Management

In the area of reservoir and lake management, support is needed to make decisions regarding water supply for agriculture, industries and domestic purposes, and hydropower operation, pollution control, mitigation of climate change effects, reservoir eutrophication, phosphorus control strategies, and operation of multiple reservoir systems. Different types of models are required to provide support in this area, such as, water allocation models to determine the distribution of water for economic production and environmental protection in a basin; or two- and three-dimensional models to analyze water quality in lakes.

Non-Point Source Pollution

In the context of non-point source pollution decision support is needed to make plans for agricultural chemical use or protection of vulnerable water bodies, stream and aquifers. Modeling and managing agricultural non-point source pollution typically requires the use of a distributed parameter watershed model. The data management and visualization capabilities are needed to allowed decision makers to identify and analyze problem areas easily.

Conjunctive Use of Surface and Groundwater

Since decision makers are typically required to consider a multitude of social, legal, economic, and ecological factors, DSSs have great potential for improving the planning and management of conjunctive use systems. This may require the integration of a number of simulation and optimization models with graphic user interface capabilities to provide an adequate framework for the discussion of water allocation conflicts in a river basin. Conjunctive use models and multi-objective decision methods can be combined to provide decision support for inter-basin water transfer planning allowing decision makers to analyze the social, economic, and environmental impacts of water transfers.

Water Treatment and Distribution Systems

The design and operation of water treatment and distribution systems are also complex tasks in which the experience of the designer or operator is critical. Typically, models of these systems have sacrificed physical accuracy so that solutions could be obtained in a timely manner. User evaluation of trade-offs between model solvability and accuracy in the design of water supply and distribution systems, evaluate investment options, and demonstrate interaction between water quantity and quality. General network simulation and optimization models can be used in scheduling and control methodology for water distribution systems in urban distribution systems to determine proper structural changes to the system that minimize disruption to existing customers. Recently, evolutionary methods, such as genetic algorithms, have been used to solve realistic models of large urban water distribution systems which are intractable with more traditional methods.

AVAILABLE WATER MANAGEMENT DECISION SUPPORT SYSTEMS

The following decision support systems are generally available either at no cost or for a license fee:

Emergency Water Management DSSs

Flood Management Decision Support Systems

CWMS The Corps Water Management System" (CWMS) is an automated water management information system(Fritz, et al., 2002) and is comprised of an integrated system of hardware and software that begins with the receipt of hydromet, watershed, and infrastructure data which are used to determine the hydrologic response of a watershed, including reservoir inflows and local uncontrolled downstream flows. Reservoir inflows are processed to compute releases to meet reservoir and downstream operation goals. River profiles are computed, inundated areas mapped, and flood impacts analyzed. Various future precipitation scenarios can be considered, hydrologic response altered, reservoir release rules investigated, and alternative infrastructure conditions evaluated. CWMS uses a relational database (ORACLE) and the models incorporated in the system include EC-HMS (hydrologic modeling), HEC-RAS (river analysis), HEC-ResSim (reservoir evaluation) and HEC-FIA (flow impact analysis).

SMS The Surface Water Modeling System (SMS) is an interface providing access to one-, two-, and three-dimensional hydrodynamic modeling software, including pre- and postprocessor software for surface water modeling (EMRL, 2004). SMS models allow calculation of water surface elevations and flow velocities for shallow water flow problems, for both steady-state or dynamic conditions. Additional applications include the modeling of contaminant migration, salinity intrusion, and sediment transport (scour and deposition).

WMS (EMRL, 2004) - Similar to SMS and GMS, the Watershed Modeling System (WMS) has been developed by the Environmental Modeling Research Laboratory (EMRL) at Brigham Young University. WMS is a graphical modeling environment for watershed hydrology and hydraulics. WMS also includes tools for automatically delineating watersheds and sub-basins including a direct linkage with ArcGIS. WMS license fees are $4,600 for a single user including all modules and interfaces.

Accidental Spill Decision Support Systems

DBAM The "Danube Basin Alarm Model" (DBAM) is an operational model for the DAWEPS for simulating the travel time and expected peak concentrations of substances released during accidental spills (Gils and Groot, 2002; Gils et al, 2004). The DBAM was designed to provide a fast assessment of the effects of a spill using limited and readily available data. The Rhine Alarm Model (RAM) was used as the basis for DB AM, but DBAM goes one step further calculates the spreading of pollution across the river (Greencross, 2003). The DBAM software consists of three main parts:

- A user interface program that reads network data and allows the user to perform selections and input data on accidental spills, and run simulations.
- A model program that reads the system input data defining the river and the case dependent input files defining the spill and associated hydrology. It produces output files containing simulation results at selected locations and times; and
- A result display program that reads the simulation result files together with river network data and produces graphics and tables.

River Spill

River Spill is a GIS (ArcView 3.2) based system that models the real-time transport of constituents within a river system (Samuels et al., 2003). River Spill calculates time of travel and concentration based on real time stream flow measurements, decay, and dispersion of constituents introduced into surface waters. River Spill contains the following capabilities: Release Type - Instantaneous or Continuous release; Agent Type - Chemical or Biological Agents; and Solution Type - Peak or non-Peak concentration. By selecting a location on a river to introduce a chemical or biological constituent, the model performs the following functions: Tracks the contaminant constituent under real time flow conditions to a water supply intake; determines the concentration of contaminant as it decays and disperses in the river; associates an intake to a water treatment plant; and identifies the population served by the plant. Instantaneous and complete mixing of the pollutant in the river water column is the most important assumption in River Spill. Any deviation from these conditions requires detailed analysis of physical and chemical processes.

WQModel

In WQModel, mass is passed to downstream locations in a basin and decays according to travel time and decay coefficients (Whiteaker and Goodall (2003) and Whiteaker (2004). The decay rate represents the loss of mass due to biological decay, sorption, uptake, etc, as material moves downstream. Accumulation of mass in lakes and other water bodies can also be calculated assuming the lake has constant inflow equal to its outflow, and that mass entering the lake is instantaneous and perfectly mixed within the lake.

Water Allocation Decision Support Systems

Aquarius

AQUARIUS is a temporal and spatial allocation model for managing water among competing uses (Diaz et al., 1997). The model is driven by economic efficiency which requires the reallocation of all flows until the net marginal return of all water uses is equal. The model is implemented in C++ under an object oriented programming framework, where each system component (e.g., reservoir, demand area, diversion point, river reach) is an object in the programming environment. In the GUI, the components are represented by icons, which can be dragged and dropped from the menu creating instances of the objects on the screen. These can be positioned anywhere on the screen or removed. Once components are placed on the screen, they are linked by river reaches and conveyance structures. The model performs optimization to identify tradeoffs between water uses by examining the feasibility of relalocating water to alternative uses. Each water use is represented by an exponential demand curve (i.e., a marginal benefit function). The model is formulated as a quadratic programming model with a linear constraint set.

Aquatool

Aquatool consists of a series of modules integrated in a system in which a control unit allows the graphical definition of a system scheme, database control, utilization of modules and graphical analysis of results(Andreu, et al., 1991; Andreu, 2004). Modules include: surface and ground water flow simulation; single- and multi-objective optimization of water resources; hydrologic time series analysis; risk based WRS management. Water quality is not included. All documentation is in Spanish.

CALSIM

The CALifornia Water Resources SImulation Model (CALSIM) was developed by the California State Department of Water Resources (DWR) and the United States Bureau of Reclamation for planning and management of the California State Water Project and the U.S. Central Valley Project (DWR, 2004). CALSIM is a hybrid linear optimization model which translates the unimpaired (i.e. natural) stream-flows into impaired streamflows, taking into account reservoir operating rules and contract water demands exerted at model nodes (Quinn et al., 2004). CALSIM uses a mixed-integer linear programming solver to route water through the river network at each time step. The model code is written in Water Resources Engineering Simulation Language (WRESL), a high-level programming language developed by the DWR, and the system of WRESL equations is solved using a proprietary solver XA (Sunset Software Inc.). The model is used to simulate existing and potential water allocation and reservoir operating policies and constraints that balance water use among competing interests (Quinn et al., 2004). Policies and priorities are implemented through the use of user-defined weights applied to the flows in the system. Simulation cycles at different temporal scales allow the successive implementation of constraints. The model can simulate the operation of relatively complex environmental requirements and various state and federal regulations.

DELFT-TOOLS

Delft-Tools is a framework for decision support developed by Delft Hydraulics for the integrating water resources simulation programs. Functions of the system include scenario management, data entry, and interactive network design from map data, object-oriented database set-up, presentation, analysis and animation of results on maps (Delft Hydraulics, 2004) . DELFT-TOOLS integrates the Delft Hydraulics models: SOBEK, RIBASIM and HYMOS. SOBEK is a one-dimensional river simulation model that can be used for flood forecasting, optimization of drainage systems, control of irrigation systems, sewer overflow design, ground-water level control, river morphology, salt water intrusion and surface water quality. RIBASIM (River Basin Simulation Model) is a river basin simulation model for linking water inputs to water-uses in a basin. It can be used to model infrastructure design and operation and demand management in terms of water quantity and water quality. HYMOS is a time series information management system linked to the Delft Hydraulics models.

EPIC

Originally developed by the USAID project "Environmental Policies and Institutions for Central Asia") EPIC determines optimal water allocation in a river basin by multi-objective optimization in monthly time steps. Transport of conservative substances, e.g., salt, and management of generated hydroelectricity can also be optimized with the model. Water management alternatives can be developed for a time period of up to 15 years based on varying supplies and changing requirements of the water users.

Models created in EPIC perform optimization calculations for operation of river networks according to a ranked list of objectives. EPIC provides an interface for automatic network and model creation, as well as data input, input of constraints on reservoirs, channel flow and salinity, setting of the objective weights and visualization of results. The modeling system generates nonlinear optimization model files for solution by the General Algebraic Modeling System - GAMS (Brooke et al., 1998). The main optimization criterion of EPIC is to minimize deficits of water delivery to users; other criteria include satisfying environmental flows, and maximizing reservoir over year storage (McKinney and Savitsky, 2001). Policy decisions are modeled through changes in the weights on the various objective terms. A detailed description of the EPIC modeling system for river, salt, and energy management and its application to the Aral Sea basin can be found in McKinney and Kenshimov (2000) and McKinney and Savitsky (2001).

Mike-Basin

MIKE-BASIN couples ArcView GIS with hydrologic modeling to address water availability, water demands, multi-purpose reservoir operation, transfer/diversion schemes, and possible environmental constraints in a river basin (DHI, 2004). MIKE-BASIN uses a quasisteady- state mass balance model with a network representation for hydrologic simulations and routing river flows in which the network arcs represent stream sections and nodes represent confluences, diversions, reservoirs, or water users. ArcView is used to display and edit network elements. Water quality simulation assuming advective transport and decay can be modeled. Groundwater aquifers can be represented as linear reservoirs. Current developments are underway to utilize the functionality of ArcGIS-9 in MIKE-BASIN. Basic input to MIKE-BASIN consists of time series data of catchment run-off for each tributary, reservoir characteristics and operation rules of each reservoir, meteorological time series, and data pertinent to water demands and rights (for irrigation, municipal and industrial water supply, and hydropower generation), and information describing return flows.

ModSim

ModSim is a generalized river basin DSS and network flow model with capability of incorporating physical, hydrological, and institutional/administrative aspects of river basin management, including water rights(Labadie et al., 2000; Labadie, 2004). ModSim is structured as a DSS, with a graphical user interface (GUI) allowing users to create a river basin modeling networks by clicking on icons and placing system objects in a desired configuration on the display. Through the GUI, the user represents components of a water resources system as a capacitated flow network of nodes (diversions points, reservoirs, points of inflow/outflow, demand locations, stream gages, etc.) and arcs (canals, pipelines, and natural river reaches).

OASIS

Developed by Hydrologics, Inc. Operational Analysis and Simulation of Integrated Systems (OASIS) is a general purpose water simulation model (Hydrologics, 2001; Randall et al, 1997). Simulation is accomplished by solving a linear optimization model subject to a set of goals and constraints for every time step within a planning period. OASIS uses an object-oriented graphical user interface to set up a model, similar to ModSim. A river basin is defined as a network of nodes and arcs using an object-oriented graphical user interface. Oasis uses Microsoft Access for static data storage, and HEC-DSS for time series data. The Operational Control Language (OCL) within the OASIS model allows the user to create rules that are used in the optimization and allows the exchange of data between OASIS and external modules while OASIS is running.

RiverWare

RiverWare is a reservoir and river system operation and planning model(Carron et al., 2000; CADWES, 2004). The software system is comprised of an object-oriented set of modeling algorithms, numerical solvers and language components. Site specific models can be created in RiverWare using a graphical user interface (GUI) by selecting reservoir, reach confluence and other objects. Data for each object is either imported from files or input by the user. RiverWare is capable of modeling short-term (hourly to daily) operations and scheduling, mid-term (weekly) operations and planning, and long-term (monthly) policy and planning. Three different solution methods are available in the model: simulation (the model solves a fully specified problem); rule-based simulation (the model is driven by rules entered by the user into a rule processor); and optimization (the model uses Linear Goal-Programming Optimization).

URGWOM

The Upper Rio Grande Water Operations Model (URGWOM) is used to support studies related to water accounting and annual operating plans for the Rio Grande from the Colorado/New Mexico border to El Paso, Texas . The model is capable of simulating water storage and delivery operations and for flood control modeling(USACE, 2004b). URGWOM is a basic "backbone" water operations DSS meant to replace the current, more cumbersome, methods that are used to plan, analyze, and evaluate river and reservoir management options. URGWOM uses HEC-DSS as the primary database.

CRSS

The Colorado River Simulation System (CRSS) model (Schuster, 1987) was created in the early 1980s to model the Colorado River Basin in order to schedule, forecast and plan reservoir operations. Since CRSS was created to model the Colorado River Basin, many of the characteristics of the basin were hard-coded into the model, including the topography of the basin itself, the methods for calculating evaporation, bank storage and other reservoir-specific information, and the policies by which water is allocated . As new information about the basin and the operation policies and technology became available, CRSS had to be updated and RiverWare was chosen for this task.

WaterWare

WaterWare is a decision support system based on linked simulation models that utilize data from an embedded GIS, monitoring data including real-time data acquisition, and an expert system (Fedra, 2002; Jamison and Fedra, 1996). The system uses a multimedia user interface with Internet access, a hybrid GIS with hierarchical map layers, object databases, time series analysis, reporting functions, an embedded expert system for estimation, classification and impact assessment tasks, and a hypermedia help- and explain system. The system integrates the inputs and outputs for a rainfall-runoff model, an irrigation water demand estimation model, a water resources allocation model, a water quality model, and groundwater flows and pollution model.

CONCLUSIONS

Highly conflicting and competing demands for finite water resources call for instant availability of viable alternatives for optimization of operations for planners and decision makers of reservoirs. This is especially true is some of the operations like flood control or accidental chemical release into the reservoirs. Traditional approaches to optimization have not been very effective in providing desired solutions. The development of computer technology and attendant developments in softwares addressing decision making has ushered in a new era in optimization of reservoir operations. There has been proliferation decision support systems for reservoir operations for various purposes including flood control, timely and most appropriate action in the event of accidental chemical release into the reservoir, meeting the demands for water for irrigation, hydropower, industries, domestic, etc. The DSSs provide several alternatives for a particular operation to planners and decision makers. Although opportunities for real-world applications are enormous, actual implementations remain limited or have not been sustained. The traces the history of decision support systems (DSSs) for optimization of reservoir operations, and provides an overview of the development therein *vis-a-vis* developments and advancements in software, hardware and data integration technology. Being a complex phenomenon there exists no single DSS for various components of reservoir operations. We conclude the article by admitting that the development of DSS for optimization of reservoir is a continuous and evolving process leading to newer and more user friendly systems.

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THEME – II

CLIMATE CHANGE AND ENVIRONMENT

Climate Change is not Global Warming but it is much more

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ABSTRACT

Climate is what you expect and Weather is what you get. Weather and Climate include temperature, precipitation, wind, relative humidity, etc; and they are inter-related and mutually interactive. Earth's climate is dynamic and always changing through natural cycles. What we are experiencing now is part of this system. Changes in climate are not new. These inbuilt natural variations were there in the past and will be there in the future. Droughts and floods form part of natural variability in climate and form main part of the climate change. These are beyond human control. We need to adapt to them. Agriculture was adapted to such vagaries by our forefathers; and built location specific technologies in terms of farming systems. Two systems, namely natural and man induced, play an important role on weather and thus on climate at local and regional scales. They present, thus high spatial and temporal variations. The natural systems include climate system and general circulation patterns. With the increased interference of humans on nature, the natural variations in meteorological parameters, particularly temperature and precipitation, are being modified based on the degree of such changes. They include global warming and ecological changes, which are human induced part of climate change. Thus, the global warming is not the climate change. To unravel these, there is a need to study agro-climate at local and regional scales for developing adaptive measures.

Keywords: Climate change, Temperature precipitation, Floods and Droughts.

INTRODUCTION

With the IPCC, a political body, climate and climate change has turned in to a political satire. It all runs around billions of dollars and as a result the science of climate change become a de-facto global warming and carbon credits. As a result nations weakened the system of climate change that affected the assessment of water resources and agriculture and pushed in to misnomer on environment. True that Nature/climate system is being destroyed by both natural disasters such as cyclonic activity, earthquakes, volcanic activity, tsunamis, etc; and activities to meet human greed such as wars, oil-gas-water extraction, physical destruction of ecologically sensitive zones and destruction of natural water flow systems, violation of acts or laws, etc are often attributed to global warming. The flood disasters in Uttarkhand in June 2013; Jammu and Kashmir floods in September 2014 [human greed related disaster, see Figure 1]; November-December 2015 floods in Chennai in Tamil Nadu and Nellore in Andhra Pradesh; September 2000 floods in Hyderabad in Telangana are the manifestations of human greed. All these disasters are associated with the apathy of government agencies as they were unable to control the illegal construction activities along the river banks and converting rainwater channels, rivers, water bodies in to concrete jungle. Now governments are wrongly putting the blame on global warming. We must realize the fact that "ignorance is terrible but exaggeration is dangerous". In Hyderabad, flooding of Rejendranagar residential areas are due to the obstruction of water flows into Himayatsagar Lake by building Outer Ring Road Phase-I.

Figure 1 The 2014 floods in Jammu & Kashmir claimed more than 200 lives and caused losses in excess of Rs 1 lakh crore

Unfortunately, it has become a ritual, to attribute every weather event to El Nino or Global Warming without looking in to weather & climate of the regions. In 2014, WMO Secretary General in his World Meteorological Day release attributed the 2013 drought & warm conditions prevailing in the Southern Hemisphere to global warming following the footsteps of IPCC -- It is not so but it is part of natural variation, see Figure 2; and the current Ethiopian drought conditions were attributed to El Nino by FAO Representative in Ethiopia -- It is not so but it is part of natural variation, see Figure 3 – Reddy (1993). Indian institutions are making even Prime Minister to make false statements like "Chennai floods are associated with the Global Warming". Even at the recent 104th [2017] India Science Congress in Tirupathi such statements were made by prominent people like M.S. Swaminathan, National Biodiversity Chairperson Dr. B. Meenakumar Wildlife Institute of India Director Dr. V. B. Mathur, etc. The government and people take such statements as granted. Professor R. Ramesh of the PRL/New Delhi says rainfall had decreased over the 200 Years; Dr. R. Krishnan of IITM/Pune attributed the decrease in monsoon rainfall over India during the last few decades to increased human activity greenhouse gases, aerosols, land use changes and equatorial Indian Ocean warming. These are false statements, see Figure 4. It is like our proverbial saying "There is Tiger, here is the Tail" and in line with this "There is global warming, here is the impact". At all India level, during 2002 and 2009 drought years [0.81% and 0.79% of average precipitation condition] the temperature was raised by 0.7 and 0.9 oC and thus evaporation and crop water needs. In wet years, they are in opposite way.

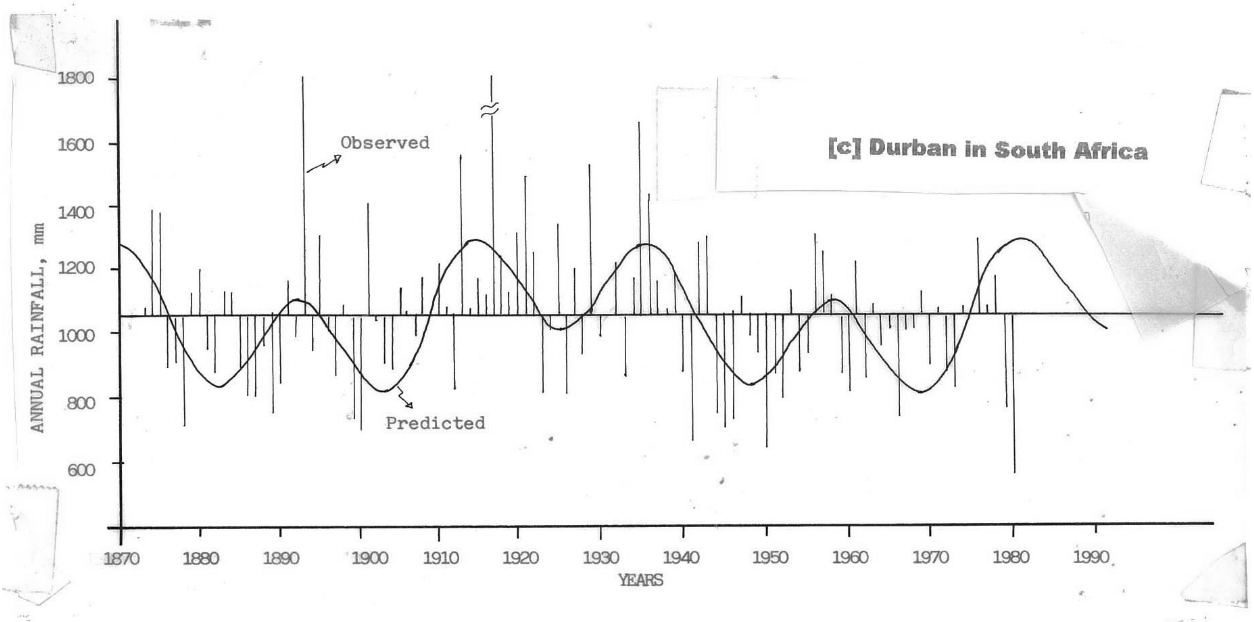

Figure 2 Annual march of Annual Durban Precipitation in South Africa [observed & predicted]

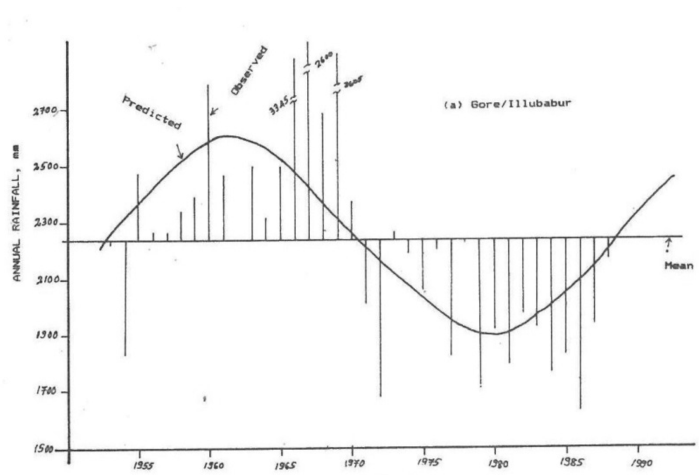

Figure 3 Annual march of Gore precipitation in Ethiopia [observed & predicted]

Heat and cold waves are also common to certain parts of India in summer and winter in association with the Western Disturbances and part of General Circulation Patterns. The IPCC conclusion in its AR4 Report that the Himalayan Glaciers will melt by 2035 has been withdrawn when UN Secretary General was questioned about the veracity of such pronouncements in 2009. Government informed the Indian Parliament after Paris meet in 2015 that 86.6% of 2181 of Himalayan Glaciers are not receding.

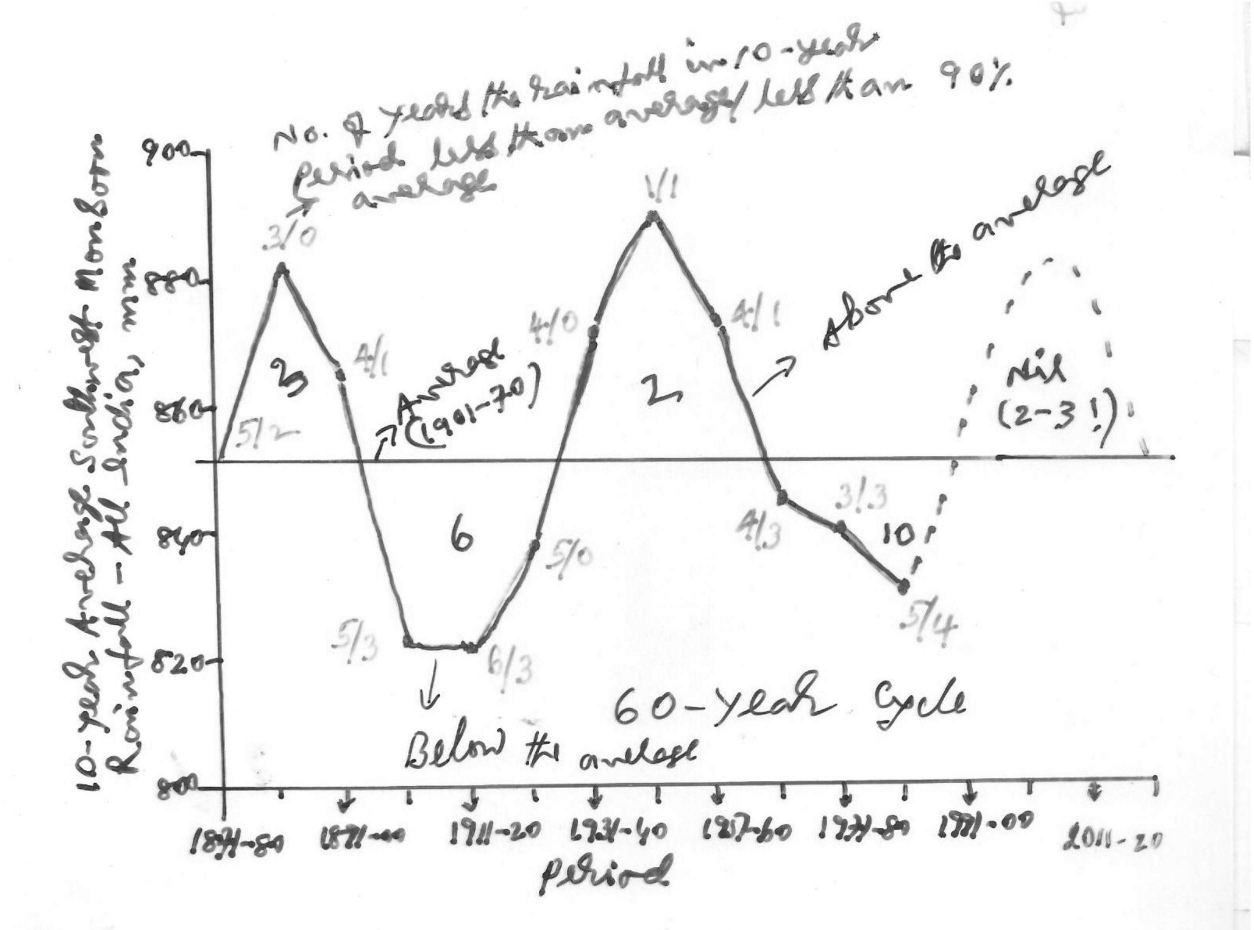

Figure 4 Ten year average march of all-India Southwest Monsoon Precipitation

CLIMATE CHANGE

Weather & Climate

Climate is what you expect, weather is what you get. Weather & climate respectively refer to short-term & long-term events in the atmosphere. Averages and extremes in climate in terms of meteorological parameters such as temperature, precipitation, wind, relative humidity, etc for individual stations can be seen in normal books published by meteorological departments using 30 year period. Thus, temperature is only one parameter of weather and climate. Meteorological parameters do not act independently but they interact with each other in the atmosphere. Change in one parameter has an impact on the other parameters, either directly or indirectly. They vary with climate system and General Circulation patterns at local and regional scales. The major components of climate system are the atmosphere, the hydrosphere, the crystosphere, the land surface and the biosphere. General circulation patterns relating to wind systems are superposed on the climate system – heat & cold waves are part of this system only. Thus, weather and climate vary with space and time.

Climate Change

Changes in climate are not new. They were there in the past and will be there in the future. These are inbuilt natural variations in nature. However, with the increased interference of humans on nature, the natural variations are being modified at local and regional scales. The combination of these is known as climate change [Reddy, 2016a].

(A) Natural variability consists of (a) irregular variations that include intra-seasonal & intra-annual variations and (b) systematic variations expressed by fluctuations or cyclic variations of different durations. These are beyond human control and thus needs to adapt to them. That is exactly what our forefathers did in the case of water resources [Reddy, 2016b] and agriculture [Reddy, 2016c].

(B) The man-induced variations have two components. They are changes through (a) greenhouse effect and (b) non-greenhouse effect. The former has two components, namely (i) global warming [since 1951] through anthropogenic greenhouse gases -- Carbon Dioxide from fossil fuel use, and (ii) impact of aerosols from volcanic eruptions. The later, non-greenhouse effect, is ecological changes. These are reflected to as trend.

Ecological Changes

Ecological changes [B(b)] though are associated with human actions but they are not part of greenhouse effect that directly converts energy in to temperature. Ecological changes are associated with the changes in land and water bodies in terms of their use and cover. In urban areas such changes are termed as urban-heat-island effects and rural areas such changes are termed as rural-cold-island effects. The former covers less than one-third of the land area and the later covers more than two-thirds of the land area. Majority of the met stations are located in urban areas. Because of this urban heat-island effect dominates the average temperature on land surface. With the sparse met network over rural areas the contribution of this to average temperature is under reported. This is clearly evident from the North Hemisphere and Southern Hemisphere temperature patterns. However, satellite data accounts all these factors and thus show nearly half to that of ground based data.

Global Warming

The global average annual temperature is derived from the data series over land and ocean but they present non-uniform distribution both with the space and the time. Same is also the case with the Carbon Dioxide data. Systematic measurements over oceans that is covering two-thirds of the globe, started only around 1990 and prior to that the ships used to take observations en-route. Contamination and covering with filth of the ocean waters steadily increasing with the time that affect weather and climate.

From 1973 onwards though satellites started measuring the temperature data, but officially the data is available since 1979. For the same period balloon data series are also available. As this data series showed lower annual average temperature over that of ground based measured data at global scale, this data was withdrawn from the internet. To show there is significant increase in global temperature due to global warming component, some organizations that are maintaining the temperature data lowered the past data and raised the current data. USA raw temperature data series presents a perfect 60-year cycle pattern. The data later drastically lowered the past data [like in the case of global average temperature data series] and thus showed a clear increasing trend. The basic problem in this is the data adjustments. Different groups, that manage temperature data sets, followed different adjustments and thus the global averages differ a lot. Some of these were exposed in 2009 December at Copenhagen summit, termed it as “climategate”. With all these the past 20 years the trend showed a hiatus-pause – the peak in 2016 is associated with El Nino plus the positive peak in 60-year cycle. Here there is another problem, groups use truncated data of a sine curve pattern and take anomaly over different base data periods. All such presentations give misleading inferences which have no practical utility or have no scientific meaning.

Global average temperature presents 60-year cycle superposed on the trend wherein the sine curve varied between - 0.3 ^{o}C to and 0.3 ^{o}C. Very recently [24th February 2014] British Royal Society and US National Academy of Sciences brought out an overview “Climate change: Evidence & causes”. They presented 10-, 30- and 60-year moving averages using 1850 to 2010 global average temperature anomaly data series and found the series after passing 60-year cycle moving average presented a near linear trend.

In the global [land & ocean] temperature anomaly data series [adjusted and not raw] of 1880 to 2010, the trend presented an increase of 0.6 ^{o}C per century. The satellite observational data series show half of this only. According to IPCC from 1951 more than half of the global average temperature anomaly is associated with anthropogenic greenhouse gases effect (B/a). Global warming is part of this (B/a/i). Even if we assume global warming component as 50%, the trend associated with the adjusted data is only 0.3 ^{o}C per century. Even this is basically because of lowering the past data and rising current data. Also, the data is corrupted by having met network concentrated in urban areas and thus overemphasizing urban-heat-island effect and by having sparse met network in rural areas [which is more than twice that of urban areas] and thus underemphasizing rural-cold-island effect. This is not the case with satellite data. Thus shows nearly half to the ground data. Thus, the global warming component is less than 0.15 ^oC only. It is insignificant when compared to intra-annual and intra-seasonal changes in temperature and thus has little impact on nature. The global warming component was attributed to cause sea level rise, ice melts, glaciers retreat, impact crop production, cause extreme weather events, rainfall-monsoon changes, etc, etc. There is no way we can expect these with that meager change in temperature.

Perth/Australia based Dr. David Evans finds that," the climate's sensitivity to carbon dioxide is much lower than was thought – a fifth or tenth of what IPCC says it is. Carbon dioxide causes minor warming – it caused less than 20% of the global warming in the last few decades. The climate is largely driven by factors outside our control". I in fact postulated that the sensitivity factor is not constant but it decreases non-linearly with the increased levels of carbon dioxide beyond 280 ppm making its contribution to global average temperature little as energy available for conversion in carbon dioxide wavelength is very limited and not infinity. This system was explained in my article [Reddy, 1995] wherein the relative water stress, relative energy stress and relative nutrient stress affect the relative growth or yield in crop production system.

NATURAL VARIABILITY

General

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development; it is also a scarce resource. India has more than 17.11% of the world's population, but has only 4.6% of world's water resources with 2.3% of world's land area. Precipitation and snow melt provide the fresh water; though they are renewable, they are highly variable with space and time; climate change plays vital role in the year to year water availability over different parts of India. Reddy (2017a & b) highlights this with Krishna River water and with reference to two drinking water Lakes in Hyderabad. At national level the variability of southwest monsoon precipitation [June to September] appears to be very low – coefficient of variation is 9.9% -- but as we go smaller areas like state or met sub-division they are higher – Coastal Andhra, Rayalaseema & Telangana Met sub-divisions, respectively they are 22.2%, 28.8% & 23.5%. The rainfall in July, August & September months over Telangana Met sub-division vary highly between 25-50 mm and more than 400-425 mm in a month. This is the type of temporal variability we experience. In the case of spatial variation, the drought proneness reaches as high as 60% of the years in rain shadow zone of Western Ghats [Reddy, 1993] like Anantapur-Bellary-Sangly belt to zero percent in good rainfall zones. Without understanding these, people make statements like "unusually extreme".

Destruction of Western Ghats and Himalayas, more particularly foot-hills, will have disastrous effect on climate, more particularly on precipitation. For example, with the removal of hillock in the Santacruz Airport for the expansion of runways, reduced the rainfall by about 300 mm; but subsequently with densely built tall structures all around brought the rainfall to more or less to the original condition. Reddy (1993) presented natural variability in precipitation in different countries of the globe. Figure 4 presents the 10-year average march of All-India Southwest Monsoon Precipitation. This data was published by IITM in 1995. This clearly shows a cyclic variation of 60 years. In sine curve, one arm shows a decreasing trend and another arm shows an increasing trend. The extrapolation is clearly showing the association of drought conditions prevailing now in parts of the globe [Figures 2 & 3].

National level variations

All India Southwest monsoon precipitation, that constitutes 78% of the annual, since 1871 to date followed a 60-year cycle [Reddy, 2016a]. By 1987, two cycles have been completed. The third cycle started in 1987 and will continue up to around 2046 in which the first 30 years form part of better rainfall period [this will end by 2016] and the next 30 years form part of poor rainfall period [starting from 2017]. The frequency of occurrence of floods in the northwestern Indian rivers followed this pattern. Hurricanes and Typhoons also follow this cyclic pattern but they are in opposite direction. Same is the case with Atlantic and Pacific oceans temperatures. The onset dates over Kerala Coast presents 52 year cycle similar to Fortaleza precipitation in northeast Brazil with sub-multiples playing important role [Reddy, 1977 & 1984].

Regional level variations

However, this is not applicable to individual states or regions. For example, Andhra Pradesh [undivided] a southeastern part of Indian States receives rainfall not only in southwest monsoon season but also in the northeast monsoon season [October to December] and as well cyclonic storms in summer [pre-monsoon season, April-May].

Both the monsoons rainfall presents a 56-year cycle but in opposite pattern. The frequency of occurrence of cyclonic activity in Bay of Bengal followed northeast monsoon 56-year cycle pattern. The annual rainfall presents 132 year cycle in which in the 66 year below the average cycle part [prior to 1935] present 12 years with excess rainfall [>110% of the average] and in 24 years with deficit rainfall [< 90% of the average]; in the 66-year above the average cycle part [from 1935 to 2000] present 24 years with excess rainfall and in 12 years with deficit rainfall. The current below the average part of 66 years cycle part will be similar to prior to 1935, started in 2001. Water availability in the Krishna River basin presents similar pattern in terms of surplus & deficit [Reddy, 2016b]. A study of agro-climatic variables also presents systematic variations similar to 56 year cycle in Kurnool in AP [Figure 5] – observed and predicted. This figure includes yearly march of effective available moisture period in weeks (G) – bottom -- and week number of commencement time of planting rains (S) – top --. This type analysis helps long and short term agriculture planning at local level. Averages only define climate condition but such analyses provide the risks associated with natural variability of climate on water resources, agriculture and thus on environment.

CONCLUSIONS

From the above discussions, it is clear that, there is a need to carryout detailed agro-climate analysis at individual station level and region level to develop adaptive measures [as explained in Reddy, 1993]; long-term agricultural planning [Reddy, 2016c]; and as well development of water resources like interlinking of rivers, construction of dams and application of micro-irrigation [Reddy, 2016b], etc. This must include the study of climatic fluctuations in precipitation. In fact such analysis provides basic information such as drought proneness, sustainable growing period and sustainable period for planting as per fluctuations in precipitation. Two papers presented in this conference included elsewhere in the proceedings looks at details on Krishna water [Reddy, 2017a] and two drinking water reservoirs issues [Reddy, 2017b].

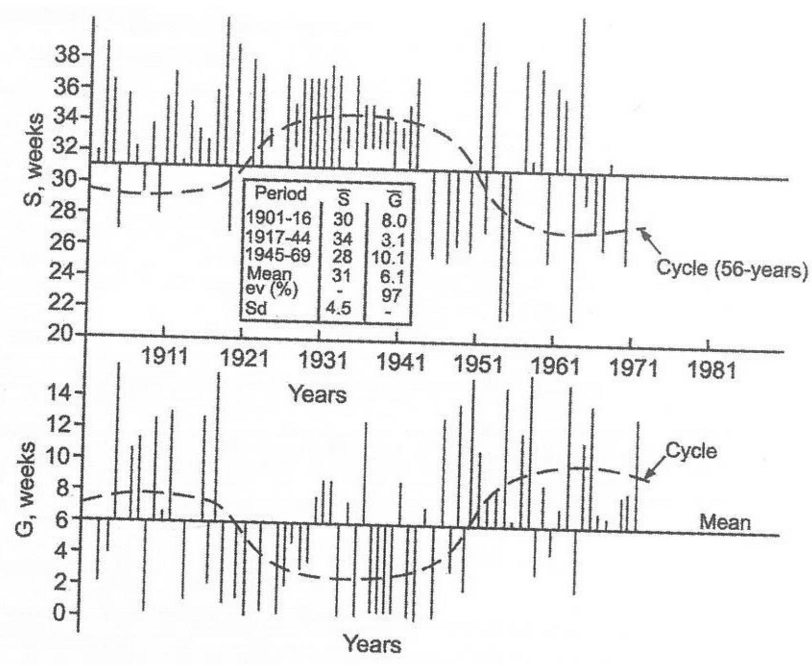

Figure 5 Annual march of Agro-climatic variables of Kurnool in AP

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Effect of Different Levels of Fertigation on Growth Parameters of High Density Plantation of Nagpur Mandarin

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ABSTRACT

A field experiment was conducted at Center of Excellence for Citrus (CEC), College of Agriculture, Nagpur during the 2015-16 on 5 year old Nagpur Mandarin crop with high plant density of 6 x 3 m accommodating double the number of plants as that of conventional 6 × 6 m spacing. Six treatments were studied in RBD with four replications, consisting of one treatment of soil application (band placement) of NPK fertilizers as per Dr PDKV Akola recommended dose for normal 6 × 6 m spacing (RDF) and 5 fertigation treatments i.e. 160%, 140%, 120%, 100% and 80% of the recommended dose of NPK fertilizers in 9 splits. Analytical work of the experiment was carried out at analytical laboratory of 'Department of Soil Science and Agricultural Chemistry', College of Agriculture, Nagpur. It was found that treatment T_2 with 160 % NPK fertigation showed superior over other treatments with regards to growth parameters.

Keywords: RBD and NPK Fertilizers.

INTRODUCTION

Citrus is an important commercial fruit crop of India. It occupies third position among fruits after banana and mango in India. Important citrus species in India are Mandarin, Acid Lime and Mosambi. Mandarin (*Citrus reticulata Blanco*) is important citrus cultivar occupying about 40% area under citrus cultivation. In India it is cultivated on 329900 ha i.e. 3.9 % of the total area under fruit crops with annual production of 3431400 MT. In India the average productivity of Mandarin is 10.4 MT/ha. (Indian Horticulture Database 2014). In Maharashtra it is mainly grown in Vidarbha and known as Nagpur Mandarin having average productivity of only 5.5 t/ha. Improper water and fertilizer management is one of the reasons of low productivity and decline of citrus orchards. Traditionally this crop is grown with 6 x 6 m spacing on level field and irrigated with basin method. Because of scarcity of water many orchard growers are adopting drip irrigation. But fertilizers are still applied with band placement or soil application method which requires more labours and also results in low fertilizer use efficiency. This practice does not match with the drip irrigation. Therefore application of fertilizers along with drip irrigation i.e. fertigation is necessary. Fertigation which combines irrigation with fertilizers is well recognized as the most effective, economical and convenient means of maintaining optimum fertility level and water supply according to the specific requirement of crop and resulting in higher yields and better quality fruits (Smith, 1979; Syvertsen, 1996). Fertigation offers the best way of supplying nutrients to the root zone in areas with scanty rainfall. The drip irrigation and fertigation in citrus has better water and fertilizer use efficiency as well as reveal other advantages like saving of labour, water and power, greater orchard uniformity, better soil water plant relationship, rooting environment, better vegetative growth, better yield and quality of citrus (Smajstrla *et al.* 1986, Shirgure *et al.* 2001). Due to recent advancements in horticultural practices on one hand and agricultural engineering on the other, establishment of densely planted, dwarfed, intensive orchards on raised beds is becoming popular and being adopted by the orchard growers. The major advantages of high density plantation are as higher convenience and efficiency of tree care, plant protection operations, harvesting and early production of commercial yield. This method has low risk of ill drainage. All the favourable factors of high density plantation result in higher yield and productivity. Early productivity shortens investment period and above all, enables quick supply of fashionable market demands for newly developed fruits. Therefore the Nagpur Mandarin orchard growers of Vidarbha region have started to take high density plantation. Keeping these points in view, an experiment was conducted on high density plantation of Nagpur Mandarin on raised beds at Centre of excellence for Citrus Farm, College of Agriculture, Nagpur, during 2015-16 to find optimum dose of fertigation for high density plantations of Nagpur Mandarin.

MATERIAL AND METHODS

A field experiment was conducted to study the effect of different levels of fertigation on high density plantation of Nagpur Mandarin crop (5 years old) on raised beds at Centre of excellence for Citrus Farm, College of Agriculture, Nagpur with plant density of 6 x 3 m. The soil was clay loam with pH 7.4 and EC 0.36 dSm^{-1}. Drip irrigation with laterals having inline drippers of 4 lph at 40 cm distance was installed (2 laterals/row). Arrangement of ventury injector was made. A field experiment in RBD with six treatments and four replications was carried out. The treatment details of fertigation treatments are given in Table 1.The fertigation was applied in 9 equal splits from June-2105 to February 2016. Irrigation was applied based on reference evapotranspiration using daily pan evaporation data on alternate day. The meteorological data in respect of rainfall, relative humidity maximum and minimum temperature was recorded at Meteorological Observatory, Department of Agronomy, College of Agriculture, Nagpur. The water soluble fertilizers 19:19:19, urea and muriate of potash (water soluble) were used for fertigation treatments (T_2 to T_6). Firstly the P dose was fulfilled by using 19:19:19 fertilizer and thereafter additional N and K were supplied through urea and muriate of potash (water soluble) fertilizers.

Table 1 Details of treatments

Treatment	Specifications
T_1	Soil application with RDF (Kg/ha)
T_2	Fertigation with 160% of RDF (Kg/ha)
T_3	Fertigation with 140% of RDF (Kg/ha)
T_4	Fertigation with 120 % of RDF(Kg/ha)
T_5	Fertigation with 100 % of RDF (Kg/ha)
T_6	Fertigation with 80 % of RDF (Kg/ha)

For treatment T_1, as per Dr PDKV Akola recommendation, the circular band placement of granular fertilizers (urea, single super phosphate and muriate of potash under basin was performed. The RDF which is expressed in Kg/plant for conventional 6 x 6 m spacing is converted into Kg/ha and accordingly calculations for all treatments were done for 6 x 3 m spacing.. Fertilizers in fertigation treatments were applied through in line drip irrigation system in 9 equal splits. The experimental soil is neutral in reaction with low electrical conductivity and low in available nitrogen, phosphorous and high in available potassium. The soil was found deficient in zinc. Therefore, zinc sulphate was applied uniformly @ 40 g $tree^{-1}$.

The initial and final soil and leaf samples were taken and their analysis was done as per standard procedures. The initial and final growth parameters were recorded as per standard guidelines and the canopy volume was estimated by using Castle's formula (Canopy volume= 0.54 HD^2) where H and D indicate height and diameter as suggested by Castle (1983). The statistical analysis of the data carried out by statistical methods suggested by Gomez and Gomez (1983). The treatments were compared for significance against critical difference (C.D.) at 5% level of probability.

RESULTS AND DISCUSSION

Growth Parameters

The effect of different levels of fertigation were studied on vegetative growth characteristics of Nagpur Mandarin plants in high density plantation. The field observations of each growth parameter were taken and analyzed. The related results are shown in Table 2a and 2b and are discussed below.

Table 2a Plant growth parameters as affected by different levels of fertigation

Treatments	Plant Height (m)	Increase in pl.ht (m)	Stock girth (cm)	Increase in stock girth (cm)	Scion Girth (cm)	Increase in scion girth (cm)
T_1 - Soil application with RDF	3.475	0.455	31.595	7.295	28.925	4.320
T_2- Fertigation with 160% of RDF	3.580	0.550	33.445	7.020	31.055	4.850
T_3- Fertigation with 140% of RDF	3.525	0.505	32.920	6.755	28.340	4.485
T_4- Fertigation with 120% of RDF	3.475	0.485	29.695	5.565	26.62	4.265
T_5- Fertigation with 100 % of RDF	3.425	0.465	32.685	7.105	27.975	4.225
T_6- Fertigation with 80 % of RDF	3.395	0.415	32.355	6.305	27.105	4.760
F Test	NS	NS	Sig	NS	NS	NS
SE (m) $\pm$	-	-	0.675	-	-	-
CD at 5%	-	-	2.03	-	-	-

Plant Height

From Table 2a it is seen that plant height in all treatments do not differ significantly. However, highest plant height is observed in treatment T_2 followed by treatments T_3, T_4 and T_5 whereas lowest plant height was recorded in treatment T_6.

Increase in plant height

From the observations in Table 2a, it is revealed that the increase in plant height over previous year was non significant among all the treatments. However highest increase in plant height was recorded in treatment T_2 followed by treatments T_3, T_4 and T_5. The lowest increase in plant height was observed in treatment T_6.

Stock girth

From recorded observations it was seen that stock girth in treatment T_2 was significantly superior and was at par with T_3, T_5 and T_6. The lowest stock girth was observed in treatment T_4.

Increase in stock girth

It is revealed that increase in stock girth was statistically non significant among the treatments. Numerically highest increase in stock girth was observed in treatment T_1 and the lowest increase in stock girth was found in treatment T_4.

Scion girth and Increase in scion girth

From the observations recorded in Table 2a it is seen that scion girth and increase in scion girth was statistically non significant among all the treatments. However highest values were observed in treatment T_2.

Table 2b Plant growth parameters as affected by different levels of fertigation

Treatments	Plant spread (m)	Increase in plant spread (m)	Canopy Volume (m^3)	Increase in Canopy Volume (m^3)
T_1 - Soil application with RDF	1.99	0.350	6.185	2.625
T_2- Fertigation with 160% of RDF	2.165	0.565	7.575	4.1
T_3- Fertigation with 140% of RDF	2.155	0.495	7.385	3.665
T_4- Fertigation with 120% of RDF	2.210	0.415	7.625	3.380
T_5- Fertigation with 100 % of RDF	2.075	0.360	6.595	2.805
T_6- Fertigation with 80 % of RDF	1.965	0.315	5.915	2.330
F Test	NS	Sig.	NS	Sig
SE (m) $\pm$	--	0.03	--	0.18
CD at 5%	--	0.098	--	0.56

Plant spread

From the data furnished in Table 2b it is seen that there is no significant difference in plant spread among all the treatments. However treatment T_2 exhibited highest value of plant spread followed by treatment T_3.

Increase in plant spread

It is seen that significantly highest increase in plant spread over previous year was observed in treatment T_2 followed by the treatments T_3 and T_4 which were at par. The treatment T_6 showed lowest increase in plant spread.

Canopy volume

From the observations recorded in Table 2b it is found that there was no significant difference in canopy volume among all the treatments.

Increase in canopy volume

It is seen from Table 2b that the significantly highest value of increase in canopy volume was observed in treatment T_2 followed by treatments T_3 and T_4 which were at par. Treatment T_6 showed lowest value of increase in canopy volume.

It is well known fact that sufficient soil moisture for progressive plant growth is maintained by drip irrigation, which leads to better development of photosynthetic area and accelerate photosynthetic rate. Thus, as a consequence, plant growth was accelerated. Availability of sufficient soil moisture along with availability of more nutrients through fertigation in higher fertigation regimes leads to better development of vegetative plant parts over lower micro-irrigation and fertigation regimes. This might be due to better nutritional environment in the root zone for the growth and development of the plant as NPK are considered as one of the major nutrients required for proper growth and development of the plant. When, there was enhanced absorption of nitrogen, phosphorus and potassium through fertigation an overall improvement in growth were observed.

CONCLUSION

The vegetative growth parameters showed higher values mostly in Treatments T_2 (Fertigation with 160% RDF) and treatment T_3 (Fertigation with 140% RDF). Therefore it seems to be a promising dose. The use of nitrogen (N), Phosphorus (P) and potash (K) fertilizers through fertigation technique can be a sustainable solution for optimum growth of Nagpur Mandarin which also cuts down the cost of cultivation. However further study is needed in this regard.

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Development and Performance Evaluation of a Solar Powered Automated Fertigation System

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ABSTRACT

Automated fertigation system is a highly advanced system for water and fertilizer administration in irrigated agriculture. It promises the application of water in right quantity along with right fertilizer at right time, thereby reducing fertilizer loss and cost of labour resulting in saving of money with the help of an automated mechanism. The present study was undertaken to develop a timer based automated fertigation system using an FIP and to evaluate the performance of the system. Field evaluation of the developed automated fertigation system was carried out by growing salad cucumber variety 'Saniya' in grow bags inside a poly house located at Agricultural Research Station, Anakkayam, Malappuram, Kerala. Comparative evaluation was carried out between biometric observations and yield parameters of the two sets of crop grown inside the polyhouse, one fertigated automatically with the developed system and the other one fertigated using venturi injector. The crop growth parameters like height of the plant, days to first flowering, days to 50 percentage flowering, days to initial budding, days to first harvest and leaf area index and yield parameters viz. size of the fruit, number of fruits harvested per plant and average yield were recorded during the study. Data collected was subjected to statistical scrutiny viz., ANOVA (Analysis of Variance) and Student-t test. Values of all these parameters were found to be better for the crops grown with automated fertigation system compared to venture injector. The developed system operates using solar panel generating a power of 250 W on an average along with a battery, which makes the system operations possible up to 4.4 days, during periods without sunshine. Hence it can be concluded that the developed automated fertigation system can ensure better yield for salad cucumber variety 'Saniya' grown inside the polyhouse.

Keywords: *Biometric observations, Cucumber, FIP, Irrigation, Solar, Timer, Yield parameters.*

INTRODUCTION

The adoption of fertigation by farmers largely depends on the benefits derived from it and fertigation is in its introductory stage in Kerala. Its success in terms of improved production depends upon how efficiently plants take up the nutrients. Proper scheduling and intervals are also needed to provide nutrients at a time when plants require them. The adoption of fertigation worldwide has shown favourable results in terms of fertilizer use efficiencies and quality of produce besides the environmental advantages. The choice of selecting various water soluble fertilizers are enormous and therefore, selection of chemicals should be based on the property of avoiding corrosion, softening of plastic pipe network, safety in field use and solubility in water. Automated fertigation system is a highly advanced system of drip automation for water and fertilizer administration in agriculture**.** It promises the application of water in right quantity with right fertilizer at right time, without manual endeavours and labour. Thus, labour cost could be reduced with the help of an automated mechanism. Using an automated fertigation system can help producers to make correct choices that can essentially affect water and fertilizer utilization and can decrease fertilizer lose. Some automated systems are capable of integrating irrigation scheduling with nutrient dosing activities while other systems only manage the nutrient dosing equipment. The present study was undertaken to develop an automated fertigation unit and to evaluate the performance of the system in the field. The developed system is powered completely by solar energy and its effectiveness is also tested to control the fertilizer mixing process and injection of nutrient solutions at various growth stages of the crop.

MATERIALS AND METHODS

The system was made by developing logical circuits between various components as shown in Figure 1. The major and auxiliary components used for the development of the system are listed below.

A. Major components

A.1 Fertilizer tank

Three fertilizer tanks are used to store concentrated fertilizer solutions individually. Each Fertilizer tank is having 40 l capacity and fertilizers are filled manually to these tanks. Water is filled for making solution through solenoid valves by a push button switch which is in turn controlled by level sensors. Solenoid valves of a particular tank will activate only when the tank is empty and it will deactivate if the tank is full and it will allow filling again only after the tank is empty.

A.2 Mixing tank

All the fertilizers which are pumped individually from each fertilizer tanks reach the mixing tank, from where it gets mixed up together thoroughly. The tank is having 10 l capacity. And this mixed solution is then injected into the drip line with the help of an injection pump which is controlled by timer and level sensors.

A.3 Fertilizer pumps

Three fertilizer pumps are used to pump fertilizer from each fertilizer tank to mixing tank. Each pump will work sequentially with the impulse from the timer. The pumps must be calibrated before setting the timer. The pumps works with 12 V DC instead of 24V AC from the timer, so it is connected through a 12V relay. If the tank is empty, the fertilizer pumps will be deactivated even if the timer sends signal to the pump.

A.4 Fertilizer Injection Pump

Fertilizer injector pump is used to inject fertilizer into the drip line. FIP with an injection rate of 10 l/h is used in this design. It works with 230 V.

A.5 Level controller

Level controllers are a set of relays controlled by level sensors / float switch; these controllers control the function of fertilizer pump, bubbler, water filling solenoid valves and fertilizer injector pump.

A.6 Timer

Timer is the major controlling device in this design and is used to control the working of fertilizer pumps, fertilizer injection pumps and the drip valve according to the preset timings. It works with 24 V AC, which can control any device that works with 24 V AC like solenoid valves. It has 2 input slots 1 common slot and 8 control slots.

1. Slot 1 or timer station T1 used to control fertilizer pump1 and bubbler 1
2. Slot 2 or timer station T2 used to control fertilizer pump 2 and bubbler 2
3. Slot 3 or timer station T3 used to control fertilizer pump 3 and bubbler 3
4. Slot 4 or timer station T4 used to control fertilizer injector pump
5. Slot 5 or timer station T5 used to control drip valve
6. Slot 6-8 or timer station T6-T8 are optional control slots for installing additional instruments like mist, side curtain.

B. Auxillary components

B.1 Transformers

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction

i. 12-0 V, 2A transformer

This transformer is used to supply power to the fertilizer pumps.

ii. 12-0-12 V, 3A transformer

Two transformers of this specification were used. One of them was used to supply power to the 8-station timer while the other supplied power to the relay boards and solenoid valves.

B.2 Relay board (4 – channel)

Four 4-Channel relay boards are used for controlling pumps, bubblers and level sensors inside the tanks and FIP. These 4-channel relay boards work in 12 V and senses voltage within a range of 3.3 V to 5 V.

B.3 Voltage regulator

Voltage regulator regulates the power supply from 12 V DC to 3.3 V DC, 5 V DC and 12 V DC.

B.4 Relay (12V 7A)

Four 12V 7A relays are used for controlling four 4-Channel relay boards that control pumps and bubbler. Other than this, eight relays of same specification are used for the working of fertilizer level indicators.

B.5 Push button switch

Push button switches are used for activating the solenoid valves for filling of fertilizer tanks with water. These are three in number.

B.6 Rectifiers

Rectifiers are used to convert AC to DC.

B.7 Solenoid valves

A solenoid valve is a valve which helps to operate a valve automatically. Solenoids operate use an electromagnetic solenoid coil to change the state of a valve from open to closed, or vice-versa. If the solenoid valve is in normally closed condition, when the coil is energized, the valve gets lifted open by the electromagnetic force produced by the coil. It requires pressurized water.

Solenoid valves of the following specifications were used:

i. 2” Solenoid valve

   2” Solenoid valves are used to switch ON and OFF drip.

ii. 1” Solenoid valve

   1” Solenoid valve is used to fill water in the fertilizer tanks.

B.8 Float switch

Float switches are used inside each tank to sense whether the tank is empty or full and send the signal to level indicator, fertilizer pump controlling relay, bubbler relay and push button switch. When the tank is full, the level indicator shows green signal, it cuts the power supply to the respective tank filling pushbutton switch and the power supply switch will be engaged only after tank is emptied. When the tank is empty, the power is supplied to the relay board connected to the red light in the level indicator.

B.9 Bubblers

Bubblers are used to agitate the fertilizer inside each tank with water to make thorough fertilizer solution before every pumping into the mixing tank and it is controlled by the timer through bubbler relay. The bubbler is working with 230 V AC instead of 24 V AC from the timer so it is also connected through a 12 V relay.

B.10 Level indicators

Level indicators are used to indicate the fertilizer level in each tank. It indicates whether the tank is empty or full. These are eight in number, 2 each for three fertilizer tanks and one mixing tank.

B.11 Solar panel

Solar panel with specification of 16 V 300 W was used in the design to supply an uninterrupted power supply to all the control units particularly the timer.

B.12 Battery

A 150 AH 12 V battery is used for storing the solar power.

B.13 Solar power generator

Solar power generator is used to convert the solar power to 230 V, 550 W.

B.14 Wooden casing

Other than fertilizer and mixing tanks, timer and level indicators all other components of the logical control circuit which control the working of the system is enclosed in a wooden casing of size 70x70x28 cm fitted with an exhaust fan to reduce the heat inside the casing

Calibration of fertilizer pumps

In laboratory, three fertilizer pumps were calibrated to find out how much amount of water it pumps out in a minute for which the pump was placed in a container with water and was allowed to pump to a height equal to the height of mixing tank for 1 minute and the amount of water coming out through pump outlet was collected and measured using a measuring cylinder,. This was done three times and the average value was noted. Calibration was done to decide how much time the pump should work so as to apply required amount of fertilizer for the plants. And this time is then set in the timer station T1, T2 and T3 for the working of fertilizer pumps. Process of calibration was done two times during the crop season as the pumping rate may vary with time due fertilizer deposition.

Fertilizer scheduling

The fertilizer recommendation for the crop for an area of 1 ha was obtained from package of practices (POP) published by KAU from which the fertilizer requirement for the required number of plants was calculated considering the recommended spacing. The total fertilizer required for the crop was provided in uneven splits in such a way that, fertigation was carried out once in three days and a break was provided in this schedule after four dozes of fertilizer application to avoid the salt injury to the crop due to fertigation. The total amount of water required for each fertilizer to achieve the desired concentration was also calculated. The total amount of fertilizer and water as per the calculations is initially filled in the tank (float switches are adjusted inside the tanks according to the amount of water initially present in each tank) and is pumped according to the schedule. The schedule was prepared for 90 days interval.

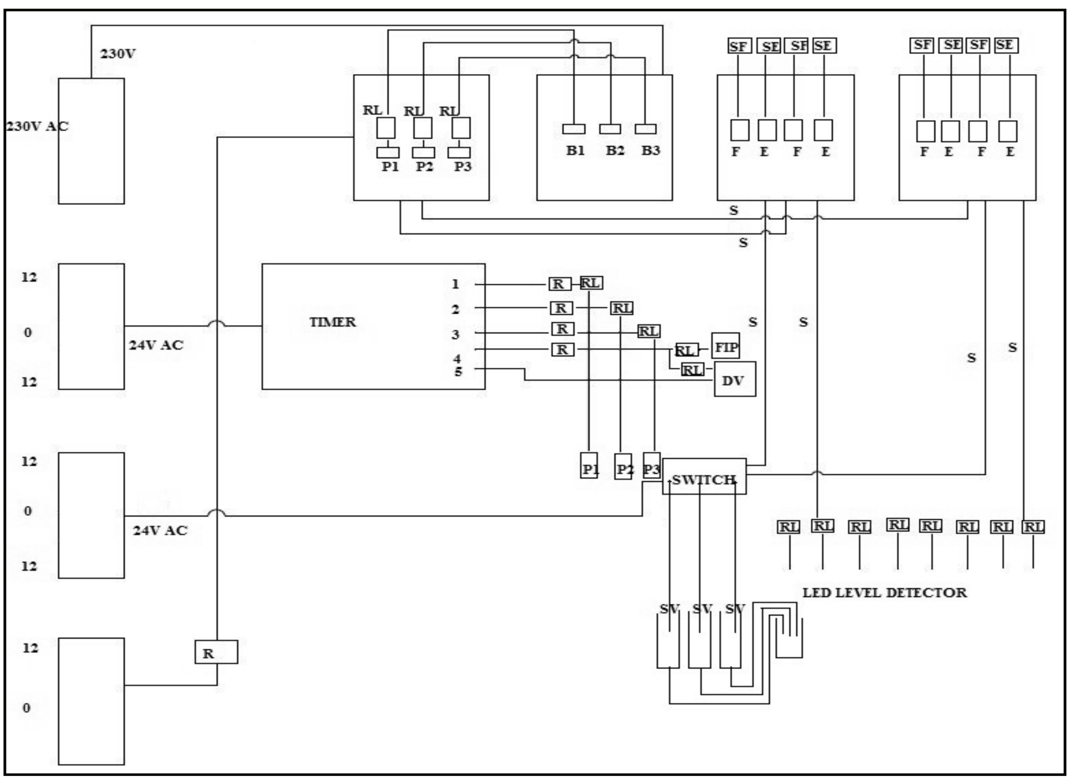

Figure 1 Logical circuits in the system

RL - Relay;B1,B2,B3 - Bubbler 1,2and 3;F and E – Full and empty; SF and SE – Full and empty signal; R-Rectifiers; FIP- Fertilizer Injection pump;S- Signal; DV-Drip valve; P1,P2 and P3 – Fertilizer pumps

During of operations

As the amount of fertilizer added during different splits and the requirement of different fertilizer differed, the time of pumping of each pump for achieving the required amount of fertilizer was calculated considering the amount of fertilizer pumped in unit time by each pump. This time of pumping thus calculated is being set in the timer stations T1, T2 and T3. As the crop growth progresses the nutrient requirement of the crop differs so the timer has to be reset accordingly. Timings of the stations T4 which controlled the fertilizer injection pump and T5 which controlled the drip valve was set to work for duration of ten minutes throughout the crop season.

Working of the system

In this design, timer station T1 becomes ON according to the pre-set timings and if tank1 is not empty, fertilizer pump P1 and bubbler B1 get activated through two 12 V relays respectively. If the tank is empty T1 goes to OFF condition or else, P1 and B1 get activated. Sequentially when timer station T2 becomes ON according to the pre-set timings, it is checked whether the tank is empty. If it is empty T2 goes to OFF condition or else fertilizer pump P2 and bubbler B2 get activated through relays. Similarly, when T3 is ON according to pre-set timings, P3 and B3 get activated through relay when tank is not empty and if it is empty, it turns OFF. When timer station T4 becomes ON according to pre-set timings, level in the mixing tank is checked, and if it is empty, it turns OFF. But if the tank is not empty, fertilizer injection pump along with drip valve get activated through relays. When timer station T5 becomes ON according to pre-set timings, drip valve turns ON. The conditions whether the tanks are empty or not empty are decided by the level sensors / float switch (which will be indicated by level indicators).

RESULTS AND DISCUSSION

Comparative evaluation was carried out between biometric observations and yield parameters of the two sets of crop grown inside the polyhouse, one fertigated automatically with the developed system and the other one fertigated using venturi injector at various stages of plant growth. It is indicated as T_1 and T_2 respectively. The readings were taken once in a week from both the plots.

Biometric observations

i. Height of the plant

Drip fertigation can enable the application of soluble fertilizers and other chemicals along with irrigation water in the vicinity of the root zone (Patel and Rajput, 2011; Narda and Chawla, 2002). The application of water and nutrients in small doses at frequent intervals in the crop root zone ensures their optimum utilization and higher growth (Jayakumar *et al., 2014*). The results showed that at the final stages, plant height was significant between the individual treatments i.e., T_1 outperformed T_2. This indicated the superiority of the automated drip fertigation T_1 than the other. It registered the maximum plant height of 273.0 cm at the 4th observation, followed by T_2 with 242.8 cm. The concentration and availability of various nutrients in the soil for plant uptake depends on the soil solution phase which is mainly determined by soil moisture availability.

ii. Flowering parameters

Earliest flowering was obtained in the treatment T_1 (21 days), whereas in the treatment T_2, it was late by 3 days. The optimum levels of nutrient status in the media aided early flowering and the increase in number of pistillate flowers might be due to the vigorous vine growth and more number of branches resulting in increased metabolic activity in cucumber (Bishop *et al.,* 1969). Similar is the case in 50 per cent flowering, first fruit and first harvest for T_1 and which was followed by T_2.

iii. Leaf Area Index

The results indicate that at all the stages; the values of T_1 were numerically higher, when compared to T_2. This indicated that uniform application of fertilizer through drip fertigation could give maximum leaf growth for cucumber. The vegetative growth of the plant is directly related to the nitrogen applied (Klein *et al*., 1989). Moreover according to studies conducted by Baruah and Mohan (1991), potassium application is important in leaf growth and development. Nitrogen, phosphorus and potassium are three necessary nutrients which affect the plant growth and thus the uniform and frequent application of fertilizer through developed automated drip fertigation system might have result in the better leaf area index.

Yield parameters

i. Number of fruits per plant

The results showed that T_1 recorded the higher number of fruits per plant than T_2 statistically significant. It registered the maximum number of 29.12 fruits per plant and this was followed by T_2 with 10.50 fruits. The increase in number of fruits of T_1 might be due to the increased vegetative growth of the plants grown under the developed system leading to enhanced nutrient uptake and better water utilization which results in increased rate of photosynthesis and translocation of nutrients into the reproductive part or the produce compared to the conventional method of fertilizer application. The present findings are in accordance with the results of (Sharma *et al*., 2011). According to Ramnivas *et al*. (2012), interaction of irrigation and fertigation might have resulted to maximum fruit weight.

ii. Size of the fruit

The results showed that the automated drip fertigation system in polyhouse T_1 recorded the higher fruit weight than the other two treatments. It registered the maximum fruit weight of 246.4 g and this was followed by T_2 with 212.9 g.

T_1 registered the maximum fruit length of 21.35 cm and it was followed by T_2 with 20.70 cm. The increase in length of the fruit might be due to regular water and nutrient supply through drip fertigation, crop plants can complete all metabolic process at appropriate time. The adequate moisture and moisture supply also helps in keeping various enzyme systems active. Therefore, quality of the produce is better in drip fertigated crops as compared to control.

The results showed that the T_1 recorded the higher equatorial circumference than the other two treatments. It registered the maximum equatorial circumference of 16.25 cm and this was followed by T_2 with 12.75 cm. This is because of the increase in crop growth due to the interaction effect between irrigation and fertigation levels. 100 percentage applications of the scheduled nutrients to the root zone had also contributed to the fruit diameter (Ramnivas *et al*., 2012). These findings are in agreement with the report of Singh and Singh (2005) that the trickle irrigation with 100% recommended nitrogen fertilizer gave the maximum fruit circumference, fruit length and fruit weight in papaya.

iii. Total yield

The results showed that the automated dip fertigation system in polyhouse (T_1) recorded the higher fruit yield of 23.86 t ha^{-1} and this was statistically significant over T_2 with 7.71 t ha^{-1}. This might be due to the combined effect of cultivars, wider spacing, poly house cultivation and timely and uniformly availability of all the nutrients through the developed automated fertigation system. The present results are in agreement with the findings of Arora *et al*. (2006) in greenhouse grown tomato; Ban *et al.* (2006) in melons.

Automated drip fertigation of cucumber adequately sustain favorable vegetative and reproductive growth as compare to conventional method of fertilizer application.

Solar power performance

The solar panel could produce a voltage level of 16 V and 13.6 V during sunny and cloudy days respectively. Average power generated by solar panel was around 250 W. Energy consumption for the system on an average was only 33.72 W-h. The battery can hold up to 1800 watt, hence the system can operate up to 53 hours equivalent to 4.4 days (as the system works only during day time) without sunshine.

CONCLUSION

Thus it can be concluded that the developed system for automatic fertigation ensured better yield and was found economically feasible for cucumber variety 'Saniya' grown inside the polyhouse. Moreover, being fully operated with solar power, the system can be installed at remote and rural locations to achieve reductions in cost of production and produce better yield.

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A Comprehensive Account of Quality of Solid Waste at Different Sampling Stations in Hyderabad City

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ABSTRACT

Waste is defined as discarded materials of no further use to the owners and the pattern of its generation is a function of the level of urbanization, industrialization and economic status of society (Afolayan *et al.,* 2012).The overall effects of urbanization, population growth and widespread industrialization have lead to extreme environmental damages. One of most neglected areas is waste management in most of the low and middle income countries like India. MSW management gets the lowest priority, mainly because disruptions and deficiencies in it do not directly and immediately affect public life and cause public reaction. The open-dumping and land filling are the two common disposal options in most parts of the world. Unorganized, indiscriminate and unscientific dumping of Municipal Solid Wastes in open dumps is very common disposal method in many Indian cities which cause adverse impacts to the environment (Mahar, 2007).Since the solid waste dumps are heterogeneous in nature, and the degradation time results in longer retention of the waste thereby increasing the chances of downward movement into the ground water and contaminating the water. Composition of MSW in India was of 30 – 45% organic matter, 30 – 40% of ash and fine earth, 6 – 10% of recyclable materials and the rest as inert matter. The calorific value of refuse was between 800 – 1000 kg / kcal and C / N ratio ranged between 20 and 30 (NEERI, 1996).Household waste, market waste, the waste from hostels and shops contains high percentage of bio – degradable materials (Ogwueleka, 2003).The present study is aimed at characterizing the solid wasteat Jawahar Nagar, Gudimalkapur Market, Mehdipatnam Market, Dump near Dilsukh Nagar Bus Depot and Kukatpally Market areas and to recommend measures to improve efficiency of handling and disposalfor planning 3R strategy in an effective manner.

Keywords: Waste, Unscientific Dumping, MSW management.

INTRODUCTION

Technological development, globalization and population growth have accelerated the urbanization in developing countries. Due to sprawling urbanization and uncontrolled growth of population, Municipal Solid Waste Management has become a major problem in India (NEERI; Kumar *et al*., 2009). Municipal Solid Waste and economic development have a positive correlation in terms of kg / capita / day (Rajput *et al.,* 2009). The composition and characteristics of Municipal Solid Waste vary throughout the world. Even within the a country it changes from place to place as it depend on number of factors such as socio economic status, life styles, geographic location, etc (Sharholy *et al.,* 2007; Benitez *et al*., 2008). Indian cities are now generating 8 times more municipal solid waste than they did in 1947. Presently, about 90million tones of solid wastes are generated annually as byproducts of industrial, mining, municipal, agricultural and other activities. The per capita generation of MSW increased at a rate of 1 – 1.33% annually (Bhide and Shekdar, 1998; Shekdar, 1999; Pappu *et al*., 2007).

Rapid urbanization in the last few decades has led to significant increase in municipal solid waste generation in India. In most cities of India, solid waste management is inefficient as systems adopted are primitive, tools and equipment outdated and inadequate & man power productivity is low. Processing and treatment of waste is limited and final disposal is in unscientific dumpsites, posing problems of soil & water contamination and air pollution. A significant portion of the population does not have access to primary waste collection service as the subject has been low priority and only 50 to 70% of waste is collected and transported for disposal. The Hyderabad city has made some efforts in the last few years to improve the municipal solid waste management (MSWM). However, there is still a need to make substantial improvements in the MSWM system of the city and make it in accordance with the Municipal Solid Waste (Management and Handling) Rules, 2016 notified by Ministry of Environment and Forests. These rules lay down procedures for waste collection, segregation, storage, transportation, processing and disposal and further mandated all municipalities and corporations to set up suitable waste treatment and disposal facilities.

Municipal Solid Waste Management has been a part of public health and sanitation and is entrusted to the municipalities for execution. Presently, the systems are assuming high importance due to population expansion of municipal areas, legal interventions, emergence of newer technologies and increasing public awareness towards cleanliness (Kumar *et al*., 2004). Rapid increase in the total amount of MSW changes their composition. Characterization studies were carried out by NEERI, 1996 indicates that MSW contains large organic fraction (30-60%), ash and fine earth (30 – 40%), Paper (3 – 6%), along with plastic, glass and metal (each less than 1%), calorific value of refuse between 800 – 1000 kcal / kg and C / N ration ranges between 20 and 30. Household waste, market waste, the waste from hostels and shops contains high percentage of bio – degradable materials (Ogwueleka, 2003).

METHODOLOGY

STUDY AREA

Hyderabad is a historic and capital city of state of Telangana State. It is one of the fastest growing cities in the country with a potential to become the cyber capital of India. The city is witnessing a rapid expansion, industrial boom, increased opportunities coupled with high population. Hyderabad is beset with increasing urban environmental problems such as solid waste management, air and noise pollution, ground water contamination etc.

The Greater Hyderabad Municipal Corporation, spread over 625 Sq.km of area and housing a population of nearly 1 crore, has only one garbage dump yard, which is fast outliving its utility. The state capital is badly suffering from shortage of garbage dump yards, with the management of waste becoming difficult for the Municipal Corporation. The present study has been carried out at different corners of the city include a major dump yard, markets and residential areas. Fivestations have been selected as study areas viz. Jawahar Nagar Dump site (Station - I), Gudimalkapur Market (Station - II), Mehdipatnam Market (Station - III), Dilsukh Nagar Bus Depot (Station - IV) and Kukatpally Market (Station - V). A brief description of the each station is given here under.

Station - I: This station is located between Longitude $78^{0}35^{1}$ 27.61□’ E and Latitude 17^{0} 30’ 1.81’’N. The dump yard is located about 35 kms away from the city in 339 acre at Jawahar Nagar, in which over 4000 tpd is dumped. There is no proper road connectivity to this dump yard.600 trucks carrying garbage visit the site daily. Even a short spell of rain is enough to make the path to the dump yard slushy and too dangerous to drive. The 339 acre dump yard at Jawahar Nagar is already over flowing with garbage and it is also acting as a major obstacle for development of areas located in its vicinity.

Station – II: Gudimalkapur wholesale market was selected as Station – II. This station is located between Longitude $78^{0}26'$ 5.89’’ E and Latitude 17^{0} 23’ 1.68’’ N. The vegetables are mainly brought from the neighboring Ranga Reddy District. Many hawkers sell outside the market yard on bicycles and mopeds. Presently, 60to 100 trucks land at the market

Gudimalkapur market is the main market center for people who are living in Mehdipatnam, Attapur, Lunger House, Shiakpet, Tolichowki, Galaxy, Mallepalli etc. Majority of the waste generated here is organic in nature. Non - biodegradable materials such as plastics, metals, and other miscellaneous item are also found in the waste.

Station – III: This station is located between Longitude 78^{0} 26’ 18.29’’ and Latitude 17^{0} 23’ 33.07’’N. Mehdipatnam market was taken as Station – III. It provides connectivity to the Rajiv Gandhi Intl. Airport through PV Narasimha Rao Elevated Expressway Corridor from major suburbs like Banjara Hills, Ameerpet, Begumpet, Kukatpally, Nampally, Musheerabad etc. It is 12 km away from the IT Corridor ofGachibowli and Madhapur.Mehdipamam is the centre for shopping for many suburbs and villages. There is a vegetable market, Rythu Bazar here, making a good addition for vegetable shopping. Majority of the waste that is generated from the market areas are wet waste or biodegradable waste consists of vegetables, paper, fish waste, plastic waste etc. Municipal Corporation employees are taking the responsibility of collection of waste in these areas.

Station – IV: This station is located between Longitude 78^{0} 31’ 30.74’’ E and 17^{0} 22’ 8.64’’N. A dump near Dilsukh Nagar Bus Depot was taken as Station – IV. Dilsukh Nagar has grown into a well-known commercial and residential suburb of Hyderabad, Andhra Pradesh, India. It has become one of the many major centers of Hyderabad. Earlier it was a purely a residential locality. The suburb has gained importance since it lies on the National highway 9 and its close proximity to Malakpet. Dilsukh Nagar has second biggest bus depot in

Hyderabad after M.G.Bus Station owned by APSRTC, it was found that the majority (80%) of the people in DSNR and Kukatpally are hand over the waste to the rag pickers, some people throwing the waste at the comers of the streets or on the road side. It was also found that few people bring their waste to predetermined locations where there is usually some form of community storage facility and refuse collection vehicles visit these sites at frequent intervals, usually once daily or every second day, to remove the accumulated waste.

Station – V: This station is located between Longitude $78^0 23' 42.07''$ and Latitude $17^0 29' 42.07''$. Kukatpally Market was taken as Station – V. Kukatpally is a major residential and commercial suburb in Hyderabad City, India. It is located on the northwest fringe of Hyderabad city. Kukatpally Housing Board Colony developed by Andhra Pradesh Housing Board is considered to be the biggest colony in Asia. Kukatpally Market waste is collected daily by Greater Hyderbad Municipal Corporation vehicles.

At these five selected stations, the characteristics of solid waste such as: Density, Moisture, Ash Content, pH, Nitrogen, phosphorus, Potassium, Total Organic Matter, Total Organic Carbon and C/N ratio have been studied.

The present study has been carried out from 2012 to 2014 at the five selected stations. The MSW Characteristics were estimated in every alternative months i.e., January, March, May, July, September, November at the rate of six samples per year from each site. The corresponding values of each parameter were expressed in standard units.

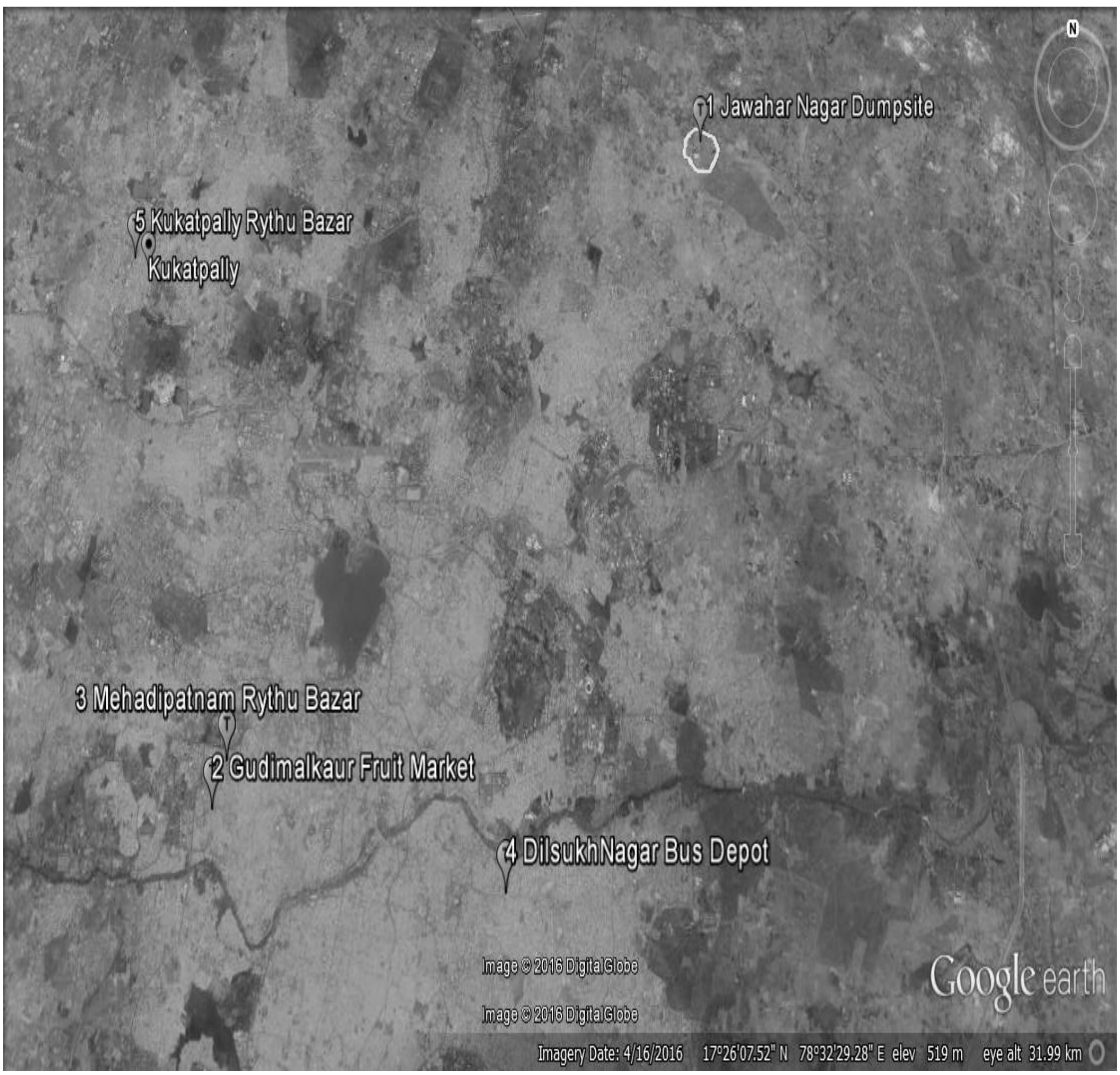

Figure 1 Map Showing the Study Area of all Five Stations

The Parameters studied for estimating Characteristics of Solid Waste are described here:

Density(Kg/m^3): Density was calculated using on small box (0.028 m^3) an done large box (1 m^3). The solid waste was taken in the small 0.028 m^3 box to give a composite sample from different parts of the heap of waste, then weighed with the help of a spring balance. After weighing, this box (0.028 m^3) is emptied in the big 1 m^3 box. This is repeated till the large box is filled to the top. The waste was not compacted by pressure. Then the weight of the big box is noted. Thus the weight per cubic meter is obtained (Bihde and Sundaresan, 2001).

Moisture (%): In order to determine the moisture content, weigh the entire crude sample collected for analysis. Spread it thinly and dry in an oven till its mass becomes constant. Drying may be generally done at 105^0 C but is case of combustibles the temperature shall be 70 to 750^0 C (IS: 9234 - 1979).

Non – Volatile Substance (Ash) (%):

Principle: When a substance is heated the organic part of it is oxidized into volatile oxidation products whereas inorganic part gives solid oxidation products.

Procedure: Place about 5 g finely ground sample in constant mass silica dish and heat in a muffle furnace up to a temperature of 600^0 c for 2 hours. Allow the dish to cool in a desiccators and weigh it again (IS – 10158 - 1982).

The volatile and non – volatile fraction were calculated separately in order to assess whether the MSW could be subjected to incineration or not.

pH: Place 10 g of the sample in a flask, add 500 ml distilled water and stir for 3 to 5 minutes. Let the mixture settle for 5 minutes and measure the pH using a pH meter with a glass electrode. Previously calibrated and corrected for temperature (IS : 10158 - 1982).

Estimation of Nitrogen (%):

Method: The percentage of nitrogen present in the waste sample was estimated by kjeldahl method (Trivedi and Goel, 1984).

Estimation of Total Phosphorus (%):

Method: The percentage of phosphorus present in the waste sample was estimated by Molybdenum blue method (Trivedi and Goel, 1984).

Estimation of Potassium (%):

Method: The percentage of potassium present in the organic waste sample was estimated by flame photometric method (Adoni, 1985).

Estimation of Total Organic Matter: Alternate Procedure: Loss of Weight on Ignition (Adapted from Storer, 1984)

Estimate Organic Matter (%): Estimation of organic matter from LOI is done by regression analysis. Select soils covering the range in organic matter expected in your state or area of testing. Determine percent organic matter by the Walkley-Black Method described above. Regress organic matter on LOI. Using the resulting equation to convert LOI to percent organic matter.

Estimation of Total Organic Carbon (%):

Method: The percentage of carbon present in the organic waste sample was estimated by Walkley – Black method (Trivedy and Goel, 1984).

Calculation of C: N Ratio: C: N ratio of organic waste was then calculated from the values obtained for organic carbon and nitrogen. It was obtained by dividing carbon value by nitrogen value.

STATION – I: Quality of Solid Waste at Jawahar Nagar Dump Yard

The solid waste samples were collected at Jawahar Nagar Dump Yard (Station - I). Density, Moisture, Ash, pH, Nitrogen, Phosphate, Potash, Total Organic Matter, Total Organic Carbon and C/N Ratio were estimated for three years in alternate months. Jawaharnagar dumpsite is only the major, largest and authorized dump site of Greater Hyderabad Municipal Corporation. It is spread over 339 acres at Shamirpet Mandal, R.R. Dist. All the solid waste collected from different temporary storage dumps is carried to Jawahar Nagar every day. The density of solid waste at the Jawahar Nagar dump yard was estimated for three years, of which, 2013 had the lowest density of 368 kg/m^3 and highest in 2014 (391 kg/m^3) with a combined mean of 378 ± 9.53. The seasonal variations in the density were discussed in individual parameters. The increasing density from the year 2012 and decreased in 2013 and again increased in 2014 is attributed to the changing life styles and affluence. The high density of the solid waste indicates the presence of vegetable waste, food waste, glass and metal pieces in the solid waste.

The moisture content in the solid waste continued decreased from 2012 to2014. This decrease of moisture content is due to regular labeling and pressing activities at the site. Only 8.7% moisture was present in the solid waste which is also highest in the study period. This is because most of the solid waste was collected and dumped here from the temporary storage sites. The combined mean of the moisture was only 7.4%. this indicates that almost dried solid waste is collected from temporary storage dumps. The Ash content in the solid waste has varied between a lowest and highest of 70.7% and 74.2% with a combined mean of 72.2%. The pH of the solid waste was slightly acidic. This acidic pH will lead to formation of acid leachate which dissolves heavy metals and pose threat of infiltration in to ground water. The nitrogen content (%) ranged between 0.49 to 0.77% in 2014 and 2013, with a combined mean of 0.66%.

The Phosphate content in the solid waste ranged between a minimum of 4.6 (%) and 6.9 (%) with a mean of 5.6 (%). The phosphates are generally less in household wastes compared to agricultural waste. The potash percentage ranged from a minimum of 14.8% and a maximum of 17.2% with a combined mean of 16.2%. The potash and phosphates are released due to microbial degradation (Phosphate solubilizing bacteria) of the inorganic waste. The total organic matter ranged between 9.5% (2014) and 13.4% (2012) with a combined mean of 11.38% while the total organic carbon ranged between a minimum of 4.19% (2014) and 9.75 (2012) with a combined mean of 6.74%. Always the TOC forms a fraction of Total organic matter and the high TOC indicate the high potential of the waste for vermicomposting or manuring. The C/N Ratio was minimum in 2014 (6.21) while it was maximum in 2013 (8.79) with a mean of 7.92.

Table – 1. Mean Values of Various Parameters during the Study Period at Station -I

Sl.No.	Parameter	2012	2013	2014	Mean ± SD
1.	Density (Kg/m^3)	376	368	391	378.33 ±9.53
2.	Moisture (%)	8.7	7.1	6.4	7.4 ± 0.96
3.	Ash (%)	70.7	74.2	71.7	72.2 ± 1.47
4.	pH	6.51	6.84	6.54	6.63 ± 0.14
5.	Nitrogen (%)	0.72	0.77	0.49	0.66 ± 0.12
6.	Phosphate (%)	6.9	5.3	4.6	5.6 ± 0.96
7	Potash (%)	17.2	16.6	14.8	16.2 ± 1.01
8	Total Organic Matter (%)	13.4	11.24	9.5	11.38 ± 1.59
9	TOC (%)	9.75	6.28	4.19	6.74 ± 2.29
10	C/N Ratio	8.76	8.79	6.21	7.92 ± 1.20

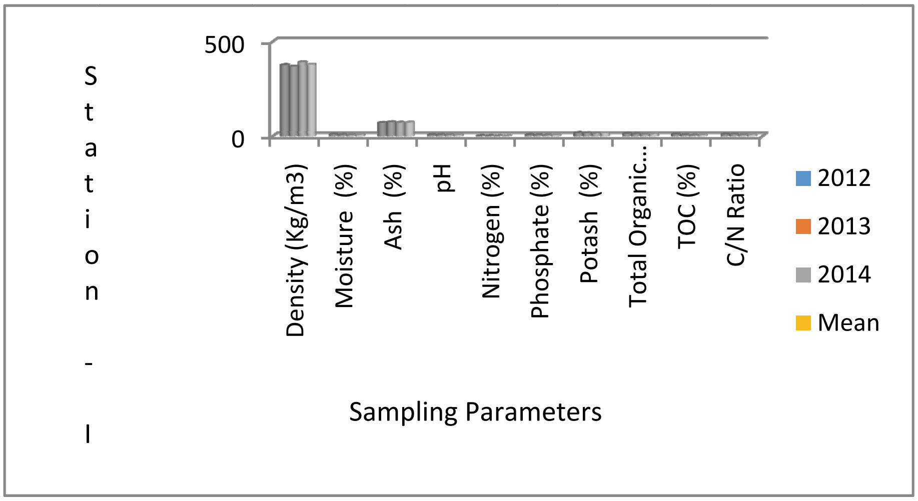

Figure 1 Graph showing the Mean Values of Various Parameters in MSW at Station–I

Station – II : Gudimalkapur Market

Gudimalkapur market is a wholesale vegetable market in the suburban area of Hyderabad city. The average density of solid waste at Gudimalkapur market was 281 kg/m^3 during the three years of study period. The lowest value of density was recorded as 271 kg/m^3 in 2012 and highest value was 289 kg/m^3 in 2014. The moisture content recorded at Gudimalkapur market was between 38.8% and 42.59 % with a mean of 40.53%. The lowest value was recorded in 2013 and highest was in 2014. The mean ash content in the solid waste during the year 2012-2014 was 52.3%. The minimum ash content was recorded in the year 2012 and maximum was in 2013 (Table. 52). pH in solid waste was observed between 7.28and 7.54 during the three years of study period. The mean of the pH was 7.45. On whole, the pH was alkaline.

The lowest percentage of Nitrogen was observed in the year 2013 (0.66%) and highest was in 2012 (0.78%) and with a mean of 0.73%. The mean Phosphate during the study period was 4.3%, the minimum Phosphate content was 3.7% and maximum was 4.6%. The percentage of Potash was observed from 4.87% to 6.04% during the three years of study period. The average mean of Potash during 2012-2014 was 5.6%. The lowest Total Organic Matter percentage was recorded in the year 2012 and highest was in 2014 with an average mean of 23.42%. The minimum and maximum Total Organic Carbon percentages during the study period were 11.40% and 13.47%. The mean C/N Ration was 53.18 during the three years of study period i.e. 2012-2014, the lowest ratio was recorded as 49.6 in 2012 and highest was as 55.74 in 2014. The C/N Ratio is sufficient to produce composting from solid waste.

Table 2 Mean Values of Various Parameters during the Study Period at Station -II

Sl.No.	Parameter	2012	2013	2014	Mean ± SD
1.	Density (Kg/m^3)	271	283	289	281 ±7.48
2.	Moisture (%)	40.2	38.8	42.59	40.53 ± 1.56
3.	Ash (%)	50.1	54.1	52.7	52.3 ± 1.65
4.	pH	7.28	7.53	7.54	7.45 ± 0.12
5.	Nitrogen (%)	0.78	0.66	0.75	0.73 ± 0.05
6.	Phosphate (%)	3.7	4.6	4.6	4.3 ± 0.42
7.	Potash (%)	4.87	6.04	5.89	5.6 ± 0.51
8.	Total Organic Matter (%)	21.8	23.9	24.56	23.42 ± 1.17
9.	TOC (%)	11.40	12.12	13.47	12.33 ± 0.85
10.	C/N Ratio	49.6	54.2	55.74	53.18 ± 2.60

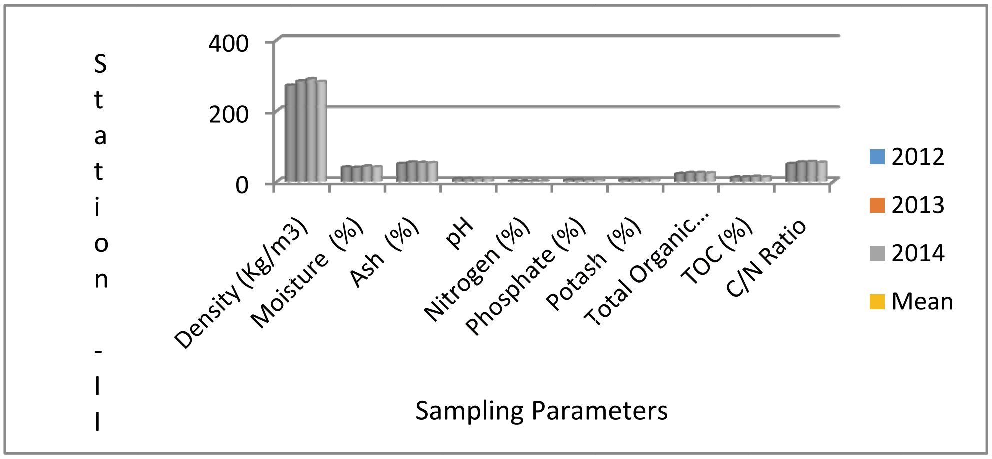

Figure 2 Graph showing the Mean Values of Various Parameters in MSW at Station -II

Station – III: Mehdipatnam Market

Mehdipatnam market is the main market center for the people living in Mehdipatnam, Attapur, Lunger House, Shaikpet, Tolichowki, Galaxy, Mallepalli etc. The mean density was 287.33 kg/m^3 during the study period of three years i.e. 2012-2014. The minimum density was 225 kg/m^3 in 2012 and maximum was 322 kg/m^3 in 2013. The lowest moisture content was recorded in 2012 and highest was in 2013. The average mean was 42.16 %. The minimum ash content of Mehdipatnam market was recorded as 48.3% in 2012 and maximum content was recorded as 53.2% in 2014 during the period from 2012-2014. The mean of three years period was 51.4%. The mean pH was 7.03 recorded during the study period. The minimum pH values was 6.88 in 2013 and maximum pH value was 7.12 in 2012.

The lowest Nitrogen content observed in 2012 (0.64%) and highest was in 2014 (0.85%). The average Nitrogen content of 0.76% recorded during the study period. The lowest Phosphate content was 3.68% in 2014 and highest was 4.19% in 2013 during the study period. The mean Phosphate was 4.0% in the period of study. The minimum and maximum Potash content from the Mehdipatnam market was 4.92% and 5.83% respectively. The mean Potash content was 5.5% in the study period. The mean Total Organic Matter during the three years study period was 21.86%. The lowest and highest values of Total Organic Matter was 19.68% in 2013 and 25.7% in 2014 respectively. The Total Organic Carbon percentage was recorded between 11.46% and 14.29 in the study period. The minimum Total Organic Carbon content was recorded in 2013 and maximum was in 2014. The C/N Ratio of Mehdipatnam market with a lowest value of 49.6 in 2013 and highest value of 55.03 in 2012. The mean of C/N Ratio was 52.91 in the three years of study.

Table 3 Mean Values of Various Parameters in MSW at Station -III

Sl.No.	Parameter	2012	2013	2014	Mean ± SD
1.	Density (Kg/m^3)	225	322	315	287.33 ±44.16
2.	Moisture (%)	39.8	43.4	43.28	42.16 ± 1.66
3.	Ash (%)	48.3	52.7	53.2	51.4 ± 2.20
4.	pH	7.12	6.88	7.09	7.03 ± 0.10
5.	Nitrogen (%)	0.64	0.79	0.85	0.76 ± 0.08
6.	Phosphate (%)	4.13	4.19	3.68	4.0 ± 0.22
7.	Potash (%)	4.92	5.83	5.75	5.5 ± 0.41
8.	Total Organic Matter (%)	20.2	19.68	25.7	21.86 ± 2.72
9.	TOC (%)	11.60	11.46	14.29	12.45 ± 1.30
10.	C/N Ratio	55.03	49.6	54.1	52.91 ± 2.37

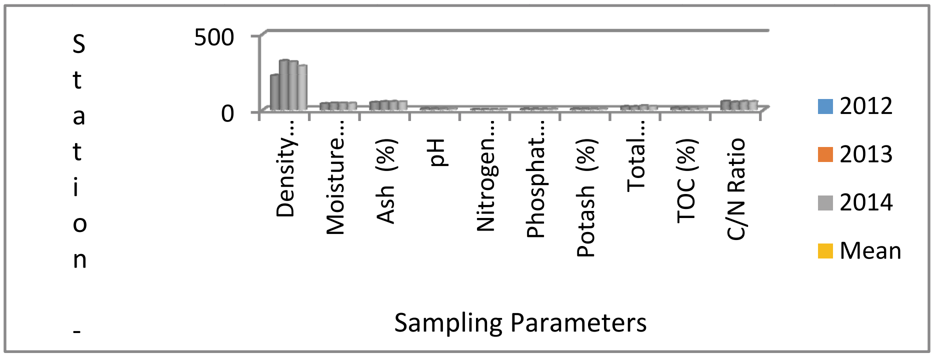

Figure 3 Graph showing the Mean Values of Various Parameters in MSW at Station -III

Station – IV: Dump near Dilsukh Nagar Bus Depot

Dilsukh Nagar Bus depot is one of the most popular and busiest bus depot of Greater Hyderabad. The density of solid waste near DSNR bus depot during the study period was with a mean of 287.33 kg/m^3. The lowest and highest contents were 187 kg/m^3 in 2012 and 245 kg/m^3 in 2014, respectively. The lowest and highest moisture contents were 31.69% in 2013 and 41.8% in 2014. The mean moisture was 35.72% during the period of study. The ash content of the DSNR Bus Depot was observed between 46.3% and 48.2% during the three of study period. The mean of the ash in the study period was recorded as 47.5%. The lowest pH values were recorded in 2012 with 6.63 and highest was in 2014 with 7.03. The mean of three years was 6.78.

The minimum and maximum percentage of Nitrogen was 0.68% in 2013 and 1.13% in 2014 in the study period. The mean of Nitrogen was 0.90% in the three years of study. The Phosphate content was recorded between 3.2% and 4.6% during the year 2012-2014. The mean Phosphate was 3.9% in the study period. The lowest Potash content was observed in 2012 (4.3%)and highest was observed in 2014 (5.2%) during the period of study. The mean of Potash in the study period was 4.8%. The Total Organic Matter content was observed with a minimum of 35.6% (2012) and a maximum of 38.51% (2014) during 2012-2014. The mean of the three years was 37.41%. The lowest and highest percentages of Total Organic Matter were recorded ad 15.63% in 2012 and 21.48% in 2014 respectively. The mean of Total Organic Carbon in the study period was 19.40%. The mean of C/N Ratio during the study period was 45.07 and minimum and maximum values were 43.2 and 46.9.

Table 4 Mean Values of Various Parameters in MSW at Station -IV

Sl.No.	Parameter	2012	2013	2014	Mean ± SD
1.	Density (Kg/m^3)	187	213	245	215 ±23.72
2.	Moisture (%)	33.67	31.69	41.8	35.72 ± 4.37
3.	Ash (%)	46.3	48.0	48.2	47.5 ± 0.85
4.	pH	6.63	6.68	7.03	6.78 ± 0.17
5.	Nitrogen (%)	0.89	0.68	1.13	0.90 ± 0.18
6.	Phosphate (%)	3.9	3.2	4.6	3.9 ± 0.57
7.	Potash (%)	4.3	4.9	5.2	4.8 ± 0.37
8.	Total Organic Matter (%)	35.6	38.12	38.51	37.41 ± 1.28
9.	TOC (%)	15.63	21.09	21.48	19.40 ± 2.67
10.	C/N Ratio	45.11	46.9	43.2	45.07 ± 1.51

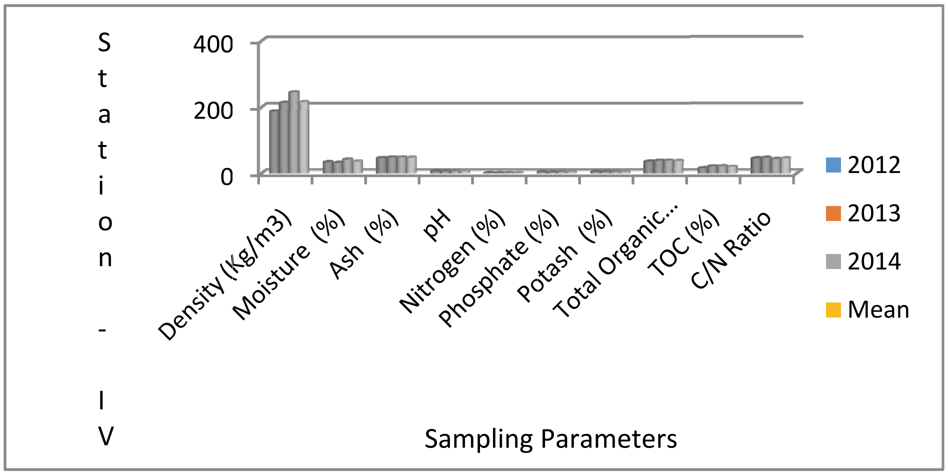

Figure 4 Graph showing the Mean Values of Various Parameters in MSW at Station -IV

Station – V: Kukatpally Market

Kukatpally market is one of the most popular Market of Greater Hyderabad The characteristics of various parameters in municipal solid waste from Kukatpally market were described here. The density content of solid waste at dumpsite of Kukatpally market was with a minimum of 192 kg/m^3 in 2012 and a maximum of 272 kg/m^3 in 2014. The mean density was 236.66 kg/m^3 in the period of study. The moisture content at the dump site of Kukatpally market was with a lowest percentage of 33.02% and a highest percentage of 42.72% during the three years of study. The mean moisture content was 36.98% during the study period. The mean ash content of the dumpsite during the three years of study i.e. 2012-2014 was 43.4%. The minimum and maximum percentages were 41.5% and 44.67% respectively. The pH content during the year 2012-2014 was with a lowest value of 6.82 and a highest value of 7.08.

The minimum and maximum Nitrogen percentages were recorded in 2013 and 2014. The mean Nitrogen content was 0.83 during the three years of study period. The mean Phosphate of dump site in the period of study was 4.5%. The lowest and highest Phosphate contents were 4.26% and 4.73% respectively. The minimum Potash content was observed in the year 2013 and maximum was in the year 2014. The mean Potash of three years study period was 4.7%. The lowest Total Organic Matter during the years of study was 34.2% and 36.73% respectively. The mean of three years was 35.39%. The mean Total Organic Carbon was 19.78% in the study period. The minimum and maximum values of the study period were 18.95% in 2013 and 20.56% in 2014. The lowest and highest values of C/N Ratio were 44.32 and 47.68 during the study period. The mean C/N Ration was 46.52 in the period of study i.e. 2012-2014.

Table 5 Mean Values of Various Parameters in MSW at Station -V

Sl.No.	Parameter	2012	2013	2014	Mean ± SD
1.	Density (Kg/m^3)	192	246	272	236.66 ±33.31
2.	Moisture (%)	33.02	35.2	42.72	36.98 ± 4.15
3.	Ash (%)	44.03	41.5	44.67	43.4 ± 1.36
4.	pH	7.01	6.82	7.08	6.97 ± 0.10
5.	Nitrogen (%)	0.83	0.77	0.89	0.83 ± 0.04
6.	Phosphate (%)	4.51	4.26	4.73	4.5 ± 0.19
7.	Potash (%)	4.58	4.39	5.13	4.7 ± 0.31
8.	Total Organic Matter (%)	35.24	34.2	36.73	35.39 ± 1.03
9.	TOC (%)	19.83	18.95	20.56	19.78 ± 0.65
10.	C/N Ratio	44.32	47.68	47.56	46.52 ± 1.55

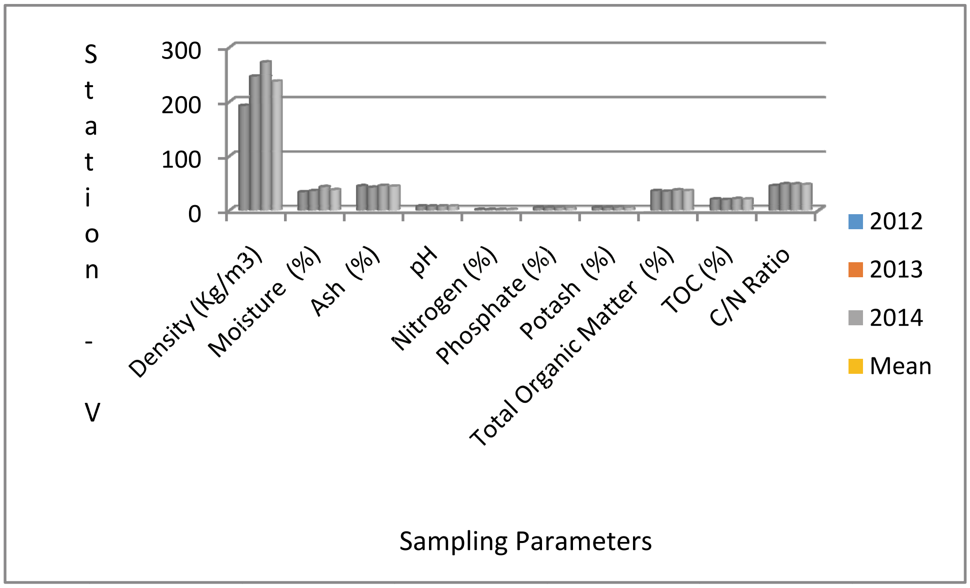

Figure 5 Graph showing the Mean Values of Various Parameters in MSW at Station –V

CONCLUSION

The Hyderabad city with its population reaching 10 million, generates 4000 tonnes of waste per day. A little above 45% of the MSW is biodegradable, which is left unused. The whole waste where ever it is generated in the city had to be transported to Jawahar Nagar dump site which is considered as for final disposal. The effects for composting are not adequate. There is a huge potential of generating wealth from waste. A forward step is this direction requires:

(a) Separation of biodegradable and non-degradable wastes.

(b) The major contributors of methane gas in India are the municipal solid waste dump sites. The nitrates/nitrites in the solid waste also are responsible for emission of Green house gases. Nearly 4000 tonnes of waste generation is not a small thing to be ignores. If scientifically calculated the emissions of GHGs from Hyderabad dumpsites will have a significant contribution at national level.

(c) Landfill emissions can be reduced by only by sanitary landfills and not by open sumps.

(d) Hyderabad has been facing acute shortage of water resource for drinking, domestic and industrial purposes. The deterioration of quality with leachates entering the ground water further worsens the problem.

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Effect of a New Upstream Reservoir on Pattern of Down Stream Flows - Need to Revise the Crop Calender of Down Stream Project

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ABSTRACT

This paper determines the change in flow pattern of Srisailam reservoir due to construction of an upstream reservoir namely Almatti reservoir. Both reservoirs are in Krishna basin on main Krishna river.When a reservoir is planned the existing pattern of flows would be considered making allowance for unutilised planned utilisations upstream. But construction of new reservoir alters the flow pattern as the flows will be stored in the upstream reservoir and water would be released only after this reservoir reaches FRL. If the reservoir is a huge one the effect will be considerable. Therefore it is necessary to study the effect of a newly constructed upstream reservoir on a down stream reservoir. The changes may be such that the cropping pattern of the down stream reservoir has to be altered or alternatively the down stream releases are to be made in the initial months of the monsoon from upstream reservoir. Hence the effects of Almatti on the inflows of Srisailam are studied in this research. The study of the inflow pattern without Almatti for the period is worked out after deducting the unutilised planned utilisations from the actually observed inflow data at Srisailam. Then Almatti is introduced and simulation studies are made for the entire system from Almatti to Srisailam. The inflow pattern is compared on monthly basis. It was concluded that there is no much variation in annual flows except the reduction due to additional utilisation. However in June there are no flows to down stream from Almatti even in good years except the regulated releases. In July the release of 5.247 TMC is the flow to down stream from Almatti which are regulated releases ordered by Tribunal in bad and average years. In good years the reduction is observed to be more than 50 % in July. In August the average reduced to 108.2 TMC from 208.1 TMC, the maximun flows have reduced to 491.6 TMC from 775.4 TMC, the 75%, 65%, 50% dependable flows reduced to 9.37,15.18,24.52 TMC from 90.04,131.9,212.9 TMC. These reductions in initial flows necessitate the change in cropping pattern of NSP and SRBC.

Keywords: Srisailam reservoir, Almatti reservoir, Flow patterns, Simulation, planned and actual utilisations

INTRODUCTION

The River Krishna rises in the Mahadev range of the Western Ghats near Mahabaleshwar at an altitude of 1337m above sea level and flows through Maharashtra, Karnataka and Andhra Pradesh gathering water on its way from innumerable rivers, streams or tributaries and drops into the Bay of Bengal. River Bhima and Tungabhara are major tributaries of river Krishna. Main Krishna, Bhima and Tungabhadra constitute the stems of the river Krishna. Jurala,Srisailam, Nagarjunasagar, Krishna delta are the major projects on main Krishna. Almatti reservoir was constructed across main Krishna in the state of Karnataka up stream of these reservoir s. Where as the flow patterns at Srisailam from Tungabhadra and Bhima do not change as there are no major reservoirs constructed newly, because of Almatti the flows are Srisailam are changing drastically. These reservoirs used to fill in almost all the years except in very bad years. But ,In the recent past, it is observed that theSrisailam and Nagarjuna sagar are not being filled even in years of dependable flows. This may be due to construction of Almatti reservoir. Further it is observed that the initial flows are getting reduced when compared with the past. The position will be more precarious when the entire upstream planned utilisations are achieved by the upper states. Presently there is lot of gap in the planned and actual utilisations. Therefore it is proposed to study this aspect by considering the historical flow series of Krishna river for the period 1972-2000(29 years) . As a first exercise the flow patterns of Srisailam would be studied after allowing for planned upstream utilisations without almatti. For this purpose the observed inflows at Srisailam would be corrected forunutilised upstream utilisations and the net flow series will be arrived at. Then Almatti reservoir will be introduced and simulation will be performed on the Almaati- Krishna delta system and the flow patterns at Srisailam are arrived at. These two are then compared to arrive at the changes in the flow patterns at Srisailam reservoir.

The salient features of the all the projects considered for simulation including Almatti reservoir are given below in Table 1.

Table 1 Salient features of Projects in Krishna Basin considered for the Study

S.No.	Name of the project	Unit	Almatti	Naryanpur	Jurala	Srisailam	Nagarjuna sagar	Pulichintala
1	**Sub-basin**		K-2	K-2	K-7	K-7	K-7	K-7
2	**Catchment area**	**(Sq.Km)**	35926	47850	129499	206030	215185	240732
3	**Gross storage**	**(TMC)**	223.52	37.96	11.94	308.00	408.24	45.76
4	**Live storage**	**(TMC)**	205.98	30.70	6.79	249.99	202.47	36.23
5	**Dead storage**	**(TMC)**	17.57	7.16		58.08	205.77	9.53
6	**F.R.L**	**m**	524.26	492.25	318.52	269.75	179.832	53.34
7	**M.D.D.L**	**m**			314.86	260.30	155.45	42.672
8	**D.S.L**	**m**	506.87	481.56			121.92	42.672
9	**Length of spillway dam**	**m**	486.50	459.00		266.39	470.916	754.9
10	**Length of non-spillway dam**	**m**	676.33	562.22			978.612	442.6
11	**Length of earthen dam**	**m**	402.00	9616.30				
12	**Total length of dam**	**m**	1564.83	10637.52	1103.50	512.00	1449.628	1197.5
13	**Crest level**	**m**	509.02	480.25	311.52	252.98	179.832	36.54
14	**Number of gates**		26	30	69	12	26	33
15	**Gate size**	**mxm**	15x10.584	15x12	12x7	18.3x16.7	13.72x13.41	18.30x16.80
16	**Type of Gate**		Radial	Radial				Radial
17	**Design flood**	**Cumecs**	31,007	37,945	30,016	38,365	58,340	57,700

LITERATURE REVIEW

Reservoir induced changes in flow fluctuations was studied for Qingyi river in China by Feng huang etc.all and it was concluded that the coefficicent of variation (Cv) has considerably reduced for flows in all cases of monthly and hourly estimates after dam construction compared to before dam construction condition .At a monthly scale, reservoirs usually impound water in the flood season for the dry season. At an hourly scale, reservoirs may restrain a flood pulse and strictly control the outflow. Thus, the reservoirs reduce variation and concentration of the runoff distribution within a year and within a day. In contrast, the reservoirs may aggravate the hourly flow fluctuation by releasing hydropeaking waves for hydropower generation. The hydrological alterations that have emerged due to construction of huge reservoirs for hydropower generation were studied by Qiang Zang etc.al. and it was concluded that (1) multi-day maxima have reduced, while multi-day minima have increased, due to hydrological reg1ulations of water reservoirs; (2) hydrological regimes of the East River have also been severely affected by hydropower generation, leading to a greater frequency of high and low pulses of lesser duration, and these effects are increasingly evident from the upper to lower East River basin; (3) owning to the water being released rapidly for hydropower generation or flood protection, the number of hydrologic reversals have increased after reservoir operations.

K. Fledler and j. Zhang have studied the alterations due to water withdrawals and dams on global scale and concluded that the Water availability has decreased by 2.7 % due to with drawals and 0.8% due to dams. The effect is severe in western and central Asia India and Mexico. They have observed that q-90 (90 % dependable flow) has decreased by about 10 %. The impact of upstream water abstractions on reservoir yield was studied by Pieter Richard Van OEL etc. And in 2008[2] in the Orós Reservoir in semi-arid Northeast Brazil and it was concluded that water abstraction for irrigation is of significant importance for reservoir yield and reliability. Yield-reliability simulations for the study area show that taking into account upstream water abstraction for a reservoir yield of 20.0 m3/s results in a water-scarcity probability of 10% on an annual basis (90% reliability). This is only 5% if upstream abstraction for irrigation is ignored.

William.L.Graf studied the effects on hydrology and geo morphology of large rivers in America due to construction of 75000 Dams and concluded that they alter the flows of every large river in America. Comparison of the regulated and unregulated reaches shows that very large dams, on average, reduce annual peak discharges 67%

(in some individual cases up to 90%), decrease the ratio of annual maximum/mean flow 60%, decrease the range of daily discharges 64%, increase the number of reversals in discharge by 34%, and reduce the daily rates of ramping as much as 60%. Dams alter the timing of high and low flows and change the timing of the yearly maximum and minimum flows, in some cases by as much as half a year. The reservoir effects on the down stream hydrology in Ebro river basin was studied by R. J. Batalla ,Gm Gomez and GMKondolf and it was concluded that there is reduction in flood magnitude which reduced by 30 % more reduction in higher impounding ratio. There is not much change in annual runoff but varibiality of daily mean flows reduced. Complete inversions in seasonal patterns due to releases for irrigation in summer season where the flows increased due to return flows.

E. D. Andrews studied the effects of reservoir construction on the down stream in case of Green river a tributary of Colorado river USA. The river has been regulated by Flamming George reservoir which is located 412 miles upstream of confluence with Colorado. The peak discharges have reduced considerably and the bank full discharge reduced by about 10 %.The sediment distribution has also decreased by about 54 %. Mean Annual flow has not been effected however the patterns have changed. Down stream effects of closure of Glenbawn dam was studied by Eriskine and it was concluded that that mean annual flow reduced by about 21*10^6 cum and the probability distribution of mean annul run off also changed and the annual flows reduced. The mean daily flows distribution has also changed.The frequency of flows smaller than 7*10^5 has increased and higher flows frequency reduced.Flood maginitude reduced.

METHODOLOGY

The ten daily inflow data at Srisailam reservoir was collected from the department for the period 1972-2000. For the period 1984-85 the observed data at Srisailam reservoir are available. For the period 1972-1983 the Cwc gauge data at Moravakonda, Srisailam was used. From the gauge data the net flows are derived by considering the catchment areas and minor irrigation utilisations in the intervening catchment between gauge stations and srisailam. The ten daily inflows in to the srisailam reservoir during the period 1972-73 to 2000-01 when Almatti has not started are collected as stated above. Simulation studies are done incorporating Almatti and routing the flows at Almaati through the system of Almatti, Narayanpur, Jurala to get the net flows in to srisailam after Almatti reservoir operation. The flows for the months of June, July, Aug and the annual flows before and After Almatti are presented in Table 2.

Table 2 Patterns of flows into srisailam before and after Almatti

	June		July		Aug		Annual	
	Ba	**Aa**	**ba**	**aa**	**Ba**	**aa**	**Ba**	**Aa**
1972	8.58	2.372	1.96	5.247	12.69	16.02	55.95	84.13
1973	4.65	0	88.33	0	220.1	79.21	732.7	602.8
1974	6.29	2.415	121.2	5.247	113.2	6.264	564.1	516.7
1975	106.8	2.415	249	16.35	775.4	106.8	1681	1506
1976	49.2	2.415	135.9	10.98	243.9	277.4	529.8	658.1
1977	43.31	2.415	103.8	5.247	120.9	15.14	528	352
1978	8	2.415	173.4	14.86	399.9	319.7	1074	1097
1979	10.17	2.415	54.89	5.247	248.7	11.69	701.1	652.7
1980	28.99	2.415	265.1	76.07	324.7	434.7	777.7	985.2
1981	39.89	2.415	144.4	5.247	264.8	29.13	830.6	770.6
1982	13.7	2.415	50.48	5.247	255.5	106.5	414.6	333.6
1983	9.74	2.415	149.8	5.247	328.1	52.38	870.9	918.7
1984	8.15	2.415	141.5	5.247	142.5	50.27	419.5	302.8
1985	5.31	2.415	42.13	6.734	80.92	11.19	146.9	170.3
1986	5.54	2.415	20.16	0	63.15	15.42	119.5	136.2
1987	0	0	12.34	4.677	18.82	0	56.67	38.33
1988	0.45	0.281	114.8	1.686	215.2	17.55	699	681.1
1989	4.03	2.415	74.78	5.247	56.56	8.761	305.8	271.2
1990	50.07	2.415	137.7	5.247	348.9	241.2	763.4	726.3

Contd...

	June		July		Aug		Annual	
	Ba	Aa	ba	aa	Ba	aa	Ba	Aa
1992	4.21	2.415	28.29	5.427	200.5	0	463.3	266.1
1993	7.54	2.415	88.42	5.247	177.5	0	600	584.4
1994	34.8	2.415	570.8	219.8	223.2	491.6	1250	1441
1995	1.72	2.415	39.61	5.247	32.83	0	175.8	118.9
1996	13.97	2.415	23.57	5.247	82.32	2.178	444.8	364.3
1997	6.09	2.499	72.51	5.247	364.7	238.3	561.8	679
1998	9.09	2.415	54.36	5.247	130	0	1067	955.4
1999	14.07	2.415	152.2	5.247	160.5	115.5	474.5	441.3
2000	9.44	2.415	36.26	5.247	70.65	19.91	286.2	307.3
Average	22.79	2.176	116.2	18.37	208.1	108.2	598.9	581.1
Maximum	117	2.499	570.8	219.8	775.4	491.6	1681	1506
75 % dep	5.68	2.415	48.6	5.247	90.04	9.37	415.8	303.9
65 % dep	7.63	2.415	57.53	5.247	131.9	15.18	465	353.8
50%	9.59	2.415	96.11	5.247	212.9	24.52	563	593.6

Note : Ba = before Almatti, aa = after Almaati

Discussion of results From the above table it could be seen that

There is not much variation in average annual flows And 50 % dependable annual flows. But there is a decrease of 175 TMC due to Almatti in the maximum annual flows. This may be due to additional utilisation allowed in Almatti. The 75 % and 65 % dependable flows have also reduced slightly because of the same reason. However the monthly flows in june , July and august have drastically reduced.

In june the average reduced to 2.176 TMC from 22.79 TMC, the maximun flows have reduced to 2.499 TMC from 117 TMC, the 75 %,65 %, 50 % dependable flows reduced to 2.415 TMC from 5.68,7.63,9.59 TMC. In fact the release of 2.415 TMC is the regulated releases ordered by Tribunal and there are no flows in JUNE to down stream from Almatti.

In july the average reduced to 18.37 TMC from 117 TMC, the maximun flows have reduced to 219.8TMC from 570.8TMC, the 75 %,65 %, 50 % dependable flows reduced to 5.247 TMC from 48.6,57.53,96.11. In fact the release of 5.247 TMC is the regulated releases ordered by Tribunal and there are no flows in July to down stream from Almatti except in good years.

In August the average reduced to 108.2 TMC from 208.1 TMC, the maximun flows have reduced to 491.6 TMC from 775.4 TMC, the 75%, 65%, 50% dependable flows reduced to 9.37,15.18,24.52 TMC from 90.04,131.9,212.9 TMC.

CONCLUSIONS

There is drastic reduction in the initial months of june, july and august. During these months no dependabale flows are expected to Srisailam and hence the cropping pattern has to be planned from august on wards and the project crop water requirements of Nagarjunasagar and SRBC are to be revised considering this required postponement of crop calender.

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Climate Change Adaptations: Imperatives for Water Security

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ABSTRACT

In large parts of the world, climate change threatens the availability of sufficient freshwater resources, and will lead to an increase in extreme weather events. Most severe cold shock is being experienced by many across the globe while the South Asia suffered with high magnitude. It was at the fag end of 2016 we have encountered massive environmental damage in the South East Asia. In the South Indian City of Chennai (erstwhile Madras) had to bear the brunt of a cyclone that derailed the city for a while along with disruption in the island of Andaman and Nicobar. Similarly in the parts of America and China faced unprecedented cold wave. Some of the northern states of India continues with the severe cold wave and has embraced snow cover. Adapting to the effects of climate change on water systems is a crucial element of water security. Needless to state that water availability is also important for climate mitigation, observations of CDP's climate change program shows that 24% of GHG reduction activities depend on the availability of good quality water. The entry into force of the historic Paris Agreement marked a paradigm shift in the global effort to address climate change. Thus for all countries, the focus moves from planning to delivery. Further to the implementation of policies and measures that will deliver the ambitious goal to hold the increase in global temperatures to much below two degrees. Efficient water management can help reduce energy use and the associated emissions. It is reported that more efficient use of water has led to lower GHG emissions. Global efforts to decarbonize the economy could therefore sink or swim based on how we manage water. Lastly, the prediction that climate change would result in great changes in the global distribution of rainfall, causing drought and desertification in some regions and floods in others is a concern. Paper attempts to summarize that water plays an important role to sustain rural, urban and growing populations the world over and can secure low carbon transition to a sustained future.

Keywords: Climate change, Climate mitigation, and Paris agreement

INTRODUCTION

Climate change and possible response strategies have high scientific and policy relevance but are also associated with major controversies. The time frame of a century or more involved in any analysis of climate change, as well as, the complexity of natural and socio-economic systems and their interactions – all shrouded by deep uncertainties – pose major scientific and policy challenges. There needs to be a shared understanding of these challenges to come to grips with the possible magnitude and nature of climate change and to craft response strategies. This all makes climate change one of the most challenging issues to be addressed by interdisciplinary research and by policy measures. How the drivers ranging from the realm of demographics, economics, and technology to social behavior and institutions shape future emissions of greenhouse gasses (GHGs)? Are there ways of "bending down" the curve of ever increasing radiative forcing? What are the real consequences of radiative forcing change on global, regional, as well as local climates both in terms of changes in magnitude (e.g., warming, precipitation) as well as in nature (most prominently variability and possibilities of extreme events)? What will be the impacts on natural and human systems of a changing climate? Finally, what are the feasibilities, costs, and benefits (in terms of avoided impacts) of response strategies? (Grubler et al 2007).There are sufficient scientific and policy reasons to justify interest in climate change and to devote a full Special Issue to this topic. However, interest in itself needs to be complemented by new analytical and methodological perspectives. The work by Grubler et al. provides key findings that are also of wider interest beyond the climate change universe. The work suggests that developments in Asia will be particularly dramatic over the next five decades with an unprecedented scale of emerging urban agglomerations in terms of population and economic activities that could surpass many-fold the currently most dense urban corridors, such as Boswash in the USA or Shinkansen in Japan. Grubler et al. emphasize the need for new infrastructure "backbones" along urban clusters rather than networks of "island" cities, particularly in the Asian urbanization "hotspots" of Bengal and the Chinese coast.

Impact of Climate Change

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level (see diagram). Historically, the responsibility for green house gas emissions 'increase lies largely with the industrialized world, though the developing countries are likely to be the source of an increasing proportion of future emissions. The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security, etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. The efforts made by the UNFCCC and the Kyoto Protocol provision are clearly inadequate to address the climate change challenge. Thus most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. (Sathaye et al., 2007) The issue of highest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to the projected climate change. India and other developing countries will face the challenge of promoting mitigation and adaption strategies, bearing the cost of such an effort, and its implications for economic development.

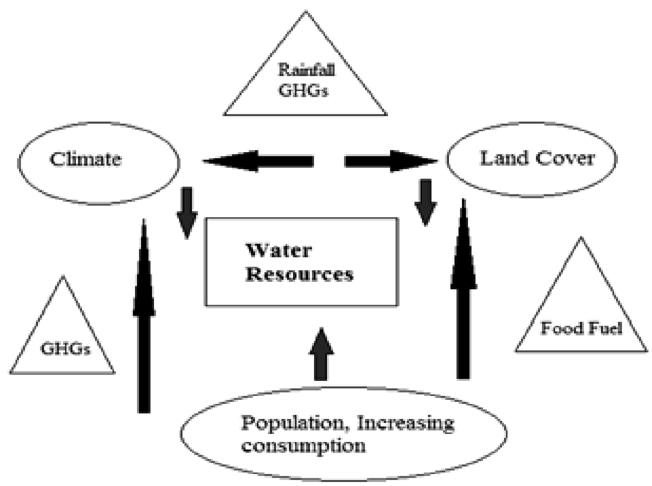


Figure 1 Climate change and water linkages

Global Carbon Cycle: Causes and Linkages

The global carbon cycle involves interaction among the atmosphere, oceans, soils and vegetation and fossil fuel deposits. The ocean contains 39,000giga tonnes of carbon (GtC), fossil fuel deposits about 16,000 GtC, and the atmosphere about 760 GtC2 and fossil fuel combustion, about 270 GtC. Of this, 180 GtC has ended up in the atmosphere, while 110 GtC has been absorbed by growing vegetation and the remainder by the oceans. It is the increasing concentration of atmospheric CO2 that is the cause for concern about global climate change. (Sathaye et. al., 2006)

The consumption of fossil fuels and other human activities are the primary sources of increased concentrations of CO2 and other greenhouse gasses. Between 1990 and 1999, an estimated 6.3 GtC/year was released due to the combustion of fossil fuels, and another 1.6 GtC/year was due to the burning of forest vegetation. This was offset by the absorption of 2.3 GtC/year each by growing vegetation and the oceans. This left a balance of 3.3 GtC/year in the atmosphere. Controlling the release of greenhouse gasses from fossil fuel combustion, land-use change and the burning of vegetation are therefore obvious opportunities for reducing greenhouse gas emissions. Reducing greenhouse gas emissions can lessen the projected rate and magnitude of warning and sea level rise. The greater the reduction in emissions the smaller and slower would be projected warming and the rise in sea levels. Future climate change is determined by historic, current and future emissions. Of the six GHGs above, CO2 accounted for 63% , methane 24%, nitrous oxide 10% and the other gases the remaining 3% of the carbon equivalent emissions in 2000. Thus in addition to CO2, global mitigation efforts need to focus on the two largest and rapidly increasing GHGs (Pl. see figure 1 & graph 1).

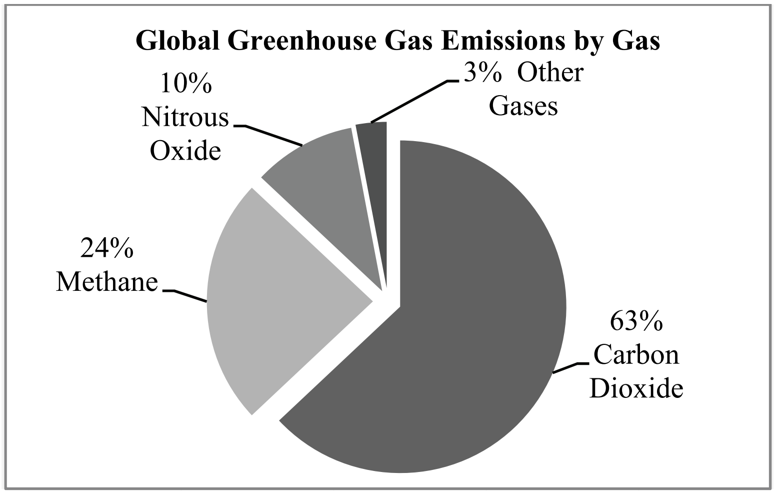
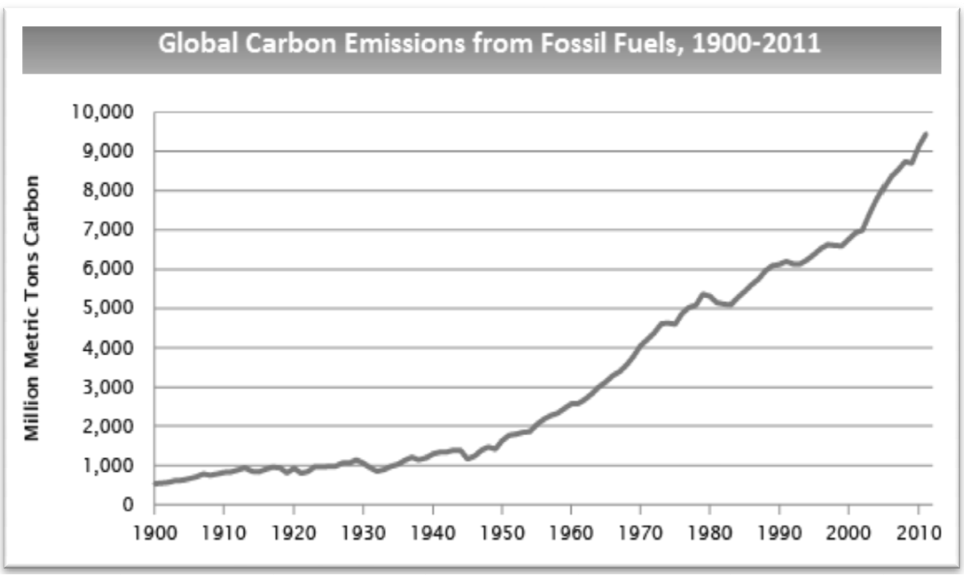


Figure 2 Source: IPCC (2014)



Graph 1: Source: Boden, T.A., Marland, G., and Andres R.J. (2015). Global, Regional, and National Fossil-Fuel CO_2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2015.

India is a large developing country with nearly 700 million rural population directly depending on climate – sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers , fisher folk, and nomadic shepherds is very low (Sathaye et. al., 2006). Climate change is likely to impact all the National Communications Report of India to the UNFCCC (GoI, 2004,2006,2007,2008,2009).

Regional Issues

South Asia is most vulnerable to climate change. The region faces daunting climate related development challenges. The impacts of climate change in the form of higher temperature, more variable precipitation and more extreme weather events are already felt in South Asia. The region is already marked by climate variability and a higher incidence of natural disasters. The region has also a long and densely populated coast line with low lying island that are vulnerable to sea level rise. Urbanization poses an additional challenge in the region. Women, poor and indigenous people are most vulnerable to climate risk (Berggren et al, 2008).

Among the 32 states and Union Territories in the country, 22 are multidisaster prone. About 40 million hectares of land in the country has been identified as flood prone and on an average 18.6 million hectare of land is flooded annually. About 57 per cent of area of the country is vulnerable to seismic activity. About 18 per cent of country's total area is drought prone, approximately 50 million people are annually affected by droughts and about 68 percent of total sown area of the country is drought prone. (Singh U B et al 2014) India has a long coastline of 8040km. This is exposed to tropical cyclones arising in the Bay of Bengal, the Arabian Sea and Indian Sea. The Indian Ocean is one of the six major cyclonic prone regions of the globe. The Coromandal coastline is more cyclones prone, with 80 percent of the total cyclones generated in these regions. About 3.9 million houses are susceptible to earthquakes of very high intensity, about 20 million houses are susceptible to damage due to winds and about 9.3 millio9n houses are susceptible to damage due to floods. Besides the risk of earth quakes, cyclones and floods are liable to very high damage and destruction of vulnerable houses under heavy rains. (Prasad et. al., 2009). Some 49 percent of the total housing stock is liable to very high damage from natural hazards, while about 1 percent of the total housing stock gets destroyed every year. It is to be noted that in earth quake, 80 percent of the causalities are due to collapsing buildings. Brick and stone buildings without proper support are liable to collapse. Non-engineered building continues to be built in the areas prone to natural disasters. Unemployment, poverty backwardness, migration from rural areas and increasing price of land and construction, millions of people are occupying disaster prone areas. Thus about 6 percent increase in disaster affected population has been reported. (SINGH The changing topography due to environmental degradation has also increased the vulnerability in the country. In 1988, 11.2 percent of total land areas was flood prone, but in 1998 floods inundated 37 percent geographical area. Three major disasters that India have experienced in the recent past are the super cyclone in Orissa (1999) , earthquake in Gujarat (2001) and Tsunami (2004) in Tamil Nadu, Pondicherry, Andaman Nicobar Island and parts of other southern states. Frequent disasters lead to erosion of development gains restricted options threatened by hazards (World Bank 2006, 2010) (Satterthwaite et al., 2007)

The continent of Asia is particularly vulnerable to disaster strikes. Between the years 1991 to 2000 Asia has accounted for 83 percent of the population affected by disasters globally. Within Asia, 24 percent of deaths due to disasters occurred in India, o9n account of its size population and vulnerability. Floods and high winds account for 60 percent of all disasters in India. Many parts of the Indian sub –continent are susceptible to different types of disasters owing to the unique topography and climatic characteristics . About 54 per cent of the sub continent's landmass is vulnerable to earthquake while about 4 crore hectares is vulnerable to periodic floods. The country has suffered four four major earthquakes in the span of last 50 years along- with a series of moderate intensity earthquakes that have occurred at regular intervals. Since 1988, six earthquakes have struck different parts of the country. Tsunami in India killed 10749 persons while $1068 million loss or damage to properties was reported. Short term and long – term changes in climatic variables such as temperature and perception may pose hazards to urban system. Changes in the climatic variables are likely to impact future patterns of spatial growth and development in cities and act as a stressor in addition to existing pressures. The populations most venerable to climate change are those living in slums and informal settlements that often lack access to basic services and infrastructure (IDS, 2007). Apart from the risk to coastal populations from sea level rise, cyclones, storm surges and other associated impacts, a high proportion of urban settlements in the low and middle-income countries are one sites that are at risk from flooding or landslides . The key primary and secondary order impacts on cities are due to short –term and long- term changes in climatic variables have been stressed elsewhere too.

Carbon Dynamics of Soil and Water

Various types of wetlands – including swamp forests, mangroves, peat lands, mires and marshes – are also important carbon sinks and stores. Anaerobic conditions in inundated wetland soils and slow decomposition rates contribute to long term soil carbon storage and formation of carbon rich peats. Peat lands can extend up to 20 m in depth and represent some 25 percent of the world soil carbon pool, an estimated 550 GtC; they are estimated to sequester another 0.3 tC/ha/yr. Maintaining and restoring wetland habitats protects these carbon sinks; clearance and drainage can lead to peat collapse and further carbon emissions. Grasslands occur on every continent except Antarctica, and constitute about 34 percent of the global terrestrial carbon stock. Changes in grassland vegetation due to overgrazing, conversion to crop land, desertification, fire, fragmentation, and introduction of non-native species affect their carbon storage capacity, and may in some cases even lead to grasslands becoming a net source of CO_2. For example, they may lose 20 to 50 percent of their soil organic carbon content through cultivation, soil erosion, and land degradation. Burning of biomass, especially in tropical savannas, contributes over 40 percent of gross global carbon dioxide emissions. Oceans, too, are substantial reservoirs of carbon, holding approximately 50 times more carbon than presently in the atmosphere (Loske 1996). They are efficient in taking up atmospheric carbon through plankton photosynthesis, mixing of atmospheric CO2 with sea water, formation of carbonates and bicarbonates, conversion of inorganic carbon to particulate organic matter and by burial of carbon rich particles in the deep sea. Clearly enhanced protection and improved management of natural ecosystems can contribute to both reductions in GHG emissions and carbon sequestration. Many protected areas, for instance, overlie areas of high carbon stocks. It has been estimated that globally, ecosystems represented within terrestrial protected areas store over 312 GtC or 15 percent of the terrestrial carbon stock, although the extent to which these stocks are protected varies with management effectiveness. Ecosystem-based Adaptation is becoming an increasingly important part of the development agenda. Protecting forests, wetlands, coastal habitats and other natural ecosystem can provide social, economic, and environmental benefits, both directly through more sustainable management of biological resources and, indirectly, through protection of ecosystem services. Natural ecosystems maintain the full range of goods and ecosystem services, including natural resources such as water, timber and fisheries on which human livelihoods depend; these services are especially important to the most vulnerable sectors of society.

Adaption to Ecosystem-based Approaches to Climate Change

In a report on 'Convenient Solutions to an Inconvenient Truth', It is envisaged to protect watersheds and regulate water flow and water quality; prevent soil erosion; influence rainfall regimes and local climate; conserve renewable harvestable resources and genetic reservoirs; and protect breeding stocks, natural pollinators, and seed dispersers, which maintain ecosystem health. Over the last decade, an increasing number of Bank projects have been making explicit linkages between conservation and sustainable use of natural ecosystems, carbon sequestration and watershed values associated with erosion control, clean water supplies, and flood control (ADB 2006) (Prasad et al 2009). Better protection and management of key habitats and natural resources can benefit poor, marginalized and indigenous communities by protecting ecosystem services and maintaining access to resources during difficult times, including drought and disaster. In response to climate change, many countries are likely to invest in even more infrastructure for coastal defenses and flood control to reduce the vulnerability of human settlements to climate change. Increased water shortages will increase demand for new irrigation facilities and new reservoirs. Similarly, natural ecosystems can reduce vulnerability to natural hazards and extreme climatic events and complement, or substitute for, more expensive infrastructure investments to protect coastal and riverine settlements. Flood plain forests and coastal mangroves provide storm protection, coastal defenses, and water recharge, and act as safety barriers against natural hazards such as floods, hurricanes, and tsunamis, while wetlands filter pollutants and serve as water recharge areas and nurseries for local fisheries. Traditional engineered solutions often work against nature, particularly when they aim to constrain regular ecological cycles, such as annual river flooding and coastal erosion, and could further threaten ecosystem services if creation of dams, sea walls, and flood canals leads to habitat loss. (WB 2010). Three of the world's greatest challenges over the coming decades are biodiversity loss, climate change, and water shortages. Biodiversity loss leads to the erosion of ecosystem services and will increase vulnerability to the impacts of climate change.

Climate change will lead to water scarcity, increased risk of crop failure, pest infestation, overstocking and permanent degradation of grazing lands and livestock deaths. Water shortages affect agricultural productivity, food security and human health. But Impacts from these challenges are already imposing severe economic and social costs, and they are likely to get more severe as climate change continues, particularly affecting already vulnerable communities. Changing climate and rainfall patterns are expected to have significant impacts on agricultural productivity, especially in arid and semi-arid regions that are already marginal for agriculture. Most climate modeling scenarios indicate that the dry lands of West and Central Asia and North Africa, for instance, will be severely affected by droughts and high temperatures in the years to come. This could lead to land degradation and agricultural expansion. By 2050, almost 40 percent of the land currently under low impact agriculture could be converted to more intensive agricultural use with poor farmers being forced to open up ever more marginal lands. One study estimates that climate change could lead to a 50 percent reduction in crop yields for rain-fed agricultural crops by 2020. According to crop-climate models, in tropical countries even moderate warming can reduce yields significantly (1°C for wheat and maize and 2°C for rice) because many crops are already at the limit of their heat tolerance.

Agriculture, Livelihood Issues and Strategies

The areas most vulnerable particularly in South Asia and Sub-Saharan Africa—also have the largest number of rural poor and rural populations dependent on agriculture. Recent studies show that farming, animal husbandry, informal forestry and fisheries make up only 7.3 percent of India's GDP, but these activities constitute 57 percent of GDP of the poor who are most reliant on natural resources and ecosystem services (see Diagram). Climate change is likely to aid the spread of invasive alien species, further threatening agricultural productivity and food security through spread of weeds, pests, and diseases of crops and livestock. The introduction of new and adaptable exotic species for agriculture and to meet increasing demands for biofuels, mariculture, aquaculture, and reforestation presents a particular challenge. Ironically, in some cases, the very characteristics that make a species attractive for introduction under development assistance programs (fast-growing, adaptable, high reproductive output, tolerant of disturbance and a range of environmental conditions,) are the same properties that increase the likelihood of the species becoming invasive. Such events are costly; invasives accidentally introduced through development assistance programs include itch grass, a major weed in cereals in South and Central America, and a range of nematode pests.

Climate change is expected to have serious consequences on water resources. Melting glaciers, higher intensity and more variable rainfall events, and increasing temperatures will contribute to increased inland flooding, water scarcity and decrease water quality. Overall, the greatest human requirement for freshwater resources is for crop irrigation, particularly for farming in arid regions and in the great paddy fields of Asia (World Bank 2010). In South Asia, hundreds of millions of people depend on perennial rivers such as the Indus, Ganges, and Brahmaputra –all fed by the unique water reservoir formed by the 16,000 Himalayan glaciers. Current trends in glacial melt suggests that the low flows will be substantially reduced as a consequence of climate change even as the demand for agricultural water is projected to rise by 6 to 10 percent for every 1 ˚C rise in temperature. As a result, even under the most conservative climate projections, the net cereal production in South Asian countries is likely to decrease by 4 to 10 percent by the end of this century.

Water security to Urban Areas

Today, half of the global population lives in towns and cities and one-third of this urban population live without clean drinking water. Municipal water accounts for less than a tenth of human water use, but clean drinking water is a critical need. These billion have-nots are unevenly distributed across the globe: 700 million city dwellers in Asia, 150 million in Africa, and 120 million in Latin America and the Caribbean. (http://siteresources.worldbank.org) In recent years, governments and city councils have begun to take an increasing interest in the opportunities for offsetting or reducing some of the costs of maintaining urban water supplies—and, perhaps even more importantly, water quality—through management of natural resources, particularly forests and wetlands. Most protected areas are established to protect their biodiversity values, but many could be justified on the basis of the other ecosystem services that they provide. From China to Ecuador and Mexico to Kenya, protected areas in forest watersheds safeguard the drinking supplies for some of the world's major cities.

Other Ecosystem-based Approaches is by supporting biodiversity conservation and protecting natural habitats and ecosystem services, thereby contributing to effective mitigation and adaptation strategies. Pilot projects which integrate protection of natural habitats and "green" infrastructure into watershed management, flood control, and coastal defense, already demonstrate the cost effectiveness of such ecosystem-based approaches. Climate change highlights the need to replicate and scale up such interventions including the ones that reported and are success stories elsewhere like:

- Protecting terrestrial, freshwater, and marine ecosystems and ecological corridors to conserve terrestrial and aquatic biodiversity and ecosystem services.
- Integrating protection of natural habitats into strategies to reduce vulnerability and disaster risks (including protection from natural hazards such as floods, cyclones, and other natural disasters). Emphasizing the linkages between protection of natural habitats and regulation of water flows and quality of water, essential for agriculture, food security, and domestic and industrial supplies.
- Scaling up investments for protected areas and ecosystem services linked to sector lending, such as infrastructure, agriculture, tourism, water supply, fisheries, forestry.

- Promoting greater action on management of invasive alien species, which are linked to land degradation, and impact negatively on food security, and water supplies.
- Emphasizing the multiple benefits of forest conservation and sustainable forest management (carbon sequestration, water quality, reducing risks from natural hazards, poverty alleviation, and biodiversity conservation).
- Promoting investments in natural ecosystems as a response to mitigation (avoided deforestation) and adaptation (wetland services).
- Integrating indigenous crops and traditional knowledge on agro-biodiversity and water management into agricultural projects as part of adaptation strategies.
- Promoting more sustainable natural resource management strategies linked to agriculture, land use, habitat restoration, forest management and fisheries.
- Developing new tools to measure the benefits of integrated approaches to climate change (ecosystem services, biodiversity conservation, carbon sequestration, livelihood co-benefits and resilience). In the global climate change debate, the issue of largest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to projected climate change (Sathaye et al). Over time, there has been a visible shift in the global climate change discussions towards adaptation. Adaptation can complement mitigation as a cost-effective strategy to reduce climate change risks. The impact of climate change is projected to have different effects within and between countries (Sathaye et al). Mitigation and adaptation actions can augment sustainable development and equity both within and across countries and between generations

CONCLUSION

Numerous studies have shown that over few decades anthropogenic activities have changed ecosystems more rapidly and extensively than at any comparable period. These changes have contributed to many net development gains but at growing environmental and social costs: habitat loss, land degradation, and reduced access to adequate water and natural resources for many of the world's poorest people. Climate change is likely to compound this environmental degradation. Water is essential for all life on Earth. Climate change impacts can be expected to have serious consequences on the availability and quality of water resources. Melting glaciers, higher intensity and more variable rainfall events, and increasing temperatures will contribute to increased inland flooding, water scarcity and decreasing water quality. Restoration and maintenance of watersheds, including management of soils, can contribute to reduce the risk of flooding and maintaining regular water supplies. Natural ecosystems such as wetlands and forests act as natural water recharge areas, storing runoff, recharging aquifers, and replenishing stream flows. This reduces flood risks associated with heavy rainfall or a glacier melt events.

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Computational Design of Syphon Aqueduct

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ABSTRACT

The design considerations of a syphon aqueduct is analyzed as given in the code IS: 7784.2.5.2000. An example of design of syphon aqueduct is considered to develop a program in MATLAB software based on the design steps and is executed by entering the input values to get the output design values. With the help of the output obtained section of syphon aqueduct is drawn in AutoCAD software.

Keywords: MATLAB Asyphon aquiduct, Auto CAD.

INTRODUCTION

A cross drainage work is a structure which is constructed at the junction of crossing of a natural drain and the canal, so that the drainage water flows without any interruption to the canal. However the alignment of the canal be this crossing with the drains is unavoidable. But a cross drainage work is generally a costly construction and must be avoided. To avoid the cross drainage works the watershed line is aligned in which the canal crosses minimum number of drains and hence economical. The number of cross drainage works can be reduced by diverting one drain into another and by changing the alignment of the canal, so that it crosses below the junction of the two drains. The objective of this project is to write a program in MATLAB software for the design of cross drainage work – syphon aqueduct as per the Indian Standard codes given for the design of cross drainage work (i.e., IS – 7784.1.1993 and IS – 7784.2.5.2000) in order to Reduce manual efforts for designing of a syphon aqueduct and to assess different parameters of syphon aqueduct

Definition

A cross drainage work is a structure carrying the discharge from a natural stream across a canal intercepting the stream.

Syphon Aqueduct

In this work the canal is taken over the natural drain in such a way that, if the HFL of the drain is higher than the canal bed level and water passes through the aqueduct under syphonic action, then the provided structure is known to be as syphon aqueduct.

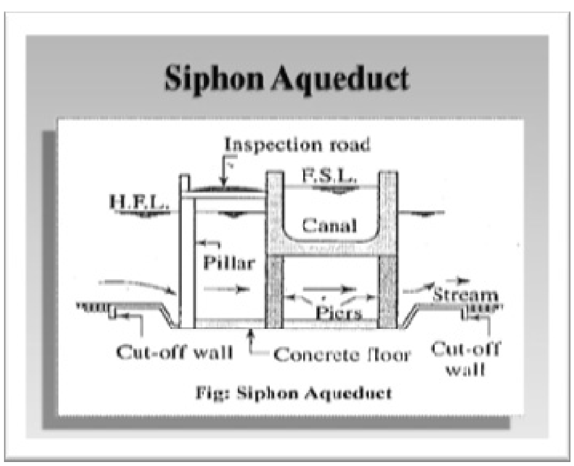

Figure 1 Cross sectional view of syphon aqueduct

IS – 4410 (part 15/sec 5): 1992 - glossary of terms relating to river valley projects. Explanation/definitions of terms relating to cross drainage works (i.e. sec - 5) of canal structure (i.e. part - 15) and used while designing a cross drainage work. The terminology used in both hydraulic design and the structural design had been defined for the easy understanding and for using appropriately. IS – 7784.1.1993 - design of cross drainage works – code of practice, part – 1. General features [WRD 13: canals and cross drainage works] which includes the category of cross drainage works, selection of type of cross drainage work depending on different natural circumstances, the data required for design of cross drainage work, design flood for drainage channel, hydraulic design aspects, requirements to be provided for good foundation and model studies.

IS – 7784.2.5.2000 - design of cross drainage works – code of practice, part – 2. Specific requirements for the design of syphon aqueducts. Data for the design, general consideration are discussed. Types of syphon aqueduct are explained. Limiting velocity and head loss of the syphon barrel at certain conditions, design of barrel type of syphon aqueduct and design of trough type syphon aqueduct are done with all general requirements.

Irrigation water management training manual no.8 structures for water control and distribution: For irrigation purpose water may need to be transported over steeply sloping land, if canal slope is same to steeply sloping field flow velocity in canal would be very high so to avoid such high velocity canal slope is designed in such a way that it is less steep than field slope ,for this it is split into sections and part of each section is constructed in cut and in fill bed level of each section is lower than the U/S concerned section of canal .In order to avoid large volumes of cut and fill ,the drop in bed level range 0.3-0.8 m .Canal sections are connected to each other by drop structures .Drop structure may also include stilling basin if canal is unlined or drop is relatively large up to 0.5 m. S. K. Mazumder, economic and innovative design of a canal drop: In conventional design of a canal drop, long length of inlet and outlet transitions are provided for improving performance. They are expensive and hydraulic performance is also not satisfactory. Analytical and experimental studies were carried out by the author in which optimum fluming ratio and optimum length of transitions were found. An innovative and economic stilling basin with rapidly diverging side walls and adversing sloping floor which simultaneously act as energy dissipater and expanding transition has been recommended. A. Melih Yanmaz and K.Hakan Turan(2005), computer-assisted design of diversion weirs.

A diversion weir is a headwork facility built across a river to raise water level and to divert water for various purposes, such as irrigation, hydropower generation, etc. In this study, a Windows-based, visual, and user friendly program named WINDWEIR is developed in Visual Basic.NET programming language for the optimum design of a diversion weir with sidewise intakes. The methodology used in the program is developed with reference to the design guidelines reported in the literature and in accordance with the common engineering practice. The program determines the overall dimensions and the total cost of a diversion weir. It also performs stability analyses. The program is relatively flexible such that a design engineer can assess various dimensions of the structure by performing quick successive test runs to achieve an optimum solution among various alternatives. An application is presented to demonstrate the use of the program.

METHODOLOGY

DATA REQUIRED

Discharge values of canal and the natural drainage; Bed levels of canal and the natural drainage; Full supply depth of canal; High flood level of drainage; Side slope of the canal; Manning's values; topographical data; geometry of both canal and drain. Software such as Visual studio software to execute MATLAB programming language, Excel worksheet and AutoCAD Civil 3D 2012 are required for analyzing data, designing, and drafting it into pictorial representation.

General Methodology:

Step 1: Review of design procedure as recommended by IS – 7784.2.5.2000.

Step 2: Algorithm is prepared for better understanding of design steps to be followed.

Step 3: A program for design of syphon aqueduct of cross drainage works is developed in MATLAB software.

Step 4: The program developed is executed in MATLAB software for the output results

Step 5: The values obtained in the output are converted into co-ordinates manually.

Step 6: Section of syphon aqueduct is drawn in AutoCAD using the results obtained previously.

Design of Syphon Aqueduct

(Source: Irrigation Engineering and hydraulic Structures, S.K.Garg – 28th edition**)**

Example: Design a syphon aqueduct if the following data at the crossing of a canal and drainage are given:

Discharge of canal	=	40 cumecs.
Bed width of canal	=	30 m.
Full supply depth of canal	=	1.6 m.
Bed level of canal	=	206.4 m.
Side slope of canal	=	1.5 H : 1 V.
High flood discharge of drainage	=	450 cumecs.
High flood level of drainage	=	207.0 m.
Bed level of drainage	=	204.5 m.
General ground level	=	206.5 m.

Solution: Since the drainage is of a large size, work of type III will be adopted. Further, because the canal bed level (206.4m) is slightly below the drainage HFL (207.0m); a syphon aqueduct is required and is also asked for. The earthen banks of the canal will be discontinued and the canal water taken in a concrete trough. For affecting economy, the canal shall be flumed.

Step 1: Design of Drainage Waterway

Lacey's regime perimeter = p $= 4.75\sqrt{Q} = 4.75\sqrt{450} = 100.8$ m.

Provide 11 clear spans of 8m each and let the width of each pier be 1.5m.

The length occupied by 11 bays of 8m each $= 11 \times 8 = 88$m

The length occupied by 10 piers of 1.5m each $= 10 \times 1.5 = 15$m

Total length of waterway = 88+15 = 103m.

Let us, now, limit the velocity through syphon-barrels, to a value, say 2m/sec.

Height of the barrel required $= \frac{Discharge}{Velocity * clear\ width\ of\ waterway} = \frac{450}{2 \times 88} = 2.56$m.

Hence, provide 11 rectangular barrels, each 8m wide and 2.5m high.

Actual velocity through barrels $= \frac{450}{11 \times 8 \times 2.5} = 2.05$ m/sec.

Step 2: Design of canal waterway

Normal bed width of canal = 30 m

Let the width be reduced to 15 m.

Providing a splay of 2:1 in contraction, the length of contraction transition

$$= \frac{30 - 15}{2} \times 2 = 15 \text{ m.}$$

Providing a splay of 3:1 in expansion, the length of expansion transition

$$= \frac{30 - 15}{2} \times 3 = 22.5 \text{ m.}$$

Length of flumed rectangular portion of the canal between abutments = 103 m (provided). In transitions, the side slopes of the canal section shall be warped in plan from the original slope of 1.5H:1V to vertical.

Step 3: Design of Bed Levels at Different Sections

At section 4-4

When the canal returns to its normal section, we have the known conditions as follows:

Area of trapezoidal canal section = (B+1.5y)y = (30+ 1.5 × 1.6)1.6 = 32.4 × 1.6 = 51.84 sq. m.

Where B = Bed width = 30 m

y = Depth = 1.6 m

Water depth(given) = 1.6 m

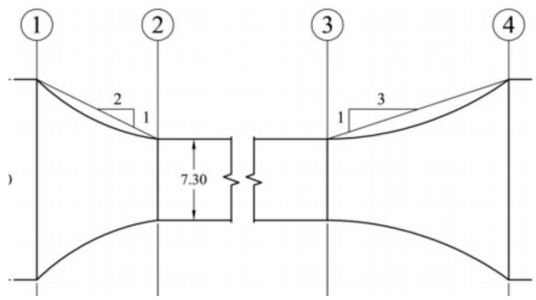

Figure 2 plan and section of canal trough in the example

Velocity head = $\frac{v_4^2}{2g} = \frac{0.77^2}{2 \times 9.81}$ = 0.030m

R.L. of canal bed at 4-4(given) = 206.4 m

R.L. of water surface at 4-4 = 206.4 + 1.6 = 208.0 m

R.L. of T.E.L. at 4-4 = 208.0 + 0.03 = 208.03 m.

At section 3-3

Assuming a constant depth of 1.6 m throughout the channel, we have at section 3-3, a rectangular channel, as follows:

Bed width = 15 m

Depth = 1.6 m (assumed constant)

Area = 15 × 1.6 =24 sq.m.

Velocity = v_3 = 40/24 = 1.67 m/sec.

Velocity head = $\frac{v_3^2}{2g} = \frac{1.67^2}{2 \times 9.81}$ = 0.142 m

Assuming that the loss of head in expansion from section 3-3 to section 4-4 is taken as

= 0.3 $\frac{v_3^2 - v_4^2}{[2g]}$ = 0.3[.142 - .030] = 0.3 × 0.112 = 0.0336 m; say0.034 m.

R.L. of T.E.L at 3-3 = R.L. of T.E.L. at 4-4 + loss of expansion

= 208.030 + .034 = 208.064 m.

R.L. of water surface at 3-3 = 208.064 – 0.142 = 207.922 m.

R.L. of bed at 3-3 = 207.922 – 1.6 = 206.322 m

At section 2-2

From section 2-2 to section 3-3, the trough section is constant. Therefore, the area and velocity at 2-2 are the same as at 3-3. There is a friction loss between 2-2 and 3-3, which may be computed by Manning's formula, as equal to

$$H_L = \frac{n^2 v^2 L}{R^{4/3}}$$

Where n is the rugosity coefficient, whose value in a concrete trough may be taken as 0.0016 and L is the length of the channel = 103 m.

Area of trough section (A) = 15 × 1.6 = 24 sq.m

Wetted perimeter (P) = 15+ 2 × 1.6 = 18.2 m

Hydraulic mean depth = R = $\frac{A}{P} = \frac{24}{18.2}$ = 1.32 m

Velocity in trough = $\frac{Q}{A} = \frac{40}{24}$ = 1.67 m/sec.

Head loss, $H_L = \frac{n^2 v^2 L}{R^{4/3}} = \frac{0.016^2 \times 1.67^2 \times 103}{1.32^{4/3}}$ = 0.051 m.

R.L. of T.E.L. at 2-2 = R.L. of T.E.L. at 3-3 + Head loss in trough

= 208.064 + 0.051 = 208.115 m.

R.L. of water surface at 2-2 = 208.115 – 0.142 = 207.973 m.

R.L. of bed at 2-2 = 207.973 – 1.6 = 206.373 m.

At section 1-1

Loss of head in contraction transition from section 1-1 to section 2-2 may be taken as

$$= 0.2\ \frac{v_1^2 - v_1^2}{[2g]} = 0.2\ \frac{1.67^2 - 0.77^2}{[2 \times 9.81]} = 0.0224 \text{ m; say } 0.022 \text{ m.}$$

R.L. of T.E.L. at 1-1 = R.L. of T.E.L at 2-2 + loss in contraction

= 208.115 + 0.022 = 208.137 m

R.L. of water surface at 1-1 = 208.137 – 0.030 = 208.107 m.

R.L. of bed at 1-1 required to maintain constant depth = 208.107 – 1.6 = 206.507 m.

Step 4: Design of Transitions

a) *Contraction Transition.* Since depth is kept constant, the transition shall be designed based on the mitra's hyperbolic transition equation, given by

$$B_x = \frac{B_n . B_f . L_f}{B_n . L_f - x\left(B_n - B_f\right)}$$

Where B_f = 15 m; B_n = 30 m; L_f = 15 m.

Substituting, we get, $B_x = \frac{30 \times 15 \times 15}{50 \times 15 - x\left(30 - 15\right)} = \frac{6750}{450 - 15x} = \frac{450}{30 - x}$

For various values of x lying between 0 to 15 m, various values of B_x are worked out. The distance x is measured from the flume section 2-2.

x in meters	0	2	4	6	8	10	12	14	15
$B_x = \frac{450}{30 - x}$ in meters	15.0	16.04	17.27	18.72	20.42	22.5	25.0	28.1	30.0

b) *Expansion Transition.* In this case, we have

B_n = 30 m, B_f = 15 m, L_f = 22.5 m

$$B_x = \frac{B_n . B_f . L_f}{B_n . L_f - x(B_n - B_f)} = \frac{30 \times 15 \times 22.5}{30 \times 22.5 - x(30 - 15)} = \frac{675}{45 - x}$$

For various values of x lying between 0 to 22.5 m, corresponding values of B_x are worked out. The distance of the flumed section is measured from section 3-3.

x in meters	0	2	4	6	8	10	12	14	16	18	20	22.5
$B_x = \frac{675}{45 - x}$ in meters	15	15.7	16.46	17.3	18.25	19.3	20.4	21.75	23.3	25	27	30

Step 5: Design of Trough

The trough shall me divided into three equal at entry = 0.505 for unshaped mouth

$f_2 = a(1+\frac{b}{R})$ where the value of a and b are taken from the table 14.1 for the cement plastered barrels as

a = 0.00316 & b = 0.030

R = Hydraulic mean depth for barrel. = $\frac{A}{P} = \frac{8 \times 2.5}{2(8 + 2.5)} = \frac{20}{21}$ = 0.953m

L = Length of the barrel = 16.4 m.

Substituting these values, we get

$f_2 = 0.00316 [1+ \frac{0.030}{0.953}] = 0.00326$

$h = [1+0.505+0.00326(\frac{16.4}{0.953})]\frac{2.08^2}{2 \times 9.81} = 0.333$ m

High flood level of drainage is given = 207.0 m

d/s H.F.L. = 207.0 m

Afflux(h)= 0.333 m

u/s H.F.L. = d/s H.F.L. + Afflux (or loss of head) = 207.0 + 0.333 = 207.333 m

Step 7: Uplift Pressure on Roof of Barrels

R.L. bottom of trough = R.L. of canal bed – slab thickness = 206.4 – 0.4 = 206.0 m.

Loss of head at entry of barrel = 0.505 $v^2/2g$ = 0.505 $\times \frac{2.08^2}{2 \times 9.81}$ = 0.108.

Uplift on roof

= u/s H.F.L. – loss at entry – level of underside of roof slab

= 207.33 – 0.108 – 206.0

= 1.225 m of water = 12.25 kN/m^2 (1.225 t/m^2)

(Assuming unit weight of water = 10 kN/m^2 or 1t/m^2)

The concrete trough slab is 0.4 m thick and will thus exert a downward load of = $0.4 \times 24 = 9.6$ kN/m^2
(Assuming unit weight of concrete = 24kN/m^2)

The balance of uplift pressure i.e. $12.25 - 9.6 = 2.65$ kN/m^2 has to be resisted by the reinforcement provided at the top of the roof slab. The roof slab has to be designed for the full canal water load (1.6 m of water) plus self weight, when the drainage water is low and not exerting any uplift. Suitable reinforcement at bottom of the slab may be provided for this downward force.

Step 9: Uplift on bottom floor of barrel

a) Static head

R.L. of barrel floor = R.L. of trough bottom – height of barrel

= 206.0 – 2.5 = 203.5 m.

Let us assume that a thickness of 0.8 m is provided.

R.L. of bottom floor = 203.5 – 0.8 = 202.7 m.

Bed level of drain = 204.5 m.

Assuming that the water level has gone upto the bed level of drain, static uplift on the floor

= 204.5 – 202.7 = 1.8 m of water.

b) Seepage head

The seepage head will be maximum when the canal is running full and the drain is dry.

Thus, the total seepage head = F.S.L. of canal – bed level of drain

= 208.0 – 204.5 = 3.5 m.

The residual seepage head at a point ‘a’ in the centre of the first barrel has been calculated by Bligh’s theory, as follows,

Assuming that the total length of drainage = 30 m.

The seepage line abc will traverse creep lengths as follows:

ab = length of u/s transition + half of the barrel span = 15 + 4 = 19 m.

bc = m (half of the total length of 30 m = assumed)

Total creep length = 19 + 15 = 34 m.

Residual seepage head at b = $3.5\left[1 - \frac{19}{34}\right] = 1.55$ m.

Total uplift = static head + seepage head = 1.8 + 1.55 = 3.35 m of water = 33.5 kN/m^2

The provided 0.8 m thickness of slab will resist due to its own wt, an uplift

= $0.8 \times 24 = 19.2$ kN/m^2.

Balance to be resisted by the reinforcement during bending action

= 33.5 – 19.2 = 14.3 kN/m^2.

Suitable reinforcement for this uplift pressure (i.e. 14.3 kN/m^2) has to be provided at the top of the culvert floor so as to counteract the bending action.

Note : The length of floor has been provided equal to 32 m as per the following considerations.

Length of floor required under barrel = 16.4 m

Extra floor length required to

Accommodate pier nose on both sides = 2×0.1 = 2.0 m

Horizontal length of d/s ramp joining

To bed level at a slope of 5:1 = 5(204.5 – 203.5) = 5.0 m

Width of d/s cut-off beyond ramp = 0.6 m

Length of extra floor provided on u/s side = 6.0 m

Total length = 30.0 m

Step 10: Design of cut offs and protection works for the drainage floor

The depth of scour (R) = 0.47 $\left[\frac{Q}{f}\right]^{1/3}$; assuming f = 1.0

R = 0.47 $\left[\frac{450}{1}\right]^{1/3}$ = 0.47 × 7.65 = 3.59 m

Provide depth of cut-offs for scour hole of 1.5R on both sides

Depth of u/s cut off below H.F.L. = 1.5R = 1.5 × 3.59 = 5.4 m

R.L. of bottom of u/s cut-off = u/s H.F.L – 5.4 m

= 207.333 – 5.4 = 201.933 m; say 201.93 m.

R.L. of bottom of d/s cut-off = d/s H.F.L. – 5.4 m = 207.0 – 5.4 = 201.6 m

Length of u/s protection (i.e. 40cm thick brick pitching)

= 2 [R.L. of u/s bed – R.L. of bottom of u/s cut-off]

= 2 [203.50 – 201.93] = 2 × 1.57 = 3.14 m; say 3.2 m

Similarly, length of d/s brick pitching

= 2 [R.L. of d/s bed – R.L. of bottom of d/s cut-off]

= 2 [204.50 – 201.60] = 2 × 2.9 = 5.8 m

The pitching may be supported by 0.4 m wide and 1 m deep toe walls.

RESULT AND DISCUSSION

Q1 = Discharge of canal, B = Bed width of the canal, FSDC = Full supply depth of canal, BLC = Bed level of canal, S = side slope of canal, Q = High flood discharge of drainage, HFLD = High flood level of drainage, BLD = Bed level of drainage, GL = General ground, level, P = Lacey's regime perimeter, c = Length of clear span, d = Width of the pier, z = No. of piers, xs = No. of clear spans, L = Total length of waterway, v = Enter the velocity through syphon barrel, H = Height of barrel required, B1 = Reduced bed width, LC = The length of contraction transition, Le = The length of expansion transition, y = Depth of water, A = Area of trapezoidal canal section, v4 = Velocity of flow in section 4-4, ha4 = Velocity head at section 4-4, BLC = R.L. of canal bed at 4-4, ws4 = R.L. of water surface at 4-4, TEL4 = R.L. of TEL at 4-4, A3 = Area at section 3-3, v3 = Velocity at section 3-3, ha3 = Velocity head at section 3-3, hle = The loss of head in expansion from section 3-3 to section 4-4, TEL3 = R.L. of TEL at 3-3, ws3 = R.L. of water surface at 3-3, BL3 = R.L. of bed at 3-3, A2 = Area of trough section, n = enter the value of rugosity coefficient, L = Length of channel, pw = Wetted perimeter, R = Hydraulic mean depth, v2 = velocity in trough, Hl = Friction loss between 2-2 and 3-3, TEL2 = R.L. of TEL at 2-2, ha2 = Velocity head at 2-2, ws2 = R.L. of water level at 2-2, BL2 = R.L. of bed at 2-2, v1 = Velocity at section 1-1, hlc = Loss of head in contraction transition from section 1-1 to 2-2, TEL1 = R.L. of TEL at 1-1, ha1 = Velocity head at section 1-1, ws1 = R.L. of water surface at 1-1, BL1 = R.L. of bed at 1-1, Bn = Bed width of the normal section, Bf = Bed width of flumed channel section, Lf = Length of contraction/expansion transition, Bx = width of contraction/expansion transition at different value of x, t = Thickness of the partition wall, tow = Thickness of outer walls, ts = Thickness of bottom slab of trough, Lb = The length of syphon barrel, f1 = coefficient of head loss at entry for unshaped mouth, R1 = Hydraulic mean depth of the barrel, h = Head loss through the syphon barrel, d/s HFL= high flood level of drainage, BT = R.L. of bottom of trough, hl = Loss of head at entry of barrel, uplift = Uplift of the roof, wt.c = Unit weight of concrete, Ldw = downward load exerted, BF = R.L. of barrel floor, tBF = Thickness of the barrel floor, Fb = R.L. of bottom of floor, uplift,f = uplift on the floor, Th = The total seepage head, TCL = Total creep length, Rhb = Residual seepage head at b, T.uplift= Total uplift, Rs = The depth of scour, dCu = Depth of u/s ct-off below H.F.L, Cu = R.L. of bottom of u/s cut-off, Cd = R.L. of bottom of d/s cut-off, Lu = Length of u/s protection=2*(R.L. of u/s bed -R.L. of bottom of u/s cut-off, Ld = Length of d/s brick pitching=2*(R.L. of d/s bed -R.L. of bottom of d/s cut-off.

Figure 3.1 MATLAB screenshot 1

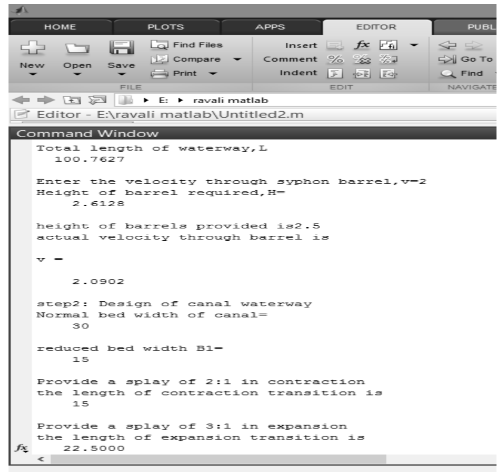

Figure 3.2 MATLAB screenshot

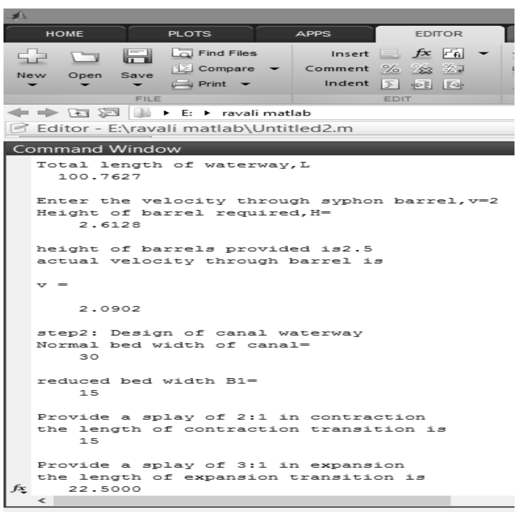

Figure 3.3 MATLAB screenshot

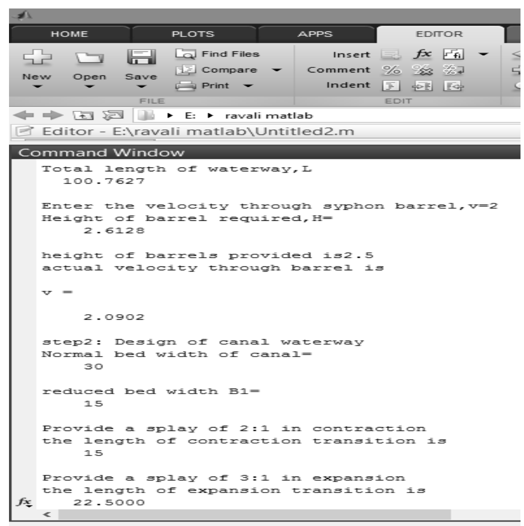

Figure 3.4 MATLAB screenshot

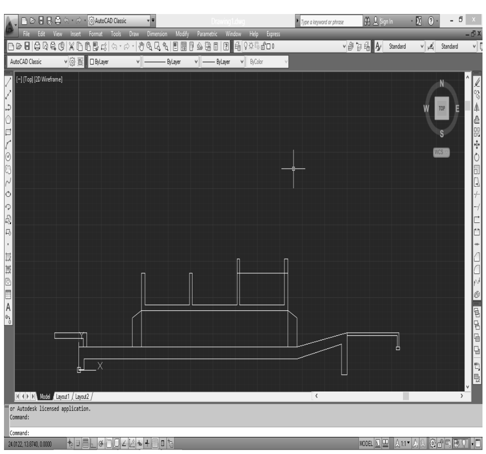

Figure 3.7 AutoCAD screenshot 1

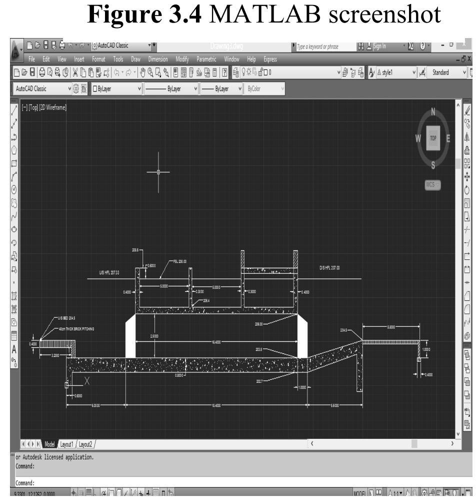

Figure 3.8 AutoCAD screenshot 1

The MATLAB programming is used to design the syphon aqueduct of cross drainage works. The values obtained from this design programming are extracted into the excel worksheet. These values are converted into co-ordinates manually by fixing one of the points as origin or one of the values as bench mark. Using AutoCAD sectional view of the syphon aqueduct is generated by copying the co-ordinates generated in excel work sheet. This procedure thus can be said as a time saving design of syphon aqueduct.

The program is written using syntax of MATLAB generally used in the market these days. Depending on the output values we have to fix the points of the complete section of syphon aqueduct manually by taking one of the value as bench mark and one point as origin. The points which are fixed manually are converted as co-ordinates in excel worksheet using the command =A1&”,”&B1.the points are numbered in an orderly manner and co-ordinates are generally orderly. After converting the points in into co-ordinates in the excel worksheet, these values are directly used in AutoCAD.

In AutoCAD the command line is selected and the co-ordinates generated in excel worksheet are copied and pasted in AutoCAD. This will generate a line diagram of the sectional view of the syphon aqueduct as per the scale. The measurements and text(if any) are indicated manually which will be the complete sectional view of the syphon aqueduct. This final AutoCAD diagram can be used for any future site works etc.

We can use this programming method to design for any type of civil engineering design works, which helps to get the results very fast and acceptably accurate which is time saving. Manually designing any of the civil structure, checking for safety and all aspect and then modifying as per the results in a long process and a time taking process. Using this method one have to keep effort to write a program once and then n number of trails can be done with different inputs.

CONCLUSION

The design of syphon aqueduct has to be designed under different working conditions. Using MATLAB software program as an interface it is very much easy to design a syphon aqueduct. The important feature of this project is to reduce the complexity to design a syphon aqueduct using a program which works as a user interface between designer and the system. When the program is executed it runs as per the specifications and gives warning when negative values of head loss or no. of piers and bays etc appear. It is flexible to use this software as the design can be done analyzed any no. of times changing the input values.

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Effect of Organic Mulches on Growth, Yield, Fruit Quality, Soil Moisture and Temperature in Acid Lime

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ABSTRACT

The present investigation “Effect of organic mulches on growth, yield and quality, Soil moisture and temperature in acid lime.” was conducted at “Acid lime garden, College of Horticulture, Dr. PDKV, Akola. The experiment was laid out in Randomized Block Design with four treatments and five replications during mrig bahar 2014-2015. Result obtained in the present investigation revealed that, organic mulches had influenced the growth, yield and quality of acid lime fruits. The acid lime trees covered with dry grass showed significantly more length of shoot (13.17 cm), number of new shoots per branch (5.67), leaf area (14.17 cm^2), number of fruits tree-1 (617.53), weight of fruits^{-1} tree (31.08 Kg), yield ha^{-1} (86.09 q), diameter of fruit (3.80 cm), average weight of fruit (50.33 g), average volume of fruit (29.54 cm^3), juice percent (50.34 %), TSS (8.06 ^{0}Brix), ascorbic acid (29.50 mg/100 ml), soil temperature (35.80 ^{0}C) and soil moisture (24.45 %) followed by wheat straw mulch. Significantly minimum fruit drop (87.45 %), and weed count (8) was observed in dry grass mulch followed by wheat straw mulch. Among the organic mulches, dry grass mulch gave significant increase in all characters.

Keywords: Randomized block design; organic mulches in Acid lime fruits.

INTRODUCTION

Citrus is considered as most important fruit crops, with their wholesome nature, multifold nutritional and medicinal values have made them so important. Its attractive appearance, penetrating aroma of peel and excellent taste, hold a remarkable position in fruit world. Although area wise it stands third in position among all sub-tropical fruit crops, value wise it on a better position. In India, area under citrus plantation is about 865.0 thousand ha with production of 8522.0 thousand MT with productivity 9.85 MT/ha. Among which, the area under acid lime and lemon is 246.0 thousand ha with production 2329 thousand MT with productivity 9.46 MT/ha (Anon., 2012).Acid lime has great value because of its various kind of uses and nutritional as well as medicinal values. It is used in preparing refreshing drinks, preserved products like pickle, syrup, marmalade and squash. Lime peel is also used as cattle feed. Lime juice is used in cosmetic also. 100 gram fruit juice content 80 percent of water, (26 IU carotene), 20 mg Vit. B1, 0.1 mg Riboflavin, 63 mg Vitamin C, 1.83 mg iron (Fe), 0.16 mg Copper (Cu), oxalo-acetic acid 0.30%, malic acid 8.2% and alkaline salt, Therefore it is an essential for human health (Decuypere’s, 2000). Mulching the basins of the trees had shown some positive effects in this regard. They discussed changes in soil moisture, soil temperature, fruit drop, yield, weed intensity around the trees. Many workers had shown that mulching increases soil moisture and also effects soil temperature. High moisture retention was found with dry leaf mulching in Mandarin (Mustaffa, 1988). In lemon, clean cultivation cum mulch contained more moisture (Saha *et al.,* 1974). Mulching also influences fruit set, fruit drop, fruit size and quality. Climatic conditions of this region are more suitable for healthy plantation of acid lime than mandarin and this is main reason for promoting acid lime plantation in this region. But negligible work on mulching was done in Vidarbha region. Therefore, an attempt is made to find out the suitable mulch for better growth, yield and quality of acid lime. Mulching the basins of trees had shown some positive effects in this regard. Hence to overcome all this problem present investigation was carried out.

MATERIALS AND METHODS

The present studies entitled “Effect of organic mulches on growth, yield, fruit quality soil moisture and temperature in acid lime” was carried out in Acid lime orchard during the year 2012-13 at College of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Material used and methods adopted during the course of investigations were outlined in this chapter. The soil on which acid lime trees were planted was medium, well drained and fertile. The plot was kept free from weed**.** The recommended dose of fertilizer i.e. 50kg FYM, 600 g N, 300 g P_2O_5 and 300 g K_2O per tree was given. Half dose of nitrogen and full dose of FYM, P_2O_5 and K_2O were applied in the month of May, 2013 at the time of release of stress and remaining half dose of nitrogen 300 g/tree was applied one month after fruit set i.e. at the pea size fruit stage. Observations were recorded on number of new shoots, length of shoot (cm), leaf area (cm^2), number of fruits per plant, fruit yield (kg tree-1), fruit yield ha-1 (q), fruit drop (%), fruit size, average weight of fruit (g), average volume (cm^3), peel percentage, fruit juice percent, Total Soluble Solids (^{0}Brix), Acidity percentage estimated value then expressed in terms of percent acid by adopting the following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{N of NaOH} \times \text{eq. wt.of acid} \times \text{vol. made up} \times 100}{\text{Wt. of sample} \times \text{aliquot taken for estimation} \times 100} \quad .....(1)$$

Ascorbic acid content in fruit juice (mg/100 ml) Ascorbic acid content was calculated by using following formula.

$$\text{Ascorbic acid} = \frac{\text{Titrate} \times \text{Dye equivalent} \times \text{Volume made up}}{\text{Aliquot taken for estimation} \times \text{weight of sample}} \times 100 \text{ (mg/100 ml)} \quad .....(2)$$

Soil temperature (°C) was recorded at every fortnight using soil thermometer at 30 cm depth.

Soil moisture (%) was calculated by using following formula.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{oven dry weight}}{\text{Oven dry weight}} \times 100 \quad .....(3)$$

Weed count in each treatment, 1 X 1 feet (30 x 30 cm) area was marked and weed flora were counted before the mulching and again at the stage of harvesting of fruits.

RESULTS AND DISCUSSION

The plant growth parameters viz. number of new shoot branch^{-1}, length of new shoot, leaf area were significantly maximum in the dry grass mulch followed by wheat straw mulch treatment. While minimum number of new shoot/branch, length of new shoot, leaf area was found in control treatment, similar results on increase leaf area with the use of natural mulches have been reported by Badiyala and Aggarwal, (1981).

Table 1 Effect of organic mulches on growth, fruit drop and weed count

Treatments	Shoot length (cm)	No. of new shoots	Leaf area (cm^2)	Fruit drop (%)	Weed count
Dry grass mulch	13.17	5.67	14.17	87.45 (9.85)	9
Wheat straw mulch	11.53	5.12	12.53	90.62 (10.01)	8
Leaf litter mulch	10.14	4.53	11.03	92.75 (10.13)	9
Control (without mulch)	8.43	3.78	09.33	96.43 (10.31)	14
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. (m) $\pm$	0.02	0.01	0.03	0.02	0.02
C.D. at 5 %	0.08	0.03	0.09	0.07	0.06

(Note - Figures in parentheses are square root transformed values)

The results are in accordance with finding of Mohanty *et al.* (2002) found that, mulching with organic mulches leads to better vegetative growth in Mandarin than control due to better moisture conservation. Increase in new shoots in dry grass mulching might be due to better soil hydrothermal regimes, better moisture conservation and suppression of weeds in the plants mulch by dry grass mulches (Badiyala and Aggarwal, 1981; Singh and Asrey, 2005).

Table 2 Effect of organic mulches on yield and quality of Kagzi lime fruits

Treatments	Fruits tree^{-1} (No)	Weight of fruits tree^{-1} (Kg)	Yield ha.$^{-1}$ (q)	Diameter of fruit (cm)	Average weight of fruit (g)	Average volume of fruit (cm^3)
Dry grass mulch	617.53	31.08	86.09	3.80	50.33	29.54
Wheat straw mulch	534.81	24.28	67.25	3.53	47.41	26.94
Leaf litter mulch	492.63	23.52	65.15	3.31	47.74	24.85
Control (without mulch)	360.7	14.84	41.10	3.04	41.15	21.92
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) $\pm$	1.28	0.06	0.17	0.008	0.11	0.06
CD at 5 %	3.97	0.19	0.54	0.025	0.35	0.19

Yield and yield attributing characters viz., number of fruits per plant, weight of fruit per tree in kg, yield / ha. in quintal and fruit physical parameters i.e. fruit diameter, average weight of fruit, average volume of fruit, fruit juice content were significantly maximum in the dry grass mulch treatment, while minimum in control treatment.

Peel content was found minimum in the dry grass mulch treatment followed by wheat straw mulch treatment. Whereas, maximum peel content was observed in control. These results are corroborated with Bajwa *et al*. (1970) in grape vine observed that, rice straw was significantly better that control in respect of yield. Patra *et al.* (2004) in Guava observed that, the mulching treatment of black polythene resulted in maximum fruit yield followed by straw mulch treatment.

Table 3: Effect of organic mulches on physico-chemical properties of Kagzi lime fruits

Treatments	Juice (%)	Peel (%)	T.S.S (°Brix)	Acidity (%)	Ascorbic acid (mg/100 ml)
Dry grass mulch	50.34 (45.19)	18.95 (4.85)	8.06	8.03 (3.33)	29.50
Wheat straw mulch	48.22 (43.98)	20.18 (4.99)	7.59	8.07 (3.34)	28.51
Leaf litter mulch	45.90 (42.65)	21.27 (5.11)	7.20	7.96 (3.32)	27.72
Control (without mulch)	42.92 (40.93)	22.97 (5.29)	6.77	7.23 (3.19)	26.70
'F' test	Sig.	Sig.	Sig.	NS	Sig.
SE (m) $\pm$	0.10	0.011	0.018	--	0.06
CD at 5 %	0.31	0.036	0.055	--	0.21

(Note - Figures in parentheses are arc sign transformed values)

Fruit quality parameters viz., total soluble solids, similar results were obtained in past. Mustaffa (1988) obtained highest T.S.S in sod culture plot of Coorg mandarin followed by digging once a year and dry leaf mulching, and ascorbic acid, past work on this aspect supports the results. Mustaffa (1998) observed highest ascorbic acid content in Coorg mandarin under dry leaf mulching. While, minimum in treatment control (without mulch) treatment and the acidity was found non-significant.

Weed count was found minimum in black polythene mulch followed by bicolour polythene mulch which was at par with silver polythene mulch. Whereas, maximum weeds were observed in control treatment which was at par with green shade net. These results are in conformity with the findings of Patel *et al*. (2009) observed that, black plastic mulch registered higher water use efficiency as compare to no mulch and also reduced weed. Patil *et al.* (2013) revealed that, mulching technique helps to avoid weeds and improve soil health.

Fruit drop was found minimum in dry grass mulch and highest fruit drop was observed with control. These results are in conformity with the findings of Kumar *et al*. (1999), Mage (1982) and Mishra *et al*. (1984).

The maximum soil temperature was observed with dry grass mulch Whereas, minimum soil temperature was observed with control treatment. Gautal *et al.* (1992) observed that, use of grass mulches helped to increase the production per unit area for all types of crops as dry grass mulch increase the soil temperature (5-7 ^{0}C) facilitating faster germination and better root proliferation in addition to checking weed growth, preserving the soil structure, retaining the soil moisture and increasing the carbon dioxide content around the plants. Mulching reduces evaporation and maintaining slightly higher temperature which could be essentially help in uptake of nutrients.

Table 4 Effect of organic mulches on soil temperature (^{0}C)

Treatment	Soil temperature (^{0}C)								
	Initial	15 June	30 June	15 July	30 July	15 Aug.	30 Aug.	15 Sept.	30 Sept
Dry grass mulch	41.20	31.56	34.28	32.14	32.01	33.12	33.26	36.78	35.80
Wheat straw mulch	41.70	30.65	34.10	32.01	31.90	33.03	32.96	36.12	35.56
Leaf litter mulch	41.69	30.71	34.15	31.97	31.87	32.84	31.38	35.86	35.02
Control (without mulch)	41.30	28.70	32.15	29.89	29.84	30.65	28.76	33.15	32.88
'F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) $\pm$	-	0.07	0.08	0.07	0.07	0.06	0.08	0.09	0.10
CD at 5 %	-	0.22	0.25	0.22	0.22	0.21	0.24	0.26	0.32

The maximum soil moisture retention was recorded under the organic mulches. However, control recorded minimum soil moisture in acid lime orchard. Earlier Chakarborty and Sadhu (1994) also reported poor ability of natural mulches to conserve soil moisture than that of polythene mulch. Aiyappa *et al.* (1966) found that soil mulch practice in citrus kept soil cooler and conserved moisture.

CONCLUSIONS

On the basis of above findings, the response of different mulches in respect to growth, yield and yield attributing characters and fruit quality of acid lime was found to be promising in dry grass mulch treatment.

Table 5 Effect of organic mulches on soil moisture (%)

Treatment	Soil moisture (%)								
	Initial	15 June	30 June	15 July	30 July	15 Aug.	30 Aug.	15 Sept.	30 Sept
Dry grass mulch	15.90	19.54	18.90	20.79	22.06	26.84	21.27	20.13	24.45
Wheat straw mulch	16.23	19.31	18.54	20.63	22.04	26.58	21.08	20.01	24.11
Leaf litter mulch	15.72	19.02	18.12	20.24	19.98	26.27	20.94	19.97	23.98
Control (without mulch)	16.40	17.04	16.11	18.09	17.96	24.03	18.84	17.98	21.92
'F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) $\pm$	-	0.04	0.04	0.05	0.05	0.06	0.04	0.05	0.06
CD at 5 %	-	0.17	0.13	0.15	0.15	0.19	0.15	0.14	0.17

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Effect of Growth Retardants on Induction of Mrig Bahar in Nagpur Mandarin

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ABSTRACT

The study was undertaken for three years during 2012-13 to 2014-15 on 15 years old Nagpur mandarin trees planted on heavy black cotton soils (Vertisol) at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for induction of the mrig bahar in Nagpur mandarin. The experiment was laid out in Factorial Randomized Design with two main plots (Stress and No-stress) conditions and seven sub plot treatments which were comprised of Cycocel-500 and 1000 ppm, Cultar-2000 and 3000 ppm as a foliar application and Cultar- 15g and 20 g as a soil application and Control. Paclobutrazol 3000 ppm in applied in stress conditions as a spray recorded maximum increase in plant volume over initial (2.07), number of flower in one meter shoot (141.52), Fruit set % (3.20), Number of fruit per plant (2581.55) and fruit yield (251.86 Kg/plant).

Keywords: Nagpur mandarin, Paclobutrazol, Cycocel, Flowering and yield.

INTRODUCTION

In Vidarbha region of Maharashtra approximately forty per cent Nagpur mandarin orchards has been planted on deep black cotton soils. This soil contents 60 to 70 % clay particles up to 60 to 90 cm depth, which holds maximum water and at some places the percentage of Calcium carbonate, is more than 10 %. In Nagpur mandarin, stress which is essential in summer season with holding of water for mrig flowering. Owing to more water holding capacity, the plant did not go under stress in black cotton soils. As a result it affects on the mrig flowering in Nagpur mandarin. By traditional method, 80 to 90 days are required for complete stress in black cotton soils for mrig flowering and many a times this stress get disturbed by pre-monsoon showers. Therefore, an experiment on induction of mrig bahar in Nagpur mandarin by growth retardants was initiated in 2012-13 and it was continued up to 2014-15.

MATERIALS AND METHODS

The study was undertaken for three years during 2012-13 to 2014-15 on 15 years old Nagpur mandarin trees planted on heavy black cotton soils (Vertisol) at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for induction of the mrig bahar in Nagpur mandarin. The experiment was laid out in Factorial Randomized Design with two main plots (Stress and No stress) conditions and seven sub plot treatments which comprised of Cycocel-500 and 1000 ppm, Cultar-2000 and 3000 ppm as a foliar application and Cultar- 15g and 20 g as a soil application and Control. Five litre of aqueous solution of Cultar was applied by opening the feeder roots in the periphery of the Nagpur mandarin tree and five litres of cycocel and Cultar were applied through spraying as per the treatments. Observations on flowering, fruit set and yield in terms of number and weight of fruits were recorded.

RESULTS AND DISCUSSION

It is revealed from the data presented in Table 1 to 4 that the increased plant volume (%) over initial, number of flowers in one meter shoot, fruit set (%) and yield of fruits in Nagpur mandarin were significantly influenced by different growth retardants during three seasons of experimentation (2012-2013 to 2014-2015).

Table 1 Increased plant volume (%) over initial in Nagpur mandarin as influenced by different growth retardants. (2012-2013 to 2014-2015)

Treatment	M_1- No stress	M_2 - Stress	Mean
S_1- Cycocel- 500 ppm	1.30	1.52	1.41
S_2 – Cycocel- 1000 ppm	1.33	1.51	1.42
S_3 - Cultar - 2000 ppm	1.52	1.94	1.73
S_4- Cultar - 3000 ppm	1.75	2.07	1.91
S_5 – Cultar - 15g/tree	1.45	1.92	1.68
S_6 – Cultar - 20g/tree	1.53	1.82	1.67
S_7- Control	1.26	1.35	1.30
Mean	1.45	1.73	
Main-Plot treatment	Sig	0.022	0.63
Sub-Plot treatment	Sig	0.042	0.11
Interaction effects	Sig	0.059	0.16

Plant Volume

Data given in Table 1 indicated that the plant volume of Nagpur mandarin trees was significantly influenced by stress and non-stress conditions and different growth retardant treatments. An increased percentage in plant volume over initial was markedly recorded in stress (1.73 %) than no-stress (1.45%) treatments. The maximum plant volume increased (1.91%) over initial was observed in the plants sprayed with 3000 ppm Cultar than other treatments.

Interaction effects

The interaction effects on percent increase in plant volume of Nagpur mandarin were found to be significant. The Nagpur mandarin trees sprayed with 3000 ppm Cultar in stress condition (M_2 x S_4) showed significantly increased percentage in plant volume over all initial except M_2 x S_3 and M_2 x S_5 interaction than other interactions. This was mainly due to the effect of growth retardants like cycocel and Paclobutrazol which acts as anti-gibberellins inhibited growth thus checked in growth rate after spray of this growth retardants leading to less increase in growth in percent compared to the control.

Table 2 The number of flower in one meter shoots of Nagpur mandarin as influenced by different growth retardants. (2012-2013 to 2014-2015)

Treatment	M_1- No stress	M_2 – Stress	Mean
S_1- Cycocel- 500 ppm	0.60	59.18	32.59
S_2 – Cycocel- 1000 ppm	0.30	76.35	39.67
S_3 - Cultar - 2000 ppm	3.33	125.73	64.53
S_4- Cultar - 3000 ppm	5.11	141.52	73.31
S_5 – Cultar - 15g/tree	0.00	94.95	47.47
S_6 – Cultar - 20g/tree	0.00	111.11	55.59
S_7- Control	0.00	20.22	10.11
Mean	2.49	89.88	
Main-Plot treatment	Sig.	3.80	11.04
Sub-Plot treatment	Sig.	7.10	20.15
Interaction effects	Sig.	10.05	28.07

Similar results of Paclobutrazol were reported by Wample and Culver (1983) and Nir *et al.* (1972) in acid lime and Delgado *et al*. (1986) in sour orange.

Number of flowers in one meter shoot

It is evident from the data presented in the Table 2 that the significantly highest number of flowers in one meter shoot (89.88) was found in stress treatment. The spraying of 3000 ppm Cultar, except Cultar 2000 ppm (Spraying) and Cultar 20g/tree (Soil application) treatments produced maximum number of flowers (73.31) in one meter shoot in Nagpur mandarin than other treatments.

Interaction effects

The Cultar 3000 ppm sprayed in stress condition was found significantly superior for producing more number of flowers (141.52) in one-meter shoot than other interactions except Cultar 2000 ppm sprayed in stress condition in Nagpur mandarin.

Table 3 Fruit set (%) in Nagpur mandarin as influenced by different growth retardants. (2012-2013 to 2014-2015)

Treatment	M_1- No stress	M_2 – Stress	Mean
S_1- Cycocel- 500 ppm	0.61	1.66	1.14
S_2 – Cycocel- 1000 ppm	0.30	2.38	1.34
S_3 - Cultar - 2000 ppm	0.40	2.87	1.63
S_4- Cultar - 3000 ppm	0.41	3.20	1.81
S_5 – Cultar - 15g/tree	0.00	2.70	1.35
S_6 – Cultar - 20g/tree	0.00	1.99	0.99
S_7- Control	0.00	0.88	0.44
Mean	0.24	2.24	
Main-Plot treatment	Sig.	0.048	0.13
Sub-Plot treatment	Sig.	0.090	0.24
Interaction effects	Sig.	0.128	0.36

Application of cycocel and Paclobutrazol known for anti-gibberellins role causes effective translocation of carbohydrates with the positive effect of Cytokinins and auxins in the conversion of vegetative bud to flower bud. These results are in accordance with results of Baskaran *et al.* (2011) in acid lime, Monselise *et al.* (1966) in lemon and Greenburg *et al.* (1993) in orange cv. Shamouti.

Per cent fruit set

The highest percentage of fruit set (2.24%) was noticed in stress than no-stress treatment. The spraying of 3000 ppm Cultar produced highest percentage of fruit set (3.20) in Nagpur mandarin except 2000 ppm Cultar than other treatments.

Interaction effects

The interactions of M_2 X S_4 (3.208 %) was found significantly superior in highest fruit set in Nagpur mandarin except M_2 x S_3 interaction than other interactions. Anti-gibberellins role of cycocel and Paclobutrazol causes effective translocation of carbohydrates with the positive effect of cytokinins and auxins in the conversion of vegetative bud to flower bud. Thus, early retention of gibberellins caused by cycocel and paclobutrazol may leads to early flowering and fruit setting.

Table 4 Number of fruits per plant in Nagpur mandarin as affected by different growth retardants. (2012-2013 to 2014-2015)

Treatment	M_1- No stress	M_2 – Stress	Mean
S_1- Cycocel- 500 ppm	16.72	1320.33	668.52
S_2 – Cycocel- 1000 ppm	6.55	1888.16	947.36
S_3 - Cultar - 2000 ppm	46.44	1946.83	996.63
S_4- Cultar - 3000 ppm	117.66	2581.55	1349.61
S_5 – Cultar - 15g/tree	0.00	1544.50	772.25
S_6 – Cultar - 20g/tree	0.00	1136.22	568.11
S_7- Control	0.00	92.66	46.33
Mean	26.73	1501.46	
Main-Plot treatment	Sig.	83.39	242.46
Sub-Plot treatment	Sig.	156.01	442.36
Interaction effects	Sig.	220.63	625.62

Similar results were reported by Monselise *et al*. (1996) in lemon, Matti *et al.* (1971) in mango, Nir *et al.* (1972) in Eureka lemon and Greenburg *et al.* (1993) in orange.

Number of fruits per plant

It is seen from Table 4 that the trees in stress condition produced the highest number of fruits per tree (1501.46) than no-stress condition. More number of fruits per tree (2581.55) was recorded by the plant sprayed with 3000 ppm Cultar than other treatments except 2000 ppm Cultar and 1000 ppm Cultar treatments. Soil application treatments of the paclobutrazol did not produced any fruits in no tress condition.

Interaction effects

Spraying of 3000 ppm cycocel in stress condition registered significantly highest number of fruits (2581.55) per plant in Nagpur mandarin than rest of the treatment combinations.

Table 5 Yield of fruits per plant (Kg) in Nagpur mandarin as affected by different growth retardants. (2012-2013 to 2014-2015)

Treatment	M_1- No stress	M_2 – Stress	Mean
S_1- Cycocel- 500 ppm	3.16	116.43	59.80
S_2 – Cycocel- 1000 ppm	0.94	187.08	94.01
S_3 - Cultar - 2000 ppm	8.70	186.24	97.47
S_4- Cultar - 3000 ppm	31.11	251.86	141.52
S_5 – Cultar - 15g/tree	0.00	156.13	78.06
S_6 – Cultar - 20g/tree	0.00	109.35	54.67
S_7- Control	0.00	14.76	7.38
Mean	6.28	145.98	
Main-Plot treatment	Sig.	6.49	18.87
Sub-Plot treatment	Sig.	12.14	34.42
Interaction effects	Sig.	17.17	48.70

The increase in yield might be due to more fruit set, fruit retention and ultimately more number of fruits per tree. These results are corroborated with the results of Ingle *et al.* (2001) and Nikhare (2002) in acid lime.

Yield of fruits per plant (kg)

Perusal of data in Table 5 indicated that significantly highest yield of fruits per plant (145.98 Kg) was obtained in trees of Nagpur mandarin kept in stress condition. The spraying of 3000 ppm Cultar had produced significantly more yield of fruits per plant (141.52 Kg) than other treatments.

Interaction effects

Maximum yield of fruits per plant (251.86 Kg) was obtained from the trees of Nagpur mandarin with the application of 3000 ppm Cultar spay in stress condition than rest of the treatment combinations.

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General Circulation Models- Big Data Models in Climate Science

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ABSTRACT

The General circulation models (GCMs) are the basis to analyze the global climate and belong to class of computer driven models which take natural and anthropogenic forcings. GCMs are huge data models which simulate the climate at global scales and contain the climate data at different geo potential heights ranging from 1000 hPa to 100 hPa. The climate data from GCMs generally available in NetCDF format. The NetCDF data can be read from softwares like Matlab/R. For instance in the present work monthly data at the global level for precipitation from GCMs Viz. Can ESM2 (Canada) and NOAA GFDL are considered. Results indicate that the models performance in the mean and standard deviation for the historical period (1979-1999) with that of observed data is comparable. Although the size of global data is huge, however, there is a need for good data mining algorithms for efficient management of GCMs data.

Keywords: General Circulation Models (GCMs), NetCDF, historical period.

INTRODUCTION

General circulation models (GCMs) are the global climate models which simulate global climate by a mathematical model of the general circulation of a planetary atmosphere or ocean. It uses the Navier–Stokes equations on a rotating sphere with thermodynamic terms for various energy sources (radiation, latent heat) [IPCC, 2007]. These equations are the basis for computer programs used to simulate the Earth's atmosphere or oceans. Atmospheric and oceanic GCMs (AGCM and OGCM) are key components along with sea ice and land-surface components. GCMs are the class of computer driven models for weather forecasting, understanding of climate and projecting of the climate for future time slices. Atmospheric Ocean GCMs (AOGCMs) and Earth system models (ESMs) represents the pinnacle of complexity of models [Taylor et al 2012; Shashikanth et al 2014; Ghosh and Mujumdar, 2009].

In the GCM model, the globe is divided in to three dimensional grids [Figure 1] in each of the grids basic equations of physics, fluid motion, conservation of energy, momentum, ideal gas laws are solved numerically and climate results are obtained. GCM models calculate winds, heat transfer, radiation, relative humidity, and surface hydrology within each grid and evaluate interactions with neighboring points. The GCMs demonstrate a significant skill and efficiency of the global climate system by capturing the behavior at the continental and hemispherical spatial scales [Knutti and Sedlacek, 2012; Kannan and Ghosh, 2013]. However, their performance at the local scale hydrology is poor [Wigley et al 1990]. Climate change may have significant impacts on global climate system which will in turn affect different sectors like water resources, energy resources, extremes and droughts [Shashikanth et al 2013; Tebaldi and Knutti, 2006]. The consequences of global warming are reflected in global as well as regional climate in terms of changes in key climatic variables such as precipitation and atmospheric moisture, snow cover, extent of land and sea ice, sea level and patterns in atmospheric and ocean circulation.

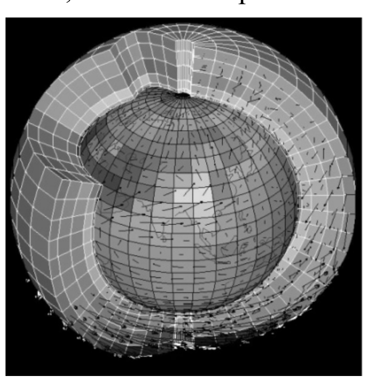

Figure 1 Coupled General Circulation Models (Source: IPCC, 2007)

Therefore, study of climate change is necessary to understand its impact on hydrological processes. Water resources are inextricably linked with climate so the prospect of global climate change has serious implications for water resources and regional development (IPCC, 2007).

The size of any individual GCM data for entire globe runs any way approximately from 2- 8 GB data depending on the data at different pressure fields or geo potential heights on daily time data. However, the monthly time step data size comparatively is of less. The data in different pressure fields ranges from surface to 100 hPa. The data at surface level is at 1000 hPa. Most of the coupled GCMs have 17 pressure fields. The size of data primarily depends on the size of grid or lat/long dimension. Finer the size greater the size of GCM and hence GCM size will be high. The GCM data is available in zipped format known as netCDF. Grid size is dependent upon the power of the computer that is available to solve these equations. Finer resolution implies a larger number of grid cells and requires a bigger and faster computer to perform the simulation. Similarly, if grid spacing is farther apart, there are fewer points that are calculated, but the results are also less detailed [http://www.gfdl.noaa.gov/climate-modeling]. Increasing climate model accuracy involves continually improving its completeness, correctness, and resolution. This includes the addition of new processes that represent components such as land and ocean carbon cycles, interactions between cloud droplets and aerosols, and ice sheets. These components are initially developed and tested offline before they are coupled into the climate model and are allowed to interact with the other components. Climate modeling is not only computationally intensive, but also increased computing power would allow for more comprehensive simulations, better represented parameterized processes, and more accurate climate change projections at regional and local scales [IPCC,2007].

The GCM data is presented in the form of lat and long as well as at different geo potential heights. Climate modeling is computationally intensive and expensive. However, we need a super computer to solve the differential equations at different time scales. The coupled Intercomparison Project (CMIP) which provides the climate data and archived at PCMDI [Program for Climate Model Diagnosis and Intercomparison] site that is hosted by US Department of Energy. With the recent release of CMIP5 simulations provide complete understanding of climate change and variability and expected to revolutionize the study of climate under plausible scenarios. The CMIP5 model outputs for future period based on RCPs (Representative concentration pathways) [Moss et al 2010]. For CMIP5 four RCPs have been formulated that are based on future population growth, energy use, land use, technological development and societal responses consequent to radiative forcings (Wayne, 2013). CMIP5 provides the data of the order of 3 PB, which is considerably big data to analyze and hence proper methods or techniques are needed to download and decipher the data for management of climate.

Data and Method

For the present work, the monthly precipitation climate data from the two GCMs from CMIP5 suite has been downloaded for the purpose of analysis for two seasons namely JJA (June-July-August) and DJF (December-January-February). The GCMs considered are Can ESM2 with grid size 128x64 (Canadian centre for climate modeling and analysis) and NOAA geophysical fluid dynamics laboratory, GFDL-ESM2 with grid size 144x90. The GCM data is interpolated to 2.5 x 2.5 degree resolution using bilinear interpolation technique and brought to GPCP (Observed or reanalysis) data level for the performance of models with respect to observed data. The sizes of data are 59, 952 KB and 456200 KB respectively for the above GCMs. The size of data after unzipping using Matlab/ R software, globe shrunk to 5000 KB each for JJA and DJF season respectively. Therefore, we need a better data mining techniques to acquire the data from the big models like GCMs.

Discussion of Results

The present work examines the hypothesis that whether the latest generation of CMIP5 models improves the regional and seasonal climatology simulations compared to observed GPCP data. Combination of statistical metrics are used to evaluate the models performance in the simulation of observed climatology. GCM models are not good in simulating day to day climatology, they are reasonably good in simulating the long term mean projections [IPCC, 2007]. Therefore, in the present work, the analysis is restricted to long term mean and standard deviation comparison between model and observed simulations of precipitation. GCM models are not weather models and they are in fact climate models. climate is usually referred in terms of mean and variability of climate parameters in a given region over a long periods of time around 30 years (World Meteorological Organization). weather in contrast which is present condition of the same elements.

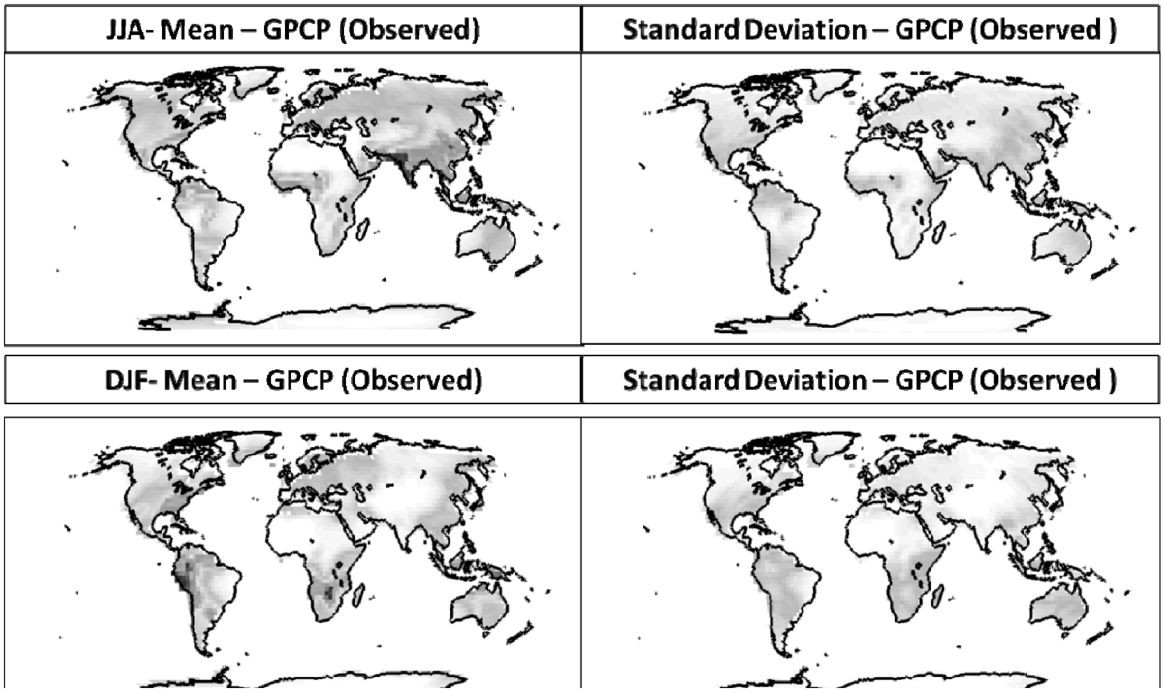

Figure 2 Observed precipitation distribution across globe in the JJA and DJF seasons.

The precipitation as simulated by GCMs are processed for the evaluation purposes. The GCMs namely CanESM2 and GFDL (NOAA) have captured the mean characteristics of precipitation. The notable feature is that Asian monsoon is well modeled by the models (Fig 3) when compared with observed rainfall (Fig 2) for both seasons. The multimodal performance is better than individual models. More the number of models higher the accuracy. There is much agreement in the in the simulation of precipitation with African continent from models with that of observed data, however show slightly under predicting the precipitation in the US regions. Similarly the standard deviation is maintained by the models as well (Fig 1 & 2) for both seasons JJA and DJF. Similarly, models have bias in simulating observed precipitation (GPCP) characteristics for both of the seasons namely JJA and DJF (Fig.4 and 5). The monthly precipitation results are expressed as mm/day. The GFDL model has positive bias in most of the regions of globe in the simulation of precipitation.

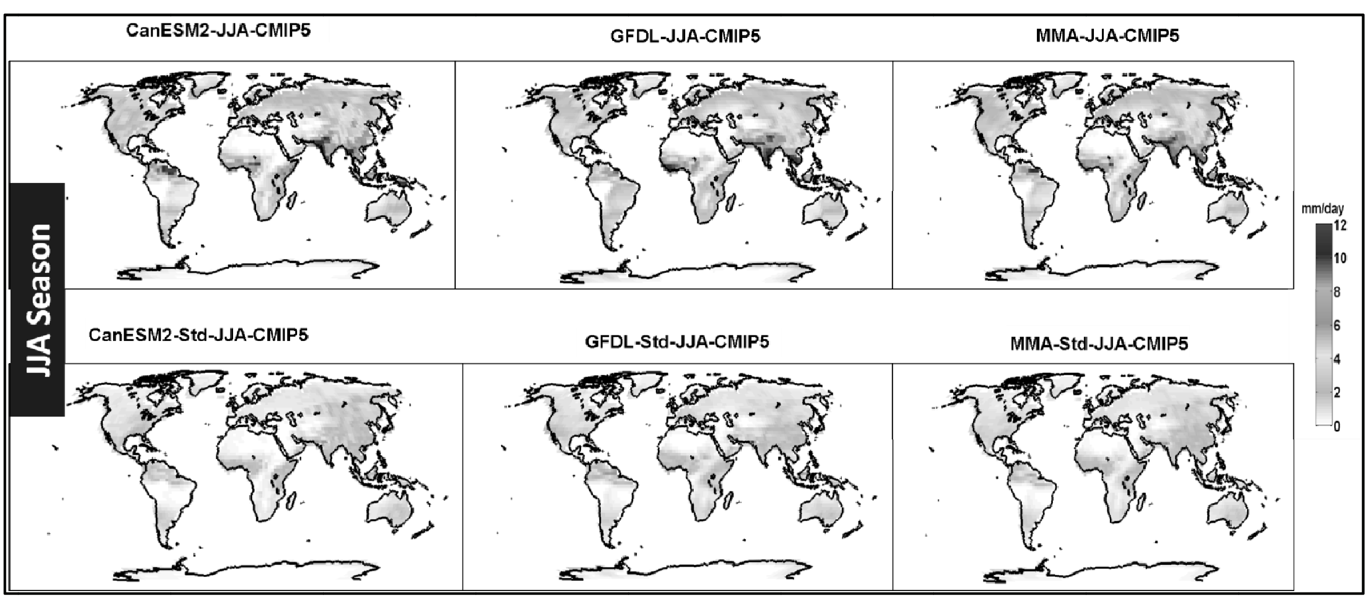

Figure 3 The mean and standard deviation plots of two GCMs and Multimodal average of two GCMs. The performance of MMA is reasonably good than the individual mean for JJA season.

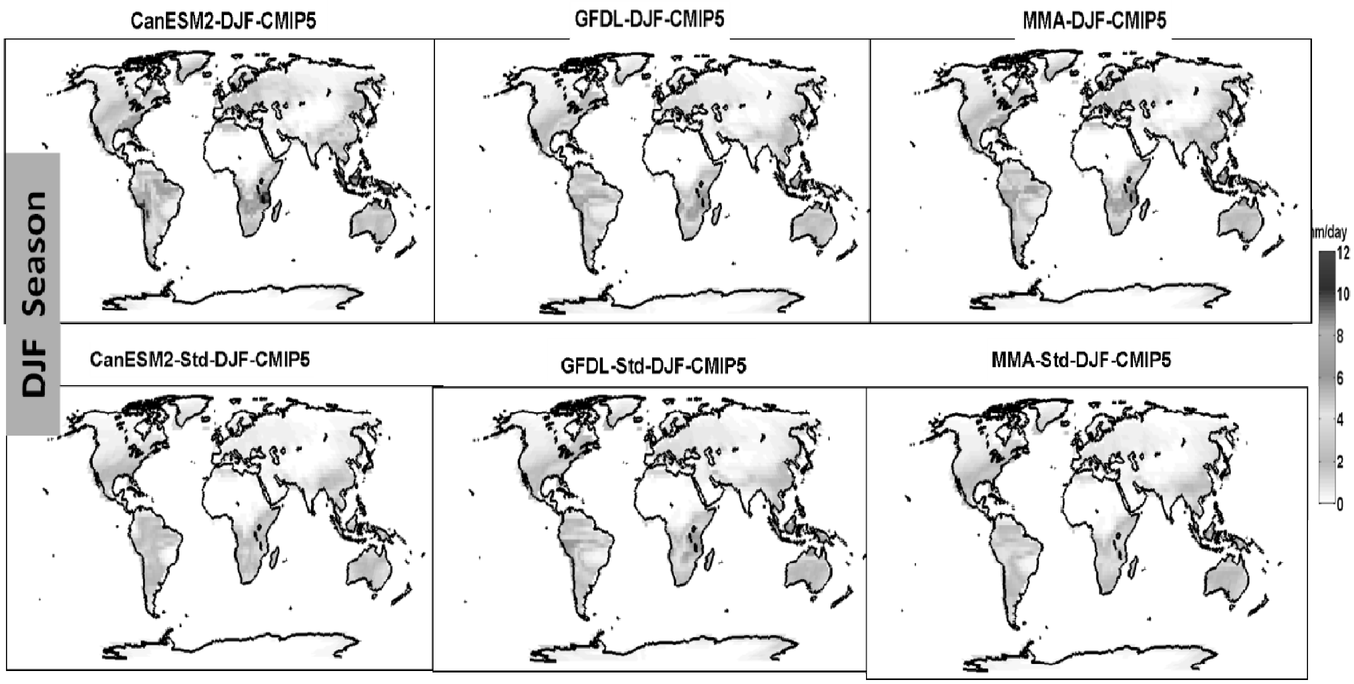

Figure 4 Figure generated for DJF season based on Fig 2.

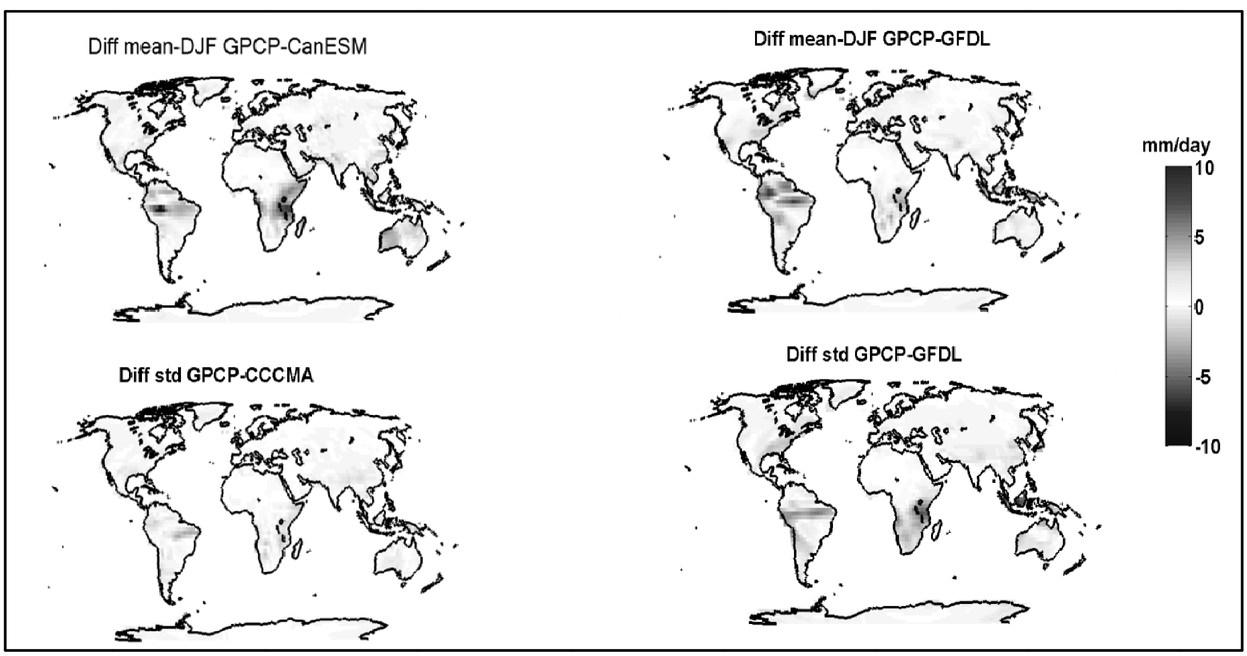

Figure 5 Differences in mean standard deviation plots for DJF season.

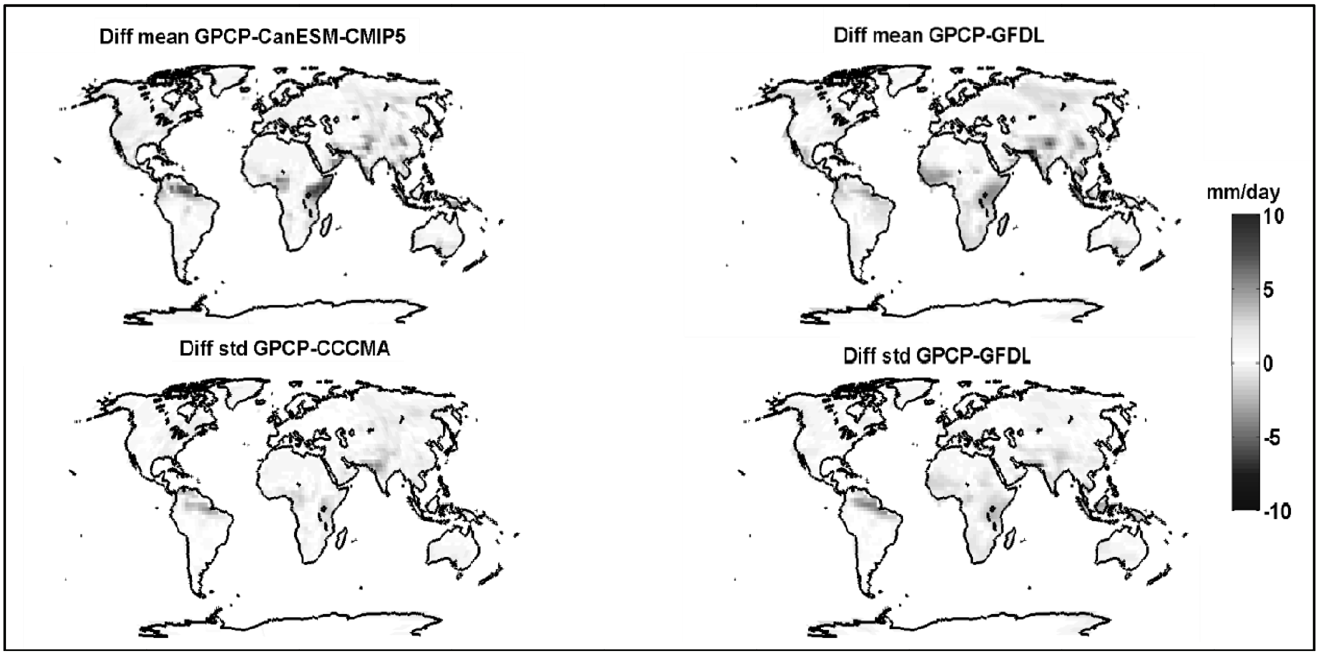

Figure 6 Differences in mean standard deviation plots for JJA season.

From the bias plots (Fig 4 and 5) still results can be improved, since models have shown positive and negative bias with respect to observed mean. Ghosh and Mujumdar (2008) and Shashikanth et al (2013) suggested implementing more number of models for multimodal average so that errors cancel each other and provide more realistic projections of precipitation.

SUMMARY AND CONCLUSIONS

All models are inadequate in representing the actual climate system, because of many reasons which includes parameterizations, coarse resolutions and computational resources etc [Salvi et al 2013]. Therefore on mean statistics models performance is good with respect to observed data provides GPCP (Global Precipitation Climatalogy Project [Addler et al 2003]. Due to lack of computing facility, we have adopted less number of models and daily data has not been used for the present work. Therefore, we need efficient algorithms for processing at a much a faster speed in the context of huge data matrix.

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Phytoplankton Bloom over the Arabian Sea

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ABSTRACT

During Winter Chlorophyll concentrations were increased over the Arabian Sea. In the winter, the winds blow from southwest Asia toward the Sea (Arabian Sea). Seasonally, the highest dust levels occurred during the winter (February) and spring, with probable source areas in India, Pakistan, Iran and the Arabian Peninsula. Spatially, the highest dust levels were found off the Omani Coast and over the Gulf of Oman. In this study we found that Phytoplankton Bloom was occur after the Dust storm. Dust storm was occur on 17 February 2005, within 3-4 days after the Dust transport over the Arabian Sea, phytoplankton Bloom was observed on 22 February 2005. Maximum Chlorophyll concentrations (41.61 mg/m$^{3)}$ were observed at 51.2 longitude and 24.6 latitude after the Dust storm over the Arabian Sea on 22 February 2005.

Keywords: Chlorophyll, Arabian Sea, Omani Coast and phytoplankton Bloom.

INTRODUCTION

Phytoplankton (plankton that use photosynthesis like plants) need nutrients and light to grow at very high rates. Since light is readily available in the surface ocean, nutrient availability is the most important driver of phytoplankton blooms. Under certain environmental conditions, canals, lakes, coastal waters and even swimming pools can experience phytoplankton or algal blooms. A bloom takes place when a species of phytoplankton reduces at a rapid rate, multiplying quickly in a short amount of time. Some times more than one species blooms at the same time. Phytoplanktons are photosynthetic organisms that live suspended just beneath the water's surface. They use energy from sunlight and raw materials to make their own food through photosynthesis. Microalgae and blue-green algae bacteria (called cyanobacteria) are two groups of organisms that belong to phytoplankton community. Blooms are often visible events. High concentrations of phytoplankton in the water column can cause the waters to appear blue-green, green, brown or even red, depending upon the pigments found in the species experiencing the bloom. Pigments are substances in phytoplankton that absorb the sun's energy, which is needed to drive the process of photosynthesis.

Over the Arabian Sea, Monsoon winds alternately blow from the northeast and the southwest, reversing their dominant direction with the seasons. In the winter, the winds blow from southwest Asia toward the Sea (Arabian Sea). Seasonally, the highest dust levels occurred during the winter (February) and spring, with probable source areas in India, Pakistan, Iran and the Arabian Peninsula. Spatially, the highest dust levels were found off the Omani Coast and over the Gulf of Oman.

STUDY AREA

The study area covering the northern part of the Arabian sea is located between latitudes 30°N and 0°N and longitudes 50°E and 78°E bordered by India, Pakistan, Iran, Somalia, Arabian Peninsula, Oman.

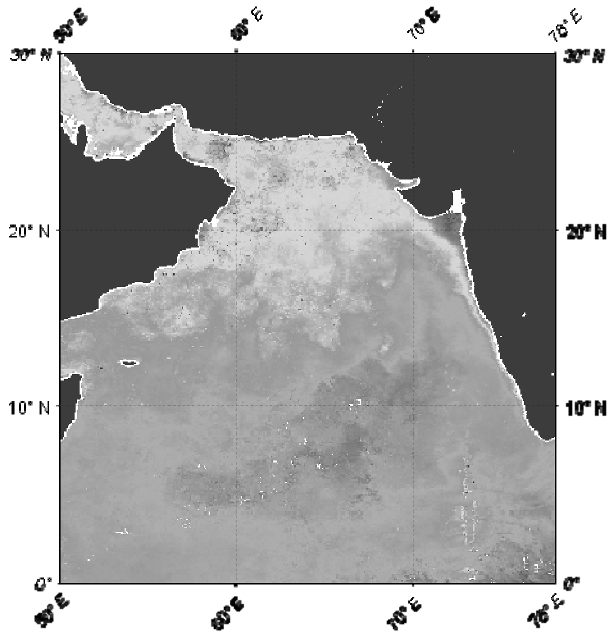

Figure 1 Study area of the Arabian Sea

MATERIALS AND METHODS

Data and methodology

MODIS (Moderate resolution Imaging Spectroradiometer) Aqua level 3 daily SMI Chlorophyll data sets of 4 km resolution from ocean color website were taken to study the effect of Dust Storm over the Arabian sea for a selected Dust storm event during February 17 2005. And also we used MODIS Level 1 images from LP DAAC website to study the dust transport over the Arabian Sea.

SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data. By using SeaDAS we crop the data into our region of interest (AOI) and mosaic the all cropped seven days images before and after the dust event into single images. The present study carried out from 30°N –0° N Latitude to 50° E – 78° E Longitude across the Arabian Sea. We found that maximum Chlorophyll a Concentrations were observed after Dust storm on 22 February 2005.

RESULTS AND DISCUSSIONS

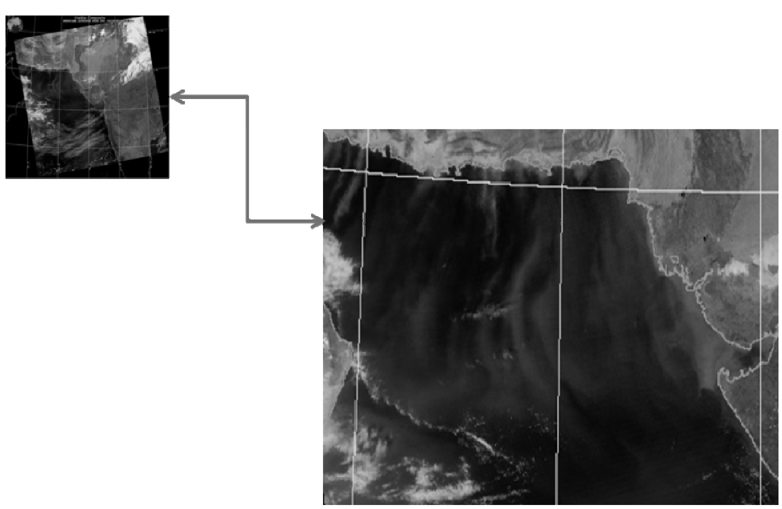

Figure 2 shows the transport of Dust from land to Arabian Sea (on 17 February 2005)

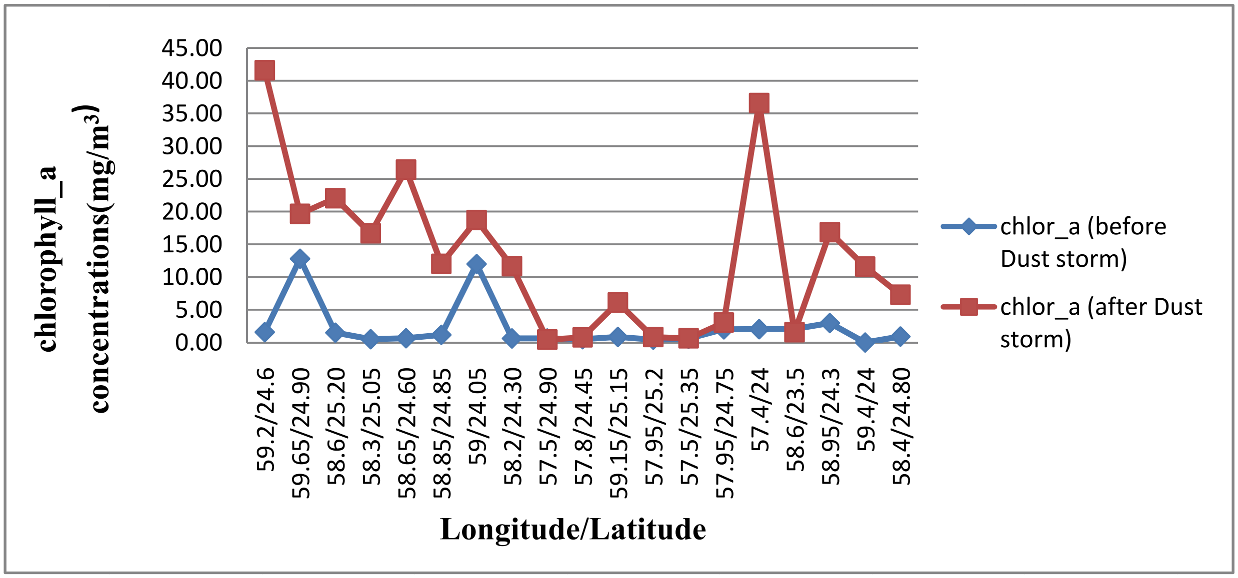

Figure 3 Showing the Maximum Chlorophyll concentration (mg/m3)over the Arabian Sea

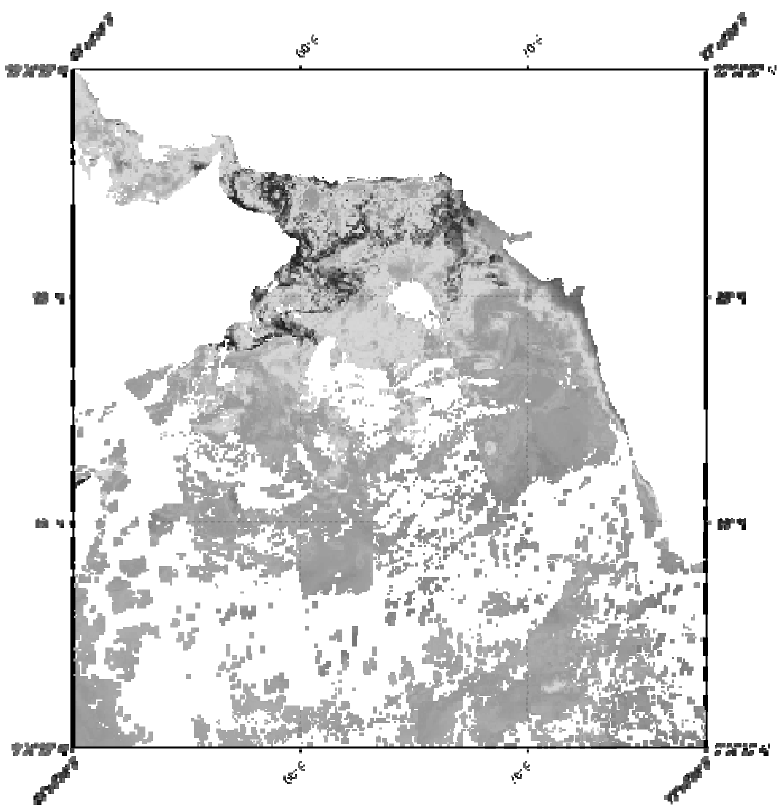

Figure 4 Phytoplankton Bloom over the Arabian Sea on 22 February 2005.

Dust Storm was occur on 17 February 2005, Fig 2 showing the transport of Dust over the Arabian Sea. Dust is rich in nutrients, which are most important for phytoplankton growth. By using these nutrients from dust and sunlight phytoplankton grow rapidly within a 3 to 4 days after the dust event over the Arabian Sea. Phytoplankton Bloom was observed on 22 February 2005. In this study we found that chlorophyll concentrations were increased after the dust event over the Arabian Sea. After the Dust event Chlorophyll concentrations were increased about 41.61 mg/m^3 at 51.2longitude, 24.6 latitude on 22 February 2005.

CONCLUSION

During Winter Chlorophyll concentrations were increased over the Arabian Sea. In the winter, the winds blow from southwest Asia toward the Sea (Arabian Sea). Seasonally, the highest dust levels occurred during the winter (February)and spring, with probable source areas in India, Pakistan, Iran and the Arabian Peninsula. Spatially, the highest dust levels were found off the Omani Coast and over the Gulf of Oman. In this study we found that Phytoplankton Bloom was occur after the Dust storm over the Arabian Sea. Dust storm was occur on 17 February 2005, within 3-4 days after the Dust transport over the Arabian Sea phytoplankton Bloom was observed on 22 February 2005. Figure 4 showing the maximum Chlorophyll concentrations about 41.61 mg/m^3 at 51.2 longitude and 24.6 latitude after the Dust storm over the Arabian Sea on 22 February 2005.

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Geospatial Technology for Disaster Management: An Overview

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ABSTRACT

Natural disasters like flood, cyclone, earth quake, landslide, forest fire, hail storm, locust, volcanic eruption, drought, etc. strike very frequently and cause devastating impact on human life, economy and environment. With the tropical climate and unstable landforms, coupled with high population density, poverty, illiteracy and lack of adequate infrastructure, Indian is one of the most vulnerable developing countries to suffer from damage due to natural disasters. Though it is almost impossible to fully recoup the damage caused by the disasters, it is possible to (i) minimize the potential risks by developing early warning strategies (ii) prepare and implement developmental plans to provide resilience (iii) mobilize resources including communication and tele-medicinal services, and (iv) help in rehabilitation and post-disaster reconstruction. Geospatial technology plays a crucial role in efficient management of disasters. While communication and weather satellites help in disaster warning, relief mobilization and tele-medicinal support, earth observation satellites provide the basic support in pre-disaster preparedness programmes, in disaster response, monitoring activities and post-disaster damage assessment, and reconstruction and rehabilitation. The article describes the applications of space technology in disaster management, identifies gap areas and projects the future scenario vis-à-vis likely developments in space and ground segments.

Keywords: Cyclones, drought, earthquakes, volcanic eruptions.

INTRODUCTION

Various disasters like earthquakes, landslides, volcanic eruptions, fires, flood and cyclones are natural hazards that kill thousands of people and destroy billions of dollars of habitat and property each year. The rapid growth of the world's population and its increased concentration often in hazardous environment has escalated both the frequency as well as the severity of natural disasters. With the tropical climate and unstable landforms, coupled with the deforestation, unplanned growth proliferation non-engineered constructions that make the disaster-prone areas more vulnerable, tardy communication, poor or no budgetary allocation for disaster prevention, developing countries suffer more or less chronically by natural disasters. Asia tops the list of casualties due to natural disaster. Among various natural hazards, earthquakes, landslides, floods and cyclones are the major disasters adversely affecting very large areas and population in the Indian sub-continent. These natural disasters are of (i) geophysical origin such as earthquakes, volcanic eruptions, landslides and (ii) climatic origin such as drought, flood, cyclone, locust, forest fire. Though it may not be feasible to control nature and to stop the development of natural phenomena but the efforts could be made to avoid disasters and alleviate their effects on human lives, infrastructure and property.

Rising frequency, amplitude and number of natural disasters and attendant problem coupled with loss of human lives prompted the United Nations to develop the frame work for action christened as The "Hyogo Framework for Action 2005-2015: Building the Resilience for Nations and Communities to Disasters" (HFA).The HFA calls upon the United Nations system and other international organizations to undertake concrete tasks within their mandates, priorities and resources (The United Nations, 2009). It emphasizes strengthening of the United Nations system to assist disaster-prone developing countries with disaster risk reduction initiatives and to support States' own efforts with technical assistance and capacity development. . It is almost impossible to prevent the occurrence of natural disasters and their damages. However it is possible to reduce the impact of disasters by adopting suitable disaster mitigation strategies. The disaster mitigation works mainly address the following: (i) minimize the potential risks by developing disaster early warning strategies, (ii) prepare and implement developmental plans to provide resilience to such disasters, (iii) mobilize resources including communication and tele-medicinal services and (iv)to help in rehabilitation and post-disaster reduction. Disaster management on the other hand involves: (i) pre-disaster planning, preparedness, monitoring including relief management capability. (ii) Prediction and early warning. (iii) Damage assessment and relief management.

Disaster reduction is a systematic work which involves with different regions, different professions and different scientific fields, and has become an important measure for human, society and nature sustainable development.

ROLE OF SPACE TECHNOLOGY

Space systems from their vantage position have unambiguously demonstrated their capability in providing vital information and services for disaster management. The Earth Observation satellites provide comprehensive, synoptic and multi temporal coverage of large areas in real time and at frequent intervals and 'thus'- have become valuable for continuous monitoring of atmospheric as well as surface parameters related to natural disasters. Geo-stationary satellites provide continuous and synoptic observations over large areas on weather including cyclone-monitoring. Polar orbiting satellites have the advantage of providing much higher resolution imageries, even though at low temporal frequency, which could be used for detailed monitoring, damage assessment and long-term relief management.

Table 1 Applications of space remote sensing in disaster management.

Disaster	Prevention	Preparedness (Warning)	Relief
Earthquakes	Mapping geological lineaments and landuse maps	Geodynamic measurements of strain accumulation	Locate stricken areas, map damage
Volcanic Eruptions	Topographic and landuse maps	Detection/ measurement of gaseous emissions	Mapping lava flows, ashfalls and lahars, map damage
Landslides	Topographic and land use maps	Rainfall, slope stability	Mapping slide area
Flash floods	Land use maps	Local rainfall measurements	Map flood damage
Major floods	Flood plain maps; land use maps	Regional rainfall; evapotranspiration	Map extent of flood
Storm surge	Land use and land cover maps	Sea state; ocean surface wind velocities	Map extent of flood

The vast capabilities of communication satellites are available for timely dissemination of early warning and real-time coordination of relief operations. The advent of Very Small Aperture Terminals (VSAT) and Ultra Small Aperture Terminals (USAT) and phased - array antennae have enhanced the capability further by offering low cost, viable technological solutions towards management and mitigation of disasters. Satellite communication capabilities fixed and mobile are vital for effective communication, especially in data collection, distress alerting, positional location and coordinating relief operations in the field. In addition, Search and Rescue satellites provide capabilities such as position determination facilities onboard which could be useful in a variety of land, sea and air distress situations.

2.1 Cyclone

The intense tropical storms are known in different part of the world by different names. In the Pacific Ocean, they are called 'typhoons', in the Indian Ocean they are called 'cyclones' and over North Atlantic, they are called 'hurricane'. Records show that about 80 tropical cyclones form over the globe every year. India has a vast coast line of 7,516 kms. And it is exposed to nearly 10% of the world's tropical cyclones. About 71% of this area falls in ten states Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Puducherry, Andhra Pradesh, Orissa and West Bengal. Cyclones occur usually between April and May (called pre-monsoon cyclonic storms) and between October and December (called post-monsoon cyclonic storms).

2.1.1 Cyclone Monitoring

Meteorologists have been using satellite images for monitoring storms for about thirty years. One of the most important applications in this endeavor is to determine the strength and intensity of a storm. In the late 1960's, meteorologists began observing tropical cyclones at more frequent intervals. The infrared sensors aboard polar orbiting satellites began providing day-and-night observations while geo-stationary satellite provided the continuous coverage during daytime. Such an observation capability allows the warning of cyclonic storm. Very severe cyclonic storm Vardah was the most intense tropical cyclone over the North Indian Ocean in 2016, which struck Andaman and Nicobar Islands as well as South India and affected areas Thailand, Sumatra, Malaysia, Andaman and Nicobar Islands and South India. It was the fourth cyclonic storm of the annual cyclone season. It originated as low pressure area near Malay Peninsula on 3 December and developed as depression on 6 December and intensified into deep depression skirting off the Andaman and Nicobar islands and into cyclonic storm on 8 December with a winds of 80 mph (130 km/h).

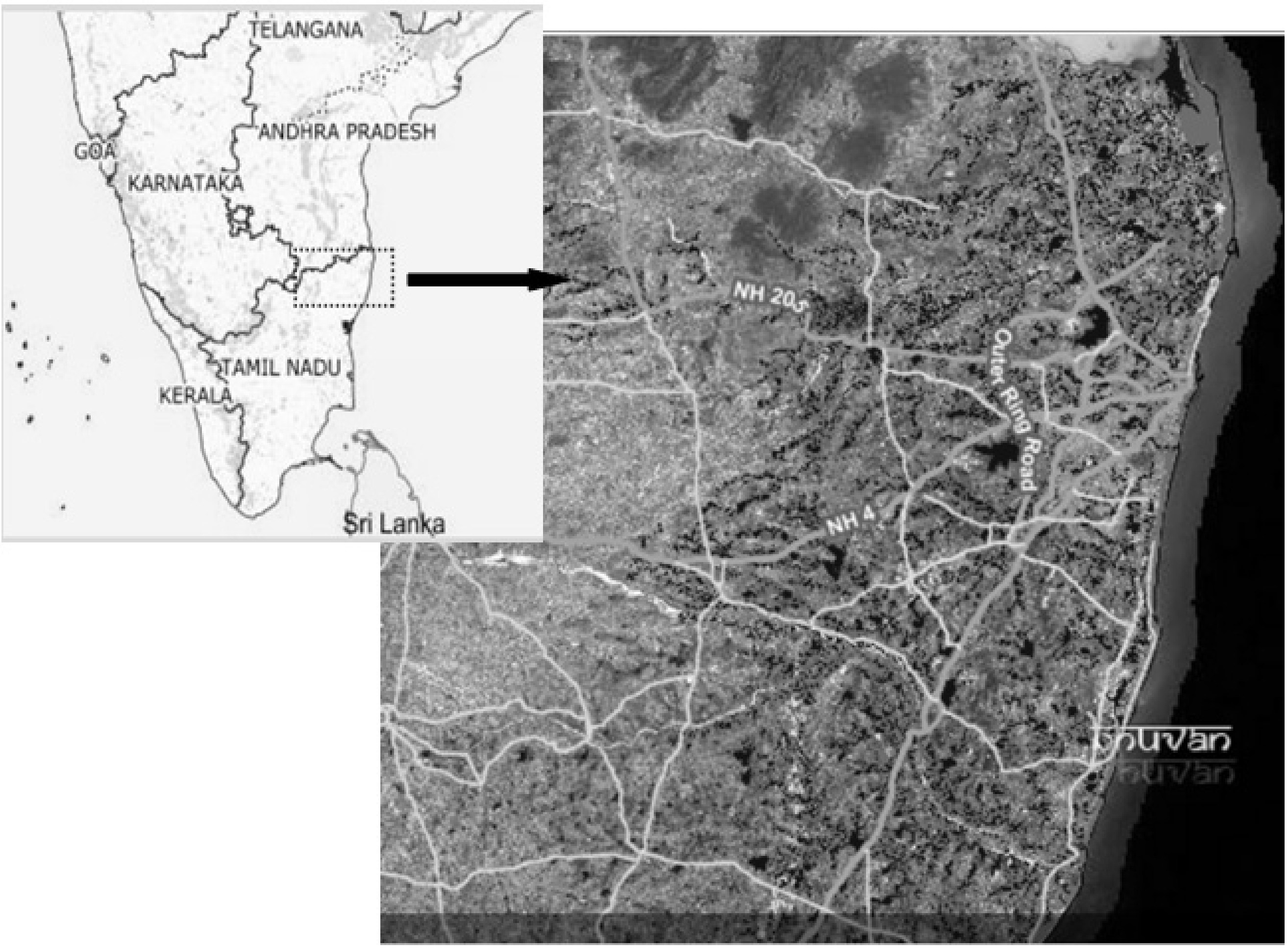

Figure 1 Satellite image showing the vardah cyclone in Tamil Nadu

2.2 Drought

Drought is the single most important weather- related natural disaster often aggravated by human action. Drought's beginning is subtle, its progress is insidious and its effects can be devastating. Drought may start any time, last indefinitely and attain many degrees of severity. Since it affects very large areas for months and years it has a serious impact on economy, destruction of ecological resources, food shortages and starvation of millions of people. During 1967-1991, droughts have affected 50 percent of the 2.8 billion people who suffered from all natural disasters and killed 35 percent of the 3.5 million people who lost their lives due to natural disasters. Owing to abnormalities in the monsoon precipitation, in terms of spatial and temporal variation especially on the late on set of monsoon, prolonged break and early withdrawal of monsoon, drought is a frequent phenomenon over many parts of India. In India, thirty three percent of the area receives less than 750mm rainfall and is chronically drought-prone, and thirty five percent of the area with 750-1125mm rainfall is also subject to drought once in four to five years. Thus, 68 percent of the total sown area covering about 142 million hectares are vulnerable to drought conditions. India has faced three major droughts in this century- 1904-1905,1965-66 and 1987, 2002, 2009. The 2009 drought has affected 47% of the country area with 41% of departure of rainfall in affected area. The role of space technology in drought mitigation is enumerated hereunder:

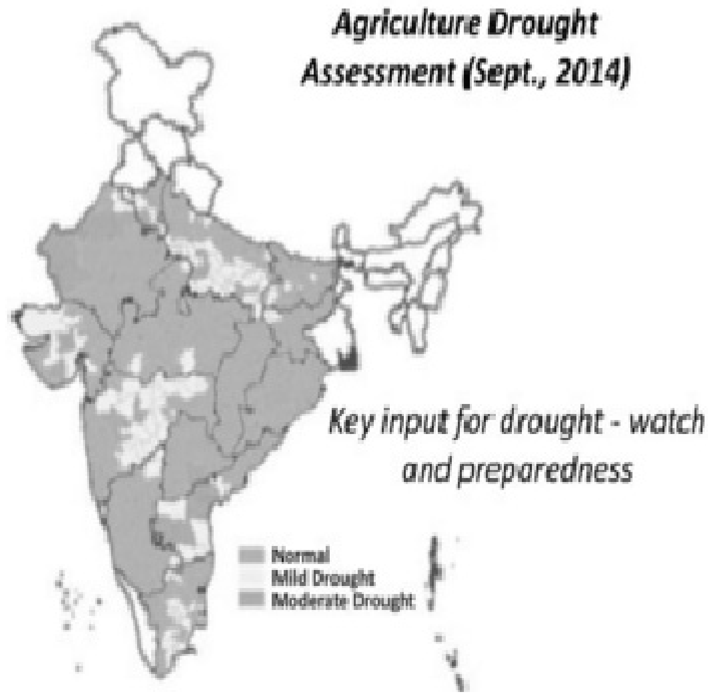

Figure 2 Agricultural drought assessment in India September 2014

2.2.1 Drought Preparedness

Drought mitigation involves three phases, namely, preparedness phase, prevention phase and relief phase. In case of drought preparedness, identification of drought prone areas information on land use and land cover, waste lands, forest cover and soils is a pre- requisite. Space-borne multispectral measurements hold a great promise in providing such information.

2.2.2 Drought Prediction

Remote sensing data provide major input to all the three types rainfall predictions; namely such as long-term seasonal predictions, medium range predictions and short-term predictions. Global and regional atmospheric, land and ocean parameters (temperature, pressure, wind, snow, El-Nino, etc.) required for long-term prediction, could be generated from observations made by geo-stationary and polar orbiting weather satellites such as INSAT and NOAA. In the medium range weather prediction, the National Centre Medium Range Weather Forecasting (NCMRWF) uses satellite-based sea surface temperature, normalized difference vegetation index, snow covered area and depth, surface temperature, altitude, roughness, soil moisture at surface level and vertical sounding and radio zoned data on water vapor, pressure and temperature, and vertical profile data in the T86/NMC model. In the short-range rainfall prediction also INSAT-based visible and thermal data are being used.

2.2.3 Drought Monitoring

Drought monitoring mechanisms exists in most of the countries using ground-based information on drought-related parameters such as rainfall, weather, crops condition and water availability, etc. Conventional methods of drought monitoring in the various states in India suffer from limitations with regard to timeliness, objectivity, reliability and adequacy (Jeyaseelan and Thiruvengadachari, 1986). Further, the assessment is generally, influenced by local compulsions. Satellite-derived Vegetation Index (VI) which is sensitive to vegetation stress is being used as a surrogate measure to continuously monitor the drought conditions on a real -time basis. Such an exercise helps the decision makers in initiating strategies for recovery by changing cropping patterns and practices.

2.2.4 Drought Relief

The State Governments are primarily responsible for both short -term and long- term relief management.

2.3 Floods

India is the worst flood-affected country in the world after Bangladesh and accounts for one-fifth of the global death count due to floods. About 40 million hectares or nearly 1/8th of India's geographical area is flood-prone. An estimated 8 million hectares of land are affected annually. The cropped area affected annually ranges from 3.5 million ha during normal floods to 10 million ha during worst flood. Flood control measures consists mainly of construction of new embankments, drainage channels and afforestation to save 546 towns and 4700 villages. Optical and microwave data from IRS, Landsat ERS and Radarsat series of satellites have been used to monitor flood events in near real-time and operational mode.

Based on satellite data acquired during pre-flood, flood and post-flood along with ground information, flood damage assessment is being carried out by integrating the topographical, hydrological and flood plain land use/land cover information in a GIS environment. In addition, spaceborne multispectral data is used for studying the post-flood river configuration, and existing flood control structures , and identification of bank erosion-prone areas and drainage congestion and identification of flood risk zones.

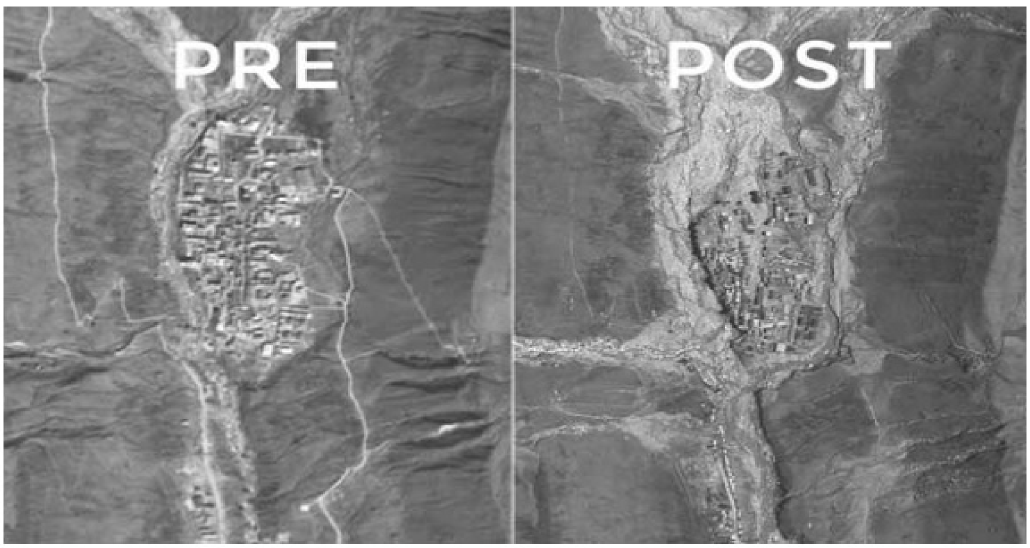

Figure 3 Satellite image showing the damages at Kedarnath village caused by the flash floods in June 2013

2.4 Earthquake

Earthquakes are caused by the abrupt release of strain that has built up in the earth's crust. Most zones of maximum earthquake intensity and frequency occur at the boundaries between the moving plates that form the crust of the earth. Major earthquakes also occur within the interior of crustal plates such as those in China, Russia and the south-east United States. Seismic risk analysis based on historic earthquakes and the presence of active faults is an established method for locating and designing dams, power plants and other projects in seismically active areas. Landsat-TM and SPOT images and Radar interferograms were used to detect the active faults (Merifield and Lamer 1975; Yeats et al.1996; Massonnet et al. 1993).

Among the major earthquakes, Chinese scientists predicted an earthquake 1-2 days ahead in 1975 (Vogel, 1980). Information on earthquake is, generally, obtained from a network of seismographic stations. Space geodetic technique with Global Positioning System (GPS) provides an accuracy of a centimeter over 1000 km and , thus, helps in measuring the surface deformations and monitoring accelerated crystal deformations prior to earth quakes with required accuracy.

Earthquake risk assessment involves identification of seismic zones through collection of geological/structural, geophysical (primarily seismological) and geomorphologic data and mapping of known seismic phenomena in the region, (mainly epicenters with magnitudes). Such an effort calls for considerable amount of extrapolation and interpolation on the basis of available data. There is also a tendency for earthquake to occur in “gaps” which are in places along an earthquake belt where strong earthquake had not previously been observed. The knowledge of trends in time or in space helps in defining the source regions of future shocks (Karnik and Algermissen, 1978).

Satellite imagery could be used in delineating geotectonic structures and to clarify seismological conditions in earthquake risk zones. Accurate mapping of geomorphologic features adjoining lineaments reveals active movement or recent tectonic activity along faults. Space techniques have overcome the limitations of ground geodetic surveys/measurements and have become an essential tool to assess the movement/displacements along faults/plate boundaries to even millimetre level accuracy.

Using Very Long Baseline Interferometry (VLBI), it is possible to record accurately the plate movement of the order of centimetre along baseline of hundreds of kilometre. Similarly, satellite-based Global Positioning system (GPS) has emerged as a powerful geodetic tool for monitoring (geological) changes over time which is the key for understanding the long-term geo-dynamical phenomena. Plate movements, slips along faults etc. have been measured using differential GPS to an accuracy of sub-centimetres.

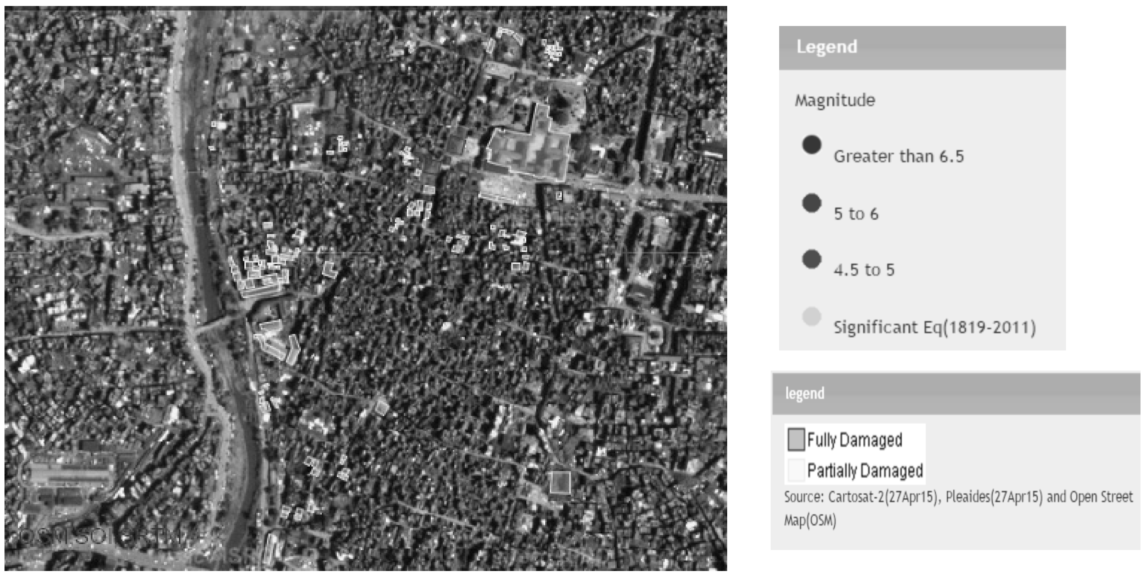

Figure 4 An earth quake at Nepal in khatmandu from Cartosat-2

2.5 Volcanic Eruption

Ground deformations, changes in the compositions of gases emitting from volcanic vents, changes in the temperatures of fumaroles, hot springs and crater lakes as well as earth tremors are preceding volcanic eruptions. Thermal infrared remote sensing is applied for volcanic hazard assessment. In the last three decades, aircraft and satellite-based thermal infrared (TIR) data have been used extensively to detect and monitor many of the active volcanoes around the world. Repetitive coverage, regional scale, and low cost of thermal infrared images from satellites make it an alternative tool for monitoring volcanoes. Although the spatial resolution of NOAA environment satellite is too coarse to record details of surface thermal patterns, the plumes of smoke and ash from volcanoes could be detected which is useful in planning the rehabilitation of affected areas.

Studies have shown that the upward migration of magma from the earth's crust just before eruption inflates the volcanic cone. Such premonitory signs can easily and quickly be detected with the aid of differential SAR interferometry. Extensive calibrations in a variety of test areas have shown that by using this technique, changes on the earth's surface can be detected to centimetre accuracy.

2.6 Landslides

Aerial photographs and large-scale satellite images have been used to locate the areas with the incidence of landslide. Higher spatial resolution and stereo imaging capability of IRS -IC and -1D enable further refining the location and monitoring of landslides. A number of studies have been carried out in India using satellite data and aerial photographs to develop appropriate methodologies for terrain classification and preparation of maps showing landslide hazards in the Garhwal Himalayan region, Nilagiri hills in south India and in Sikkim forest area. Such studies have been carried out using mostly aerial photographs because of their high resolution enabling contour mapping with intervals of better than 2m in height.

2.7 Forest Fire

Several thousands of hectares of forests are burnt annually due to manmade forest fires causing extensive damage to forest wealth. The behavior of forest fire depends upon three parameters: fuel, weather, and topography. Each parameter has several characteristic parameters. The most important task in the preparedness phase is to assess the risk. For risk assessment variables such as land use/land cover, demography, infrastructure and urban interface are considered. Effective mitigation of forest fire involves fuel (land cover, weather, terrain, vegetation type and moisture level) mapping, identification of fire risk areas, rapid detection, local and global fire monitoring and assessment of burnt areas. The analysis of near-real time low spatial resolution (1km) and high repetivity data from NOAA and high spatial resolution data with low repetivity from earth resources satellites could provide the information on areas under fire.

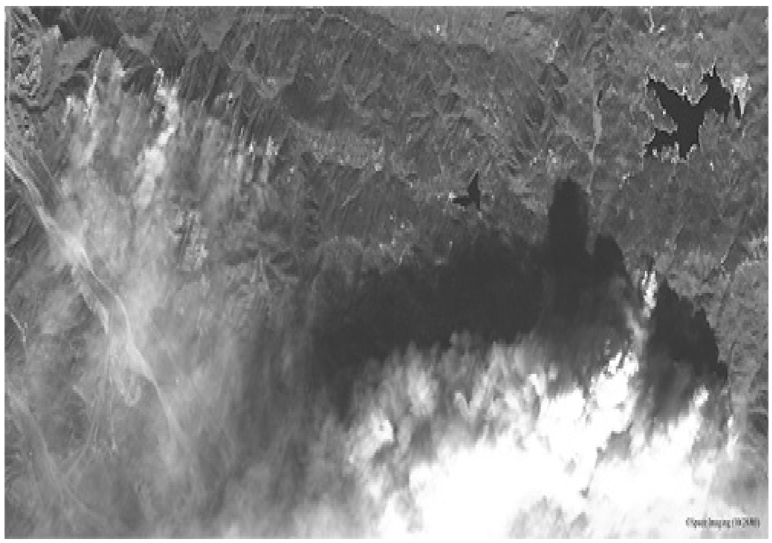

Figure 5 Satellite photographs of wildfires in San Bernardino, California

CONCLUSIONS

Apart from loss of human lives, natural disasters inflict severe damage to ecology and economy of a region. Space technology has made significant contribution in all the three phases, i.e. preparedness, prevention and relief of disaster management. With a constellation of geostationary and polar earth observation satellite with improved spatial and temporal resolutions the global space powers are in the process of developing an operational mechanism for disaster warning especially cyclone and drought, and their monitoring and mitigation. However, prediction of certain events likes earthquake, volcanic eruption and flood is still at experimental level. Developments in space-based earth observation and weather watch capabilities in future may help refining existing models/approaches for prediction of such events and their management.

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THEME – III

URBANISATION, BIO-DIVERSITY AND EIA AND HUMAN HEALTH

Assessment of Dependency on Resources for Livelihood and People's Attitude towards Conservation: A Study on Selected Villages Around Loktak Lake of Manipur

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ABSTRACT

Loktak lake, the largest freshwater wetland in northeastern region of India and designated as a "Wetland of International Importance" under the Ramsar Convention plays an important role in the ecological and economic security of the region. A large population living in and around the lake depends upon its resources for sustenance. People of Manipur are culturally, socially and economically linked with the Loktak Lake and hence the lake has been referred to as lifeline of Manipur. The present study was conducted on five villages in and around the lake with the aim to identify the dependency of the villagers on the lake for livelihood generation and to assess their awareness regarding the condition of the lake. A total of 300 households were interviewed with the help of research schedules, focus group interview and direct observation. Fishing, agriculture, collection of different bioresources from the lake forms the major economic activity of the rural people. Socioeconomic condition of the people is weak, income level is low, education is poor and hence dependency on the lake is more. All the respondents felt that the natural resources of Loktak Lake are declining. There is need to conserve the valuable resources of the wetlands from various anthropogenic pressures so that livelihood of the people are secured. Although, for the conservation and sustainable development of the lake effective conservation and management programs are being taken up by the government and local authorities, community participation is necessary. Considering the ecological condition of the lake the floating vegetation *phumdi* which causes various problems are being removed by the Loktak Development Authority and traditional practice of *Athaphum* fishing has been stopped as a conservation measure. Awareness regarding conservation was assessed among the respondents and it was observed that willingness and awareness exists but proper initiatives have to be taken and alternative source of livelihood has to be made available for successful and sustainable management of the lake.

Keywords: Loktak lake, Resource dependency, peoples' participation, conservation awareness

INTRODUCTION

Loktak lake is located between 24°25' to 24°42'N and from 93°46' to 93° 55' E in the southern part of the Imphal valley of Manipur. The lake is oval in shape with maximum length and width of 26 Km and 13 Km respectively. The depth of the lake varies between 0.5 to 4.58 m with average depth recorded at 2.07 m (LDA and WISA, 1999). The lake is the largest freshwater lake in Northeast India. Because of its ecological status and its biodiversity values the lake has been designated as a "Wetland of International Importance" under the Ramsar Convention on 23rd March, 1990. Keibul Lamjao, the only floating national park in the world and the home of the endangered Manipur Brow Antlered Deer "Sangai"– *Cervus eldi eldi* is situated at the south-west part of the lake. The characteristic feature of the Loktak lake is the presence of floating islands covered with vegetation, locally known as *phumdis* (Trisal and Manihar, 2004). A large population living in and around the lake depends upon its resources for sustenance. People of Manipur are culturally, socially and economically linked with the Loktak Lake and hence the lake has been referred to as lifeline of Manipur (Singh and Moirangleima, 2009).

Nongmaikhong, Phoubakchao, Laphupat Tera, Karang and Ithing are five lakeshore villages located in and around the Loktak lake of Manipur. People living in these five villages depend on the resources of the Loktak lake like fishes, vegetable items, prawns, fuelwoods, etc. for their livelihood since long time. Laishram and Dey (2013) documented dependency of the people on the bioresources in two island villages *Ithing* and *Karang* of the Loktak lake and assessed the socio-economic conditions of the villages. In recent years the livelihood and income generation activities of the people residing in lakeshore villages have become threatened because of increasing dependency on the lake and overexploitation of resources. Hence, the present study was taken up in the above five lakeshore villages with the aim to identify the dependency of the villagers on the lake for livelihood generation and to assess their awareness regarding the condition of the lake.

MATERIALS AND METHODS

The present study was conducted using research schedules, focus group interviews with knowledgeable persons of the villages and direct observation in the five purposively selected lakeshore villages keeping in mind the aim and objectives of the study and also the accessibility of the villages. Sampling of about 20% of the households was conducted (Sah and Heinin, 2001; Shrivastava and Heinen, 2007; Singh and Moirangleima, 2009) which resulted in selection of 300 households from the five villages (40 from Nongmaikhong, 100 from Phoubakchao, 80 from Laphupat Tera, 50 from Karang and 30 from Ithing) for the survey. A total of 300 respondents (one respondent per household) were interviewed from the selected households in the five villages. The research schedule used in this study was designed in English and asked in Manipuri, which is the local language of Manipur. It sought to obtain information regarding the socioeconomic condition of the villagers, their dependency on the lake for livelihood generation and assessment of their awareness regarding the condition of the lake. The research schedule was prepared referring Sah and Heinin, 2001; Baral, 2005; Baral and Heinin, 2007; Mishra *et al.*, 2008 and in consultation with other relevant literatures.

RESULTS

Particulars of the respondents are presented in Table 1. Among the 300 respondents interviewed, 77.33% were males and 22.67% were females. Overall the highest percentage in terms of the age of the respondents was 31.67% in the age range of 31-40 years and the lowest 1.67% in the range of above 71 years. Majority of the community in the five villages were Hindus (70.33%), followed by Islam (27%) and Christians (2.67%). In Nongmaikhong village 100% of the respondents followed Hinduism.

Table 1 Particulars of the respondents

Particulars	**V_1 N=40**	**V_2 N=100**	**V_3 N=80**	**V_4 N=50**	**V_5 N=30**	**Overall N=300**
1) Gender of respondents						
1) Male	33 (82.5)	75 (75)	69 (86.2)	34 (68)	21 (70)	232 (77.33)
2) Female	7 (17.5)	25 (25)	11 (13.8)	16 (32)	9 (30)	68 (22.67)
2) Age of the respondents						
1) 20-30 years	8 (20)	24 (24)	18 (22.5)	6 (12)	5 (16.67)	61 (20.33)
2) 31-40 years	12 (30)	35 (35)	27 (33.75)	8 (16)	13 (43.33)	95 (31.67)
3) 41-50 years	13 (32.5)	21 (21)	19 (23.75)	17 (34)	5 (16.67)	75 (25)
4) 51-60 years	3 (7.5)	16 (16)	6 (7.5)	12 (24)	6 (20)	43 (14.33)
5) 61-70 years	3 (7.5)	2 (2)	8 (10)	7 (14)	1 (3.33)	21 (7)
6) Above 71 years	1 (2.5)	2 (2)	2 (2.5)	0 (0)	0 (0)	5 (1.67)
3) Religion						
1) Hindu	40 (100)	39 (39)	56 (70)	47 (94)	29 (96.67)	211 (70.33)
2) Christianity	0 (0)	0 (0)	4 (5)	3 (6)	1 (3.33)	8 (2.67)
3) Islam	0 (0)	61 (61)	20 (25)	0 (0)	0 (0)	81 (27)

Figure in parentheses indicate the percentage of each category

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

The respondents collected 10 types of bioresources from the Loktak lake for livelihood and income generation. The resources collected by the respondents included 38 species of fish, 1 species of prawn, 2 species of snail, 1 species of mussel,16 species of vegetable items, 8 species of fodder, 6 species of fuelwood, 3 species of thatching material, 12 species of medicinal plants and 2 species of handicraft material. Major species of fishes collected by the respondents include *Monopterus albus, Labeo rohita* and *Puntius sophore*. Major species of prawns collected was *Macrobrachium dayanum. Pila globossa* and *Lymnaea stagnalis* were the major species of snails collected.

Unio marginalis was the major species of oyster collected. Most abundantly collected species of vegetable items were *Oenanthe javanica*, *Alpinia nigra* and *Ipomoea aquatica*. The local people were also found to collect some other bioresources like fodders, fuelwoods, thatching materials, medicinal plants and handicraft materials which they use mainly for household purposes (Table 2).

Table 2 Bioresources collected from Loktak lake

Bioresources	Number of species	Most Abundantly/Commonly used species
1) Fishes	38	*Monopterus albus, Labeo rohita, Puntius sophore*
2) Prawns	1	*Macrobrachium dayanum*
3) Snails	2	*Pila globossa, Lymnaea stagnalis*
4) Oysters	1	*Unio marginalis*
5) Vegetable items	16	*Oenanthe javanica*, *Alpinia nigra*, *Ipomoea aquatica*
6) Fodders	8	*Zizania latifolia*, *Echinochloa stagnina, Panicum notatum*
7) Fuelwoods	6	*Phragmites karka, Saccharum spontaneum*, *Saccharum narenga*
8) Thatching materials	3	*Zizania latifolia, Imperata cylindrica, Chrysopogon zizanioides*
9) Medicinal plants	12	*Stephania glabra, Mukia maderaspatana, Eclipta prostrata*
10) Handicrafts materials	2	*Schoenoplectus lacustris, Cyperus alternifolius*

Community participation in conservation of the Loktak lake is presented in Table 3. All the respondents thought that Loktak lake played an important role for livelihood and income generation of the people living in and around it. All the respondents were also willing to undertake any work for the conservation of Loktak lake. Although most of the respondents did not participate in any conservation programme organized by the government or any other organization for the conservation of the lake, it is felt that lack of motivation is the main cause. Among the villages the highest percentage of participation was found in Ithing village (36.67%). The activities included awareness programme for conservation of wildlife of the lake (46.66%- highest) and removal of *phumdi* by local clubs (6.67%) as lowest. 100% of the respondents from Ithing village participated in removal of *Phumdi* by Loktak Development Authority (LDA). For the conservation and sustainable management of Loktak lake in all the villages the highest activity undertaken by the respondents themselves was removal of *phumdi* (11.67%) and the lowest was removal of *Azolla pinnata* (Kang) (0.33%).

Table 3 Community participation in conservation of the Loktak lake

Particulars	V_1 N=40	V_2 N=100	V_3 N=80	V_4 N=50	V_5 N=30	Overall N=300
1) Do you think that Loktak lake plays an important role for livelihood and income generation of the people living in and around it?						
1) Yes	40 (100)	100 (100)	80 (100)	50 (100)	30 (100)	300 (100)
2) No	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2) Are you willing to do any work for the conservation of Loktak lake?						
1) Yes	40 (100)	100 (100)	80 (100)	50 (100)	30 (100)	300 (100)
2) No	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3) Do you participate in any programme of the government or other organization for the conservation of Loktak lake?						
1) Yes	14 (35)	5 (5)	0 (0)	0 (0)	11 (36.67)	30 (10)
2) No	26 (65)	95 (95)	80 (100)	50 (100)	19 (63.33)	270 (90)
	V_1 N=14	V_2 N=5	V_3 N=0	V_4 N=0	V_5 N=11	Overall N=30

Contd…

Particulars	V_1 N=40	V_2 N=100	V_3 N=80	V_4 N=50	V_5 N=30	Overall N=300
4) If so, activities taken up in the programme						
1) *Phumdi* removal by LDA	0 (0)	0 (0)	0 (0)	0 (0)	11 (100)	11 (36.67)
2) Awareness programme for conservation of the lake	2 (14.29)	1 (20)	0 (0)	0 (0)	0 (0)	3 (10)
3) *Phumdi* removal by Local club	2 (14.29)	0 (0)	0 (0)	0 (0)	0 (0)	2 (6.67)
4) Awareness programme for conservation of wildlife of the lake	10 (71.42)	4 (80)	0 (0)	0 (0)	0 (0)	14 (46.66)
	V_1 N=40	**V_2 N=100**	**V_3 N=80**	**V_4 N=50**	**V_5 N=30**	**Overall N=300**
5) Activities you have undertaken for the conservation and sustainable management of Loktak lake						
1) *Phumdi* removal	19 (47.5)	5 (5)	5 (6.25)	2 (4)	4 (13.33)	35 (11.67)
2) Removal of *Azolla pinnata* R. Br. (Kang)	1 (2.5)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.33)
3) None	21 (50)	95 (95)	75 (93.75)	48 (96)	26 (86.67)	265 (88)

Figure in parentheses indicate the percentage of each category

V_1= Nongmaikhong, V_2=Phoubakchao, V_3= Laphupat Tera, V_4=Karang, V_5=Ithing

DISCUSSION

In the present study most of the respondents interviewed from the selected households in the five villages were males. Majority of the community in the five villages followed Hindu religion. There was high rate of illiteracy found in the villages because of the low income level of the households and they cannot afford money for education. Fishing and agriculture (cultivation of paddy mainly in Laphupat Tera and Phoubakchao) were the major occupation in the villages. All the five villages lie in close proximity with the lake and hence the main occupation of the people was found to be fishing. The income level was found to be low in general. This may be due to high level of illiteracy, lack of government employment opportunities in the villages.

In all 10 types of bioresources were collected from the Loktak lake by the respondents for livelihood and income generation. Various species of fishes, prawns, snails, vegetables were found to be collected from the lake and sold in the local market. Singh (1997) also found that the resources of Loktak lake played an important role not only in the livelihood of the people living in phoom huts but also for the state of Manipur. All the respondents felt that the natural resources of Loktak lake is declining because of increasing dependency on the lake and human activities like unsustainable agricultural practices, water pollution, siltation, construction of Ithai dam etc. A study on water quality of the Loktak Lake (Laishram and Dey,2014) showed that the water of Lokak lake is moderately polluted and unsuitable for human consumption.. For the survival of life forms and meeting human needs proper treatment is needed.. Implementing conservation measures and generating awareness among the people towards the lake which provides livelihood to the people and forms an integral part of the social, economic and cultural life is essential.

The respondents have high level of awareness about the importance of the Loktak lake for their livelihood and income generation. However, the participation of the local community in various programmes of the government or other organization for the conservation of Loktak lake was less. This may be because of lack of initiatives and lack of communication between the government and the local communities. All the communities were willing to undertake conservation activities to save Loktak lake. This willingness is because of the respondent's awareness regarding the importance of Loktak lake in their livelihood and income generation. Chun *et al.* (2012) also found high awareness and willingness of the local public in the river conservation project of an urbanized Temiang River watershed located in Peninsular Malaysia. A small section of the respondents were found to have undertaken up *phumdi* removal and removal of *Azolla pinnata* (Kang) as activities for the conservation and sustainable management of Loktak lake.

CONCLUSION

In the present study high dependency on Loktak lake of the local community living in the five study villages for livelihood and income generation were observed but due to the various anthropogenic pressures, the lake was found to be affected from pollution and ecological degradation resulting in poor socio-economic condition of the people.

High rate of illiteracy among the people make them more depended on the natural resources of the lake. Loktak Development Authority (LDA) and other concerned authorities are taking up various conservation activities like removal of *phumdi,* stoppage of *Athaphum* fishing etc. Some other conservation programs have also been undertaken by NGOs like NECEER, Imphal. Compensation to the Athaphum owners and livelihood packages to the Phumhut dwellers were given as part of the development and conservation programme. Any conservation activities taken up by the concerned authorities need to be more effective and should develop interest among the communities to participate in the activities. Involving more number of organizations, local communities, organizing more effective conservation related programme and providing alternative source of livelihood may help in the successful conservation and sustainable management of the Loktak lake and its surrounding environment.

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Land Use/Land Cover Change Detection Mapping based on Remote Sensing and GIS Technology

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ABSTRACT

The study of Land use/land cover (LULC) change detection mapping is important for the environment planning, development and implementation of management strategy to assemble the rising demands for essential human requirements and safety of the day by day increasing population. This study shows the status of changes in land use/land cover mapping in the Akola Block of Maharashtra state with the help of an included approach of Remote Sensing, Geographic Information System (GIS) technology and ground truth verification. In the land use land cover classes based classification, it was found that the Agricultural land is the major LULC class in the Akola area covering 1042.71 sq. km, followed by Forest land, Wastelands, Built-up land and water bodies contributing in that order of the entire geographical area using GIS software. This study have been reviewed the uniqueness of urban cover and waste land then their effect on quality of life and water quality, the obvious powerful forces and its effect on development activities direct effect of land use land cover of Akola Block. The study emphasis that in Akola area Agriculture land and waste land were also contributed the highest land cover, while the lowest was contributed by water bodies and displays a major impact of urbanization on the ecosystem condition.

Keywords: GIS, Remote sensing, Land use/land cover, GPS and Akola.

INTRODUCTION

The land use/land cover classes of a region are a result of environmental and socio-economic factors and their utilization by human in time and space. Land is suitable a limited natural resource due to vast farming and demographic pressure. Hence, information on land use/ land cover change detection and possibilities for their optimal use is necessary for the selection, development planning and implementation of land use land cover schemes to gather the rising stress for basic human requirements and benefit Pande C. and Moharir K. (2014). Recent remote sensing and gis technology offers collection and analysis of data from ground-based, atmospheric, and Earth-orbiting platforms with linkages to GPS and GIS data and functions and up-and-coming modeling capabilities Franklin, S.E. (2001). Remote sensing information in show with available, enabling technologies such as GPS and GIS can form the information base upon which sound planning decisions can be made, while remaining cost effective Franklin et. al. (2000). This has completed remote sensing technology an important source of land cover and land use mapping. Land use/ land cover is two divide terminologies which are often have used for interchangeably Dimyati, M. et. al. (1996). While land use/land cover refers to the way in which land mapping has been used by man and their locale, typically with the accent on the useful role of land use/land cover mapping for cost-effective activities. Land use/land cover data sets are main inputs for environmental change analysis, modeling and monitoring, natural resources management, policy-making, carbon cycle studies, hydrology and global climate change analysis Song, K.S et. al. (2011).

Study Area

The Patur block is situated in and around the southern parts of Akola district, Maharashtra. The block has covered about 1042.71 sq. km, lying in between 76°37′30”E to 77°7’30’’E longitude and to 20°34’30” N to 20°16’30’’ N. (Fig: 1). The Patur block is covered by Survey of India (SOI) toposheet 55H/6, 55H/7, 55H/1 and on 1:50,000 scale. This area is under in basaltic rocks and undulating topographic in this area. The area intense rainfall in June to October during the monsoon season with a regular annual rainfall of 800 and 900 mm of Patur block respectively.

Table 1 Land Use/ Land Cover area under different Classes

Land Use Land Cover Classes	2010 (Sq. Km)	2015 (Sq. Km)
Agriculture Land	350.92	323.75
Scrub Land	118.45	97.05
Urban Land	42.71	67.06
Forest Land	170.28	210
Water Body	18.66	23.89
Total	**701.67**	**701.67**

METHODOLOGY

The present study satellite image processing and visual interpretation methods were carried out to supervised image classification techniques with the help of digital data, field verification and False Colour Composite (FCC) satellite images. The image classification is adopted to prepare land use and land cover change detection mapping. The LISS-III satellite image and Landsat TM images have used for change detection mapping of land use/land cover for the year 2010 and 2015. The geospatial data sets were used to generate a thematic land use/land cover maps with the help of Arc GIS software 1.3.

RESULTS AND DISCUSSION

For the enhanced comprehensive development, planning and management of the Patur block, it is required to have accurate information on land use/ land cover classes and the powerful forces that affect the environmental system in Patur block regions. LISS-III satellite data of 1:50,000 scale for the year 2010 and 2015 was digital interpreted for the extraction of land use/ land cover categories of the study area. The different land use/ land cover classification levels based on digital interpretation in the study area includes urban land, Agricultural land, Forest land, Water bodies, Wastelands. The statistical distribution of land use/ land cover classes of Patur block in Akola district is depicted in Table 1 and the land use/ land cover maps of Patur block is shown in Figure 3.

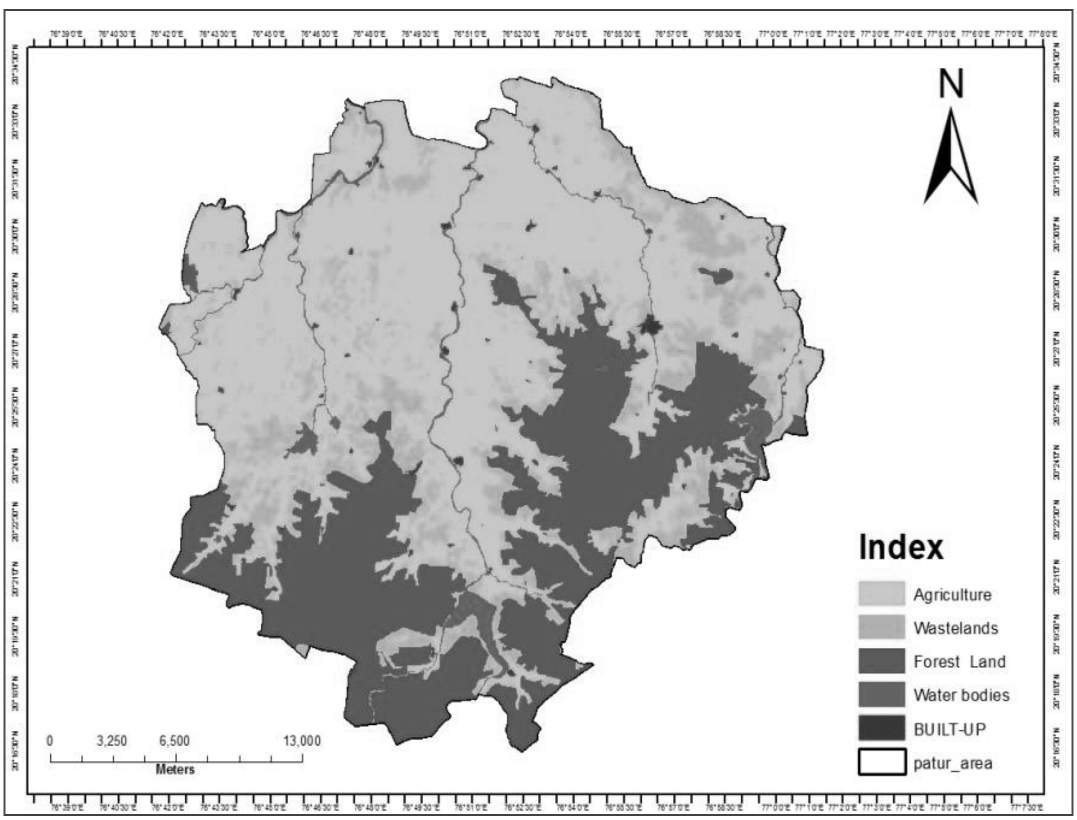

Figure 1 Land Use/Land Cover Map of 2010

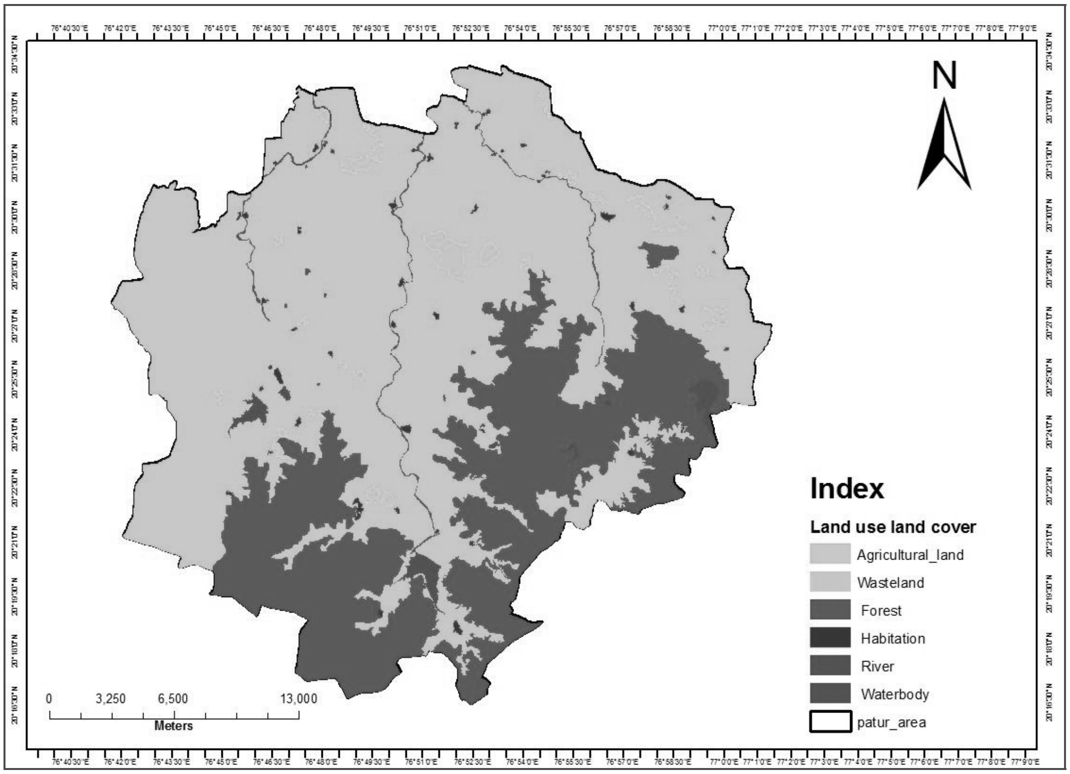

Figure 2 Land Use/Land Cover Map of 2015

CONCLUSION

In present study focuses on land use/land cover changes in a patur block, Maharashtra, India using satellite images data, GIS technology and ground truthing by using GPS technology. Our results clearly display that Land use and land cover classes changes were important during the period from 2010 and 2015. On the other indicator there is reduction in agricultural area water spread area and forest areas. This study visibly shows the important effect of population, ecological and its growth activities on land use and land cover change during 2010 and 2015. This study proves that integrated of GIS and remote sensing techniques is very most effective technology for land use and land cover changes development, planning and management. The important of land use and land cover changes of Patur block is most useful for environmental management groups, policymakers and for public to better understand the surrounding.

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"Assessment of Soil Quality around Pharma –Industry"

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ABSTRACT

Assessment of Soil Quality is one of the key parameters for the Evaluation of Environmental Contamination. Soil Quality is linked with human health in many ways. Soils are under increasing environmental pressure, this effects the capacity of the soil to continue to perform its functions. Modern Industrial practices and indiscriminate use of fertilizers, pesticides etc., and anthropogenic activities invariably results in the depletion of soil quality and resulting in various health hazards. The presence of pollutants can affect the soil quality and imparts its life sustaining capacity. A Pharma industry was chosen and an attempt was made to assess the soil quality and impact of industrial pollution, the soil samples were collected and physical, chemical parameters like moisture content, bulk density, P_H, Electrical Conductivity, Organic Carbon, Organic Matter, Potassium, Phosphorous have been analyzed using Standard methods. The present study was concluded with 20 Soil Samples and analyzed for above parameters. These samples were collected at a distance of 1 to 5 kms from pharma Industry in the locations of MEDCHAL, MAISAMMA GUDA, BACHUPALLY, DUNDIGAL. Out of 20 Samples, 13 Samples are poor, 3 are good and 4 are average.

Keywords: Soil quality, Pharmaceutical industries, Moisture content, Bulk density.

INTRODUCTION

Soil is considered as 'mother of earth'. Soil is a natural body consisting of layers (soil horizons) of mineral constituents of variable thickness, which differ from parent materials in their morphological, physical, chemical and mineralogical characteristics. Soil is essential for survival of living world, especially for human population. Rapid growth in population and industries in the past few decades have led to several environmental problems relating to soil and groundwater. Rapid industrialization, urban activities are the biggest contributors to pollute the land scapes by unsafe disposal of industrial wastes in to water streams and into air without giving appropriate treatment. Soil in urban areas is recipient of diverse physical and chemical contaminants that are frequently used as indicators of environmental quality. Soil degradation impacts agricultural production and adversely affects other natural resources. use of excessive amounts of pesticides and fertilizers in agriculture that can result in surface water and/ or ground water contamination.

Soil Quality

The capacity of a soil to function within ecosystem boundaries to sustain biological productivity maintains environment quality and promotes plant and animal health is called soil quality. Soil quality (SQ) and understanding its importance, leads to the forefront of environmental sustainability. The terms such as, soil quality, soil degradation, soil health and soil resilience are being used more frequently and their greater urgency in connection with strategies to protect global environment. The need to improve quality of life and protect natural resources are forcing society to recognize importance of soil resource. Soil quality has a direct influence on water and atmospheric quality, human and animal health (doran *and parkin, 1994*). Soil is a vital resource for producing the food and fiber needed to support an increasing world population (*parretal. 1992*).

Significance of soil quality (SQ) assessment

The improvement of agriculture and the increase in societal concerns on environmental protection and food quality in industrialized countries and continued land resources degradation and 'basic human needs insecurity' in developing countries, requires the focus on the impact on soil quality (SQ). Improvement in SQ leads economic benefits in the form of increased productivity; nutrient and pesticides use efficiency, water and air quality enhancement and amelioration of greenhouse gases. A SQI is an aggregate measurement of a soil's performance of critical ecological and agronomic functions. The complexity of co-evaluating the status of many soil parameters has prompted investigators to integrate multiple indicators in a SQI.(*R.E. Masto, S. Sheik,, 2015)*

The most common approach suggests that soil quality index is a function of a set of number of specific soil quality elements and that it should be based on conditions that maximize production and environmental performance criteria for each element of ecosystem. One of the main problems with the implementation of soil quality index is related tothe cost and difficulty of collecting data on the soil attributes, especially when they are needed in time series format. Five soil attributes namely pH, Organic matter (OM), phosphorous (P), Potassium (K) and Electrical conductivity (EC) have been combined to construct an index to represent the soil quality. The soil quality index has been formulated by following the method given by Brejda and Moorman (2001).

$$SQI = (DpH + D_{OM} + D_P + D_K + D_{EC}) / 5 \quad .....(1)$$

Where $D_{pH} = 1$ If pH > 6.5 and 0 Otherwise

$D_{OM} = 1$ If OM (%) > 2and 0 Otherwise

$D_p = 1$ If P(ppm) > 20 and 0 Otherwise

$D_K = 1$ If K(ppm) > 80 and 0 Otherwise

$D_{EC} = 1$ If EC (ds/m) < 2 and 0 Otherwise

SQI is bounded between 0 and 1

Table 1 Soil Quality Index and Rating (Source: Brejda and Moorman, 2001)

Soil Quality Index	Rating
0.1 – 0.4	Poor
0.5 – 0.6	Average
>0.7	Good

Industrial wastes:

Rapid industrialization has resulted in the generation of huge quantity of wastes, both solid and liquid, in industrial sectors such as sugar, pulp and paper, fruit and food processing, sago/ starch, distilleries, dairies, tanneries, slaughterhouses, poultries, etc. despite requirements for pollution control measures, these wastes are generally dumped on land or discharged into water bodies, without adequate treatment, and thus become a large source of environmental pollution and health hazard. The disposal of the industrial waste is often more serious problem, especially for pharmaceutical industries. It is very important to dispose of pharmaceutical property because there can be very negative consequences to improper disposal. Improper disposal can result in

1. Contaminated water supplies 2. The diversion and resale of expired or inactive medicines

Showing different disposal methods of pharmaceutical wastes

Table 2 Disposal methods of pharmaceutical wastes.

Category	Disposal methods
Solids	Landfill
Semi-solids	Waste encapsulation
Powder	Waste inertization
Liquids	Sewer

PRIMARY DATA COLLECTION

Gland Pharma at Dundigal village, Gandimysamma, Hyderabad. The location map of gland Pharma industry are shown in Fig. 1. Gland pharma have a wide range of injectables, including vials, ampoules, pre-filled syringes, lyophilized vials, dry powders, infusions and ophthalmic solutions.

Figure 1 Location of pharma industry

The products of the gland Pharma company are show in the table

Table 3 Products of the gland Pharma company

Product	Presentation
Adenosine inj	3mg/ml
Oxytocin inj	5mg/ml
ciprofloxacin inj	100mg/ml
Livofloxacininj	10mg/ml
Iron Sucrose Inj	20mg/ml
Vitamin B-1 (thiamine HCI) inj	2ml Amp
Vitamin B-12 (cyanocobalamin) inj	1ml Amp

Sample collection

Soil samples were collected from the study area and analyzed for a number of physical and chemical properties of the soil. Samples were collected in the area surrounding the industry distance of 1.0km, and 2km and so on. Established collection and the presentation were used to ensure that each sample is a representative of ground soil quality. The standard methods were used to extract the soil quality parameters.The analysis of pollution is studied under two headings, the soil quality and water quality. In the present study soil quality parameters are analyzed. The analyzed data is compared with the base data.

Figure 2 Various sample collection places

Methodology

The samples which are collected are been tested for the soil quality assessment. The tests are categorized into physical and chemical. The soil quality parameters and their methods for the testing are tabulated

Table 4 Soil quality parameters and their methods for analysis

Soil quality parameters	Method/instrument used for analysis
Moisture content	Oven-dry method
Bulk Density	Standard proctors compaction test
Dry Density	Standard proctors compaction test
pH	pH Meter
Electrical Conductivity	Conductivity Meter
Phosphorous	Spectrophotometer
Potassium	Flame photometer

Tests include Moisture Content, Bulk density, Dry density

Moisture Content

Moisture content is the quality of water contained in a soil. is expressed as ratio, which can range from completely dry to the value of the material porosity at saturation.

$$M = \frac{Ww}{Ws} \times 100$$

Where, M = water content (%)

W_{w} = weight of water

W_s= weight of solids (weight of oven dry soil)

Bulk and Dry density

Bulk density is an indicator of soil compaction and soil health

Bulk density (γ_b) $= \frac{\text{weight of compacted soil}}{\text{volume of soil}}$ x 100

Weight of the compacted soil = W_2 - W_1 g

Volume of soil = volume of the mould = $\frac{\Pi}{4}$ x d^2x h

Dry density (γ_d) $= \frac{\text{bulk density}}{1+w}$g/cc

Electrical Conductivity (EC)

The electrical conductivity of water extract of soil gives a measure of soluble salt content of the soil.Electrical conductivity is expressed in dS/m.

Organic carbon

Organic carbon places a major in deciding biological activity as well as fertility of the soil.

% Organic carbon: (B-S) x N x 0.003 x 100/Wt of soil (oven dry)

Where, B = ml of std. 0.5N Ferrous ammonium sulphate required for blank

S = ml of std. 0.5 N Ferrous ammonium sulphate required for soil sample

N = Normality of std Ferrous ammonium sulphate (0.5)

RESULTS & DISCUSSIONS

Table 5 Results of various tests at various sample collection paces

S.No	Location	Distance (km)	Bulk Density g/cc	Dry Density g/cc	Water content %	pH	EC dS/m	OC %	OM %	P PPM	K PPM	SQI	Rating
1	Medchal	1.0	1.88	1.34	4	6.33	1.00	0.61	1.05	15	64	0.4	Poor
2		2.0	1.83	1.66	10	6.46	0.95	0.58	1.00	17	71	0.2	Poor
3		3.0	1.79	1.70	5	6.62	1.19	0.64	1.10	16	88	0.4	Poor
4		4.0	1.94	1.79	8	6.44	1.39	0.76	0.8	14	82	0.4	Poor
5		5.0	1.95	1.72	12	6.58	2.57	0.51	0.87	18	88	0.4	Poor
6	Maisammaguda	1.0	1.95	1.65	11	6.42	1.40	0.67	1.16	14	77	0.2	Poor
7		2.0	2.16	1.91	13	6.51	1.25	0.71	1.22	24	83	0.8	Good
8		3.0	2.14	1.86	15	6.62	2.61	0.84	1.49	19	81	0.6	Avg
9		4.0	2.15	1.97	9	6.39	1.81	0.76	1.31	15	89	0.6	Avg
10		5.0	2.06	1.82	14	6.50	1.79	0.79	1.37	16	75	0.4	Poor
11	Bachupally	1.0	1.99	1.84	8	5.72	1.01	0.89	1.53	13	68	0.4	Poor
12		2.0	2.16	1.92	12	6.23	1.15	0.64	1.10	15	75	0.4	Poor
13		3.0	1.87	1.71	9	6.17	2.10	0.78	1.44	21	88	0.8	Good
14		4.0	1.84	1.61	14	6.42	1.98	0.81	1.40	18	81	0.6	Avg
15		5.0	1.75	1.56	12	6.80	2.14	0.50	0.87	16	73	0.4	Poor
16	Dundigal	1.0	1.95	1.80	9	6.11	1.18	0.91	1.57	14	78	0.2	Poor
17		2.0	2.10	1.87	12	6.13	1.00	0.98	1.69	28	81	0.8	Good
18		3.0	2.15	1.91	12	6.46	1.78	1.32	2.28	14	88	0.6	Avg
19		4.0	1.84	1.60	15	6.38	2.48	1.16	2.00	18	75	0.2	Poor
20		5.0	1.92	1.69	12	6.53	1.76	1.10	1.90	14	78	0.4	Poor

In the present study 20 soil samples have been collected and analyzed. The different parameters are being analyzed which include Bulk Density, Moisture Content, Organic Carbon, Organic Matter, pH, Phosphorous, Potassium.

The soil samples are collected at distance of 1km and 2km and so on. Established collection methods were used to ensure that each sample is a representative of ground soil quality. The standard methods were used to extract the soil quality parameters. The analysis of pollution is studied.

Analysis of Moisture Content values

The variations of moisture content values in all directions around the pharma industry are shown in the graph. The Minimum moisture content is observed in Medchal direction and Maximum is observed in Maisammaguda direction.

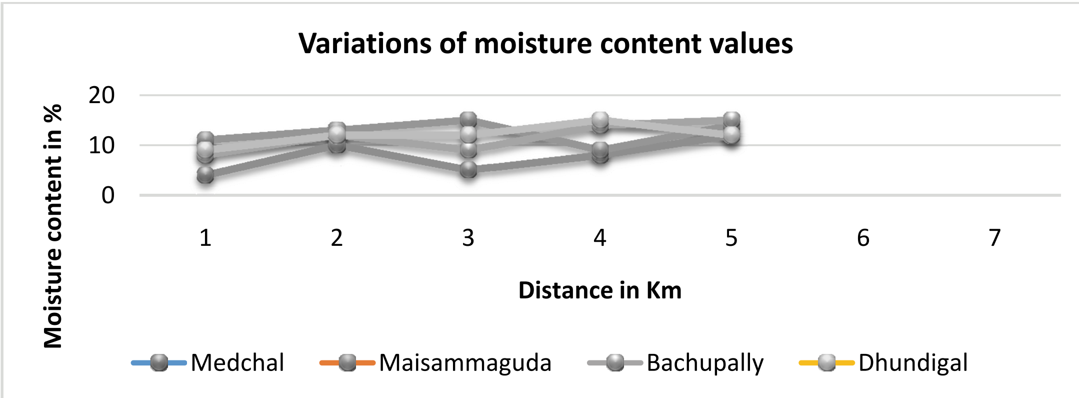


Figure 3 Showing variations of moisture content

Analysis of pH values

The variations of pH values around the pharma industry is shown in graph. The minimum pH value is observed to be 6.11 and the Maximum pH value is Observed to be 6.62. Therefore, all the samples in the study area for pH are within the permissible limits.

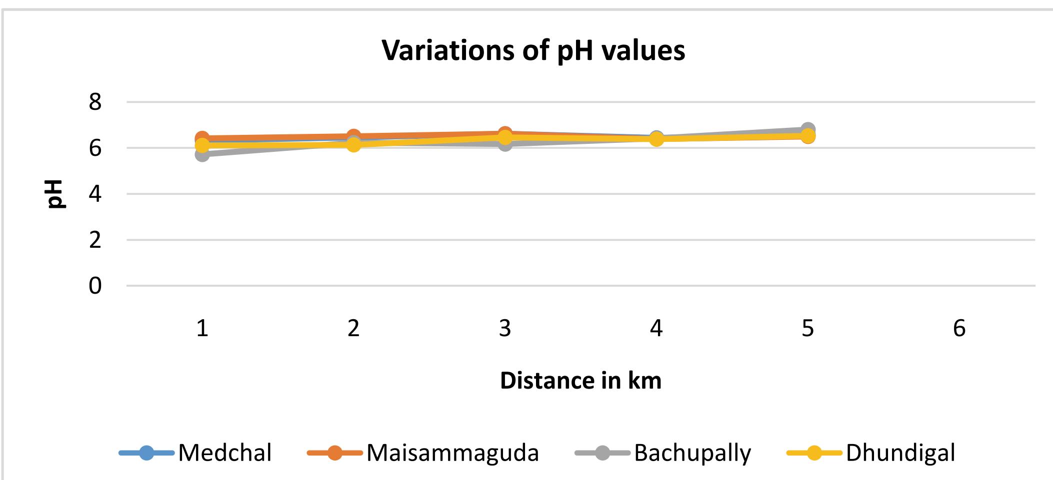
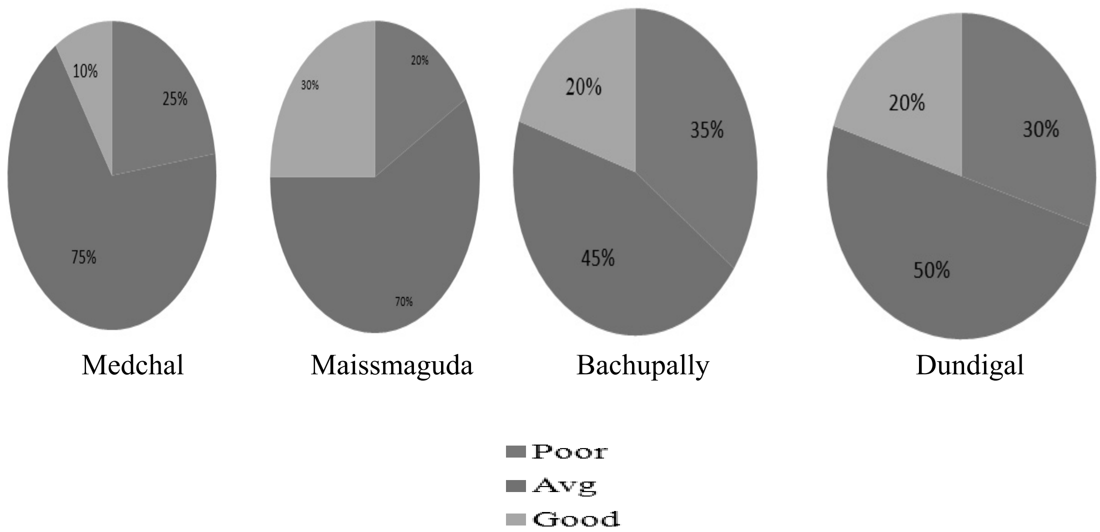


Figure 4 Showing variations of pH

CONCLUSIONS

Based on all above parameters, Soil Quality Index (SQI) was computed to determine the soil quality and categorized into good, average, poor (Brejda and Moorman (2001)). From the analysis results and soil quality rating scale, it is revealed that 13 samples (60%) were poor with SQI ranging from (0.1 to 0.4), 3 samples (30 %) rated as average (SQI of 0.5-0.7).

The soil quality index at different sample collection places are:



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Breach Modelling of Embankments

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ABSTRACT

Dams are the important hydraulic structures built across the rivers for various purposes. In the earlier time, mostly dams were of embankment type. The embankment dams are constructed for irrigation, water supply for domestic and industrial resolutions. As the earthen embankments made up of erodible materials, so these embankments may fail due to erosion of material by the flow of water which involves the sediment transportation, mixed regime flow. The breach of an embankment occurs when water flows over or through the embankment at such a rate that the embankment is eroded and a hole created, through it, that permits flood water to pass through. The development of breach depends upon various parameters, hydraulic as well as geotechnical. Failure of any embankment results in massive loss of lives as well as loss of structures. So, it is of prime interest to analyze the breaching of embankments. It becomes more important when the populations are sited close to the downstream side of dam, to estimate warning time. Many researches developed different methods and models which are based either on case studies, breach parameter, erosion process or experimentation. This paper describes the existing models ranging from simple methods, appropriate for appraisal-level estimates, to more complex methods and classified on the basis of components involved like use standard principles of hydraulics, sediment transport and soil mechanics. The paper includes the newly developed computational models for dam breaching.

Keywords: Hydraulic structures Dams, and Computational models

INTRODUCTION

Dams on rivers have a vital role to play in human civilization. The earliest dams were in the form of earthen embankments at Jawa (Jordan) about 3000 BC and at Wadi Garawi (Egypt) about 2600 BC (Singh, 1996). Embankments are constructed to ensure safe water supply for domestic use, irrigation, industrial purposes and also for improving navigation. Along with their benefits, the failure of any embankment results in loss of lives as well as loss of structures. Dam failure can be primarily attributed to number of major key factors including earthquake, differential settlement, seepage, overtopping, dam structure deterioration, rockslide and poor construction (Rico et al., 2008a). From the literature, earth dam failure occurs due to overtopping, sliding and conduit leakage are the dominant causes of earth dam failures. The main cause of failure of Machhu II (Gujarat, India, 1974) was overtopping which occured as a result of insufficient flood design (Loukola etal.,1993). The dam failure may be sudden and instantaneous or gradual. The assumption of a sudden and instantaneous failure is commonly made in dam breach modeling. For the breach analysis of embankment, it is necessary to predict the reservoir outflow hydrograph and then routing of that hydrograph through the downstream valley (Wahl, 1998). The first step becomes more important when the population is located close to the dam and to develop evacuation action time. This paper presents an overview of typically used methods for predicting dam breach analysis.

BACKGROUND

Kaddam dam, built in 1957 - 58 in Andhra Pradesh, India, was a composite earth-rock fill gravity dam. In spite of a free board allowance of 2.4 m, the dam overtopped in August 1958, by 46 cm of water above the crest and causing a major breach of 137.2 m wide. Kodaganar Dam was constructed in 1977 in Tamil Nadu, India, on a tributary of Cauvery River as an earthen dam. The dam was 15.75 m high above the deepest foundation, having a 11.45 m of height above the river bed. A 2.5 m free board above the maximum water level was provided but the dam failed due to overtopping by flood waters and breached the dam along various reaches. Machhu II dam (Gujarat, India) was built on River Machhu in August, 1972, as a composite structure. The dam failed on August 1, 1979, because of abnormal floods and inadequate spillway capacity and consequent overtopping of the embankment caused a loss of 1800 lives. There are a lot of examples of dam failure due to overtopping which occurred in other countries. Teton Dam, high earth fill dam of 98 m height, was designed by the U.S. Bureau of Reclamation in Madison County, southeast Idaho, USA and failed in June 1976 just as it was being completed and filled for the first time.

METHODS AND MODELLING FOR BREACH ANALYSIS

Failure of dam by overtopping or piping may cause significant risks to people and property nearby and the services provided by the structure. Therefore, many dam breach models have been developed in recent decades. The breaching of dams can be analyzed by predicting the reservoir outflow hydrograph. But there observed a lot of uncertainties in most situations in predicting the reservoir outflow hydrograph, especially for embankment dams in which dam failure occurs as a result of progressive erosion process. So, the reservoir outflow hydrograph was estimated first by predicting the breach characteristics viz. shape, depth, width, rate of breach formation and then computing the outflow through the breach from principles of hydraulics. There are numerous breach prediction methods and technologies. The researchers grouped the analysis methods into different categories on different basis. The different methods are described under different heads.

Empirical equations and parametric models based on case studies

There are various regression equations to estimate peak discharge which were based on case study data. Different researchers developed regression equations for different types of dam failures. During 1980's several researchers' compiled database and developed predictive equations for breach peak outflow like Ponce-1982, MacDonald & Langridge-Monopolis-1984, Costa-1985, Froehlich -1987 and 1995, Singh & Scarltos-1988). Xu and Zhang (2009) had also compiled the database from 184 earth and rock fill dam failures and then recommended a multi-parameter non-linear regression model to develop empirical formulas. The prediction or estimation of breach parameters (geometric and temporal) is necessary for risk assessment studies. For predicting breach parameters there are numerous equations and models. Singh and Snorrason (1982) gave the first quantitative guidance on breach width by plotting breach width vs dam height for 20 dam failures and found that breach width was generally between 2 and 5 times the dam height. The dam break flood forecasting model (DAMBRK) was developed by Fread (1984). Singh and Snorrason (1984) used the DAMBRK and HEC-1 models to study the effects of breach parameter variations on the predicted peak outflow for eight hypothetical breached dams. The DAMBRK model has been simplified by Wetmore and Fread (1984) for quick prediction of downstream flooding and it was designed as SMPDBK. Froehlich (1987) developed non-dimensional prediction equations for estimating average breach width (W_b), side slope factor and breach formation. He revised his analysis (1995) using data from a total of 63 case studies and developed new prediction equations for average breach width and time of failure. Singh and Scarlatos (1988) documented breach geometry characteristics and time of failure tendencies from a survey of 52 case studies. Von Thun and Gillette (1990) used the data from Froehlich (1987) and MacDonald and Langridge-Monopolis (1984) and developed the guidance for estimating breach side slopes, breach width at mid-height, and time to failure. Various investigators, like Reclamation-1988, FLDWAV (Fread, 1993) also proposed different relations. Recently Froehich (2008) developed expressions for expected values of final width and side slope of a trapezoidal breach by collecting the data from 74 embankment dam failures and dam erodibility was found to be the most important factor. Clearly, accurate prediction of breach parameters is necessary to make reliable estimates of peak outflow. The relations which were used for predicting above parameters were developed from statistical analysis of data collected from historical dam failures. So predictor equations suffer from various problems, and regression relations based on the available data have high uncertainty. Wahl (2004) presented the analysis of uncertainties of many of breach parameter methods.

Physical models

Cristofano (1965) was the first to have simulated gradual dam breach erosion by assuming overflow section as trapezoidal in shape. In 1967 Harris and Wanger presented a simple model for earthen dam breach erosion due to overtopping or piping through a dam embankment. Based on the work of Harris and Wanger (1967), Brown and Rogers (1981) developed a model, called BRDAM for simulation of progressive breach erosion of earth dam due to overtopping or piping. Ponce and Tsivoglou (1981) presented a mathematical model (PT model) for gradual failure of an earthen dam by assuming that a breach begins to grow at some weak point of the crest and downstream face. Lou (1981) developed a mathematical model for predicting the flood hydrograph resulting from a dam breach which was similar to PT model except for description of breach morphology. Cheng (2000) used 3 non-dimensional numbers to explore peak outflow changes of a dam breach section. In the early time, various regression and mathematical models have been designed to facilitate several different approaches to the modelling of the breach process, but none of these routing models had specifically attempted to integrate a detailed simulation of the erosion processes that lead to dam breach. Detailed simulation of the breach process has required the use of separate models specifically focused on erosion processes that provide output of breach geometry development over time. NWS BREACH model (Fread, 1988) was one of the well-known models. The BREACH model was the first physically based mathematical model developed by Fread (1988). This model was used for predicting the earthen dam breach outflow hydrograph. The critical material properties of the dam, considered for dam breach, were angle of internal friction, cohesion strength and average grain size diameter. This model was mainly based on the principle of hydraulics, soil mechanics, and sediment transport and reservoir characteristics. The breach erosion of earthfill dams (BEED) was developed by Singh and Scarlatos (1988). These methods offered the potential for more detailed results, such as prediction of breach initiation time and prediction of intermediate breach dimensions as well as ultimate breach parameters. These methods were used to predict the development of a breach and the resulting breach outflows using an erosion model based on principles of hydraulics, sediment transport, and soil mechanics. Some researchers proposed a dam breach model which predicts the peak discharge as well as whole outflow hydrograph and breach development for overtopping failures in a simple but physically based manner. But physically based models suffered from a poor understanding of the mechanisms of breach development.

Detailed physically based dam breach models

The next step in the development of dam-break modelling technology is the integration of models that simulate embankment erosion and breach processes with the models used to route the resulting flood. Wahl and Erdogan (2008) described some of the erosion models being considered as part of one such effort. Breaching processes into phases and erosion mechanics are predominant in these models.

Table 1 Dam breach models

Model	Embankment types	Erosion Modes	Erosion processes
SIMBA (2005)	Homogeneous cohesive	Overtopping	Headcut formation, deepening, and upstream advancement; lateral widening
HR-BREACH (2002)	Homogeneous cohesive, or simple composite embankments with noncohesive zones, surface protection (grass or rock) and cohesive core	Overtopping, piping	Variety of sediment transport / erosion equations and multiple methods for application. Discrete breach growth using bending, shear, sliding and overturning failure of soil masses
FIREBIRD BREACH (2002, 2006)	Homogeneous, cohesive or noncohesive	Overtopping	Coupled equations for hydraulics and sediment transport Overtopping erosion

All of three models can make use of measured soil erodibility parameters, which sets them apart from most previous embankment dam breach models. Francesco (2008) considered the geometry of the embankment, the shape of the reservoir, and the hydraulic characteristics of the flow through the breach and its erosive capacity, and the shape of the breach. Then he proposed a dam-breach model. As external and internal erosion are the main potential risks of failure of the earthen embankment hydraulic structures, it is essential to characterize the embankment soil erodibility. The erosion process observed by Zhu et al. (2010) during embankment breaching tests in the laboratory and then they analyzed the results.

Experimental method

Laboratory experimentation has been one of the key elements used to understand embankment breaching processes and collect reliable data to develop embankment breach models. Wahl (2010) reviewed a lot of laboratory dam breach experiments conducted by many investigators. Most of the experiments focused on small-scale, noncohesive (rockfill, sand, and fuse plug), and homogeneous embankments with overtopping erosion as the initiation mechanism. The prominent efforts have been made in the fuse plug dam breach experiments of Pugh (1985). Considering that laboratory experiments often encounter scale effects and simplifications that may make them not readily comparable with real-life breach situations, full-scale field experiments are inevitably one of the most important steps required to understand the complex natural phenomena and validate embankment breach models. To facilitate future calibration and validation of embankment breaching and flood propagation models, more reliable data is needed to establish a database consisting of available data sets of historical events and past laboratory/field experiments. For each case, the data should have sufficient documentation breach outflow hydrograph, breach geometry (shape, side slope, and width), failure time, embankment geometry before failure, embankment material properties (particle size, clay content, erodibility, construction method, cohesion, and shear strength), embankment designs (rockfill and earthfill), and downstream flood characteristics (water level, inundation area, and arrival time). The source reference and reliability of each item of the data should be verified, rated, and reported. Orendorff et al. (2010) provided the experimental basis for a new numerical dam breach model which will help to address many of the shortcomings identified in the literature. Based on an experimental research program process by Mahmoud et. al. (2010), several new concepts were proposed to incorporate geotechnical factors and techniques which must be considered during the laboratory testing of earth fill dam breaching.

CONCLUSION

Embankment breaching processes are very complex and involve strong vertical and lateral erosion, discrete mass failure, and headcut migration. The failure mode and mechanism are affected by upstream and downstream water conditions, embankment configurations and soil properties. A number of parametric, empirical, erosion and physically-based embankment breach models have been established in the past decades, but prediction with these models involves significant uncertainties. The biggest limitation of the existing breach models is quantifying erosion rates or erodibility of cohesive soils under embankment breaching flows. Great progress has been made to investigate embankment breaching processes through laboratory and field experiments and real-world case studies. However, most laboratory experiments were for small scale homogeneous embankments, only a few outdoor experiments were conducted at large scales. It is important to conduct more large-scale laboratory experiments and field case studies to improve existing embankment breach models or develop new ones.

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Effect of Soil Moisture Conservation Measures on Moisture use Efficiency, Soil Fertility and Productivity of Sorghum in Inceptisol under Semi Arid Conditions

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ABSTRACT

A field investigation entitled “Effect of soil moisture conservation measures on moisture use efficiency, soil fertility and productivity of sorghum in Inceptisol under semi arid conditions” was conducted during the kharif season of 2010-11 at Research field of AICRP for Dryland Agriculture, Dr. PDKV Akola, Maharashtra. The experiment was laid out on Inceptisol in Randomized Block Design with five treatments viz. T_1(Furrow opening), T_2 (Mulching), T_3 (Thinning), T_4 (Combination of Furrow opening+ Mulching + Thinning), T_5 (control) replicated four times with a common fertilizer dose of 80:40:00 NPK kg ha^{-1} to sorghum crop. The experimental soil was alkaline in nature, low in available nitrogen, medium in organic carbon, phosphorus and high in potassium. The results indicated that in-situ moisture conservation through mulching improved the bulk density, hydraulic conductivity, and available water capacity and mean weight diameter of soil. Addition of crop residue as mulch also build up fertility status of soil and improvement in moisture use efficiency of sorghum**.**

Hence, it is concluded that in-situ moisture conservation through mulching improved physical properties of soil, build up soil fertility and moisture use efficiency of sorghum in Inceptisol under semi arid conditions of Maharashtra.

Keywords: *Inceptisol, moisture use efficiency, soil fertility.*

INTRODUCTION

Moisture as well as soil are the two basic natural resources on the interaction of which depends the prospects of our agriculture. The conservation of these resources is an important task for good prospects of agriculture. In dryland agriculture, management of soil moisture needs top most care due to the uncertainty and erratic distribution of rainfall, which causes severe reduction in the success rate. Soil moisture plays an important role in determining growth and yield of crop, which is directly related to plant water status. Sorghum (*Sorghum bicolor L. Moench*) is major source of food for millions of people in the semi-arid tropics. It is staple food for millions of people in the tropics. It ranks third in acreage and production among cereals in India and is a major dryland food grain crop. It is truly the poor man’s bread. The kharif sorghum mostly cultivated as rainfed sorghum on light to medium type of soil having very low water holding capacity. Hence it is must to conserve soil moisture during important growth stages of rainfed sorghum by using various methods of soil moisture conservation. Mulches have beneficial and favourable effect, which results in conservation of soil moisture for a longer period and help in improving the yield attributing characters and ultimately grain yield (Mandal and Vamadevan,1975 and Mandal and Ghosh, 1984).

METHODOLOGY

The study on “Effect of soil moisture conservation measures on moisture use, soil fertility and productivity of sorghum in Inceptisol under semi arid conditions” was conducted during the kharif season of 2010-11 at Research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola (M.S.). The soil of the experimental site was clayey in texture, calcareous, moderately alkaline in reaction, medium in organic carbon, low in available nitrogen, medium in phosphorus and high in potassium. The five treatments viz., T1- Furrow opening, T2- Crop residue mulch, T3- Thinning, T4- Combination of furrow opening, crop residue mulch and thinning and T5- Control were replicated four times in randomized block design on Inceptisol. The plot wise soil samples from the experimental site were collected from 0-15 cm depth after harvesting of crop for determining the physical and chemical properties of soil as per standard methods (Black, 1965 and Jackson, 1973).

RESULTS AND DISCUSSIONS

The data on various physical properties of soil as influenced by various treatments are presented in Table 1 and the various parameters are discussed as under.

Bulk density

The data presented in Table 1 indicate that the treatment variations in bulk density were found to be non significant and values ranged from 1.27 to 1.34 Mg m^{-3}. The lowest bulk density (1.27 Mg m^{-3}) was observed in treatment T2-mulching, followed by treatment T1-furrow opening (1.31Mg m^{-3}). The lower value of the bulk density in mulching may be due to increase in organic matter in soil and also the addition of biomass.

Similar results were also reported by Badanur *et al.* (1990), Guled et *al.* (2002), Patil *et al.* (2004), Surekha and Rao (2004) and Hati *et al.* (2006).

Saturated Hydraulic Conductivity

The highest hydraulic conductivity(0.69 cm hr^{-1}) was recorded in treatment application of soybean crop residue as a mulch(T2), followed by treatment T4 combination of furrow opening + mulching + thinning (0.68 cm hr^{-1}) and furrow opening (0.64 cm hr^{-1}). The lowest hydraulic conductivity was recorded in thinning (T3). There were marked changes in this parameter due to addition of soybean crop residue as mulch, which resulted in increase in organic matter content in soil, thereby increasing the porosity of soil and resultant increase in the hydraulic conductivity of soil.

Similar results were also reported by Heilkah *et al.* (1981), Guled *et al.* (2002) and Dahiya *et al*.(2003).

Table 1 Effect of various treatments on physical properties of soil

Treatment		BD (Mg m^{-3})	HC (cm hr^{-1})	AWC (cm hr^{-1})	MWD (mm)
T1	Furrow opening	1.31	0.64	24.18	0.43
T2	Mulching	1.27	0.69	25.03	0.46
T3	Thinning	1.34	0.61	19.82	0.42
T4	Combination of Furrow opening + Mulching+Thinning	1.32	0.68	23.12	0.44
T5	Control	1.34	0.60	18.95	0.41
S.E. (m±)		0.569	0.020	1.45	0.008
C.D. at 5%		-	0.061	4.47	0.023

Mean weight diameter

The mean weight diameter was significantly influenced due to treatment of mulching (T2) under study. The highest mean weight diameter (0.46 mm) was recorded in mulching treatment (T2) followed by treatment T4 combination of furrow opening+ mulching + thinning (0.44 mm). This was because of better aggregation of soil particles due to high organic carbon content under treatment T2 mulching. There was considerable reduction in organic carbon of soil which discourages better aggregation of soil particles as a result of which lowest value of mean weight diameter was recorded under treatment T3 thinning. Similar results were observed by Kurval and Tripathi (1990), Tiwari *et al.* (2000) and Hati *et al*. (2006).

Available water capacity

The data from the Table 1 revealed that the values of available water capacity were significantly influenced due to treatment T2 addition of soybean straw as mulch. However, the available water capacity values under different treatments showed variation of 25.03 to 18.95 cm hr^{-1} . Highest available water capacity was found under the mulching treatment (T2) followed by treatment T4 combination of furrow opening + mulching + thinning which were found to be at par with each other. These results are in conformity with finding of Singh *et al.* (2001) and Hati *et al.* (2006).

Soil reaction (pH)

It is the negative logarithm of hydrogen ion activity, which indicates the acidity or alkalinity of soil and usually expressed as pH value. The pH of soil before initiation of the experiment was 7.88.

Table 2 Effect of various treatments on chemical properties of soil

Treatment		pH (1:2.5)	EC (dSm^{-1})	OC (g kg^{-1})	$CaCO_3$ (g kg^{-1})
T1	Furrow opening	7.84	0.22	6.4	12.00
T2	Mulching	7.88	0.21	6.7	12.13
T3	Thinning	7.94	0.23	5.9	12.08
T4	Combination of Furrow opening+Mulching+ Thinning	7.87	0.22	6.6	12.53
T5	Control	7.95	0.21	5.5	12.43
S.E. (m±)		0.025	0.009	0.09	0.194
C.D. at 5%		0.076	-	0.26	-

The data presented in Table 2 indicate that the pH of soil ranged from 7.84 to 7.95 indicating that the soil was slightly alkaline in reaction. Higher pH (7.95) was recorded in treatment T5 (control). Lower value of pH was recorded in treatment T2 (mulching) due to decomposition of soybean crop residue which results in production of certain organic acids which lower the pH of soil. However, treatment wise variation in pH was found to be significant. Similar results were observed by Yaduvanshi *et al.*(1985), Tyagi and Bharadwaj (1994) that application of crop residues lowered the value of pH due to decomposition of crop residues.

Electrical conductivity

The electrical conductivity is a measure of soluble salt concentration in soil. Higher amount of salts in the soil restrict the nutrient uptake and thus affect the plant growth. The data in respect of electrical conductivity ranged from 0.21 to 0.23 dSm^{-1} and treatment wise variation was found to be non significant. The maximum electrical conductivity (0.23 dSm^{-1}) was recorded in treatment T3 i.e. thinning while the minimum values (0.21 dSm^{-1}) was found in treatment T2 (mulching). Similar results were also reported by Tyagi and Bharadwaj (1994) and Dahiya *et al.* (2003), that application of crop residue decreased salt accumulation.

Organic carbon

Organic matter is an indication of organic carbon fraction of soil formed due to microbial decomposition of organic residue. The data pertaining to the organic carbon content of soil as influenced by different treatments was statistically significant and it ranged from 5.5 to 6.7 g kg^{-1} indicating that the soil was moderately high in organic carbon content. The highest (6.7 g kg^{-1}) organic carbon was recorded in treatment T2 i.e. soybean crop residue as mulch which was at par with the treatment T4 which is the combination of furrow opening, mulching and thinning. The lower value of organic carbon (5.5 g kg^{-1}) was observed in control i.e. T5 treatment. The organic carbon content of soil in treatment T2 mulching was increased by 19% over the initial and 21% over the control. The higher values of organic carbon content in treatments T2 and T4 may be due to the addition of soybean crop residue as mulch and higher addition of biomass into the soil as evidenced from the higher yields obtained in these treatments. Similar results were also reported by Badanur *et al.* (1990), Aggarwal *et al.* (1997) and Guled *et al.* (2002) that organic carbon status of soil was significantly increased when crop residues were added into the soil.

Calcium carbonate

The presence of calcium carbonate affects the physical and chemical characteristics of soil. Carbonate nodules are inert than the diffused form of lime. It's high concentration may not severely restrict water movement but also prevent root penetrations. The calcium carbonate content in soil at start of experiment was 12.2 per cent. The soils were base enriched to strongly calcareous in nature. The data (Table 2) in respect of calcium carbonate ranged from 12.00 to 12.53 percent indicating the calcareous nature of soil. However, the data in respect of calcium carbonate content in soil was found to be non significant. Similar results were recorded by Chalwade *et al.* (2006). The data presented in Table 3 indicate the grain and fodder yield of sorghum as influenced by various soil moisture conservation treatments. The sorghum grain and fodder yield was found to be non significant indicating that the various soil moisture conservation measures could not affect the biological yield performance of sorghum, due to excess rains during the kharif 2010-11 and as such the highest sorghum grain and fodder yield (33.18 and 72.98 q ha^{-1} respectively) were recorded in treatment T5 i.e. control with recommended dose of fertilizers followed by the sorghum grain yield of 32.86 q ha^{-1} with the application of soybean crop residue as a mulch(T2).

Table 3 Effect various treatments on yield of sorghum(q ha^{-1})

Treatment		Grain	Fodder
T1	Furrow opening	31.38	72.85
T2	Mulching	32.86	72.40
T3	Thinning	28.81	70.67
T4	combination of Furrow opening+ Mulching+ Thinning	30.93	71.18
T5	Control	33.18	72.98
S.E. (m±)		1.75	3.89
C.D. at 5%		-	-

Similar observations of higher yield of sorghum with crop residues as mulch were also recorded by Handekar *et al*. (1999), Sharma et al. (2001) and Patil et al. (2004).

Available nutrient status of soil

The available nutrients status of soil was recorded after harvest of sorghum. The treatment wise samples were taken and analyzed for determination of available nitrogen, phosphorus and potassium to assess the effect of various treatments on fertility status of soil.

Available nitrogen status in soil

The data pertaining to available nitrogen status of soil under influence of different treatments are presented in Table 4. Application of soybean straw as a mulch significantly increased available nitrogen in soil after harvest of sorghum. The highest available nitrogen (213.18 kg N ha^{-1}) was observed in treatment T2 (mulching) which was significantly highest. While all other treatments were significantly superior over control (197.93 kg N ha^{-1}) treatment. The data on available nitrogen status indicate that soil was low in available nitrogen. Similar results were recorded by Biswas *et al.* (1971), Bhat *et al.*(1998), Surekha and Rao (2004) that application of crop residue as mulch increased the availability of nitrogen.

Table 4 Available nutrient status (kg ha^{-1}) as influenced by various treatments

Treatment		Avail. N	Avail. P	Avail. K
T1	Furrow opening	199.43	10.62	331.26
T2	Mulching	213.18	11.36	344.07
T3	Thinning	197.57	11.27	337.66
T4	Combination of Furrow opening+ Mulching+ Thinning	202.52	11.10	339.22
T5	Control	197.93	9.29	325.86
S.E. (m±)		2.42	0.19	0.85
C.D. at 5 %		7.46	0.58	2.62

Available phosphorus status in soil

The data pertaining to available phosphorus status (Table 4) of soil under the influence of different treatments indicate that the application of soybean straw as a mulch significantly increased available phosphorus (11.36 kg P ha^{-1}) in soil after harvest of sorghum. It was observed that highest available phosphorus was recorded in treatment T2 (mulching) and found to be at par with T4 (11.10 kg P ha^{-1}) and treatment T3 i.e. thinning. Similar results were recorded by Bairathi *et al.* (1974), Bhat *et al.*(1998) who observed that addition of crop residue increased availability of phosphorus.

Available potassium status in soil

The data pertaining to available potassium status in soil under influence of different treatments are presented in Table 4. Application of soybean straw as a mulch significantly increased available potassium in soil after harvest of crop. It was observed that the significantly highest (344.07 kg K ha^{-1}) potassium in soil was observed in treatment T2 (mulching). Similar results were recorded by Surekha *et al.* (2004) who observed that addition of crop residues and organic manures to soil increase availability of nutrients due to increase in humus content and organic carbon content of soil.

Soil moisture content (%) at critical growth stages of sorghum

The data pertaining soil moisture (%) at various growth stages of sorghum are presented in Table 5.The data indicate that treatment T2 soybean crop residue as mulch showed higher soil moisture content (%) at various growth stages of sorghum followed by treatment T4 (combination of furrow opening, mulching and thinning) compared to all other treatments in surface and sub surface layer. The higher soil moisture content in these treatments might be due to addition of soybean crop residue as mulch that respond well to conserve more soil moisture.

Table 5 Soil moisture (%) at various growth stages of sorghum

Treatments	Depth	Vegetative stage (30 DAS)	Boot stage (45 DAS)	Flowering Stage (75 DAS)	Grain filling Stage (95 DAS)
T1-Furrow opening	0-15cm	29.3	21.58	24.55	19.51
	15-30cm	26.0	25.6	21.51	19.63
T2- Mulching	0-15cm	31.91	28.3	24.53	21.93
	15-30cm	30.81	25.25	24.19	21.22
T3- Thinning	0-15cm	31.67	28.3	23.27	18.86
	15-30cm	33.1	30.7	22.2	18.82
T4-Combination of furrow opening, mulching and thinning	0-15cm	27.15	23.95	21.93	19.62
	15-30cm	27.27	28.05	21.22	20.64
T5- Control	0-15cm	30.7	22.09	23.7	18.86
	15-30cm	29.5	25.13	22.55	18.82

In general, the higher values of moisture were observed during vegetative stage and decreased during grain filling stage. Similar results were reported by Bhan and Kiem (1994), Patil *et al.* (1994), Pakhale *et al.* (2009).

Moisture use efficiency

Moisture use efficiency is a function of yield and total moisture use. The data pertaining to moisture use efficiency (MUE) values under different treatments are presented in Table 6. It was observed that the moisture use efficiency (MUE) values were influenced by various soil moisture conservation measures. The highest moisture use efficiency (4.59 kg ha^{-1} mm^{-1}) was recorded with the application of soybean crop residue as mulch (T2) while the lowest moisture use efficiency (3.91 kg ha^{-1} mm^{-1}) was observed under thinning treatment.

Table 6 Moisture use efficiency of sorghum under different treatments

Treatment		MUE (kg ha^{-1} mm^{-1})
T1	Furrow opening	4.30
T2	Mulching	4.59
T3	Thinning	3.91
T4	Combination of Furrow opening+ Mulching+ Thinning	4.23
T5	Control	4.47

The highest moisture use efficiency observed in treatment (T2) crop residue as mulch is due to the more soil moisture conservation as a result of reduction in evaporation losses due to mulching and ultimately lesser moisture use in this treatment. The higher value of moisture use efficiency in control treatment (T5) is due to the higher biological yield recorded in this treatment.

Conclusion

In view of the above, it is concluded that in-situ moisture conservation through mulching improved physical properties of soil, build up soil fertility and moisture use efficiency of sorghum in Inceptisol under semi arid conditions of Maharashtra.

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Characterization and Classification of Different Soil Type of Gariyaband District of Chhattisgarh

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ABSTRACT

A study was carried out during 2014-15 on soil characterization and classification of Gariyaband district of Chhattisgarh. The objectives of the study were to characterize the major soil types of the district. Three soil profiles were identified, excavated, described and sampled for morphological, physical and chemical properties and were classified in to three different soil-groups. Pedon-1 indicated the presence of cambic B horizons and placed in *Inceptisols,* pedon-2 showed argillic horizons keyed out in *Alfisols* and pedon-3 was classed in *Vertisols* soil order due to the presence of wide cracks, slicken sides and high clay content. All the pedons belonged to *Usteps* suborder since they had *Ustic* soil moisture regime. The horizons were simple and no calcic orgypsic or duripan were observed, they were placed in *Haplustepts* Great Group. All the pedons represented the central concepts of great group and hence classified as Typic *Haplusteps* at subgroup level. Based on the different properties the soils were classified as for pedon -1 as Fine sand clay loamy, kaolinitichyperthermic, *TypicHaplustepts* , pedon-2 as Fine clay loamy, kaolinitic mixed hyperthermic,*TypicHaplustalfs and pedon-3 as* Fine clay, Montmorillonitic mixed hyperthermic,*TypicHaplusterts* .

Keywords: Characterization, Classification, Soil type

INTRODUCTION

Soil is the uppermost layer of variable depth of the earth consisting of loose material, which is the main support for natural vegetation and other life forms of our planet. Soil is an independent dynamic body of nature that acquires properties in accordance with the forces which act upon it. The important soil forming factors such as parent material, climate, relief, organism and time have direct impact on soil properties. The soil forming processes as oxidation, reduction, eluviations and illuviation are related to soil solution and further on stages of soil development (Tamgadge *et al.,* 2002). Soil profile characteristics as conditioned by different processes and factors of soil formation have great influence on fertility of soil and productivity of land. Therefore an understanding of morphology and physico-chemical characteristics in relation to added fertilizer is necessary to suggest appropriate fertilizer schedule for different crops in order to obtain optimum yield (Mishra, 2005). Knowledge of vertical distribution of plant nutrients in soil is useful as roots of most of the crop plants go beyond the surface layer and draw part of their nutrient requirements from the sub-surface layer (Brar and Sekhon, 1987; Pal and Muckhopadhyay, 1992; Sangwan and Singh, 1993; Kumar *et al*., 1996). Soil characterization and classification provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can make prediction about their characters and potentialities. It also provides adequate information in terms of land form, slope, profile characteristics of soils (viz., depth, color, texture, structure etc.) which can be utilized for the planning and development.

MATERIAL AND METHOD

Chhattisgarh state has been divided into three agro-climatic zones *viz.* Chhattisgarh plains, Bastar Plateau, and Northern hills zone covering 51, 28 and 21 % of the geographical area, respectively. The location of the state is such that it is close to the Bay of Bengal, which is instrumental in bringing monsoon in the Northern part of the country. The state is comprised of 27 districts, bordered by Jharkhand and Uttar Pradesh in the north, Andhra Pradesh in the south, Orissa in the east and Madhya Pradesh and Maharashtra in the west. The state lies at 17°46' N to 24°5'N latitude and 80°15' E to 84°20' E longitude.

Gariyaband district is situated in the fertile plains of Chhattisgarh Region. This district is situated between 20^o 57' N and 81^o 53' E and at an altitude of 292 meters MSL. The Gariyaband district is surrounded by district Raipur, Mahasamund, Dhamtari and Orissa State in the East. The present investigation were carried in 91 villages out of 710 villages of five blocks (viz., Fingeshwar, Chhura, Gariyaband, Mainpur and Devbhog) in Gariyaband district of Chhattisgarh. Geographical and other information related to district given in Table 3.1. The region comes under hot, sub humid climate, having average rainfall of 1157.1 mm. The maximum temperature during the summer may exceed up to 46^0C and the minimum temperature often falls below 9.0^0C during winter season. The hottest and coolest months are May and December, respectively.

Geological and morphological parameters were used to facilitate the selection. Three soil profiles were identified, excavated, described and sampled following standard procedures (FAO, 1977; Munsell Color Company, 1954; Soil Survey Staff, 1999). The colour of the soil horizons were determined by matching the colour with Munshell Soil Color Chart. Exact locations of the sites in terms of international coordinates were determined using Global Positioning System (GPS) Receiver.

Table 1 Salient features of profile under investigation

	Pedon-1	Pedon-2	Pedon-3
Location	Village –Mohanda Tehsil- Mohanda Distt- Gariyaband	KVK farm – Gariyaband Tehsil- Gariyaband Distt- Gariyaband	Village – Kokdi Tehsil- Gariyabandh Distt- Gariyabandh
Physiographic position	$20^0 22'$ N latitude $83^0 13'$ E longitude	$20^0 38'$ N latitude $82^0 04'$ E longitude	$20^0 38'$ N latitude $82^0 57'$ E longitude
Annual av. rainfall (mm)	1200 -1400 mm	1200 -1400 mm	1200 -1400 mm
Land slope	3-6 % Gently slopping	1-4 % Very gently slopping	1-3 % Very gently slopping
Drainage and permeability	Well drain and slow permeability	Moderately drain and slow permeability	Poorly drain
Land use and vegetation	Urd, Tamarind, Babul, Plum	Chickpea Paddy, Wheat, , Tamarind, Guava , Plum	Paddy, palaas and Babul,
Geology and parent material	Quartzide, sandstone	Alluvium	Alluvium

RESULTS AND DISCUSSION

Morphological Characteristics of Soils

Three representative pedons were examined for morphological properties and results are presented in Table 2.

Depth of soil

The results presented in Table 2 revealed that the depth of different pedons varied from 70 cm to 156 cm. The lowest depth of 70 cm was observed in pedon-1 and depth of pedon-2 and pedon-3 were recorded 155 and 156 cm, respectively. The soils on more slopping positions are generally shallow and have weekly-developed profile in pedon-1due to accelerated erosion that removes surface materials before it has time to develop. Percolation of water through the soil gets reduced because of runoff. Moreover, availability of water to plants is reduced which are responsible for checking of erosion and soil formation. On nearly leveled topographic positions, almost the entire water received as rainfall percolate through the soil. Therefore, deep profiles were observed in pedon-2 and pedon-3. Similar result was also observed by Parmasivan and Jawahar (2014) and they reported that the maximum depth of the soils *Vertisols* ranged from 115 to 150 cm in southern region of Tamil Nadu state of India.

Soil Color

The data in Table 2 presents morphological characteristics of three representative pedons of the Gariyaband district. It is evident from the results that yellowish brown (10YR5/4) to very dark gray (10Y3/1) in color. The yellowish brown (10YR 5/4 to 10YR 5/6) color in case of pedon-1, dark grayish brown (2.5Y3/2) to grayish brown (2.5Y5/2) color for pedon-2 and gray (10YR5/1) to very dark gray (10YR3/1) for pedon-3 were observed. Meena *et al.,* (2014) also observed the similar characteristics for Inceptisols of Hubali district at Karnataka which was further supported by Walia and Chamuah (1992) and Bhaskar and Sarkar (2013). In case of pedon-3, lower chromas exhibited darker color in surface horizon due to presence of higher organic matter contents. However, at lower depth higher chromas with decreasing level of organic matter were also recorded. Such reports were also presented by Parmasivan and Jawahar (2014) who had noticed hue 10 YR with value varied from 3-4 and chroma 1-2 due to the occurrence of free cations in *Vertisols* of southern region at Tamil Nadu.

Soil Texture

The data presented in the Table 2 indicate that textural classes of soil of different pedons varied from sandy clay loam to clay soil. Sandy clay loam texture was observed in surface and subsurface horizons of pedon-1. Likewise, Meena *et al*. (2014) reported that the sandy loam to sandy clay loam texture were observed in surface and subsurface soils (*Inceptisols*) of Hobli district of Karnataka.Pedon-2 displayed clay loam texture in surface and subsurface horizons up to depth 77 cm and sandy clay texture were found in other lower horizons of pedon-2. Clayey texture was found in entire horizons of pedon-3 and clay content progressively increased in lower horizons. These results are in accordance with the earlier findings of Srinivasa Rao *et al.,* (2008) in Black soils where clay content increased with increase in depth. The mean values of sand percent were 58.17, 39.18 and 28.3 in pedon-1, pedon-2 and pedon-3 respectively. Sand fraction decreased with increasing soil depth in pedon-1 however,pedon-2 and pedon-3 showed an increasing trends. The average percent of silt fraction in three pedons (pedon-1, pedon-2 and pedon-3) were in the order of 11.93, 23.20 and 17.88, respectively. In general, these fractions was found higher in surface horizons and lower percent were found in sub surface horizons of pedons-2 and pedon-3, while such variation was not observed in pedon-1 although it decreased in lower horizon. The average values of percent clay contents were 29.90, 37.62 and 53.82 in pedon-1, pedon-2 and pedon-3, respectively. The percent clay content was lower in upper horizons and increased with increasing depth. The enrichment of clay content in lower horizon may be due to illuviation or vertical migration of clay. Similar results were also opined by Sarkar *et al.,* (2002).

Soil Structure

The data pertaining to soil structure in three pedonsare presented in Table 2. Results revealed that subangular blocky (sbk) type of structure was identified in all pedons except inpedon-2 whereinangular blocky type structure was observed in subsurface horizon (B_{t4}). Week grade (1) in surface horizon of the pedon-1 and pedon-3 and moderate grade (2) was found in pedon-2. Subsurface horizon (2,m,sbk) were noticed to be common in pedon-1 and pedon-2.Subsurface horizon (3,m,sbk) were found in pedon-2, Almost all the horizons of the profiles strong, medium, and sub angular blocky (2,m,sbk) and angular blocky (3,m,abk) type of structure observed in subsurface horizon which may be attributed to higher clay content and low organic matter content (Singh and Agrawal 2005).

The surface horizon of pedon-1 had very hard (dry) and friable (moist) consistency. Whereas, Pedon-3 showed characteristics of *Vertisols* such as slickensides, pressure faces and cracks. These soils had well developed slickenside in Bss3. Intersecting slickensides forming structural aggregates that break mostly to strong coarse, angular blocky peds. Few, very fine to fine roots 2 to 11 cm wide with continuous vertical cracks and diffused wavy boundaries between horizons has been observed. Similar characteristics of *Vertisols* group was also described by Ram *et al.* (2010).

Bulk Density

Bulk density of different horizons Table 2 ranged from 1.36-1.47, 1.32-1.49 and 1.24 -1.37 Mg m^{-3} with mean value of 1.43, 1.41, and 1.31 Mg m^{-3} in pedon -1 ,pedon -2 and pedon -3, respectively. In general, bulk density increased with depth. Lower bulk density of surface soils could be attributed to higher organic matter content (Rao *et al.,* 2008), whereas higher bulk density in sub-surface horizons might be due to greater compaction in soils (Jewitt *et al*., 1979; Ahuja *et al*., 1988).

Table 2 Morphological and physical properties of the Pedons

	Sl. No.	Depth (cm)	Horizon	Color	Sand (%)	Silt (%)	Clay (%)	Structure	Texture	Bulk Density (g/cc)
Pedon-1	1	0 – 20	Ap	10YR5/4	61.1	12.8	26.1	1,m,sbk	Scl	1.36
	2	20 – 45	BW_1	10YR5/6	57.6	13.2	29.2	2,m,sbk	Scl	1.40
	3	45 – 70	BW_2	10YR5/6	55.8	9.8	34.4	2,m,sbk	Scl	1.47
	4	70 – 100	C_r	Weathering Parent Material						
		Mean	-	-	58.17	11.93	29.90	-	-	1.43
Pedon-2	1	0 – 17	Ap	2.5YR5/2	35.5	31.4	33.1	2,m,sbk	Cl	1.32
	2	17 – 47	Bt_1	2.5YR4/2	37.3	26.6	36.1	3,m,sbk	Cl	1.34
	3	47 – 77	Bt_2	2.5YR4/2	39.7	21.7	38.6	3,m,sbk	Cl	1.44
	4	77 – 130	Bt_3	2.5YR3/2	41.6	19.2	39.2	3,m,sbk	SC	1.49
	5	130 –155	Bt_4	2.5YR3/2	41.8	17.1	41.1	3,c,abk	SC	1.46
		Mean	-	-	39.18	23.20	37.62	-	-	1.41
Pedon 3	1	0 – 18	Ap	10YR5/1	20.5	29.1	50.4	1,m,sbk	C	1.24
	2	18 – 42	$B_{W;}$	10YR4/2	33.7	12.8	53.5	2,m,sbk	C	1.29
	3	42 – 68	B_{ss1}	10YR4/2	25.6	18.9	55.5	2,m,sbk	C	1.30
	4	68 – 110	B_{ss2}	10YR3/1	27.8	13.9	58.3	2,m,sbk	C	1.34
	5	110 – 156	B_{ss3}	10YR3/1	33.9	14.7	51.4	2,m,sbk	C	1.37
		Mean	-	-	28.3	17.88	53.82	-	-	1.31

Soil classification

Based on morphological and physico-chemical characteristics, soils were classified into different soil-groups adopting the standard procedure (Soil Survey Staff, 1999). The classification took in to account of presence and absence of diagnostic surface and subsurface horizons, temperature and moisture regimes and other specific characters (Table 3).

The Pedon 1 in the present study was grouped in *Inceptisols* soil order due to change in color and some accumulation of clay in sub-surface horizon indicating the presence of cambic B horizons. All the pedons belonged to *Ustepss*uborder since they had *Ustic* soil moisture regime. The horizons were simple and no calcic or gypsic or duripan were observed, thus they fell in*Haplustepts* Great Group. All the pedons represented the central concepts of great group and hence classified as Typic*Haplusteps* at subgroup level. These results are in conformity with those of Patil and Prasad (2004).

The Pedon 2 were set out in *Alfisols* due the presence of argillic horizons (Bt i.e. accumulation of clays) with *ustic* soil moisture regime and thus belonged to *Ustalfs* suborder, since the horizons sampled had no calcic or gypsic or duripan observed and placed in *Haplustalfs* Great Group. Finally this pedon has been classified at subgroup level as Typic*Haplustalfs* being representing the central concept of Great Group. Gupta *et al.,*(1999) and Pradeep and Verma (2005) have also reported the similar results with*Haplusters*.

The Pedon 3 was classed in *Vertisols*soil order because of the presence of wide cracks, slicken sides and high clay content. Due to the presence of ustic soil moisture regime, it was placed in usterts suborder. No salic or gypsic or calcic or duripan were observed in subsurface horizons, hence, it belonged to *Haplusters* Great Group. Further it was classified as typic at subgroup level since it represented the central concept of Great Group. The results corroborate the findings of Gupta *et al*., (1999) and Singh *et al.*, (2000).

Table 3 Classification of the different soils identified in gariyaband district

Pedons	Classification	Soil order
Pedon 1	Fine sand clay loamy, kaolinitichyperthermic, *TypicHaplustepts*	*Inceptisols*
Pedon 2	Fine clay loamy, kaolinitic mixed hyperthermic,*TypicHaplustalfs*	*Alfisols*
Pedon 3	Fine clay , Montmorillonitic mixed hyperthermic,*TypicHaplusterts*	*Vertisols*

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Impact and Assessment of Jalyukt Shivar Abhiyaan, Water Conservation Scheme in Maharashtra State of India

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ABSTRACT

Maharashtra government has launched the project "Jalyukt Shivar Abhiyaan" in a bid to make Maharashtra a drought-free state by 2019. The Maharashtra government has spent around Rs 1,400 crore on its flagship water conservation programme 'Jalyukt Shivar Abhiyaan' and completed work in 2,939 villages since its launch in March this year, a state CMO official said. The project involves deepening and widening of streams, construction of cement and earthen stop dams, work on nullahs and digging of farm ponds. The IMPACT AND ASSESSMENT OF JALYUKT SHIVAR ABHIYAAN WATER CONSERVATION SCHEME IN MAHARASHTRA STATE OF INDIA, work out with following, main objectives set by the Government of Maharashtra state to overcome regular drought in particular region of Maharashtra state can be effectively accomplished by the Jalyukt Shivar Abhiyaan. The main focus of water scarcity in the state which was believe to be overcome by 2019 can be achieved by Jalyukt Shivar Abhiyaan. As the above stated objectives get accomplished there will be scope for industrialization in Maharashtra state which is the boost for overcome the local employment problem.

Keywords: Water conservation, Industrialisation, Employment generation.

INTRODUCTION

Maharashtra government has launched the project "Jalyukt Shivar Abhiyaan" in a bid to make Maharashtra a drought-free state by 2019. The Maharashtra government has spent around Rs 1,400 crore on its flagship water conservation programme 'Jalyukt Shivar Abhiyaan' and completed work in 2,939 villages since its launch in March this year, a state CMO official said. The project involves deepening and widening of streams, construction of cement and earthen stop dams, work on nullahs and digging of farm ponds. The mobile app, developed by MRSAC, is being used to map these locations. The mapped location can be monitored through this web page. The user will be able to download the application, view instruction manual and view mapping locations along with photographs. District-wise, taluka-wise, work-wise statistics is also available both in tabular and graphics form. The project aims to make 5000 villages free of water scarcity every year. In a state where over 3,200 farmers have committed suicide in 2015, if there is some ray of hope to significantly help the agrarian community in the drought-hit and parched lands of Maharashtra, then it possibly is in a much-applauded scheme – micro irrigation, which delivers water right at the base of the plant through a system of flexible irrigation tubing, drip emitters, and micro sprays.

Jalyukta Shivar Abhiyaan - Committees

Monitoring and implementation of JalyuktShivar Abhiyan carried out in Maharashtra state by following committees:

- Taluka level committee under the chairmanship of Sub Divisional Officer .
- District level committee under the chairmanship of District Collector.
- District level monitoring and review committee under the chairmanship of Guardian Minister.
- Divisional level Co-ordination Committees under the chairmanship of respective Divisional Commissioners.

Jalyukt Shivar Abhiyan :- Public Awareness

- Gram Sabha / Meetings at Village.
- To Arrange Morning Rallies, Essay Compétition, Drawing Compétition,

Elocution etc. For creating Awareness among students.

- Creation of Awareness Through Electronic Media.
- To Distribute Booklets, Leaflets Regarding Mission.
- To Advertise Through Jingles.
- Effective Use of Publicity Media (Like Press, T.V.).

Objective of the campaign

Considering drought-like situation occurring frequently in the state, Jalyukta Shivar campaign is being taken up under 'water for all - drought-free Maharashtra 2019':

- Harvesting maximum rainwater in the surrounding of village itself.
- Increasing level of groundwater.
- Increasing area under irrigation in the state - Increasing assured water for farming and efficiency of water usage.
- Guaranteeing availability of sufficient water for all in the state - Increasing water supply by resurrecting dead water supply schemes in the rural area.
- Implementing groundwater act.
- Creating decentralized water storages.
- Initiating new projects to create water storage capacity.
- Reinstating / increasing water storage capacity of existing and dysfunctional water sources (small dams / village tanks / percolation tanks / cement dams).
- Extracting sludge from existing water sources through public participation and increasing water storage of water sources.
- Encouraging tree plantation and planting trees.
- Creating public concern / awareness about balanced use of water.
- Encouraging / creating awareness about efficient utilization of water for farming.
- Sensitising people about water harvesting / increasing public participation.

Objective of the Study

- To study the area covered under the jalyukt shivar abhiyan in Maharashtra state.
- To study expenditure and costs in jalyukt shivar abhiyan in Maharashtra state.
- To study the status of the Reservoir in Maharashtra state.
- To examine reports of VEDC.

Jalyukt Shivar Abhiyan- Fund Flow

Sr. No.	Activity Detail	Fund Flow	Implementing Agency
1	Compartment Banding, Graded Band, Farm Pond ENB, CCT	IWMP, MNREGA, NHM, State fund, TSP ,OTSP, VIIDP, SCP	Agriculture
2	CNB/Nalla Deepning/Nalla Widning	CM Relief Fund, IWMP State Fund, DPDC, MP/MLA Fund, VIIDP, ZP CESS Fund, NGO's Fund, Co-Operative Sugar Factories, CSR and Other institutional Fund	Agriculture and Small Scale Irrigation (water Conservation)

Sr. No.	Activity Detail	Fund Flow	Implementing Agency
3	Rejuvenation of Old Structures of Water Conservation	CM Relief Fund, State Fund, DPDC, ZP CESS Fund, NGO's Fund, Co-Operative Sugar Factories, CSR and Other institutional Fund, Machinery available in department, Mahatma Phule Jal bhumi Abhiyan, MNREGA, IWMP-EPA Fund.	Agriculture and Small Scale Irrigation (water Conservation)
4	To Improve usage of existing Water Conservation Structure like KT Weir, Storage Bandhara.	State Fund , DPDC, ZP CESS Fund , **NGO's Fund,** Co-Operative Sugar Factories, Public Participation	Agriculture and Small Scale Irrigation (water Conservation)
5	Optimum use of Irrigation Potential of existing Major and Medium projects.	State Fund , DPDC, NGO's Fund, Co-Operative Sugar Factories, **Public Participation**	Water Resources Department
6	Connecting Nallas with Rivers Joining projects	State Fund	Water Resources Department
7	Desilting of Percolation Tank, Village Tank, Storage Tank, Shivkalin Tank, Britishkalin Tank, Nizamkalin Tank, ENB etc.	MNREGA, Public Participation, Co-Operative Sugar Factories, Mahatma Phule Jalbhumi Abhiyan,	Agriculture and Small Scale Irrigation (water Conservation), ZP
8	Strengthening of Drinking Water resources	ZP CESS Fund and DPDC, Central Fund	Water Supply Department, GSDA and ZP
9	Recharging of open dug wells and tube wells	MNREGA, Mahatma Phule Jalbhumi Abhiyan,	Agriculture and GSDA
10	Efficient use of available waters and cropping pattern	National Micro Irrigation Mission, State Fund	Agriculture
11	Dryland Agriculture Farming Mission	State Fund	Agriculture
12	Strengthening of Water User Associations	State Fund, Public Participation	WRD/ WCD
13	Channel Repairing	MNREGA	WRD EGS
14	Public Awareness	IWMP, Mahatma Phule Jal Bhumi Abhiyan	Agriculture
15	Publicity	IWMP, Mahatma Phule Jal Bhumi Abhiyan	Agriculture

Methodology

For this study secondary data from various sources like government of Maharashtra publication, portals and economic survey of Maharashtra 2014-15 were collected for the year 2014-15 and 2015-16 resp. The gathered data were analysed for the percentage on total basis in the state as well as Vidarbha region in Maharashtra state with simple tabular analysis of the gathered facts and figures.

RESULT AND DISCUSSION

Table 1 Percentage distribution of Jalyukt shivar Abhiyaan Districtwise in Maharashtra 2015-16.

District	Total	Mapped	Unmapped	Received
	%	%	%	%
Akola	1.40	1.28	1.54	1.47
Amravati	3.10	1.32	5.31	0.88
Ahmednagar	4.85	**7.50**	1.58	**8.31**
Usmanabad	**6.35**	5.20	**7.77**	3.92
Aurangabad	2.49	3.14	1.68	4.83
Kolhapur	0.95	0.60	1.39	0.60
Gadchiroli	2.18	2.39	1.91	2.30
Gondiya	1.23	0.79	1.78	1.17
Chandrapur	**6.43**	**7.32**	5.34	**6.21**
Jalgaon	3.09	3.04	3.15	3.08
Jalna	2.82	0.99	5.08	1.50
Thane	1.71	1.83	1.56	2.21
Dhule	1.47	2.17	0.62	2.82
Nandurbar	1.66	2.79	0.26	2.51
Nanded	2.48	2.73	2.17	2.82
Nagpur	2.19	2.87	1.36	2.78
Nasik	3.54	4.12	2.81	5.70
Parbhani	2.12	1.27	3.18	1.87
Palghar	1.17	0.91	1.49	0.75
Pune	3.09	4.47	1.38	4.63
Beed	2.02	1.78	2.32	1.83
Buldhana	5.38	3.35	7.90	3.24
Bhandara	0.90	0.52	1.37	0.74
Yavatmal	5.62	1.58	**10.62**	1.41
Ratnagiri	0.98	1.73	0.06	1.90
Raygad	0.48	0.61	0.32	0.50
Latur	3.15	1.47	5.23	2.23
Wardha	4.38	1.48	**7.97**	1.62
Washim	1.46	1.58	1.32	1.74
Sangli	2.36	2.05	2.75	1.71
Satara	3.32	3.93	2.58	3.21
Sindhudurga	0.33	0.35	0.31	0.26
Solapur	**13.98**	**22.07**	3.99	**18.31**
Hingoli	1.28	0.78	1.90	0.95
Total %	100	100	100	100

Table 1 reveals the percrntage distribution of the districtwise Jalyukt Shivar Abhiyaan in the Maharashtra state. Table 1 shows that the total worked carried out in Solapur district as 13.98 per cent was the higher amongst all other district of Maharashtra state, followed by Chandrapur and Usmanabad as 6.43 and 6.35 per cent resp. In case of Mapped area covered Solapur region shows 22.07 per cent followed by 7.50 and 7.32 per cent in Ahmednagar and Chandrapur district resp. As peer into the area unmapped 10.62 per cent work carried out in Yavatmal district which was higher, followed by Wardha and Usmanabad district found as 7.97 and 7.77 per cent resp. In caseof received work Solapur district shows 18.31 percentage of work done which is the higher percentage received in the state, followed by Ahmednagar and Chandrapur district as 8.31 and 6.21 per cent resp.

Further table 2 depicts the percrntage distribution of the Jalyukt Shivar Abhiyaan in the Vidarbha region. From table 2 it is conclude that the total worked carried out in Chandrapur district as 18.76 per cent was the higher amongst all other district of Vidarbha region, followed by Yavatmal and Buldhana as 16.40 and 15.70 per cent resp. In case of Mapped area covered Chandrapur district shows 29.93 per cent followed by 13.68 and 11.72 per cent in Buldhana and Nagpur district resp. As peer into the area unmapped 22.87 per cent work carried out in Yavatmal district which was higher, followed by Wardha and Buldhana district found as 17.17 and 17.02 per cent resp. In case of received work Chandrapur district shows 26.35 percentage of work done which is the higher percentage received in the state, followed by Buldhana and Nagpur district as 13.75 and 11.81 per cent resp.

Table 2 Percentage distribution of jalyukt shivar abhiyaan work in Vidarbha 2015-2016.

District	Total	Mapped	Unmapped	Received
	%	%	%	%
Akola	4.07	5.22	3.32	6.25
Amaravati	9.05	5.38	11.44	3.74
Gadhchiroli	6.34	9.77	4.12	9.76
Gondiya	3.60	3.23	3.84	4.97
Chandrapur	**18.76**	**29.93**	11.50	**26.35**
Nagpur	6.39	**11.72**	2.92	**11.81**
Buldhana	**15.70**	**13.68**	**17.02**	**13.75**
Bhandara	2.63	2.12	2.96	3.13
Yavatmal	**16.40**	6.46	**22.87**	5.98
Wardha	12.79	6.04	**17.17**	6.89
Washim	4.27	6.46	2.84	7.37
Total	**100**	**100**	**100**	**100**

Table 3 PercentagedistributionTalukawiseinVidarbha2015-16

District	Taluka	Total	Mapped	Unmapped	Received
		%	%	%	%
Amravati	Achalpur	3.36	5.56	2.68	5.85
	Amravati	10.85	8.54	11.55	9.92
	Chandur- Bajar	6.66	3.37	7.67	3.07
	Chandur Railway	3.52	7.83	2.21	7.42
	Chikhaldara	3.17	1.02	3.84	1.71
	Tiwasa	7.91	11.35	6.86	10.56
	Daryapur	11.41	**11.51**	11.39	**10.71**
	Dhamangaon Railway	5.14	8.61	4.07	8.21
	Dharni	3.91	4.39	3.76	4.14
	Nandgaon khandeshwar	4.18	7.75	3.09	7.35
	Bhatkuli	1.98	1.80	2.04	1.64
	Morshi	**11.49**	10.96	**11.65**	10.21
	Warud	**21.25**	**15.27**	**23.08**	**17.20**
	Total	100.00	100.00	100.00	100.00

Contd....

District	Taluka	Total	Mapped	Unmapped	Received
		%	%	%	%
Nagpur	Narkhed	**13.23**	10.58	**20.17**	**9.18**
	Nagpur (Rural)	5.43	6.15	3.56	4.34
	Parshivni	1.82	1.58	2.44	1.08
	Bhivapur	7.36	9.21	2.53	8.07
	Mauda	2.34	2.27	2.53	2.53
	Ramtek	12.14	**11.37**	**14.17**	8.25
	Savner	4.24	4.86	2.63	4.93
	Hingana	**15.47**	**16.58**	12.57	**11.84**
	Total	100.00	100.00	100.00	100.00
Wardha	Aarvi	12.23	12.35	12.20	**16.86**
	Aashti	6.80	11.03	5.83	8.76
	Karanja	**20.58**	**17.86**	**21.21**	15.31
	Devli	11.51	10.61	11.72	11.74
	Wardha	7.28	15.56	5.38	14.84
	Samudrapur	**18.53**	12.42	**19.93**	14.11
	Selu	7.54	3.14	8.54	2.44
	Hinganghat	15.53	**17.03**	15.19	**15.93**
	Total	100.00	100.00	100.00	100.00

Table 3 shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinVidarbha2015-16. In this table central Vidarbha zone which comprises of the Amaravati, Nagpur and Wardha district shows the fruitfull results of the Jalyukt Shivar Abhiyaan, in Amravati Warud taluka shows 21.25 per cent work carried out followed by Morshi and Daryapur as 11.49 and 11.41per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerened. In case of mapped work again Warud taluka leading the Amaravati district as 15.27 per cent followed by Daryapur as 11.51 per cent and Tiwasa as 11.35 per cent resp. In case of unmapped area covered work Warud taluka shows higher work carried out in the Amaravati district as 23.08 per cent followed by Morshi as 11.65 per cent and Daryapur as 11.39 per cent resp. In received area covered Warud taluka shows 17.20 per cent while Daryapur shows 10.71 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 3.

Table 3 furthe shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wisein Nagpur district Hingana taluka shows 15.47 per cent work carried out followed by Ramtek as 12.14 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again Hingana taluka leading the Nagpur district as 16.58 per cent followed by Ramtek as 11.37 per cent resp. In case of unmapped area covered work Ramtek taluka shows higher work carried out in the Nagpur district as 14.17 per cent. In received area covered Hingana taluka shows 11.84 per cent while ramtek shows 8.25 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 3. Table 3 furthe shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wisein Wardha district Karanja taluka shows 20.58 per cent work carried out followed by Samudrapur as 18.53 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again Karanja taluka leading the Wardha district as 17.86 per cent followed by Hinganghat as 17.03 per cent resp. In case of unmapped area covered work Karanja taluka shows higher work carried out in the Wardha district as 21.21 per cent. In received area covered Aarvi taluka shows 16.86 per cent while Hinganghat shows 15.93 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 3.

Table 4 PercentagedistributionTalukawiseinVidarbha2015-16.

District	Taluka	Total	Mapped	Unmapped	Received
		%	%	%	%
Gadchiroli	Aheri	9.80	11.39	7.33	12.21
	Aarmori	5.11	4.62	5.86	3.80
	Atapalli	12.15	**14.03**	9.26	**12.45**
	Kurkheda	6.76	5.83	8.19	5.91
	Korchi	4.06	4.32	3.66	4.24
	Gadchiroli	**17.65**	**17.95**	**17.19**	**23.18**
	Chamorshi	5.19	3.63	7.59	3.59
	Desaing Vadsa	2.99	3.71	1.87	3.23
	Dhanora	**15.87**	12.69	**20.79**	11.25
	Bhamragad	6.16	5.39	7.33	5.23
	Mulchera	6.47	9.28	2.13	9.47
	Sironcha	7.81	7.16	8.79	5.45
	Total	100.00	100.00	100.00	100.00
Gondiya	Ajurni / Morgaon	7.07	11.24	4.79	14.25
	Aamgaon	3.84	6.80	2.22	7.58
	Gondiya	**27.45**	12.42	**35.67**	9.84
	Goregaon	13.96	10.20	16.01	10.32
	Tiroda	10.72	**19.74**	5.79	16.40
	Devari	12.57	**17.52**	9.86	**21.51**
	Sadak / Ajurni	4.34	5.10	3.93	5.11
	Salekasa	**20.06**	16.99	**21.73**	**15.00**
	Total	100.00	100.00	100.00	100.00
Chandrapur	Korpana	4.11	4.30	3.79	3.23
	Gond Pipri	5.52	7.85	1.57	6.84
	Chandrapur	2.28	1.82	3.05	2.63
	Chimur	**10.37**	**11.71**	8.11	**13.93**
	Jivti	**24.53**	**26.23**	**21.66**	**20.54**
	Nagbhid	5.75	7.85	2.19	6.36
	Pombhurna	5.90	5.83	6.01	5.42
	Balharpur	6.44	9.89	0.60	11.64
	Bramhapuri	2.71	3.72	1.00	4.84
	Bhadravati	7.57	4.66	**12.50**	5.86
	Mul	4.49	2.17	8.42	3.12
	Rajura	6.96	3.75	12.40	3.30
	Warora	6.28	3.85	10.40	5.28
	Savali	3.60	2.47	5.51	2.68
	Sindevahi	3.49	3.92	2.77	4.32
	Total	100.00	100.00	100.00	100.00
Bhandara	Tumsar	**21.48**	16.10	**23.98**	12.01
	Pavani	10.99	8.55	12.13	9.54
	Bhandara	17.88	**20.87**	16.48	**19.51**
	Mohadi	**23.94**	**31.41**	**20.46**	**26.06**
	Lakhani	11.37	8.15	12.87	14.40
	Lakhandur	5.81	5.96	5.74	7.75
	Sakoli	8.53	8.95	8.33	10.73
	Total	100.00	100.00	100.00	100.00

Table 4 shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinVidarbha2015-16. In this table eastern Vidarbha zone which comprises of the Gadhchiroli, Gondiya, Bhandara and Chandrapur district shows the work caaried out in the Jalyukt Shivar Abhiyaan, in Gadhchiroli,Gadhchiroli taluka shows 17.65 per cent work carried out followed by Dhanora as 15.87 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerened. In case of mapped work again Gadhchiroli taluka leading the Gadhchiroli district as 17.95 per cent followed by Atapalli as 14.03 per cent resp. In case of unmapped area covered work Dhanora taluka shows higher work carried out in the Gadhchiroli district as 20.79 per cent followed by Gadhchiroli as 17.19 per cent resp. In received area covered Gadhchiroli taluka shows 23.18 per cent while Atapalli shows 12.45 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 4.

Table 4 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinGondiya district Gondiya taluka shows 27.45 per cent work carried out followed by Salekasa as 20.06 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work Tiroda taluka leading the Gondiya district as 19.74 per cent followed by Devari as 17.52 per cent resp. In case of unmapped area covered work Gondiya taluka shows higher work carried out in the Gondiya district as 35.67 per cent. In received area covered Devari taluka shows 21.51 per cent while Salekasa shows 15.00 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 4. Table 4 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinChandrapur district Jivti taluka shows 24.53 per cent work carried out followed by Chimur as 10.37 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again Jivti taluka leading the Chandrapur district as 26.23 per cent followed by Chimur as 11.71 per cent resp. In case of unmapped area covered work Jivti taluka shows higher work carried out in the Chandrapur district as 21.66 per cent. In received area covered Jivti taluka shows 20.54 per cent while Chimur shows 13.93 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 4.

Table 4 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wisein Bhandara district mohadi taluka shows 23.94 per cent work carried out followed by Tumsar as 21.48 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again mohadi taluka leading the Bhandara district as 31.41 per cent followed by Bhandaratalukaas 20.87 per cent resp. In case of unmapped area covered work Tumsar taluka shows higher work carried out in the Bhandara district as 23.98 per cent. In received area covered mohadi taluka shows 26.06 per cent while Bhandara taluka shows 13.93 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 4.

Table 5 PercentagedistributionTalukawiseinVidarbha **2015-16.**

District	Taluka	Total	Mapped	Unmapped	Received
		%	%	%	%
Akola	Akot	8.53	10.51	6.52	11.70
	Akola	**25.07**	**27.24**	**22.85**	**22.59**
	Telhara	16.66	**22.72**	10.48	**25.88**
	Patur	**20.13**	12.53	**27.89**	11.23
	Barshi -Takli	5.19	5.09	5.28	5.85
	Balapur	9.47	9.38	9.57	9.95
	Murtijapur	14.94	12.53	17.41	12.81
	Total	100.00	100.00	100.00	100.00
Buldhana	Khamgaon	11.15	9.03	12.26	8.41
	Chikhali	6.41	7.24	5.98	6.62
	JalgaonJamod	5.26	3.73	6.06	2.35
	Devulgaon Raja	4.52	4.50	4.53	6.16
	Nandura	0.77	0.52	0.90	0.97
	Buldhana	7.30	**14.51**	3.53	12.30
	Malkapur	2.21	3.76	1.40	3.21
	Mehkar	**12.97**	**22.50**	7.99	**19.29**
	Motala	5.45	8.51	3.85	7.30
	Lonar	6.61	4.16	7.90	2.99
	Shegaon	**13.06**	5.49	**17.02**	5.52
	Sangrampur	**12.98**	3.36	**18.01**	2.70
	Sindkhed Raja	11.30	12.70	10.57	**22.18**
	Total	100.00	100.00	100.00	100.00

Contd....

District	Taluka	Total	Mapped	Unmapped	Received
		%	%	%	%
Yavatmal	Aarni	**8.31**	12.93	7.46	12.41
	Umarkhed	5.37	2.55	5.89	2.95
	Kalamb	5.77	**16.00**	3.90	13.43
	Kelapur	8.16	4.11	8.91	3.48
	Ghatanji	2.84	14.76	0.65	**19.59**
	Zari Jamni	5.92	3.40	6.38	3.44
	Darvha	8.01	2.94	8.94	3.12
	Digras	6.89	2.42	7.71	5.18
	Ner	3.66	1.96	3.97	1.74
	Pusad	3.32	4.51	3.11	4.15
	Babhulgaon	8.46	4.64	**9.16**	3.70
	Mahagaon	2.11	3.98	1.76	3.79
	Maregaon	6.18	3.33	6.70	2.59
	Yavatmal	**11.02**	**17.05**	**9.91**	**15.57**
	Ralegaon	6.87	1.76	7.80	1.87
	Vani	7.12	3.66	7.76	2.99
	Total	100.00	100.00	100.00	100.00
Washim	Karanja	16.98	18.29	15.06	**17.69**
	Mangrul-Pir	12.50	16.00	7.34	16.93
	Manora	**25.05**	**18.94**	**34.07**	16.53
	Malegaon	15.00	**18.81**	9.36	**18.05**
	Risod	**17.37**	13.65	**22.88**	15.15
	Washim	13.09	14.30	11.29	15.66
	Total	100.00	100.00	100.00	100.00

Table 5 shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinVidarbha2015-16. In this table western Vidarbha zone which comprises of the Akola, Buldhana, Yavatmal and Washim district shows the work caaried out in the Jalyukt Shivar Abhiyaan, in Akola, Akola taluka shows 25.07 per cent work carried out followed by Patur as 20.13 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerened. In case of mapped work again Akola taluka leading the Akola district as 27.24 per cent followed by Telhara as 22.72 per cent resp. In case of unmapped area covered work Patur taluka shows higher work carried out in the Akola district as 27.89 per cent followed by Akolataluka as 22.85 per cent resp. In received area covered Telhara taluka shows 25.88 per cent while Akola taluka shows 22.59 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 5.

Table 5 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinBuldhana district Shegaon taluka shows 13.06 per cent work carried out followed by Mehkar as 12.97 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work Mehkar taluka leading the Buldhana district as 22.50 per cent followed by Buldhanataluka as 14.51 per cent resp. In case of unmapped area covered work Shegaon taluka shows higher work carried out in the Shegaon district as 17.02 per cent. In received area covered Sindhkhed Raja taluka shows 22.18 per cent while Mehkar shows 19.29 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 5.

Table 5 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinYavatmal district Yavatmal taluka shows 11.02 per cent work carried out followed by Aarni as 8.31 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again Yavatmal taluka leading the Yavatmal district as 17.05 per cent followed by Kalamb as 16.00 per cent resp. In case of unmapped area covered work Yavatmal taluka shows higher work carried out in the Yavatmal district as 9.91 per cent. In received area covered Ghatanji taluka shows 19.59 per cent while Yavatmal taluka shows 15.57 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 5.

Table 5 further shows the percentagedistribution of Jalyukt Shivar Abhiyaan taluka-wiseinWashim district Manora taluka shows 25.05 per cent work carried out followed by Risod as 17.37 per cent as far as the total area covered in Jalyukt Shivar Abhiyaan is concerned. In case of mapped work again Manora taluka leading the Washimtaluka as 18.94 per cent followed by Malegaon taluka as 18.81 per cent resp. In case of unmapped area covered work Manora taluka shows higher work carried out in the Washim district as 34.07 per cent. In received area covered Malegaon taluka shows 18.05 per cent while Karanja taluka shows 17.69 per cent work done in Jalyukt Shivar Abhiyaan as indicated intable 5.

Table 6 Jalyukt Shivar Abhiyaan Works Status

Division	Selected Villages	Works Started In Villages	No. Of Works
Kokan	203	203	35396
Nashik	941	941	26764
Pune	903	903	34026
Aurangabad	**1682**	**1682**	**65263**
Amarawati	**1396**	**1396**	**25579**
Nagpur	1077	1077	15062
Total	**6202**	**6202**	**170233**

Under Jalyukta Shivar Abhiyan works of compartment bunding, desiltation, mud nalla bunding, cement check dams, repairs of bunding, KT weirs,farm ponds and village talao, refilling of wells, recharge shaft, drip irrigation and sprinkle irrigation have been brought together. District-wise details of works till July 10, 2015, is as follows:

Table 7 Impetus to Jalyukta Shivar Abhiyan

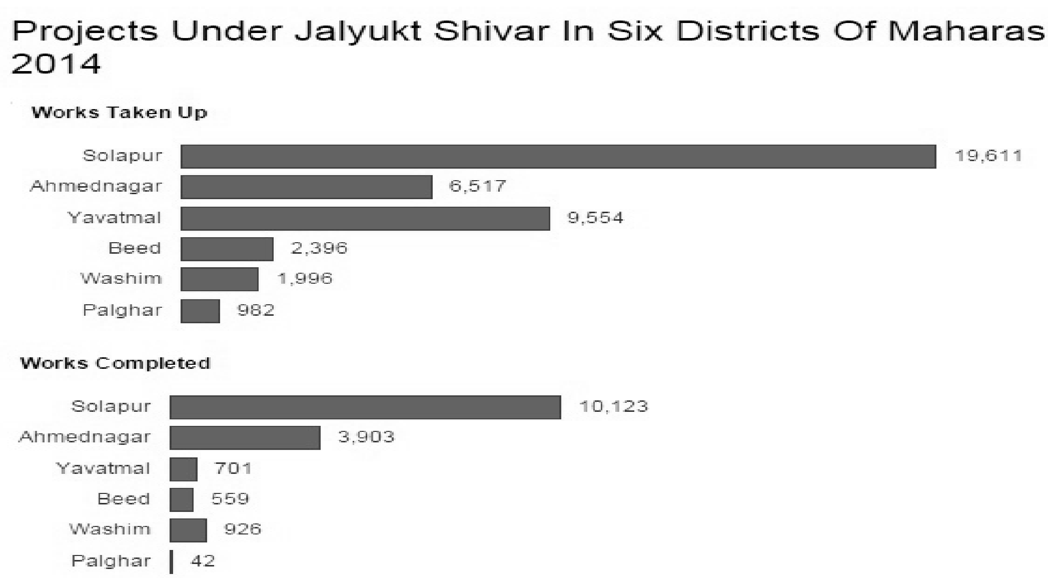
District	Villages Selected	Works started with public participation	Estimated cost of works (in crore)
Ahmednagar	219	**279**	2.59
Dhule	129	26	4.56
Jalgaon	232	71	5.47
Nandurbar	72	70	1.4
Nashik	229	128	11.89
Amravati	253	22	1.59
Akola	200	117	26.64
Buldhana	**330**	206	15.24
Washim	200	68	3.33
Yavatmal	**413**	46	5.46
Nagpur	313	134	0.06
Bhandara	86	86	0
Gondia	94	52	5.03
Chandrapur	218	30	0
Gadchiroli	152	58	0.69
Wardha	214	24	0.57
Pune	198	159	21.31
Satara	215	153	4.81
Sangli	141	93	1.78
Solapur	280	**280**	**27.3**
Kolhapur	69	69	0.0005
Thane	26	0	0
Palghar	50	25	0.0528
Raigad	45	1	0.5943
Ratnagiri	47	47	0.0003
Sindhudurg	35	9	0.0705
Aurangabad	228	135	18.11
Jalna	209	90	3.8
Beed	271	22	5.66
Parbhani	170	115	7.4
Hingoli	124	34	4.22
Nanded	261	85	15.97
Latur	202	162	**47.85**
Osmanabad	217	130	10.48
Total	**6202**	**3993**	**253.9311**

Provision of Funds

- Central Govt. Fund, State Govt. Fund, DPDC Fund are the main sources of the fund .
- Apart from regular DPDC Provision, Rs. 1600 Cr special provision is made available for the programme which can be used by collectors for any work of JSA. Also additional Rs. 400 Cr. will be made available in April, 2016.
- Under Rashtriya Krishi Vikas Yojana i.e. RKVY in 2014-15 Rs.75.00 Cr and in 2015-16 Rs.40.00 Cr grant was made available under Mahatma Phule Jalbhumi Abhiyan which is mainly used for providing fuel for desilting and deepening/widening of nalas, Rejuvenation of old water bodies.
- Integrated Watershed Management Programme is back bone and core part of the Jalyukt Shivar Abhiyan
- 5% scarcity programme fund and 5% of regular DPDC scheme fund is allowed to spent for JSA. Apart from this, 10% DPDC regular scheme fund is allowed to spent for repair works in JSA. 3.5% Innovative Scheme fund is allowed to spent on JSA. Up to Rs.20.00 lakhs from MLA Local Development Fund is also allowed to spent on repair works as well as new works
- Peoples contribution is also important and has contributed considerable amount by way of donations/shramdan.
- Corporate Social Responsibity – CSR is also source of fund.

Table 8 Distribution of State Reservoirs Add 148 TMC in 5 Days (6 Aug. 2016)

Region	Total projects	Capacity*	Aug 5*	%
Konkan	160	99.11	89.26	90.06
Marathwada	818	270.44	50.84	10.28
Nagpur	367	151.37	80.54	53.20
Amravati	480	105.75	68.57	64.84
Nashik	351	180.36	102.40	56.77
Pune	409	470.62	304.27	64.65
Others	11	62.88	49.71	79.14
Total	2596	1340.53	745.97	55.64
*Figure in TMC (Source: The Times of India, Nagpur Saturday, August 6, 2016 @timesgroup.com)				



Vidarbha Economic Development Council (VEDC) survey report of irrigation projects in Vidarbha.

A. **Findings of the survey by VEDC in Vidarbha**

- The Lower Wardha Project was proposed in Jan-1981 at Village Dhanodi (Bahadarpur), Tah. Arvi, Dist. Wardha with a project cost of 48.08 Crores.
- This project had a capacity to store 8.9 TMC of water. This could have irrigated 126 hectares in Arvi, 26920 hectares in Deoli, 9476 hectares in Wardha and 6728 hectares in Hinganghat Taluka.
- Thus a total of about 44150 hectares of land. The proposed lift-irrigation scheme and barrage would have added to about 4407 total potential of 63333 hectares of land if this project would have been completed in time. This project has affected villages in Amravati and Wardha District.
- The last financial approval to this project was given in 2011 and the present cost of the project as per the 2011 rates is Rs. 2356.57 Crores. As per figures available till Dec-2011, Rs. 1024.41 has been spent on this project.
- As per the affidavit filed by VIDC and Government of Maharashtra in Dec-2012, they have stated that the canal work on the forest land is complete. The main canal is 80% completed; distribution system is 45% completed. Potential created up to Jun-2012 is 17379 hectares. Till up to 2011-12, actual irrigation of 328 hectares has been done on this project.
- Gosikhurd irrigation project- VIDC filed an affidavit in reply to the Loknayak Bapuji Aney Smarak Samiti PIL, mentioning that the Gosikhurd irrigation project's dam & spillway were with storage up to RL 237.20 m. Earth work of right canal completed and structures were in progress. Lift Irrigation Scheme from 0-23 km. complete.
- Actual benefit to farmers started from 2011 -2012 actual irrigation of 325 ha is done.
- Rs. 8000 crores have been invested in the project but on visit it was found that actual irrigation benefit is reaching the farmers in 350 acres only .

B. **The Bembla Irrigation Project, Yavatmal, on 23rd Aug. 2015**

- The right bank canal of 113 km. 2012 i.e. two years from 2010 when the work was started, but it was not done.
- By another two years to July 2014 and the work was still not completed.
- It has now once again been extended by two years to July 2016 and the contractor has been paid an escalation cost of Rs. 41 crores.

C. Ner Dhamna Barrage Irrigation Project, Akola

- From the last two years the proposal for laying pipelines for 85 km which would take water to the farms, is pending with the Govt. of Maharashtra .

D. Ghungshi Irrigation Project, Akola District

- Where the canal is supposed to have been constructed, now there will be pipelines according to the new proposal with an additional cost of 80 crores.
- New barrage work has started now and is to be completed in June 2016. Then the work of distributaries and sub-distributaries network will get completed by end of 2019.

E. Katepurna Irrigation Project, Akola District

- The findings for Katepurna are similar to those of Ghungshi

F. Uma Irrigation Project, Akola District

- In spite of three years of no work for which he should rightly have been blacklisted, no action has been taken against contractor, nor any penalties realized from him which should have been to the tune of Rs. 1 lakh per day of absenteeism. On the contrary, surprisingly, he has been given the benefit of a cost-escalation of Rs. 9 crores.
- No other contractor has been employed either in the meantime.

- If the work had not stopped for three years, the farmers would have got water, preventing suicides. It must be remembered that Akola is a water-scarcity, suicide-affected belt.

Success Stories of Jalyukt Shivar Abhiyaan in Maharashtra

- The results of bending nature according to our whims are best explained by the villagers of Telhara, a small hamlet in the foothills of Satpuda range. With good precipitation, agriculture has been flourishing here. However, every year during the rains, the villagers used to be on their toes. River Gautama flows near the village and there was a huge encroachment on the banks. Trees were proliferating in the river bed and the river had become shallow. Every rainy season, Telhara used to get waterlogged and the farmers suffered huge losses. During the floods in 2014-15, an area of 383 ha around the village was affected. To overcome the problem, there was a need to deepen the river bed. People joined hands and a stretch of 10 km was deepened and widened. Sediment to the extent of 5.4 lakh cu.m was removed. The farmers made use of the sediment to make their soils fertile.
- The story of Divthana village in Akot taluka is similar. The stream at Divthana was deepened by the villagers, who also carried out repairs to existing cement nalla bunding. The farmers around said that the stream used to overflow during the rainy season. This year, the month of June went without rains, but the nalla had abundant water. The farmers could save the crops by pumping water from the nalla. A total of 70 cement nalla bundings were widened,deepened and repaired in the taluka alone.
- Another success story of Jalyukta Shivar Abhiyan has been recorded at Ghusar village in Akola district. The village has 256 farm ponds. One can spot these water bodies while passing through the village. The village comes under the salt land area. There is no other way for wet farming here. The farmers are now taking up crops such as cotton, soybean and gram with the support of these farm ponds.
- Sadarpur is another village, where a community lake has been built by the villagers. The lake has a storage capacity of 1.9 lakh cu. m of water. The130 m x 150 m lake can now give a new lease of life to 450 ha of agriculture land.

Jalyukt Shivar Abhiyan : Outcome / End Results

- Increase in Water Storage Capacity
- Recharge of Ground Water Level
- Increase under protective Irrigation Area
- Increase in Cropping intensity
- Increase in the Horticulture Area
- Increase in the Agriculture Produce and productivity
- Increase in Fodder Production
- Increase in area under Soil Moisture Security
- Improvement of Environment through Tree Plantation
- Improving Productivity and Socio-economic Condition of farmers

CONCLUSIONS

1. The main objectives set by the Government of Maharashtra state to overcome regular drought in particular region of Maharashtra state can be effectively accomplished by the Jalyukt Shivar Abhiyaan.
2. The main focus of water scarcity in the state which was believe to be overcome by 2019 can be achieved by Jalyukt Shivar Abhiyaan.
3. As the above stated objectives get accomplished there will be scope for industrialization in Maharashtra state which is the boost for overcome the local employment problem.
4. The area created potential under Jalyukt Shivar Abhiyaan if get actual irrigation area will be very beneficial in suicide belt of the Maharashtra state.

5. There is good scope for the crop diversification in state as there is availability of water throughout the year possible due to effective implementation of the Jalyukt Shivar Abhiyaan.
6. Success stories of Jalyukt Shivar Abhiyaan may helps in creating awareness among the people of the state.

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Land Use / Land Cover Change Mapping using NDVI Method

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ABSTRACT

Land use / Land cover change mapping is one of the valuable information for the researchers, planners, for the utilization and development activities of the region. the multi satellite temporal data can useful to identify and mapping the changes in the region. In this context to assess the changes in Land use and land cover multi temporal satellite data sets using NDVI as methodology applied to West Godavri district. The land use and land cover classified into three classes namely, Water bodies, soil without vegetation cover, and vegetation. The results are concludes that, water bodies are increased trend from 583.67 Sq kms to 1268.34 sq kms. it indicates that aquaculture is increased 684.67 sq kms area in the district. for this studies RS and GIS techniques are very helpful tools to assess the district resources.

Keywords: LUCC, NDVI, RS abd 4 IS, N.B, Soil, Vegetation.

INTRODUCTION

The land use/land cover spatial and temporal patterns of a region are an outcome of natural and socio and economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. land use Changes classify the land information and human interactions done by previously for the sustainability (Verburg et al., 2004). Researchers consider attention on biodiversity and aquatic ecosystems impacts predominantly to the land use changes (Turner et al., 2001). Land use changes will impacts on water quality and supply within the region. For instance, land use patterns change due to watershed development frequently resulting in increased surface runoff, reduced groundwater recharge and transfer of pollutants (Turner et al., 2001). for the present to first to assess the changes in the district from multi temporal satellite data sets.

STUDY AREA

The study area is of West Godavari district located in Andhra Pradesh. West Godavari district occupies an area of approximately 7,742 square kilometers lying in between 81°20' to 81°50' E longitude and 16°5' to 16°35' N latitude. The study area is in between the delta regions of the Krishna and Godavari rivers. The region mostly has a tropical climate like the rest of the Coastal Andhra region. The summers (March–June) are very hot and humid while the winters are pleasant. The rainy season (July–December) is the best time to visit the district with the fields brilliantly green with paddy crops, rivers flowing with water and the relatively cool climate. It is bounded by khammam district on the north, Krishna district on south west and Bay of Bengal on the south. Topographically the district is divided into the Delta and the uplands. In the Delta, aquaculture, coconut, lemon and rice are cultivated. The district is popularly known as the Granary of India since about 50% of the state's rice production comes from the district. In the uplands, oil palm, sugarcane, corn, mango, banana and other fruits as well as tobacco and cotton are produced.

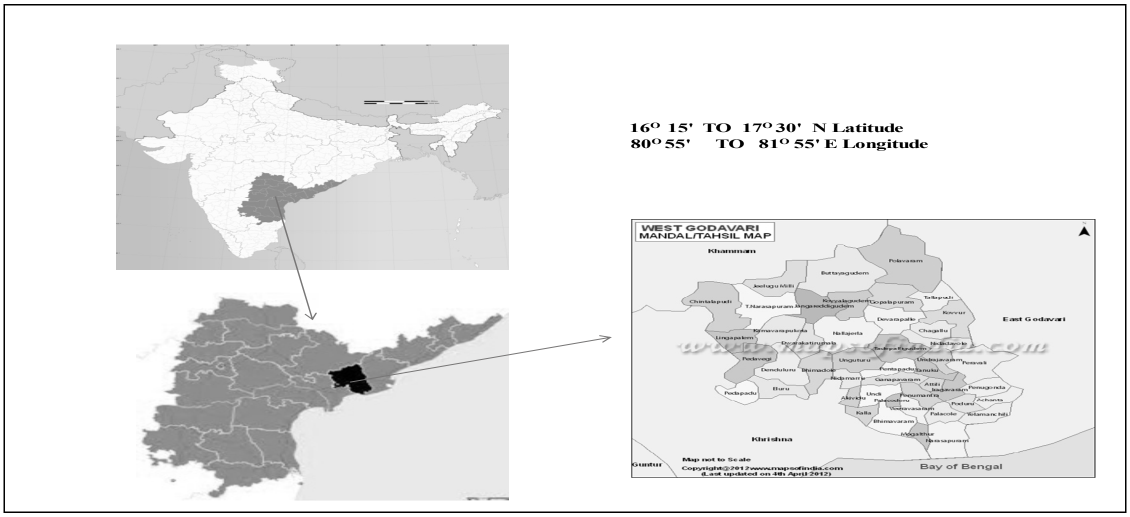

Figure 1 Location Map of the study area

Data Acquired and Methodology

The temporal images of WestGodavari district were downloaded from GLCF website. Multi- temporal satellite data set observed by LANDSAT, Thematic Mapper (TM), and Multi Spectral Scanner (MSS). Survey of India Taluk map drawn on 1:50,000 scale were used for the analysis shown in (Table.1).

Table 1 Spatial data sources

Data	Date of scene
Land Sat (TM)	August 2000
Land Sat (TM)	November 1990

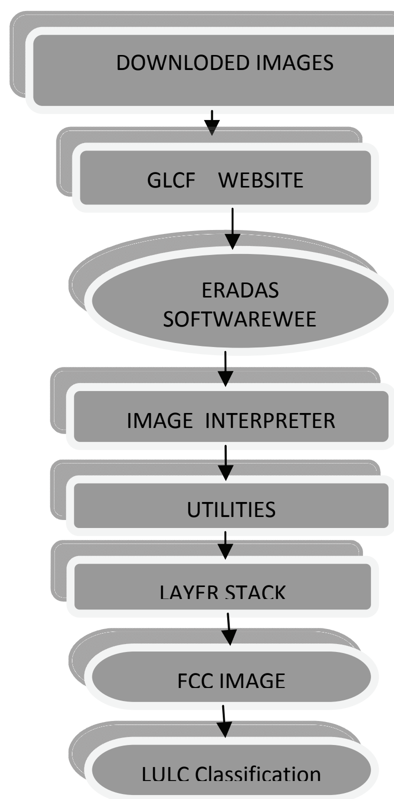

Figure 2 Flow Chart of methodology

NDVI process

The Normalized Difference Vegetation Index (NDVI) is a standardized index allowing you to generate an image displaying greenness (relative biomass). This index takes advantage of the contrast of the characteristics of two bands from a multispectral raster dataset—the chlorophyll pigment absorptions in the red band and the high reflectivity of plant materials in the near-infrared (NIR) band. An NDVI is often used worldwide to monitor drought, monitor and predict agricultural production, assist in predicting hazardous fire zones, and map desert encroachment. The NDVI is preferred for global vegetation monitoring because it helps to compensate for changing illumination conditions, surface slope, aspect, and other extraneous factors. The differential reflection in the red and infrared (IR) bands enables you to monitor density and intensity of green vegetation growth using the spectral reflectivity of solar radiation. Green leaves commonly show better reflection in the near-infrared wavelength range than in visible wavelength ranges. When leaves are water stressed, diseased, or dead, they become more yellow and reflect significantly less in the near-infrared range. Clouds, water, and snow show better reflection in the visible range than in the near-infrared range, while the difference is almost zero for rock and bare soil. The NDVI process creates a single-band dataset that mainly represents greenery. The negative values represent clouds, water, and snow, and values near zero represent rock and bare soil.

$$\boxed{\mathbf{NDVI = arctangent((IR - R)/(IR+R))}} \quad \text{.....(1)}$$

IR = pixel values from the infrared band

R = pixel values from the red band

This produces a single-band dataset, mostly representing greenness, where any negative values are mainly generated from clouds, water, and snow, and values near zero are mainly generated from rock and bare soil. This index outputs values between -1.0 and 1.0. Very low values of NDVI (0.1 and below) correspond to barren areas of rock, sand, or snow. Moderate values represent shrub and grassland (0.2 to 0.3), while high values indicate temperate and tropical rainforests (0.6 to 0.8). For the present study area the NDVI values are represented in table 2.

Table 2 NDVI Classification Values

Values	Contents
-ve value	Water bodies
0.01-0.09	Aquaculture without crop
0.10-0.20	Soil
0.20-0.30	Low vegetation
0.31-0.60	Thick vegetation

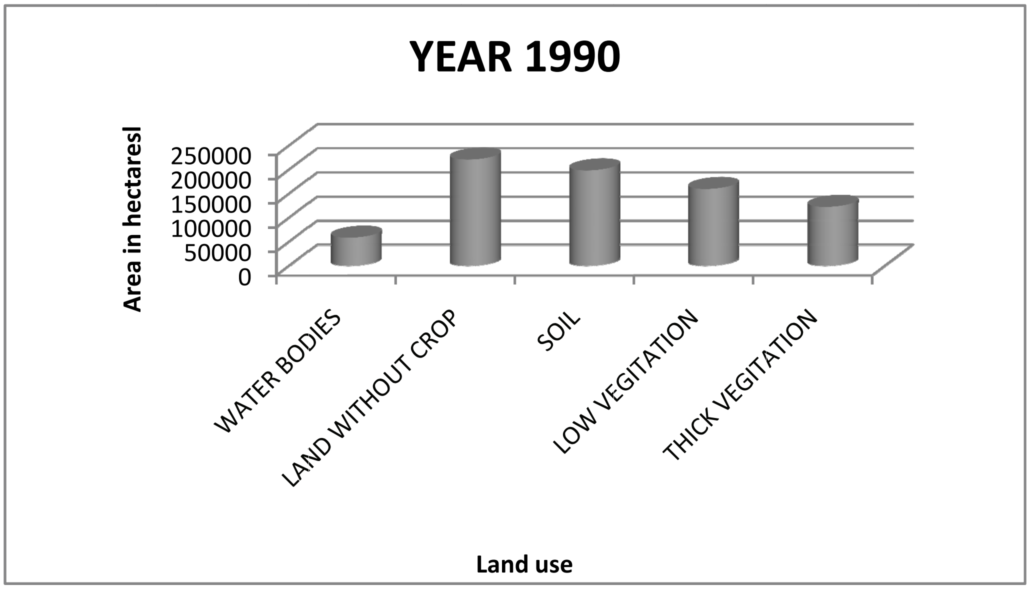

Figure 3 LULC Static data of west Godavari

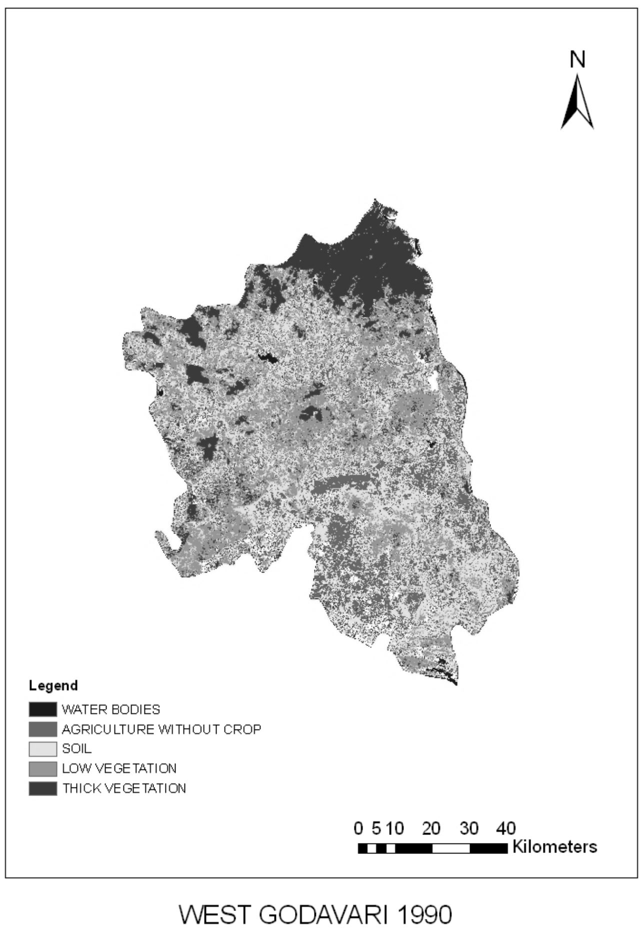

Figure 4 LULC map of study area year 1990

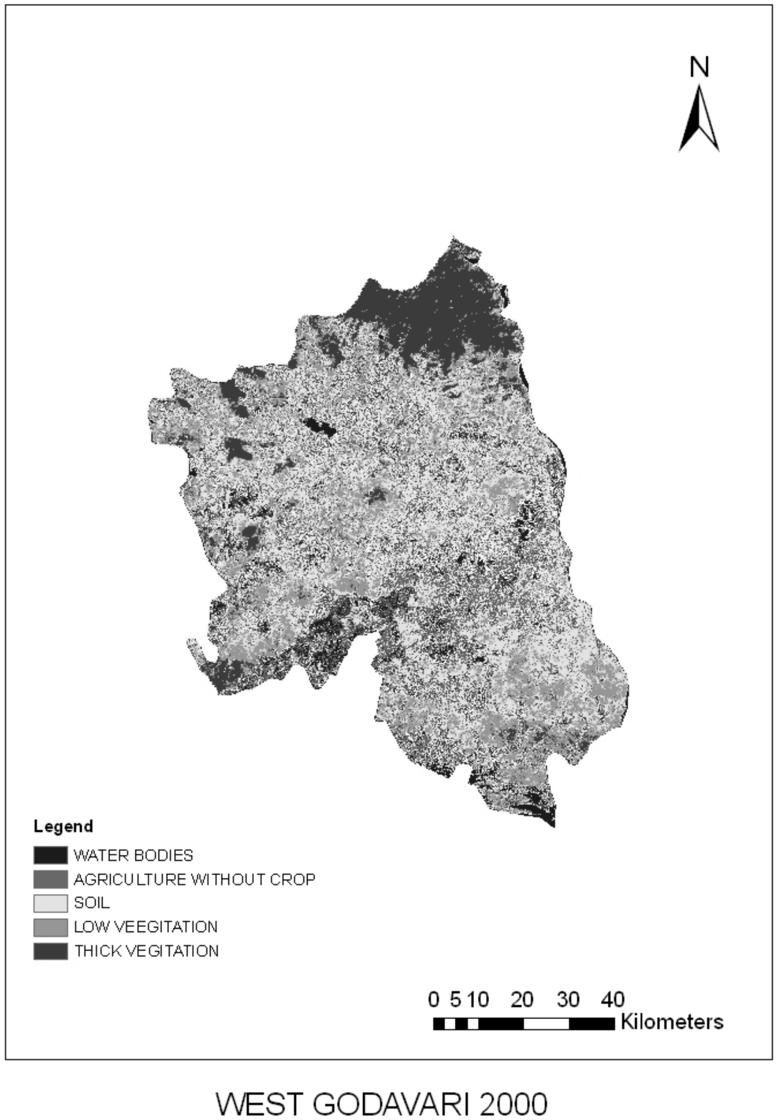

Figure 5 LULC map of the study area year 2000.

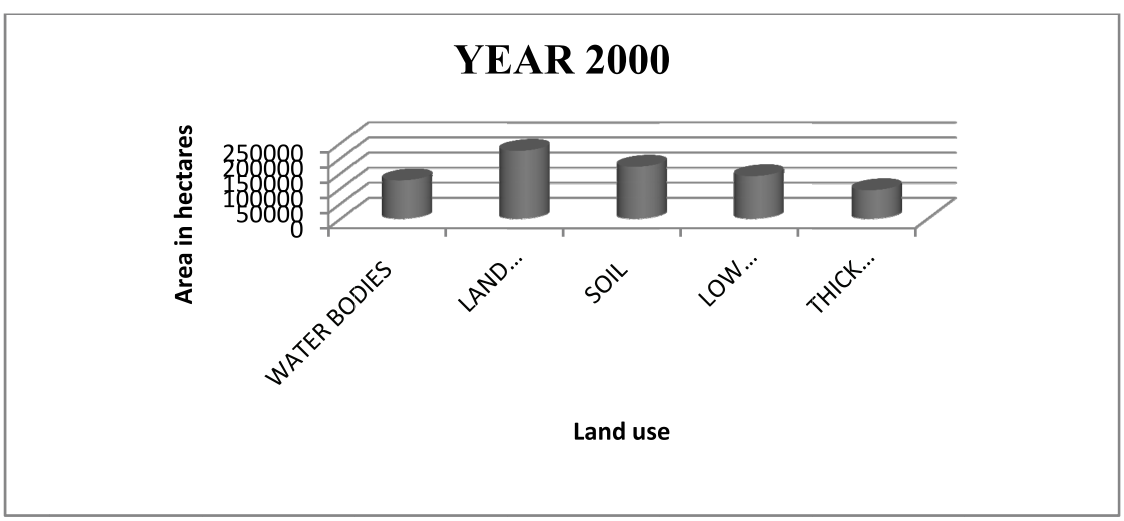

Figure 6 LULC statics of study area year 2000.

Table 3 Land Use Land Cover Distribution (1990 and 2000) Values in Ha.

Year	Water bodies	Agricultural land without crop	Soil	Low vegitation	Thick vegitation
1990	58637	220827	198269	159802.7	122542
2000	126834	224701	172072	140870	94299

CONCLUSION

The present study shows that satellite remote sensing based land cover mapping is very effective. The high resolution satellite data such as Landsat TM are good source to provide information accurately. Under utilization of potential land, increased population, and land conversion are the major driving forces for the change in land use during the past 10 years. This research work demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible five land use land cover classes as they change through time. From the temporal trajectories statistics, 60% of the study area was not changed, and 40% was changed by manmade processes due to Deforestation, increasing of Aquaculture and commercial activities. However, it should also be noted that since 1990s, the area of aquaculture has increased up to 2000. Forests area has decreased from the year 1990 to 2000. In 1990 forest area is 16% and it is decreased to 12% in 2000. This is mainly due to deforestation. Due to increase in population agricultural area has been converted in to commercial area. The results suggest that in terms of affected area, the human impact on the environment was still relatively minor in this area, but if the same trend continues our future generations will be in threat due to scarcity of resources.

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A Study of SW Monsoon Variability Over India During Contrast Monsoon Years of 2009 and 2010

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ABSTRACT

2009 was a large deficient (-22%) Monsoon year while 2010 was a good Monsoon (+2%) year. In this study, it is attempted to analyze the basic meteorological reasons for such contrasting situations in both the years. For the country as a whole, the rainfall for the 2009 SW Monsoon season (June-September) was deficient (78% of its long period average (LPA)) which is the third deficient monsoon year of the decade after 2002 & 2004. 2009 was a El Nino year & 2010 was a La Nina year. El Nino (La Nina) is associated with the lower (higher) than normal rainfall. In 2009 SW Monsoon, moderate El Nino conditions prevailed over east Pacific from middle of the monsoon season resulting in large rainfall deficiency during the second half of the season. In 2010 SW Monsoon, moderate to strong La Nina conditions prevailed over east Pacific from middle of the monsoon season resulting normal to above normal rainfall over most subdivisions of the country.

Keywords: SW Monsoon, El Nino, La Nina, TRMM, SST anomalies, Precipitation Rate, Sea DAS.

INTRODUCTION

SW Monsoon (June- September):

Monsoon derived from a Greek word "mausim" which means reversal of winds. The annual oscillation in the apparent position of the Sun between the Tropics ofCancer and Capricorn causes the annual oscillation in the position of the thermalequator (region of maximum heating) on the Earth's surface. This is associated withannual oscillation of temperature, pressure, wind, cloudiness, rain etc. This isthe cause of the Monsoons. On the Earth's surface, there are asymmetries of land and Ocean. The differential heating of land and Ocean cause variations in the intensity of the annual oscillation of the thermal equator and hence regional variations in the intensity of Monsoon. The southwesterly wind flow occurring over most parts of India and Indian Seas gives rise to southwest Monsoon over India from June to September.

Monsoon regime:

A Monsoon regime (Lat 35°N-Lat 25°S and Long 30°W-long 170°E) is an area, where there is a definite change in the prevailing wind direction at lower levels between summer and winter. Constancy and steadiness of the wind also quite high in the Monsoon regime.

Features of SW Monsoon:

Heavy to heavy rainfall occurs along the west coast and over NE India. And there is a pronounced low rainfall on the leeward side of the Western Ghats. Rainfall is moderate over central parts of India and decreases progressively towards NW India. The driest area is the west Rajasthan and SE tip of peninsula. Because of the unevenly distribution of rainfall and orographic effect, droughts occur in some places and floods occur in some places over India.

Tele Connections between ENSO and Indian Monsoon rainfall:

El Nino (La Nina) is associated with the lower (higher) than normal rainfall. It is observed that El Nino years are associated with negative pressure anomalies in the southeast pacific, positive anomalies over the Indian region (low southern Oscillation Index, SOI), weaker SW Monsoon over the Arabian Sea, and below normal rainfall over India**.** ENSO tele connection with Indian monsoon is usually explained through alterations in the tropical Walker circulation. The Walker circulation is placed normally in the western Pacific, but during El Nino events it shifts toward the anomalously warm water in the central and eastern Pacific. An anomalous subsidence which causes suppression of convection and precipitation is developed over the western Pacific and India. This phenomenon is related with anomalously high pressure over the western Pacific and low pressure over the eastern and central Pacific.El Nino leads to warming of sea surface temperatures, which in turn affects wind patterns and triggers both floods and droughts in different parts of the world. El Nino occurs when the threshold value of 0.5 deg C of ONI is met or crossed a minimum of 5 consecutive overlapping seasons of three months. El Nino affects rainfall in India during Monsoon months. Trade winds normally blow westward from South America towards Asia during Indian monsoon moths. Warming of the pacific results in weakening of these winds. Moisture and the heat content thereby, gets limited and results in reduction and uneven distribution of rainfall across the Indian sub-continent. ENSO-induced warm zones in the pacific causes the warm air over them to rise and initiate circulation cells. Such cells along northern Australia, Indonesia and the eastern edge of the Indian ocean could have their downwards sides over a nascent monsoon circulation cells in the Indian Ocean, which would disrupt its formation, causing poor monsoon rains over the subcontinent.

Study Area: The study area (India) is situated north of the equator between 8°4′to 37°6′ north latitude and 68°7′ to 97°25′ east longitude. India lies on the Indian Plate, the northern portion of the INDO-Australian Plate, whose crust forms the Indian subcontinent.

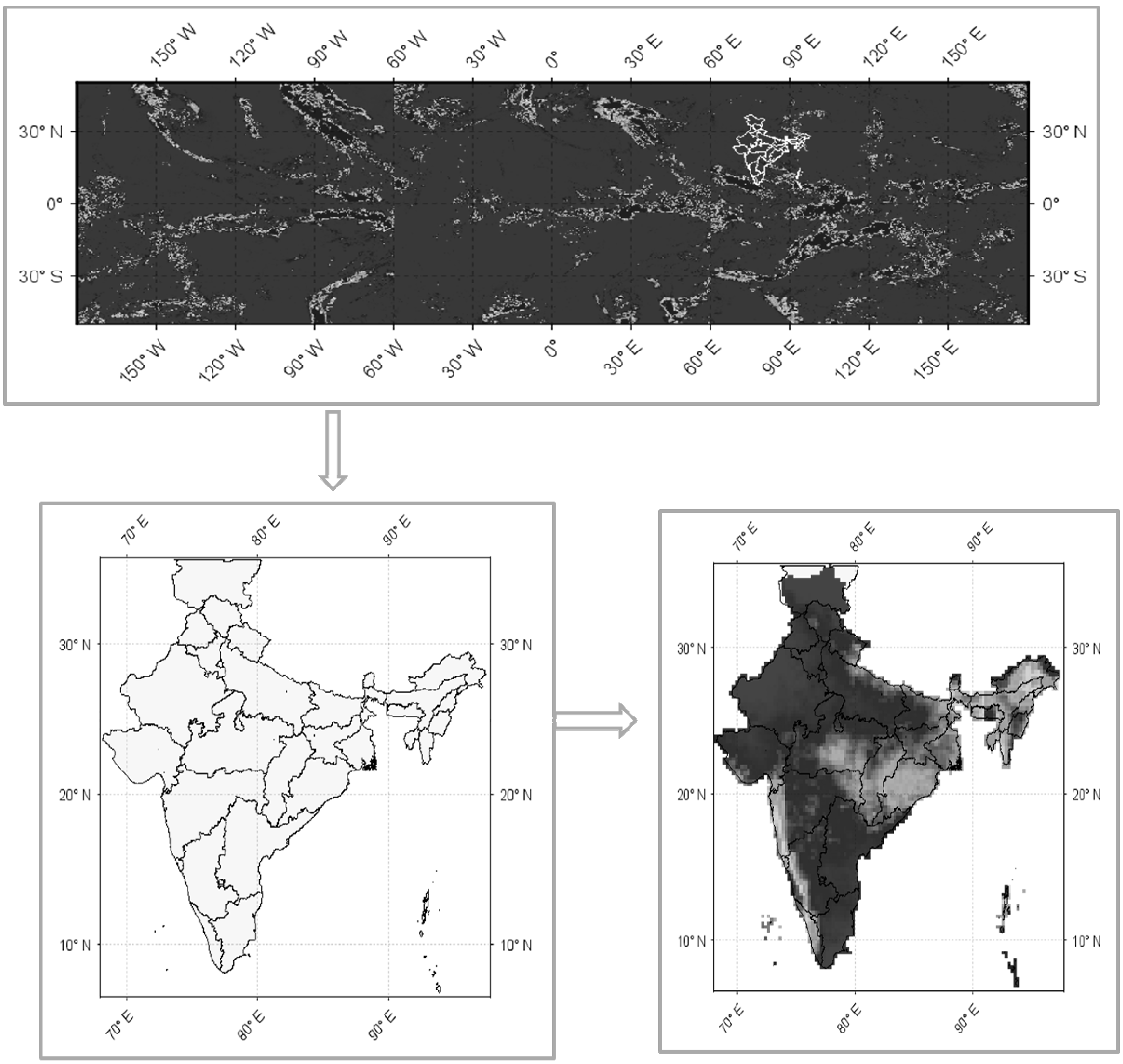

Figure 1 Map Showing the Study Area of the Indian SW Monsoon Season.

MATERIALS AND METHODS

Data & Methodology:

TRMM (Tropical Rainfall Measuring Mission) Precipitation L3 1 daily 0.25 degree × 0.25 degree V7(TRMM_3B42_Daily) data (mirador.gsfc.nasa.gov) products were taken to study the SW Monsoon variability over India during contrast monsoon years of 2009 and 2010.This daily accumulated Precipitation product is generated from the 3 hourly TMPA (3B42), and the result is given in mm/day.The TRMM_3B42_Daily products of June, July, August, and September months for the both the years (2009&2010) downloaded from mirador.gsfc.nasa.gov website and analyzed in SeaDAS.

SeaDAS is a comprehensive image analysis package for processing, display, analysis and quality control of data from NASA, TRMM. By using SeaDAS croped the daily L3 data sets into our region of interest that is study area 8°4□S to 37°6□N latitude & 68°7□W to 97°25□E longitude, then analyze the precipitation(mm/day) rate in SW Monsoon season for both years. Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua Monthly (Level-3 data sets of 9km resolution) Sea Surface Temperatures (°C) at 11 microns were taken to study the El Nino and La Nina events in Pacific Ocean. MODIS Aqua Monthly Climatology (Long Term Monthly Averages from 2002 to 2015) data sets also taken to study the SST anomalies in four NINO regions. By using Sea DAS created SST anomalies for the 2009(El Nino) and 2010 (La Nina) years.

RESULTS AND DISCUSSIONS

Time series of area averaged (mean) precipitation rate daily was computed for both the years (2009 & 2010). Finally we found that 2010 SW Monsoon received above normal rainfall (+2%) and 2009 SW Monsoon received deficient rainfall (-29%). The 2009 southwest Monsoon rainfall over the country as a whole was substantially below normal from its long period average value. Rainfall activity during the 2009 SW Monsoon season except in July, the last week of August and the first week of September was generally very subdued. Monsoon was weak throughout June, many days in August and the last three weeks of September. During June 2010 precipitation over the country as a whole was reduced, and in July and August and September precipitation over the country receive above normal rainfall. Because 2009 was a El Nino year and 2010 was a La Nina year.

During January 2009, the SST anomaly over the NINO 3.4 region was -1°C, and for the January-February-March season it was -0.7°C. In the month of May SST anomalies across the equatorial Pacific became positive. Thus the negative SST anomalies weakened and become positive in the month of May. Thus the NINO 3.4 SST anomaly index continuously increased from mid-January and during June crossed the threshold value of 0.5°C and during the subsequent moths, moderate El Nino conditions prevailed with positive SST anomalies over all NINO regions. During June SST anomalies over the NINO regions ≥0.5°C were observed. During July SST anomalies was ≥1°C observed in NINO regions. As a whole moderate El Nino conditions prevailed over the equatorial pacific from July onwards.

The El Nino conditions were originated from June 2009 and peaked in December 2009 and then Started to weaken to reach ENSO-neutral conditions in May 2010. This continued till mid June when weak La Nina conditions emerged. The SST anomalies in the NINO 3.4 region continuously decreased from January and crossed the threshold value of -0.5°C during the later part of the month of June. In June 2010 the SSTs in the NINO 3.4 region were slightly below average (-0.4°C), and during the subsequent months, the SST anomaly decreased continuously, La Nina conditions prevailed with negative SST anomaly in the NINO3.4 region during the remaining months of the Monsoon season. Thus the Moderate to strong La Nina conditions prevailed from July onwards to end of the Season.

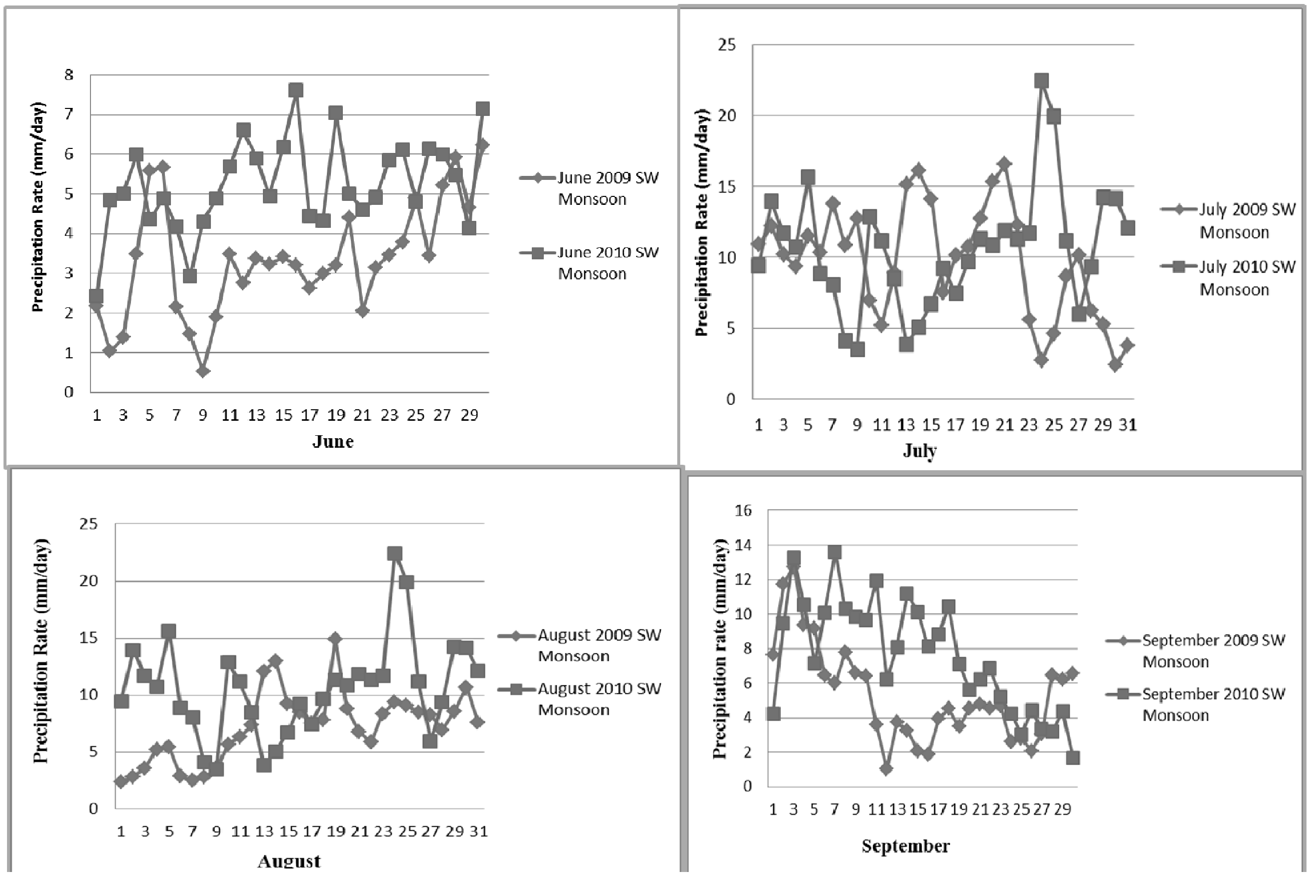

Figure 2 Time Series of Area averaged Precipitation Rate (mm/day) Daily 0.25deg (TRMM_3B42_Daily v7) over contrast Monsoon Years of 2009 (deficient) and 2010 (Above normal), India.

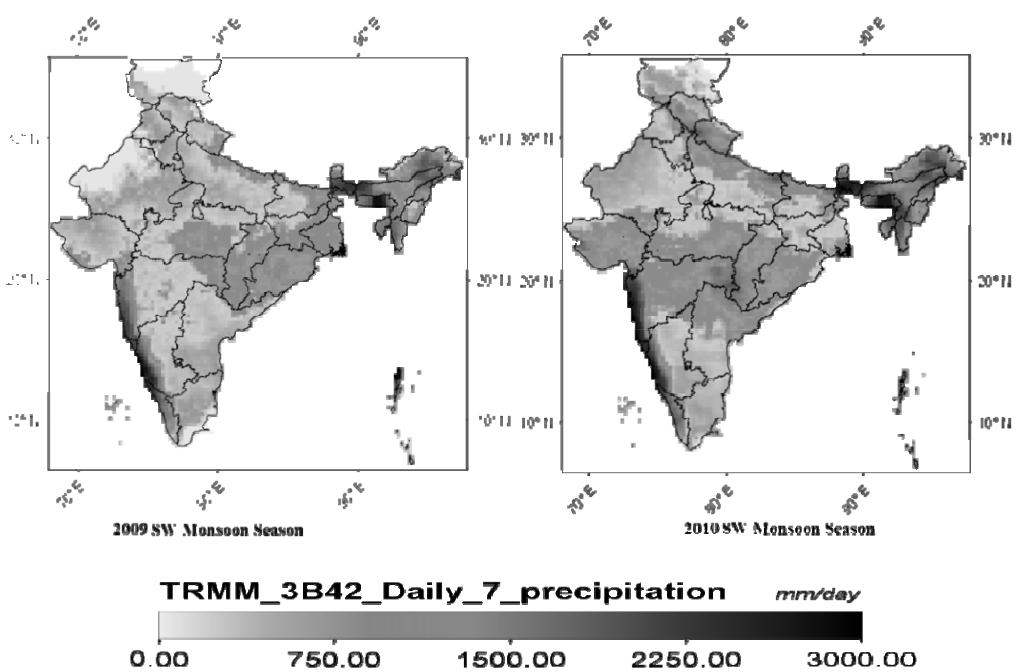

Figure 3 Total accumulated Daily Precipitation Rate (mm/day) from June 2009 & 2010 to September 2009 & 2010 over India.

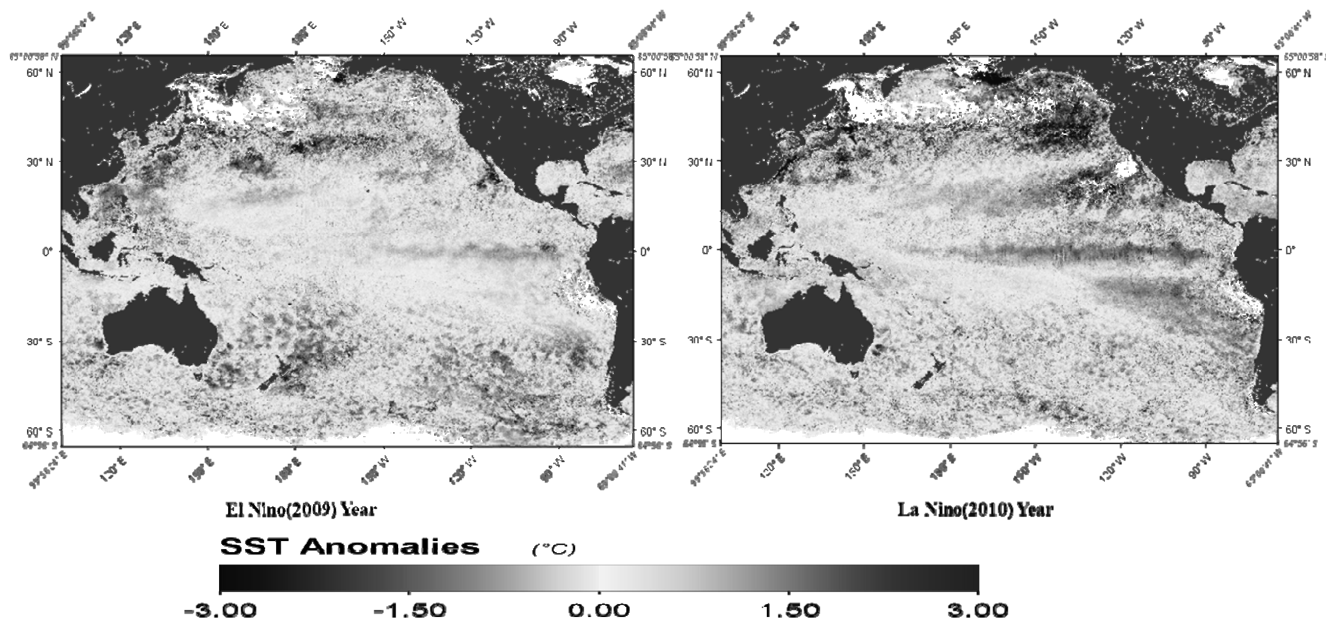

Figure 4 SST anomalies in Nino regions {(Nino 1+2: (0°-10°S, 90°W-80°W), Nino3: (5°N-5°S, 150°W-90°W), Nino3.4: (5°N-5°S, 170°W-120°W), Nino3.4: (5°N-5°S, 150°W-160°E)}.

CONCLUSION

2009 was a large deficient (-22%) Monsoon year while 2010 was a good Monsoon (+2%) year. For the country as a whole, the rainfall for the 2009 SW Monsoon season (June-September) was deficient (78% of its long period average (LPA)) which is the third deficient monsoon year of the decade after 2002 & 2004. El Nino (La Nina) is associated with the lower (higher) than normal rainfall. In 2009 SW Monsoon, moderate El Nino conditions prevailed over east Pacific from middle of the monsoon season resulting in large rainfall deficiency during the second half of the season. In 2010 SW Monsoon, moderate to strong La Nina conditions prevailed over east Pacific from middle of the monsoon season resulting normal to above normal rainfall over most subdivisions of the country.

ACKNOWLEDGEMENTS

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Effect of Temperature on Soil Enzymes

Aruna Kumari J. and Rao P.C.

ABSTRACT

Soil enzymes play a major role in mineralization of nitrogen, phosphorus and sulphur. mineralization is the process of transformation of organically bound elements into mineral form which will readily taken up by plants and is crucial to plant nutrition and indirectly plays a role agriculture productivity. The abiontic enzymes present in the soil play an important role in catalyzing several important reactions necessary for the life processes of microorganisms in soils and their by stabilizing soil structure, the decomposition of organic wastes, organic matter formation and nutrient cycling. when the temperatures are increased due various changes caused by global warming and other aspects they have a profound influence on soil enzymes and indirectly on agricultural productivity. Every enzymes has its own optimum temperature below the optimum temperature the enzyme activity is less due to inactivation and above the optimum temperature the enzyme activity decreases due to denaturation. due to increase in temperature the enzymes are denatured and nutrients availability is decreasing and indirectly effecting productivity. to study the effect of temperature on soil enzyme activity four different soils samples were collected and incubation studies were carried out at different temperatures ranging from 20 ^{o}C to 80 ^{o}C with two Alfisols and two Vertisols. L-asparaginase enzymes has shown to posses highest activity at 40^{o}C, which converts L-asparagine present in the soil to asparatic acid and ammonical nitrogen readily accepted by plants and which indirectly plays a role in productivity is greatly influenced by climate change ie:- temperature. the enzyme activity at different temperatures is as follows where the activity is measured as µg of NH_4^+ released g^{-1} soil h^{-1}, at 20^{o}C 0.6, at 30^{o}C 1.5, at 40 ^{o}C 3.4, at 50^{o}C 2.9 and at 60^{o}C 1.10.

Keywords: Alfisol, L-asparaginase, Temperature, Climate change and Productivity.

INTRODUCTION

Agriculture is influenced by climate change, temperature being one of the key component. While farmers are often flexible in dealing with weather and by their experience choose a highly adaptive varieties to the local climate and in the soils of arid and semi arid tropics, the soil available nitrogen is grossly inadequate for sustainable agriculture unless it is replenished with the mineralization of organic nitrogen. Nitrogen mineralization is one of the most important part of nitrogen cycle that includes mostly a group of hydrolases like L-asparaginase, urease L-glutaminase etc. These enzymes play key roles in overall process of organic matter decomposition and organic nitrogen in soil system which are important reactions necessary for the live processes of microorganisms in soils and stabilization of soil structure decomposition of organic waste, organic matter formation and nutrient cycling (Dick *et al.,* 1994). During the decomposition of organic matter these enzymes are constantly synthesized, accumulated, inactivated and decomposed in soils, hence they play an important role in Agriculture (Tabataba,i 1994, Dick, 1997 and Vandana 2012) soil enzymes have potential to provide unique interactive biological assessments of soils because of their relationship to soil biology ease of measurement and rapid response to change in soil management (Dora *et al.,* 2008).

Among the different facets of soil enzymes the insitu behaviour of soil enzymes in heterogeneous environment of the soil system in respect of their thermal sensitivities, pH effects, kinetics and moisture effects are of prime importance. Hence the present investigation was designed for studying the effect of temperature on soil enzyme L-asparaginase activity.

The enzyme L-asparaginase catalyses part of organic nitrogen in soils which is present in the form of amides and one of the important enzyme of nitrogen cycle that includes mostly a group of amidohydrolase. L-asparaginase catalyses the hydrolysis of L-asparagine to L-asparatic acid and ammonia. Thus this enzyme is important in making amide form of nitrogen available to plants. It has been reported that significant quantities of ammonia released in acid hydrolysis came from amide forms mostly asparagine and glutamine residues in soil organic matter (Bremner, 1965) further it has been shown that after acid hydrolysis of humic fractions about 7.3 to 12.6 % of nitrogen was in the form of amide nitrogen (Stevenson, 1994).

METHOD

Reagents

L-asparagine (0.125M): This was obtained by dissolving 18.77 g of L-asparagine in 1 litre of water THAM buffer (0.1M): 12.28 g of THAM (Tris hydroxyl methyl amino methane) was dissolved in 800 ml of distilled water and the pH was adjusted by the addition of 0.1N HCl and 0.1N NaoH to obtain the desired pH , then the volume was made up to 1litre.

Potassium chloride (2.5M) + Silver Sulphate (100ppm) KCl- Ag_2SO_4 solution: 100 mg of Ag_2SO_4 was dissolved in 700 ml distilled water to which 300 ml of water containing 186.4 g of KCl was added.

MgO: Magnesium oxide was heated in an electrical furnance at 500°C for an hour and the powder was collected in dessicator and stored in a tightly stoppered bottle.

4% Boric acid`: 40gms of Boric acid was dissolved in a beaker containing hot distilled water about 800ml. Then 5ml bromocresol green and 15 ml of methyl red were added and the volume was made up1 litre with hot distilled water.

0.005 N H_2SO_4: This solution was prepared by taking 5 ml of 1N H_2SO_4 is taken in a 1 litre volumetric flask and make up to the mark by the addition of distilled water.

Procedure

Soil sample (10 g) was taken in a 150 ml conical flask. 12 ml of 0.1M THAM buffer of desired pH or distilled water and 8 ml of 0.125M L-asparagine were added, and then the contents were gently shaken for few seconds and covered with polythene paper. The contents were incubated at 37± 0.5°C for 2 hours in BOD incubator. After incubation, reaction was terminated by addition of 50 ml of KCl-$AgSO_4$ solution. The contents were agitated on mechanical shaker for 30 min to release all NH_4^+ formed and the suspension was allowed to settle and filtered. The NH_4^+ released was determined by steam distillation method (Frankenberger & Tabatabai, 1991a & b). In the controls the same procedure as described above was followed with the addition of L-asparagine solution after termination of the reaction with KCl-$AgSO_4$ solution.

The activity of L-asparaginase was assayed by Steam distillation method. In this method thirty ml of the supernatant with KCl-$AgSO_4$ extract was taken and transferred to Kjeldahl flask. To this a pinch of MgO was added which was kept at one end of the distillation unit. During steam distillation for 4 min, the solution containing MgO was heated and the ammonia was released into boric acid containing mixed indicator through a tube dipped in the solution. The ammonia released would change the colour of the solution from pink to pale green at the end of the distillation. This was titrated against standardized 0.005N H_2SO_4 and the amount released was calculated and expressed as µg of NH_4^+ released g^{-1} soil h^{-1}.

RESULTS

The results regarding to the effect of temperature on soil L-asparaginase activities are depicted graphically in Figure (1). L-asparaginase activity of all soils used in the study increased with increase in temperature from 20 – 40°C and then activity decreased slowly till 60°C and rapidly decreased with further increase in temperature to 80°C. Denaturation occurred beyond 40 °C. for the present study both Alfisols and Vertisols were taken higher activity was observed in Alfisols, the range observed in different soils is as follows in Vertisol I was 0.60 µg of NH_4^+ released g^{-1} soil h^{-1} at 20 °C and increased to 1.54 µg of NH_4^+ released g^{-1} soil h^{-1} at 30 °C and further increased to 3.40 µg of NH_4^+ released g^{-1} soil h^{-1} at 40 °C and then when the temperature is increased beyond their optimum temperature its activity decreased to 2.90 µg of NH_4^+ released g^{-1} soil h^{-1} at 50 °C and further decreased to 1.10 µg of NH_4^+ released g^{-1} soil h^{-1} at 60 °C and in Vertisol II, the range of enzyme activity was as follows 0.40 µg of NH_4^+ released g^{-1} soil h^{-1} at 20 °C and increased to 0.90 µg of NH_4^+ released g^{-1} soil h^{-1} at 30 °C and further increased to 2.60 µg of NH_4^+ released g^{-1} soil h^{-1} 40 °C and then when the temperature is increased beyond their optimum temperature its activity decreased to 2.10 µg of NH_4^+ released g^{-1} soil h^{-1} at 50 °C and further decreased to 0.80 µg of NH_4^+ released g^{-1} soil h^{-1} at 60 °C. In case of Alfisol I it was observed that the enzyme activity increased as follows 1.10 µg of NH_4^+ released g^{-1} soil h^{-1} at 20 °C and increased to 3.10 µg of NH_4^+ released g^{-1} soil h^{-1} at 30 °C and further increased to 6.80 µg of NH_4^+ released g^{-1} soil h^{-1} at 40 °C and then when the temperature is increased beyond its optimum temperature its activity decreased to 3.60 µg of NH_4^+ released g^{-1} soil h^{-1} at 50 °C and further decreased to 2.20 µg of NH_4^+ released g^{-1} soil h^{-1} at 60 °C and in Alfisol II, the range of enzyme activity was as follows 1.40 µg of NH_4^+ released g^{-1} soil h^{-1} at 20 °C and increased to 3.70 µg of NH_4^+ released g^{-1} soil h^{-1} at 30 °C and further increased to 7.60 µg of NH_4^+ released g^{-1} soil h^{-1} 40 °C and then when the temperature is increased beyond their optimum temperature its activity decreased to 4.40 µg of NH_4^+ released g^{-1} soil h^{-1} at 50 °C and further decreased to 2.80 µg of NH_4^+ released g^{-1} soil h^{-1} at 60 °C beyond 60 °C of temperature, negligible increased was observed in case of activity because the thermal stability of the enzyme was completely lost. the temperature coefficient of the enzyme was calculated. The results pertaining to temperature coefficient were given in the Table (1). Temperature coefficient values ($Q_{10)}$ were calculated in the temperature range of 20 to 70°C. These values depend on the type of soil which varied from 0.3 to 2.5 in case of Vertisol I and 0.3 to 2.3 in case of Vertisol II in Alfisol a slight higher temperature Coefficient was observed ie:- 0.3 to 2.8 in Alfisol I and 0.3 to 2.6 in case of Alfisol II.

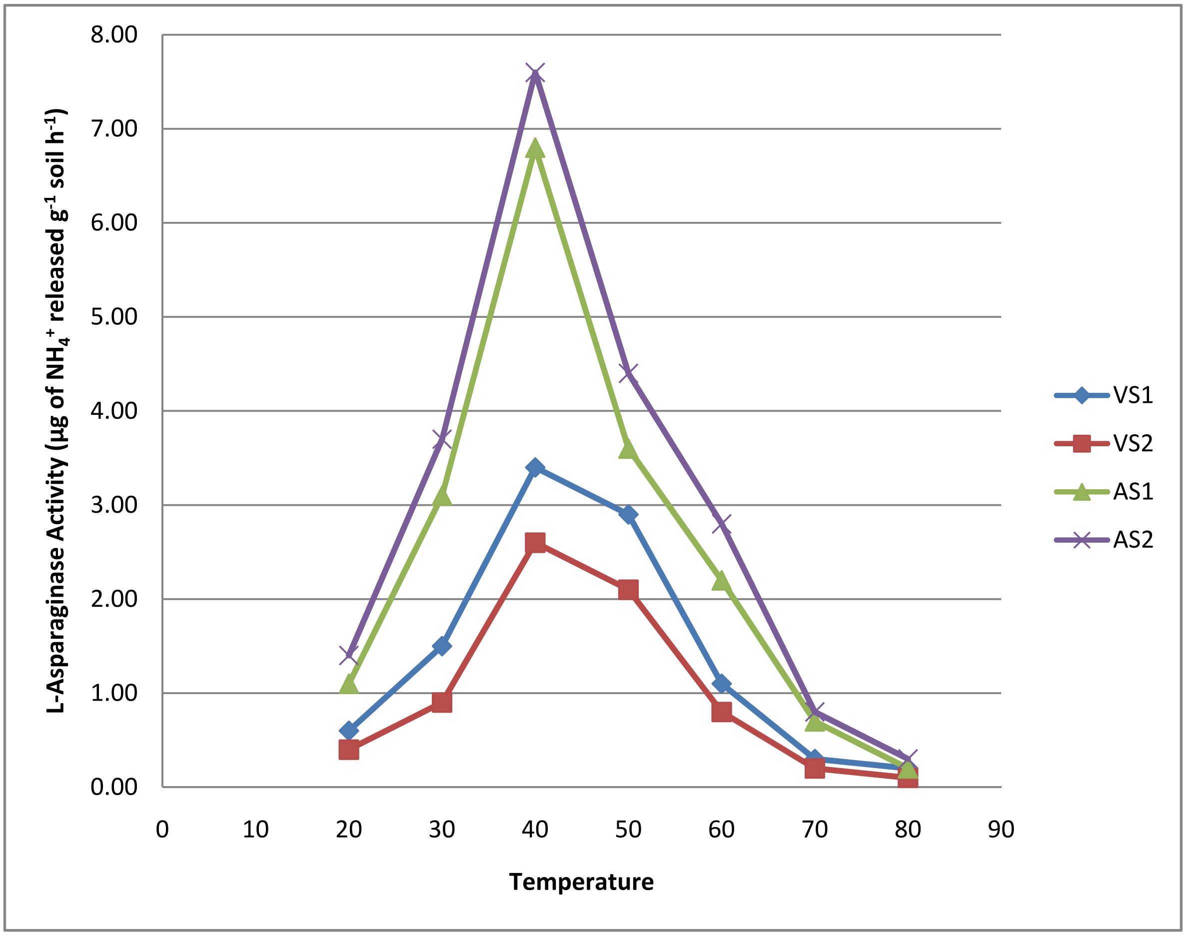

Figure 1 Effect of Temperature on Soil L-Asparaginase activity

Table 1 Temperature Coefficient Values (Q_{10}) of L-Asparaginase Enzyme

Temperature (°C)	Temperature Coefficient Values (Q_{10})			
	VS1	VS2	AS1	AS2
20-30	2.5	2.3	2.8	2.6
30-40	2.3	2.9	2.2	2.1
40-50	0.9	0.8	0.5	0.6
50-60	0.4	0.4	0.6	0.6
60-70	0.3	0.3	0.3	0.3

DISCUSSION

Temperature has a profound effect and controls soil enzyme activities, changing enzyme kinetics and stability, substrate affinity and enzyme production because it can influence the size and activity of microbial biomass. As soil hydrolytic enzymes are the main drivers of soil organic matter (SOM) degradation and litter decomposition, the dependence of these enzymes on global changes including warming, precipitation, drought and associated soil moisture will assist in understanding the relationships among SOM stock, global carbon cycle and microbial nutrient demand. Moreover, the possible interference of nitrogen demand in soil has also to be considered, being nitrogen a fundamental element not only for several metabolic routes but mainly because involved in protein and therefore enzyme synthesis. The results obtained was is in contrast to the results obtained by (Frankenberger and Tabatabai 1991, Law and Wriston, 1979) and was similar to the results obtained by Pavani (2015) for L-glutaminase activity. The optimal activity for L-asparaginase was found to be approximately 10 °C lower than that of L-glutaminase.

It has been observed by Davidson *et al.* (1977) that L-asparaginase activity from *Pseudomonas ascidovaries* under goes thermal deactivation when exposed to 50°C for 10 minutes. It is know that the temperature needed to deactivate enzymes in soils is about 10 °C higher than the temperature needed to inactivate the same enzyme in absence of soil. This has been generally attributed to the immobilization of soil enzymes on soil colloids and cell debris (Tabatabai 1982, Srinivas 1993, Raman and Reddy 1998, Srinivas and Raman 2000 and Vandana 2012). Changes in temperature not only effect the enzyme production but also effect enzyme degradation rates in the environments. Biological responses includes changes in enzyme production rates with shifts in microbial population and composition. The variation in these values may be due to heterogeneity in composition and the state of enzymes at temperature above 40°C. When the Q10 values were less than 1 which indicates the deactivation of the enzymes set in at that temperature. Recent increases in climate variability may have affected crop yields in countries across Europe since around the mid-1980s (Porter & Semenov 2005) causing higher inter-annual variability in wheat yields. This study suggested that such changes in annual yield variability would make wheat a high-risk crop in Spain. Even mid-latitude crops could suffer at very high temperatures in the absence of adaptation. In 1972, extremely high summer averaged temperature in the former Soviet Union (USSR) contributed to widespread disruptions in world cereal markets and food security (Battisti & Naylor 2009).

Changes in short-term temperature extremes can be critical, especially if they coincide with key stages of development. Only a few days of extreme temperature (greater that 32°C) at the flowering stage of many crops can drastically reduce yield (Wheeler *et al*. 2000). Crop responses to changes in growing conditions can be nonlinear, exhibit threshold responses and are subject to combinations of stress factors that affect their growth, development and eventual yield. Crop physiological processes related to growth such as photosynthesis and respiration show continuous and nonlinear responses to temperature, while rates of crop development often show a linear response to temperature to a certain level. Both growth and developmental processes, however, exhibit temperature optima. In the short-term high temperatures can affect enzyme reactions and gene expression. In the longer term these will impact on carbon assimilation and thus growth rates and eventual yield. The impact of high temperatures on final yield can depend on the stage of crop development. Wollenweber *et al*. (2003) found that the plants experience warming periods as independent events and that critical temperatures of 35°C for a short-period around anthesis had severe yield reducing effects. However, high temperatures during the vegetative stage did not seem to have significant effects on growth and development. Reviews of the literature (Porter & Gawith 1999; Wheeler *et al*. 2000) suggest that temperature thresholds are well defined and highly conserved between species, especially for processes such as anthesis and grain filling. Although groundnut is grown in semi-arid regions which regularly experience temperatures of 40°C, if after flowering the plants are exposed to temperatures exceeding 42°C, even for short periods, yield can be drastically reduced (Vara Prasad *et al*. 2003). Maize exhibits reduced pollen viability for temperatures above 36°C. Rice grain sterility is brought on by temperatures in the mid-30s and similar temperatures can lead to the reverse of the vernalizing effects of cold temperatures in wheat. Increases in temperature above 29°C for corn, 30°C for soya bean and 32°C for cotton negatively impact on yields in the USA. Release of nutrients in soil by means of organic matter degradation

The impacts on productivity may depend more on the magnitude and timing of extreme temperatures because these effect the release of nutrients in soil by means of organic matter degradation by soil enzymes.

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THEME – IV

GROUNDWATER EXPLORATION, DEVELOPMENT, RECHARGE, MODELING AND QUALITY

Simulation of Pollutant Discharge to Canadian Lake Shore and Indian Sea Coast

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ABSTRACT

Human activities on coastal watersheds provide the major sources of nutrients entering shallow coastal ecosystems. Contamination loadings from watersheds are the most widespread factor that alters structure and function of receiving aquatic ecosystems. Subsurface water discharges are recognized as potentially significant contaminant pathway from the watershed to the coast by human activities. This interaction affects the water quality and quantity in both surface and subsurface waters. The diversity, in combination with the range of disciplines and of time and space scales involved; complicate the use of data for purposes other than those envisioned by the original investigators. As land and water resource development increases in the coastal watersheds, it is becoming readily apparent that subsurface and surface waters interaction must be considered in establishing water management policies. All these interactions occur along coastal watersheds of Great Lakes and other coast. In this paper, some example watersheds shows the roles of geo-hydrology and hydro-geochemical processes are investigated by the application of numerical models for water quality modelling of receiving waters. This model also predicts the movements of contaminants in subsurface and surface waters and coastal sediments.

Keywords: Watershed, Contaminants, Sediments coastal.

Introduction

Groundwater discharge to coastal waters and estuarine waters has been a topic of theoretical and practical interest for at least a century (Bobba, 1993). Most work has stressed controls on saltwater intrusion to freshwater aquifers and it has been only recently that field measurements of groundwater discharge have shown the importance of subsurface flow on water and nutrient budgets in coast and estuaries. Submarine groundwater discharge has shown to be a source of nitrogen, typically as nitrate, in shallow sediments of lakes and coastlines. For example, upland aquifers contribute to direct groundwater discharge greater than 20% of the freshwater and 75% of the nitrogen that enters the Great South Bay, new York (Bokuniewicz, 1980) Excess nitrogen in groundwater derived from sewage and fertilizer has drastically affected water quality in other estuaries and coastal lagoons as well (Johannes and Hearn, 1985). Ecosystem of the world's coastlines are receiving extraordinary amounts of nutrients as a consequences of human activities such as fertilizers, industrial emissions to the atmosphere, and disposal of waste water in watersheds adjoining coastal waters. The loadings of nitrogen and phosphorous to coastal aquatic environments even exceed those to fertilized agro-ecosystem. Increased nutrient loading from anthropogenic sources is pervasive and function of shallow coastal ecosystems during coming decades.

Although increased nutrient loading by precipitation has been documented, most research has focused on deeper estuaries in which flow from rivers and streams dominates water budgets and contributes the major of nutrients. Rivers and direct precipitation, however, are not the sole source of freshwater - borne nutrients to coastal environments. Even in places without rivers, salinity is often depleted in coastal waters due to groundwater input. Groundwater flow is especially important where underlying coastal sediments are coarse, unconsolidated sands of glacial or marine origin. In such situations flow of groundwater may be the major source of nutrients to coastal waters. In unconsolidated sediments, groundwater moves through the watershed shoreward in paths that have downward vertical as well as horizontal vector. Downward flow is caused by additional water infiltrating along the path of the water. Freshwater eventually moves close enough to shore to meet the denser saltwater that saturates interstitial space in sediments beneath the sea. The presence of sea water in the pore space acts together with lower head pressures in the near shore zone compared with offshore to deflect the path of fresh groundwater sharply upward (Bobba, 1993). As a result, most of the groundwater flow occurs very near the shore. During the last decade, it has become apparent that groundwater flow and transport of nutrients into shallow coastal water are far more significant and widespread than had been realized. The importance of ground water is not so much because of the magnitude of flow rates, but rather because of the high nutrient concentrations in groundwater compared to those in receiving coastal water. Although highly variable, the nutrient content of groundwater discharging onto coastal water may be up to five orders of magnitude larger than concentrations in receiving seawater.

Consequences of groundwater nutrient transport

There is enormous freshwater literature that deals with the consequences of eutrophication. The response of primary producers to nutrient loading within an estuary must be dependent on the balance between increased growth due to elevated inputs of the limiting nutrient and losses related to the flushing rate. This is the point of the well documented relation between phosphorous loading and phytoplankton chlorophyll. Additional evidence, based on correlations and inference from N:P values, on enrichments within small containers, and on whole - system enrichments in fresh waters, is consistent with the phosphorus loading results, and shows that in fresh water phosphorus limits potential primary production. In coastal systems the evidence of the role of nitrogen in limiting phytoplankton growth is based on inferences from loading calculations, on ambient nutrient concentrations, and more importantly, on nutrient enrichment experiments. Groundwater entering the coastal areas flows from watersheds where urbanization has taken place. Human activities such as disposal of wastewater via septic tanks, and use of fertilizers increase nutrient concentrations in groundwater. We presently lack of data groundwater along coastal areas, but can make preliminary comparisons using data from nearby locations, where watersheds include some urbanized areas. This paper focuses on application of numerical model to predict subsurface water and pollution discharge to coast.

Subsurface Hydrology of a Coastal Watershed

The two main sources of pollutants are point sources (Table 1) and non-point sources (Table 2). Pollutants from the two sources may be released continuously or at discrete intervals (Figure 1). Point sources of pollution can be geometrically defined and the dimensions are amenable to mathematical analysis in assessing pollution loads and rates of discharge determined. Distributed sources of pollutants are much more widespread and can rarely be geometrically defined as precisely as a point source. Hence, it is more difficult to subject the input/output source to precise mathematical analysis. Rather a measured and intelligent assumption of the affected area is made for use in modelling and analysis. In heavily polluted areas, both point sources and distributed sources may occur together or may be independent of one another.

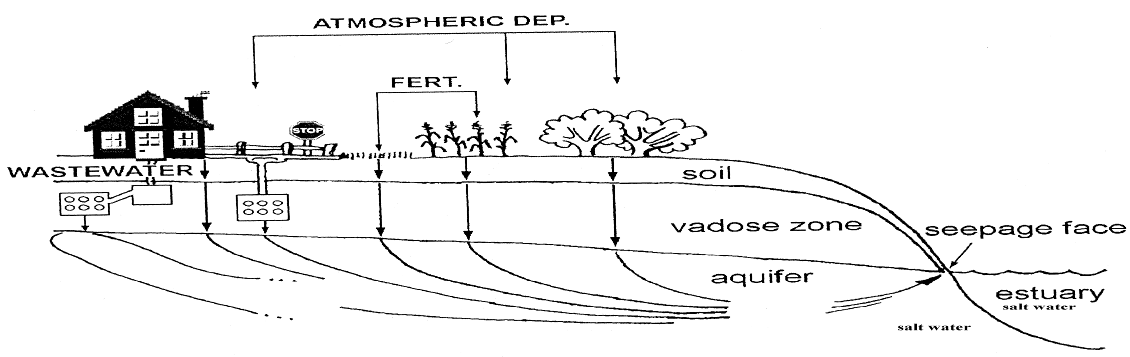

Figure 1 Different sources of pollutants in a coastal watershed

A watershed is a topographically defined as an area that water enters through precipitation and leaves as evapotranspiration, surface runoff, and subsurface water discharge. In the case of a coastal watershed, runoff and subsurface water discharge enter the sea (Figures 1 & 2). Rainfall and potential rate of evapotranspiration are determined by climate. Actual evapotranspiration is limited by the climatically controlled potential rate, vegetation and the wetness of the soil. Soil properties, topography, and the history of rainfall and evapotranspiration determine runoff and subsurface water discharge. For the purpose of this discussion, surface runoff includes direct runoff which occurs as stream flow immediately following a rainstorm, and drainage of subsurface water into creeks which accounts for stream flow between streams. The amount of direct runoff generated by a storm depends on the amount of rainfall and on the moisture condition of the soil. In general, more runoff occurs when the soil is initially wet. The subsurface water discharge can be calculated if rainfall, evapotranspiration, runoff, and the change in the amount of water stored on the watershed are known.

A link between rising sea level and changes in the water balance is suggested by the general description of the hydraulics of subsurface water discharge at the coast. Fresh subsurface water rides up over denser salt water in the subsurface system on its way to the sea (Figure 2), and subsurface water discharge is focused into a narrow zone that overlaps with the inter tidal zone. The width of the zone of subsurface water discharge measured perpendicular to the coast is indirectly proportional to the discharge rate. The shape of the water table and the depth to the fresh/saline interface are controlled by the difference in density between freshwater and saltwater, the rate of freshwater discharge and the hydraulic properties of the subsurface system. The elevation of the water table is controlled by mean sea level through hydrostatic equilibrium at the shore.

Table 1 Point sources of pollution in a coastal watershed.

Type of Pollution	Examples
Sewage disposal systems	Sewage lagoons, septic systems, cesspools, barnyards/feed lots
Surface waste disposal sites	Landfills, garbage dumps, surface waste dumps.
Underground waste disposal sites	Storage tanks (low, medium, high level wastes)
Spills, washings, and intrusions	Oil, gas, waste spills: Auto workshop washings, Research laboratory washings, seawater or saltwater intrusions.
Mining sources	Acid mine drainage: Mine waste dumps, seepages gas explosions.
Natural mineral / ore deposits	Saline springs, hot spring waters, anhydrite, pyrite deposits etc.

Table 2 Non-point sources of pollution in a coastal watershed.

Source	Examples
Agriculture	Cropland, irrigated land, woodland, feed lots
Silviculture	Growing stock, logging, road building
Construction	Urban development, highway construction
Mining	Surface, underground
Utility maintenance	Highways, streets and de-icing
Urban runoff	Floods and snowmelt

Because pollutants are transported in large part by the bulk motion of subsurface water, the parameters of subsurface water flow are of major importance in the understanding of pollution processes. The various aspects of the subsurface water environments, as well as stratigraphic factors that control or could influence subsurface water motion are also of major consideration. The subsurface hydrology environment is shown schematically in Figure 2. It consists mainly of saturated and unsaturated zones. The unsaturated zone occurs above the capillary fringe where the soil pores are partially saturated with water. This zone is important in waste management because in most cases, it is the burial zones for wastes. Consequently, a thick unsaturated zone may sometimes be preferred for waste disposal since it would take a much longer time for pollutants to reach the water table. In the saturated zone, the pores are saturated with water. When this zone is capable of transmitting significant quantities of water for economic use it is referred to as an aquifer. In most field situations, two or more aquifers occur, separated by impermeable strata or aquitard. In the situation illustrated in Figure 2, the upper or unconfined aquifer is much more prone to pollution than the lower confined aquifer.

Computer simulation of subsurface and contamination discharge to coast

Bobba and Singh (1995) presented a detailed description of available model characteristics and recent trends in subsurface water flow and contamination transport modelling. Flow models are used to determine the quantitative aspects of subsurface water motion, such as direction, rate, changes in water table or potentiometric head, stream-aquifer interaction, etc. Transient 2-D models for simulating groundwater flow are widely available.

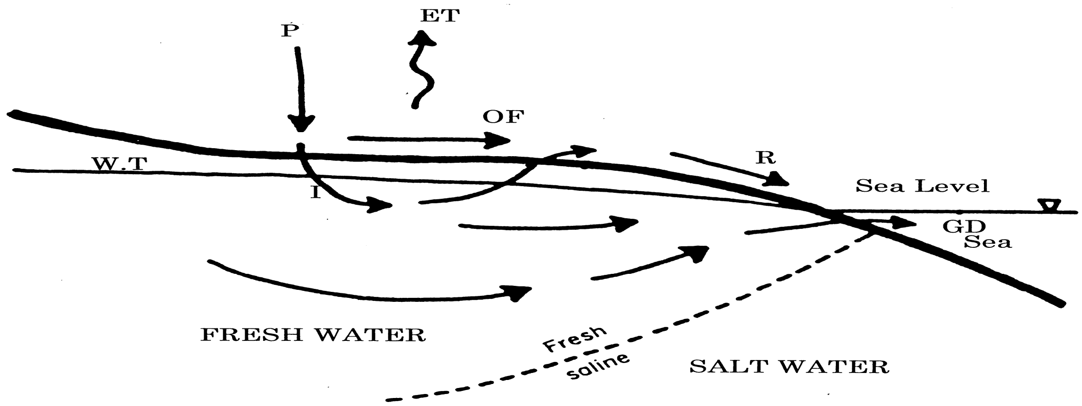

Figure 2 Hydrological pathways in a coastal watershed

One common goal of these models is to predict and characterize the movement of the transition zone in the aquifer where fresh water and salt water meet in coast. Another purpose of modeling is to predict the degree and extent of mixing that occurs in this transition region. In this way, models allow problems to be defined before they actually occur. The details of the models presented earlier by Bobba (1996), Bobba and Singh (1995), Bobba et. al. (2000a, 2000b).

In this paper, a finite element model, SUTRA (Voss, 1984) is applied to three different type of cases. This model simulates water movement and the transport of either dissolved substances or energy in the subsurface system. The model can be applied areally or in cross section. It uses a two-dimensional, combined finite-element and integrated-finite difference method to approximate the equations that describe the two interdependent processes being simulated. When used to simulate saltwater movement in the subsurface system in cross section, the two interdependent processes are the density-dependent saturated subsurface-water flow and the transport of dissolved solids in the subsurface water. Either local - or regional - scale sections having dispersed or relatively sharp transition zones between saltwater and freshwater may be simulated. The results of numerical simulation of saltwater movement show distributions of fluid pressures and dissolved - solids concentrations as they vary with time and also show the magnitude and direction of fluid velocities as they vary with time. Almost subsurface properties that are entered into the model may vary in value throughout the simulated section. Sources and boundary conditions may vary with time. The finite - element method using quadrilateral elements allows the simulation of irregular areas with irregular mesh spacing. The model has been applied to real field data and observed to give favorable are explained as follows (Voss, 1984, Bobba, 1993b, 1998, Bobba et al. 2000a, Bobba et al. 2000b).

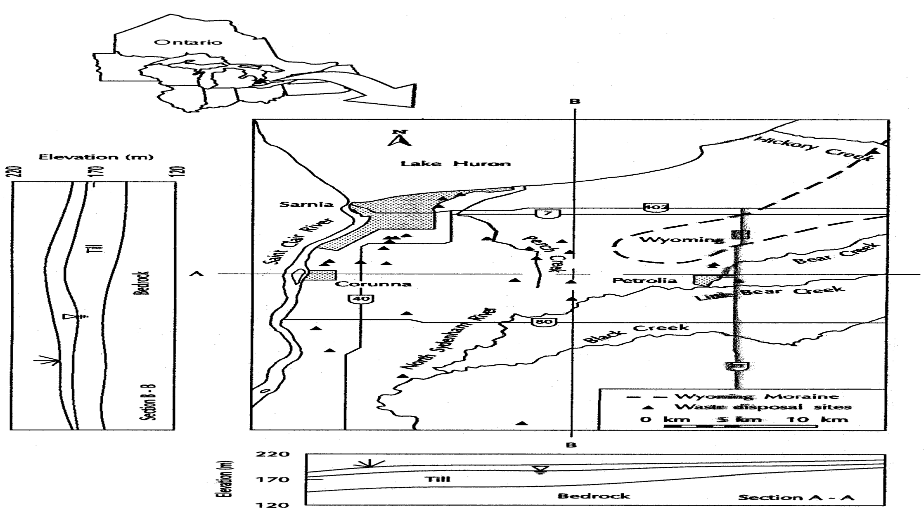

Figure 3 Location of Lambton County where Sections A-A and B-B shows the surface geology and hydrogeology of region in East-West and North-South cross sections.

Case Study 1: Lambton County, Ontario, Canada

Lambton County is located in the province of Ontario, Canada (Figure 1). The study region occupies most of Lambton County is located along the Saint Clair River between Lakes Huron and Saint Clair. The region is boundary to the by Lake Huron and to the west by the Saint Clair River. Numerous chemical and petrochemical companies operate in this region and the wastes generated by these facilities have historically been managed using near surface burial and deep well injection. Sporadic discharge of formation fluids, and possibly industrial waste, to the surface has caused concern over the contamination of Lake Huron, the Saint Clair River, and the regional aquifer that serves as a water supply for rural Lambton County. Migration of wastes injected at depth to the near surface via discontinuities in the confining strata and abandoned deep wells is a plausible mechanism for the contamination of surface and subsurface waters. The numerical models are used to determine rates and directions of groundwater flow for contamination transport studies, predict the impact of varying climatic conditions and groundwater consumption, guide sampling programs for natural and anthropogenic contamination, and determine groundwater discharge to surface water bodies. The geology and hydrogeology of the site are described earlier (Bobba, 1993). The groundwater is obtained from sand and gravel deposits at depths below 60 m. The aquifer is called as Fresh Water Aquifer is floating on top of high saline water due to density difference. Flow in this aquifer is likely be strongly influenced by precipitation events and results in either discharge to shallow ditches, creeks and rivers of recharge to the deeper formations.

The application of the numerical explained earlier (Bobba, 1993). Figure 4 shows the computed hydraulic head map which best approximates the observed water table. The model results indicate that virtually all of the water flowing through the aquifer discharges to the St. Clair Rive and Lake Huron. The water level contours in the bedrock valley indicate a generally westward groundwater flow system. Since hydraulic gradient varies across the bedrock valley, the rates of groundwater flow also vary. Calculations indicate that groundwater flux into and out of the valley are about 0.9 and 0.5 m^3 / sec, respectively, for a 100 m strip of aquifer. The amount which flows westward out of the (0.5 m^3 /sec) probably discharges to the St. Clair River. Discharge of groundwater from the Canadian side of the Fresh Water Aquifer is calculated to be between 0.45 and 0.50 m^3 / sec for that portion of the river between Lake Huron and Stag Island.

Case Study 2: Port Granby radioactive disposal site

Canada has a uranium refinery, at Port Hope, Ontario. The waste from refinery was disposed at Port Granby waste management site located on the north shore of Lake Ontario (Figure 5). In recognition of concern over the possible contamination of surface lake waters, the concentrations of radium and uranium were measured in water samples collected of Lake Ontario coastal zone near waste site. These data showed that the leachate infiltrating and seeping to coastal zone of Lake Ontario. The plume, moving parallel to the shoreline in the direction of the prevailing wind direction. (Figure5). The finite element model applied to calculate hydraulic head and contamination discharge to lakeshore. The predicted Ra-226 contamination concentration from waste disposal site to beach is shown in figure 6. The groundwater discharge from the waste disposal site between the east and west creeks is computed by applying Darcy's law.

The groundwater flow to Lake Ontario from the site is 2.5 x 10^5 m^3/ y. This annual volume of water is about 3 - 4% of the total solid volume of the site, assuming a depth of about 35 m. If the ^{226}Ra activity in the shore piezometers averages about 100 Bq m^{-3}, about 2.5 x 10^{7} Bq y^{-1} is carried into the lake. But the total amount of ^{226}Ra which has been disposed of at the site is 2.3 x 10^{13} Bq, so that only about 10^{-6} of this is lost from the site per year. A comparable calculation for uranium indicates that about 25 kg of this element reaches the lake. The details of the application of model and interpretation of results were presented earlier (Bobba and Joshi, 1988, 1989).

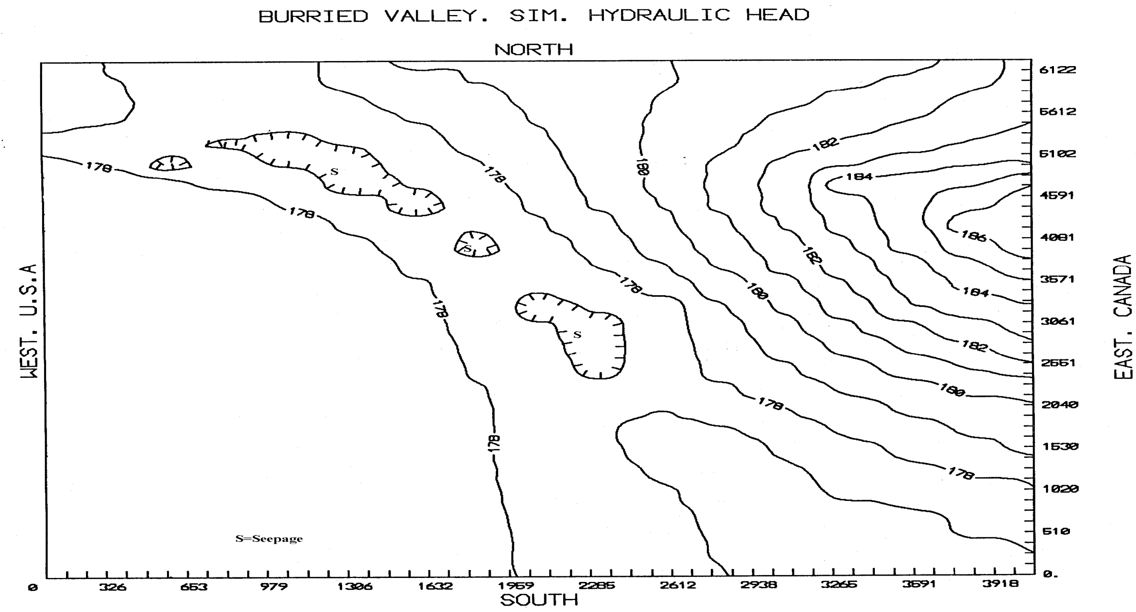

Figure 4 Simulated hydraulic head map of the buried valley, and groundwater seepage locations in Saint Clair River, Canada and USA boundary.

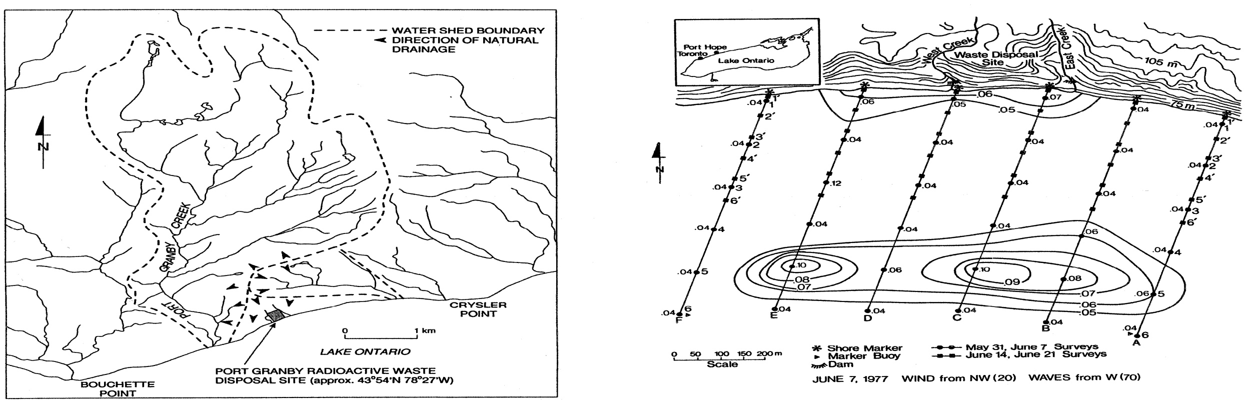

Figure 5 Location of waste disposal site and Ra-226 concentration in Lake Ontario, Canada

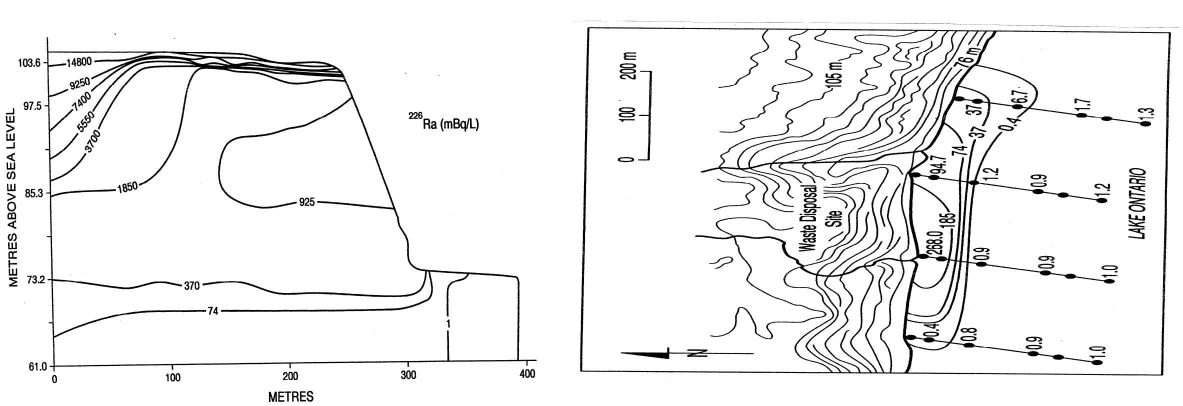

Figure 6 Computed Ra -226 concentration in waste site, beach and observed concentration in coast (Bobba and Joshi, 1988).

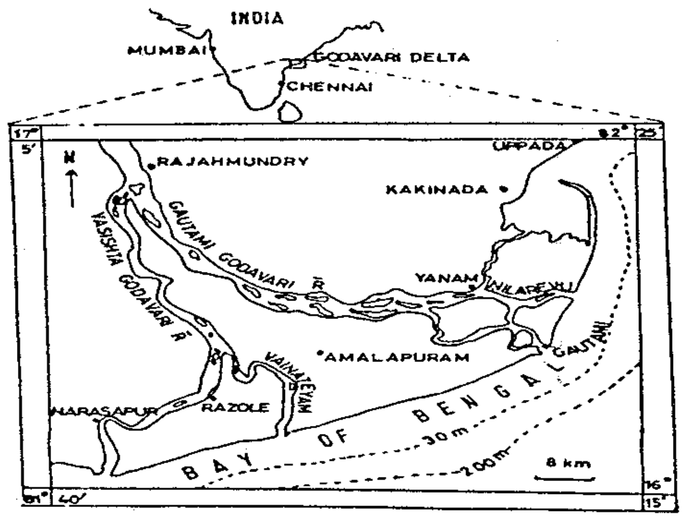

Figure 7 Location of Godavari Delta

Case Study 3: Godavari Delta, India

The Godavari delta is located in East Coast of India (Figure 7). The details of geology and environmental problems have been explained earlier (Bobba 2002a). The Godavari delta lies between the sea level and 12-m contour. The delta has a projection of about 35-km into the sea from the adjoining coast. The Godavari delta consists of alluvial plain. It has a very gentle land slope of about 1-m per km. The coastal line along the study area measures to about 40 km and the general elevation varies from about 2m near the sea to about 13m at the upper reach. Texturally, a major part of the study area consists of sandy loams and sandy clay loams. The silty soils, which are very deep, medium textured with fine loamy soils is located all along the Godavari River as a recent river deposits. The very deep, coarse textured soils with sandy sub-soils representing the coastal sand are also found along the sea.

The delta has a network of canal systems and increased use of new crops along with chemical fertilizers and pesticides have brought about rapid growth in the agricultural output. The crops irrigated with river water throughout the year except between the last week of April and the second week of June. As ample surface water is made available to irrigate the delta, there has been no effort to use groundwater. Potassium fertilizers are extensively used for increasing the crop yield. The variation in potassium concentrations in groundwater in the study area is shown in Figure 8. The peak values are generally observed in November. Higher concentrations are found due to the application of potash fertilizer besides contribution from soils. The temporal variation of chloride and bicarbonate from groundwater samples is shown in Figure 9.

The ratio of chloride/bicarbonate + carbonate can be used as criteria to evaluate sea water intrusion. Chloride is the dominant ion in seawater and it is only available in small quantities in groundwater while bicarbonate, which is available in large quantities in groundwater, occurs only in very small quantities in seawater. The details of the model and application to the Godavari delta basin have been explained earlier by Bobba (2000, 2002a). The prediction of the water table depth due to irrigation and saltwater intrusion reported earlier (Bobba, 2000, 2002a). Figures 10b, and 11b depict the influence of irrigation (rainy) and non- irrigation seasons. During the irrigation season periods, the water table is raised due to irrigation water recharged to subsurface. The distance between surface and water table in the coastal area is very small, and the material is generally composed of sands, which do not retain significant amounts of moisture under unsaturated conditions. Hence, the irrigated water overflows and directly recharges the unsaturated zone. The distance between the water table and surface is at a minimum in the central portion of the delta. It has been observed that areas of minimum depth from the ground level to the water table have high freshwater potential whereas lowering of the water table from the ground surface reduces the freshwater potential substantially. The water table elevation varies from 0.5 m to 1 m from MSL and decreases gradually towards the coastal side. Patches of freshwater zones are also present along coastal areas (Figures 10b and 11b).

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SUMMARY AND CONCLUSIONS

Mathematical and numerical models are useful to estimate subsurface water and contamination discharge to coastal areas from point and non-point source areas. Applications of two types of numerical models were presented in this paper. As an example, a finite element model, considering open boundary conditions for coasts and a sharp interface between freshwater and salt water was applied under steady-state conditions to the phreatic aquifer for fresh water surplus and deficits at the coastline due to El Nino effect. When recharges of saltwater occur at the coastline, essentially of freshwater deficits, a hypothesis of mixing for the freshwater - saltwater transition zone allows the model to calculate the resulting seawater intrusion in the aquifer. Hence, an adequate treatment and interpretation of the hydrogeological data that are available for a coastal aquifer are of main concern in satisfactorily applying the numerical model.

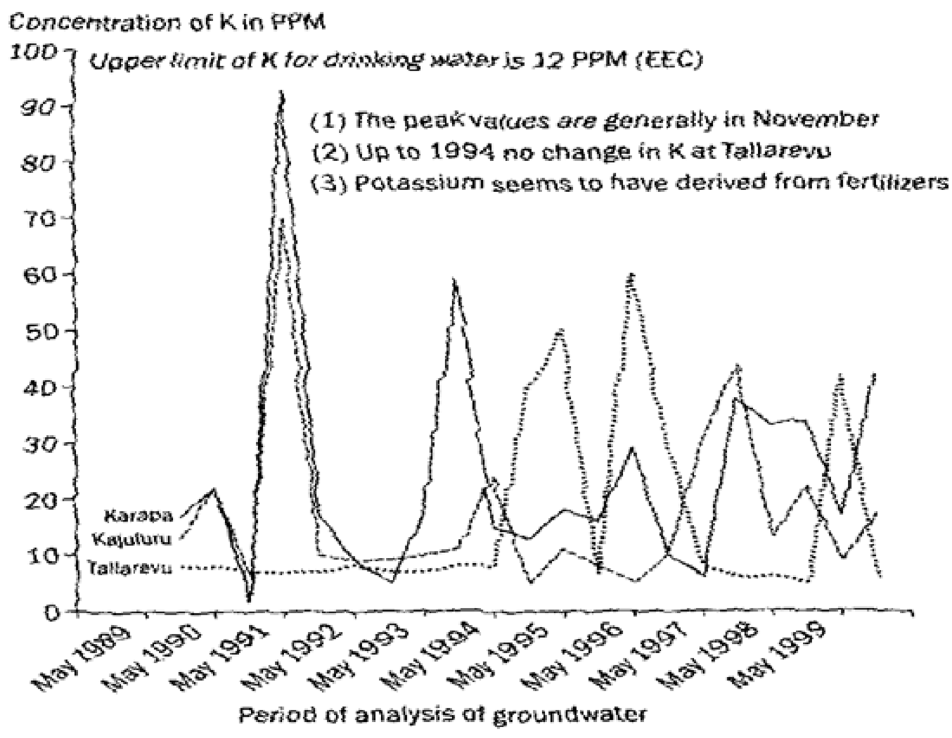

Figure 8 Variation of potassium concentration in groundwater in the Godavari Delta (Chachadi and Teresa, 2002)

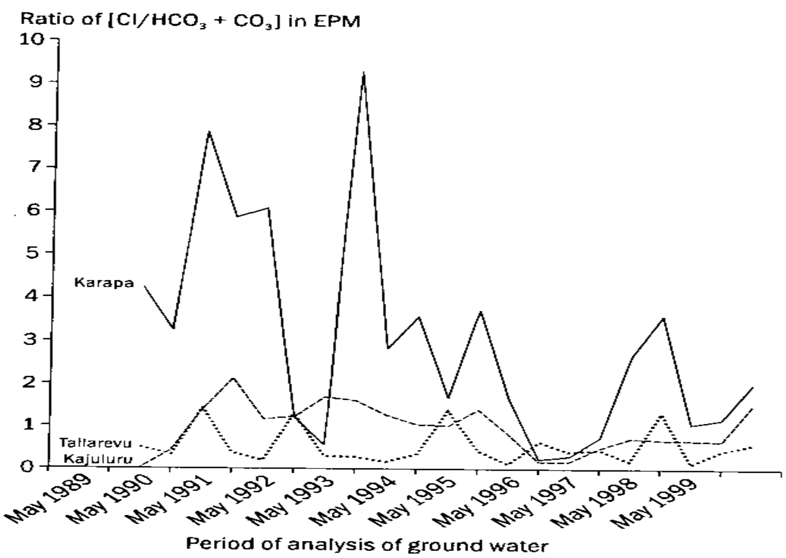

Figure 9 Variation of [Cl/HCO_3+CO_3] ratio in groundwater in the Godavari Delta (Chachadi and Teresa, 2002)

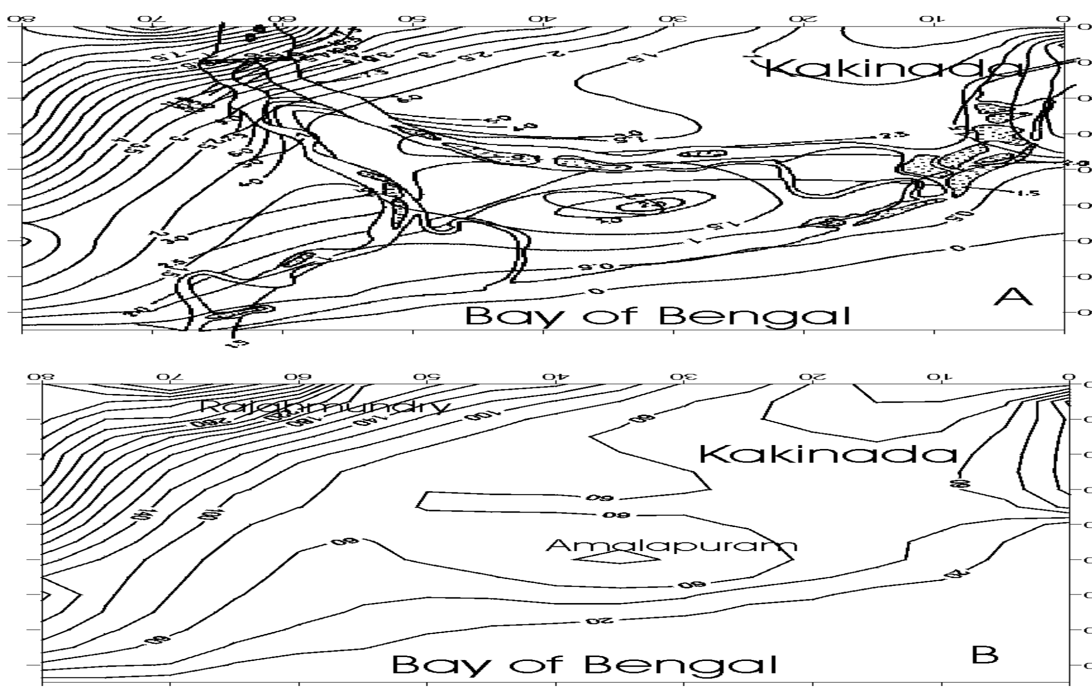

Figure 10 Simulated hydraulic heads (A) and freshwater depth (B) of Godavari delta in non-irrigation months (Bobba, 2002a).

The results of the steady state simulations showed reasonable calculations of the water table levels and the freshwater and saltwater thicknesses, as well as, the extent of the interface and seawater intrusion into the aquifer for the total discharges or recharges along the coastline. As a result of the present hydrogeological simulations on the subsurface system, a considerable advance in seawater intrusion would be expected in the coastal watershed if the sea level rises due to climate change and El Nino effects.

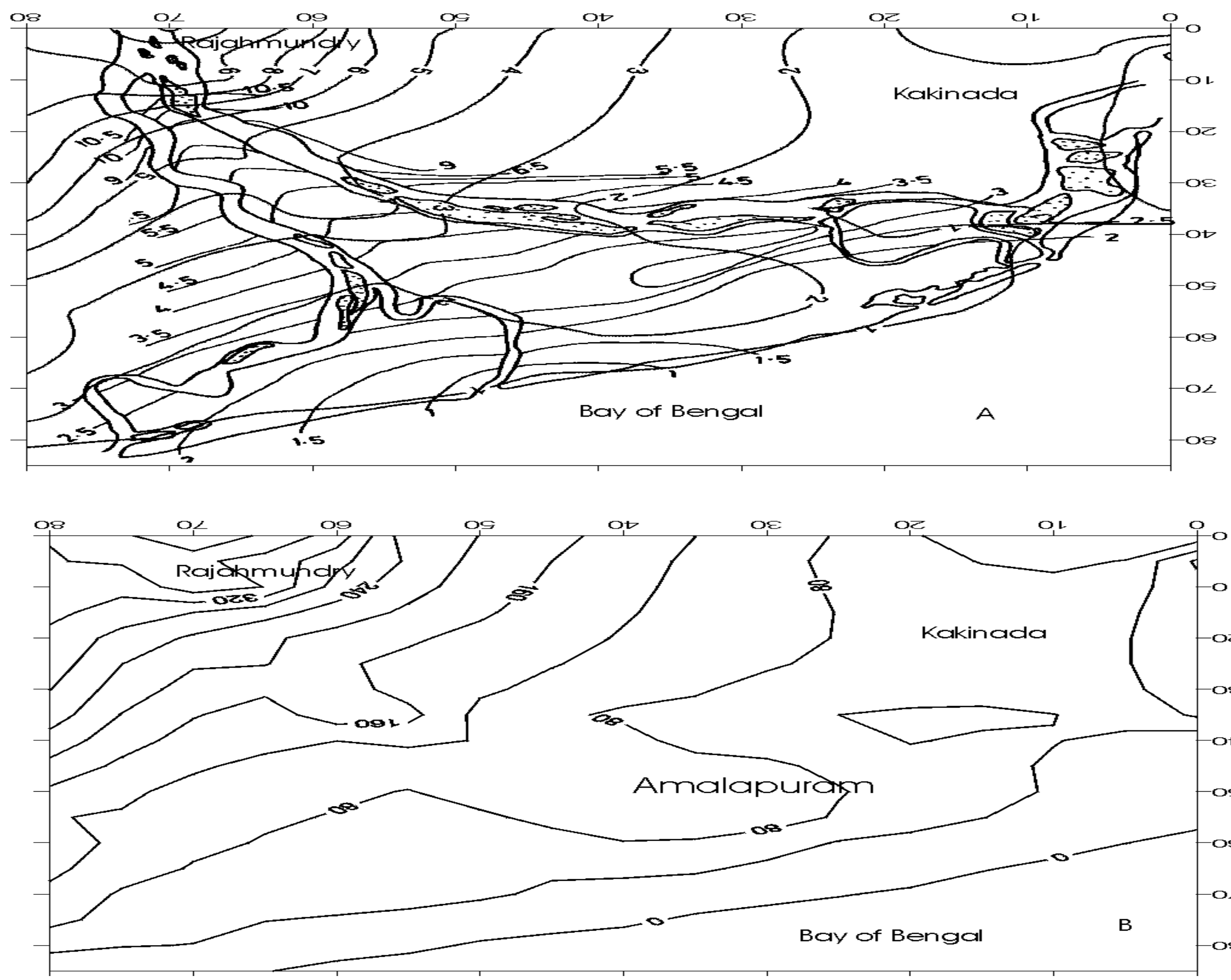

Figure 11 Simulated hydraulic heads (A) and freshwater depth (B) of Godavari delta in irrigation season months (Bobba, 2002a)

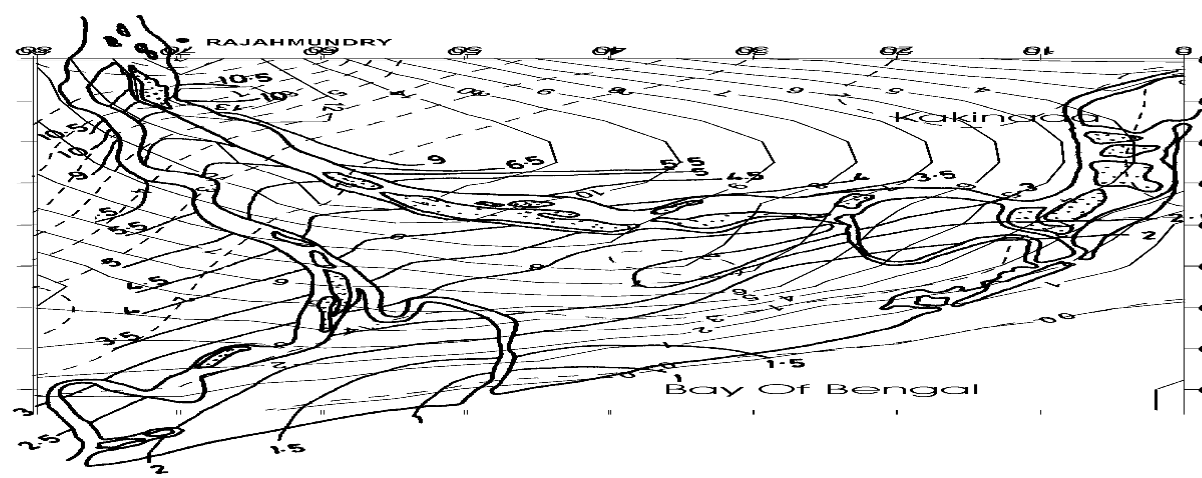

Figure 12 Simulated hydraulic heads of Godavari delta in different seasons (solid line in heavy rainy season, ---- drought conditions) (Bobba, 2002a).

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Environmental Problems in Subsurface Water System due to Human Activities

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ABSTRACT

In many instances, human's activities can have an impact on subsurface quantity and quality. Some of the effects derive from direct actions on subsurface water to exploit it for beneficial purposes or to reclaim wetlands, but there are many other effects that are the indirect consequence of activities not directly or intentionally dealing with subsurface water. In many instances, such indirect effects change the subsurface water environment dramatically, both on a local and regional scale, and there is seldom an awareness of its real importance and its delayed and irreversible consequences. The impact is generally negative, since any change in the natural environment and any offsetting of the natural equilibrium is considered undesirable, but this is not always the case. Water quantity changes are an important aspect to be considered, especially in arid and semi-arid areas. The fast development of many of these areas in recent years, together with the spectacular decrease in groundwater reserves and exploitable resources constitute a tremendous challenge to the human capability of solving acute new social, economic and even political problems. But water quantity problems are not the only ones; quality aspects frequently overshadow them, especially near densely populated urban areas and as the result of the development of mining activities, industrial belts and intensive agriculture, aquaculture and live-stock raising. Solid and liquid wastes from any one of the human activities are fast-growing problems that lack the necessary will to find a solution, since they are placed at the end of the chain, once the direct benefits have already been obtained. Nuclear wastes present special characteristics and need special treatment, though some industrial wastes may be equally or more dangerous. Some related examples will help to understand the diverse circumstances involved in different climates and geohydrological environments. Public education and well-designed monitoring networks are needed to assist in coping with problems related to the subsurface environment.

INTRODUCTION

The increasing power of human to alter and poison his environment, together with a greater concern about health conditions, quality of life, scenery and wildlife preservation, has led to a worldwide reaction to stop further degradation and, even to start restoration programs. Never before has mankind had so huge a capability to excavate and move the earth, to build on it, to reach the most remote areas, and to produce such a quantity and diversity of wastes, artificial chemicals and radio isotopes. Chemicals are used not only in industry, but also intensively and extensively in households and in agriculture and live stock raising. The effects of man's activities can be easily observed through surface water and air changes and even through landscape modification, hence the fast growing activities to cope with them. Most countries now have environmental policies aimed at air and water protection, or have imposed restrictions to the previously unbounded development and production goals. But these activities have their "Cinderella" in what can be called the subsurface environment, which includes groundwater. Direct observation is important to create the awareness of a problem and to cause public concern but underground processes are hidden from observation and thus easily escape concern. Notwithstanding, the subsurface environment is an essential part of human's environment, and has close links with the other external components. Since many ground processes are slow and depend upon the sluggish movement of fluids, the observable effects may be much delayed, even up to one or more human generations. This adds to the difficulties of recognizing the role of the subsurface environment. There is a clear need for general education and dissemination of scientific progress on this field.

Among others, some well known and very serious cases of subsurface pollution and contamination, e.g. the infamous Love Canal in USA; the results of extensive de-watering by groundwater over exploitation or mining activities; massive sea water intrusion in coastal formations; and the prospects of geological isolation of highly radioactive substances in deep repositories; have helped tremendously in the creation of public concern on the matter, and have dramatically increased the efforts to better understand the basic principles of the subsurface environment.

Environmental Aspects of Ground Water

The environmental aspects of ground water can be discussed from various viewpoints:

(a) Effects of ground water occurrence, flow and exploitation on the environment, both external and subsurface.

(b) Effects of human's activities on the subsurface environment.

(c) Interaction between human's activities and subsurface.

The effects are in some instances the direct result of ground water exploitation, but in many other situations are a consequence, not always well recognized, of water use and handling by human, and even the result of activities unrelated to water use. Thus, one can consider direct and indirect effects, both with possible important implications, some in the short term, while others may be delayed decades.

The effects and implications generally involve negative aspects and most descriptions and studies put special emphasis on these. Intensive use of reserves, nitrate build-up in agricultural areas, creating anaerobic conditions, sea water encroachment in coastal aquifers and subsidence are typical negative aspects. Positive aspects can be found also, such as wetland reclamation for agriculture after groundwater exploitation, saline water flushing from under new irrigated areas, or increased water regulation by conjunctive use of surface water and groundwater. But the classification into positive and negative aspects is rather relative, since it depends on the point of view. Wetland drainage after extensive groundwater abstraction is a positive result with regard to agricultural, housing and even human health aspects, but negative from the viewpoints of recreation, wild-life protection and migratory bird conservation.

Groundwater Environment System

The subsurface environment is a complex system of physical, chemical and biochemical interactions among solid matter, dissolved matter and water and also soil, air and gases in the unsaturated zone. Many examples are given in the literature (Freeze and Cherry, 1979; Matthess, 1982; Custodio and Llamas, 1976; Back and Cherry, 1976; Back and Custodio, 1983; Back and Langmuir, 1974; Baedecker and Back, 1979); and it is clear that this environment is highly sensitive to modifications and changes. Human's activities readily produce perturbations and pollution, the effects of which may remain long hidden if appropriate observation methods, equipment and networks are not available. The common idea that groundwater and springs are well protected against pollution is too simple and generally cannot be justified as groundwater pollution has led to a rapid increase in literature.

Though many reactions and evaluations are still poorly known, especially when organic matter and new chemicals are involved, technical and scientific knowledge is rapidly developing as demonstrated in literature (Bobba and Singh, 1995). Redox, sorption, complexation, coprecipitation, hydration and ultrafiltration processes, together with biochemical reactions, play an important role. The movement and behavior of many substances, such as heavy metals and chlorinated hydrocarbons, depend heavily on them. Human's impact on the groundwater environment may involve the mobilization or the effective retention of certain components. Small changes may produce great shifts that are barely noticeable from outside.

The continuous change of the redox potential because of movement of the water table and de-watering, modification of recharge, and altering the soil cover, readily affect iron and manganese contents in water, the presence of nitrates, nitrites and ammonium, the reduction of sulfates or the oxidation of sulfides, the decay of organic matter, the types of microorganisms present , etc.

When considering the groundwater environment, other aspects must be considered also, such as pore and fissure water pressure, the distribution of recharges and discharge areas, and the effect on river flow, lakes and wetlands. Changes in pore water pressure may produce land subsidence, landslides and even the collapse of cavities. Changes in discharge may create water logging, creation of swampy areas, changes in wetlands, modification of river regime and water quality, lake stage modification, sea water encroachment or flushing, and changes in local salinity in close-to-shore areas. Some aspects of this incomplete list will be discussed below.

Health Implications

Groundwater is generally regarded as a safe source of potable water. This is mostly true from the biological point of view, since pathogenic germs and even viruses are easily killed and destroyed. Most experiences and studies support an almost complete decontamination after a few days in the ground, especially in highly sorbing clays and fine materials. To be safe, it is recommended that the minimum period of retention in the fastest groundwater flow-path be 30 days, perhaps 60 days and even 90 days in more sensitive situations. Only karstic formations, very heterogeneous fissured rocks and coarse sediments may show insufficient travel times in some circumstances. Human can dramatically change a given situation by having biological pollution sources close to potable water abstraction works, e.g. through land disposal of wastes, excavation of trenches, drilling of wells, destruction or removal of protective layers, etc., and through changes in the groundwater gradients. All this poses serious challenges to human's ability to preserve the subsurface environment.

In addition to biological considerations, many chemical aspects have decisive health implications. Natural groundwater in some cases may contain excessive and even noxious quantities of certain mineral substances, e.g. boron, arsenic, vanadium and fluorine. But human's activities can introduce into the groundwater environment many compounds that can be changed or decay to others not well known and sometimes more dangerous, or promote the mobilization of minerals that are normally firmly bonded in the soil. Water treatment can be difficult since the noxious substances are difficult to remove; they are dangerous at very low concentrations or they may give way to more troublesome ones during the treatment process. Typical examples are nitrates, organic-chlorinated compounds, and the substances created after chlorine treatment or by reaction with bromine liberated from salts added in potash mining activities. The effect of these new substances on human's health is poorly known, and the ground is a defenseless receptor of covert and sometimes treacherous and criminal actions of waste disposal. The risk to human society is also poorly understood. Present civilization may be threatened by human's uncontrolled impact on the groundwater environment.

Impact of Groundwater Exploitation and Overdraft

The impact of groundwater exploitation by human is related to interference with the hydrological cycle, through groundwater head changes needed to create the head gradient toward the abstraction works. In the past, the capacity of human to change the natural groundwater regime has been small due to the lack of efficient abstraction methods for large discharges. Only galleries or water mines and excavated drains were able to get substantial quantities of groundwater in appropriate situations. After the introduction of mechanical drilling machinery, able to attain great depths with enough diameters, and especially after the availability of mechanically driven turbine water pumps, the situation changed dramatically. The abstraction capacity is only limited by the local aquifer transmissivity and in many instances may exceed the aquifer recharge. People generally do not recognize that well yield is not necessarily related with groundwater resources.

The most significant impacts in response to excess groundwater head drawdown are:

A. ***Decrease in pore water pressure:*** In unconsolidated rocks some irreversible compaction may occur, especially in recent confined formations or when there is extensive de-watering of previously saturated fine sediments. Not only is there a decrease in porosity and specific yield, but a more or less regional subsidence of the land surface. In flat areas, the subsidence not only affects existing man-made constructions such as water canals, but also changes the surface water drainage pattern and the groundwater recharge. These areas become more prone to inundations and ponding. River and creek channels must adjust to the new topography if they are not controlled. In coastal areas the shore-line moves landward and the sea-tide penetrates further inland (Bobba, 1993). The water table may become closer to the ground surface, thus affecting plants, crops and soils, and at the same time increasing evaporation losses and/or decreasing rainfall recharge. Simultaneously, natural or artificial drainage's cut deeper where they are present. Subsidence is well known in many areas, e.g. Cuidad de Mexico, California, Tokyo and Venice.

In soluble consolidated rocks, such as limestone and massive gypsum, cavities may have formed by the process known as karstification. In the present situation these cavities may be below the water table. When the water table is lowered or the cavities are emptied, the roof is more prone to collapse, and crater-like depressions may appear at the surface.

B. Reduction of groundwater outflow: This decreases the natural discharge to streams and lakes, or vegetated areas in arid lands. In large aquifers this can be a slow process evolving unobserved for many years, and even be erroneously explained as a drought consequence. The base flow of rivers, or the water level in lakes, or the summer flows of springs are progressively reduced, and wetlands and natural areas of phreatophytes can shrink and even disappear. Some special and delicate ecosystems can be greatly disturbed.

C. ***Modification of the dynamic balance with other water bodies:*** The most dramatic example is that of coastal aquifers (Bobba, 1993). The reduction in outflow to the sea as a consequence of lowered groundwater head changes the salt water-fresh water relationships, the salt water wedge encroaches inland and the mixing zone expands, even if some fresh water outflow is left (Bobba, 1998). The fresh water storage in the aquifer is reduced and most or all of the reduction is fresh water formerly wasted to the sea. In some circumstances e.g. in flat coastal areas and small pervious coastal islands, the expansion of the salt water body may be accompanied by a progressive deterioration of the chemical quality of a large part of the remaining fresh water body. Other salty and low quality waters can occur underground, e.g. highly mineralized stagnant waters, relict marine waters, water in close contact with evaporite rich sediments, and high bicarbonate waters related with carbon dioxide from magmatic rocks. A change in the fresh water head allows the displacement of these waters, which then invade areas of fresh water and mix with it. Thus the groundwater environment changes to a new one with other chemical concentrations and compositions.

Close to rivers, lakes and other surface areas in hydraulic connection with groundwater, the outflow can be reduced up to the reversal point, after which surface water may be induced into the ground, thus modifying the underground environment. Most changes refer to chemical values, but some changes may also appear on the infiltration surface, since suspended solids are retained on it. The effect of this clogging is highly variable and depends on the size, kind and load of suspended matter, and also on its removal rate and evolution with time. The penetration process, also called induced recharge, may bring in polluted and contaminated waters, which may have a deleterious impact on the groundwater environment, nor amenable to easy control and management.

D. ***Changes in the exploitation conditions of aquifers:*** These changes depend on the aquifer properties, but they are mainly related to the decrease in the saturated thickness (reduces effective transmissivity, which gives an associated decrease in well yield) and the need to deepen existing partially penetrating wells, or to abandon shallow ones or shallow water galleries and drains. There is a parallel increase in water abstractions costs, and these may present an upper limit, beyond which groundwater abstraction cannot be sustained without a change in the water use or in the form of application. All this can lead to the devising of new water schemes, the promotion of new social habits and the introduction of new technologies in industry and agriculture. This induces new social environments, conditioned by a change in the groundwater environment.

The most dramatic effects are related to sustained aquifer over exploitation. After several years or decades of overdraft, problems of aquifer dewatering, excessive water level depth, decrease in well yield, escalating water costs and even water quality deterioration appear. This is a current common situation in the United States (Texas, Arizona, California, Ogallala aquifer), Mexico (Hermosillo in Sonora, to some extent in La Laguna), Israel, Spain (Canary Islands, La Mancha, Central Mediterranean coast, Tarragona) to mention only a few. The future in these areas is not clear and a great deal of imagination and good water management is needed to solve the problems, or to drastically reduce the economic activity. In some instances, rivers and wetlands have been changed and large agricultural areas will be abandoned in the future. They may take centuries to recover.

Groundwater quality deterioration, or a change in the land use, can lead to a fast reduction in water abstraction. As a consequence, the water table trend is to return to the natural situation or even to a higher position if recharge is increased. Thus, underground constructions (subway tunnels, underground parking stations, sewers) and building foundations, placed when the water table was permanently depressed, can become flooded and subject to uplift. Serious problems of this kind are known in urban areas and also in areas affected by ground subsidence. From another point of view, the use of wells abstracting salt water, for example for cooling purposes, in a certain measure protects other inland wells in intensively exploited aquifers. When the salty water wells are closed the protection effect ceases.

Only in relatively recent years has agriculture been recognised as having a significant effect on groundwater quality. The dramatic increase in the agricultural land output has some detrimental effects, mainly connected with the massive application of fertilizers, especially artificial ones. Since they are not fully used by the plants, they are leached downwards by the excess of soil water. The increase in nitrate in well water used for municipal water supply in some agricultural areas of the United States, India, etc. This concern is justified by the fact that the maximum allowable content of nitrate in drinking water (about 50 mg/l) is easily attained and exceeded (more than 500 mg/1 is reported in some irrigated areas). But it is also justified by the fact of the slow vertical movement of the pollutant though the unsaturated zone, which in many areas is rather thick. This movement is generally not observed since sampling need expensive and complicated devices. Transit times from a few years to many tens of years are possible, and in many situations the bulk of the contamination is still on its way down and, in the case of non-degradable chemicals, will certainly appear in the future. However, it continues to be ignored by many agronomists who see only the improvement in the quantity and the quality of the agricultural output, and at most consider the leaching of fertilizers as an economic loss to be reduced if it does not increase other costs and expenses.

Nitrate is not the only concern, since many other substances (pesticides, herbicides etc.) are leached down and influence the groundwater quality. An increase in total solids content comes from the almost total solution of the mineral part of many fertilizers such as sulfates which are not used by the plants. The fate of other fertilizer components such as potassium and phosphorus is less clear, since both of these are used by plants. Phosphorus can be easily precipitated or retained by the soil particles and minerals, but in some conditions both can also reach the groundwater table. Ammonia is generally oxidized to nitrate. The fate of pesticides is highly variable and often poorly known. Many of them are effectively sorbed by soil particles and perhaps there is enough time to decay before they reach the groundwater table. Due to the health effects associated with them, their use is more controlled, but is not known if the most dangerous ones are still in the unsaturated zone and moving downwards. Since the percolating water may have a different ion concentration and composition, cation exchange can occur, not only altering the chemistry of the groundwater but possibly also the hydrodynamic properties of the soil and aquifer.

When natural organic fertilizers, such as manure, are used and they are not properly prepared or applied, soluble organic matter can be leached down. If available underground oxygen is consumed, anaerobic conditions may develop in certain ground zones, as a consequence of which water quality changes are possible, e.g. nitrate reduction to dissolved nitrogen and ammonia, iron and manganese dissolution, sulfate reduction and sulfide precipitation. Ammonia is readily sorbed in cation exchange, up to a saturation limit. A later penetration of oxygen can reverse the situation, with the oxidation of precipitated sulfides and sorbed ammonia, and the consequent increase in soluble sulfates and nitrates. These changes are more probable when live-stock or sewage effluent sludge is applied to the ground.

Other effects of agriculture are related to irrigation with local groundwater. Besides the leaching of natural or added fertilizers, there is an increase in the percolating water salinity since most of the applied water is evaporated or transpired and the applied salts concentrate in the remaining water. Most of the soluble salts contained in the irrigation water return to the water table, and thus the phreatic groundwater quality is being impaired progressively, and also irrigation water if it comes from the same aquifer. This effect is well known in arid and semi arid areas of the United States, India, and Mexico and the tropical countries. It is a serious challenge to future generations, which may be unable to get fresh irrigation water.

When subsurface water is of poor quality or dissolved salts are not leached down, a progressive impairment of the agricultural soil occurs and finally alkaline and saline soil conditions develop. This requires the growing of more salt tolerant crops, up to the stage when the soil fertility is destroyed. Such conditions are not rare in some irrigated areas in India.

Another undesirable condition appears when irrigation projects are undertaken in areas with saline soils or sub-soils. The excess irrigation water is generally highly saline and pollutes the local aquifers or the watercourses which receive these waters, through ground seepage or by means of agricultural drains. This and the concentration by evaporation have been deteriorating the quality of groundwater and rivers in south western United States and is of great concern in Hariyana state in India.

When irrigation uses imported or surface water and drainage to local aquifers is difficult, excess irrigation water piles up and finally some areas may be water logged, or become salted through direct evaporation of groundwater. It has been a classical issue in the Punjab and Hyrayana area, in the Indus basin. In such cases, when the recharge is still fresh water, new usable groundwater storage is created, and can be put to beneficial use, at the same time controlling the above-mentioned undesirable effects.

Live-stock raising is a source of groundwater pollution, mainly in connection with disposal of excreta. It is generally not a serious problem since the benefaction effects of the soil can mostly cope with the organic matter disposed of. In fractured rocks and karstic areas some chemical pollution and even bacteriological pollution may reach the groundwater system, and cases of impairment of water supplies from springs and wells are known. The use of salt as a feed stock complement may lead to local increases in salinity.

Intensive and stabled live-stock raising is much more prone to cause pollution of the underground environment, especially in the cases of pigs and cows. The disposal of ranch sludge by surface spreading often creates a lack of oxygen in the ground, thus promoting anaerobic environments. Iron and manganese problems in local wells for water supply are rather common. Other pollutants are also found.

Industry and Urban Areas

Industry, urban areas, dwellings and even parking lots and camping grounds interfere with the subsurface water environment by changing the land surface and by producing wastes. These changes alter and generally reduce groundwater recharge and also retard oxygen penetration into the ground and carbon dioxide out gassing. As a consequence the groundwater regime is modified, the groundwater environment has less available oxygen and may become anaerobic. Also, groundwater hardness and bicarbonate content may increase.

The effect of wastes is generally more serious. Solid wastes, disposed of in very different forms and under highly variable circumstances, in pits, old quarries, over the land surface, in engineered refuse tips, in land depressions, etc., can contain a large diversity of soluble substances and chemicals which can be leached down by infiltrating water or directly by groundwater when the wastes are within the saturated zone. Some of them are conservative and remain in the subsurface water; others are exchanged or sorbed on the soil minerals, or precipitated, or subject to chemical changes and degradation through sometimes complex biochemical redox processes. The behavior of many substances is unknown and others may decompose and decay through poorly known intermediate products. Much recent literature is devoted to current case studies, experiences and research on this topic, but in many aspects the science and the technology are just starting.

A similar discussion can also be applied to liquid wastes when effluents are disposed of in such a way that at least a fraction of them can find their way to the groundwater environment, either directly, or through land disposal, leakage, diffusion pits and wells, polluted river infiltration, etc. Liquid wastes are usually polluted water, fully miscible with groundwater, but other wholly and partially soluble or insoluble liquids are not rare, e.g., hydrocarbons, organic solvents and concentrated acids. Some of these liquid wastes such as hydrocarbons move in the ground in a separate form to groundwater; others promote chemical reactions with the solid underground environment (dissolution, enhanced hydrolysis, precipitation, changes in clay particle volume and hydration state).

Many typical subsurface water environment pollutants can be mentioned, causing problems ranging from total dissolved salt augmentation to temperature increase. They include organic matter, hexavalent chromium, hydrocarbons, boron compounds, detergents, phenols, etc. All hydrogeologists can surely present a long list taken from their own experience.

Wastes introduced into the atmosphere, directly or through stacks, can also be a source of changes in the subsurface water environment, in the same way as other air-borne substances enter the ground. Generally they extend over a large area surrounding the source (mine, industrial complex, urban area, thermal power plant, oil refinery, petrochemical plants). The effects are barely noticeable at the beginning, but accumulate steadily over the years.

Typical pollutants which alter the subsurface water environment after atmospheric pollution and transport are sulfates, nitrogen compounds, trace but significate quantities of halogenated organic compounds, some heavy metals (lead, mercury, arsenic, and cadmium) and the worrying and challenging acid rain (Bobba et. al. 1995). Rainfall washes down the pollutants, and movement in the ground follows the same patterns as those coming from solid wastes and liquid effluents. Acid rain affects soil permeability through changes in the vegetation cover and in the soil itself, and may promote further dissolution and weathering.

It is clear that changes in the groundwater environment can be attained and be noticed in the surface water environment after some time, in accordance with the mass transport properties of the underground environment.

Mining and Milling Operations

Mining activities are important human undertakings that directly affect the underground environment through deep and extensive excavations or by means of engineered cavities. Interferences with the underground and the subsurface water environment are numerous and sometimes intense. The fact that in many instances the mines are far from densely populated areas and that generally they try to keep from outsiders its data, exploitation methods and problems, is why these interferences are commonly not well known or recognized.

The major impacts on the subsurface water environment are related to:

- The need to keep the mining areas and extraction fronts free of water. This is achieved through intense dewatering works or major drainage and pumping operations. They pose similar problems to those associated with intensive groundwater exploitation, such as subsurface water outlet reduction and even suppression, and possible land subsidence. The abstracted water must be disposed of, and this may change river flow regimes, create new ponded areas, or alter the recharge of related aquifers. In arid and semi arid belts, mine drainage can waste highly valuable water resources that will need centuries to be restored.
- The need to remove deep seated saline waters, when they occur, frequently mixed with other waters. Besides polluting receiving surface streams, related aquifers may be affected.
- The penetration of atmospheric and water dissolved oxygen into rocks and tailings which contain materials unstable in an oxidizing environment. Acidic and/or saline waters, or waters anomalously high in some components, may form. These changes are typical when sulfates in minerals or in milled rocks are oxidized to sulfates and sulfuric acid, and iron then dissolves in the low pH waters. This is frequent in pyretic rocks and in coal mines (Bobba, 1971). The disposal of these waters may be a different problem if pollution is to be avoided.
- The flow of groundwater through newly opened fissures or through disturbed materials can dissolve soluble matter otherwise not in contact with it. These situations reach their most dramatically expression in salt and potash mines. Brines and salt water can originate from excavated areas and salt tailings, as well as the brines discharged at the salt mineral treatment facilities-and mills. Surface streams and aquifers near the site or downstream can be severely affected.
- Mining activities may also cause extensive changes in the surface drainage pattern, in the soil characteristics and in the sediment transport or rivers. Subsurface water recharge may be altered consequently.

Besides the above-mentioned problems, quarries and gravel pits can present new ones when used to dispose of solid and liquid wastes, unfortunately a worldwide common situation.

Some important tunnels or large civil works that involve excavations and earth movements produce similar impacts, apart from the effect, of permanent or engineered underground structures which can interfere with the subsurface water flows opening new paths, damming others or changing the water pressure distribution. Springs may dry out and the base flow of rivers can increase, wetlands may be altered, and so on.

Nuclear Activities

The nuclear energy production cycle releases and produces radioisotopes in its diverse stages, and they can be released into the groundwater environment.

Natural radioisotopes related to the natural radioactive series of uranium and thorium are reworked during uranium mining operations and the concentration and purification processes. Release of radon and radium is of concern. Radon readily escapes to the atmosphere and decays, having a short half-life of 3.8 days. It is not a major problem to the subsurface water environment, except in special situations of' rapid solution in water percolating through mine tailings or mineral stock piles, and fast transit time to the groundwater outlets. Radium can be easily incorporated into subsurface water after mineral milling (Bobba and Joshi, 1988, 1989), since it behaves as a moderately soluble earth-alkaline cation. Since it has a rather long half-life of 1620 years, it can reach neighboring wells, springs and watercourses in higher-than-normal concentrations. Uranium can also be a problem since it is readily oxidized to valence 6, and some soluble anionic complexes with sulfate and carbonate can form, or uranil cations are taken in acidic solutions. Generally, it is a localized problem, but subsurface water with abnormally high uranium content can reach water courses, springs and wells in nearby areas.

However, the major concern focuses in the production of fission and activation radioisotopes in nuclear reactors. The most deleterious concentrations are found in irradiated nuclear fuel elements, which contain high concentrations of fission products, plutonium and others. Up to now the raw spent irradiated nuclear fuels, or the solid and liquid wastes resulting when it is reprocessed to recover the plutonium, and the remaining uranium are temporarily stored in special pools and tanks, whilst methods of their final disposal are being studied and tested. These nuclear wastes, in an appropriate stable and highly insoluble solid form must be effectively isolated for many millennia (times between 105 to 106 years are sometimes proposed), and it poses unprecedented problems for low volumes of high concentration. Geological confinement seems and is probably the most promising means of geological term isolation (Davis, 1979, 1980), with a reasonable guarantee of a tolerable very low radioactive leakage to the environment.

The effectiveness of such confinement is mainly related to the deep subsurface water environment, which presents in many aspects new challenging situations, currently being studied and tested. Regional groundwater flow systems must be considered in detail (Toth, 1962, 1979). Special testing projects are being carried out in several countries. The international venture in the strip mine in the granites of Sweden, or the German and American undertakings in thick salt domes is especially relevant. Also, new modelling efforts and parameter gathering and study techniques are being instigated (Bobba and Singh, 1995, Piggott et al. 1996, 1995).

Up to now, main interest has been concentrated on dry rocks such as salt and granites, but deep homogeneous non-fissured porous rocks also offer good prospects and more reliable hydraulic and mass-transport parameters. The existence of groundwater is not a major handicap, but the public need assurance in these regards.

The major concern is the behavior of mobile long-lived radioisotopes such as I-129, plutonium and some other transuranides. Some understanding of the behavior of fission-related radioisotopes in the subsurface has been gained through the study of the geochemistry around the million years old natural fission reactor of Oklo (Gabon). Much smaller quantities but much larger volumes of radioactive and potentially radioisotope containing wastes are produced in nuclear reactors, nuclear facilities and scientific and medical laboratories. One of the disposal methods is burial in controlled trenches, excavations and old mine galleries, generally in more or less well sealed drums, or directly, depending on the nature and radioactive characteristics of the material. The control and the quality of the disposal form has not been always safe enough, and some of the contained radioisotopes have leaked into the groundwater environment (Bobba and Joshi, 1988, 1989). Especially important are the Sr-90 (half-life 28 years) and the Cs-137 (half-life 30 years) jointly with ruthenium-106 and minute quantities of plutonium and other transuranides. Their movement in the subsurface can be substantially delayed by sorption processes, mainly through cation exchange. This is a desirable condition since it favors decay before the outlet is attained, but the process can be dramatically changed when the groundwater geochemical environment is modified. The presence of some common cleaning products, such as the ethylendiaminotetracetic acid (EDTA), used to decontaminate surfaces, tools, devices and others, may promote the formation of highly soluble, stable, much less sorbable complexes.

Ternary fission processes in nuclear reactors produce large quantities of tritium ($^3H_1$), the soft beta-decay radioactive isotope of hydrogen, with 12.3 years half-life. The use of lithium hydroxide to control the pH of the moderating and cooling water in light water reactors adds to the tritium build-up. Part of this tritium can reach the groundwater environment, in addition to that contributed from the past tests of nuclear weapons, mainly from 1957 to 1963, and incorporated in rain water. Tritium that forms part of the water molecule behaves and moves almost identically to normal water. Krypton-85 (10.6 years half-life) is another normal gaseous fission produce released in nuclear plants and spent fuel reprocessing facilities, and if not retained before reaching the stacks and vents, it passes into the atmosphere. From there it can be taken up by the rain and thence into the groundwater environment, but current concentrations are not of concern. A possible atmospheric emission of I-131 in accidents is not a serious danger to the groundwater environment due to the great dilution and short half-life (8.02 days).

Other Impacts of Human

In the proceeding paragraphs a short review of human's activities which affect the hydrogeological environment has been given. But there are other activities not directly mentioned, although they can be fitted into some of the categories discussed.

Artificial groundwater recharge produces the reverse effects of withdrawal and thus can be easily understood, but direct introduction of water into the saturated medium avoids most of the soil-water interactions and physical, chemical and biochemical reactions that tend to protect the groundwater environment against man's effects. The recharge of extraneous or in some way polluted waters needs some caution in surface water-groundwater conjunctive use schemes and projects.

Closely related is deep injection of liquid wastes, which poses special problems and in many aspects is only a means of disposal by storage in the ground (Piper, 1969; Cook, 1972; Custodio and Llamas, 1976). Operational failures, poor management and inadequate safeguards often produce environmental problems, including an increase in earthquake activity.

Surface water reservoir construction by damming rivers also can have a clear response in the groundwater environment by changing the groundwater levels and in some instances favoring recharge, as is frequent in limestone areas in countries and islands in the Mediterranean area (Custodio and Llamas, 1976).

Assessing and Coping with Human's Impact on the Groundwater Environment

The preservation of the groundwater environment is an important goal to be achieved before changes and damages reach too far. But it is more difficult than protecting surface water, since this is a one-dimensional aspect and aquifers present at least two dimensional, and often three dimensional problems; moreover they are hidden from direct observation. Whilst river reaches are generally public land, accessible for surveys, the underground environment may be below extensive private lands or under constructions, dwellings, factories, urban areas, etc.

To assess human's impact it is necessary to install and maintain a well planned observation network, including springs, wells, piezometric bore-holes, special wells for water sampling, and also appropriate instrumentation and measuring devices. It needs a decisive will to do this and to provide permanent human, material and financial means, which commonly are not available. Also a continuous research effort is needed. The value of the environment to be protected justifies this, especially in semi-arid and arid areas, where water is perhaps the main raw material.

But perhaps one of the most needed methods to provide for the proper management and protection of the hydrogeological environment is public education commencing from primary school. Currently the teaching of subsurface water principles is almost absent from primary school and even from secondary school and University; and when something is taught, it mostly uses very primitive concepts which include some erroneous or inaccurate descriptions, in which chemistry and environment are usually absent.

The slow and cumulative effects inherent in the groundwater environment can produce important social and socioeconomic implications. They need new decisions in politics that must find a new dimension in the short term policies that are currently adopted by many democracies.

CONCLUSIONS

The groundwater environment is an essential part of the underground environment, and can be easily and extensively influenced by external actions. The effects may appear after a long delay, thus posing unprecedented problems. Also, the groundwater environment is reflected in the surface water environment, landscape and wildlife. Human has currently the capacity of producing intense and extensive changes through groundwater withdrawal, generating wastes, using improved agricultural practices, mining minerals and rocks, and many other activities, including the water cycle management, all of which alter the hydrogeological environment, including both negative and positive effects. Not only are direct actions on groundwater responsible for changes; many others have indirect effects. Since groundwater is hidden from direct observation, many impacts are not perceived for many years, or they are not recognised at all, being attributed to other causes. A thorough education on subsurface water and environmental science is needed, starting from primary school, in order to point up the necessity of coping with current and future problems; an informed public opinion is essential to support long term policies and the instigation of observation networks, research, regulations, safeguards and surveys which are necessary to conserve and correctly use and manage the subsurface environment and its relationships with the human and living environment.

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A Comparative Study of Hydrogeochemistry of Shallow Groundwater of two Districts in Northern Kerala

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ABSTRACT

Hydrochemical assessment of shallow ground water of two districts in northern Kerala is presented in this study. The two districts selected for the study are (i) Kozhikode with the total area (2344 km^2) and coastal length of 71km and ii) Wayanad district with total geographical area (2131 km^2) and comes under the physiographical category - high land. Physico-chemical parameters like pH, EC, DO, ORP, TDS and temperature were determined in situ. The chemical analysis include major ions such chloride, sulphate, bicarbonate, sodium, potassium, magnesium and other water quality parameters like TA, TH, CaH and MgH. Laboratory analyses were done following standard procedures. pH of water samples of the study area ranged between slightly acidic 4.4 to 7.8 with an oxidative potential at all locations. The water quality of the study area was found to be suitable for drinking and domestic purposes. Major water type found at both the districts is Ca-HCO_3- type.

Keywords: Hydrochemistry, Shallow ground water, Water quality, Hydrochemical facies, Kozhikode, Wayanad.

INTRODUCTION

The consumption of water and other natural wealth has increased in an alarming rate by the day by day escalating population. Ground water is the major source of water for all the basic needs of man. It sustains many activities like drinking, domestic and agricultural uses and industrial consumption. There has been a tremendous amplification in groundwater contamination issues in past few years (Yanggen and Born, 1990). Many cases of groundwater contamination have been reported worldwide. Together with the climate change and other environmental problems, groundwater contamination is hence a topic of concern.

Like other natural waters, groundwater is solution of various substances in water. When water moves from soil surface to sub surface it comes in contact with many minerals present in both the soil and bedrock (Lloyd, 1985). This process takes a very long period of time. Eventually there occur various chemical reactions through the process of dissolution. Chemical reactions like acid - base reactions, redox reactions and solution – precipitation etc. take place beneath the soil surface. Due to this nature, the chemical reactions of water play a major role in studies related to groundwater and its movements through aquifers. Thus all these chemical factors together with the geological factors contribute in determining the quality of groundwater. Recent developments related to the varying climatic conditions in Kerala, has increased the importance of the water quality studies. This work is relevant as the ground water is the main source of drinking water in predominant places of Kerala. The study aims on the quality and suitability of the drinking water. The study conducted here is in two districts of the Northern part of Kerala which are Wayanad and Kozhikode.These two districts are facing major problems related to drinking water availability and its quality.

MATERIALS AND METHODS

Study area

The study area is extends from 11.2588°N to 11.6854°N and 75.7804°E to 76.1320 °E. It includes two northern districts of Kerala i.e. Wayanad which falls exclusively under the physiographic zone - highland and Kozhikode with three physiographic zones *viz.* lowland, midland & highland with coastal line of about 71 km. 70% of total rainfall in the study area is contributed by the south west monsoon and 30% by north east monsoon. The whole study area of 4475km^2 was divided into 6x5 grids (30 km^2) and the centre point was taken as the sampling location so that there will be an even distribution of sampling locations throughout the study area. The maps were prepared prior to sampling using ArcGIS version 9.1software. The salient features of the districts are given in the Table 1.

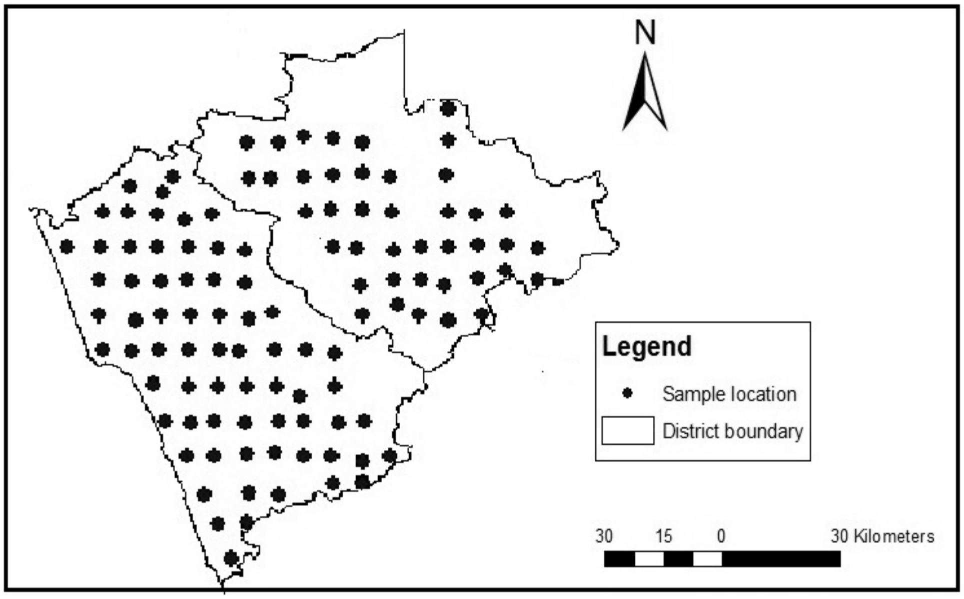

Figure 1 Map of the study area with sampling locations

Table 1 Salient features of the study area

District	Total area (km^2)	Average rainfall (mm)	Temperature (°C)		Population density (per km^2)
			Min	Max	
Wayanad	2131	2786	13.87	33.9	383
Kozhikode	2344	3698	22	32.9	1318

(*Source: CGWB, 2009; DES, 2013; Census, 2011*)

METHODOLOGY

Sampling and Analysis

Water samples were collected from open dugwells (shallow ground water) used for drinking and other domestic purposes during the post monsoon period (October 2015-January 2016). 38 samples were collected from Wayanad district and 63 from Kozhikode district. Water samples were collected in low density plastic bottles (2.5 l) which were pre cleaned and rinsed with sampled water many times before collection. The various physico-chemical parameters like pH, Electrical Conductivity, Total Dissolved Solids, Dissolved Oxygen, Oxidation-Reduction Potential and Temperature were measured in the field site itself using portable water quality analyzer (Eutech). The collected samples were analyzed for all the water quality parameters like total hardness, total alkalinity, cations (Na, K, Ca, Mg) and anions (Cl, SO_4, PO_4, NO_3, HCO_3^-) as per standard procedures (APHA, 1995) at the Isotope Hydrology Division, CWRDM.

RESULT AND DISCUSSION

Hydrochemistry of ground water

In the study area, water used for drinking and domestic purposes was colorless, odor less, free of turbidity and of acceptable taste. The water sample which was above the limits prescribed by BIS is not included in the table. The general statistics of all the parameters for rest of the samples are given in Table 2.

Table 2 General Statistics of Wayanad and Kozhikode

Parameter	Wayanad				Kozhikode				BIS Standard Values
	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	
pH (pH units)	5.2	7.8	6.4	0.7	4.4	7.6	5.8	0.65	6.5-8.5
EC (µS/cm)	58	599	208	126	47	626	127	97	---
TDS (ppm)	37	383	133	80	30	401	81	62	500
DO (ppm)	2.1	5.0	3.4	0.7	2.07	6.7	4.8	1.3	---
Temp (^{0}C)	21	32	27	2.9	24	30	27	1.0	---
ORP (mV)	116	315	243	36	123	228	192	23	---
Cl (ppm)	3.55	62	14	12.8	6.2	38.1	15	7.2	250
SO_4 (ppm)	0.12	9.35	2.51	1.63	1.9	15.2	3.1	2.2	200
HCO_3 (ppm)	17.08	200	74	50.4	7.3	236.7	38	40	---
Na (ppm)	0.30	43	7.6	8.16	1.6	20.5	8.6	4.6	---
K (ppm)	0.03	1.50	0.49	0.38	0.0	8.7	1.2	1.5	---
Ca (ppm)	7.28	84	33	21.8	2.4	92.0	14	14	75
Mg (ppm)	0.00	7.2	1.81	1.76	0.0	8.6	1.5	1.8	30

At Wayanad, pH varied from 5.2 to 7.8 with a mean value of 6.4. The EC values ranged between 58µS/cm and 599µS/cm with a mean value of 208µS/cm. The TDS values ranged from 37 mg/l 383 mg/l with a mean value of 133 mg/l. The DO values showed a very low mean of 3.4 mg/l. This is very low compared to Kozhikode district.

At Kozhikode, pH varied from 4.4 to 7.6 with a mean value of 5.8. The acidic range of pH is normal for the lateritic terrain which is the predominant geological unit. The EC values were observed to have a minimum value of 47µS/cm and a maximum of 626µS/cm with a mean value of 127µS/cm. The TDS values ranges from a minimum value of 30 mg/l to a maximum value of 401 mg/l with a mean value of 81 mg/l. DO values ranges from minimum of 2.07mg/l to maximum of 6.7 mg/l with a mean of 4.8mg/l.

Wayanad, being a highland station is expected to have low TDS and EC values than the low land area of Kozhikode. However in the present study TDS of Wayanad is found to be more than Kozhikode. Wayanad district is having lot of agricultural activities compared to Kozhikode. Studies have reported excessive use of agrochemicals in the Wayanad district (Devasiya and Mathew, 2012.; Joshu et al.,2016). The excessive use of fertilizers in the Wayanad district may be causing leaching of ions into the shallow ground waters over a period of time elevating TDS and EC values.

The poor maintenance of the wells usually results in a low DO value. One of sample at Wayanad district with lowest DO value of 2.1mg/l was in a tribal colony. This well was found to be contaminated by many waste materials like plastic bottles, papers, clothes etc. DO value below 3 mg/l may be hazardous to man (Radhakrishnan et al.). At Kozhikode, one sample locateded at Feroke, a coastal town, showed very high values of TDS (1620 mg/l) and EC (2531µS/cm). The ionic concentration was also found to be relatively higher than other groundwater samples of the district. The area being near to the coast makes it prone to saline water intrusion. The ground water in this area may be used judiciously to prevent the further deterioration. This sample is omitted in further discussion on hydrochemistry of groundwater of this district.

Statistical analysis

The statistical analysis was performed for the data obtained from Kozhikode and Wayanad. The correlation matrix of Wayanad and Kozhikode was computed and it was found that a strong correlation of EC with Cl, Ca, Mg, and SO_4 existed in both the districts.

Table 3 Pearson's correlation matrix of Kozhikode (α = 95%)

	HCO_3	Cl	SO_4	Na	K	Ca	Mg	TDS	EC
HCO_3	1.00								
Cl	0.42	1.00							
SO_4	0.31	0.42	1.00						
Na	**0.51**	**0.88**	0.61	1.00					
K	0.47	0.45	-0.08	0.39	1.00				
Ca	**0.90**	0.45	0.60	0.58	0.35	1.00			
Mg	0.57	0.59	0.62	0.60	0.17	0.57	1.00		
TDS	0.57	**0.53**	**0.96**	0.71	0.10	0.79	0.72	1.00	
EC	0.57	0.53	0.96	0.71	0.10	0.79	0.72	1.00	1.00

Table 4 Pearson's correlation matrix of Wayanad

	HCO_3	Cl	SO_4	Na	K	Ca	Mg	TDS	EC
HCO_3	1								
Cl	0.12	1							
SO_4	0.42	0.19	1						
Na	0.27	**0.93**	0.31	1					
K	0.26	0.05	0.03	0.17	1				
Ca	**0.97**	0.2	**0.40**	0.32	0.25	1			
Mg	0.65	-0.04	**0.46**	0.1	0.04	0.54	1		
TDS	0.96	0.39	**0.46**	0.52	0.26	**0.96**	0.59	1	
EC	0.96	0.39	**0.46**	0.52	0.26	0.96	0.59	1	1

Gibb's classification

Gibbs diagram is used to predict the origin and composition of the groundwater (Gibbs, 1970). The Gibbs plot is classified into 3 major categories (i) evaporation dominance, (ii) rock-water interaction dominance and (iii) precipitation dominance. Gibbs diagram plotted for Wayanad district given in figure 2 (a) showed that the majority of water samples were in the rock-water interaction dominance region. The ground water of Wayanad district can be considered as low saline raised HCO_3^- and calcium levels. The Gibbs diagram of Kozhikode district is shown in figure 2 (b). Majority of the water samples of Kozhikode district was in the precipitation dominance region except that in the coastal zone, which was in the seawater intrusion/evaporation dominance region. The ground water of Kozhikode is transitional water types with no dominant ions and with low salinity.

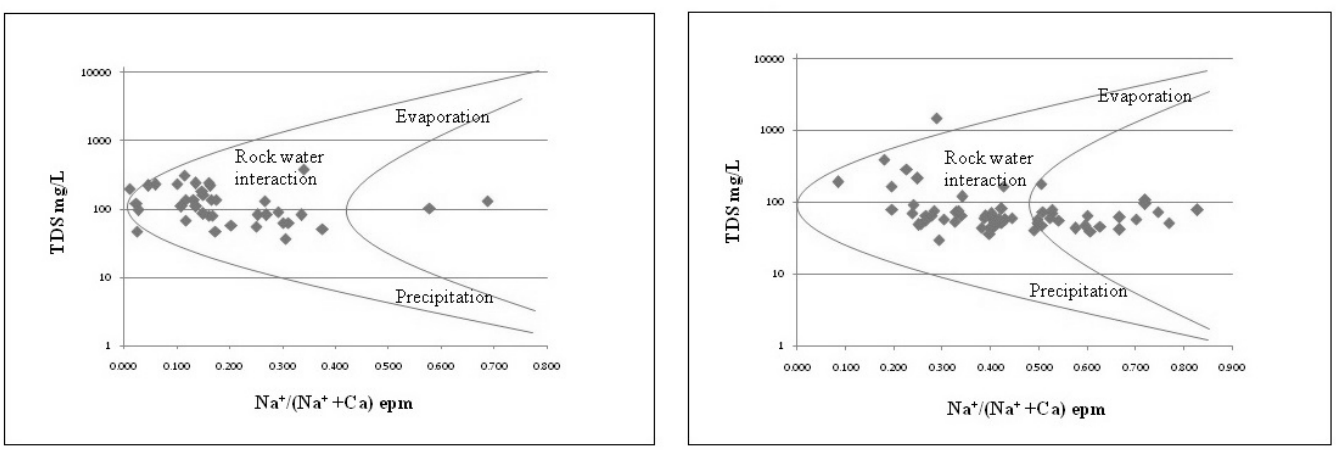

Figure 2 Gibb’s Plots for (a) Wayanad district (b) Kozhikode district

Hydrochemical Facies

The Piper plot helps us to identify the hydrochemical evolution of water (Piper, 1944). The major cations and anions are plotted tri linearly to deduce the relationship and identify the dominant water type. This diagram exhibits the similarities among the samples collected. They are seen to be clustered in groups in the plot. The geochemical evolution can be understood from the Piper plot (Piper, 1944). It has six categories viz. Type - I (Ca-HCO_3), Type - II (Na-Cl), Type - III (mixed Ca-Na-HCO_3), type - IV (mixed Ca-Mg-Cl), type - V (Ca -Cl) and type - VI (Na-HCO_3).

The piper plot of Kozhikode district is presented in figure 3 (a). The majority of the samples fall under the type - I (Ca-HCO_3), followed by type – IV (mixed Ca-Mg-Cl) and type -II (Na-Cl). Only two samples were seen in the type - V (Ca -Cl). The Piper plot of Wayanad district is given in figure 3 (b). The majority of samples fall in the type - I (Ca-HCO_3). In both the district the alkaline earth metals dominate the ion chemistry.

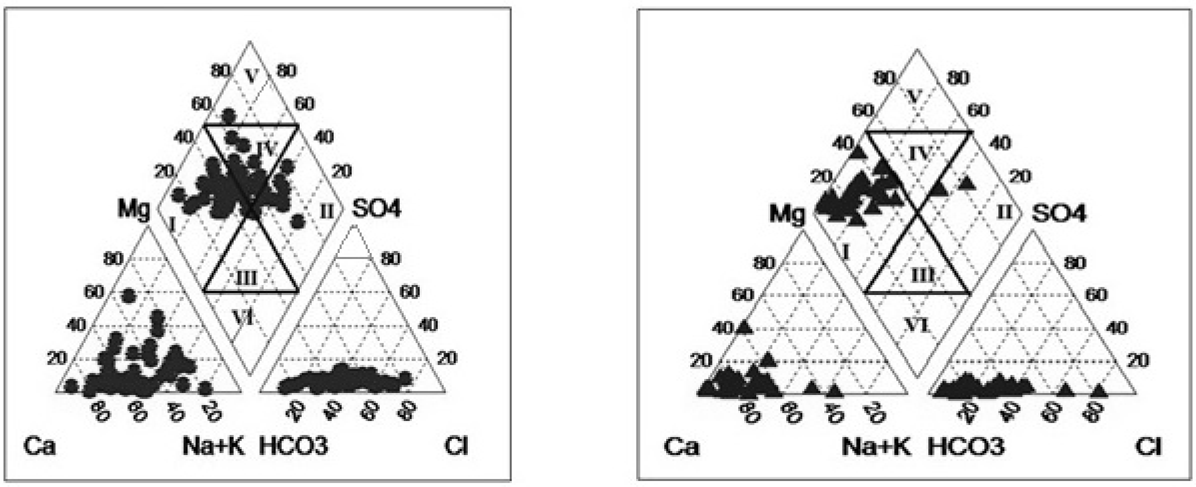

Figure 3 Piper Plots for (a) Kozhikode district and (b) Wayanad district

CONCLUSIONS

The shallow groundwater of two northern districts (Kozhikode & Wayanad) in Kerala with different physiography was investigated in detail for the water quality assessment and hydrgeochemistry. The major conclusions drawn from the study are

1. The chemical quality of shallow ground water of Kozhikode and Wayanad districts was found to be within the limits prescribed by BIS and is suitable for drinking purpose except for the coastal area which shows influence of seawater
2. At Kozhikode, groundwater was found to be recharged by precipitation and a few samples were influenced by saline water influence. The groundwater can be considered as transitional water type with no dominant ions.
3. At Wayanad, rock-water interaction was found to be the major geochemical process. The groundwater can be considered as low saline and with raised HCO_3 and calcium
4. The Wayanad district is exhibiting higher TDS and EC values than the Kozhikode district may be the result of leaching of agrofertilizers used extensively.
5. The major hydrochemical facies of groundwater in the two districts is Ca-HCO_3 and the water type was mixed.

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Groundwater Potential Zones Mapping of Purna Watershed (PT-7) in Akola District using Geoinformatics Technology

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ABSTRACT

Groundwater is one of the world's most valuable natural resources management. Hydro-logically and geologically the area consists of basaltic rocks and alluvium part in this watershed, while as a result, agriculture ofthis watershed area is mostlyintercropping system and thus perhectare manufacture is also small as matched to other regionsof Akola district. That's why the watershed has been approved out to estimate the potential zones for groundwater resource management affecting in Purna watershed (PT-7) of Akola district using anintegrated remote sensing and GIS data, Survey of India topographicalsheets and ground truth verification. Hydro-geologicalfeatures (geomorphological and geological units, slope, lineaments digital elevation model etc.) that effect groundwater resource management occurrence were cropped and combined to appraise the hydro-geomorphological characteristics of the watershed area. Thematic maps of the cropped features were generated with the help of geo-informatics technology and Arc-GIS 10.3 software. Weightage values were allocated to thevarious charactersgiving to their comparativesignificance to groundwater potentiality zone mapping and combinedthrough remote sensing and geographicInformation System environment. Finally on the origin of grid-wise theme weight values and class weights thegroundwater potential zone map was generated by overlay analysis thethematic datalayers.

Keywords: Remote sensing, Groundwater, GIS, Watershed**.**

INTRODUCTION

Groundwater is one of the world's most precious and significant natural resources for sustenance of life and also for any developmental activity (Subba et al. 2001; Hutti and Nijagunappa 2011; Biswas et al. 2012). Hence it plays a fundamental role in human well-beings, as well as that of some aquatic and terrestrial ecosystems.GIS and remote sensing tools are widely used for the management of various natural resources (Magesh et al., 2012).Delineating the potential groundwater zones using remote sensing and GIS is an effective tool. In recent years, extensive use of satellite data along with conventional maps and rectified ground truth data, has made it easier to establish the base line information for groundwater potential zones (Tiwari and Rai, 1996; Das et al., 1996; Thomas et al., 1999; Chowdhury et al., 2010). Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Murthy, 2000;). The movement and occurrence of ground water in a terrain depends upon various variable viz. geology, lithology, soil, morphometric parameters of the area.

Study area:

The PT-7 watershed area is drained by Purna River which is a tributary of the Tapi River. The sub watershed area is represented by the survey of India Topographical maps; 55D/13, and 55C/16 on 1:50000 scale. The area is confined between 20°51'0"N and 21°14'30"N latitude and between 76°46'0"E and 77°3'0"E longitude, covering an area of 564.55sq.km (Figure.1).

Methodology

The present study was carried out using Satellite Remote Sensing data and GIS software which provide an opportunity for better observation and more systematic analysis over a large area. In order to assess the groundwater potential in the study area, five thematic maps, namely, geomorphology, soil, topographic elevation [digital elevation model (DEM)], LULC, drainage were generated using RS and conventional data with the help of ArcGIS10. All the thematic maps are verified through field checks. The thematic details thus finalized are transferred to the base map prepared from the survey of India toposheets. The workflow of the present study covers the following major steps: georeferencing, dizitization, map preparation. Further an intensive fieldwork was

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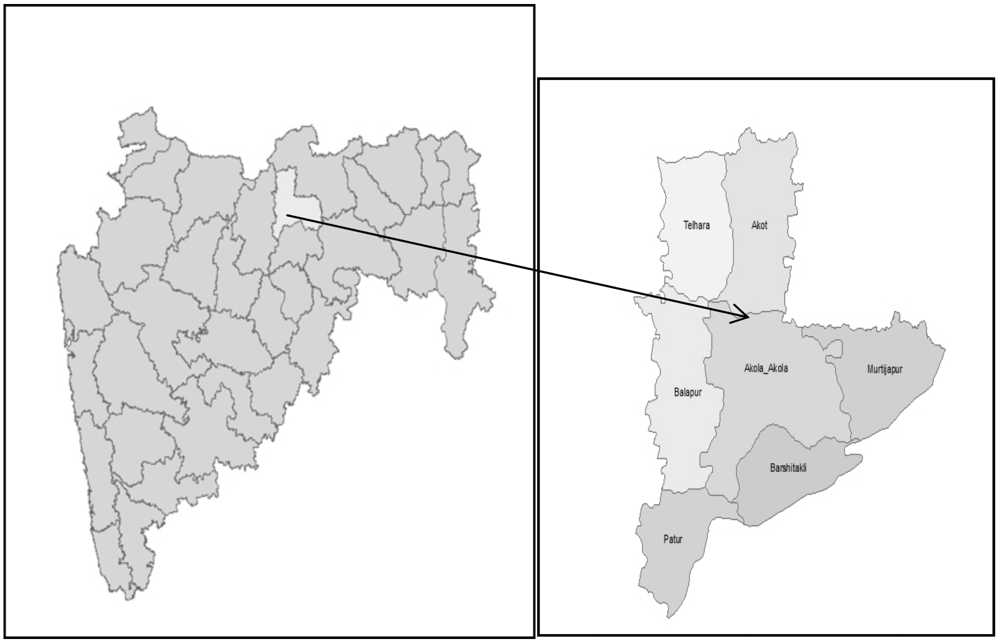
conducted in and around PT-7 in order to collect ground truth information. The varied land forms were traversed and several geomorphologic features have been observed throughout the studied area.



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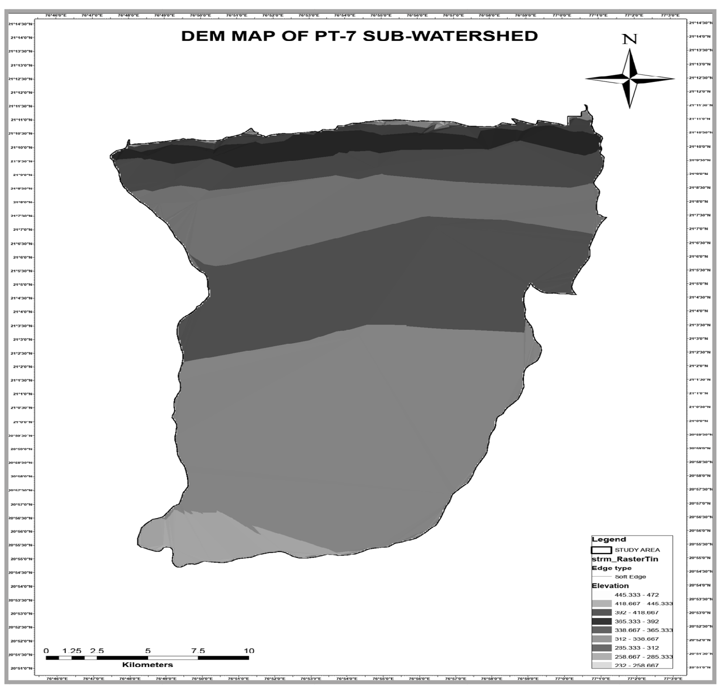

Figure 1 Location map of PT-7 sub-watershed

RESULTS AND DISCUSSION

Geomorphology:

Groundwater conditions are indicated by topography. The geomorphic imprints can be considered as surface indicators for identification of subsurface water conditions. The information provides a reliable base for effective planning, development and management of groundwater resources of area (Preeja et al. 2011). Geomorphology was assigned the highest weight because it has a dominant role in the movement and storage of groundwater (Thomas et al., 2009). The study area consists of pediment, pediplain, structure hills, alluvial plain water body etc. as shown in Figure 2.

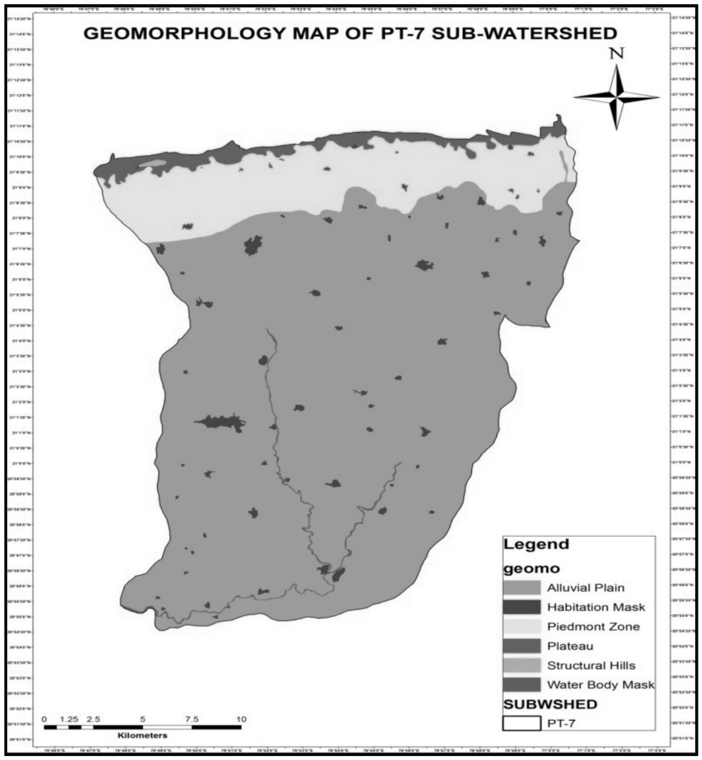

Figure 2 Geomorphology Map of PT-7 sub-watershed

Land Use Land Cover:

Man's activities on land are called as land use. The land use of the study area is characterized by a mixture of forest cover, agricultural activities and wasteland besides water body and river sediment (Saraf, 1999,PandeandMoharir 2014). Agricultural land, fallow and scrubland, settlement, forest and water bodies are the various land use classes are classified through unsupervised classification techniques in Erdas Imagine. Field verification, some other collateral data like district land use statistical report, district agriculture information report, etc are very helpful for classification (figure 3).

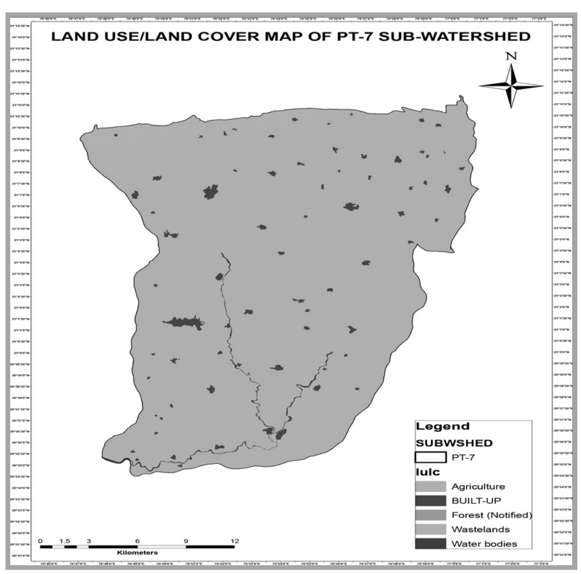

Figure 3 Land use land cover Map of PT-7 sub-watershed

Soil

Soil has a considerable role on the infiltration of water and the rate of infiltration mainly depends on the grain size. The soil information for the study area was digitized from the soil map. Generally, seven (7) types of soil had been identified in the study area. At the lower area of watershed consists of clayey soil. The erosion of the top soil decreases the productivity of land and leads to failure of crops (Figure 4). Soil spectral reflectance can be rapidly and easily obtained with high repeatability, numerous samples can be studied to establish trends of change in soil hydraulic properties in a watershed.

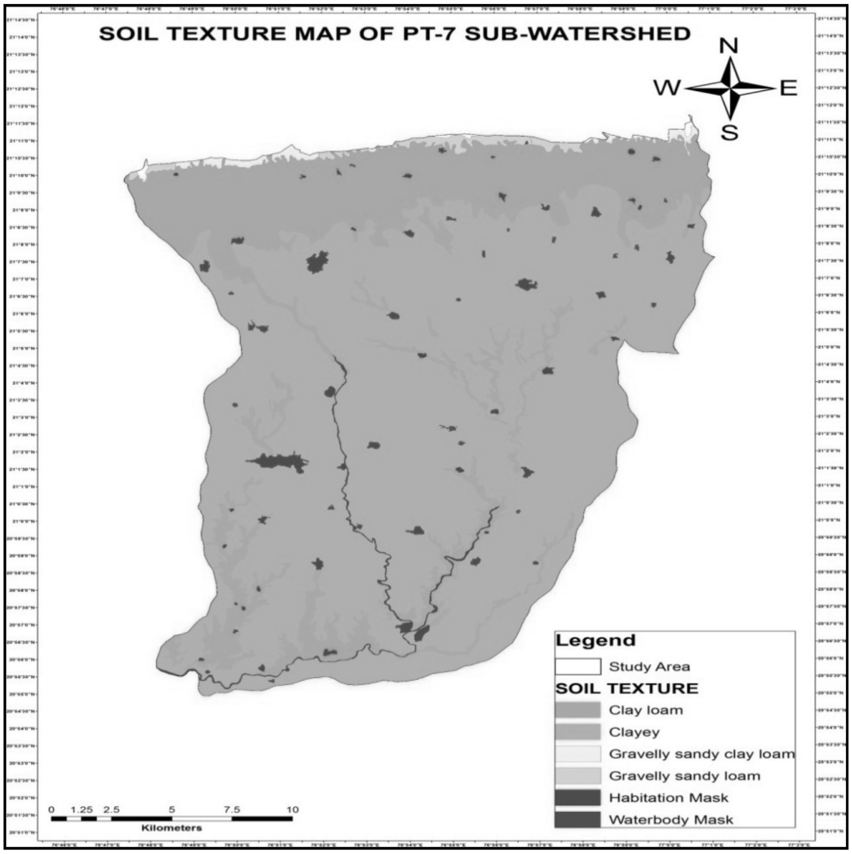

Figure 4 Soil Texture Map of PT-7 sub-watershed

Ground Water Potential Zones:

Dynamic system is forms by hydrological cycle and groundwater is a part of it. Remote sensing and GIS techniques permit rapid and cost effective natural resource survey and management. Moreover, for groundwater prospecting remote sensing data serve as vital tool (Chatterjee and Bhattacharya 1995; Tiwari and Rai 1996; Ravindran 1997) in identifying landform features, drainage pattern and geomorphic indicators for location of recharge and discharge areas. The groundwater prospecting especially in hard rock terrain requires thorough understanding of geology, geomorphology and lineaments of an area, which are directly or indirectly controlled by the terrain characteristics (Karanth and SeshuBabu 1978; Ravindran and Jayaram 1997; Pradeep 1998; Kumar et al. 1999; Lokesha et al. 2005; 2007). In the present study, the groundwater level map and ground water potential map is used for the quantitative estimate of groundwater recharge in the PT-7 watershed. The Role of Remote Sensing and GIS in Artificial Recharge of the Ground Water Aquifer in the PT-7 Sub Watershed in the Purna River Basin, Akola District, Maharashtra. A conventional approach for groundwater recharge assessment has some limitations in spite of its simplicity and wide applicability in varied hydrogeological setup (figure 5).

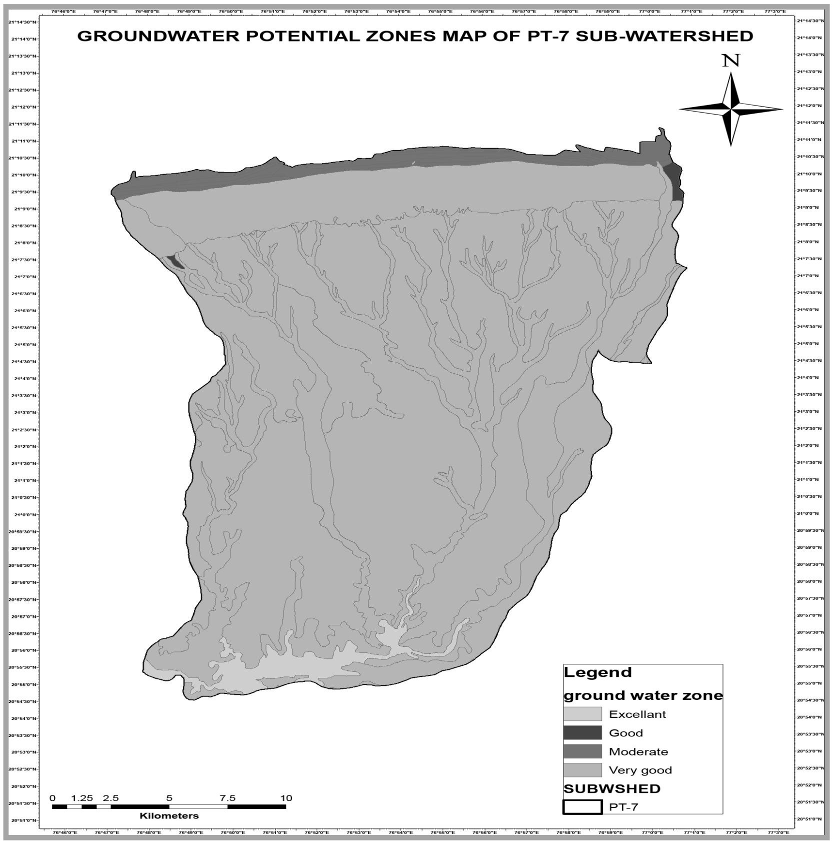

Figure 5 Ground Water Potential Zones Map of PT-7 sub-watersheds

CONCLUSION

The abundant exploitation of groundwater due to increasing population, urbanization, industrialization and slowly reduction of groundwater table due to insufficient recharge presents a looming water issues. Satellite data, thematic maps, soil data, land use land cover data and geomorphology data integrated with RS and GIS were used to delineate groundwater potential zones in the study area. In study area most of the part is in very good zone. Moderate zone are present on north side of area. Southern side small area is in excellent zone.Development and demonstration for evaluation of groundwater resources remote sensing and GIS play important role. Combination of geology, land use land cover, geomorphology, soil and digital elevation model has been found very useful in the ground water potential zone. Moderately high-resolution satellite images data (LISS-III) provide details of the terrain, as well as a synoptic overview, to visualize the general groundwater condition indirectly.

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Trace Elements in Coastal Aquifer, Chennai, Tamilnadu, India

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ABSTRACT

Trace element analyses were done for the water samples collected from the coastal area of Chennai, Tamilnadu, India. Totally, hundred and five groundwater samples were collected during Pre-monsoon season (June 2016). The groundwater samples that are being used for domestic purposes by the residents are being collected for the present study. These samples were analyzed in Atomic Absorption Spectrophotometry (AAS). Heavy metals like, Fe, Mn, Pb, Zn, Ni, Cu, Co, and Cr concentrations were quantified. The analytical results were compared with Bureau of Indian Standards (BIS, 2012). The spatial distribution diagram shows the concentration of trace elements in the study area. In the study area, Zn, Co and Cu were found within the permissible limit. The concentration of the Fe is above the permissible limit in 6 locations namely, Edyanchawadi, Ariyalur, Villivakkam, Palavakkakuppam, Panaiurkuppam and B.V. Nagar. The concentration of the Cr, Pb and Ni is above the permissible limit in 66%, 60% and 30% of the locations, respectively. In 10 locations, the concentration of Mn is above the permissible limit. The higher concentration of trace elements is due to anthropogenic activities, such as sewage effluents, industrial and agricultural runoff. Consuming of groundwater that has high concentration of trace elements will lead to health hazards like, kidney, liver and spleen diseases.

Keywords: Groundwater, Trace elements, Atomic Absorption Spectrophotometry, BIS 2012.

INTRODUCTION

The environmental impact of human activity on the groundwater is considered as one of the major hazard in world. Groundwater forms the major source of water supply for drinking, industrial and agricultural purposes in most parts of India. It is estimated that approximately one third of the world's population use groundwater for drinking purposes (Nickson et al., 2005). The chemistry of groundwater often reflects the primary suit of minerals in aquifer. The hydrogeochemical processes of the groundwater vary spatially and temporally, depending on the geology and chemical characteristics of the aquifer (Lakshmanan et al., 2003). In this world the increasing population, urbanizations and industrial activities are given rise to environmental stress and pollution all over the world. Unused fertilizers, pesticides, effluents discharged from industries and sewage water are main contaminants in the groundwater (Venugopal et al., 2009).

Life without water is like a man without soul. The quality of groundwater in coastal region is generally affected due to natural processes such as saline water intrusion, evaporation, and interaction of groundwater with hard rock formations (Polemio et al., 2006; Srinivasamoorthy et al., 2011). Ramesh et al., (1995) reported several health hazards among people around the slum areas. Trace metal studies are of wide application in varied branches of scientific discipline. The toxicity of an element depends on the dose, chemical form, route of exposure bioavailability, distribution in the body and storage and excretion parameters (TaqveemAlikhan, 2011). Some of the trace metals like, Fe, Mn, Ni, Cu and Zn are essential for the human body to activate vital functions and biological processes. But, the trace metals beyond the permissible limit can cause several health problems (Krishna Kumar et al., 2012). The present study focuses on the groundwater, especially, in trace metals concentration in coastal aquifer Chennai, Tamilnadu.

STUDY AREA

The study area is around 520 sq km in Chennai along the coast and towards inlands, which covers Thiruvallur and Kancheepuram district. The study area falls in the geographical coordinates of 13°00'59.8" to 12°56'30" N latitude and 80°19'46.8"to 80°14'30" 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 study area 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 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 source of groundwater recharge is precipitation only. The main source of coastal pollution in Chennai arises from Cooum and Adyar rivers, Ennore creek outlets and industrial effluent discharged at various places along the coastal region especially, in north Chennai region.

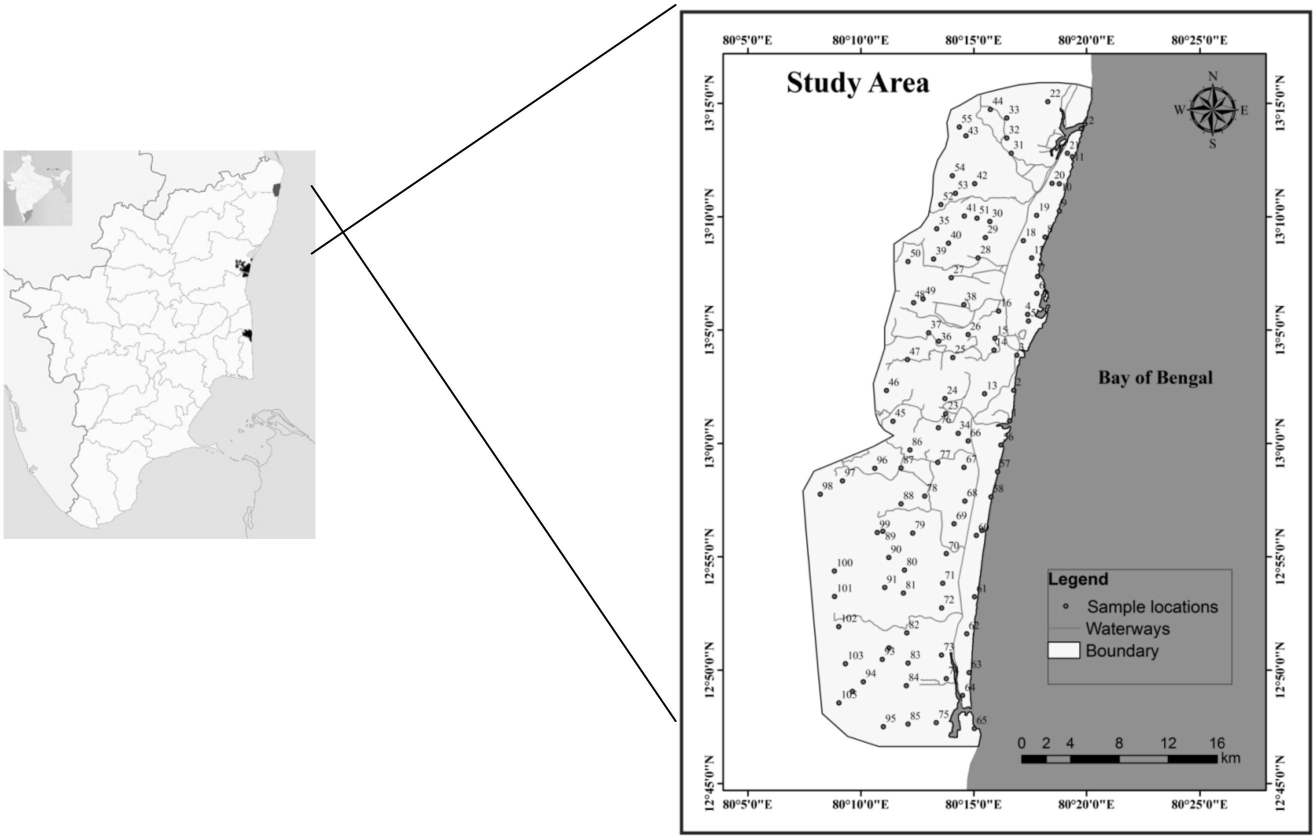


Figure 1 Study area with sample locations

METHODOLOGY

Groundwater samples are collected from bore well and dug wells from the same aquifer in the study area. 100ml of water samples are collected from each location in polyethylene bottles during the month of June 2016 (pre-monsoon season). Bottles are washed with distilled water and acidified with HNO_3. A total of hundred and five samples are collected from locations within study area. The water samples are analyzed for trace metals according to international standard methods (APHA, 1995). Trace elements such as Fe, Cr, Ni, Mn, Cu, Zn, Pb and Co are analyzed using Atomic Absorption Spectrophotometry (AAS). The obtained results are compared with Bureau of Indian Standard (BIS 2012) for determining the quality of groundwater for drinking purpose and health hazard. Distribution of eachtrace element are shown as spatial distribution diagram using Arc GIS Software.

RESULTS AND DISCUSSION

The results of the trace element analysis in groundwater (comparison of heavy metal with BIS standards 2012) of the study area are presented in Table 1. Concentration of trace elements in the study area, are controlled by various hostrocks in the study area and also various anthropogenic processes like, agricultural and industrial activities.

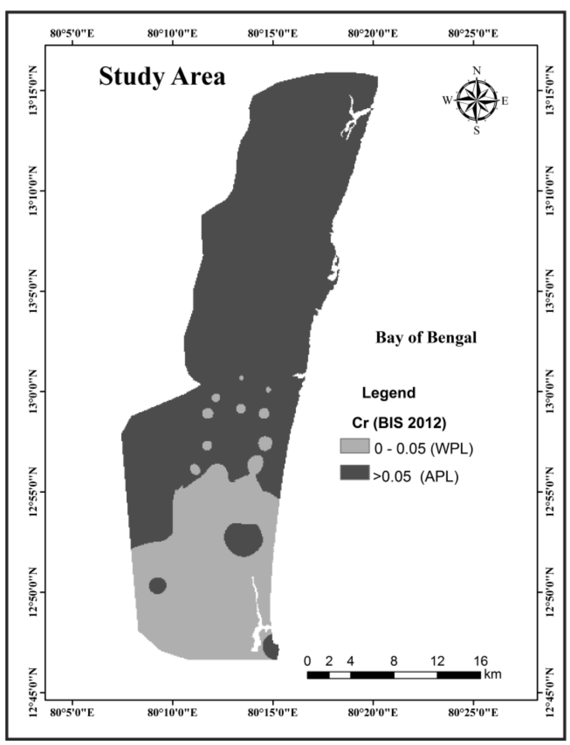
Table 1 Comparison of heavy metal with BIS standards (2012)

Elements	Min.	Max.	Avg.	B IS Limit (2012)		Below required limit	Within the permissible limit	Above permissible limit
				Required Limit	Permissible limit			
Fe (mg/l)	BDL	2.801	0.115	0.30	-	99	-	6
Cr(mg/l)	BDL	0.943	0.402	0.05	-	35	-	70
Zn(mg/l)	BDL	2.062	0.149	5.00	15	105	-	-
Cu(mg/l)	BDL	0.107	0.007	0.05	1.5	1	104	-
Ni(mg/l)	BDL	0.096	0.024	0.02	-	72	-	33
Pb(mg/l)	BDL	0.706	0.105	0.01	-	42	-	63
Co(mg/l)	BDL	0.090	0.009	No recommended value in BIS				
Mn(mg/l)	BDL	2.579	0.176	0.10	0.3	9	86	10

BDL: Below detectable limit

Chromium (Cr)

Cr (III) is considered as an essential trace element for the maintenance of an effective glucose, lipid and protein metabolism in mammals. On the other hand, Cr (VI) is toxic for biological systems. Chromium is water soluble and extremely irritating and toxic to human body tissue owing to its oxidizing potential and permeability of biological membranes (Anderson, 1999). Chromium levels in the study area range from BDL to 0.943 mg/l, with an average of 0.402 mg/l. According to BIS standards, 66% of the samples were above the permissible limit. Therefore, the source of Cr appears to be anthropogenic namely,from the Electro-plating processes and painting pigments industries found in the study area (Campos et al., 2005). Cr is highly distributed in northern and central part of the study area (Fig. 2). High doses of Cr cause liver and kidney damage and chromate dust is carcinogenic (SEGH 2001; Mugica et al., 2002).



WPL: Within permissible limit

APL: Above permissible limit

Figure 2 Spatial distribution diagram of Cr in groundwater

Iron (Fe)

Iron is an essential element in human nutrition. Anemia caused by lack of iron is the commonest nutritional deficiency in the world (FakheeAlam 2013). In the study area, the concentration of iron ranges from BDL to 2.801 mg/l with an average of 0.115mg/l. The source of iron is rock-water interaction with Fe bearing rock and corrosion of house hold pipes in groundwater (Mondal et al., 2010). Fe is considered as pro-oxidative element which leads to spermatogenesis, sperm motility and fertilization when present excess amount in human body (Kasperczyk Aleksandra et al. 2015). Spatial distribution diagram (Fig.3) shows the higher concentration of iron in northern part of the study area. The high value of iron is due to the corrosion effect of borehole materials, and industrial activities of the study area.

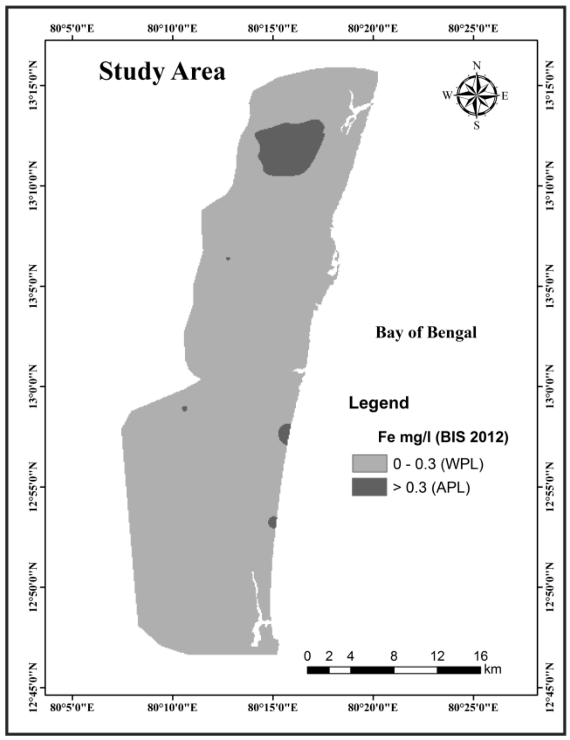


Figure 3 Spatial distribution diagram of Fe in groundwater

Zinc (Zn)

Zinc is also an essential trace element found in virtually all kinds of food and potable water in the form of salt or organic complexes (Sridhar et al., 2014). Zn concentration ranges from BDL mg/l to 2.062 mg/l, with an average of 0.149 mg/l. All the samples are within the required limit of 5 mg/l BIS (2012). There is no elevated concentration of Zn in the study area.

Copper (Cu)

Cu concentration ranges from BDL mg/l to 0.107 mg/l, with an average of 0.007 mg/l. Copper is also an essential trace elements for human. It helps in binding of bacteriotoxins and increases the activity of antibiotics, and also help bone metabolism effectively (Dermience Michael et al., 2015). As reported by Mirlean et al (2009), the present study area also shows concentrations of Cu which is attributed to copper-based fungicides and fertilizers. Cu is within the permissible limit in all the samples.

Nickel (Ni)

Nickel concentration in groundwater shows that 30% samples have exceeded its permissible limit of 0.02 mg/l and it ranges from BDL mg/l to 0.096 mg/l, with an average of 0.024 mg/l.Sources of nickel in water include contamination from municipal sewage sludge, wastewater from sewage treatment plants, and groundwater near landfill sites. Industries like, ceramics, steel and alloys, electroplating, and refractory are contributors of nickel to water (SrinivasaGowd et al., 2007). The lung is the target organ for nickel toxicity in humans.Spatial distribution diagram (Fig. 4) shows the higher concentration in north western part of the study area. The source of nickel is municipal sewage waste and industrial activities in the study area.

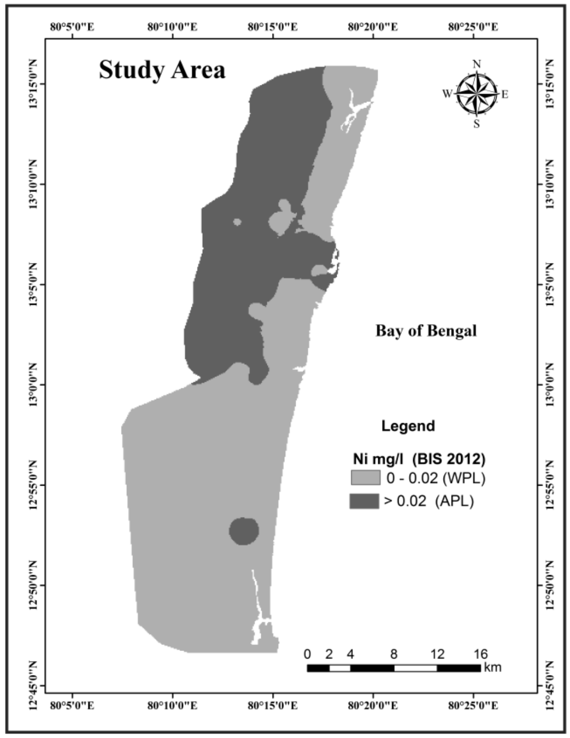


Figure 4 Spatial distribution diagram of Ni in groundwater

Lead (Pb)

Lead is a heavy metal belonging to carbon group, mostly used in the manufacture of lead acid storage batteries. Lead is also released from smelting, motor vehicle exhaust fumes and from corrosion of lead pipe (Sajil Kumar et al., 2012). The concentration of lead varies from 0.268 mg/l to 0.706 mg/l with an average of 0.105 mg/l. The desirable limit of Pb in drinking water is 0.01mg/l (BIS 2012). Pb concentration in groundwater exceeded the permissible limit in 60% of the samples in the study area. The spatial distribution diagram of Pb is shown in Fig.5. The consumption of lead in higher quantity may cause hearing loss, blood pressure and hypertension (Tiwari et al., 2014). The higher concentration of Pb in the study area is mainly attributed to anthropogenic activities such as burnt fuel of motor vehicles and sewage effluents in the study area.

Cobalt (Co)

The cobalt concentration varies and it ranges from BDL to 0.090 mg/l with an average of 0.009 mg/l. There are no BIS guidelines values for cobalt in drinking water. Generally, Ni and Co shows similar geochemical behaviors in groundwater and they are co-precipitated with iron oxide especially, with manganese in ferromagnesian igneous-rock minerals (Hem, 1985). The concentration of Co may derive from fertilizers and industrial effluents apart from rock-water interaction.

Manganese (Mn)

Manganese is an essential nutrient for humans. Manganese deficiency can disrupt the central nervous system and reproductive functions (Golekar, 2013). Its value varies from BDL to 2.579 mg/l, with an average of 0.176 mg/l. Most of the samples in the study area are within the permissible limit except 10 locations where industrial effluents containing manganese bearing discharged untreated. The spatial distribution (Fig. 6) shows that the northwest and southeast part of the study area has higher concentration where industries are located.

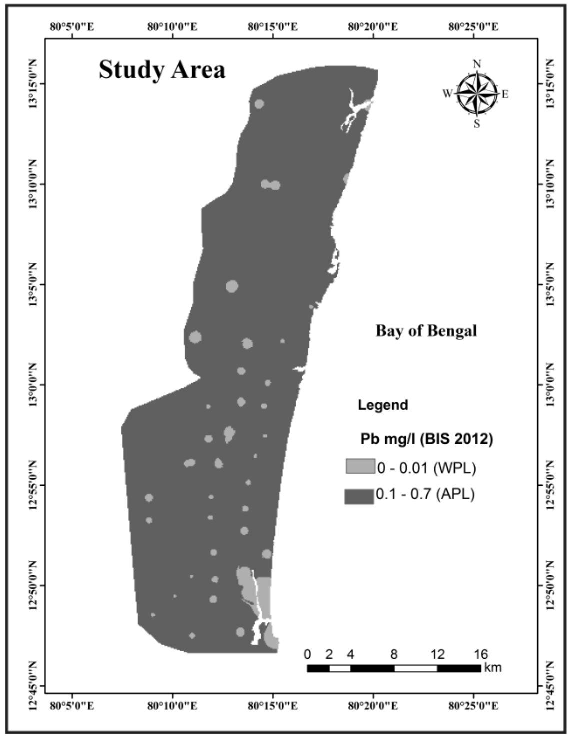


Figure 5 Spatial distribution diagram of Pb in groundwater

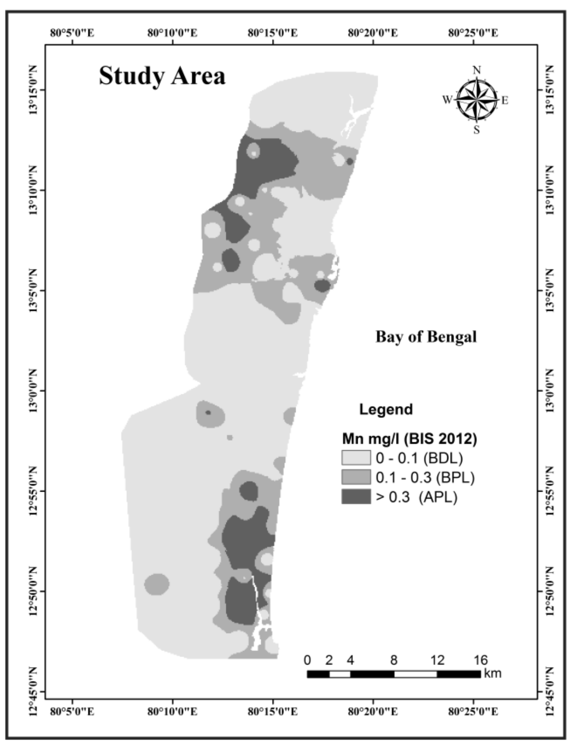


Figure 6 Spatial distribution diagram of Mn in groundwater

CONCLUSION

The study specifies the various concentrations of trace metals and their spatial variation in groundwater of the study area, namely, coastal aquifer in Chennai. In the study area, Zn and Cu were found within the permissible limit. The Fe concentration is above permissible limit in six locations. The high value of iron is due to corrosion effect of borehole materials, and industrial activities of the study area. Cr, Pband Ni exceed the permissible limit in 66%, 60% and 30% of the sample collected. In 10 locations, the concentration of Mn is above the permissible limit.The spatial distribution diagram shows higher concentration of Mn in northwestern and southeastern part of the study area where industries are located. The higher concentration of trace elements is due to anthropogenic activities, such as agricultural runoff, sewage effluents and burnt fuel of motor vehicle. The health hazards related to these elements, namely, Pb, Cr, Fe, Mn and Ni is being warned off.

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Identification of Seawater Intrusion in South Chennai Coastal Aquifer, Tamil Nadu, India

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ABSTRACT

Seawater intrusion is a major groundwater problem in coastal aquifer. The present study helps to understand the impact of seawater intrusion in South Chennai coastal aquifer. Totally, fifty groundwater samples were collected from dug and bore wells from the same aquifer in the study area during pre-monsoon (June 2016) season. These groundwater samples were analyzed for physico-chemical parameters, such as pH, EC, TDS, TH, HCO_3, SO_4, NO_3, Cl, Ca, Mg, Na, and K. The groundwater is brackish to alkaline in nature. Analytical results were compared with BIS (2012), and found that locations, namely, Besant nagar, Kumenan nagar, Nakkumpalayam nagar, Chromepet are having TDS, Na, Cl concentrations above the permissible limit due to seawater intrusion. The spatial distribution of EC clearly indicates that nearer to the coastal area it has higher concentration due to seawater intrusion. Box and Whisker plots indicate cations and anions in the order, Na > Ca > Mg > K for cations and Cl > HCO_3 > SO_4 > NO_3 for anions, respectively. Chadha's plot shows that the majority of the samples are falling in Na-Cl and Ca-Mg-Cl facies, which indicate seawater intrusion and reverse ion exchange process. The major molar ratio such as Mg/Ca vs Cl/(HNO_3+CO_3) indicate that the groundwater is being contaminated by seawater intrusion.

Keywords: Groundwater, Chadha's plot, Box and Whisker plot, and Seawater intrusion.

INTRODUCTION

Groundwater is the only replenisable resources available to man. Usage of groundwater has been growing steadily over the year for domestic, agriculture and industrial purposes. Groundwater has a major role in the life of the people, for it is used in industries, municipal purpose and other domestic purpose. Rapid industrialization in the name of development has led to indiscriminate digging of well and merciless uses of groundwater without adequate recharge. Surface water source are normally a major source of recharge to groundwater system and consequently, a possible source of contamination of groundwater, when these water course are polluted as it often happens in the urban environment. The seawater intrusion is a main cause for salinity, and groundwater generally demonstrates high concentration not only in total dissolved solids (TDS) but also in cations and anions as well as the selective trace elements.Study of chemical budget of the major ions gain importance since it explains the origin of the ions in groundwater and the level of the contamination by natural as well as anthropogenic sources (Jalali, 2005; SubbaRao, 2006; Sridhar *et al.,* 2013; Balasubramanian *et al*., 2016). The present study was carried out to identify seawater intrusion in South Chennai coastal aquifer.

The 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 240 km^2. The rainfall in study area is mainly controlled by northeast monsoon with average annual rainfall of 1200 mm. The study area is having a tropical climate with annual temperature from 24.3º to 32.9º C. The major part of the area has flat topography with gentle slope towards east. Geologically, the coastal aquifer consists of Archaean rock and recent alluvium formation and it consist of sand, silt and clay.

Materials and methodology

Totally, fifty groundwater samples from the same aquifer were collected during pre-monsoon (June 2016) season, from the bore well and dug well. These samples were collected in 1 liter capacity polyethylene bottles. Using portable field measurement kit, pH, and EC, and were measured in the field. The samples collected were analyzed in laboratory for cation and anion analysis by titration method, bicarbonate and carbonate were determined. The base map of the study area **(Fig. 1)** was prepared using the Survey of India toposheets 66 D/1 and 66 D/5 and was digitized using ARC GIS 9.3 software.

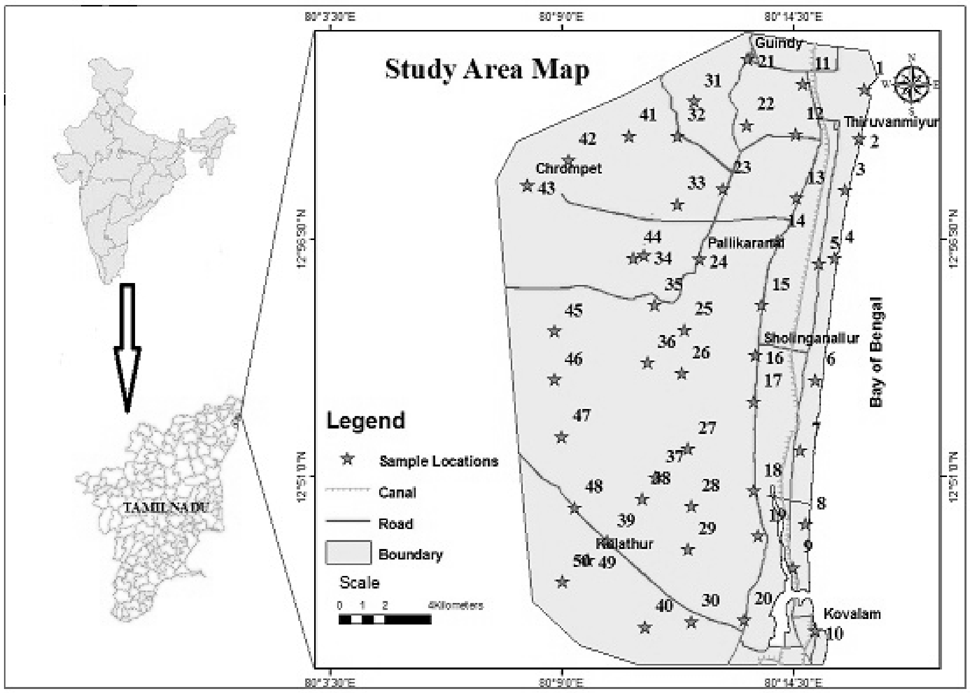

Figure 1 Study area with sample locations.

RESULTS AND DISCUSSION

The analytical results are presented for the study area pre-monsoon (June 2016). The minimum and maximum comparing BIS (2012) for drinking water standard are presented in **Table 1**.

Table 1 Minimum and maximum concentration for different parameter of the study area

Parameter	Pre-monsoon (June 2016)		Bureau of India standard BIS(2012)	
	min	max	Acceptable limit	Permissible limit
PH	7	8.9	6.5-8.5	No relaxation
EC	270	12580	1500	No relaxation
TDS mg/l	172	8051	200	2000
Ca mg/l	21	260	75	200
Mg mg/l	8	249	30	200
Na mg/l	48	2127	-	100
K mg/l	2	70	-	42
Cl mg/l	28	3040	250	1000
SO_4 mg/l	13	584	200	400
NO_3 mg/l	2	584	45	No relaxation
HCO_3 mg/l	85	725	200	600

Physico-Chemical parameters of groundwater

Minimum and maximum 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 7 to 8.9 during pre-monsoon. EC is an indirect measure of ionic strength and mineralization of natural water. In the study area, EC ranges from 270 to 12580 μS/cm during pre-monsoon. In the pre monsoon season, the value of TDS varies from 172 to 8051 mg/l.

TDS shows a higher concentration in the study area during pre-monsoon season as in Table 1, may be due to the seawater intrusion for samples from 1 to 10 parallel to the coast in the study area. However, in some locations which are having outlet of industrial efficient and untreated sewage water are the reason behind increase in TDS in the study area as found by Sridhar *et al*., (2013), and Balasubramanian *et al.,* (2016).

Chemical parameters of groundwater

Calcium ion concentration in the pre-monsoon season varies from 21 to 260 mg/l. Magnesium ion concentration varies from 8 to 249 mg/l. Sodium ion concentration in the pre monsoon season varies from 48 to 2127 mg/l. Potassium ion concentration varies from 2 to 70. The higher values during Pre-monsoon are due to lowering of water table during non-rainy season, where the abstraction of groundwater is from deeper level, whose groundwater are having higher residence time that interact with its surrounding rocks. The concentration of Calcium and Magnesium in the study area may be due to Seawater intrusion and weathering (Sridhar *et al*., 2013; Balasubramanian *et al.,* 2016). 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 and efficient from the industries. The feldspar of igneous rocks is a good source of sodium when weathered (Rajmohan *et al*., 2000).

Chloride ion concentration in the pre-monsoon season varies from 28 to 3040 mg/L. Bicarbonate concentration in the pre monsoon season varies from 85 to 725 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 from Bay of Bengal (Mondal *et al*., 2010). For the study area, the higher chloride content in groundwater may be attributed to the presence of soluble chloride from rocks and saline water intrusion.

Box and Whisker

Box and Whisker 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). They are 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) for the study area**.** The abundance of the major cations is in the order of Na > Ca > Mg > K. The abundance of major anions is in the order of Cl > HCO_3 > SO_4 > NO_3. Kanagaraj (2013) reported Na > Ca> Mg for cation and Cl> HCO_3 > SO_4 for anion in South of Chennai. Compare to this Cl is reported additionally for Cation and NO_3 is reported for anion for the study area. They are attributed to seawater intrusion for Cl and due to fertilizer and industrial effluents for NO_3.

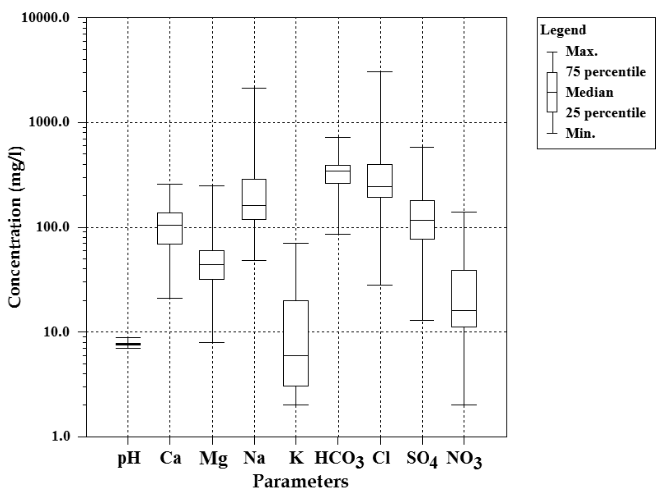

Figure 2 Box and Whisker plots for study area.

Spatial distribution of Electrical Conductivity

Electrical conductivity the value is measured in micro-siemens per centimeter and is a measure of salt content of water in the form of ions. In the study area, electrical conductivity values range from 270 µS/cm to 12580 µS/cm. The spatial distribution map (Fig. 3) of EC clearly indicates that nearer to the coastal area it has higher concentration due to seawater intrusion.

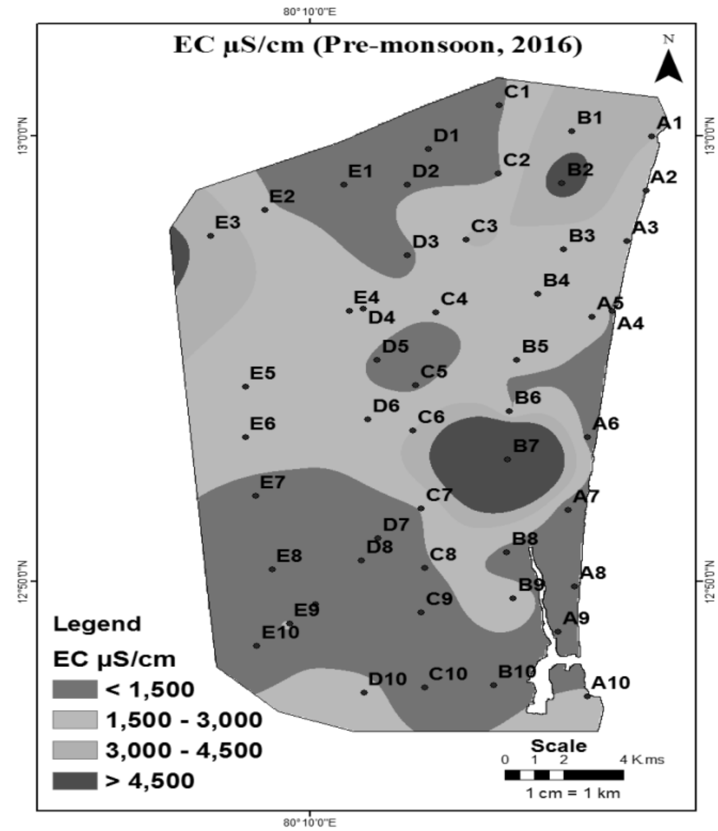

Figure 3 Spatial distribution of EC for the study area.

Chadha's plot

A hydrochemical diagram proposed by (Chadha 1999) has been applied in this study to Interpret the hydrochemical processes occurring in the study area. The same procedure was successfully applied by (Singaraja *et al.* 2013a; Vandenbohede *et al*. 2010) in a coastal aquifer to determine the evolution of two different hydrogeochemical processes. Data were converted to percentage reaction values (milli equivalent percentages) and expressed as the difference between alkaline earths (Ca^{2+} + Mg^{2+}) and alkali metals (Na^{+} + K^{+}) for cations and the difference between weak acidic anions (HCO_3^{-} + CO_3) and strong acidic anions (Cl^{-} + SO_4^{2-}). The hydrochemical processes suggested by Chadha (1999) are indicated in each of the four quadrants of the graph.

These are broadly summarized as:

Field-1. Ca-HCO_3 Recharging Water type

Field-2.Ca–Mg-Cl Reverse Ion-Exchange Water type

Field-3. Na–Cl Sea water type

Field-4. Na-HCO_3 Base Ion-Exchange Water type

From the Chadha's plot (**Fig. 4),** it is observed that majority of groundwater samples fall in the reverse ion exchange water (Ca-Mg-Cl water type), which is also seen as indicative of active seawater intrusion into the aquifer. The rest of the samples fall in the sea water Na-Cl water type) these samples are found to be located near the coastline indicating the predominance of seawater influence into the aquifer.

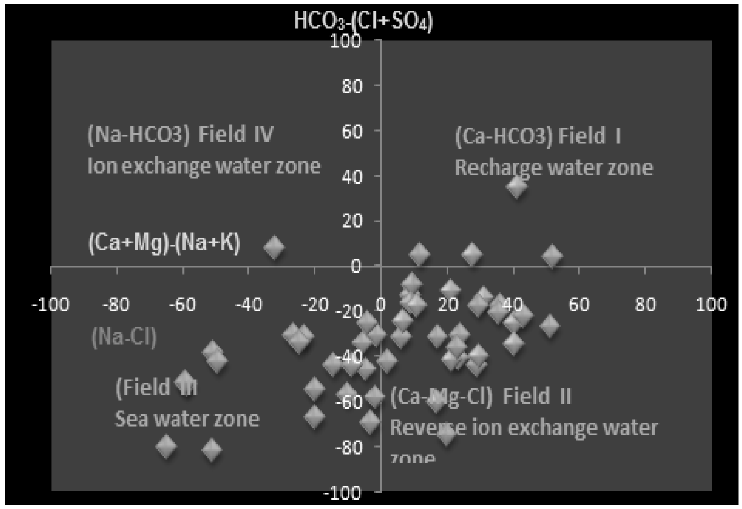

Figure 4 Chadha's plot for the study area

Mg/Ca vs Cl/HCO_3+CO_3 molar ratio

Generally, freshwater has higher value of calcium, and sea water has higher value of magnesium. Dissolution of dust results in relatively higher concentrations of Ca^{2+} and alkalinity in rainwater than in sea water (Faure 1992), but these elements are also affected by rock–water interaction occurring in the inland region, such as mineral weathering and ion sorption (Herczeg and Lyons 1991). The Mg^{2+}/Ca^{2+} ratio serves as an indicator for delineating the seawater–freshwater interface. Mondal *et al*. (2008) observed that extremely low Cl^-/HCO_3^- and high Mg^{2+}/Ca^{2+} (molar ratios) indicate the transformation of fresh groundwater to saline water in coastal aquifers. The Mg/Ca vs Cl/HCO_3+CO_3 molar ratio **(Fig. 5)** indicate that most of the groundwater samples have higher Mg^{2+} values compared to Ca^{2+}, which has been indirect bearing of the seawater intrusion.

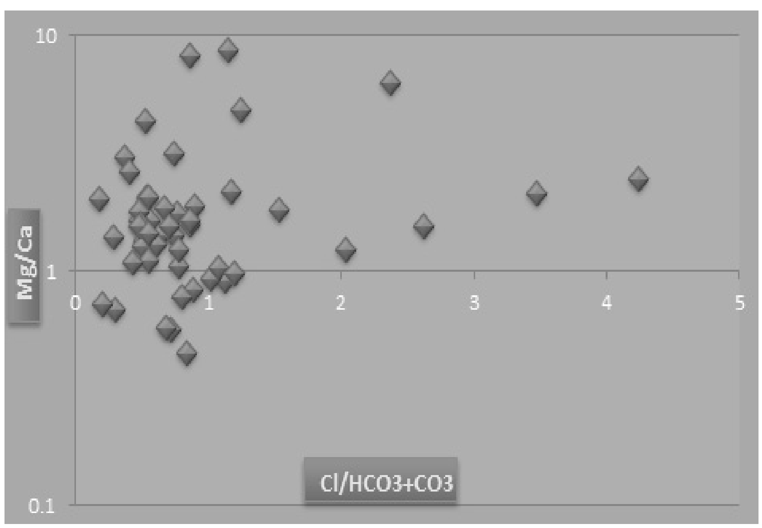

Figure 5 Mg/Ca vs Cl/HCO_3+CO_3 molar ratio.

CONCLUSION

The groundwater is brackish to alkaline in nature. Analytical results were compared with BIS (2012), and found that locations, namely, Besant nagar, Kumenan nagar, Nakkumpalayam nagar, Chrompet are having TDS, Na, Cl concentrations above the permissible limit due to seawater intrusion. Rapid urbanization and industrialization make an impact on groundwater quality of the study area. The Box and whisker plot shows the abundance of the major cation is in the order of Na > Ca > Mg > Cl and the abundance of major anions is in the order of Cl > HCO_3 > SO_4 > NO_3. Chadha's plot the majority of the samples are falling in Na-Cl and Ca-Mg-Cl facies, which indicate seawater intrusion and reverse ion exchange process water zone in the study area. The Mg/Ca vs Cl/HCO3+CO3 molar ratio indicates freshwater groundwater being contaminated by seawater intrusion.

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Water Well Logging in a Hard Rock Terrain – A Case Study in JNTUH Campus

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ABSTRACT

Well Logging is the technique of making petrophysical measurements in the sub-surface earth formations through the drilled borehole to determine the physical properties of rocks and the fluids. Well Logging studies are carried out through the drilled bore wells, in the JNTU campus to delineate the fractured zones and boundaries between different layers by using the equipment namely ABEM SAS 300 Well Logger. In this study, seven bore wells are taken into consideration. The Sonde (logging tool) is lowered into the bore wells by means of the logging cable. The obtained logging data for Spontaneous Potential, Short Normal, Long Normal and Lateral is recorded, processed and plotted on the graphs with Excel to identify the fracture zones and boundaries of the different litho units. The results indicated that the fractured zones are not having uniform resistivity. From the fence diagram of the fracture zones, south-east region of the campus is having deeper fractures and is identified as a suitable region for ground water recharge.

Keywords: Well logging, ABEM SAS 300, Sonde, JNTU, Resistivity

INTRODUCTION

Water is the most vital element for the life. Most of the rural population in India does not get good quality of water even for drinking. A number of factors contribute to the scarcity and pollution of the water. While the wide spacio-temporal variations of rainfall and hydro geological conditions are the main reasons for the scarcities, illiteracy, lack of education and industrial effluents are the other reasons for pollution of water. Therefore, it is necessary to utilize proper scientific management methods for optimal utilization of water resources. This investigation is carried out as a part of the systematic study to understand the subsurface lithology for groundwater management. Hard rocks are complex and heterogeneous media where random fractures, cracks and joints provide most of the porosities and permeability to store and transmit water through it. Hard rocks of crystalline and compact nature are devoid of primary porosity; however forms a good aquifer zone due to secondary porosity development such as joints, fractures and fissures. There are various methods in which a detailed logging record of the geological formations penetrated by a bore hole can be made. Electrical resistivity logging is a one such technique which has not been employed earlier in an around the study area. This study gives a fair amount of knowledge on the boundaries between various litho units, fracture zones in the bore wells. A total of 7 bore wells have been identified in the study area. The electrical resistivity well logging is employed in these bore wells to delineate the sub surface lithology. The main aim of the study is to detect the fracture zones in the hard rock areas through logging of water wells. The detailed objectives are delineation of subsurface lithology by using electrical resistivity and spontaneous potential well logging surveys. Deciphering of the fracture zones in all the water wells and determination of resistivities of various litho units.

LITERATURE SURVEY

Melanchthon et al. (1986) conducted experiment to determine the fractures and different rock types using geophysical logs in hard rock areas of Anantapur district, Andhra Pradesh. The geophysical logging is employed to determine fractures and micro fracture zone, to study the continuity of fractures, ground water flow, hydrological conditions, and petrological characters by using NIMS 3200 mineral logging systems. The studies revealed that gamma log against fractures were not predictable. Granites were observed to have the highest activity and basic rocks the lowest.

Roy and Dutta (1991) has conducted experiment on transitional invaded zone to determine borehole DC response. The objective of the study is to determine the behavior of the kernels due to transition and compared with those models without transition zone. The integrals, which contain these kernels are numerically solved using seven point gauss quadrature formula and computed the apparent resistivities for all known electrode configurations.

Raja Mukhopadhyaya and Bhattacharya (1993) conducted experiments to delineate coal beds & estimation of its parameters from well log data using singular value decomposition (SVD). Density and sonic logs are used for the determination of coal quality and its parameters by using SVD.

Kamble and Desai (1996) conducted experiments on borehole geophysical logging for assessment of insitu characteristics of foundation at ERAI Dam, Maharashtra. The borehole geophysical logging was adopted with a view to determine the bulk density and porosity of foundation rock and also to evaluate insitu foundation conditions of the rock. Nuclear and electrical loggings were conducted in the existing drainage holes and boreholes drilled in the gallery where excess leakages were noticed.

METHODOLOGY

Logging data is collected from all the bore wells by using electrical resistivity logging method. In this method ABEM terameter and SAS-300 logger is used. The Sonde is lowered down the bore hole by using logging cable and as it was raised that calculates the response of the logging to various electrical parameter measurements. The recorded values are short normal, long normal, lateral and spontaneous potential logging tools. This obtained data is processed and graphs are plotted with excel. The fracture zones, corresponding to resistivity values, depths and boundaries between different litho units are analyzed.

LOCATION OF THE STUDY AREA

Hyderabad the capital city of Telangana is situated in the Musi basin a part of Krishna basin. Musi River passes through the city and bifurcates it into Northern and Southern Hyderabad. The area selected for present study is in the campus of Jawaharlal Nehru Technological University Hyderabad, located in the Northern part of the city of, Telangana, India which lies between latitudes 170°29□23.5□□to170°29□50.3□□North and longitudes 780°23□22.9□□ to 780°23□41.3□□East. The areal extent of the study area is 89.19Acres. Total existing built-up area within the campus is 53,822.24 m^2. The slope of the ground in the campus and surrounding areas is from North West to South East. The area is 576 m to 594 m above M.S.L. The climate in the study area is semiarid with an average annual rainfall of 821 mm, monsoon rainfall is 591.40 mm and non-monsoon rainfall is 230.30 mm. The minimum and maximum temperatures range from 12^{o}C in winter to 43^{o}C in summer respectively. Daily mean relative humidity is 51%. The highest wind speed is 136 km/hr. The Spatial representation of the study area is shown in the Figure 1. It is covered by topo sheet No. 56K on 1:2, 50,000 scale.

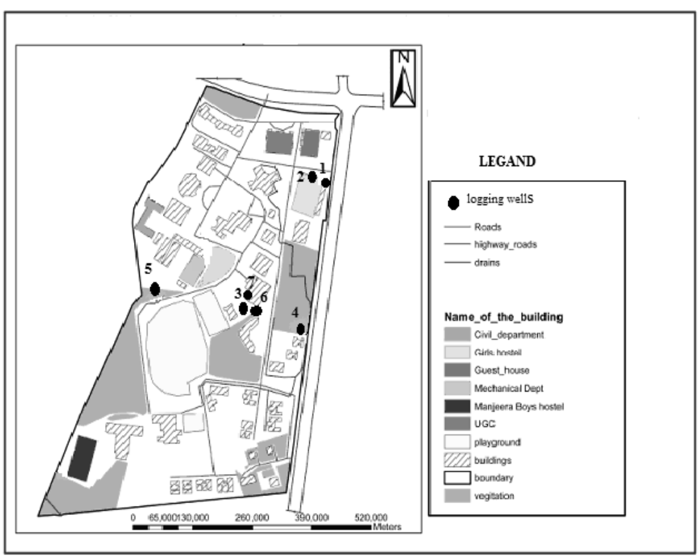

Figure 1 Study Area in JNTUH campus

The JNTUH campus is underlain by massive and hard grey and pink granites of Achaean age. The ground water occurs in weathered granite under unconfined conditions to joints fractures and fissures in semi confined conditions below the weathered mantle. Generally, weathered granite is present up to a depth of 15 m followed by hard and pink granites. Occasional fractures occur down to depth of 100 m bgl. Arcian soils are predominantly available in the study area. The thickness of the soil in the area of study varied from a few centimeters to about a few meters.

WELL LOGGING TECHNIQUES

Electrical Resistivity well logging survey is carried out at 7 bore wells in the study area to identify the boundaries between different layers and to identify resistivity characteristics of different subsurface layers there by to find out water potential zones. During the data collection in all the wells, Self Potential(SP) and temperature measurements are also taken in downward direction apart from Lateral, Long Normal(LN), Short Normal(SN) and SP measurements which are logged in upward direction.

INTERPRETATION OF WELL LOGGING DATA

The detailed interpretation of the resistivity logging of all the individual wells are given below. Their location is as shown in Table. 1 and Fig. 1

Table 1 Location of wells in the Study area

Bore Well ID	Location	Longitude	Latitude
1	Between Girls hostel compound wall and new incubator building	17°29'39.6"N	78°23'37.1"E
2		17°29'40.3"N	78°23'36.4"E
3	Behind new IST building JNTUH.	17°29'38.9"N	78°23'30.4"E
4		17°29'34.5"N	78°23'31.6"E
5	Behind new IST building JNTUH	17°29'34.4"N	78°23'31.4"E
6	Near Second gate	17°29'29.9"N	78°23'34.9"E
7	Near Whether Station	17°29'36.492"N	78°23'24.633"E

Well logging at well no. 1

Well no. 1 is located between the Girls hostel compound wall and new incubator building between the longitudes 17°29'39.6"N and latitudes 78°23'37.1"E. The SP, SN, LN and lateral measurements observed during conducting the experiment are noted and graphs are plotted in excel between Depth Vs SP and Depth Vs SN, LN and lateral in Ωm are as shown in Fig 2.

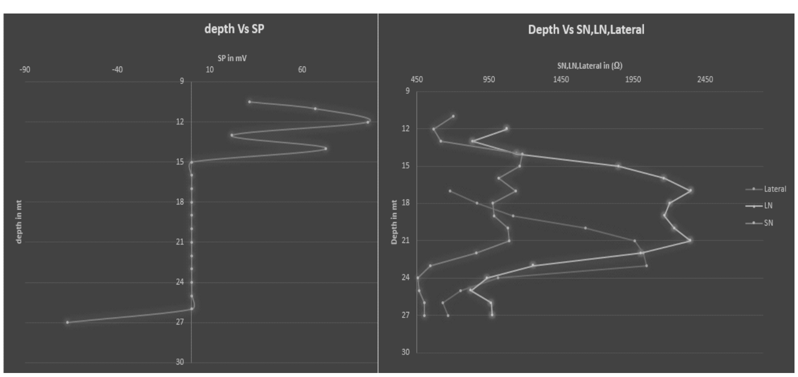

Figure 2 Graphs of various well logging measurements at well no. 1

The depth of the well is 30.45 m and static water level is 10.5 m. The resistivity logging is carried out from the depth of 11 m to 27 m at an interval of 1 m as shown in the figure no. 2. The logging is started below 11 m onwards.

The decreased resistivity values at the depths between 17 m to 19 m, 23 m to 24 m and 25 m to 27 m which are observed in all the logs i.e., lateral, Short Normal and Long Normal are considered to be an indication of fracture zones. Mean while the Self Potential values have gone either positive or negative at the fracture zones. Depth ranges and resistivities of fracture zones with respect to lateral, SN and LN for well no. 1 is as shown in Table 2.

Table 2 Depth ranges and resistivities of fracture zone with respect to lateral, SN and LN.

	Depth in m	**Resistivities of fracture zones in Ωm.**
SN	11 – 13	701.42 – 616.48
	16 – 18	1018.3 – 975.53
	23 – 27	542.61 – 500.49
LN	12 – 13	1073.5 – 1144.1
	23 – 27	2349.6 – 2165.9
	26 - 27	1256.3 – 972.20
Lateral	17 - 19	676.79 – 114.5
	20 – 24	1618.9 – 1013.9
	25 - 27	753.41 – 666.84

Well logging at well no. 2

This well is also located between Girls hostel compound wall and new incubator building between the longitudes 17°29'39.6"N and latitudes 78°23'37.1"E. The SP, SN, LN and lateral measurements observed during conducting the experiment and graphs are shown in Fig. 3. The depth of the well is 60.96 m and static water level is 8.93 m. The resistivity logging is carried out from a depth of 9 m to 59 m at an interval of 1 m. Thus the logging was started below 9 m onwards.

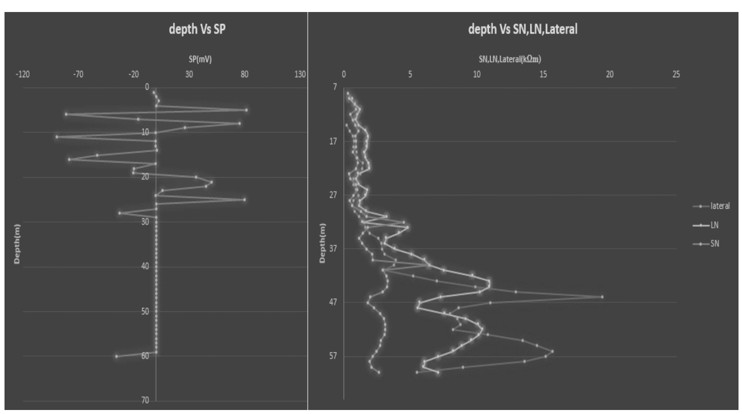

Figure 3 Graphs of various well logging measurements at well no. 2

The decreased resistivity values at the depths between 17 m to 24 m, 47 m to 49 m and 58 m to 59 m which are observed in all the logs i.e., lateral, Short Normal and Long Normal are considered to be an indication of fracture zones. Mean while the Self Potential values have gone either positive or negative at the fracture zones. Depth ranges and resistivities of fracture zones with respect to lateral, SN and LN for well no. 2 is as shown in Table 3.

Table 3 Depth ranges and resistivities of fracture zone with respect to lateral, SN and LN for well no. 2.

	Depth in m	**Resistivities of fracture zones in Ωm.**
SN	17 – 24	888.9 – 487.6
	47 – 56	2243.6 – 2179.2
	59 - 60	2092.6 – 2631.2
LN	17 – 24	1730.1 – 915.4
	46 – 49	7273.9 – 5553.3
	57 – 59	2179.2 – 2092.6
Lateral	17 – 24	746.3 – 735.2
	47 – 53	10994 – 10815
	58 - 60	13598 – 5486.4

Well logging at well no. 3

This well is also located behind new IST building between the longitudes 17°29'34.4"N and latitudes 78°23'31.4"E. The SP, SN, LN and lateral measurements are shown in Fig. 4. The depth of the well is 62.96 m and static water level is 28.66 m. The resistivity logging is carried out from the depth of 29 m to 62 m at an interval of 1 m. The logging were started below 29 m onwards.

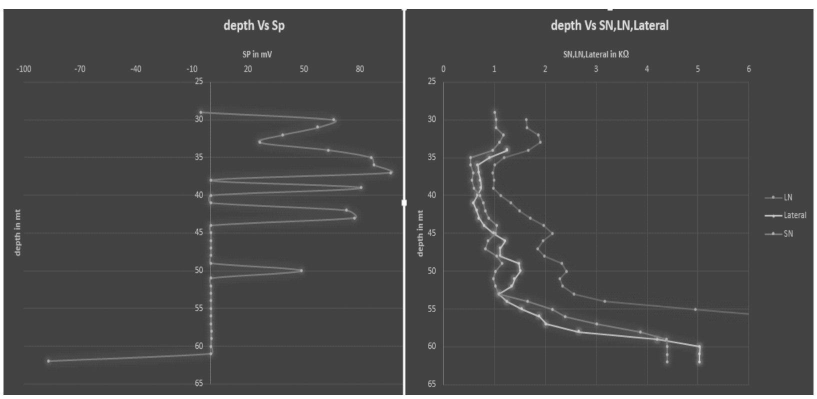

Figure 4 Graphs of various well logging measurements at well no. 3

The decreased resistivity values at the depths between 35 m to 39 m, 49 m to 52 m and 60 m to 62 m which are observed in all the logs i.e., lateral, Short Normal and Long Normal are considered to be an indication of fracture zones. Mean while the Self Potential values have gone either positive or negative at the fracture zones. Depth ranges and resistivities of fracture zones with respect to lateral, SN and LN for well no. 3 is as shown in Table 4.

Table 4 Depth ranges and resistivities of fracture zone with respect to lateral, SN and LN for well no. 3.

	Depth in m	**Resistivities of fracture zones in Ωm.**
SN	34 - 39	962.8 – 593
	49 - 52	1150.7 – 1082.6
	60 - 62	4394.8 – 4392
LN	33 – 39	1906.5 – 977.2
	49 – 51	2326.5 – 2279.1
	60 - 62	15278 – 15262
Lateral	35 – 39	904.2 – 738.9
	48 – 53	1114.2 – 1086.7
	60 - 62	5037.5 – 5030.6

Well logging at well no. 4

This well is situated backside of the park between the longitudes 17°29'29.9"N and latitudes 78°23'34.9"E. The SP, SN, LN and lateral measurements observed during conducting the experiment are shown in Fig no. 5. The well is 30.45 m deep and static water level is 1.07 m. The resistivity logging is carried out from a depth of 2 m to 22 m at an interval of 1m. Thus logging was started below 2 m onwards.

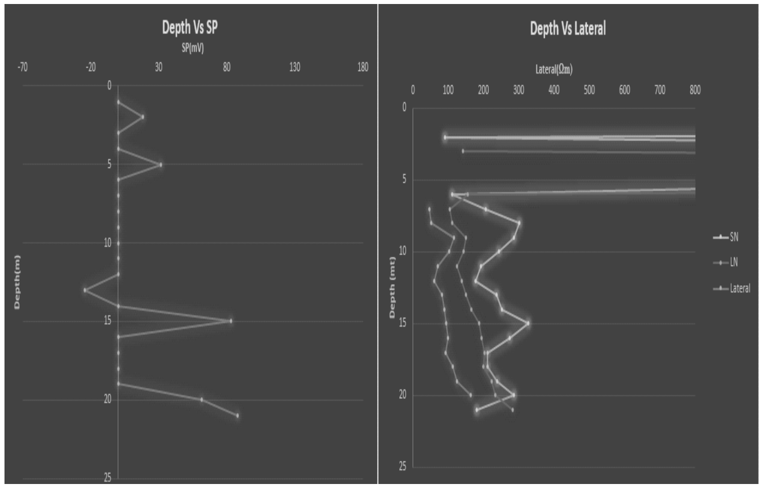

Figure 5 Graphs of various well logging measurements at well no. 4

The decreased resistivity values at the depths between 9 m to 11 m, 15 m to 17 m and 19 m to 21 m which are observed in all the logs i.e., lateral, Short Normal and Long Normal are considered to be an indication of fracture zones. Mean while the Self Potential values have gone either positive or negative at the fracture zones. Depth ranges and resistivities of fracture zones with respect to lateral, SN and LN for well no. 4 is as shown in Table 5.

Table 5 Depth ranges and resistivities of fracture zone with respect to lateral, SN and LN for well no. 4.

	Depth in m	**Resistivities of fracture zones in Ωm.**
SN	9 – 13	286.30 – 236.10
	15 – 17	326.04 – 210.05
	19 - 21	238.65 – 181.08
LN	6 – 11	155.79 – 124.53
	17 – 18	203.5 – 199.04
	19 - 21	223.14 – 282.76
Lateral	10 – 17	115.81 – 70.418
	16 – 18	93.593 – 99.517
	19 - 21	113.18 – 163.09

Well logging at well no. 5

This well is also located near weather station between the longitudes 17°29'36.492"N and latitudes 78°23'24.633"E. The SP, SN, LN and lateral measurements observed during conducting the experiment are noted and graphs shown in Fig no. 6. The total depth of the well is 48.76 m and depth to water level is 25.8 m. The resistivity logging is carried out from a depth of 26 m to 50 m at an interval of 1m. Thus the logging was started below 26 m onwards.

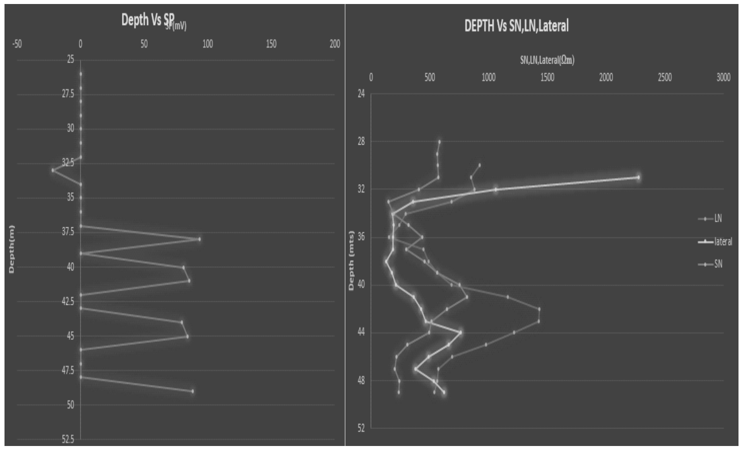

Figure 6 Graphs of various well logging measurements at well no. 5

The decreased resistivity values at the depths between 33 m to 35 m, 41 m to 43 m and 47 m to 49 m which are observed in all the logs i.e., lateral, Short Normal and Long Normal are considered to be an indication of fracture zones. Mean while the Self Potential values have gone either positive or negative at the fracture zones. Depth ranges and resistivities of fracture zones with respect to lateral, SN and LN for well no. 4 is as shown in Table 6.

Table 6 Depth ranges and resistivities of fracture zone with respect to lateral, SN and LN for well no. 5.

	Depth in m	Resistivities of fracture zones in Ωm.
SN	32 – 35	407.25 – 315.8
	41 – 43	816.97 – 514.12
	45 - 49	309.31 – 234.14
LN	33 – 36	486.45 – 293.68
	41 – 45	1162.4 – 975.46
	47 - 49	569.87 – 539.65
Lateral	33 – 35	355.85 – 190.25
	37 – 39	187.52 – 175.05
	45 - 47	659.22 – 375.69

Well logging at well no. 6

This well is also located behind new IST building between the longitudes 17°29'34.5"N and latitudes 78°23'31.6"E. The SP, SN, LN and lateral measurements are shown in Fig 7.

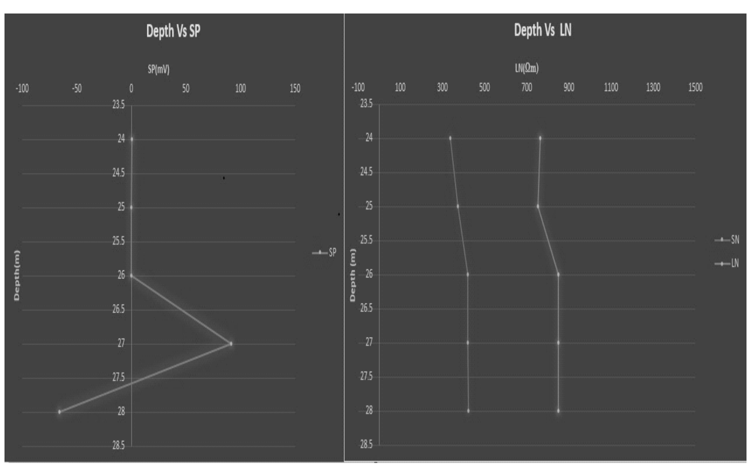

Figure 7 Graphs of various well logging measurements at well no.6

The depth of the well is 30.45 m and static water level is 26.9 m. The resistivity logging is carried out from a depth of 27 m to 30 m at an interval of 1 m. Thus logging was started below 27 m onwards. Due to very low water levels, only 4 resistivity measurements are observed from which we cannot conclude the number of zones or boundaries.

Well logging at well no. 7

This well is also located behind new IST building between the longitudes 17□29'38.9"N and latitudes 78□23'30.4"E. The SP, SN, LN and lateral measurements are shown in Fig no. 8.

The depth of the well is 30.45 m and static water level is 24 m. The resistivity logging is carried out from a depth of 24 m to 28 m at an interval of 1 m. Thus logging is started below 24 m onwards. Due to very low water levels only 4 resistivity measurements are observed from which we cannot conclude the number of zones or boundaries.

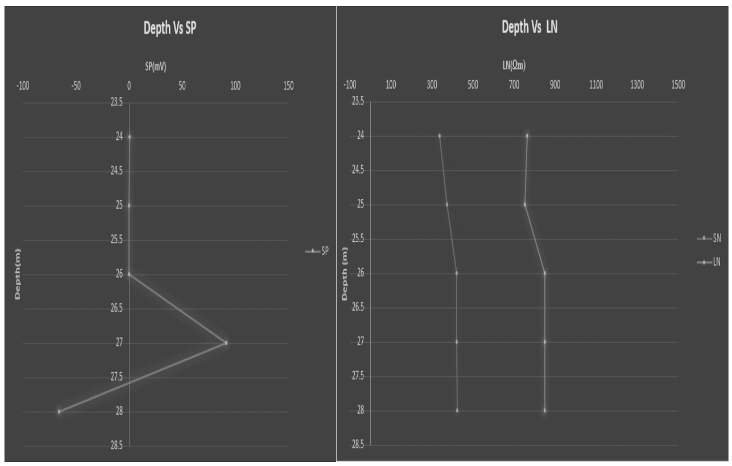

Figure 8 Graphs of various well logging measurements at well no. 7

Fence Diagram for fracture zones

From the fence diagram in Fig. 9 it can be observed that well numbers 3 and 5 has deeper fractures, while well numbers 1, 2 and 4 are having shallower fractures. Though it cannot be certainly said, but the indication is that the south-east portion of the campus is having a promising fractures and suitable for ground water recharge.

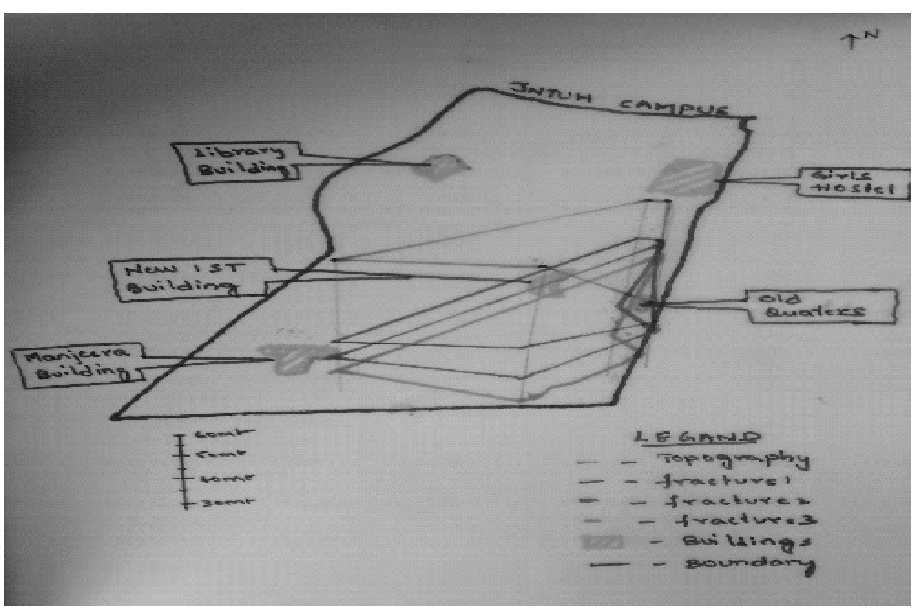

Figure 9 Fence Diagram for Fracture Zones

SUMMARY AND CONCLUSIONS

The well logging surveys which are conducted in the study area and the interpretation of the graphs which are obtained from various logging measurements have revealed the following results Lateral resistivity range for fracture zones of well no. 1 is in between 114.5 Ωm – 1618.9 Ωm. Lateral resistivity range for fracture zones at well no. 2 is in between 735.2 Ωm – 13598.0 Ωm. Lateral resistivity range for fracture zones at well no. 3 is in between 738.9 Ωm – 5037.5 Ωm. Lateral resistivity range for fracture zones at well no. 4 is in between 70.418 Ωm – 163.09 Ωm. Lateral resistivity range for fracture zones at well no. 5 is in between 175.05 Ωm – 659.22 Ωm.

In the study area it is observed that formation resistivities are varying with wide ranges. Subsurface lithology, boundaries and fracture zones are determined by using electrical resistivity and Spontaneous Potential well logging surveys. The resistivity logs are indicating the fracture zones but not having uniform resistivity in all the wells. South-East region of the campus is more suitable for ground water recharge which is determined by using fence diagram.

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Appraisal of Groundwater Quality from Sirpur Kaghaznagar Area, Adilabad District, Telangana

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ABSTRACT

Ground water quality plays an important role in promoting agricultural production and standard of human health and the sources and causes of ground water pollution are closely associated with human use of water. For many years ground water was thought to be protected from contamination by the layers of rocks and soil that acts as a filter, but contaminants do make their way into the ground water and affect its quality. The present paper deals with the assessment of seasonal variation in ground water and its suitability for drinking purposes. For this purpose major ions were assessed and Water Quality index was calculated for both pre monsoon and post monsoon season. A comparison of ground water quality in relation to drinking water quality standards proves that the ground water quality was altered with respect to parameters such as pH, EC, TDS, Ca^{2+}, Mg^{2+} and TH showcased higher levels. Similarly WQI calculated for both the seasons ranged to fall in poor to unsuitable category. The degradation of ground water quality can be attributed to the use of agricultural fertilizers by farmers, by paper industry effluents and mineral composition of aquifers in the study area. The suggested measures includes, proper disposal of effluents by paper industry, change in cropping pattern and bringing awareness in the local people and providing safe drinking water through Mission Bhagiratha.

Keywords: Water Quality Index, Physico-chemical parameters, Groundwater quality, spatial distribution and seasonal variation.

INTRODUCTION

Groundwater is of vital importance with respect to domestic, industrial and agricultural purposes and can be linked to human welfare and development. In the recent past tremendous increase in fresh water usage and its huge demand has created environmental stress and is being threatened and overexploited posing adverse consequences in the near future (Rama Krishna *et al* 2009). Unchecked growth of population with rapid developmental activities leading to urban sprawl along with fertilizers and fungicide use in agricultural productions are main reasons for the change in the quality of ground water. Groundwater being the main source of drinking water, wastes from industries, agricultural sector and excess nutrients from domestic sewage are being constantly added by man's activities to make it polluted (Panda and Sinha, 1991). Most of the epidemics which create adverse impact on human health especially in developing countries can be linked to unsafe water quality lacking wholesome water supply.

Study Area

Sirpur Kaghaznagar area is located in the north eastern part of Adilabad district, Telangana and lies on $19^0 33' 33''$ North Latitude and 79^0 48' 33" East Longitude with an average elevation of 174 metres. It is situated on Chennai-Delhi railway line. As of 2011 India census the town had a population of 57,583. Average population density of the Sirpur Kaghaznagar town is 6,900 per sq. Km and well known for Sirpur Paper Mills (SPM) one of the oldest paper mills in India (Figure.1). The study area is mainly underlain by the Sullavai formation comprising grits, conglomerates and sandstone. The nearby areas are well endowed with many mineral resources like coal deposits; limestone, iron ore and clay are found.

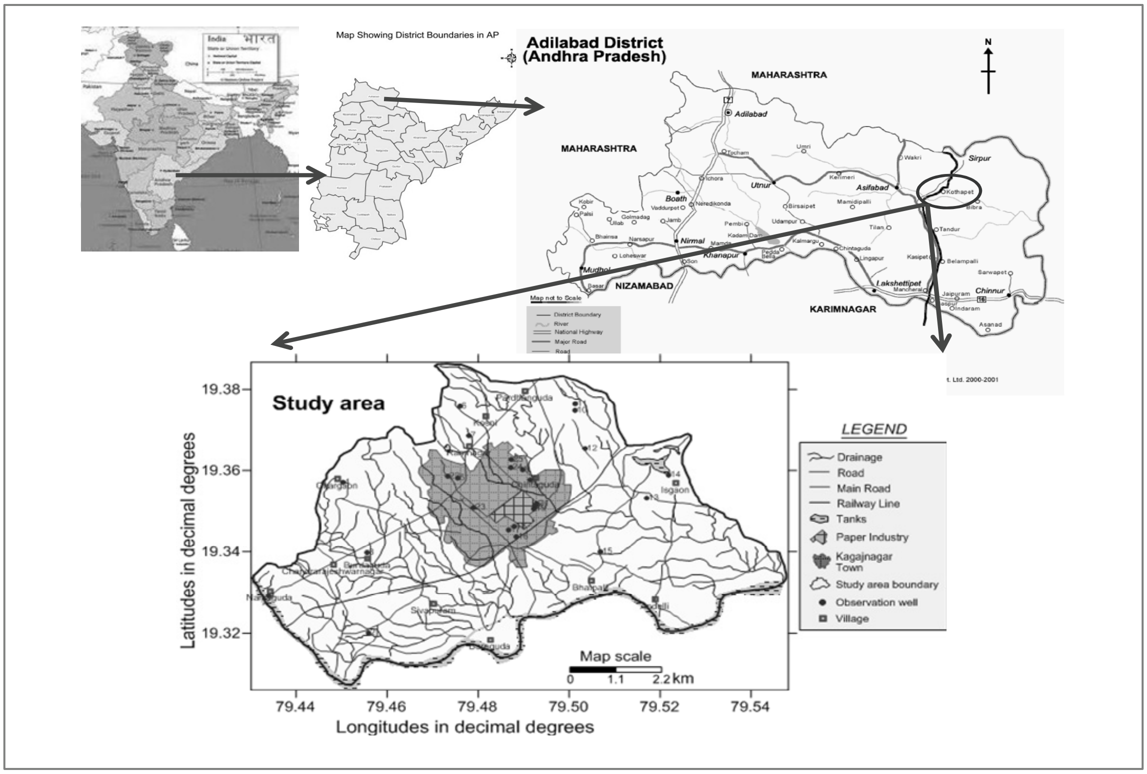

Figure 1 Location map of the study area

MATERIALS AND METHODOLOGY

Total 5 representative water samples (Ground water: 4 no s and Surface water: 1 no s) were collected for two seasons, viz., pre-monsoon, and post-monsoon seasons of 2012-2013 (Table.1). Samples were collected as per the standard procedure laid down in APHA (2012) in 1 litre polythene bottles pre-cleaned with double distilled water. The samples were filtered by Whatman filter paper prior to analysis in the lab. Analysis was carried out major ions (cat and anions) by following standard methods (APHA 2012).

Table 1 Location of sampling stations with latitude & longitude

Sample No.	Location of sampling stations	Longitude	Latitude
1	Peddavagu River	79.433935	19.329136
2	Sarsilk (Hand Pump)	79.489785	19.360207
3	Chintaguda (Hand Pump)	79.501303	19.374788
4	Sangam Basthi (Dug Well)	79.473309	19.358634
5	Ram Mandir Area(Hand Pump)	79.487272	19.362682

The parameters like pH and conductivity were measured in the field with the hand held instrument (Hanna Make). Total dissolved solids were estimated by gravimetric method, total hardness and calcium by ethylene di amine tetra acetic acid (EDTA) titration method using Eriochrome black-T and murexide indicators, chlorides by argentometric method, nitrate-nitrogen by colorimetric method using brucine sulfanilic acid, magnesium by indirect method and sodium and potassium were estimated with the help of Flame photometer were analyzed.

Calculation of Water Quality Index (WQI)

WQI is an important tool which gives a meaningful approach to understand the overall water quality with respect to rivers, lakes and other surface water sources intended to its designated use. The water quality index was calculated based on fourteen parameters by using drinking water quality standard recommended by the World Health

Organization (WHO, 2011). The weighted arithmetic index method (Brown, 1972) used for the calculating WQI of the water body in following steps:

a. Calculation of Sub Index of Quality rating (*qn*)

Let there be ***n*** water quality parameters, where the quality rating or sub index (***qn***) corresponding to the ***nth*** parameters is a number reflecting the relative value of these parameters in the polluted water with respect to its standard permissible value. The value of ***qn*** is calculated using the following expression.

$$qn = 100\,[Vn\text{-}Vio]/[Sn\text{-}Vio] \quad \textbf{(1)}$$

Where, ***qn*** = Quality rating for the ***nth*** water quality parameters

Vn = Estimated value of the ***nth*** parameter at a given sampling station.

Sn = Standard permissible value of the ***nth*** parameters

Vio = Ideal value of ***nth*** parameter in pure water.

(i.e., 0 for all other parameters except the parameter pH and dissolved oxygen (7.0 and 14.6 mg l-1 respectively) (Tripaty and Sahu, 2005).

b. Calculation of Quality rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

$$qpH = 100\,[(VpH - 7.0)/(8.5 - 7.0)] \quad \textbf{(2)}$$

Where, ***VpH*** = observed value of pH during the study period.

If quality rating $qn = 0$ means complete absence of pollutants,

While $0 < qn < 100$ implies that, the pollutants are within the prescribed standard.

When $qn > 100$ implies that, the pollutants are above the standards.

c. Calculation of Unit Weight (*Wn*) Calculation of unit weight (***Wn***) for various water quality parameters are inversely proportional to the recommended standards value ***Sn*** of the corresponding parameters.

$$Wn = K/Sn \quad \textbf{(3)}$$

Where, ***Wn*** = Unit weight for the ***nth*** parameters.

Sn = Standard value for ***nth*** parameters.

K = Proportional constant, this value considered (1) here, also can calculate using the following equation:

$$K = 1/\Sigma\,(1/Sn) \quad \textbf{(4)}$$

The overall Water Quality Index was calculated by aggregating the quality rating with the unit weight linearly.

If water quality index (WQI) is less than 50 such water is slightly polluted and fit for human consumption, WQI between (51 - 80) moderately polluted, WQI between (50 -100) excessively polluted and WQI-Severely polluted (Sinha *et al.,* 2004) (Table.2).

$$WQI = \sum_{n=1}^{n} qn\,Wn \Big/ \sum_{n-1}^{n} Wn \quad \textbf{(5)}$$

Table 2 Water Quality Index (WQI) and status of water quality [Chaterjee and Raziuddin, 2002]

Water Quality Index Level	Water Quality Status	Grading
0-25	Excellent Water quality	A
26-50	Good Water quality	B
51-75	Poor Water Quality	C
76-100	Very Poor Water quality	D
>100	Unsuitable	E

RESULTS AND DISCUSSION

Water Quality Index of the ground water samples was established based on various important physico-chemical parameters for five different sites from for both seasons. The WQI, from 5 different sites during pre monsoon varied from 52.42 (site 1) to 145.62 (site 2), and during post monsoon season it ranged from 50.95 (site 1) to 141.70 (site 2). The mean of major ions during pre and post-monsoon season is given in table-3 and table-4 respectively.

pH is indicated by the acidity and alkalinity is the hydrogen ion concentration contributed by many factors. Many of the mineral constituents coordinate to give the resultant pH. The results obtained for pH ranged between (8.76- 8.9). The minimum of 8.76 at site 1 (Peddavagu) and maximum pH of 8.9 was found at sites 2, 3, 4 and 5 (Sarsilk), (Chintaguda), (Sangam Basthi) and (Ram mandir) constantly in pre monsoon season. During the post monsoon season it ranged between (8.78 - 8.9) with minimum of 8.76 at site 1 and maximum was recorded at sampling sites 2, 3, 4 and 5. The pH was alkaline mostly in both the seasons in the study area. The alkaline pH above 8.6 could be due the surface water interaction with ground water and agricultural runoff. The alkaline pH in both the seasons might also be due to the use of lime in paper making process from paper mill in the near vicinity (Govindaradjane et *al*., 2007).

Electrical conductivity values investigated for the study period ranged between (300 – 2000 µmhos/cm) in pre monsoon season. The minimum was recorded at site 1 and maximum at site 2 where as it ranged from (350- 2004 µmhos/cm) in post monsoon with minimum value of (350 µmhos/cm) at site 1 and maximum value of (2004 µmhos/cm) at site 2. The higher values of EC recorded at sarsilk colony are obviously due to presence of paper mill in the nearby surrounding area. Leaching of various ions and use of organic material in paper mill effluents is indicated. Similar studies were reported by Yadav *et al.,* (2014).

TDS concentration monitored for both the seasons was found to vary between (192- 1280 mg/L) in pre monsoon with 192 mg/L minimum at site 1 and maximum of 1280 at site 2. In the post monsoon it ranged between (205- 1284 mg/L) with lowest value of 205 mg/L at site 1 and highest 1284 mg/L at site 2. The high values of TDS at site 2 (Sarsilk) may be due to excess usage of insoluble organic matter and seepage of chemicals from pulp and paper industry. Bamakanta, *et al.,* (2013) recorded similar observation in Nagavali river water on seasonal variations at the vicinity of JK paper mill, Rayagada. Similar studies were also reported by Kumar *et al.,* (2015), Patil, V.T. and P.R. Patil, (2011) Srinivas *et al.,* (2000), Tripathi *et al., (*2013).

Chloride may be available from natural phenomenon of the earth and also from industrial use. High levels of chloride impart a salty taste and affect people with hypertension and cardiac problems. In the present study chloride concentration varied from (6- 170 mg/L) at sites 1 and 5 in pre monsoon whereas it varied between (5- 170 mg/L) at site 1 and 5 in post monsoon season. The fluoride concentration in the pre monsoon ranged between (0.45 - 4 mg/L) at sites 1 and 2 whereas in the post monsoon season it was recorded as (0.19 - 3.9 mg/L) at sites 4 and 2. Calcite and gypsum containing minerals are responsible for calcium leaching in aquifers and up to some extent human use. Calcium values were in the range of (26.59- 194.93 mg/L) in pre monsoon and in the post monsoonal season the values ranged between (26.12-195.17 mg/L). The values were within the permissible limit prescribed by BIS.

The concentration of magnesium in the study area during pre monsoon varied between (65.54-153.13 mg/L) and in the post monsoon it ranged between (71.24-153.13 mg/L) at sites 3 and 5. Sulphate concentrations in the study area ranged from (31- 152 mg/L) in pre monsoonal season whereas in the post monsoon it recorded as (31.5-143 mg/L) at sites 1 and 4. Use of agricultural fertilizers and domestic sewage rich with organic matter enhance the nitrate in water. Nitrate values recorded in the pre monsoon ranged from 1.15- 36.9 mg/L and in post monsoon it was (1.01- 34.3 mg/L) at sites 2 and 3.In both the seasons the nitrate values were within the permissible limit given by BIS. However increased levels of nitrate at site 3 in pre and post monsoon seasons with values 36.9 and 34.3 mg/L may be contributed from usage of agricultural fertilizers and domestic sewage.

Sodium and potassium concentrations ranged from (198.21- 657.48 mg/L and 199- 452 mg/L) and (5.44 -66.6 and 4.6- 66.29 mg/L) in both the seasons respectively. High values of sodium in water clearly hints the use of sodium based chemicals from paper industry. Total Hardness was found to range between (100-351 mg/L) in pre monsoon and in post monsoon it ranged as (130- 336 mg/L) at sites 1 and 3.

Table 3 Mean of physico-chemical parameters during pre monsoon season.

Sampling Sites	**Peddavagu River**	**Sarsilk HandPump**	**Chintaguda HandPump**	**Sangabasthi Hand pump**	**RamMandir Hand Pump**
Code	1	2	3	4	5
pH	8.76	8.9	8.9	8.9	8.9
EC	300	2000	901	1070	1560
TDS	192	1280	577	685	998
Chloride (Cl^-)	6	150	100	150	170
Fluoride (F)	0.45	4	0.54	0.28	3.3
Calcium (Ca^{2+})	194.93	26.59	162.61	149.87	43.95
Magnesium (Mg^{2+})	80.5	75.2	72.34	65.54	153.13
Sulphates (SO_4^{2-})	31	90	115	152	92
Nitrates (NO_3^-)	2.15	1.15	36.9	22	2.15
Sodium (Na^+)	198.21	415.06	222.08	376.81	657.48
Potassium (K^+)	17.48	5.44	6.74	66.6	10.6
Total Hardness(TH)	100	160	340	280	351

All parameters are expressed in mg/L except pH & EC.

Table 4 Mean of physico-chemical parameters during post monsoon season.

Sampling Sites	**Peddavagu River**	**Sarsilk HandPump**	**Chintaguda HandPump**	**Sangabasthi Hand pump**	**RamMandir Hand Pump**
Code	1	2	3	4	5
pH	8.78	8.9	8.9	8.9	8.9
EC	350	2004	900	1085	1006
TDS	205	1284	630	690	1030
Chloride (Cl^-)	5	135	101	145	122
Fluoride (F)	0.4	3.9	0.32	0.19	3.4
Calcium (Ca^{2+})	195.17	26.12	160.01	149.71	95.75
Magnesium (Mg^{2+})	81.63	75.21	71.24	63.91	104.25
Sulphates (SO_4^{2-})	31.5	90	115	143	56
Nitrates (NO_3^-)	2.15	1.01	34.3	22	2.15
Sodium (Na^+)	199	395.24	219.02	356	452
Potassium (K^+)	17.23	4.6	6.95	66.29	8.5
Total Hardness(TH)	130	150	320	301	336

All parameters are expressed in mg/L except pH & EC.

Table 5 Calculation of WQI for site 1 Peddavagu River during pre monsoon & post monsoon seasons for 2012-2013 year

Parameter	Observed Value (Vn)		Standard Value (Sn)		1/sn		Unit Weight (Wn)		Quality Rating (qn)		qnWn	
	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon
pH	8.76	8.78	8.50	8.50	0.12	0.12	0.10	0.10	117.33	118.67	11.61	11.74
EC	300.00	350.00	1500.00	1500.00	0.00	0.00	0.00	0.00	20.00	23.33	0.01	0.01
TDS	192.00	205.00	1000.00	1000.00	0.00	0.00	0.00	0.00	19.20	20.50	0.02	0.02
Cl^-	6.00	5.00	250.00	250.00	0.00	0.00	0.00	0.00	2.40	2.00	0.01	0.01
F	0.45	0.40	2.00	2.00	0.50	0.50	0.42	0.42	22.50	20.00	9.46	8.41
Ca^{2+}	194.93	195.17	75.00	75.00	0.01	0.01	0.01	0.01	259.91	260.23	2.91	2.92
Mg^{2+}	80.50	81.63	100.00	100.00	0.01	0.01	0.01	0.01	80.50	81.63	0.68	0.69
SO_4^{2-}	31.00	31.50	200.00	200.00	0.01	0.01	0.00	0.00	15.50	15.75	0.07	0.07
NO_3^-	2.15	2.15	10.00	10.00	0.10	0.10	0.08	0.08	21.50	21.50	1.81	1.81
Na^+	198.21	199.00	250.00	250.00	0.00	0.00	0.00	0.00	79.28	79.60	0.27	0.27
K^+	17.48	17.23	12.00	12.00	0.08	0.08	0.07	0.07	145.67	143.58	10.21	10.06
TH	100.00	130.00	500.00	500.00	0.00	0.00	0.00	0.00	20.00	26.00	0.03	0.04
			K	k	0.84	0.841	0.71	0.707			37.08	36.04
WQI =Σ qn Wn / Σ Wn = 52.43 (Pre Monsoon)												
WQI =Σ qn Wn / Σ Wn = 50.95(Post Monsoon)												

Table 6 Calculation of Water Quality index for site 2 Sarsilk during pre monsoon & post monsoon seasons for 2012-2013 year

Parameter	Observed Value (Vn)		Standard Value (Sn)		1/sn		Unit Weight (Wn)		Quality Rating (qn)		qnWn	
	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon
pH	8.90	8.90	8.50	8.50	0.12	0.12	0.10	0.10	126.67	126.67	12.53	12.53
EC	2000.00	2004.00	1500.00	1500.00	0.00	0.00	0.00	0.00	133.33	133.60	0.08	0.08
TDS	1280.00	1284.00	1000.00	1000.00	0.00	0.00	0.00	0.00	128.00	128.40	0.11	0.11
Cl^-	150.00	135.00	250.00	250.00	0.00	0.00	0.00	0.00	60.00	54.00	0.20	0.18
F	4.00	3.90	2.00	2.00	0.50	0.50	0.42	0.42	200.00	195.00	84.10	82.00
Ca^{2+}	26.59	26.12	75.00	75.00	0.01	0.01	0.01	0.01	35.45	34.83	0.40	0.39
Mg^{2+}	75.20	75.21	100.00	100.00	0.01	0.01	0.01	0.01	75.20	75.21	0.63	0.63
SO_4^{2-}	90.00	90.00	200.00	200.00	0.01	0.01	0.00	0.00	45.00	45.00	0.19	0.19
NO_3^-	1.15	1.01	10.00	10.00	0.10	0.10	0.08	0.08	11.50	10.10	0.97	0.85
Na^+	415.06	395.24	250.00	250.00	0.00	0.00	0.00	0.00	166.02	158.10	0.56	0.53
K^+	5.44	4.60	12.00	12.00	0.08	0.08	0.07	0.07	45.33	38.33	3.18	2.69
TH	350.00	150.00	500.00	500.00	0.00	0.00	0.00	0.00	70.00	30.00	0.12	0.05
			k	k	0.84	0.84	0.71	0.71			103.10	100.22
WQI =Σ qn Wn / Σ Wn = 145.71(Pre Monsoon)												
WQI =Σ qn Wn / Σ Wn = 141.70(Post Monsoon)												

Table 7 Calculation of Water Quality index for site 3 Chintaguda during pre monsoon & post monsoon seasons for 2012-2013 year

Parameter	Observed Value (Vn)		Standard Value (Sn)		1/sn		Unit Weight (Wn)		Quality Rating (qn)		qnWn	
	Pre mon	Post mon	Pre mon	Post mon	Pre Mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon
pH	8.90	8.90	8.50	8.50	0.12	0.12	0.10	0.10	126.67	126.67	12.53	12.53
EC	901.00	900.00	1500.00	1500.00	0.00	0.00	0.00	0.00	60.07	60.00	0.03	0.03
TDS	577.00	630.00	1000.00	1000.00	0.00	0.00	0.00	0.00	57.70	63.00	0.05	0.05
Cl^-	100.00	101.00	250.00	250.00	0.00	0.00	0.00	0.00	40.00	40.40	0.14	0.14
F	0.54	0.32	2.00	2.00	0.50	0.50	0.42	0.42	27.00	16.00	11.35	6.73
Ca^{2+}	162.61	160.01	75.00	75.00	0.01	0.01	0.01	0.01	216.81	213.35	2.43	2.39
Mg^{2+}	72.34	71.24	100.00	100.00	0.01	0.01	0.01	0.01	72.34	71.24	0.61	0.60
SO_4^{2-}	115.00	115.00	200.00	200.00	0.01	0.01	0.00	0.00	57.50	57.50	0.24	0.24
NO_3^-	36.90	34.30	10.00	10.00	0.10	0.10	0.08	0.08	369.00	343.00	31.03	28.85
Na^+	222.08	219.02	250.00	250.00	0.00	0.00	0.00	0.00	88.83	87.61	0.30	0.30
K^+	6.74	6.95	12.00	12.00	0.08	0.08	0.07	0.07	56.17	57.92	3.94	4.06
TH	340.00	320.00	500.00	500.00	0.00	0.00	0.00	0.00	68.00	64.00	0.11	0.11
			k	k	0.84	0.84	0.71	0.71			62.77	56.02
WQI =Σ qn Wn / Σ Wn = 88.74 (Pre Monsoon)												
WQI =Σ qn Wn / Σ Wn =79.21 (Post Monsoon)												

Table 8 Calculation of WQI for site 4 Sangam Basthi during pre monsoon & post monsoon seasons for 2012-2013 year

Parameter	Observed Value (Vn)		Standard Value (Sn)		1/sn		Unit Weight (Wn)		Quality Rating (qn)		qnWn	
	Pre mon	Post mon	Pre mon	Post mon	Pre Mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon
pH	8.90	8.90	8.50	8.50	0.12	0.12	0.10	0.10	126.67	126.67	12.53	12.53
EC	1070.00	1085.00	1500.00	1500.00	0.00	0.00	0.00	0.00	71.33	72.33	0.04	0.04
TDS	685.00	690.00	1000.00	1000.00	0.00	0.00	0.00	0.00	68.50	69.00	0.06	0.06
Cl^-	150.00	145.00	250.00	250.00	0.00	0.00	0.00	0.00	60.00	58.00	0.20	0.20
F	0.28	0.19	2.00	2.00	0.50	0.50	0.42	0.42	14.00	9.50	5.89	4.00
Ca^{2+}	149.87	149.71	75.00	75.00	0.01	0.01	0.01	0.01	199.83	199.61	2.24	2.24
Mg^{2+}	65.54	63.91	100.00	100.00	0.01	0.01	0.01	0.01	65.54	63.91	0.55	0.54
SO_4^{2-}	152.00	143.00	200.00	200.00	0.01	0.01	0.00	0.00	76.00	71.50	0.32	0.30
NO_3^-	22.00	22.00	10.00	10.00	0.10	0.10	0.08	0.08	220.00	220.00	18.50	18.50
Na^+	376.81	356.00	250.00	250.00	0.00	0.00	0.00	0.00	150.72	142.40	0.51	0.48
K^+	66.60	66.29	12.00	12.00	0.08	0.08	0.07	0.07	555.00	552.42	38.90	38.71
TH	280.00	301.00	500.00	500.00	0.00	0.00	0.00	0.00	56.00	60.20	0.09	0.10
			k	K	0.84	0.84	0.71	0.71			79.83	77.69
WQI =Σ qn Wn / Σ Wn = 112.87 (Pre Monsoon)												
WQI =Σ qn Wn / Σ Wn = 109.85 (Post Monsoon)												

Table 9 Calculation of Water Quality index for site 5 Ram Mandir during pre monsoon & post monsoon seasons for 2012-2013 year

Parameter	Observed Value (Vn)		Standard Value (Sn)		1/sn		Unit Weight (Wn)		Quality Rating (qn)		qnWn	
	Pre mon	Post mon	Pre mon	Post mon	Pre Mon	Post mon	Pre mon	Post mon	Pre mon	Post mon	Pre mon	Post mon
pH	8.90	8.90	8.50	8.50	0.12	0.12	0.10	0.10	126.67	126.67	12.53	12.53
EC	1560.00	1006.00	1500.00	1500.00	0.00	0.00	0.00	0.00	104.00	67.07	0.06	0.04
TDS	998.00	1030.00	1000.00	1000.00	0.00	0.00	0.00	0.00	99.80	103.00	0.08	0.09
Cl^-	170.00	122.00	250.00	250.00	0.00	0.00	0.00	0.00	68.00	48.80	0.23	0.16
F	3.30	3.40	2.00	2.00	0.50	0.50	0.42	0.42	165.00	170.00	69.38	71.48
Ca^{2+}	151.24	95.75	75.00	75.00	0.01	0.01	0.01	0.01	201.65	127.67	2.26	1.43
Mg^{2+}	153.13	104.25	100.00	100.00	0.01	0.01	0.01	0.01	153.13	104.25	1.29	0.88
SO_4^{2-}	92.00	56.00	200.00	200.00	0.01	0.01	0.00	0.00	46.00	28.00	0.19	0.12
NO_3^-	2.15	2.15	10.00	10.00	0.10	0.10	0.08	0.08	21.50	21.50	1.81	1.81
Na^+	657.48	452.00	250.00	250.00	0.00	0.00	0.00	0.00	262.99	180.80	0.89	0.61
K^+	10.60	8.50	12.00	12.00	0.08	0.08	0.07	0.07	88.33	70.83	6.19	4.96
TH	351.00	336.00	500.00	500.00	0.00	0.00	0.00	0.00	70.20	67.20	0.12	0.11
			k	k	0.84	0.84	0.71	0.71			95.03	94.22
WQI =Σ qn Wn / Σ Wn = 134.36 (Pre Monsoon)												
WQI =Σ qn Wn / Σ Wn = 133.22 (Post Monsoon)												

Table 10 Water Quality statuses with sample locations for two different seasons.

S. no	Sampling Sites	Water Quality Status	
		Pre monsoon	Post monsoon
1	Peddavagu River	Poor	Poor
2	Sarsilk Colony	Unsuitable	Unsuitable
3	Chintaguda	Very poor	Very poor
4	Sangam Basthi	Unsuitable	Unsuitable
5	Ram Mandir	Unsuitable	Unsuitable

CONCLUSIONS

The sources and causes of ground water pollution are interlinked with human health and the quality of water plays an important role in sustaining life activities. The ground water quality results during pre monsoon and post monsoonal seasons from Sirpur Kaghaznagar town reveals that important parameters like pH is above the permissible limit prescribed by BIS standards in both the seasons. EC was measured above permissible limit at sampling station 2 in post monsoon season. TDS, Ca^+, Mg^+ and TH was recorded higher than the acceptable limits in both the seasons where as the highest water quality index status was recorded at site 2 (sarsilk) pre monsoon and post monsoon (WQI= 145.62 and 141.70) as shown in (Table 6) and the lowest quality index was found at site 1 (Peddavagu) (WQI= 52.42 and 50.95) as shown in (Table 5). From the WQI analysis it is very clear that out of the five sampling locations three falls in unsuitable category, one in very poor and one sample site in poor water quality status category (Table 10) indicating the impact of paper mill effluents and indicate some degree of treatment before use. It is also very much evident from WQI analysis that almost all the sites are severely affected with the paper mill effluents on a long term basis through percolation. Therefore there is a need for integrated approach in people to protect ground water contamination in the study area.

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THEME – V

WATER QUALITY, WATER TREATMENT, POLLUTION AND SOCIETY

Study on Heavy Metal (Cd, Cr, Pb and Ni) Accumulation in Water and Soil in and Around Some Selected Functional Brick Kilns in Cachar District, Assam

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ABSTRACT

Brick kilns are essential for economic development and urbanization. However, they cause several types of environmental problems. Concentration of different heavy metals in soil and aquatic systems around the brick kiln chimneys was studied during the year 2015-2016. The aim of the present study was to assess the accumulation of selected heavy metals (Cadmium, Chromium, Lead and Nickel) in aquatic systems and soil in functional brick kilns in Cachar district, Assam. A total of 108 water and 96 soil samples were collected and heavy metal contents were analyzed using ICP-OES (Perkin Elmer, Optima 2100 DV). Based on the mean value the abundance of heavy metals in the study sites followed the order of Pb>Ni>Cr>Cd in both water and soil samples. Also, it was observed that the level of heavy metal accumulation in soil and water is indirectly proportional to the distance from the brick kiln chimney. Lead (Pb) concentration in water samples ranged between 0.001-0.07mgl^{-1} but in some sites concentration was below detection level; Nickel ranged between 0.003- 0.05 mgl^{-1}; Cadmium and Chromium concentrations ranged between 0.02-0.04mgl$^{-1.}$ In soil samples Pb concentration ranged from 1.11-154.43 mg/kg; Ni concentration ranged from 7.9 to 105.45 mg/kg; highest concentration of Cr in soil samples was 92.53mg/kg and Cd was 8.48 mg/kg. The study revealed that heavy metals pollution from brick kilns is an important threat to the ecosystem as it deteriorates both water and soil quality. Hence, monitoring of ecosystem is essential to prevent harmful impact on human health and on biodiversity.

Keywords: Heavy metals, Contamination, Soil degradation, Accumulation, Environmental pollution.

INTRODUCTION

Environmental pollution is a worldwide problem. Although industrialization is very important for the development of a country but this is a bitter fact that it speeds up the process of environmental degradation. Pollution is defined as any departure from purity while environmental pollution means departure from a normal rather than a pure state. In our country fired clay brick is one of the most important building materials. These brick industries are unorganized small scale rural industries. Bricks are made up of clay and good quality soil. About140 billion bricks are annually produced by these industries according to Singh and Asgher (2005). In Cachar though these brick industries provide economic support to the local people but at the same time they are responsible for removal of vegetation cover over a large area which may lead to degradation of soil quality and loss of biodiversity, air pollution and water pollution. The releases of toxic substances from these brick kilns are adversely affecting soil, water bodies, plant, amenity and heritage in their vicinity. Animals and people residing in nearby areas are affected specially women, children and the brick workers (Bhanarkar *et al*., 2002). Brick kilns play a key role in heavy metal toxicity. A heavy metal is a member of an ill -defined subset of elements that exhibits metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides (Iqbal *et al*., 2011). Accumulation and transformation of heavy metals occur both by natural and anthropogenic sources. The contamination by heavy metals in soil and water is one of the major issues faced throughout the world and requires attention because heavy metals above their normal ranges are extremely toxic to both plant and animal life. The present study was conducted to assess the accumulation of heavy metals (Cd, Cr, Ni and Pb) in aquatic systems and soil in the vicinity of some selected brick kilns in Cachar district.

MATERIALS AND METHODS

Study area: For the study 6 brick kilns named (A,B,C,D,E,F) were selected from three stations i,e. Bariknagar, Silcoorie and Natunbazar from Cachar district. Four aquatic bodies (i,e. affected site A1, A2, A3 and A4 as control) from each brick kiln and three sites as control from Chatla (G1, G2, G3) were selected. 12 soil samples from each brick kilns at the distance of 10m, 50m, 100m, 200m from the brick kilns were collected for the study. The sampling was done during March 2015- March 2016. The water samples were collected in plastic bottles (1L) with proper labeling. Then the samples were digested and kept for further analysis. Composite soil sampling was done with the help of soil corer at 0-20 cm and samples of soil were collected in polythene bags (1kg) following Iqbal (2011).

Preparation of water samples: The water samples were collected according to the method recommended by Richards (1954). To one liter of water 5ml of Nitric acid was added and kept for further analysis.

Preparation of soil samples: In laboratory the samples were first air dried, then dried in oven at 105ºC till a constant weight was acquired. After that the sample was ground in mortar and pastel. Then passed through 0.5mm nylon mesh sieve and was kept for further analysis (Saied and Rafiq, 1980).

Determination of Heavy metals (Pb, Cd, Cr and Zn) in soil and water samples: 30 ml of digested water samples were kept for heavy metal determination. 5gm of dry soil samples were taken in a beaker and mixed with 2 ml of aqua regia (1 part of conc. HCL: 3 parts of conc. HNO_3). The mixture was digested in fume chamber at 95ºC for 1 hr and allowed to cool to room temperature. The supernatant was filtered and then diluted to 50 ml using distilled water. Pb, Cd, Cr and Ni were analyzed in the soil and water samples using ICP-OES (Perkin Elmer, Optima 2100 DV). The calibration standards were prepared using stock solutions of 100ppm (Perkin Elmer multi-element). For the multi-element calibration, 2% nitric acid (HNO_3) was used as blank.

RESULTS AND DISCUSSION

The average metal concentration showed a diverse variation with respect to the distance. Based on the mean value of the heavy metals in both water and soil followed the order of Pb>Ni>Cr>Cd. According to WHO the permissible limit of lead in water is 0.05mgl^{-1}. The level of Pb concentration in water samples ranged between 0.001 mgl^{-1} to 0.07mgl^{-1} . It was lowest in control site G3 and highest in affected site D1 (Fig. 4). It was below detection level in control sites A4, B4 and D4. The analyzed soil samples observed across all directions revealed that Pb concentration ranged from 1.11-154.43 mg/kg (Table 1). Higher concentration of Pb was observed almost among all the sites at 10 m distance from the brick kiln chimney and was maximum in site S17 i,e. 154.43 mg/kg (Table 1) which is more than the maximum permissible limit i,e. 85 mg/kg in unpolluted soil (WHO,1996). It may be due to burning of coal and tyres during baking of bricks, while at 200m distance i,e site S12 it was low, indicating the fact that there is decrease in soil contamination along with the increase in distance from the kiln chimney which is similar to the observations of Achakzai *et al.,*(2015). Nickel has been considered to be an essential trace element for human and animal health (Hassan *et al.,* 2012). In the present study in water samples the Ni concentration ranged between 0.003 in control sites G3 and F4 to 0.05 mgl^{-1} in affected site A1(Fig. 3) which is more than the maximum permissible limit given by BIS (2012) i,e. 0.02 mgl^{-1}. The concentration of Nickel in soil was found in the range of 7.9mg/kg to 105.45 mg/kg (Table.1). The acceptable limit of Ni is 35 mg/kg and maximum permissible limit is 210 mg/kg recommended by WHO (1996). The highest concentration of Ni was found in site S5 i,e.105.45mg/kg which is more than the acceptable value and lowest concentration in site S24 i,e. 7.9mg/kg. Cr concentration in water samples ranged between 0.002 mgl^{-1} in control site F4 and 0.04 mgl^{-1} in affected site A1 (Fig.2) which is within the permissible limit i,e. 0.05 mgl^{-1} as per BIS and WHO guidelines. The concentration of Chromium in soil samples ranged from 4.64-92.53 mg/kg (Table.1). Highest concentration was reported in site S5 i,e. 92.53 mg/kg at 10m distance from the brick kiln which was found to be more than the acceptable value when compared to WHO standards. This was also observed by Iqbal *et al*., (2011) and lowest concentration of Cr was observed in site S8 i,e. 4.64 mg/kg at 200m distance from the brick kiln chimney (Table 1). The results revealed that there is decrease in metal accumulation as the distance from kiln chimney increased. Similar results were reported by Achakzai *et al.,*(2015) and Ismail *et al.,*(2012) where they also noticed variations of Cr concentration with distance from brick kilns. Cd concentrations in water ranged between 0.0001-0.02 mgl^{-1} (Fig.1) which is more than the maximum permissible limit i.e. 0.005 mgl^{-1} according to WHO. The Cd concentration in soil samples ranged from 0.014mg/kg in site S12 to 8.48mg/kg in site S13 which is at 200m distance from brick kiln chimney (Table.1). The highest concentration of Cd in site S13 may be due to the fallout of heavy load of dust from the brick kiln chimneys that contaminate the soil at 10m distance. Similar observations were also made by Ismail *et al*., (2012) where they found heavy metals in the dust samples showing that Cd and Cr are added into environment from brick kiln chimney.

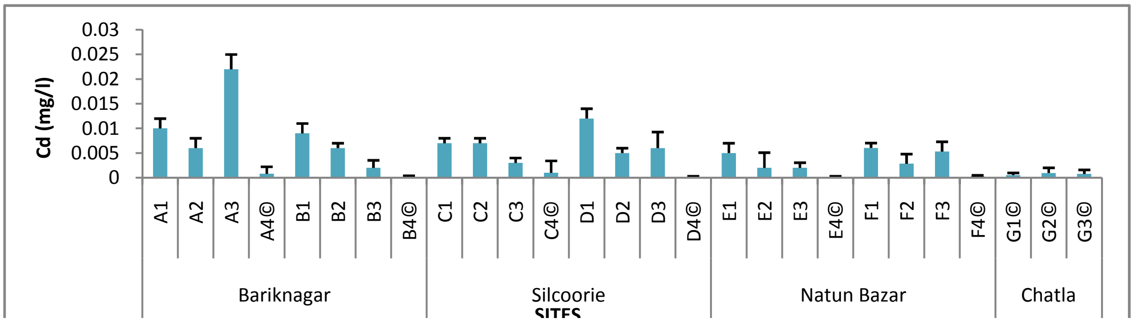

Figure 1 Cd concentration in water samples at 27 sites during 2015-2016

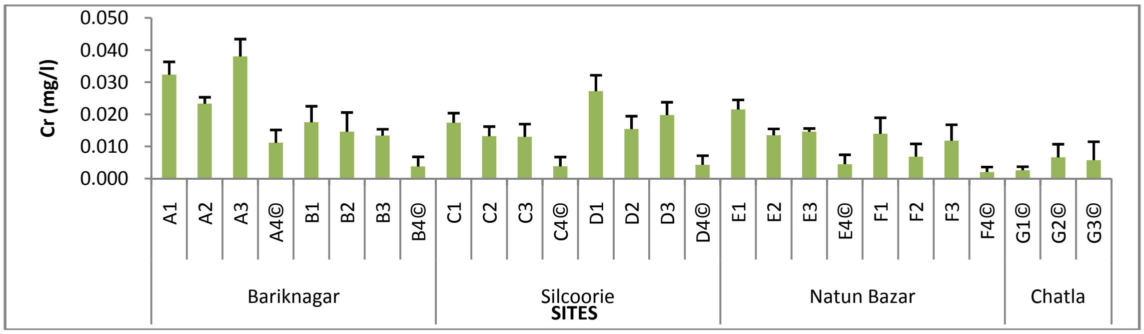

Figure 2 Cr concentration in water samples at 27 sites during 2015-2016

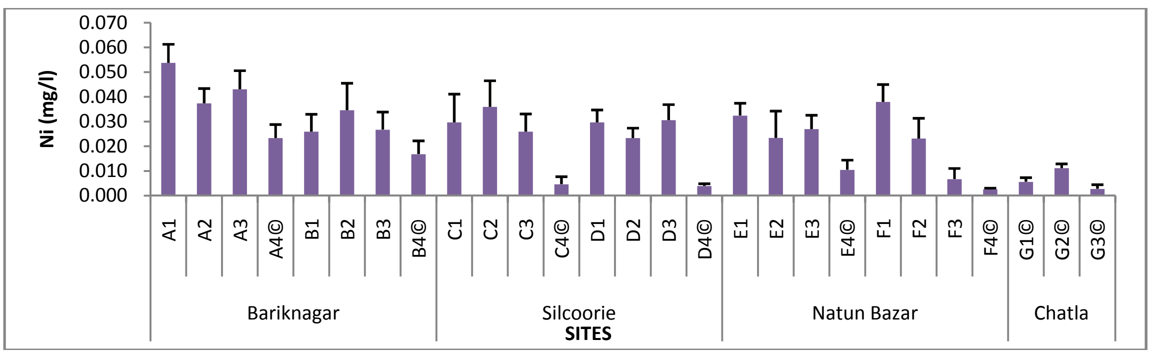

Figure 3 Ni concentration in water samples at 27 sites during 2015-2016

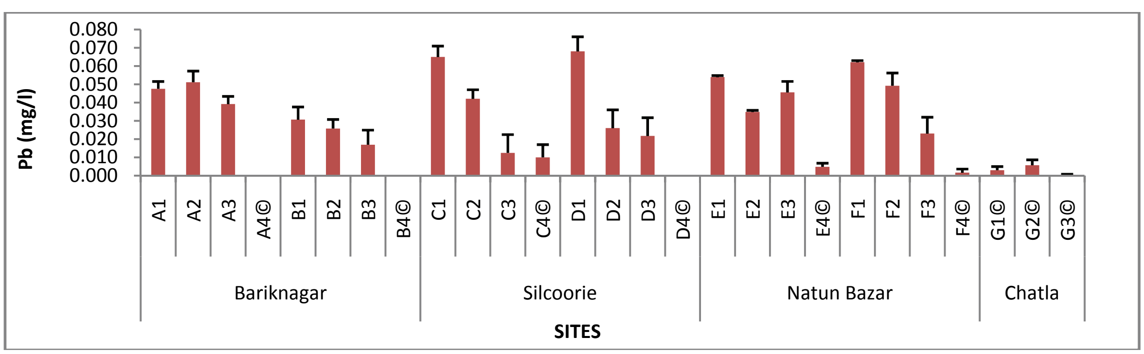

Figure 4 Pb concentration in water samples at 27 sites during 2015-2016

Table 1 Heavy metal concentration in soil samples during 2015-2016

DISTANCE	SITES	Pb	Cd	Cr	Ni
10m	S1	72.94±17.9 (53.5-96.9)	3.32±2.6 1.09-6.5	31.61±8.6 (24.8-43)	29.53±3.1 (27.06-33.3)
	S5	55.4±8.8 (44.5-59.19)	3.19±1.8 (1.4-5)	92.53±21.3 (74-123.05)	105.45±20.6 (83-126.55)
	S9	94.75±21.8 77-125.7	6.03±2.2 (3-8)	45.62±8.2 (34.5-54.35)	43.37±16.1 (29.35-64.6)
	S13	75.65±18.3 (522-95.6)	8.48±2.2 (5.5-10.9)	62.18±8.03 (53-70.5)	76.15±19.7 (57.8-98.68)
	S17	154.43±16.5 (137.63-170.5)	2.8±1.1 (1.6-4)	27.59±16.1 (9.5-44.7)	34.67±5.9 (26.5-39.4)
	S21	117.22±26.3 (84.5-148.06)	8.28±0.9 (7-9.2)	23.31±8.6 (15.5-34.4)	41.18±11.8 (28.4-56.7)
50m	S2	49.02±13.2 (32.5-64.16)	1.1±0.6 (0.4-1.8)	14.14±11.9 (3.5-27.06)	22.95±4.3 (17.8-28.25)
	S6	46.52±19.7 (24.5-68.59)	0.74±0.3 (0.3-1.23)	58.36±26.2 (34.5-93.6)	59.49±25.3 (37.28-93.75)
	S10	50.67±11.3 (37.5-65.05)	3.75±1.2 (2.5-5.5)	24.35±13.8 (10-39.15)	26.93±7.08 (16.9-322.6)
	S14	51.35±7.8 (44.8-62.5)	5.3±1.5 (4-7.5)	37.78±14.8 (24-52.1)	54.19±26.5 (37.1-93.2)
	S18	79.23±18.08 (59-102)	2.28±1.2 (1.29-4)	14.95±14.5 (5.5-36.57)	23.21±9.01 (11.26-32.85)
	S22	77.05±12.9 (61.5-89.5)	2.27±1.8 (0.5-4.84)	10.83±10.1 (4.5-26.01)	38.39±13.5 (21.15-51.5)
100m	S3	35.86±6.7 (27-42.7)	1.19±0.7 (0.4-2.1)	14.12±3.3 (10.15-18.74)	13.08±4.2 (7.6-15.9)
	S7	36.64±21.3 (16-63.8)	0.96±0.6 (0.3-1.4)	23.39±11.5 (14-39.07)	39.65±16.1 (17.52-53.91)
	S11	33.67±6.6 (29-43.16)	2.73±1.2 (1.9-4.5)	33.6±8.2 (27.4-45.3)	20.86±4.7 (16.25-27.38)
	S15	32.72±4.2 (27.6-37.5)	4.05±1.6 (2.5-5.9)	32.79±12.3 (21.5-47.08)	33.9±6.8 (27.49-34.35)
	S19	48.90±9.4 (36.2-58.9)	1.52±1.04 (0.6-3)	9.13±8.5 (4-21.81)	15.67±9.5 (5.96-28.22)
	S23	49.53±13.02 (37-65.9)	0.71±0.5 (0.3-1.5)	78.47±4.5 (2.5-13.27)	19.18±6.3 (9.98-24.31)
200m	S4	12.42±6.5 (3-17.66)	0.59±0.3 (0.5-0.21)	4.99±4.8 (1-11.7)	9.19±5.6 (5.12-17.4)
	S8	2.8±2.6 (nd-5.5)	0.49±0.7 (nd-1.5)	4.64±5.2 (0.5-1.8)	28.31±12.2 (10.62-37.81)
	S12	1.11±0.9 (nd-1.9)	0.014±0.02 (0-0.036)	8.16±2.7 (5.1-11.73)	14.9±3.1 (11.85-18.85)
	S16	2.19±1.3 (0.14-3.15)	0.46±0.3 (0.14-1)	19.6±8.8 (12-31.51)	25.72±4.9 (21.3-32.7)
	S20	25.20±4.4 (21.5-31.5)	0.4±0.7 (nd-1.5)	8.96±2.3 (5.5-10.37)	8.47±3.4 (5.4-13.26)
	S24	5.9±4.3 (0.94-10.5)	0.15±0.16 (0.02-0.4)	4.66±2.7 (1.6-7.8)	7.9±2.4 (5.18-11.05)

CONCLUSION

It can be concluded after the analysis of soil and water samples taken from different distances from brick kilns that the soil and water quality is degrading due to increase in heavy metal content. It has been observed that the heavy metal accumulation in the water samples from Chatla sites (approx. 500m distance from the brick kilns) is lower in comparison to the affected sites. It can be inferred from the results of the present study that the area surrounding the brick kilns are significantly contaminated with toxic metals like Pb, Cd, Cr and Ni. High amount of these metals in soil and water bodies may give rise to various health hazards and affect the biodiversity. The high concentration of heavy metals in the sites near the brick kiln chimney indicate that the soil contamination occurs due to heavy metals which decreased with the increasing distance from the chimneys. Highest concentration of Pb in both soil and water samples is probably due to the impact of coal burning in the brick kiln chimneys. The increase in heavy metal concentrations nearer to the brick kilns clearly reveal the fact soil quality degrades, productivity and soil health is affected (Rahman *et al*., 2012). The fertile agricultural land is used for manufacturing of clay brick per kiln resulting in land degradation, degradation of herb density, soil micro flora and fauna also micro-nutrient disorder in plants and trees in the immediate vicinity (Pawar *et al.,* 2011), Therefore, it is recommended to follow several conservation strategies to sustain the land and protect from degradation and loss. Periodic survey for monitoring of brick kilns are required to know whether they are following the EIA guidelines or not. Also as seen in the present study distance is an important factor which indicates the impact of brick kilns, therefore residential areas, schools, and roads should be at least 500m away from the brick kiln chimneys. Proper and periodic plantation is required and 200m distance is suitable for vegetation so we can minimize the soil degradation and environmental pollution from the brick kiln chimneys by planting trees and with proper mitigation strategies.

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Hydrochemical and Water Quality Assessment of Groundwater in the Coastal Area of Kollam District, Kerala

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ABSTRACT

The coastal groundwater is generally under constant threat of both quality and quantity deterioration due to rapid urbanization, industrialization, modernization of agriculture and various anthropogenic activities. In this study, the coastal district, Kollam in southern Kerala is selected for detailed water quality assessment. Groundwater samples were collected during summer along the coastal stretch of the district. The samples were analyzed for physico-chemical parameters *in situ* and for major and minor ion compositions. As per the BIS drinking water quality standards, majority of the samples were found to be within the limits with an exception of iron and TDS. The major hydrochemical facies obtained from Piper classification was Ca-Na-HCO_3-Cl. In Gibbs plot, majority of the samples were in the rock-water interaction dominance field. Drinking water quality was assessed by the Canadian Council of Ministers of the Environment - Water Quality Index (CCME-WQI) and was found that most of the groundwater samples fall under the 'fair to poor' category. The poor drinking water quality of the groundwater in the study area was mainly caused by low dissolved oxygen concentration. The samples were assessed for irrigational water quality also. Ionic ratios like Sodium Adsorption Ratio (SAR), Kelly's Ratio (KR), Residual Sodium Carbonate (RSC) Index and Magnesium Hazard (MH) were found to be in the range of 0.42 – 5.85, 0.17 – 8.44, -1.62 – 1.92, 1.66 – 66.7 respectively. 95% of the water samples of the study area were found to be 'good' for irrigation.

Keywords: Coastal groundwater, water quality parameters, CCMEWQI, Irrigation water quality, Kollam.

INTRODUCTION

Water is an essential natural resource for sustaining life and environment. Among the various sources of water, groundwater is naturally occurring renewable resource and is the major source of water available on earth. It is well known that 20% of fresh water present on the earth surface is in the form of groundwater (Jat, 2009). It becomes a useable source when the water bearing formations are permeable to yield adequate quantity of good quality of water. Unlike any other mineral resources, it gets its annual replenishment from meteoric precipitation. But of late, these pristine hidden resources are progressively getting depleted and contaminated by natural as well as anthropogenic activities such as municipality sewages, industrial effluents, agricultural field run off (Jat, 2009).

Assessment of water quality is very important for knowing its suitability for various purposes like drinking, irrigation and industrial activities. The most extensive use of groundwater in the world is for irrigation. The present irrigated area in India is 60 million hectors of which 40% is irrigated with groundwater (Jat, 2009). In Kerala, 65% of the population mainly depends on groundwater for their essential needs. One of the problems faced by the coastal aquifers in Kerala is sea water intrusion due to large withdrawal of groundwater (Laluraj et al. 2005; Krishna Kumar et al. 2014; Santhosh Kumar et al. 2014).

MATERIALS AND METHODS

Study area

Quilon or Kollam, an old sea port town on the Arabian Sea coast, located on the southern part of Kerala State and extends from Lakshadweep Sea to the Western Ghats and is bordered by Thiruvananthapuram district on the South and Alapuzha and Pathanamthitta districts in the North and Thirunelveli district of Tamil Nadu State in the East and Lakshadweep sea in the West. The study area lies between latitudes 8° 52'23.8" to 9°7' 37.5" N and longitudes 76°28'14" to 76°36'30.4" E and with a coastal length of 37km.. The sampling locations and drainage map of Kollam coastal region are shown in Fig.1. The district is enriched with three west flowing rivers viz Achenkovil, Ithikkara and Kallada originating in the eastern hilly region. The district receives an annual average rainfall of about 2428 mm. The major soil types in this area are laterite, coastal riverine alluvium, grayish onattukara etc. Onattukara is an acidic, low nutrient, low water retention capacity, fluvial and marine sandy soil present along Kollam Coast. Groundwater samples were collected from 17 dug wells and 3 tube wells from the coastal area of Kollam District during pre-monsoon season of the year 2014. The samples were collected in the two liters of polyethene bottles, which were pre cleaned with distilled water. The samples were analyzed for pH, Dissolved Oxygen (DO), salinity and Electrical Conductivity (EC) *in situ* using water quality analyser and the composition of major and minor ions using the standard procedures recommended by APHA (2005).

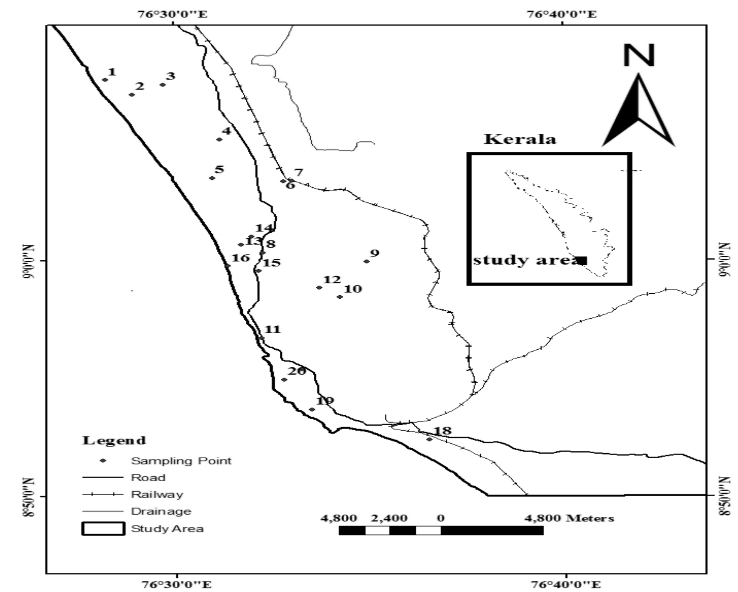

Figure 1 Location of water quality monitoring station in Kollam Coast

Water Quality Index (WQI)

CCME - WQI provides a convenient means of summarizing complex water quality data and facilitating its communication to a general audience and is well documented (CCME 2001). The CCME - WQI is an objective based index that compares measured water quality values to guidelines to produce a score ranging from 0, representing worst water quality, to 100, representing best quality. The index scores are calculated as follows

$$\text{CCME QII} = 100 - \sqrt{(F1^2 + + F2^2 + F3^2)} / 1.732 \qquad \text{.....(1)}$$

where, F1 (Scope) represents the percentage of the selected variables that do not meet their respective guidelines at least once during the time period considered, F2 (Frequency) represents the percentage of individual sample's measurements that do not meet their respective guidelines in the time period considered, and F3 (Amplitude) represents the amount by which failed measurements do not meet their respective guidelines, calculated in three steps and scaled to a value between 0 and 100.

The CCME - WQI is ranked by relating it to one of the following categories:

Excellent: 95-100, Good: 80-94, Fair: 65-79, Marginal: 45-64 and Poor: 0- 44.

RESULTS AND DISCUSSIONS

Drinking water Quality

The results of groundwater quality analyses are given in Table 1. The parameters were found to be in the following range:

Cations: Ca (1.6 -78.4 mg/l), Mg (0.48 – 13.44 mg/l), Na (7.1 – 76 mg/l)

Anions: Cl (3.6 -105.3 mg/l), HCO_3 (14 – 301 mg/l).

In this study, lowest pH value (4.5) was observed at Chavara (W15) and the highest value (7.5) at Ayiramthengu (W2) and Maruthadi (W20). Most of the samples were having pH of the range 6 to 7.3. The measured EC values ranged between 77.7 - 829 µS/cm, with the highest value being 829 µS/cm at Panmana (W8).

Groundwater quality data was compared with drinking water standards of BIS and found that most of the groundwater samples were within the limit except a few wells (W2, W6, W8, W19 & W20) having high Total Alkalnity, TDS, Ca, NO_3 and Fe.

Table 1 Hydrochemical data of groundwater samples of Kollam coast during pre monsoon season (all values are expressed in mg/l , pH in pH unit and EC in µS/cm. BDL = Below Detectable Limit)

Constituents/Characteristics	**Minimum**	**Maximum**	**Average**	**BIS Limit**
Dissolved Oxygen (DO)	1.65	6.8	3.5	5.0
pH	4.49	7.75	6.6	6.5-8.5
Total dissolved salts	77.70	829.00	432	500
Total Alkalinity (TA)	11.76	246.96	107.4	200
Total Hardness (TH)	4.0	218.00	105	200
Chloride (Cl)	3.57	105.25	32.9	250
Iron (Fe)	0.02	1.32	0.2	0.3
Fluoride (F)	0.1	0.96	0	1.0
Sulphate (SO_4)	1.4	79.88	27	200
Phosphate (PO_4-P)	BDL	0.74	0.08	…..
Nitrate (NO_3)	BDL	8.45	2.6	45.0
Sodium (Na)	7.1	76.00	32.0	….
Potassium(K)	0.80	14.8	5.4	…..
Calcium(Ca)	1.6	78.4	38	75
Magnesium (Mg)	0.48	13.44	3.1	30

Correlation analysis

The degree of linearity between the dissolved ions is established through correlation analysis. The result of the statistical analysis is shown in Table 2. Some of the ions in the groundwater samples show significant correlation (α = 95%) between Na and Cl, Na and SO_4, HCO_3 and Mg, HCO_3 and Ca, and HCO_3 and F. Ca and Mg showed moderately strong correlation with each other (r = 0.49).

Table 2 Correlation matrix of the water quality parameters of the study area

	pH	**EC**	**HCO_3**	**Cl**	**SO_4**	**Na**	**K**	**Ca**	**Mg**	**F**	**NO_3**	**PO_4-P**	**Fe**
pH	1												
EC	0.27	1											
HCO_3	0.65	0.60	1										
Cl	-0.10	0.70	0.01	1									
SO4	-0.20	0.56	-0.16	0.56	1								
Na	-0.08	0.54	-0.02	0.82	0.49	1							
K	0.04	0.35	0.03	0.22	0.37	0.06	1						
Ca	0.45	0.82	0.80	0.31	0.35	0.10	0.21	1					
Mg	0.39	0.47	0.70	0.11	-0.20	0.07	-0.04	0.49	1.00				
F	0.51	0.25	0.68	-0.26	-0.37	-0.14	-0.07	0.31	0.52	1.00			
NO_3	-0.45	-0.11	-0.36	0.16	-0.01	0.09	-0.08	-0.16	-0.21	-0.23	1.00		
PO_4-P	-0.13	-0.11	-0.13	-0.29	0.14	-0.21	0.07	-0.05	-0.16	-0.05	-0.23	1.00	
Fe	0.12	-0.05	-0.05	0.01	0.03	*0.43*	-0.12	-0.27	-0.02	0.36	-0.15	-0.03	1

Major Hydrochemical facies

In the present study, various cation and anion compositions of surveyed samples were represented in the Piper trilinear diagram. This diagram permits the cation and anion compositions of many samples to represent in a single plot, in which, major groupings or trends in the data can be distinguished visually. Because each analysis is represented by a single point, water with very different total concentrations of ions can have identical representations on this diagram. The Piper plot of cations and anions of 20 analyzed samples is given in figure 2. It can be observed that the data points mostly fall in the mixed Ca-Na- HCO_3-Cl water type.

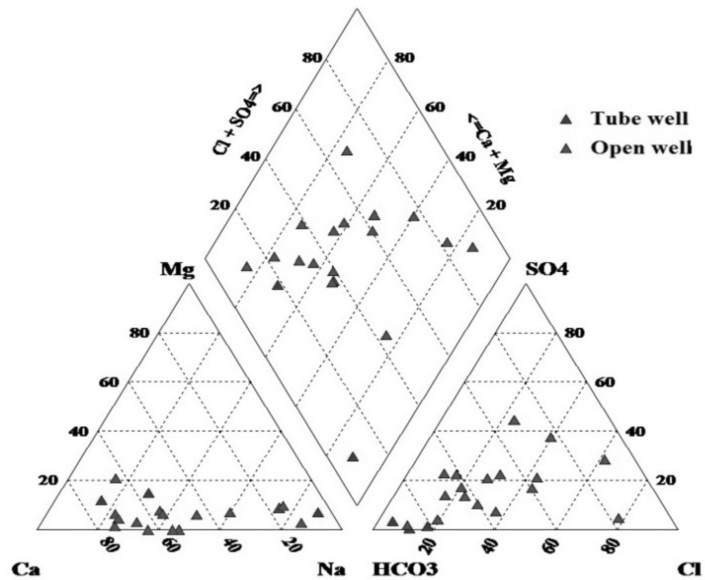

Figure 2 Piper diagram

Gibb's plot

Gibb's plot is mainly used to establish the relationship between groundwater chemistry and aquifer lithology (Gibbs, 1970). Three distinct fields are described on it, mainly precipitation dominance, rock water interaction dominance and evaporation dominance. It is a useful tool to find out the genesis of groundwater. Gibbs ratio is mainly calculated by the equation given below

Gibbs ratio for Cation is (Na+K) /(Na + K +Ca) **…………………(2)**

The Gibb's plot for cations (Fig. 3) showed that the samples were mainly no dominant ion type and with low to moderate salinity. Since the ratio of (Na+K)/(Na+K+Ca) is greater than 0.5 some of the samples is also affected by saline water.

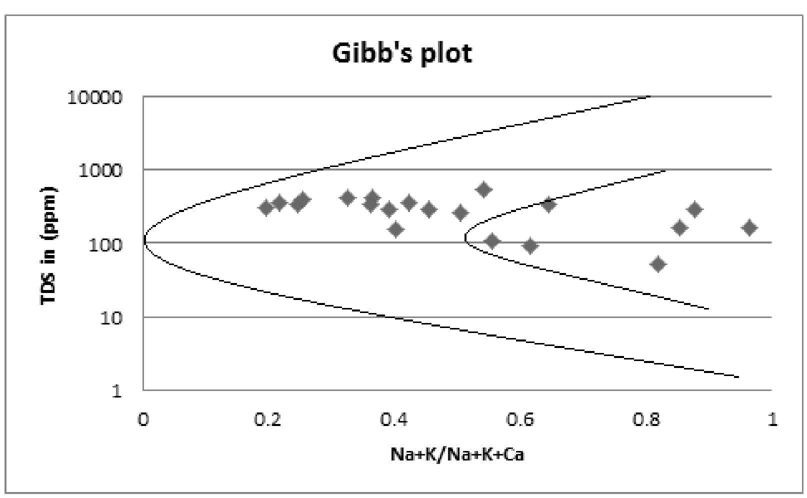

Figure 3 Gibb's plot for Cations

CCME - Water Quality Index

WQI was computed with 11 parameters (pH, EC, TDS, TA, DO, Cl, SO_4, NO_3, F Ca, Mg, and Fe) using the index method developed by CCME. It was found that 45 % of the samples were with in the 'fair' category with an index value of 65 – 79, 45% groundwater samples were with in the 'marginal' category with the index range of 45 – 64 and the rest 10% falls under 'poor' category with the index range of 0 – 44 (Table 3). In order to have a visual apprehension of the groundwater quality of the study area, a spatial map of categorization of samples based on CCME-WQI is attempted and is given in figure 4. The groundwater in the Kallelibhagam (W7) and Thekkumbhagam (W10) have very low DO values making them unfit for drinking.

Table 3 CCME -WQI for groundwater samples

Code	WQI	Remarks	Location
W1	56.2	Marginal	Azhikkal
W2	81	Fair	ayiramthengu
W3	67.9	Fair	Alumpeedika
W4	60.9	Marginal	Thuraikadavu
W5	46.8	Marginal	Marathoorkulangara
W6	60.0	Marginal	Karunagapally
W7	42.3	Poor	Kallelilbhagam
W8	78.7	Fair	Panmana
W9	64.5	Marginal	Koivila
W10	37.4	Poor	Thekkumbhagam
W11	75.0	Fair	Neendakara
W12	45.6	Marginal	Menampalli
W13	47.0	Marginal	Ponmana
W14	48.2	Marginal	Edappallikotta
W15	62.1	Marginal	Chavara
W16	67.3	Fair	Kovithottam
W17	68.4	Fair	Sakthikulangara
W18	69.0	Fair	Amruthakulam
W19	75.9	Fair	Thirumullavaram
W20	79.0	Fair	Maruthadi

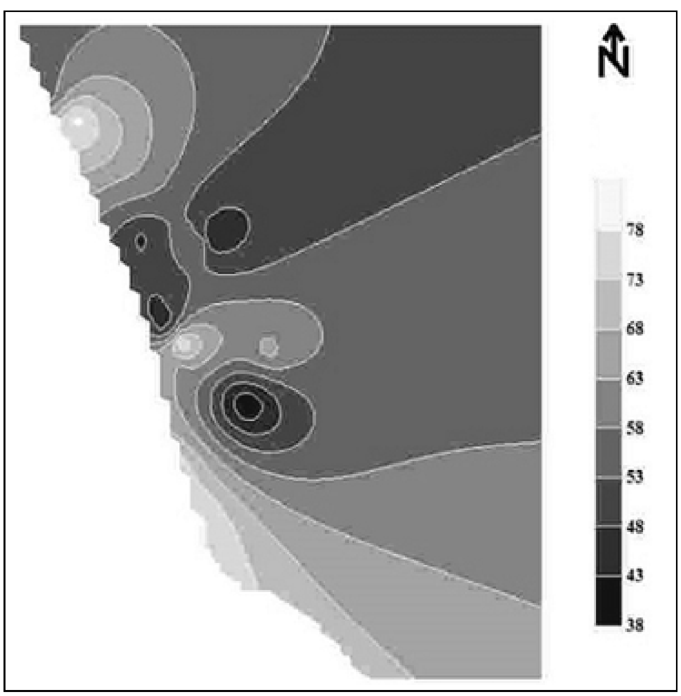

Figure 4 Spatial representation of WQI of the study area

Groundwater quality for irrigation

The most extensive use of groundwater in the world is for the irrigation of crops. Water quality constraints for irrigation are examined by Sodium Adsorption Ratio (SAR), Kelly's Ratio (KR), Magnesium Hazard (MH) and Residual Sodium Carbonate (RSC).

Sodium Adsorption Ratio (SAR): The U.S. Salinity Laboratory (1954) defined the sodium Adsorption Ratio of water as a measure of suitability of water for use in agricultural irrigation, as determined by the concentration of solids dissolved in the water. The formula for S.A.R is

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \qquad \text{……………..} (3)$$

where concentrations of sodium, calcium and magnesium were in meq/l. The higher the SAR, the less suitable the water is for irrigation because it leads to a decrease in infiltration and permeability of the soil to water, leading to problems with crop production. The SAR value <10 is 'Excellent', between 10–18 is 'Good', between 18-26 is 'Doubtful', >26 is 'Unsuitable' for irrigation. In this study, SAR of the samples were in the range of 0.42 – 5.85 and is in the 'excellent' class for irrigation.

Kelly's Ratio (KR): The concentration of Na^+ measured against Ca^{2+} and Mg^{2+} is known as Kelly's ratio, based on which irrigation water can be rated.

$$\text{Kelly's Ratio (KR)} = Na^+/(Ca^{2+} + Mg^{2+}) \qquad \text{……………..} (4)$$

As per the Kelly's ratio, groundwater from the study area are categorized into 'Suitable' if KR is <1, 'Marginal', when KR is 1-2 and 'Unsuitable' if KR is >2. It was found that 75% of groundwater samples of the study area were suitable for irrigation purpose while 10% of the samples were marginally suitable and the rest, 15% of the samples are not suitable.

Residual Sodium Carbonate Index (RSC): Eaton (1950) proposed the concept of RSC for evaluating high carbonate water. The RSC index of irrigation water or soil water is used to indicate the alkalinity hazard for soil. The RSC index is used to find the suitability of the water for irrigation in clay soils which have a high cation exchange capacity. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity.

$$\text{RSC index} = [HCO_3 + CO_3] - [Ca + Mg] \qquad \text{…………………..}(5)$$

As per Eaton's conclusion the RSC Index values are categorized into 'Suitable', if RSC is <1.25, 'Marginal', when RSC is 1.25 – 2.5 and 'Unsuitable', if RSC is >2.5. The RSC value of the groundwater samples varied from -1.62 – 1.92. It was found that 95% of the groundwater samples were under 'Suitable' water quality for irrigation category while 5% were under marginal.

Magnesium Hazard (MH): Magnesium Hazard was proposed by Szaboles and Darab (1965) for irrigation water.

$$MH = \frac{Mg}{Ca + Mg} \times 100 \qquad \text{……………}(6)$$

The MH value >50 is considered as harmful for irrigation activity. In this study MH for groundwater samples varied from 1.6 to 66.7 and revealed that 95% of the groundwater samples were suitable for irrigation. The summary of irrigational water quality indices of the groundwater samples of the study area showed in the Table 4.

Table 4 Summary of water quality indices for irrigation

Irrigation Quality Indices	Number of samples suitable for irrigation	Number of sample not suitable for irrigation	Percentage of sample suitable for irrigation
SAR	20	Nil	100%
KR	16	4(W6,W10,W12,W14)	75%
RSC	19	1(W6)	95%
MH	19	1(W6)	95%

CONCLUSION

The groundwater resources in the Kollam coastal region of Kerala were evaluated for their chemical composition, drinking water quality and suitability for irrigation. Analysis of water samples indicated that most of the groundwater sample in the study area was chemically suitable for drinking and agricultural uses. The drinking water quality assessed with CCME-WQI and found that 90% of the groundwater samples were in the fair to marginal water quality. 10% of the samples were in poor water quality. The major hydrochemical facies of the groundwater was mixed Ca- Na-HCO_3-Cl type. Gibb's plot of cations illustrated that the groundwater were of no dominant ion type with low to moderate salinity. The irrigational water quality indices, SAR, KR, RSC and MH, indicated that the groundwater is 'good' for irrigation.

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Municipal Waste Water Treatment Process: A Case Study

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ABSTRACT

Water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of organisms. Water covers 71% of the Earth's surface. It is vital for all known forms of life. On Earth, 96.5% of the planet's crust water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor (and precipitation. Only 2.5% of this water is fresh water, and 98.8% of that water is in ice. A greater quantity of water is found in the earth's interior. Sewage is a water-carried waste, in solution or suspension that is intended to be removed from a community. Also known as domestic or municipal wastewater of greywater (from sinks, tubs, showers, dishwashers, and clothes washers), black water (the water used to flush toilets, combined with the human waste that it flushes away); soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper). It is more than 99% water, but the remainder contains some ions, suspended solids and harmful bacteria that must be removed before the water is released into the sea. The safe treatment of sewage is thus crucial to the health of any community. Sewage treatment is the process of removing contaminants from wastewater, primarily from household sewage. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of sewage treatment is usually a semi-solid waste or slurry, called sewage sludge that has to undergo further treatment before being suitable for disposal or land application. The present study involves various aspects of Sewage collection, Sewage treatment and disposal, Low cost sanitation and Electric crematoria etc. at river Musi as well as quality improvement of water environment

Keywords: *Water, Sewage Treatment, Environment, Disposal and Treatment.*

INTRODUCTION

Hydrological Cycle

The movement of water on the earth's surface and through the atmosphere is known as the hydrologic cycle. Water is taken up by the atmosphere from the earth's surface in vapour form through evaporation. It may then be moved from place to place by the wind until it is condensed back to its liquid phase to form clouds. Water then returns to the surface of the earth in the form of either liquid (rain) or solid (snow, sleet, etc.) precipitation. It moves from one reservoir to another by processes like: evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, and groundwater

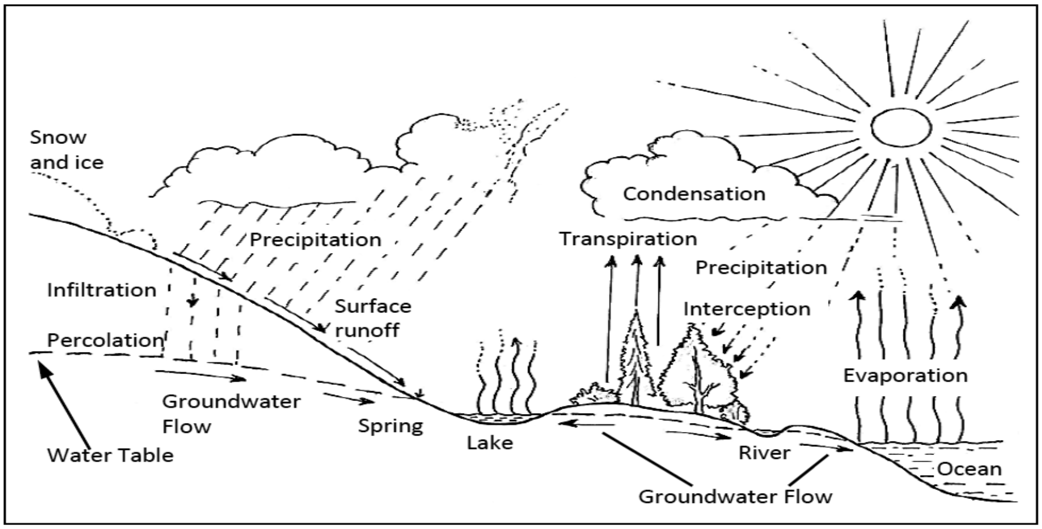

Figure 1 Hydrological Cycle

Water and its Classification:

Water is classified majorly as two types they are:

1. Surface water
2. Underground water

Surface Water:

Surface water is water on the surface of the planet such as in a river, lake, wetland, or ocean. It can be contrasted with groundwater and atmospheric water.

Non-saline surface water is replenished by precipitation and by recruitment from ground-water. It is lost through evaporation, seepage into the ground where it becomes ground-water, used by plants for transpiration, extracted by mankind for agriculture, living, industry etc. or discharged to the sea where it becomes saline.

Ground Water:

Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps, and can form oases or wetlands.

Waste Water & its Source:

Waste water is any water that has been adversely affected in quality by anthropogenic influence. Wastewater can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm water, and from sewer inflow or infiltration.

Municipal wastewater (also called sewage) is usually conveyed in a combined sewer or sanitary sewer, and treated at a wastewater treatment plant. Treated wastewater is discharged into receiving water via an effluent pipe. Wastewaters generated in areas without access to centralized sewer systems rely on on-site wastewater systems. These typically comprise a septic tank, drain field, and optionally an on-site treatment unit. The management of wastewater belongs to the overarching term sanitation, just like the management of human excreta, solid waste and storm water (drainage).

Sewage is a type of wastewater that comprises domestic wastewater and is therefore contaminated with feces or urine from people's toilets, but the term sewage is also used to mean any type of wastewater. Sewerage is the physical infrastructure, including pipes, pumps, and screens, channels etc. used to convey sewage from its origin to the point of eventual treatment or disposal.

Source:

Wastewater can come from:

- Human excreta (feces and urine) often mixed with used toilet paper or wipes; this is known as backwater if it is collected with flush toilets
- Washing water (personal, clothes, floors, dishes, cars, etc.), also known as grey water or silage
- Surplus manufactured liquids from domestic sources and industries
- Urban rainfall runoff from roads, car parks, roofs, and sidewalks/pavements (contains oils, animal feces, litter, gasoline/petrol, diesel or rubber residues from tires, soaps cum, metals from vehicle exhausts, etc.)
- Highway drainage (oil, de-icing agents, rubber residues, particularly from tires)

Objective of Study:

The aim of the study is the prevention of pollution of river Musi as well as improvement of environment of the city through various aspects:

- Sewage collection
- Sewage treatment and disposal
- Low cost sanitation
- Electric crematoria etc.

Main components of sewage collection, treatment and disposal are:

- Interception and diversion works
- Conveying mains
- Sewage treatment plants and disposal
- Groundwater infiltrated into sewage after it has undergone some treatment, the "treated wastewater" remains,

  e.g.:

  - Septic tank discharge
  - Sewage treatment plant discharge

DESCRIPTION OF STUDY AREA

Area & location of Uppal plant:

Location	:	Nallacheruvu, Uppal, Hyderabad.
Built up Area	:	18.00 Acres
Capacity	:	30 Million Liters' per Day.
Process	:	UASB Reactors followed by Facultative Aerated Lagoons and Post Chlorination System
Catchment	:	Uppal, Ramanthapur, Hubsiguda, Nacharam
No. of Aerators	:	12 Nos. of 20HP
Aeration Lagoon Size	:	117*70*3.5 LD
Polishing Pond Size	:	137x77.5x1.5 LD
Power Requirement	:	6238 KWh/day
Biogas Production	:	512.00 cum / day
Sludge Production	:	6 Tons / Day

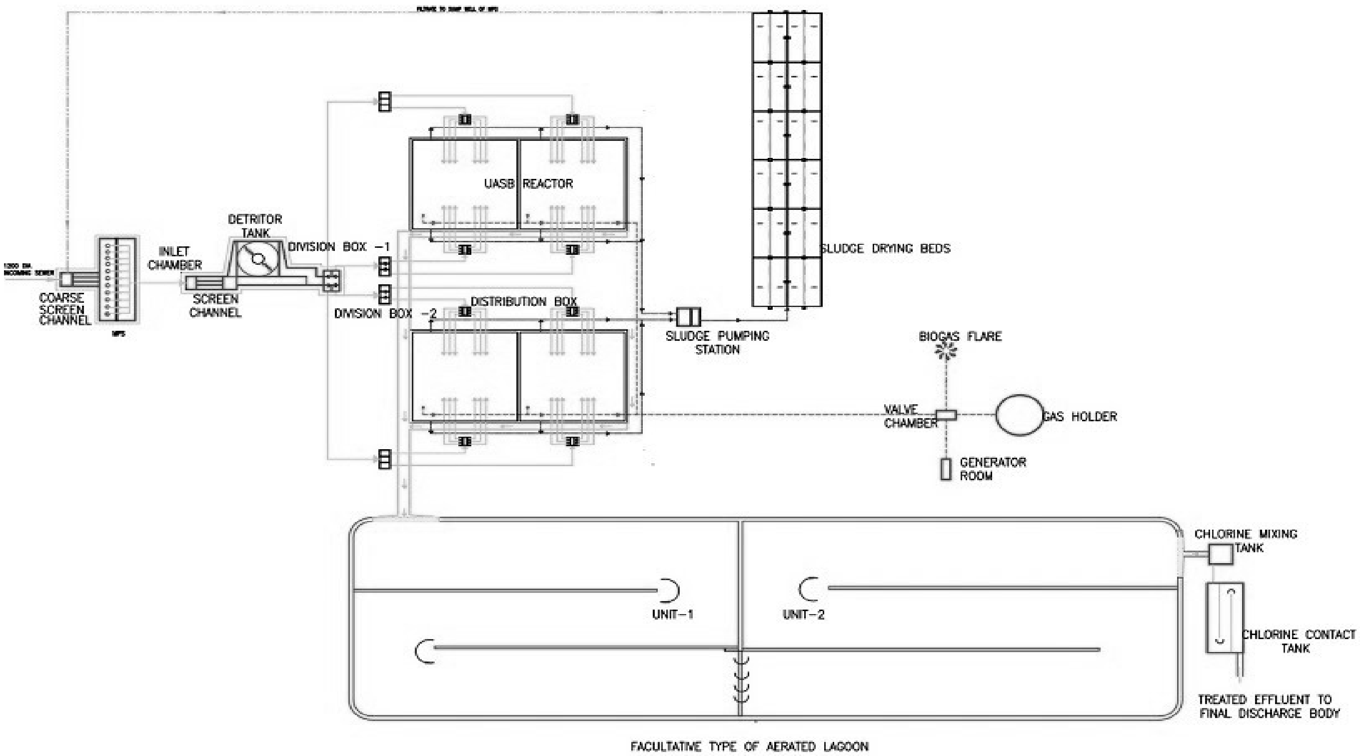

Figure 2 Flow diagram of sewage treatment plant:

Process of sewage treatment at plant

Waste water treatment consists of applying known technology to improve or upgrade the quality of waste water. Usually wastewater treatment will involve collecting the waste water in a central, segregated location (the waste water treatment plant) and subjecting the waste water to various treatment processes. While most wastewater treatment processes are continuous flow, certain operations, such as vacuum filtration, involving as it does, storage of sludge, are routinely handled as periodic batch operations.

Wastewater treatment, however, can also be organized or categorized by the nature of the treatment process and operation being used: for example physical chemical or biological.

Treatment process at nallacheruvu:

Total of 30MLD sewage flow will be treated in the STP proposed at Nallacheruvu. A main pumping station is proposed at the sewage treatment plant site. A single rising main from delivers the sewage into the inlet chambers. The treatment waste water after UASB reactors is further treated in the facultative type of aerated lagoons, chlorine mixing tank and the chlorine contact tank.

The treatment units at the Nallacheruvu STP will consists of the following treatment units:

1. Inlet chamber
2. Coarse screen channel
3. Main Pumping Station
4. Main rising Dia
5. Inlet chamber
6. Detritor tank

7. Distribution box
8. UASB reactor
9. Sludge pumping station
10. Sludge drying beds
11. Gas holder
12. Facultative Aerated Lagoon-1
13. Facultative Aerated Lagoon-2
14. Chlorine House
15. Chlorine Mixing Tank
16. Chlorine Contact Tank

Design criteria for MPS:

Design flow	=	30000cum/day
Hydraulic retention	=	5minutes
Invert level of incoming sewer	=	466.00m
Ground level at MPS	=	470.50m
Floor level of inlet sump	=	465.50m
Floor level of screen channel	=	465.70mPump efficiency at MPS
Hydraulic retention time at MPS	=	5Min
Capacity of sump required	=	234.38cum
Depth of sump provided	=	3.0m
Area of sump required	=	volume/depth
	=	234.38/3.0
	=	78.13sq.m
Required length of sump	=	22.0m
Width of sump	=	area/length
	=	2.55m
Max water level in sump	=	465.40m
Min water level in sump	=	462.40m
Top level of sump	=	471.50m
Dead water zone for pump	=	1.20m

Figure 3 Various unit operations of sewage treatment plant

RESULTS

Characterization and Analysis of Waste Water

Composite samples of dry weather flows from all the drains contributing to Uppal STP have been collected and analyzed.

Table 1 The design raw water characteristics at Nallacheruvu, Uppal:

Sl. No	Parameters	Value
1	Average flow	30MLD
2	Peak factor	2.25
3	BOD	280Mg/l
4	COD	600Mg/l
5	Total suspended solids (TSS)	480Mg/l
6	Sulphide	1.00Mg/l
7	Fecal coliform	3x10^5 Mpn/100ml

Table 2 Disposal standards:

SL NO	PARAMETERS	VALUE
1	BOD	<30Mg/l
2	TSS	<50Mg/l
3	COD	<250Mg/l
4	Sulphide	<2Mg/l
5	Fecal coli form	<10000 MPN/100Ml

Table 3 Analysis of waste water:

Parameter	Influent	Effluent	Limits
pH	7.2-7.4	7.8-8.5	9.0
Dissolved oxygen	0.12-0.30mg/lit	4-4.20mg/lit	>4mg/lit
Total suspended solids	450-500mg/lit	30-40mg/lit	<50mg/lit
COD	550-600mg/lit	120-150mg/lit	<250mg/lit
BOD	240-280mg/lit	14-20mg/lit	<30mg/lit

CONCLUSIONS

Waste water treatment consists of applying known technology to improve or upgrade the quality of waste water. Usually waste water treatment will involve collecting the waste water in a central segregated location and subjecting the waste water to various treatment processes. Most often, since large volumes of waste water are involved, treatment processes are carried out on continuously flowing wastewater rather than as batch or a series of periodic treatment processes while most waste water treatment processes are continuous flow certain operations such as storage of sludge the addition of chemicals, filtration and removal or disposal of the treated sludge, are usually handled as periodic batch operations.

The objective of sewage (wastewater) treatment is to produce a disposal effluent without causing harm to the surrounding environment and prevent pollution.

1. The contaminants under turbidity are removed.
2. The palatable water is obtained which can be used for all industrial and commercial use except for domestic use.
3. Disinfection or destruction of pathogenic bacteria.
4. Prevention of treated water from decomposition.

5. Waste water treatment removes as much of the suspended solids as for as possible before the remaining water, called effluent, is discharged back to the environment.
6. Sludge produced during the wastewater treatment process can be used as a pesticide in the agricultural fields.

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Physico-Chemical Studies on Fox Sagar Lake, Jeedimetla, Hyderabad.

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ABSTRACT

The present study deals with the physico-chemical studies on Fox Sagar Lake. Fox Sagar Lake, also Jeedimetla Cheruvu or Kotta Cheruvu, is the fifth largest lake, spread over 2 km^2, in Hyderabad, India. It is located in Jeedimetla near Kompally, Hyderabad. It is home to flamingos, yellow-billed storks, ospreys, great cormorants, kingfishers, baya weavers, garganeys, among others. The lake is polluted by emissions from an adjoining industrial estate, killing fish and migratory birds. The lake is popular for fishing and a popular spot for picnics. On the basis of physico-chemical parameters the water was alkaline in Fox Sagar lake. Carbonates and dissolved oxygen were recorded in low concentration. Organic matter, COD, phosphates and nitrates were recorded in high concentration. This clearly indicates that the lake is eutrophic.

Keywords: Fox Sagar Lake, Physico-chemical parameters and Eutrophication.

INTRODUCTION

Physico-chemical environment plays a vital role in influencing the quality of water bodies besides topographical, geological and other environmental factors. In lentic waters physical and chemical parameters keep fluctuating by the cycling of water through evaporation and its subsequent return in rain. (Pagriya, 2012). These changes in addition to the anthropogenic activities affect also the biological environment. Eutrophication can produce problems such as bad tastes and odours as well as green scum algae (Premlatha Vikal, 2008). Also, the growth of rooted plants increases, which decreases the amount of oxygen in the deepest waters of the lake. It also leads to the death of all forms of life in the water bodies (Mustapha, 2003).

A lake's structure has a significant impact on its biological, chemical, and physical features. Lakes can be classified on the basis of a variety of features, including their formation and their chemical or biological condition, as oligotrophic and eutrophic. The main objective of physico-chemical analysis of water is to determine the nutrient status of the medium. Since the water contains dissolved and suspended constituents in varying proportions it has different physical and chemical properties along with biological variation (Sahni and Yadav, 2012). The quality of water may be affected in various ways by pollution. Anions like carbonates, bicarbonates, sulphates, chlorides and cations such as sodium, potassium, calcium, magnesium contribute to the total salinity of water and act as buffer systems in preserving the natural alkaline nature of the fresh waters.

MATERIAL AND METHODS

Fox Sagar Lake, also Jeedimetla Cheruvu or Kotta Cheruvu, is the fifth largest lake, spread over 2 km^2, in Hyderabad, India. It is located in Jeedimetla near Kompally, Hyderabad. It Coordinates 17.524°N, 78.470°E. The lake is popular for fishing and a popular spot for picnics. The Nizam constructed a dam on the lake naming it Fox Sagar in 1897, as part 31 lakes created for improving water sources for the city of Hyderabad. A pump house was built on the bund, constructed in a typical Nizam architecture.

The water samples from the surface were collected from the three sampling stations every month in polythene cans for a period of 2 years from June 2014 to May 2016. Water samples were collected in separate 250 ml glass bottles (BOD bottles) for the estimation of dissolved oxygen. All the samples were carried to the laboratory. The samples were analyzed on the same day for different physico-chemical factors following the standard methods.

RESULTS AND DISCUSSION

The physico-chemical parameters are given in Table 1.

Table 1 Average values of Physico-chemical parameters

All Parameters are expressed in mg/L except pH and Temperature (^{0}C)

S.No	Physico-Chemical Parameters	Station - I	Station - II	Station - III
1	Temperature	23.30	23.50	23.80
2	pH	8.25	8.20	8.18
3	Carbonates	17.30	14.13	12.62
4	Bicarbonates	213.14	217.63	216.68
5	Chlorides	364.95	375.99	365.72
6	Dissolved Oxygen	2.90	3.10	2.95
7	BOD	94.00	82.00	96.00
8	Organic Matter	17.00	16.87	18.05
9	Total Hardness	529.27	530.08	530.94
10	Calcium	79.15	82.46	82.13
11	Magnesium	67.14	70.78	71.21
12	Sulphates	42.20	37.79	33.04
13	Phosphates	3.57	3.03	3.50
14	Nitrites	0.28	0.19	0.25
15	Nitrates	6.80	6.25	4.20

Water Temperature

In the present investigation the water temperature ranged from 22.50 ^oC to 25.00 ^oC at station-I, 22.00 ^oC to 25.50 ^oC at station-II and 22.50 ^0C to 25. 00 ^0C at station-III. The water temperature was high in summer and low in winter. Temperature is one of the most significant factors that affect the aquatic environment (Sedamkar and Angadi, 2003).

pH

During the period of investigation the pH value ranged from 8.00 to 8.80 at all the stations. The average value is 8.20 at all the stations. The pH shows an alkaline condition throughout the period of study. Pawar and Mane (2006) has stated that the higher value of pH during monsoon was due to the uptake of CO_2 by photosynthesizing organisms

Carbonates

Carbonates acts as buffer in regulating the pH of water. The average values are 17.30 mg/L, 14.13 mg/L and 12.62 mg/L in station-I, station-II and station-III respectively. Carbonates exhibited a direct relationship with dissolved oxygen and an inverse relationship was observed with chlorides. The high values of carbonates may be due to dissolution of calcium carbonate in bottom layer of lake (Wetzel and Likens, 2000 and Araoye, 2009).

Bicarbonates

Bicarbonates were dominant in inorganic carbon complex in the lake. The average values were 213.14 mg/L at station-I, 217.63 mg/L at station-II and 216.68 mg/L at station-III. Maximum values were recorded at Station-II and minimum at station-I the variation in the concentration probably due to the fluctuations in the inflow of domestic and industrial wastes. However with constant pH values, bicarbonates showed much fluctuation as was evident in the present study. This is in conformity with the observations made by Prasad and Manjula (1980).

Chlorides

Chlorides constituted the major inorganic anion in water and waste water. Chlorides from pollution sources can modify natural concentration to a great extent. The average values were 364.95 mg/L at station-I, 375.99 mg/L at station-II and 365.72 mg/L at station-III.

Dissolved Oxygen

The average were 2.90 mg/L at station-I, 3.05 mg/L at station-II and 2.92 mg/L at station-III. Disolved oxygen in relation with water temperature and organic matter gives a clear picture of the status of pollution in the lake. In the present investigation temperature and organic matter have shown a direct relation and existed an inverse relationship between dissolved oxygen and organic matter.

Biological Oxygen Demand

The average values were 94.00 mg/L at station-I, 82.00 mg/L at station-II and 96.00 mg/L at station-III. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded by aerobically (Pagriya, 2012).

Chemical Oxygen Demand

The average of COD values was 97.49 mg/L at station-I, 95.08 mg/L at station-II and 85.00 mg/L at station-III. In the present investigation COD values were low in winter, high in summer and moderate in monsoon. The high concentration of COD could be attributed to the accelerated rate of bacterial decomposition and partly to its consumption in the chemical process of oxidation (Sawane *et al*., 2006).

Oxidizable Organic Matter

The average values were 17.00 mg/L at station-I, 16.87 mg/L at station-II and 18.05 mg/L at station-III. The maximum in winter values could be attributed to the autochthonous organic matter due to the death of *Eichhornia crassipes* that was abundant in the lake. In Fox Sagar planktonic populations were high. It was also observed that higher planktonic populations were succeeded by high values of organic matter. This could be attributed to the accumulation of organic matter by decaying algal material. This is in confirmation with the work of Tiwari (2005).

Total Hardness

The averages are 529.27 mg/L at station-I, 530.08 mg/L at station-II and 530.94 mg/L at station-III. Total hardness and calcium exhibited a positive relation between each other. This is an agreement with the findings of Ravikumar, (2006).

Calcium

Calcium is refered to as a basic inorganic nutrient for the growth and population dynamics of flora. The average values were 79.15 mg/L at station-I, 82.46 mg/L at station-II and 82.13 mg/L at station-III. The waters were rich in calcium , could be attributed to the high concentrations of bicarbonates as evident in the observation made by Sahni and Yadav (2012) that richness of bicarbonates are usually rich in calcium could be due to conversion of the soluble calcium carbonate into insoluble bicarbonate .

Magnesium

The average values were 67.14 mg/L at station-I, 70.78 mg/L at station-II and 71.21 mg/L at station-III. The high values observed in summer could be due to evaporation, increasing the concentration of magnesium (Ravikumar, 2006). During the period of investigation, magnesium contents were found to be high in Fox Sagar lake.

Sulphates

The average values were 42.20 mg/L at station-I, 37.79 mg/L at station-II and 33.04 mg/L at station-III. The major sources of sulphur in natural waters are rocks, fertilizers and waste discharges from industries.

Phosphates

The average values were 3.57 mg/L at station-I, 3.03 mg/L at station-II and 3.50 mg/L at station-III. In the lake, the phosphate values were on higher in winter and monsoon with minimum values during summer. Similar observation was made by Mishra *et al.,* (2008) and Mustapha (2003).

Nitrites

Nitrites form an intermediate oxidation state of nitrogen both in the reduction of ammonia and nitrates. Average values in Fox Sagar were 0.28 mg/L, 0.19 mg/L, and 0.25 mg/L in station-I, station-II and station-III. Nitrites in the lake was formed dominantly by the process of reduction from nitrates, in the presence of denitrifying bacteria which are active at moderately high temperature (Foster *et al*., 1987) in the oxygen deficient condition, rather than by oxidation of ammonia.

Nitrates

The average values were 6.80 mg/L at station-I, 6.25 mg/L at station-II and 4.20 mg/L at station-III. In the present investigation the determination of nitrates is significant in that it is a measure of the status of eutrophication as it gives the content and availability of decomposable organic matter. Premlatha Vikal, 2008 reported that nitrates increased a few days after rainfall.

CONCLUSION

The physico - chemical characteristics exhibited certain interrelationships. The pH and carbonates are directly correlated. The pH and carbonates are inversely proportional to bicarbonates. Chlorides showed an inverse correlation with carbonates. Dissolved oxygen shows an inverse correlation with organic matter and biological oxygen demand. The total hardness negatively correlated with carbonates. Sulphates and phosphates showed positive correlation with chlorides. Nitrates showed positive correlation with carbonates, bicarbonates, calcium and negatively correlated with total dissolved solids.

Carbonates and dissolved oxygen were recorded in low concentration. Organic matter, COD, phosphates and nitrates were recorded in high concentration. On the basis of physico-chemical characteristics the lake is polluted and eutrophic.

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Effect of Ecosan Compost Application on Ground Water Quality of Musiri (TK), Trichy District, TN

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ABSTRACT

Ecosan is a good model for providing the basic need of community compost chambers in problem areas like rocky, sandy, and water scarce environments. Human waste compost was obtained from the ECOSAN compost chambers constructed by SCOPE (NGO) at Musiri, Trichy (Dt). To study the impact of human waste compost on changes in soil and ground water quality, field experiments were conducted at Musiri. The well water samples were collected around the human waste compost applied field of Musiri, Trichy (Dt) from four locations from June 2009 continuously for three seasons. The distances of ground water sample collection from the human waste compost applied field are given below. I sample - 300 meters , II sample - 500 meters , III sample - 1000 meters , IV sample - 2000 meters from the Ecosan compost applied field. First application of Ecosan / human waste compost to the field was from July 2009 and the sampling of ground water / well water samples started from June 2009. During the first season (June 2009 to September 2009), the well water samples were collected from four locations around the human waste compost applied field of Musiri. The pH ranges from 7.18 to 7.89 and the EC ranges from 1.06 to 1.45 $dSm^{-1.}$ The Nitrate- N content ranges from 3.25 to 4.51 mgl^{-1}.The Phosphate - P content of the water sample ranges from 1.60 to 1.93 mgl^{-1}. The quality parameter of all the four well water samples were within the tolerance limit and it is found to be neutral to slightly alkaline. The EC also found to be suitable for irrigating the agricultural land. During the second season (October 2009 to March 2010), the well water samples were collected from the same four locations. The quality parameters of all the well water samples were more or less similar to the previous season and there is no wide variation in the water quality. The slight variation might be due to the rainfall and other climatic parameters. During the third season also (April 2010 to September 2010), the well water samples were collected from the same four locations. The quality parameter of all the four well water samples was within the tolerance limit and the tests for the pathogens like *E.coli, salmonella* were negative. In all the samples of every month and season, the pH, EC and other parameters are found to be normal and suitable for irrigation. But the long term effect of this Ecosan compost application on ground water quality need to be studied.

Keywords: Ecosan compost, Compost chambers, Ground water quality, Pathogens.

INTRODUCTION

Ecosan is a good model for providing the basic need of community compost chambers in problem areas like rocky, sandy, and water scarce environments. In the conventional system of toilets or by open defecation, the human faeces seriously contaminate the soil, air and water eco-system. Ecological Sanitation (ECOSAN) is a holistic approach to sanitation and water management and represents a break with the poorly performing end of pipe technologies of the past recognizing human excreta and domestic used water as a resource that should be made available for reuse. Without pre treatment or composting, the disposal of night soil poses a serious threat to the environment especially water eco-system (Babiker *et al*., 2007). Society for Community Organization and Peoples Education (SCOPE), the NGO in Tiruchirappalli has constructed over 1000 Ecosan toilets in rural areas including coastal villages of Tamil Nadu. The compost obtained from Night soil / Ecosan toilets are odourless after six months and free from pathogens. SCOPE, the NGO located in Trichy city has produced enormous quantity of night soil compost through ECOSAN toilets constructed around Musiri and Surrounding areas of Tiruchirappli District and it should be used effectively for agricultural purposes.

It represents an approach where wastes such as human faeces (night soil) are not considered as waste but as a resource to replenish the soil fertility and save the large quantity of precious water, now used for flushing the toilets through the underground sewage system (Janardhana,2007). Composted night soil is utilized carefully; we can increase the productivity of crops besides improving the soil fertility status. Continuous monitoring of night soil compost applied lands and nearby ground water eco-system would make this waste as a rich nutrient source rather than pollutant **(**Kuo and Harsh, 1997).

Various experiments conducted at different countries clearly indicated that the night soil compost application in agro-eco-system could be beneficially practiced as source of fertilizer nutrients, organic matter and other micronutrients, etc., (Kathryn and Gregory, 2005) The characterization of night soil compost, evaluation of the efficiency of compost on soil and crop in a cropping sequence results that, there is a lot of potential to utilize these solid wastes to sustain the soil health and crop productivity in the long term field experiments. Hence there is a good scope for using night soil compost for sustaining soil health and crop productivity.

MATERIALS AND METHOD

This experiment was carried out in the field of SCOPE (NGO) at Musiri, Trichy (Dt). To study the impact of human waste compost on changes in soil and ground water quality, field experiments were conducted at Musiri. The well water samples were collected around the human waste compost applied field of Musiri, Trichy (Dt) from four locations from June 2009 continuously for three seasons. The distances of ground water sample collection from the human waste compost applied field are given below. I sample - 300 meters , II sample - 500 meters , III sample - 1000 meters , IV sample - 2000 meters from the Ecosan compost applied field. First application of Ecosan / human waste compost to the field was from July 2009 and the sampling of ground water / well water samples started from June 2009. During the first season (June 2009 to September 2009), the well water samples were collected from four locations around the human waste compost applied field of Musiri.

Procedure to know the presence of *E.coli* and *Salmonella* in the ground water samples taken in and around human waste compost applied field.

The procedure followed is the serial dilution technique with specific media.

One ml of water sample was taken in the 100 ml water blank and it was mixed thoroughly. Then it was shaked for 15 min for complete dispersion (10^{-2} dilution). One ml of the 10^{-2} diluted suspension was transferred to 9 ml water blank (this is 10^{-3} dilution).Then it was serially transferred up to 10^{-4} and 10^{-5} dilution. From 10^{-4} and 10^{-5} dilution 1 ml was transferred to petridishes. Three replications were maintained for each dilution. The melted and cooled media (just before solidification) was poured into petridishes for about 15 ml and it was mixed well by shaking clock wise and anticlockwise for 3 or 4 times. The plates were incubated in the inverted position at room temperature for 2 -3 days. After three days the plated were observed for the *E. coli* and *Salmonella***.** There were no colonies developed after 2 and 3 days of incubation. Because there is no pathogens in the water samples.

The media composition for *E. coli* and *Salmonella* were given below.

Mac conkey agar medium composition for isolation of *E. coil*

Bacto peptone	-	17.0 g
Proteose peptone	-	3.0 g
Lactos	-	10 g
Bile salts mixture	-	1.5 g
Sodium chloride	-	5.0 g
Agar	-	13.5 g
Neutral red	-	0.03 g
Crystal violet	-	0.001 g
Distilled water	-	1000 ml
pH	-	7.1

Media composition for isolation of *Salmonella*

Beef extract	-	5g
Enzymatic digest of casein	-	2.5 g
Enzymatic digest of animal tissue	-	2.5 g
Lactose	-	10g
Bile salts	-	8.5 g
Sodium citrate	-	8.5 g
Sodium thiosulfate	-	8.5 g
Ferric citrate	-	1 g
Brilliant green	-	0.00033 g
Neutral Red	-	0.025 g
Agar	-	13.5 g
Distilled water	-	1 lit
pH	–	7.0 ± 0.2 at 25º C

RESULTS AND DISCUSSION

Table 1 Characteristics of well water samples collected around the human waste compost applied field (collected during June 2009)

S.No.	Parameters	Sample			
		I	II	III	IV
1.	pH	7.23	7.11	7.80	7.09
2.	EC (dSm^{-1})	1.03	0.97	1.09	1.33
3.	Nitrate-N (mgl^{-1})	3.11	4.40	3.41	3.16
4.	Phosphate -P (mgl^{-1})	1.82	1.83	1.66	1.51
5.	Calcium (m.eq l^{-1})	3.13	3.63	3.36	4.24
6.	Magnesium (m.eq l^{-1})	1.53	1.56	1.41	2.76
7.	Sodium (m.eq l^{-1})	5.63	4.53	6.34	6.33
8.	Potassium (m.eq l^{-1})	0.23	0.29	0.21	0.33
9.	Chlorides (m.eq l^{-1})	5.80	4.83	6.73	7.75
10.	Sulphates (m.eq l^{-1})	1.82	1.23	1.24	1.13
11.	Carbonates (m.eq l^{-1})	0.19	0.85	0.66	0.53
12.	Bicarbonates (m.eq l^{-1})	2.46	1.17	2.37	3.64
	Microbial population				
13.	Bacterial population (x 10^6 l^{-1})	4.0	4.0	5.0	3.0
14.	Fungal population (x 10^3 l^{-1})	4.0	3.0	3.0	3.0
15.	Actinomycetes population (x$10^{4\ -1}$)	1.0	-	-	1.0

(Mean of Three replications)

The well water samples were collected from four locations around the human waste compost applied field of Musiri, Trichy (Dt). The pH ranges from 7.09 to 7.80. The EC ranges from 0.97 to 1.33. Nitrate- N content ranges from 3.11 to 4.40 mg l^{-1}. The Phosphate – P content ranges from 1.51 to 1.83 mg l^{-1}. Salinity, total dissolved solids, and chlorides are the most frequently identified pollutants impairing the use of groundwater (Todd,1980) The quality parameter of all the four well water samples were within the tolerance limit and it is found to be neutral to slightly alkaline. The EC also found to be suitable for irrigating the agricultural land.

Table 2 Characteristics of well water samples collected around the human waste compost applied field (collected during October 2009)

S.No.	Parameters	Sample			
		I	II	III	IV
1.	pH	7.16	7.04	7.73	7.02
2.	EC (dSm^{-1})	0.96	0.90	1.02	1.26
3.	Nitrate-N (mgl^{-1})	3.03	4.33	3.34	3.09
4.	Phosphate -P (mgl^{-1})	1.75	1.76	1.59	1.44
5.	Calcium (m.eq l^{-1})	3.06	3.56	3.29	4.17
6.	Magnesium (m.eq l^{-1})	1.46	1.49	1.34	2.69
7.	Sodium (m.eq l^{-1})	5.56	4.46	6.27	6.26
8.	Potassium (m.eq l^{-1})	0.16	0.22	0.14	0.26
9.	Chlorides (m.eq l^{-1})	5.73	4.76	6.66	7.68
10.	Sulphates (m.eq l^{-1})	1.75	1.16	1.17	1.06
11.	Carbonates (m.eq l^{-1})	0.12	0.78	0.59	0.46
12.	Bicarbonates (m.eq l^{-1})	2.39	2.00	2.30	3.57
	Microbial population				
13.	Bacterial population (x $10^6 l^{-1}$)	3.0	4.0	3.0	3.0
14.	Fungal population (x $10^3 l^{-1}$)	2.0	3.0	3.0	2.0
15.	Actinomycetes population (x$10^4 l^{-1}$)	-	1.0	-	-

(Mean of Three replications)

During October 2009, the drainage canal i.e. mettuvaikkal near the SCOPE (NGO) field is diluted with rain water and also the quantity of water was reduced due to the construction of drainage channels. The microbial population found is the common species and the test for the *E.coli* was negative. There are no pathogens such as *salmonella* in the Ecosan compost as well as in ground water sample. The quality parameter of all the four well water samples were within the tolerance limit and it is found to be neutral to slightly alkaline. The EC also found to be suitable for irrigating the agricultural land.

Table 3 Characteristics of well water samples collected around the human waste compost applied experimental field (April 2010)

S.No.	Parameters	Sample			
		I	II	III	IV
1.	pH	7.32	7.20	7.89	7.18
2.	EC (dSm^{-1})	1.12	1.06	1.18	1.45
3.	Nitrate-N (mgl^{-1})	4.09	4.51	3.50	3.25
4.	Phosphate -P (mgl^{-1})	1.93	1.91	1.75	1.60
5.	Calcium (m.eq l^{-1})	3.22	3.72	3.45	4.33
6.	Magnesium (m.eq l^{-1})	1.62	1.65	1.50	2.85
7.	Sodium (m.eq l^{-1})	5.72	4.62	6.47	6.42
8.	Potassium (m.eq l^{-1})	0.32	0.38	0.30	0.42
9.	Chlorides (m.eq l^{-1})	5.89	4.91	6.82	7.84
10.	Sulphates (m.eq l^{-1})	1.91	1.32	1.33	1.21
11.	Carbonates (m.eq l^{-1})	0.28	0.94	0.75	0.62
12.	Bicarbonates (m.eq l^{-1})	2.55	2.16	2.46	3.73
Microbial population					
13.	Bacterial population (x $10^6 l^{-1}$)	4.0	4.0	5.0	3.0
14.	Fungal population (x $10^3 l^{-1}$)	4.0	3.0	3.0	2.0
15.	Actinomycetes population (x$10^4 l^{-1}$)	-	-	-	-
Pathogens					
16.	*E.coli*	Nil			

(Mean of Three replications)

The well water samples were collected from same four locations around the human waste compost applied field of Musiri, Trichy (Dt). The pH ranges from 7.18 to 7.89. The EC ranges from 1.06 to 1.45 $dSm^{-1.}$ The Nitrate- N content ranges from 3.25 to 4.51 mgl^{-1}. The Phosphate - P content of the water sample ranges from 1.60 to 1.93 mgl^{-1}. The quality parameter of all the four well water samples were within the tolerance limit and it is found to be neutral to slightly alkaline.

Table 4. Characteristics of well water samples collected around the human waste compost applied field (collected during October 2010)

S.No.	Parameters	Sample			
		I	II	III	IV
1.	pH	7.36	7.22	7.88	7.20
2.	EC (dSm^{-1})	1.11	1.05	1.18	1.44
3.	Nitrate-N (mgl^{-1})	4.08	4.52	3.51	3.27
4.	Phosphate-P (mgl^{-1})	1.93	1.91	1.74	1.60
5.	Calcium (m.eq l^{-1})	3.49	3.83	3.52	4.43
6.	Magnesium (m.eq l^{-1})	1.59	1.56	1.44	2.83
7.	Sodium (m.eq l^{-1})	5.54	4.78	6.59	6.58
8.	Potassium (m.eq l^{-1})	0.30	0.38	0.29	0.31
9.	Chlorides (m.eq l^{-1})	6.09	5.08	6.70	7.93
10.	Sulphates (m.eq l^{-1})	1.95	1.27	1.42	1.44
11.	Carbonates (m.eq l^{-1})	0.21	0.93	0.78	0.50
12.	Bicarbonates (m.eq l^{-1})	2.59	2.55	2.58	3.80
Microbial population					
13.	Bacterial population (x 10^6 l^{-1})	3.0	3.0	4.0	2.0
14.	Fungal population (x 10^3 l^{-1})	3.0	3.0	2.0	2.0
15.	Actinomycetes population (x10^4 l^{-1})	-	-	-	-
Pathogens					
16.	*E.coli*	Nil			

(Mean of Three replications)

The well water samples were collected from the same four locations and analysed for the chemical and biological properties. The pH ranges from 7.20 to 7.88. The highest pH value was observed in sample number three. The EC ranges from 1.05 to 1.44 dSm^{-1}. The Nitrate-N content ranges from 3.27 to 4.52 mgl^{-1}. The Phosphate-P content ranges from 1.60 to 1.93 mgl^{-1}.

There is no major deviation in quality parameters and this indicates that the Ecosan compost does not influence or affect the ground water sources. In all the samples and all the months, the pH, EC and other parameters are seems to be normal and in the initial months, the microbial load may be due to the presence of mettuvaikkal, which is the canal it carries the drainage and sewage of the Musiri Town Panchayat. It is running near the sampling wells located around the field. Also, the human waste compost was applied only from July 2009 for the field. The test for the *E.coli* was negative. There was no pathogen such as salmonella in the compost as well as in ground water sample. In all the samples of every month, the pH, EC and other parameters are found to be normal and suitable for irrigation. It indicates that there are no harmful pathogens and metals in the compost as well as ground water in and around the compost applied field. But the long term effect of Ecosan compost application on ground water quality needs to be studied.

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Quality Assessment of Surface Water Bodies in and around GHMC

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ABSTRACT

Deteriorating water quality of lakes is alarming concern in Hyderabad city. This is on the whole true for lakes which are surrounded by urbanized area and industries. Disposal of waste water and sewage has become menacing problem in cities due to increased population. Lakes facing degradation due to anthropogenic activities such as directing sewage, domestic waste and effluents into lakes and changes in land use pattern etc. thus leading to the worsening of environmental sustainability. This study is main consideration to assess the characterization of water quality parameters, to identify polluting sources and its impacts. Water quality measurements had been carried out during pre and post monsoon seasons of the year 2015 for 30 lakes which are considered in research. Water samples were collected and tested for chemical parameters (pH, Total Dissolved solids, CO_3, HCO_3, CL, F, NO_3, SO_4, Na, K, Ca, Mg and Total Hardness) using Bureau of Indian Standards (BIS). Based on the water quality analysis, the concentrations of parameters during post monsoon was found to be lesser than pre monsoon season which is phenomenon of rainwater dilution in lakes during monsoon. From the analysis it is discerned that concentration of all parameters varying moderately during pre and post monsoon seasons, excluding parameters like fluorides and nitrates. The anomalous concentrations of F ranging from 1.53 mg/lit – 1.63 mg/lit and NO_3 ranging greater than 30 mg/lit for some lakes which are more than BIS.

Keywords: Urbanization, Sustainable environment, Pre-monsoon, Post-monsoon, water quality, WQI, BIS.

INTRODUCTION

Today surface water is most vulnerable to pollution due to its easy accessibility for disposal of pollutants and wastewaters. Worldwide surface water quality is governed by complex anthropogenic activities and natural processes [1, 2] including weathering, erosion, hydrological features, climate change, precipitation, industrial activities, agricultural land use, sewage discharge, and the human exploitation of water resources. The evaluation of water quality in most countries has become a critical issue in recent years, especially due to concerns that freshwater will be a scarce resource in the future [3 - 6]. The protection of integrity of world water resources have been given topmost priority in the 21st century due to limited supply of fresh water and the role of anthropogenic activities in deteriorating the water quality[7 - 10].

GHMC has individual physical identity characterized by rock formations and water bodies. The last 50 years of its growth have witnessed large scale destruction.During the last decade, widespread deterioration in water quality of water bodies has been reported due to rapid development of industries, agriculture, and urban sprawl. The reliance of a large population on these polluted water resources has significant implications for public health. Despite steady investment in treatment plants, the current infrastructure used to treat wastewater is inadequate, and 50 percent of sewage is left untreated. The objective of present study is to qualitatively study different chemical parameters of water samples for pre and post monsoon seasons of the year 2015.

Study Area

Greater Hyderabad Municipal Corporation is situated at an attitude of 536 meters (1607ft) above sea level. It lies in the Deccan Plateau, housing multiple lakes and large water tanks. Since cities are built on a rocky terrain, the potential for using groundwater is limited. Present study includes four mandals/taluks namely Rajendranagarmandal, Medchalmandal, Hayatnagarmandal, and GHMC. Rajendranagarmandal consists of 14 lakes, Medchalmandal consists of 5 lakes, GHMC consists of 3 lakes, and Hayatnagarmandal consists of 7 lakes.The 30 surface water bodies in GHMC which are under study areDurgam cheruvu, Khajaguda cheruvu, Timmidkunta Lake, Sunnam cheruvu, Mullakathuva cheruvu, Malaka cheruvu, Chinna maisamma cheruvu, Kamuni cheruvu, Ambir cheruvu, Ibrahim cheruvu, Langarhouz cheruvu, Osman sagar, Himayat sagar, Mundi kunta, Peeran cheruvu, Hussain sagar, Jeedimetla cheruvu, Bon cheruvu, Noor Mohammed cheruvu, Safilguda Lake, Ramanthapur cheruvu, Saroornagar Lake, Banda cheruvu, Alwal Lake, Pedda Cheruvu Uppal, Nalla cheruvu, Rama cheruvu, Pedda Cheruvu Balapur, Kapra cheruvu and Shamirpet Lake.

Review Literature

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities [11]. Water quality is usually determined by analyzing samples of water collected by personnel visiting monitoring stations at regular intervals.Freshwater systems are highly threatened by a range of anthropogenic activities including intensive agriculture, urbanization, industrialization and land cover change [12]. Industrial effluents entering the water bodies are one of the major sources of environmental toxicity and it has deleterious impacts on aquatic ecosystem [13]. This degradation of water quality erodes the availability of water for humans and ecosystems,increasing financial costs for human users, and decreasing species diversity (14).

MATERIAL AND METHODS

The step by step methodology adopted in delineating the surface water bodies in and around GHMC is as follows:

Google Earth satellite images → Digitization of water bodies using polygon tool → shape file creation from Google earth → save shape file in .kml format → convert .kml file to Arc view shape file using DNR-Garmin software version 5.4.1 → The Arc view shape file is opened in Arc map → legend is given to the shape files in layout view → export file in layout view.

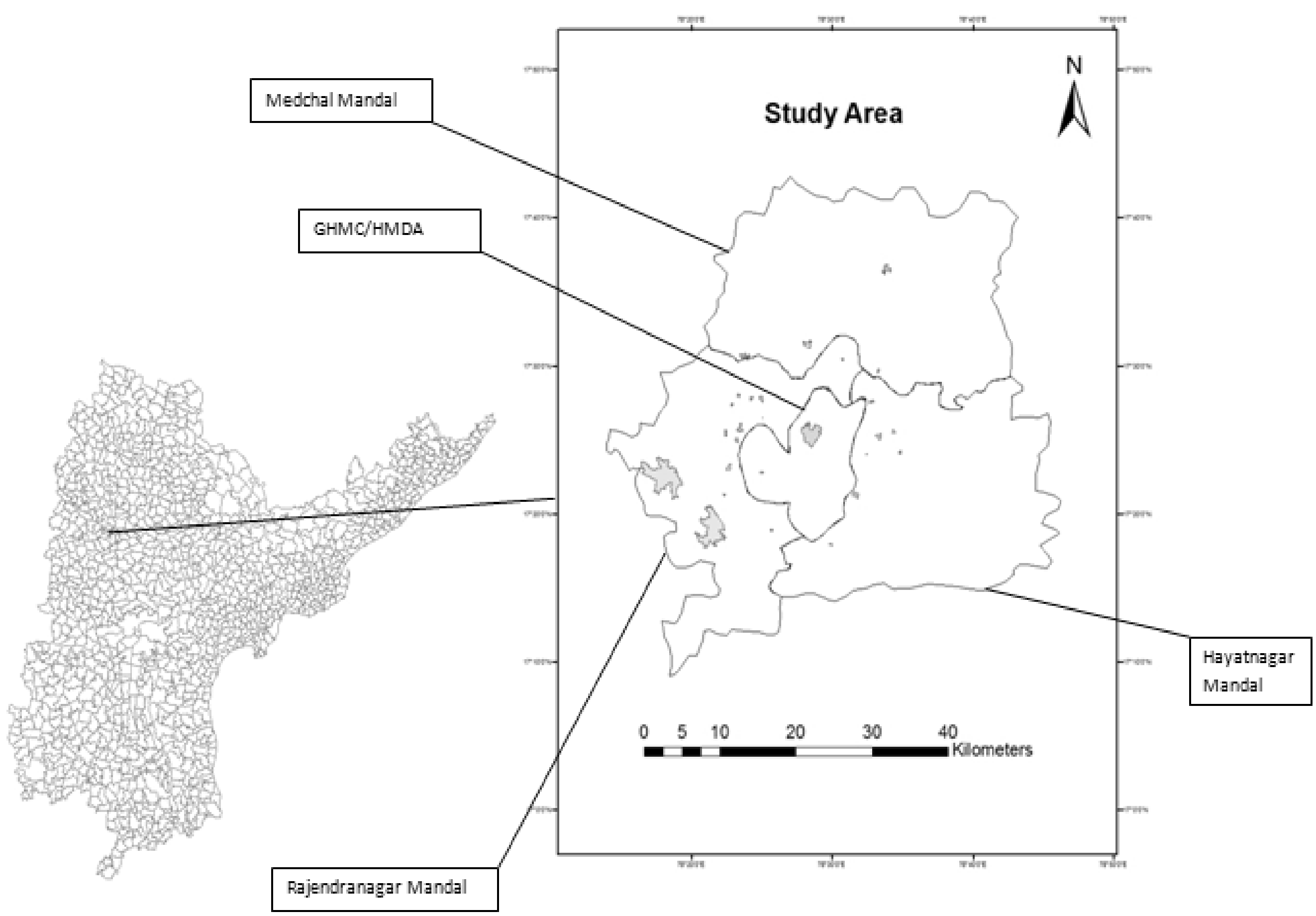

Figure 1 Study area showing four Mandal boundaries and 30 lakes under study

Sampling and data collection: The samples were collected from 23 water bodies during pre-monsoon season and 26 water samples during post monsoon seasons for the year 2015. The collections weremade during day time. Maximum care was taken for the collection of samples, their preservation and storage as per the BIS standards. Latitude and Longitude of the sampling stations are also marked by using GPS.

Measurement and analysis of water quality parameters: Water quality was analyzed for chemical parameters such as pH, Total Dissolved solids, CO_3 as $CaCO_3$, HCO_3 as $CaCO_3$, CL, F, NO_3, SO_4, Na, K, Ca, Mg and Total Hardness as $CaCO_3$ for more accurate value of Water Quality Index. These parameters were measured as per standard methods.

RESULTS AND DISCUSSION

From the methodology and analysis, the following are the observed values of water quality of 23 lakes in pre monsoon season. The observed values are compared with Bureau of Indian standards.

Table 1 (A) Characterization of water samples (Pre-monsoon)

S.No	Name of the Sample	pH	TDS mg/lit.	Co_3 as $CaCo_3$ mg/lit	HCO_3 as $CaCo_3$ mg/lit	CL mg/lit	NO_3 mg/lit
	BIS Permissible Limits for Drinking water	**6.50 to 8.50**	**500-2000**	**200-600**	**200-600**	**250-1000**	10.16
1	Durgam cheruvu	8.31	969	20	246	230	**24**
2	Khajaguda cheruvu	8.36	883	40	226	190	**30**
3	Timmidkunta cheruvu	8.32	803	20	233	180	**14.5**
4	Sunnam Cheruvu	8.25	618	0	144	120	**34.5**
5	Malaka cheruvu	8.11	1001	0	309	230	**20**
6	Chinna maisamma cheruvu	8.33	758	40	224	140	**17.5**
7	Kamuni cheruvu	**8.52**	744	60	210	150	**14**
8	Ambir cheruvu	8.38	996	40	292	230	**17.5**
9	Ibrahim cheruvu	8.16	950	0	200	250	**33**
10	Langarhouz cheruvu	7.9	681	0	220	120	**27**
11	Osman sagar	8.43	336	40	130	40	2.2
12	Himayat sagar	8.4	227	40	100	10	1.55
13	Peeran cheruvu	8.19	592	0	166	150	4.1
14	Hussain sagar	8.31	922	40	195	210	**24**
15	Jeedimetla cheruvu	8.25	1760	0	164	780	5.41
16	Bon cheruvu	8.4	781	40	241	190	2.89
17	Safilguda Lake	8.37	849	40	208	220	**11.5**
18	Saroornagar cheruvu	**8.54**	708	20	199	160	**13**
19	Alwal cheruvu	**8.75**	916	40	270	200	**15**
20	Pedda cheruvu Uppal	7.73	751	0	221	150	**24**
21	Nalla cheruvu	8.43	823	40	181	170	**27.55**
22	Kapra cheruvu	**8.69**	774	60	229	140	8.95
23	Shamirpet Lake	8.31	463	40	54	140	6.35

Table 1 (B) Characterization of water samples (Pre-monsoon)

S.No	Name of the Sample	F mg/lit	So_4 mg/lit	Na mg/lit	K mg/lit	Ca mg/lit	Mg mg/lit	T.H. as $CaCo_3$ mg/lit
	BIS Permissible Limits for Drinking water	1.0-1.5	200-400	NG	NG	75- 200	30-100	200-600
1	Durgam cheruvu	1.28	70	174	20	96	29	360
2	Khajaguda cheruvu	1.14	40	158	26	104	15	320
3	Timmidkunta cheruvu	1.23	60	115	18	96	29	360
4	Sunnam Cheruvu	0.54	40	94	18	56	29	260
5	Malaka cheruvu	1.2	67	184	24	104	24	360
6	Chinna maisamma cheruvu	0.85	60	116	20	72	34	320
7	Kamuni cheruvu	1.04	42	113	17	88	24	320
8	Ambir cheruvu	0.84	50	161	28	120	24	400
9	Ibrahim cheruvu	1	62	178	33	88	24	320
10	Langarhouz cheruvu	1.25	39	98	19	80	24	300
11	Osman sagar	0.49	25	36	5	48	15	180
12	Himayat sagar	0.61	15	25	4	32	10	120
13	Peeran cheruvu	**1.53**	63	101	21	48	24	220
14	Hussain sagar	1.2	93	156	22	88	34	360
15	Jeedimetla cheruvu	1.46	75	384	26	32	107	520
16	Bon cheruvu	1.29	43	107	19	88	34	360
17	Safilguda Lake	**1.63**	55	105	18	112	34	420
18	Saroornagar cheruvu	0.95	55	101	15	80	29	320
19	Alwal cheruvu	1.31	61	128	20	96	44	420
20	Pedda cheruvu Uppal	1.16	60	107	16	80	34	340
21	Nalla cheruvu	1.09	74	111	22	96	34	380
22	Kapra cheruvu	1.3	77	103	22	80	39	360
23	Shamirpet Lake	**1.6**	42	101	5	24	19	140

From the methodology and analysis, the following are the observed values of water quality of 26 lakes in post monsoon season. The observed values are compared with Bureau of Indian standards.

Table 2 (A) Characterization of water samples (Post-monsoon)

S.No	Name of the Sample	pH	TDS mg/lit.	Co_3 as $CaCo_3$ mg/lit	HCO_3 as $CaCo_3$ mg/lit	CL mg/lit	NO_3 mg/lit
	BIS Permissible Limits for Drinking water	**6.50 to 8.50**	**500-2000**	**200-600**	**200-600**	**250-1000**	**10.16**
1	Durgam cheruvu	7.11	1130	0	456	200	3.19
2	Khajaguda cheruvu	7.31	1084	0	503	190	1.41
3	Timmidkunta Lake,	7.26	973	0	317	220	7.18
4	Sunnam cheruvu	6.87	832	0	418	90	4.39
5	Malaka cheruvu	7.07	1010	0	331	210	6.64
6	Chinna maisamma cheruvu	7.07	932	0	337	210	3.76
7	Kamuni cheruvu	7.09	940	0	400	170	10.00

Contd…

S.No	Name of the Sample	pH	TDS mg/lit.	CO_3 as $CaCO_3$ mg/lit	HCO_3 as $CaCO_3$ mg/lit	CL mg/lit	NO_3 mg/lit
8	Ambir cheruvu	7.10	1079	0	336	250	9.00
9	Ibrahim cheruvu	7.13	1064	0	470	180	1.85
10	Langarhouz cheruvu	7.06	954	0	381	180	2.04
11	Osman sagar,	7.61	295	0	155	20	0.99
12	Himayat sagar,	7.64	285	0	172	10	0.85
13	Peeran cheruvu,	7.30	634	0	160	100	1.20
14	Hussain sagar,	7.30	1024	0	256	250	2.69
15	Jeedimetla cheruvu,	7.12	2048	0	230	860	5.37
16	Bon cheruvu,	7.19	944	0	323	220	2.11
17	Safilguda Lake,	7.21	1075	0	460	180	10.00
18	Ramanthapur cheruvu,	7.18	840	0	391	140	5.00
19	Saroornagar Lake,	7.26	1101	0	425	190	3.06
20	Banda cheruvu,	7.15	925	0	252	230	2.81
21	Alwal Lake,	7.24	1166	0	410	260	8.45
22	Pedda cheruvu	7.09	1030	0	515	150	2.10
23	Nalla cheruvu,	7.19	1062	0	500	170	3.35
24	Rama cheruvu	7.25	1169	0	284	370	2.49
25	Kapra cheruvu,	7.10	915	0	325	180	10.00
26	Shamirpet Lake	7.05	529	0	145	140	2.92

Table 2 (B) Characterization of water samples (Post-monsoon)

S.No	Name of the Sample	F mg/lit	SO_4 mg/lit	Na mg/lit	K mg/lit	Ca mg/lit	Mg mg/lit	T.H. as $CaCO_3$ mg/lit
	BIS Permissible Limits for Drinking water	**1.0-1.5**	**200-400**	**NG**	**NG**	**75- 200**	**30-100**	**200-600**
1	Durgam cheruvu	1.02	120	204	22	112	34	420
2	Khajaguda cheruvu	1.05	60	187	22	104	39	420
3	Timmidkunta Lake,	1.10	96	158	19	88	44	400
4	Sunnam cheruvu	0.78	80	106	20	96	39	400
5	Malaka cheruvu	1.35	125	163	17	128	24	420
6	Chinna maisamma cheruvu	1.45	71	143	19	80	49	400
7	Kamuni cheruvu	1.23	49	137	19	104	39	420
8	Ambir cheruvu	1.06	109	160	19	104	53	480
9	Ibrahim cheruvu	1.22	89	164	18	80	63	460
10	Langarhouz cheruvu	1.20	92	152	18	120	24	400
11	Osman sagar,	0.52	40	30	6	40	15	160
12	Himayat sagar,	0.74	30	27	5	40	15	160
13	Peeran cheruvu,	1.00	177	107	21	72	15	240
14	Hussain sagar,	1.22	167	184	22	88	39	380
15	Jeedimetla cheruvu,	**1.57**	117	439	33	32	131	620
16	Bon cheruvu,	**1.64**	86	102	18	96	63	500
17	Safilguda Lake,	1.46	78	155	24	136	34	480
18	Ramanthapur cheruvu,	1.35	41	119	19	104	29	380
19	Saroornagar Lake,	1.38	142	161	15	96	63	500
20	Banda cheruvu,	1.28	124	141	19	96	39	400

Contd…

S.No	Name of the Sample	F mg/lit	SO_4 mg/lit	Na mg/lit	K mg/lit	Ca mg/lit	Mg mg/lit	T.H. as $CaCO_3$ mg/lit
21	Alwal Lake,	1.35	91	185	29	128	39	480
22	Pedda cheruvu	1.27	60	152	17	96	53	460
23	Nalla cheruvu,	1.24	67	162	21	96	53	460
24	Rama cheruvu	1.30	86	220	35	80	49	400
25	Kapra cheruvu,	1.21	90	118	20	136	24	440
26	Shamirpet Lake	1.40	54	133	7	40	5	120

The characteristics of surface water bodies in and around Greater Hyderabad Municipal Corporation are shown in Table 1 and 2. It should be recognized that, like dissolved oxygen, pH also varies in water naturally throughout the day due to the photosynthesis and respiration cycles in the presence of algae in water bodies. The pH is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion concentration. The pH has no direct adverse effects on health; however, higher values of pH hasten the scale formation in water heating apparatus and also reduce germicidal potential of chloride. High concentrations of Nitrates and Phosphates in lake water causes eutrophication. The parameters such as Na, K, pH, Total dissolved solids doesn't cause much effect on lake ecosystem and no guidelines are followed by Bureau of Indian standards, but the parameters such as fluorides, nitrates, phosphates causes serious damage to ecosystem. The other parameters are considerable with in or near to the permissible limits given by Bureau of Indian Standards.

The high concentrations of fluorides are generally observed in groundwater but it is investigated in analysis during pre-monsoon season that, out of 27 samples from different lakes, 3 lakes have the fluoride levels greater than the permissible limits. Nitrates are the nutrient required for the plant growth, which is generally released from agricultural fertilizers. In urban areas, most of the nitrate concentration comes from the sewage released from households and kitchen wastes. During pre-monsoon season 16 lakes have nitrates values greater than the permissible limits. It is general observed that in groundwater samples fluoride concentration is more but it is investigated in analysis that, out of 23 samples from different lakes, 2 lakes have the fluoride levels greater than the permissible limits.

CONCLUSIONS

The present paper analyzes the water quality collected from different surface water bodies in GHMC. Important issues include decreasing water quality, alternations in sustainable environment, increase in nutrient concentrations and contaminant migration into the water bodies. During pre-monsoon season 16 surface water bodies have nitrates values greater than the permissible limits, this nitrate values shows drastic increase of nutrient contamination due to anthropogenic activities, nutrient loading from sewage and households, in-turn causing eutrophication of lakes.In pre and post monsoon seasons, pH concentration of lake water had been slightly acidic and alkaline in nature. As per the analysis of the results it can be seen that in the pre monsoon season chemical parameters are higher than post monsoon season. So itcan be concluded that during monsoon season dilution of rainwater into the water bodies reduced the contamination migration into the lake, thusresult in post monsoon is better in quality of water.

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Pollution Index: A Tool for Assessment of Water Quality

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ABSTRACT

Water Quality Index (WQI) is one of the tools that effectively conveys the information of water quality to the public in a simple manner. Water quality is analyzed by physico-chemical and biological characteristics. It is difficult to understand the intervened chemistry and biology involved in water by normal public. So, it becomes complicated to evaluate and analyze the huge water parametric data in a study. Hence the evaluation through indices is given utmost significance in water quality perspective. There are huge number of indices that are used across the globe after 1970. All the indices cannot be used for all the water bodies. It is because WQI is geographic specific and source specific indicator that cannot be used for all the water bodies. There are simple and reliable WQI's that are most commonly used by many researchers across the World. Weighted arithmetic water quality index (WAWQI), National sanitation foundation WQI (NSFWQI) and Nemerow's pollution index (NPI) were widely used. In this study, NPI was evaluated for the water samples in three seasons collected from twelve sampling stations along Gostani Velpur stream of Godavari river.

Keywords: Water quality index, Nemerow's pollution index, Physico-chemical parameters.

INTRODUCTION

Next to air, water is very important for survival on the earth. Even though three-fourth of the earth is covered by water, only a small portion of it is useful. No live stock on the earth survives without water (Srinivas et al., 2013). Water is a transport medium for various diseases. Safe drinking water with acceptable limits is of utmost importance for every human being on earth. Almost 200 million people in India do not have access to safe and clean drinking water and 90% of the Country's water resources are polluted (Vatkar et al., 2013). Modern urbanization, industrialization and agriculture activities deteriorate water quality o the maximum extent (Manjusha et al., 2013). The physical, chemical and biological characteristics of water influence the quality of a water body as a whole (Venkatesharaju et al., 2010). The multiple parametric data can be simplified by development of a single index. Water quality index (WQI) summarizes the overall quality data into a simple number that is easy to public for understanding (Yogendra et al., 2008). The WQI was first developed by Horton in the early 1970's. At least 36 WQI's are being used across the World, with the number of attributes ranging from 3 to 72. WQI finally tells about the quality of water as is excellent, good or bad (Bharti et al., 2011).

Wqi development

WQI's are classified into four main groups say public indices, specific consumption indices, designing or planning indices and statistical indices. Water samples are analyzed in terms of physical, chemical and biological characteristics with different units and different weights. So, all the data is transformed to sub indices through statistics into values with similar units. Weights are assigned to each variable according to their importance. Finally, aggregation of sub-indices is done to generate a cumulative index. In order to get meaningful information from multivariate data, statistical approaches such as cluster analysis (CA), factor analysis (FA), principal number of assumptions and improves the accuracy of the index (Dinius, 1987). In this study, weighted arithmetic water quality index was calculated for different water samples collected.

MATERIALS AND METHODS

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, aquaculture and industries are surviving with these abundant water resources. Irrigation in West Godavari is carried on through a network of canals, namely Eluru canal, Narasapur canal, Venkayya Vayyeru canal, Gostani canal, Attili Canal etc. Gostani canal is considered as a main source for this study. The study was carried out at 12 locations of Gostani Velpur canal. The sampling stations selected for the analysis are: S1 - Relangi, S2 – Tanuku, S3 – Chivatam, S4 – Undrajavaram, S5 – Achanta, S6 – Iragavaram, S7 – Veeravasaram, S8 – Palakoderu, S09 - Yanamadurru, S10 – Dirusumarru, S11 – Deyyalatippa, S12 – Gollavanitippa. In this paper, samples from sampling stations mentioned along the canal source and samples from the outlets of water supplies in respective stations along the canal were considered for the analysis. Panchayat Raj station was selected as the sampling station for analysis.

Data collection

The water collected from all the 12 sampling stations is evaluated experimentally in laboratory for the physico-chemical parameters such as pH, Electrical conductivity (EC), Total dissolved solids (TDS), Hardness, Calcium(Ca^{2+}), Magnesium(Mg^{2+}), chlorides(CL^{-}) and nitrates(NO^{3-}) in three seasons respectively.

Basic procedure for WQI development

Nemerow's pollution index (NPI) is a very simple indicator for water pollution (Zheng et al., 2011).

NPI is calculated below:

$$NPI = Ci / Li$$

Where Ci = observed concentration of ith parameter

Li = permissible limit as per BIS standards.

The permissible standards for the parameters are given in Table 1.

Table 1 Drinking water standards (BIS Limits)

SNO	Parameter	BIS LIMITS
1	pH	8.5
2	EC	300
3	TH	300
4	Cl	250
5	Mg	30
6	Ca	75
7	TDS	500
8	NO3	45

RESULTS AND DISCUSSION

The statistical summary of the data in three seasons is presented in Table 2, Table 3, and Table 4.

Table 2 Descriptive statistics summary (Pre Monsoon)

Descriptive statistics	pH	EC	TDS	Hardness	Ca^{2+}	Mg^{2+}	CL^-	NO^{3-}
Mean	8.47	975.83	655.83	248.33	56.33	26.12	185.49	19.06
Standard Error	0.24	196.61	132.08	51.31	12.79	5.14	49.06	5.49
Minimum	7.19	260.00	170.00	80.00	24.00	3.66	42.54	2.73
Maximum	9.77	2300.00	1500.00	600.00	152.00	58.30	584.90	68.60
Sum	101.63	11710.00	7870.00	2980.00	676.00	313.44	2225.87	228.70

Table 3 Descriptive statistics summary (Monsoon)

Descriptive statistics	pH	EC	TDS	Hardness	Ca^{2+}	Mg^{2+}	CL^-	NO^{3-}
Mean	8.56	263.33	179.17	111.67	25.67	11.55	52.89	7.16
Standard Deviation	0.23	97.73	67.88	44.07	6.02	10.10	43.68	2.45
Minimum	8.14	170.00	120.00	70.00	12.00	0.02	17.90	1.97
Maximum	9.02	520.00	350.00	220.00	32.00	34.02	134.71	9.79
Sum	102.77	3160.00	2150.00	1340.00	308.00	138.60	634.73	85.93

Table 4 Descriptive statistics summary(Post Monsoon)

Descriptive statistics	pH	EC	TDS	Hardness	Ca^{2+}	Mg^{2+}	CL^-	NO^{3-}
Mean	8.12	586.67	410.83	98.72	25.83	8.30	37.65	3.28
Standard Deviation	0.41	745.62	534.10	24.84	10.84	7.76	13.46	5.10
Minimum	7.52	190.00	130.00	80.00	8.00	0.02	28.36	0.03
Maximum	8.93	2500.00	1800.00	170.00	40.00	21.80	70.90	17.80
Sum	97.40	7040.00	4930.00	1184.60	310.00	99.62	451.78	39.38

The average values of Nemerow's pollution index were presented in Table 5.

Table 5 Average NPI values (three seasons)

SNO	Parameter	Pre Monsoon		Monsoon		Post Monsoon	
		Avg	NPI	Avg	NPI	Avg	NPI
1	pH	8.47	1	8.56	1.01	8.12	0.96
2	EC	975.83	3.25	263.33	0.88	586.67	1.96
3	TDS	655.83	2.19	179.17	0.6	410.83	1.37
4	Hardness	248.33	0.99	111.67	0.45	98.72	0.39
5	Ca^{2+}	56.33	1.88	25.67	0.86	25.83	0.86
6	Mg^{2+}	26.12	0.35	11.55	0.15	8.3	0.11
7	CL^-	185.49	0.37	52.89	0.11	37.65	0.08
8	NO^{3-}	19.06	0.42	7.16	0.16	3.28	0.07

pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. Most of the biological processes and biochemical reactions are pH dependent. In this study, higher values of pH were seen in summer and monsoon seasons.

Electrical Conductivity is a measure of water capacity to convey electricity. The present study reveals that most of the water samples tested exceeds the permissible range. The value observed was very high compared to permissible range. EC has closed relationship with Total Dissolved Solids (TDS). The higher value may be due to proximity to the seacoast. If TDS is more, water cannot be used for drinking. TDS affects palatability of food cooked and also causes gastro-intestinal irritation.

Total hardness of water is characterized by contents of calcium and magnesium salts. In summer, hardness is as high as 600 mg/L in sampling station S3. On an average, water is not bad with respect to hardness.

Higher concentration of chloride indicates higher degree of pollution. Seasonally, Chloride was found to be higher in summer and low during winter. Nitrate is used to assess the self purification of water bodies and nutrient balance in surface waters and soil and the state of determination of organic matter present in waters. Nitrate ion concentration is very important in public water supplies because it causes methemoglobinemia (blue baby disease) in children. During summer, nitrate concentration was found to be very high 68.60mg/L in sampling station S3.

Dissolved oxygen decreases with increase in temperature. Biological oxygen demand is a parameter to assess the organic load in a water body. Many researchers have recorded higher values in polluted water. BOD values in all the sampling stations were found to be within permissible limits. As noticed from the Table 5, most of the parameters were found to have the index values exceeding 1 that clearly depicts that there is pollution in water in the study area concerned.

Most of the parameters were maximum in summer due to high temperature, high evaporation and low water level and minimum in winter due to increased water level. In monsoon season also, the water quality was not good due to more intrusions from point and non-point sources.

CONCLUSIONS

Water is very much essential and its quality is of utmost priority to everybody. Water quality index (WQI) takes information from a number of sources and combines them into a single number that presents an overall picture of the quality of water at a meticulous time and site. The samples selected in the study area have higher concentrations compared to permissible limits. Hence it is clear that all the samples need treatment before the water is used for drinking purpose. The deterioration of water quality in Gostani Velpur canal may be due to large intrusions of waste from point and non-point sources nearby and practice of open defecation.

It is therefore suggested to reassess the required facilities of water treatment plants, and to take effective steps to put them into full operation to achieve clean and safe water.

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Treatment of Urban Sewage Water using Phytoremediation

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ABSTRACT

Land, surface waters, and ground water worldwide, are increasingly affected by contaminations from industrial, research experiments, military, and agricultural activities either due to ignorance, lack of vision, carelessness, or high cost of waste disposal and treatment. Large amount of water is being consumed in agriculture, industry, domestic and municipal use which imposes a further demand on this resource. Every community produces both liquid and solid wastes in day to day life. The water supply of the community results into wastewater after it has been fouled by a variety of uses. Today most of the water bodies are polluted by anthropogenic activities including release of untreated sewage. Hence, there is a gradual decline in the availability of fresh water. Plants act as bio-filters in the wastewater treatment technologies. Interest in phytoremediation as a method to solve environmental contamination has been growing rapidly in recent years. Phytoremediation involves growing plants in a contaminated matrix to remove environmental contaminants by facilitating sequestration and/or degradation (detoxification) of the pollutants. In this paper, marshy plants *Colacasia esculenta* and *Canna indica* are used. The studies aim at developing and assessing sewage treatment efficiency through Constructed wetland pilot scale plant for treatment of sewage to recycle and reuse. Treatment site is JNTUH Campus. Parameters to be analyzed: EC, DO, COD, BOD, pH, TDS, TSS, TS, NO_3, PO_4, SO_4. The efficiency of the two plants for phytoremediation is compared. The treated water obtained was clear in color and the values indicate that Canna indica is more efficient than the Colacasia esculenta. The future scope of the phytoremediation may ensure the better performance by using the Genetically Modified plants by combining different species for the Phytoremediation technique.

INTRODUCTION

Water is elixir of life and vital for survival of all living beings. The development of the water resources plays a key role in the sustainable growth of any society. Globally water supply and environment are in peril with increasing pollution, degradation and over exploitation. Effective collection and treatment of urban wastewater is a critical problem in India. Conventional high-technology wastewater treatment system is not a suitable solution in developing countries because it is not sustainable to install wastewater treatment facilities that require guaranteed power supply, replaceable spare parts and a skilled labour for operation and maintenance. Current and future fresh water demand can be met by enhancing water usage efficiency and demand management. This emerges the wastewater/low quality water as a potential source for demand management after essential treatment.

Phytoremediation is the use of green plants, including grasses and woody species to remove or render harmless environmental contaminants such as heavy metals, metalloids, trace elements, organic compounds, and radioactive compounds in soil or water. It avoids excavation and transport of polluted media thus reducing the risk of spreading the contamination and has the potential to treat sites polluted with more than one type of pollutant. Angular Horizontal flow constructed wetland is used for the treatment of the sewage water from the JNTUH campus. Two plants *Colacasia esculenta* and *Canna indica* are used for the treatment of the sewage water through phytoremediation. Raw sewage contains mostly water (about 95%) which often comes from washing and flushing toilets. They also contain organic particles (such as faeces, food, paper fibres, plant materials, etc.), inorganic particles (such as sand, metal particles, ceramics, etc.), pathogens and nonpathogenic organism, animals such as protozoa, insects, etc., macro solids such as sanitary napkins, diapers etc., gases such as hydrogen sulphide, methane etc. and toxins amidst others. The rich and wide diversity of nutrients in raw sewage makes them habitat for various organisms and plants.

The main aim of the present study is to emphasize the sewage water treatment to combat water crisis in urban landscapes, to examine the efficiency of the Phytoremediation technique, to analyze and characterize the sewage water collected from campus, to investigate the feasibility of applying a constructed wetland system to treat the campus waste water, to analyze and characterize the sewage water after treatment and to compare the treatment efficiency of the two plants *Colacasia esculenta* and *Canna indica* along with control.

MATERIALS AND METHODS

Experimental Site and Sample Collection:

Experimental Site is JNTUH Campus and the samples are collected near the new and old IST buildings only.

Wetland construction:

Constructed wetlands innovation is a built technique for refining wastewater as it goes through a characteristic procedure, which includes soil, sand, miniaturized scale life forms and vegetation. Constructed wetlands also known as root-zone system is or bio-filter reed bed system or treatment wetland system or phytotechnology or phytoremediation system. In sub-surface horizontal flow constructed wetlands, waste water flows horizontally through the substrate. Angular horizontal sub surface flow wetlands are constructed for the process of the Phytoremediation with a slope of 10^0 with three layers of support using pebbles, soil and garden soil with 10cm height each. Vertical buckets are used as holding tank (Inlet) to hold the waste water. The vertical pipe was placed above the tub in an inverted 'T' shape for equal distribution of wastewater which was connected with the rubber pipe to the inlet of holding tank for each set. Plastic cans were used for the collection of treated water and for flowing out from the root zone bed through the outlets.

Measurement and Analysis of water quality parameters:

The sewage water collected from the Campus was analyzed for different parameters such as pH, Electrical Conductivity, Total Suspended Solids, Total Dissolved Solids, Total Solids, Biological Oxygen Demand, Chemical Oxygen Demand, NO_3, PO_4 and SO_4. These parameters were measured as per the standard methods of APHA before and after the treatment.

RESULTS AND DISCUSSION

Table 1 Values of the sewage water sample before treatment

S. No	Conc. of sewage	pH	EC	TSS	TDS	TS	BOD	COD	NO_3	PO_4	SO_4
1	10%	**8.00**	**0.99**	**115**	**607.5**	**722.5**	**4.76**	**14.8**	**5.4**	**3.60**	**28**
2	20%	7.79	1.10	153	659	817	5.87	17.4	6	5.12	39
3	30%	7.56	1.20	159	786.5	945.5	6.72	19.3	9.5	8.66	53
4	40%	7.49	1.29	166	848.5	1014.5	7.18	21.8	11.7	9.86	66
5	50%	7.32	1.38	167.5	957	1124.5	9.49	24.4	13.2	12.41	78
6	60%	**6.63**	1.46	237.5	998.5	1236	10.90	27.7	17	14.56	84
7	70%	6.85	1.61	259	1125.5	1384.5	17.57	36.9	19.6	16.83	89
8	80%	6.87	1.74	299	1235.5	1534.5	29.22	46.6	21.4	17.92	94
9	90%	6.78	1.96	346	1323	1669	41.03	92.8	24.6	18.81	97
10	100%	6.77	**2.59**	**393**	**1362**	**1755**	**46.72**	**118**	**26.8**	**21.60**	**107**

Table 2 Values of the sewage water sample after treatment with Colacasia esculenta

S. No	Conc. of sewage	pH	EC	TSS	TDS	TS	BOD	COD	NO_3	PO_4	SO_4
1	10%	7.89	0.91	103.80	471.49	575.17	3.74	11.12	4.1	2.90	23
2	20%	7.61	0.99	137.90	473.46	607.71	4.43	12.31	4.3	3.98	31
3	30%	7.44	1.04	141.78	522.97	665.01	4.86	12.76	6.1	6.32	39
4	40%	7.32	1.09	130.21	533.19	663.63	4.97	13.66	7.12	6.86	46
5	50%	7.34	1.16	117.83	564.12	682.51	6.71	14.32	7.22	7.90	51
6	60%	7.73	1.16	148.94	550.27	699.13	6.48	14.62	7.71	8.86	53
7	70%	7.18	1.23	139.46	561.74	701.26	6.41	15.24	7.94	8.92	54
8	80%	7.17	1.35	182.50	710.91	893.78	13.69	20.29	9.94	9.86	59
9	90%	7.25	1.57	226.34	767.74	994.19	20.84	40.63	12.69	11.23	64
10	100%	7.24	2.09	298.76	799.17	1097.87	23.98	51.83	14.34	13.76	78

Table 3 Values of the sewage water sample after treatment with Canna indica

S. No	Conc. of sewage	pH	EC	TSS	TDS	TS	BOD	COD	NO_3	PO_4	SO_4
1	10%	7.51	0.84	98.29	454.63	553.02	3.32	8.9	3.2	2.41	19.5
2	20%	7.29	0.89	127.16	452.81	583.42	3.97	9.6	3.3	3.26	26
3	30%	7.25	0.94	122.45	505.39	627.71	4.22	10.1	4.6	5.26	34
4	40%	7.17	0.97	122.73	521.84	644.41	4.28	10.3	5.2	5.63	39
5	50%	6.98	1.00	119.20	544.02	662.52	4.97	10.5	5.3	6.83	42
6	60%	6.66	1.02	128.19	548.72	676.90	5.41	10.9	6.1	7.56	46
7	70%	7.24	1.12	130.50	550.28	680.77	6.84	11.2	6.3	7.76	47
8	80%	7.26	1.16	136.09	551.08	687.08	7.66	11.5	6.4	7.88	48
9	90%	7.21	1.33	205.59	580.68	786.05	13.01	28.4	6.7	8.92	49
10	100%	7.27	1.83	231.41	661.02	892.47	17.33	41.4	7.2	10.63	57

Table 4 Values of the sewage water sample after treatment with Control

S. No	Conc. of sewage	pH	EC	TSS	TDS	TS	BOD	COD	NO_3	PO_4	SO_4
1	10%	7.71	0.93	107.87	475.52	583.24	3.80	11.36	4.6	3.12	25
2	20%	7.69	1.00	137.90	472.28	613.75	4.49	12.65	4.9	4.34	33
3	30%	7.52	1.06	138.74	540.33	679.29	4.94	12.86	7.2	6.87	42
4	40%	7.44	1.14	139.16	571.35	710.75	4.93	12.92	8.9	7.08	55
5	50%	7.34	1.21	120.75	676.95	797.77	7.43	15.76	10.4	10.56	68
6	60%	7.75	1.30	175.10	702.35	877.41	8.67	18.56	13.6	12.78	74
7	70%	7.18	1.44	197.23	792.46	989.78	14.19	25.12	15.8	14.08	79.5
8	80%	7.21	1.56	258.22	921.56	1181	24.38	33	18.2	15.96	84
9	90%	7.29	1.77	299.13	998.26	1297.55	35.65	78.56	21.2	16.96	88
10	100%	7.20	2.34	341.86	1046.53	1388.37	40.54	102	23.4	19.84	100

The treatment efficiency of the Angular Horizontal Subsurface Constructed Wetland unit was examined by wastewater quality parameters such as pH, EC, TSS, TDS, TS, BOD, COD, Nitrate, Phosphate and Sulphate respectively, in the inlet and outlet of wastewater at HRT of 4 (96 hrs) days. The treated and untreated samples of sewage with different dilutions viz. 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% were tested and compared with a reference set as control (without plants). The sewage collected was initially having turbid colour. It was full of dirt containing solids. The colour and odour were removed and hence treated samples were observed clear and odorless.

Figure 1 Sewage water before treatment

Figure 2 Water after treatment

Figure 3 CW with *Control*

Figure 4 CW with *Canna indica*

Figure 5 CW with *Colacasia esculenta*

pH

pH refers to the measure of hydrogen ion concentration in a solution and defined as the negative log of H+ ions concentration in water and wastewater. The minimum and maximum values of pH before treatment are 6.63 and 8.0 respectively. After treatment the values of the pH are around 7 only which indicates that the neutral pH is maintained. Drinking water with a pH between 6.5 and 8.5 is generally considered satisfactory.

The average wastewater pH values obtained in the plant bed for the inlet and outlet of Angular- HSSF- CW were 7.17 to 7.89 and 6.66 to 7.51 in Colacassia esculenta and Canna indica respectively and in the control bed 7.18 to 7.75 respectively.

Electrical conductivity

Conductivity of a substance is defined as “the ability or power to conduct or transmit heat, electricity or sound”. The minimum and maximum values of EC before treatment are 0.99 and 2.59 respectively. Irrigation waters up to 2 millisiemens / cm conductance have been found to be suitable for irrigation depending on soils and climatic characteristics. It is also used indirectly to fine out inorganic dissolved solids. The water samples after treatment have less than 2 milli Siemens/ cm except in 100% sewage concentration of Colacasia esculenta and control.

The maximum EC reduced was by 23.60% and 33.33% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Total suspended solids

Total suspended solids can be referred to materials which are not dissolved in water and are non filterable in nature. It is defined as residue upon evaporation of non filterable sample on a filter paper. The values before treatment are almost above 150 mg/l and after the treatment on with Canna indica all the values are below 150 mg/l except 90% & 100% concentrations and in case of the Colacasia esculenta 80% to 100 % concentrations are above 150 mg/l.

TSS was reduced by 46.15% and 54.48% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Total dissolved solids

Total dissolved solids refer to materials that are completely dissolved in water. These solids are filterable in nature. It is defined as residue upon evaporation of filterable sample. If the TDS value of the water sample is less than 1000 mg/l, then the water is considered to be fresh water. Except in control all the treated water has the TDS values below 1000 mg/l.

TDS were reduced by 50.08% and 56.10% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Total solids

Total Solids is the term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. It is defined as residue upon evaporation of free water. Thus, Total solids are nothing but summation of total dissolved solids and total suspended solids. If the TS value of the water sample is less than 1000 mg/l, then the water is considered to be fresh water. Except in control all the treated water has the TS values below 1000 mg/l.

TS were reduced by 49.34% and 55.22% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Biological oxygen demand

BOD of water or polluted water is the amount of oxygen required for the biological decomposition of dissolved organic matter to occur under standard condition at a standardized time and temperature. Any effluent to be discharged into natural bodies of water should have BOD less than 30 mg/L. All the BOD values after the treatment are less than 30 mg/l except in the control indicating that the treated water may be released in to the nearest water bodies and can be used for the irrigation purposes.

BOD was reduced by 63.51% and 68.29% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Chemical oxygen demand

The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. The COD values before treatment were above 100 mg/l but after the treatment the COD values have been reduced to less than 50 mg/l. The COD value is almost 2.5 times the BOD value.

COD was reduced by 58.69% and 75.32% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Nitrates

Determination of nitrate (NO^{3-}) is difficult because of the relatively complex procedures required, the high probability that interfering constituents will be present and the limited concentration ranges of the various techniques. Nitrate is the most highly oxidized form of nitrogen compounds commonly present in natural waters. Excess of the nitrates in the surface water may cause eutrophication. Nitrates concentration has been reduced to less than 10 mg/l after treatment.

The maximum NO_3 was reduced by 59.48% and 73.13% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Phosphates

Detergents are among the greatest contributors to phosphate content in rivers and lakes because phosphate containing compounds are used in detergent formulation as water softeners (builders). Phosphate is not toxic to animals or plants. In fact, it is a plant nutrient which stimulates the growth of aquatic Weeds and algae. This may cause lakes and rivers to become clogged and overrun with plants. The phosphates concentration has been reduced to almost 50% after the treatment.

PO_4 was reduced by 46.99% & 56.02% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

Sulphates:

Sulphate is widely distributed in nature and may be present in natural waters in concentration ranging from few hundred to several thousand mg/L. These dissolved minerals contribute to the mineral content of drinking-waters. The values of the sulphate before treatment was nearly 100 mg/l but after treatment it was around 50 mg/l except in high concentrations of the control indicating that the treatment is efficient in reducing the values.

SO_4 was reduced by 39.32% & 49.48% in case of the *Colacasia esculenta* and *Canna indica* respectively in present study.

CONCLUSION & FUTURE WORK

The difference in the efficiency of each parameter in both sets indicated that the use of *Canna indica* is helpful for better treatment of sewage at almost all concentrations as compared to *Colocasia esculenta* and reference or control set of CW. The pollution reduction efficiency is higher up to 70% dilution factor in experimental test set with *Colocasia esculenta* than the reference or control set (without plant). It has considerable capacity of pollution reduction and generating treated water which is useful for some common uses like gardening, washing, irrigation and general uses like toilet flushing, cooling, fish cultivation, floor washing and cleaning applications in both, households and industries.

After an elaborate analysis of the significant parameters on the Phytoremediation using Constructed wetlands, the future scope of study may encompass the Correlation of the parameters using various methods for quantity of the water filtered and the time taken & Constructed wetlands planted with mixed culture of different species or using Genetic Engineering may give the better performance than the single species.

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A Jar Test Study on the use of Alum and Ferric Chloride for Turbidity Removal

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ABSTRACT

In-line coagulant injection facility is an innovative application technology in restoring Eutrophic lakes. In this technology, guidelines for dose calculation and application are lacking. Coagulation in combination with flocculation and sedimentation is a process that is commonly used in water treatment to remove undesirable contaminants. Ferric chloride and Alum, which are the most common types of coagulants in water treatment plants of Iran as well as many other countries, were investigated with the aim of determining their capabilities to reduce turbidity of water sample collected from Durgam Cheruvu in the month of June 2016. In this study, Jar tests are carried out to optimize coagulant dose and study the effect of Alum and Ferric chloride on Physicochemical parameters such as pH, EC, TDS, SO_4, NO_3, Cl and Alkalinity. Results showed that coagulation process could remove turbidity effectively using Alum and Ferric chloride tested within (50-100 mg/L) dose range. It was noted that turbidity removal is dependent on pH, coagulant dosage as well as initial turbidity of lake for both used coagulants. The highest turbidity removal efficiency was within 66-76 % for Alum and 71-80% for Ferric chloride over applied range of dose. Both applied coagulants demonstrated promising performance in turbidity removal from the lake sample.

Keywords: Durgam Cheruvu, Turbidity removal, Jar test, Coagulation, Ferric chloride, Alum.

INTRODUCTION

Lakes in urban region are ecologically sensitive zones and true indicators of sustainable and progressive urban development. Generally, the wastewater discharged to lakes contains excess levels of nutrients such as nitrogen, phosphorous and organic substances. These are an important macro-nutrient for plant and microorganisms growth resulting in excessive growth of algae and aquatic weeds in lakes resulting in serious impairment to water quality leading to eutrophication. Thus, it is necessary to reduce the concentration of external phosphorus, nitrogen from inflowing wastewater to prevent the algal bloom. To achieve this innovative method of reducing organic loading to lakes uses engineered systems to treat lake inflows with chemical coagulants such as aluminum sulfate (Alum), polyaluminum chloride, aluminum chlorohydrate and iron-based coagulants like Ferric chloride, Ferric sulfate and Ferrous sulfate. The addition of these coagulants to inflowing wastewater results in the production of chemical precipitates which remove pollutants.

Durgam Cheruvu (Fig 1.) is a freshwater lake located in Rangareddy district, Telangana, India. The lake, which is spread over 83 acres (34 ha), is located near the city of Hyderabad. The lake is also known as Secret Lake because it is hidden between the localities of Jubilee Hills and Madhapur. Under the rule of the Qutb Shahi dynasty (ca. 1518–1687), this lake served as the drinking water source for the residents of Golkonda fort. In 2001, the tourism department of the local government initiated steps to promote the lake as a tourist destination. Because of the unique rock formations abutting the lake, it was designated as a protected area. In 2001, the state high court issued an order to the local pollution board and the city's water supply and sewerage board not to allow development of new residential localities near the lake. Furthermore, the court order also asked these agencies to take immediate steps for prevention or collection and treatment of domestic sewage flowing into the lake from the residential colonies in the vicinity and catchment area of the lake. Despite these notifications, the local agencies have failed in controlling both pollution and illegitimate constructions on the lake bed.

OBJECTIVE

The main objective of this study was to estimate the efficiency of coagulant dose for coagulation of Lake Durgam Cheruvu, by considering the maximum turbidity removal. Specific objectives were:

- To understand the process of flocculation, coagulation and settling
- To estimate the optimal dose and coagulant for treating lake water
- To evaluate the effect of coagulants on removal of turbidity
- To investigate the effect of coagulants on physicochemical parameters
- To estimate the performance of an ideal sedimentation tank

Figure 1 Status of Durgam Cheruvu in the month of June, 2016

REVIEW OF LITERATURE

Findings on various coagulation processes have been reported in literature. Some of these include;studying the effect of dosage and mixing conditions on the flocculation of concentrated suspensions using polymeric coagulants (Ghaly et al., 2007; Faiku et al., 2010); coagulation of synthetic water by plant seeds (Diaz et al., 1999) and coagulation of low turbidity water using bentonite (Shen, 2005). Guida et al. (2007) used alum as coagulant to remove COD and Total Suspended Solids (TSS) from municipal wastewater samples. The coagulation experiments indicated that alum effectively removed COD (65%) and TSS (>75%) on the average values of COD using 150 mg L^{-1} aluminum sulfate at a pH range of 5-8 (Guida et al., 2005).

MATERIALS AND METHODS

Qualitative analysis of Durgam Cheruvu sample pre and post jar test study was successfully performed in water quality laboratory of JNTUH. The water sample was collected in the month of June 2016 at 17.4327866°N 78.3889856°E coordinates using polythene cans of 10L capacity from a depth of 0.5 m below the surface of lake. Physicochemical parameters such as pH, EC, Turbidity, TDS, SO4, NO3, Cl and Alkalinity were measured using Elico | Water Quality Analyzer PE 138 as per water quality guidelines and laboratory methods enforced by NEERI. Quality report was validated by comparing the current study results to BIS 10500 : 2012. Stock solutions of 1% Alum and Ferric chloride were prepared. All the chemicals used in the study were of Analytical grade. Jar test experiments on the collected samples of 1L volume were used to study the performance of Aluminum Sulphate (Al2(SO4)3.18H2O) and Ferric Chloride (FeCl3. 6H2O) coagulants on a six stirrer DBK Flocculator Jar testing apparatus (Fig 2.) at room temperature with experimental characteristics as summarized in Table 1. At the end of Jar test after providing sufficient settling time leaving the settled flocs aside, 50 mL of supernatant was withdrawn from the jar of 1L capacity and thoroughly filtered using filter paper and stored for future analysis.

Table 1 Experimental characteristics for Jar test study

Characteristics	Description
Coagulants	Alum and Ferric Chloride
Coagulant dose range	50-100 (mg L^{-1})
Rapid mixing	2 min at 161 (rpm)
Slow mixing	30 min at 25 (rpm)
Settling time	2 hours

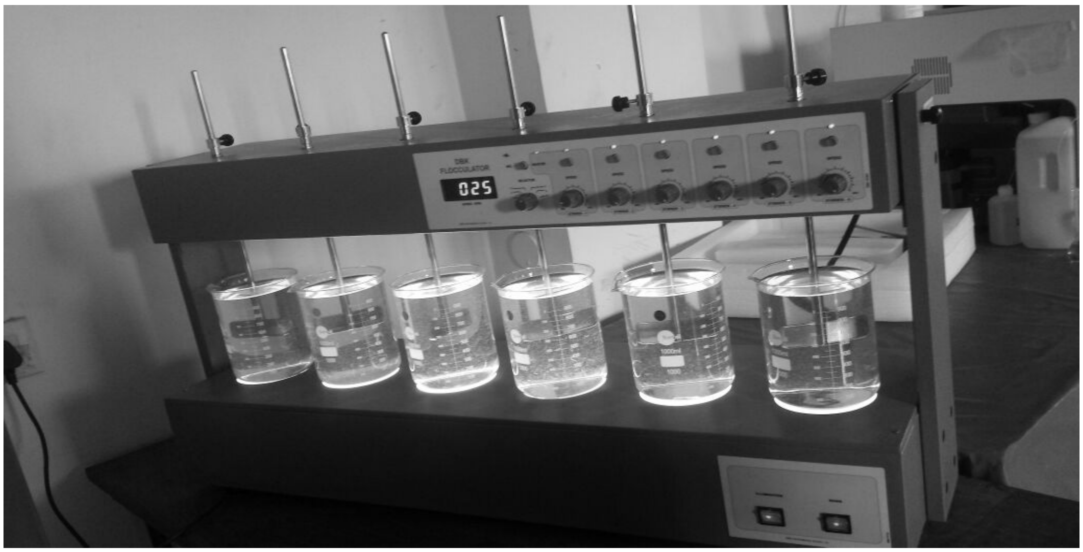


Figure 2 DBK Flocculator Jar testing Apparatus

RESULTS AND DISCUSSIONS

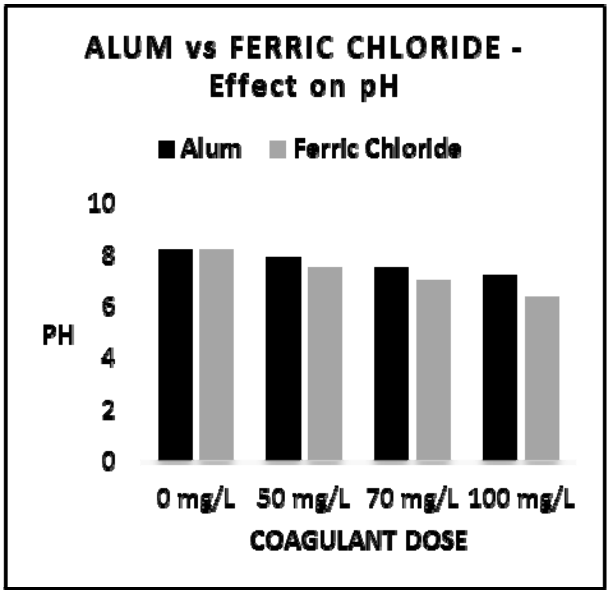
Figure 3 presents the results obtained for pre and post Jar test studies performed on Durgam Cheruvu samples using Alum and Ferric chloride tested within (50-100 mg/L) dose range. Results indicated that performance of ferric chloride was better than alum in all cases, however, turbidity removal efficiency showed an almost similar pattern for both alum and ferric chloride. Coagulation and flocculation process is a primary and cost-effective process in water treatment plants which can effectively remove turbidity from low to high turbidity waters when operational condition is optimized. Optimization of pH and coagulant dose may increase the coagulation efficiency and reduce the sludge volume and subsequently sludge management costs.Coagulant aids may improve coagulation process and turbidity removal. But it should be considered that coagulant aids should not increase water treatment costs significantly. Their accessibility and preparation procedure should also be considered when selecting a coagulant aid. It should be noted that rapid mixing parameters including time and intensity of mixing, as well as slow mixing parameters may also affect turbidity removal efficiency in coagulation process.

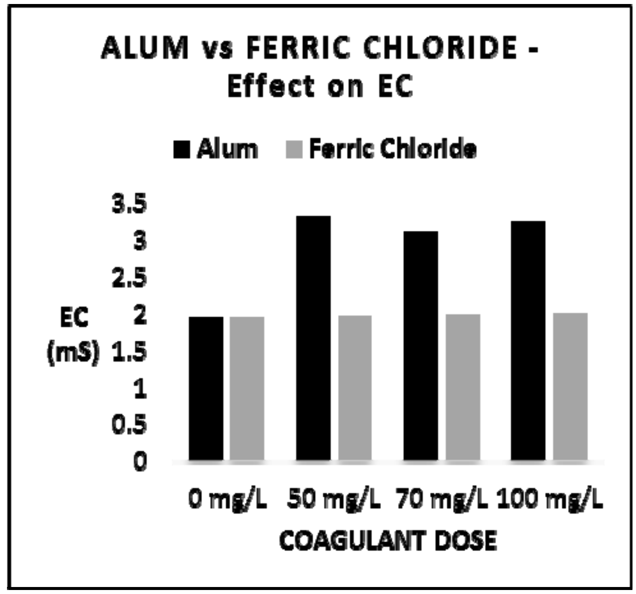
Basic stoichiometric reactions occuring during the coagulation process for ferric chloride and aluminum sulfate (Alum) are given below:

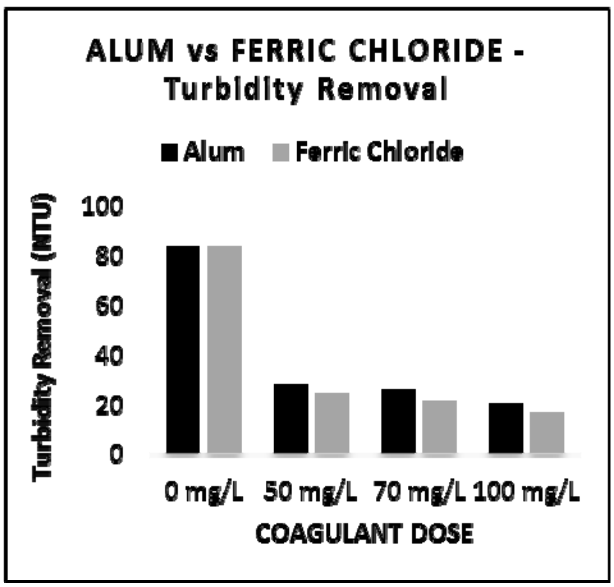
$$FeCl_3 \cdot 6H_2O + 3(HCO_3^-) \rightarrow Fe(OH)_{3,am\downarrow} + 3Cl^- + 6H_2O + 3CO_2$$

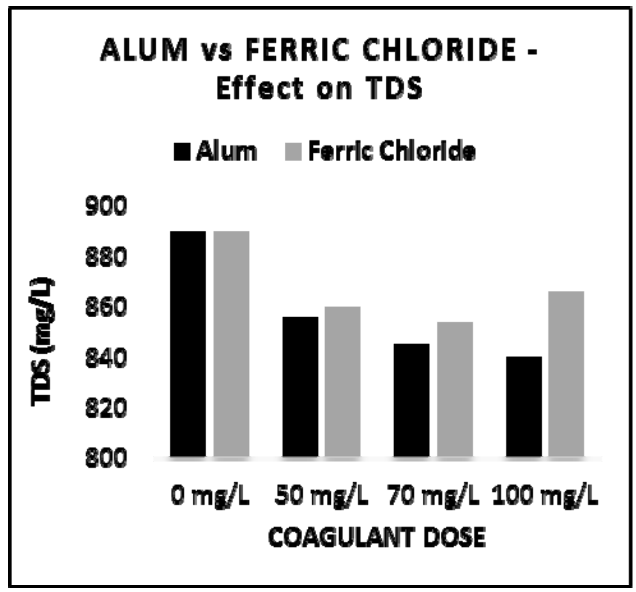
$$Al_2(SO_4)_3 \cdot 14H_2O + 6(HCO_3^-) \rightarrow 2Al(OH)_{3,am\downarrow} + 3SO_4^{2-} + 14H_2O + 6CO_2$$

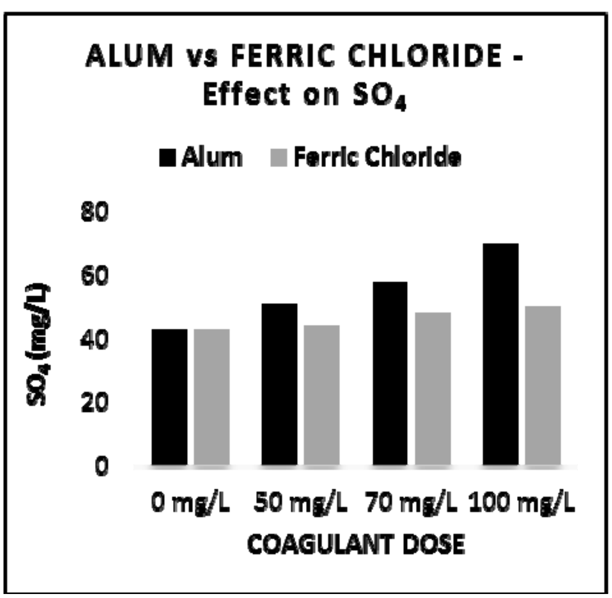
The natural alkalinity of the lake is thus a key parameter for determining the allowable dosing of the water with alum and ferric chloride. Coagulants react with available alkalinity such as carbonate, bicarbonate and hydroxide or phosphate to form insoluble salts.

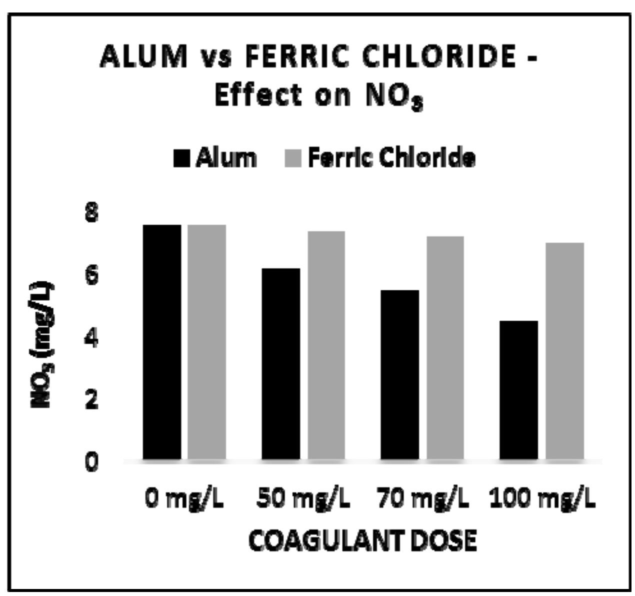

ALUM vs FERRIC CHLORIDE - Effect on pH
Alum
Ferric Chloride
PH
10
8
6
4
2
0
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE

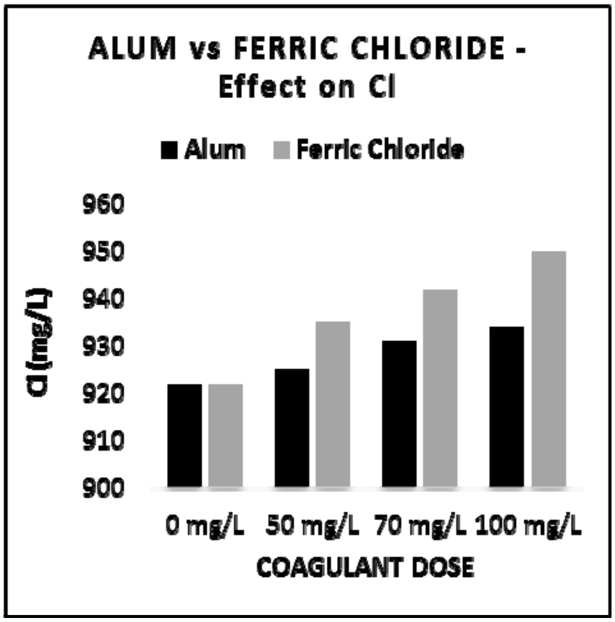

ALUM vs FERRIC CHLORIDE - Effect on EC
Alum
Ferric Chloride
EC (mS)
3.5
3
2.5
2
1.5
1
0.5
0
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE


ALUM vs FERRIC CHLORIDE - Turbidity Removal
Alum
Ferric Chloride
Turbidity Removal (NTU)
100
80
60
40
20
0
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE


ALUM vs FERRIC CHLORIDE - Effect on TDS
Alum
Ferric Chloride
TDS (mg/L)
900
880
860
840
820
800
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE


ALUM vs FERRIC CHLORIDE - Effect on SO4
Alum
Ferric Chloride
SO4 (mg/L)
80
60
40
20
0
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE


ALUM vs FERRIC CHLORIDE - Effect on NO3
Alum
Ferric Chloride
NO3 (mg/L)
8
6
4
2
0
0 mg/L
50 mg/L
70 mg/L
100 mg/L
COAGULANT DOSE



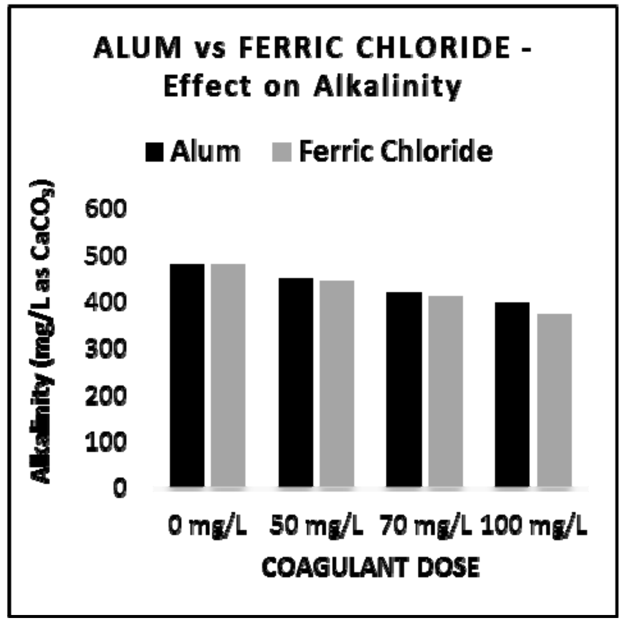


Figure 3 Results obtained for pre and post Jar test studies using alum and Ferric chloride coagulants

Coagulation with Alum

Results of coagulation studies with alum shows the optimum dose of alum to be 100 mg/l for higher turbidity removal. It was observed that the turbidity removal efficiency increased with increase in dose. It is to be noted that addition of alum to lake sample had increasing and decreasing effects on all the physicochemical parameters tested in the current study. A slight decrease in pH was observed with increase in dose this may be due to the reaction of alum with available alkalinity of sample thus reducing alkalinity upon adding alum. Interestingly, The electrical conductivity of lake samples increased beyond the permissible limits with increase in dosage which is undesirable. This may be due to dissociation of alum in water that produced ions to increase EC. Negligible reduction in TDS and NO_3 and slight increase in SO_4 and Cl parameters were observed with increasing dose of alum when compared to the raw lake sample. Alum showed better results in reducing nitrate levels of raw lake sample when compared to Ferric chloride.

Coagulation with Ferric Chloride

Results of coagulation studies with ferric chloride shows the optimum dose to be 100 mg/l for higher turbidity removal. It was observed that the turbidity removal efficiency increased with increase in dose. It is to be noted that addition of ferric chloride to lake sample had increasing and decreasing effects on all the physicochemical parameters tested in the current study. Decrease in pH after ferric chloride addition was slightly greater than alum with increase in dose. This may be due to the reaction of ferric chloride with available alkalinity of sample thus reducing alkalinity much more than alum. The electrical conductivity of lake sample negligibily increased with increase in dosage. Negligible reduction in TDS and NO_3 and slight increase in SO_4 and Cl parameters were observed with increasing dose of ferric chloride when compared to the raw lake sample.

Coagulation processes do not reduce turbidity alone, and in some cases, turbidity increases during the coagulation process because the coagulant adds more particles to the water being treated. The combined process of coagulation, flocculation, and sedimentation are required to reduce turbidity. In this study highest turbidity removal efficiency was within 66-76 % for Alum and 71-80% for Ferric chloride over applied range of dose. Both applied coagulants demonstrated promising performance in turbidity removal from the lake sample.

CONCLUSIONS

The Jar test experiments using Alum and Ferric chloride indicated that coagulation process effectively removed turbidity from Durgam Cheruvu samples applied over 50-100 mg/L dose range. The highest turbidity removal efficiency was within 66-76 % for Alum and 71-80% for Ferric chloride. Generally results showed that turbidity removal efficiency was almost same for Aluminium sulphate and Ferric Chloride. However, the sludge volume obtained after settling of flocs were comparitively high in case of Ferric chloride than Alum. Formation of larger flocs can cause problems during filtration stage. Hence, clogging of filters must be avoided by regular maintenance to enhance coagulation results. Turbidity removal efficiency was insufficient to meet national drinking water limits of India (5 NTU) at tested doses. The reason may be due to raw water characteristics leading to poor settling which is causing an impact in reducing the removal efficiency to certain extent. Water sources with poor settling characteristics would require a longer amount of time for flocculation and sedimentation in order to significantly decrease the water's turbidity. Application of different dosage and alternative coagulants to meet allowable limits should be further studied. Investigating the influence of agitation time and settling time for varying doses and pH conditions on turbidity removal by other coagulants is suggested for future studies.

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THEME – VI

WATER CONSERVATION AND IRRIGATION MANAGEMENT

Diversity of Algae in the River Krishna near Gadwal, Telangana

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ABSTRACT

Phycological study was made in the river Krishna to assess diversity and the quality of water. Three sampling stations, covering a distance of 20 km. were selected near Gadwal. Surface water and algae were sampled once a month and analyzed for various parameters. pH, dissolved oxygen and carbonates were recorded in high concentrations. Nitrates were present moderately whereas phosphates, chlorides, organic matter, nitrites and total hardness were in low proportions. The algal spectrum revealed the abundance of diatoms followed by Cyanophyceae and Chlorophyceae. Desmids were present good in number. The critical analysis of diatoms showed biraphidae members in high quantity. *Cymbella cesati, C. aspera, C. microcephala, Nitzschia denticula* var. *curta, Cosmarium granatum* and *C. subspeciosum* were very common indicating the clean water conditions

Keywords: River Krishna, Physico-chemical parameters, Phytoplankton and Diversity.

INTRODUCTION

The rivers are getting polluted due to the entry of domestic, agricultural and industrial wastes, thus creating ecological imbalance in the ecosystem. This problem warrants systematic suitable methods for its detection, assessment and control. The study of river ecology has gained immense importance in recent years because of multiple uses of river waters for human consumption, in agriculture and industry. Biological methods are used for monitoring river water quality for a variety of reasons most of which have been well documented (Kumar and Sinha, 2010).

Algae are the ubiquitous; they are the primary producers for all the aquatic systems. In total 40% of global photosynthesis is contributed by algae. The algae are tremendously diverse and show an ability to tolerate a wide range of environmental conditions. Under natural conditions they usually grow in a mixed community. Phytoplankton succession is a well-known phenomenon in aquatic ecology and several studies have described the patterns and underlying mechanisms of the seasonal dynamics (Badola and Singh, 1981). The present paper deals with the ecological diversity of algae in the river Krishna near Gadwal.

MATERIAL AND METHODS

The River Krishna is 1300km long, rises near Mahabaleshwar in the Western Ghats and transverses through the states of Maharashtra, Karnataka, Andhra Pradesh and Telangana. In Telangana and Andhra Pradesh it flows through Mahabubnagar, Srisailam, Nagarjunakonda and Vijayawada and finally joins the Bay of Bengal. It is a major source of irrigation for Maharastra, Karnataka, Andhra Pradesh and Telangana. The present study deals with the ecological study of the river Krishna at Gadwal in Telangana to collect the algae for diversity.

The diversity of algae in the river Krishna has been studied for 1 year (May 2015 to April 2016). Three sampling stations covering a distance of about 20km were selected along the course of the river at Kothapally, Agraharam and Molkalpally near Gadwal town. For this purpose the algal samples and water samples were collected and analyzed quantitatively and qualitatively. Water samples were analysed some important nutrient parameters by following the standard procedures APHA (2005). All the collected water samples were fixed with 4% formaldehyde and the final volume of the sample was reduced to 50mL by sedimentation. This concentrated material was used for frequency measurements and species identification. Uniform size pebbles were collected for benthic algae. For the collection of benthic algae the field technique adopted by Blum (1957) and Venkateswarlu (1969a).

RESULTS AND DISCUSSION

Physico-chemical parameters

The average values of various physico-chemical factors are given below in Table-1. The river water was alkaline with pH always above 8.5. Carbonates were present at all the stations throughout the period of investigation. Bicarbonates were found high during summer season (March-June) and low during rainy season. Organic matter and nitrites were recorded in very low concentrations throughout the period of investigation. Phosphates could not be detected for most part of the investigation. Silicates were present considerable quantities. Calcium was always higher than the Magnesium.

Dissolved oxygen was always present in considerable quantities. It is one of the most important factors in water quality studies and it influences the distribution and abundance of algal populations (Hujare, 2005). It is also important in bringing about various biochemical changes. In general unpolluted sites of the river show satisfactory concentrations of DO. i.e. more than 5.0 mg/L. However in the present investigation water is well aerated with high DO content. (Average values 8.1, 8.8 and 8.2 mg/L at station-I, II and III respectively. Silicates constituted an important major nutrient for the abundance of diatoms and play an important role in succession and productivity of this group (Khaiwal *et al*., 2003). In the river Krishna they were present in considerable quantity. The concentration of silicates depends upon the nature of the substratum. In general freshwater will always have low hardness. In the river Krishna the hardness of water appears to be temporary which is mainly due to carbonates and bicarbonates of calcium and magnesium (Joshi *et al*, 2009).

Table 1 Average values of physico-chemical parameters
(All parameters are expressed in mg/L except pH)

Parameters	Station-I	Station-II	Station-III
pH	8.6	8.5	8.6
CO_3^{2-}	23.3	23.8	23.3
HCO_3^-	128.9	136.4	134.1
Cl^-	68.0	69.8	69.7
DO	8.1	8.8	8.2
OM	1.3	1.5	1.4
TH	152.9	152.8	152.1
Ca^{2+}	30.6	30.1	29.7
Mg^{2+}	18.5	19.0	19.1
SO_4^{2-}	56.6	58.8	58.3
PO_4^{3-}	traces	traces	traces
SiO_2	6.8	5.5	5.4
NO_3^-	0.001	0.001	0.001
NO_2^-	0.76	0.75	0.76

Phytoplankton

In the river the microscopic observations of the flora revealed that the plankton is represented by different groups of algae. The percentages of various groups and the number of species present have also been calculated (Table-2). The diatoms constituted the main bulk of benthic algal populations. Chlorophyceae, Cyanophyceae and Dinophyceae were represented by a few species of algae. The neutral or slightly alkaline waters harbor more number of species (Venkateswarlu, 1969c).

Table 2 Percentage of various groups of phytoplankton

Phytoplankton	Station-I	Station-II	Station-III
Bacillariophyceae	78.4	75.6	72.4
Chlorophyceae	9.6	7.8	9.2
Cayanophyceae	10.6	9.2	10.2

Diatoms maximum growth and development was observed during winter months and minimum during summer and rainy seasons. High dissolved oxygen, low organic matter, alkalinity and substratum were influenced the diversity of diatoms (Naik *et al.,* 2005). Among diatoms *Cymbella aspera,* C. *tumida, C. cymbiformis, C.affinis, C.tumidula, C.cistula, Gomphonema montanum, G. constrictum* var. *capitatum, G. gracile, G. Lanceolatum, Stauroneis phoenicenteron, Navicula cuspidata, N. bacillum, Mastogloia smithii, Raphalodia gibba, Amphora ovalis* mainly formed the bulk of populations.

Chlorophyceae was mainly represented by desmids. However Chlorococcales were present low numbers. High Chlorophycean count registered during summer months due to low DO and bicarbonate level prevailing during these periods, which favors its quick growth (Ibrahim and Abdullahi, 2009). Station-I and Station-III exhibited high percentage of green algae as compared to station-II. These algae attaines maximum development during December-March and minimum during June-October. The peaks were mainly due to the presence of *Cosmarium granatum, C. variolatum* var. *rotundatum, C. subspeciosum* and *C. leave*. Apart from chlorococcales and desmids filamentous green algae were also present in the river (*Oedogonium sp.,* and *Spirogyra sp*.)

Desmids constitute the main bulk of green algal populations. As expected they occur in oligotrophic and unpolluted water. Desmids are considered to be very sensitive group of phytoplankton. They are unable to withstand even negligible changes in the quality of aquatic habitats. High DO, pH, low organic matter and nitrates seem to be the factors responsible for their distribution in the river.

In the present study the blue-greens constituted the low number of phytoplankton. Cyanophyceae showed maxima in summer months (March-May) and minima in winter (January, February) at all the study stations. Most of the investigators (Venkateswarlu, 1969a, Manikya Reddy and Venkateswarlu, 1992 and Sudhakar *et al.,* 1994) recorded this group in polluted environments and used it as good indicator of water quality. In cyanophyceae *Gomphosphaeria aponina, Oscillatoria princeps*, *O. formosa*, *Chroococcus turgidus* and *Merismopedia glauca* were present. These species always prefer unpolluted habitats and can survive well under high DO and low organic matter content (Jafari and Gunale, 2007).

In the river Krishna the critical analysis of diatoms showed that biraphidae represented high percentage followed by monoraphidae and araphidae. Centric diatoms were not encounteres. With in biraphidae *Cymbella* constitute the main bulk of population (Table 3). This clearly suggests that diatoms can be used as good indicators of river water quality. The species of *Cymbella* specially serve as indicator of clean water.

Table 3 Critical Analysis of diatoms in the river Krishna

Group	Genera	Species	Number of frustles
Centrales	Not recorded		
Pennales a. Araphidae 12.4%	*Synedra*	*S.ulna var.equalis* *S.tabulate* var.*obtusa*	690 200
b. Monoraphidae 14.3%	*Achnanthes*	*A.Minutissima* var.*cryptocephala* *A.microcephala*	780 625
c. Biraphidae 73.6%	*Cymbella*	*C.cesati* *C.affinis* *C.microcephala* *C.turgida* *C.aspera* *C.cuspidata* *C.cymbiformis*	640 610 600 565 355 200 180
	Calonies	*C.silicula* var.*trancatula* *c.bacillum*	570 530
	Mastogloia	*M.smithi* var.*amphicephala*	525
	Nitzschia	*Ni.denticula* var.*curta* *N.bacillum* *N.pupula f.rectangularis*	740 260 240
	Amphora	*A.ovalis*	390
	Diploneis	*D.ovalis*	335
	Rhopalodia	*R.gibba*	230
	Cymatopleurea	*Cy.solea*	300

CONCLUSION

The algal species composition in the river represents clearly the unpolluted organisms and showed rich diatom diversity. Thus it can be concluded that water in the river Krishna near Gadwal is unpolluted and can safely be used for drinking, agricultural and recreational purposes.

ACKNOWLEDGEMENT

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Eternal and Abundant Water Supply for India

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ABSTRACT

The “cause” of third world war, predicted by so many eminent and visionary personalities , is ”WATER”. The upcoming environmental and ecological changes that are taking place also are suggestive that the things are taking shape towards that disaster. The country that caters by harnessing its available water source to use it eternally and abundantly will be topping the list of successful and powerful countries of future world. Countries like India which needs to identify and harness its alternative source of water abundance to fully and profitably utilize its unique TROPICAL nature of advantageous atmospheric condition, along with huge availability of cultivable land utilization for productive use. The recently spoiled all beneficial project like “RIVER JOINING” was only on partisan local considerations having POLITICAL,SOCIAL elements, and “EGOS” that were involved by all participating personalities. Can we not think of an alternative concept, which could fetch India, for future generations together, every year replenishable , abundant sweet water ,to utilize it for all inclusive comprehensive growth, and still will not disturb in any form the existing nature’s ecological cycle ? It is a well known fact that during active monsoon of 15 to 40 days, there is huge downpour having floods, and, excess water flows to seas unutilized. My Unique concept is to harness 50% excess water that flows out to seas unutilized, Till this date, which is supposed to be beyond “HUMAN CAPABILITY”. This particular attempt is made in this project to give, Eternal and abundant water for INDIA

INTRODUCTION TO SOME RIGID FACTS

Let us now take into consideration some of the facts those exist now. Per capita water storage that persists for India is meager 262 cubic meters as compared to china’s around 2500,Australia’s 4700,Russia’s 6000 and America’s 6150cubic meters !!

- Out of 329 million hectors of available land for cultivation in India, 50% of this land needs to be made “Productive” as this land can not be irrigated for the reason—Insufficient Water.
- And most Importantly, Out of total rainfall water qty of 4000 BCM (billion cubic meters) available every year, out of which about 1750 to 1800 BCM water flows out to sea “Unutilized”, within the short spell of 20 to 40 days of Actual rainfall.
- Recent situation as far as Indian scenario is concerned, the authentic figures say that per capita availability of water has been reducing from 5200 cu. Meters in the year 1950 to almost 1200 cu. Meters in the year 2015 !!! (All the thanks for Population Explosion!) Though there is substantial increase in Nos of dams, from 300 in 1950 to about 5000 in 2014, adding to huge amounts of usable waters available, but actually ,the silt deposition in dams, and evaporation rate in exposed water surface of dam is still adding to water scarcity
- Reasons of this growing scarcity are known to every one-
    1. Exploding Population count
    2. Illegitimate use of Irrigation water for high water consuming cash crops like sugarcane, Banana etc
    3. Huge demand for growing Industries
    4. Equally responsible reason is pollution by mixing of effluent water into fresh water, making it unavailable as fresh water!!-
- It is equally important to know the fact about the shortage of electric power to source the subsoil and underground water for either purpose of irrigation or potable, industrial or other purposes. Hence the availability of subsoil water may not be the source of sure water quantity that is available for meeting the water scarcity.
- The ill effects of shortage of water on one side and equally polluting the fresh water sources more speedily on the other side, the end result and impact is seen in terms of
    1. Epidemics/disease on rise for inland population.

2. Overall sanitation scenario in bad shape.
3. Use of such polluted water reducing output norms of agricultural produce
4. Huge threat to aquatic life.

What could be the viable and plausible solution to this acute national level problem??

Tropical country like India, where by virtue of its topographical structure, maximum agricultural and forestation productivity can be planned, by making available the required water quantity, from the available source of monsoon water, going waste to seas during active monsoon.

As all of you ,and general people in India are aware of the much talked, surveyed and debated scheme of "River Joining", which could not take place for various reasons, prominent of them being

-"Sharing Quantities" from each beneficiary share of water in the river

-"Increase in benefits" after sharing the water is doubtful

-"EGO'S" of all the so called people's representatives in sharing the benefits!!

Consequent Effect—The scheme has been cold shouldered and transferred to " Non- Feasible" category

Preamble

In an attempt to find Perennial and Eternal solution for the recurring and irritating problem of water shortage, once for all, a concept of Huge capacity water reservoir is contemplated. In so many articles, surveys, seminars, conferences of knowledgeable and authority champions of water matters in India, as well as world renowned persons have unanimously agreed on the solution, to have "Huge Storage capacities, in terms of reservoirs", as, then only, the enormous needs of agricultural, industrial, infrastructural, and consequently Social growth of the society as whole could be a possibility !!

The obvious constraints of available land, safe storage parameters., no loss to Environmental aspects, as also the rehabilitation of destabilized people, are all to be taken care of while devising the means to think on this unique concept. The Unique concept of harnessing the excess 50% water that is flowing to seas during short period of active Monsoons, which till now is taken for granted "Beyond Human Capability " to harness and store, is thought of tacitly diverting and storing in a huge "Reservoir Canal".

Indian Rivers

There are about 10 major and another 15 other of sub- major rivers which have east bound flows ending into "Bay Of Bengal". These rivers form major outflow of waterto seas.There are only 3 major rivers which are west bound and join Arabian Sea. All the rivers flow as per their natural descending pathway as per the Topographic structure of terrains through which they flow. There are also rivers from north India which enter and terminate into seas, in other country's terrain/sea, and hence they are not taken into consideration, except Ganga.

Estuaries and Creeks

The water of any river joins the sea firstly thro' the Estuary or Lagoon and then thro' creeks to finally seas. Water retains its sweet nature almost to the end of estuary unless its topographical level is not below the creek topographic levels. But it starts the mixing with saline waters once it enters the creeks and salinity increases when it nears the sea levels. High tide and low tide phenomenon add to salinity increase and decrease at creeks as the case may be.

It appears that almost all the locations of estuaries of east bound rivers are in the range of 20 to 30 meters height from MSL and at a varying distance from sea shore, ranging between 20 to 35 kilometers. This is seen in Topographic images of entire

Indian east coast as well as west coast region.(Exact details to be further confirmed)

It is the uniqueness of this project that, the additional water quantity, that flows to seas is partially tapped out at a selective spot , just slight above the MSL height of estuary location spot, and diverting it by gravity, during active monsoon. This water then joins Main Canal through Connecting Canals of appropriate dimensions, at a location of suitable MSL height. The suave design (calls for engineering talents), serving the principle of decantation to shed off max amount of silt it carries, and overflows the decanted water, into Main Reservoir. Once such locations of all Connecting Canals for all the east bound rivers are confirmed, the partially drawn excess rain water flow from rivers easily keeps replenishing the rainwater every year into the huge Main Reservoir dug at an appropriate MSL height to get the water emptied by gravity flow from all the connecting canals. This Main Reservoir is dug along all coastal line at a distance of about 35 to 40 km inside land of coast. Thus the gravitational gradient is properly achieved to flow the water from spot before estuary to connecting canals and finally into main reservoir for ultimate use.

Main Reservoir Canal

A 2 meter wide land strip, at 35mtres above MSL and about 30 to 50 k.m (as the case may be),inside the coast (land side) will have to be earmarked alongside the entire seashore length of 7500 k.m. for the purpose of digging the Reservoir Canal .

The Reservoir canal forms the main backbone of this Eternal and Abundant water project. This canal will be having the dimensions of one kilometer width at top, and at every 100 meters width, it will have a step of 2 meter depth while moving towards centre place. The total depth will be 10 meters which because of stepwise inclination will have 5 meters average depth. In other words the depth at center will be 10 meters(sufficient to operate small transport boats) gradually reducing to lower depths at both banks. All the connecting canals will keep on replenishing the excess rain water tapped before estuaries into this reservoir canal perennially. If we extend the reservoir canal to entire coastal length of 7500 kilometers, then the total water storage that would be available is about 375,00,000cubic meters. which is huge at any scale. About 200 meters space will be left vacant for Agricultural crops on both banks, and adjacent to that 100 meters width roads will be provided on both sides, for transportation of goods and agricultural products. Almost 2.5 to 3.0,lakh Sq. k.m. land will be available for assured perennial irrigated farming, for the people staying on banks of this reservoir. Any Increase in depth at later stages could add to further storage capacities.

As regards safety ,and operational parameters of this reservoir canal , to control gushing waters with speed, and not getting contained in the reservoir canal this canal will have overflow weirs at appropriate interval of distances to have safest outlet to seas. The excavation and maintaining possible straightness of its path and a common bottom height is a gigantic task for the engineers of “Golden Quadrangle” technical team.

Installation of Thermal plants

Once the task of collecting the large quantity of water is completed, the next obvious move is the judicious utilization of this huge resource as Irrigation water. And this calls for Macro Level thinking. All the new thermal plants will be stationed at banks of this reservoir canal, which will have assured supply of abundant water. Fuel coal can be supplied to these power plants utilizing the water way transport of reservoir canal, utilizing the available water for washing of coal, effecting the cost cutting. The power plant presently facing the closure for almost more than 100 days can also be shifted at suitable locations on the banks of this canal. The enormous amount of electrical power generated will be utilized to pump the water at a height about 150 to 250 meters continuously into the small capacity reservoirs identified in eastern and western ghats as well as at such proper height storage locations .Since there will be constant power generation, and supply, no transmission losses of electricity for running these huge water pumps on 24*7*365 days basis. Ample water will be continuously available at higher height which further can be meticulously used by gravity for

1. Gravity Irrigation of lakhs of hectors of Plateau regions of UP, AP, MP, KTR, and MAH states.
2. On its gravitational fall pathway, there could be supplementary generation of Hydroelectricity
3. On its gravitational descending path, huge areas could be turned into new forests. Phase wise, in eastern and western ghats supporting much concerned “Biodiversity”
4. Combination of thermal and hydro electrical power models could bring down the cost of electricity as well as augment the availability of electricity, plentifully.
5. Since all the major irrigation will be by gravitational flow of water, hydro electricity could be profitably used for Industrial use, and supplementing needs of lifting of subsoil water for Potable water projects for human consumption.

Rehabilitation of affected people

The 2 kilometer wide strip running between sea shore and the adjoining land at a location of 30 -35 k.m. inside land and at a height of 35 meters from MSL(sea water level)will call for evacuation of people, properties, institutions, and even strategic locations. As this national project is mainly conceptualized for benefits of present as well as future generations. The chronic problem of water scarcity could be better answered by implementation of this project and hence it can decide country’s eternal future growth, on very larger scale. But it is equally important to safeguard the existence and well being of life of these affected people and their properties. This can only happen if we take care of proper rehabilitation of these people in accordance with the existing laws of land. In view of this ,All the affected people will be located and rehabilitated on the banks of this reservoir canal, to make them prosperous farmers, who are eligible to use this water from canal freely / at concessional rate. They can take 3 crops comfortably, as the water is not at all the constraint for them. The population that is going to be affected may be less as the coastal area density of population is less as compared to, that on central plateu plains. Hence the rehabilitation problem could be answered satisfactorily.

Overall Benefits

- Eternal and abundant water availability for large scale irrigation of presently non irrigable land upto 25 to 30 lakh hectors.
- Enormous growth of forests by reforestation using this water during its gravitational descent in mountain terrain and forest areas.
- Huge generation of dual form of thermal as well as secondary hydropower generation during gravitational descent path, taking country to a power surplus status.
- Assured irrigation along side of reservoir canal area for community farming, contract farming, crop pattern farming as well as selective individual farming could yield highest returns of food grain and fruits-vegetables.
- Alternative cheap waterway transportation of fuel coal and other materials compared to much costlier road surface transport.
- Round the clock monitoring of coastal area surveillance thro the reservoir canal by deploying coastal guard apparatus.
- No drought situation, no powercuts, no drinking water shortages, and most importantly ,there can be no dearth of subsoil water availability as the rise in water table will be sufficiently high.

Constraints / obstacles.

- The first important and essential thing needed is Public's Ardent Desire" to overcome this chronic problem once for all adopting this out of box solution.
- A sufficiently strong "Political Will " to implement the national mega project of longer duration and hyper costing nature.
- A killer instinct attitude by operation team to face, devise and accomplish all odds to complete this project in time bound fashion.
- Govt's inclination to provide an eternal solution to recurring problems arising out of water scarcity., like,
- Huge non productive burdens of expenditure to counter droughts, famine compensation, providing reliefs to affected people, non employments, low food grain produce, other related problems reducing growth rate of country.

INFERENCES AND CONCLUSION

This is a national project of Mega nature and calls for about 5 to 8 years to complete it on war footing. A prior detailed study needs to be at place for feasibility, affordability, cost benefit ratios, as also the social upliftment of human society purpose. Since 70% of coastal area is plain, only 30% area may call for provision of Tunnels, overways and diversions as the case may be for making this constant depth bottom reservoir canal. Prima facie budgets of this could be planner's wild imagination running into lakhs of crores of rupees, but once in place it could lead India to be a super power within no time. Since I am proposing this in my Individual capacity, it is likely to be questioned by experts of this subject. But once if they all agree this project's logical need and pathway to overcome this never ending crisis ,technical difficulties could be then "Non Issues" as we then can move towards **"From Impossible to making it Possible** "

An Assessment on Impact of Land Useland Cover Changes on Urban Watershed Management – A Case Study of Hyderabad Region

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ABSTRACT

Water, Land and Vegetation are the three basic natural resources essential for any life support system on the surface of Earth.Today the world is facing serious environmental problems like resource depletion, environmental degradation, scarcity of clean water and loss of biodiversitydue to increase in population. It is necessary to restore the ecological imbalance by developing these degraded wastelands and harness the full potential of available water resources and prevent its further degradation. Urbanization and industrialization are mainly responsible for changes in Land Use Land Cover thus contributing to degradation of the natural environment.These changes are leading to numerous environmental problems ranging from local to global scale such as decreased water supply, local climate alteration, land degradation, increased energy demands, increased water, air, soil pollution, poor sanitation facilities, traffic congestion, reduction in biomass and carbon storage/sequestration. Environmental Impact Assessment (EIA) particularlydue to urbanization has become the top priority andmany studies have been conducted with a goal to better understand the impact and issues related to LULC changes. The problems relating to water, degraded land, and its management are not only complex but also multi-dimensional in nature. Maintaining a balance between urban development and optimal utilization of available fresh water resources is a great challenge to engineers and hydrologists, thus an integrated watershed management approach needs to be adopted. The strategies employed shall not only be able to resolve conflicts among different users by keeping in view of ever increasing developmental activities in watershed regions but also to create awareness about the importance of sustainable watershed development.The goal of this review paper is to investigate the complexities of Land Use Land Coverchanges in the past in Hyderabad area and their influence on environment and specially onwater bodies. It also emphasizes how modern geospatial techniques like SDSS, Remote Sensing and GIS could be effectively used to detect the LULC changes at the earliest and take necessary measures so as to restore its majesty.

KeyWords: Land Use Land Cover,Watershed, Environmental degradation, Urbanization

INTRODUCTION

Nicknamed the blue planet, Earth is covered with one of the most precious natural resource thatisessential to sustain life. Unfortunately the resource is badly affected due to several factors like climate change, urbanization, deforestation, land use and land cover changesetc. Proper management of these resourcesis essential to satisfy urban needs, demadfromvarious sectors and also maintain ecological balance. Particularly in developing countries with huge population and agriculture as their main occupation, LULC changes have a serious impact on regional hydrological processes. Usage of conventional methods for gathering and analyzing dynamics of Land Use Land Cover changesare not only time consuming but error prone. Thus, we require new technologies which not only have the capability of acquiring timely data but also monitor the change detection at the earliest and help in mitigation for better environmental management. The study of Land Use Land Cover changes is very important for proper planning, utilization of available natural resources and their managementin developing countries which are densely populated. The urban sprawl of a city can be best understood by studying the dynamics of LULC change which can be easily generated by using sequential satellite images, required for the prediction of urban growth. The use of sophisticated hydrologic simulation models and Geographic Information Systems (GIS) has become the standard for evaluating these impacts of urban sprawl on water resources systems. These technologies can also be used for making better decisions in areas related to watershed management, hydrological analysis, flood monitoring etc.

The city of Hyderabad, is located in the Musi Sub-Basin (11,000 km^2), which is part of the larger Krishna Basin (265,000 km^2), that spreads across three states in India. Rapid development and economic growth of the city increased the city's population to around 7 million in year 2010 (UN-Habitat 2008) and these changes challenge urban developers, hydrologists and engineers. Urban water demand has grown exponentially within last two decades and water supply within the city limits has been inadequate to supply the growing needs leading to piped imports from more remote sources. Also, the area of land used for agricultural purposes within the city has been diminishing with the pressure for infrastructure development, while people have been migrating from rural areas in search of employment and better wages, which will only further stress service providers. The Musi River, a tributary of the Krishna River, flows through the city of Hyderabad and has become extremely polluted with discharges from the city. The scarcity of freshwater has encouraged wastewater irrigated agriculture, ranging from cereal to perishable crops, within and around the city boundaries, despite health and environmental risks. The city has witnessedchanges in the areal extent, distribution of water bodies and green cover in and around it based on the satellite image data analysis.It may be noted that as per national policy on forests, 1988 any area should be occupied by 33% of tress so as to maintain environmental stability and have a better environment to live in but unfortunately the green coveris dimished due to serious Land Use Land Cover changes.

SIGNIFICANCE OF THE STUDY

These LULC changes have significant impact on natural resources, socioeconomic development and environmental systems. However, to assess the effects on the stream flow, it is important to have an understanding of the LULC patterns and hydrological processes of the watershed. Understanding the impact of LULC changes is an essential indicator for resource base analysis andthis also aids in development of effective strategies for sustainable management of the available natural resources.Several researchers have focused on LULC studies because of their adverse effects on ecology of that area and moreover, the study presents a method to detect Land Use Land Cover changes and their impact on hydrological regime.

Watersheds – Conserving Natural Resources for a Better Future: Watershed development mainly focuses on conservation, regeneration and judicious utilisation of available resources. Proper watershed management bringsthe best possible balance between available resources on one side and increasing demand of human beings on other. Human beings and ecology are interdependent and significant changes in the environment directly affect lives of people depending on it. A degraded environment means a degraded quality of life of people which can be tackled effectively through holistic development of watershed. It is the process of guiding and organizing water, land use and other resources in a watershed to provide desired goods and services without adversely affecting water and soil resources. It also involves protection of land against all forms of degradation, restoration of degraded land, sedimentcontrol, pollutant control, and prevention of floods, etc. Monitoring of runoff and silt at the outlet of the watershed can assess the impact of various treatments aimed at conserving water, soil and protecting vegetation.

STUDY AREA

The area selected for the present study is Greater Hyderabad Municipal Corporation area which is situated between 17° 22' 31" North latitude to 78° 28' 27" East longitude.GHMC is the present urban planning agency that oversees Hyderabad, the capital and is the largest city in the State of Telangana. The city is nestled on the Deccan Plateau and is positioned at a height of around 500 meters from the sea level. The areal extent of the expanded city is 922.66 sq.km. River Musi flows through the city and in certain locations it was encroached by slum population. Himayathsagar, Hussainsagar, Osman sagar, Mir Alam, Manjira are important historical & major water sources of the city.

Climate: Hyderabad has a tropical wet and dry climate bordering on a hot semi-arid climate.The annual mean temperature is 26.6 °C while the monthly mean temperatures are 21–33 °C. Heavy rains from the south west monsoon fall betweenJune and September,supplying Hyderabad with most of its mean annual rainfall.Hyderabad gets about 32 inches (about 810 mm) of rain every year, almost all of it concentrated in the monsoon months. The highest temperature ever recorded was 45.5^{o}C (113.9 °F) on 2 June 1966, while the lowest recorded temperature was 6.1^{o}C (43°F) on 8 January 1946. The heaviest rainfall recorded in a 24-hour period was 241.5 mm(10 in) on August24th, 2000. The influence of South-West Monsoon is predominant in Telanganastate.

Demographics: As per demographics are concerned, the population in the city was 3.6 million in the year 2001. With time, it grew to become 6.3 million during 2009 and the population of Greater Hyderabad, as per the 2011 census including the merged villages, is more than 7.1 million. The rapid rise in the population can be attributed to the fact that the city is witnessing unparalleled growth in several industrial sectors and has become a sought-after IT hub in the nation. Land cover changes have been influenced both due to increase and decrease of a population. In developing countries like India, population growth has been a dominant cause of LULC changes. There is a significant correlation between population growth and LULC changes specifically due to the increasing demands of food production, agricultural lands.

METHODOLOGY

Firstly we have to collect the data from various sources such as SOI toposheets, Remote sensing data for the proposed study. Conversion of analog map sheets covering the study area needs to be scanned in required format to digial format. The topsheets are then Georeferenced with the datum and then the required features are needed to be delineated. Ground truth is also checked for further accuracy and then the thematic maps are prepared for further analysis of the proposed study area.

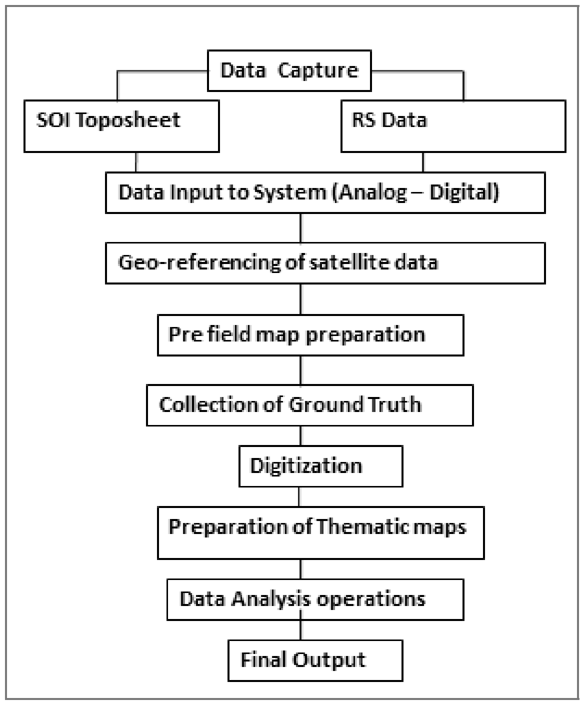


Figure 1 Methodology for LULC change detection

Review Analysis of the study area

Table 1 LULC changesof Hyderabad for 1980, 1990, 2000, 2007 years

Percentage wise area break up					
	Parameters	**1980**	**1990**	**2000**	**2007**
1	Built Up area	8.31	14.97	26.20	30.45
2	Transportation	0.79	0.98	2.62	3.88
3	Water Bodies	4.39	4.77	4.98	5.10
4	Forests	2.43	3.98	4.74	5.02
5	Agriculture	83.47	75.30	61.01	54.74
6	Open Space	0	0	0.45	0.81
	Total	100	100	100	100

Table 2 LULC classes of study area

		Area (hectares)	
Sl.No	**Theme classes**	**1989**	**2001**
1	Water bodies	33751.51	15577.33
2	Built up area	39921.84	198813.86
3	Crop/Weeds	38350.14	52956.18
4	Others	448787.94	248605.03
5	Vegetation	221016.15	265874.54
	Total	781827.58	781826.95

Table 3 Change in Area of water bodies between 1989-2001 in Study area

	Zone	**50 km**	
	year	**1989**	**2001**
	Category (Ha)	**Area (Ha)**	
1	< 100	10428.80	8820.79
2	100 - < 200	1061.77	923.93
3	200 - < 300	657.44	0
4	300 - < 400	319.86	0
5	400 - < 500	854.08	862.53
6	>= 500	3856.73	3326.49
	Total	17178.68	13933.74

Table 4 Change in Number of water bodies between 1989-2001

	Year	**1989**	**2001**
	Category (Ha)	**Number**	
1	< 100	981	968
2	100 - < 200	8	6
3	200 - < 300	3	0
4	300 - < 400	1	0
5	400 - < 500	2	2
6	>= 500	2	2
	Total	997	978

Table 5 Population density for study area for the past 4 decades

Sl.No	**Year**	**Population**
1	1981	10,666,080
2	1991	9,845,594
3	2001	11,537,040
4	2011	11,141,142

Change detection in land cover for Hyderabad during 1980, 1990, 2000, 2007.

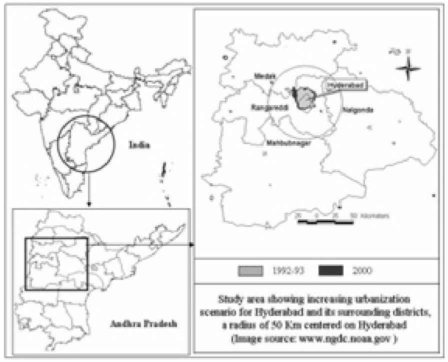


Figure 2 -Location siteof study area

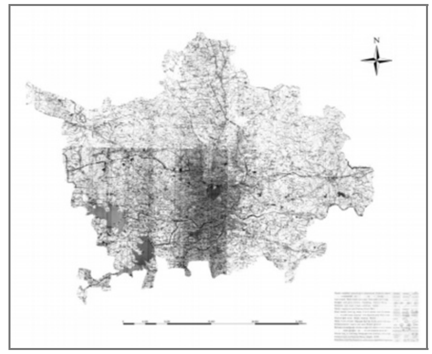


Figure 3 – Aerial Extent of the study area

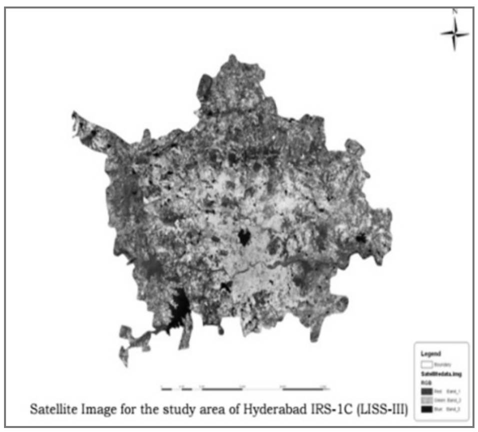


Figure 4 - Satellite image for Hyderabad IRS – 1c (LISS-III)

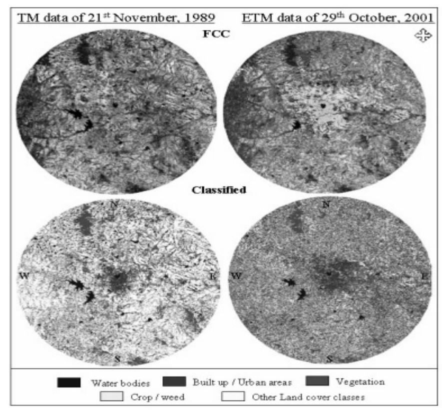


Figure 5 - Change Analysis of satellite data (1989-2001)

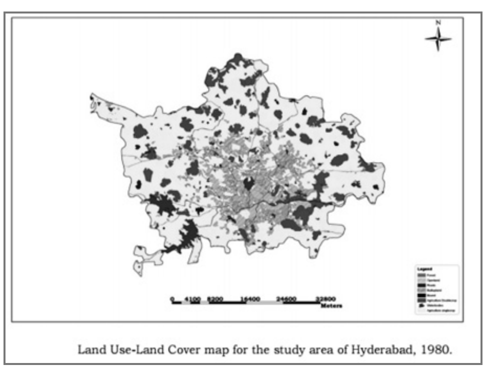


Figure 6 - Land Use Land Cover map for Hyderabad in the year 1980

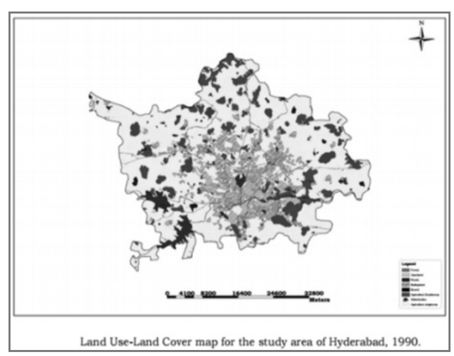


Figure 7 - Land Use Land Cover map for Hyderabad in the year 1990

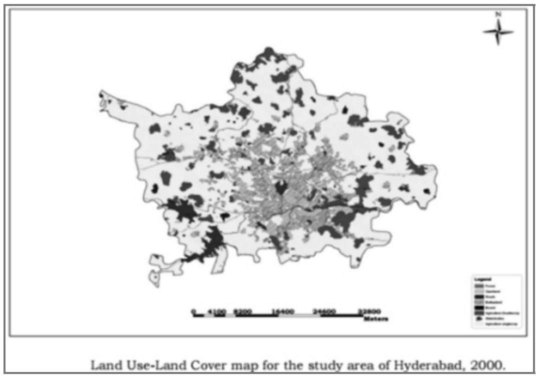


Figure 8 Land Use Land Cover mapfor Hyderabad in the year 2000

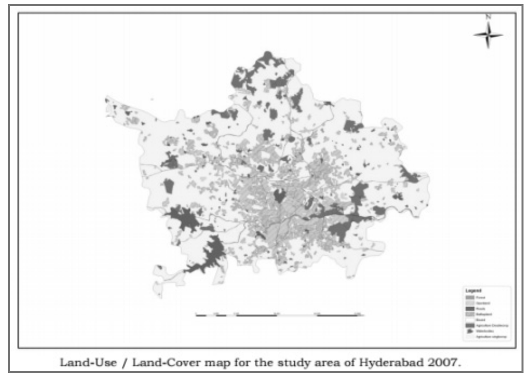


Figure 9 Land Use Land Cover map for Hyderabad in the year 2007

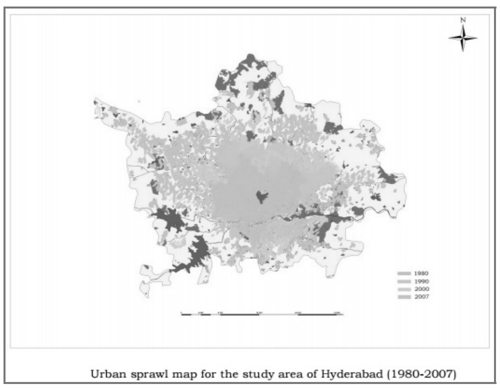


Figure 10 Urban Sprawl map for Hyderabad (1990 -2007)

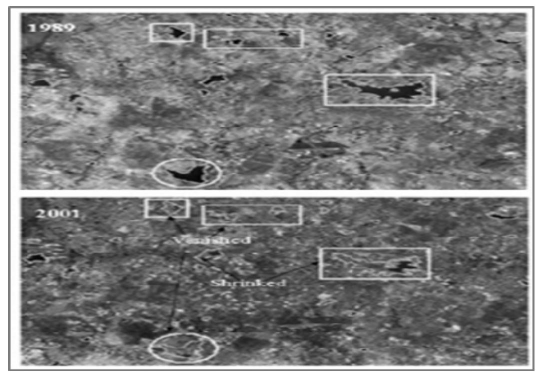


Figure 11 Land Cover during1989 & 2001 showing vanished water bodies & shrunk area towards northern parts of Hyderabad city.

Source of figures 2 to 11 : Journal of Spatial Science (March 2009) Vol II (2): 43-52

It may be noted from the above figures 2 to 11 that there is a drasticchange in the Land Use Land Cover pattern for the past 4 decades and also it is observed that the water bodies are shrunk not only in areal extent but alos in number.

Changes in green cover in Hyderabad during 2001, 2005, 2010.

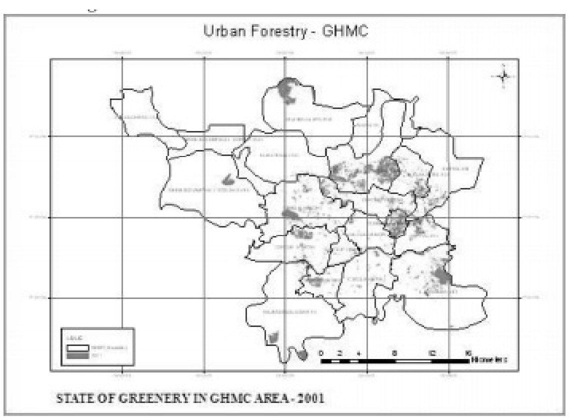


Figure 12 Extent ofgreen cover (2001)

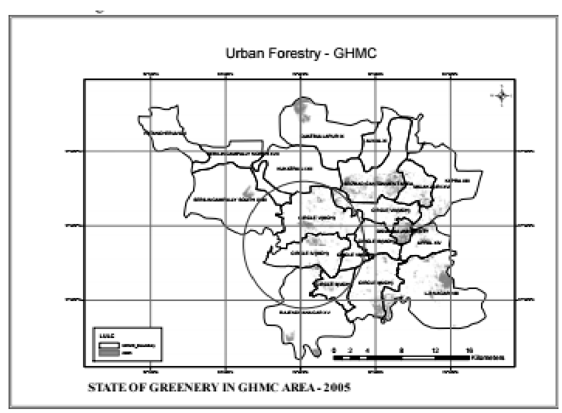
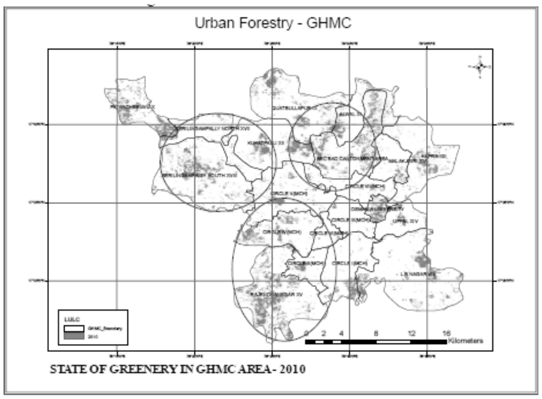


Figure 13 Extent of green cover (2005)



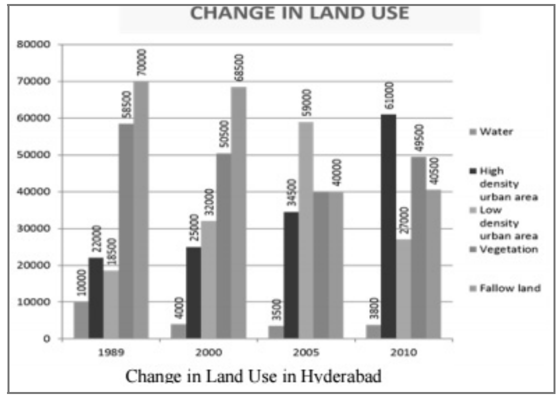
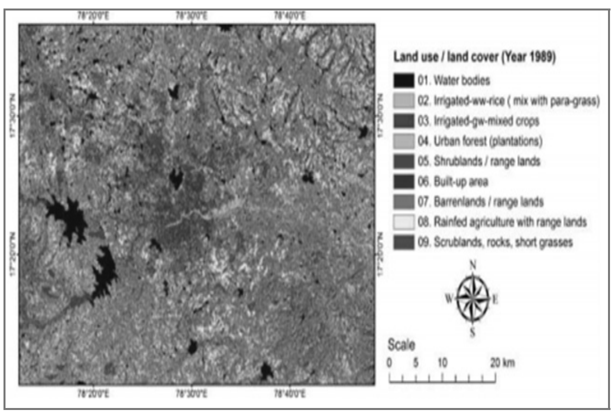


Figure 14 Extent of green cover (2010) **Figure 15** Graph showing changes in land use pattern - Source: ZameerAhmed

The figures 12 to 15 depictsthe areal extent of green cover during the past few years. It may be noted that there is a distinguished decrease in the amount of green cover in the proposed study maily due to urbanization, industrialization and increase in the urban population.

Changes in Land Use pattern in Hyderabad region during 1989 & 2002



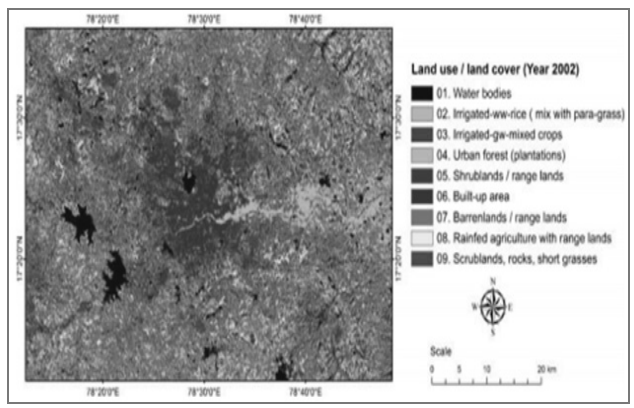


Figure 16 Details of LULC during 1989 **Figure 17** Details of LULC during 2002

CONCLUSIONS

The review concludes that there is a rapid change in LULC pattern in the proposed study area for the past four decades. These changes are mainly due to increase in population, economic growth and industrialization which have stimulated rapid urbanization and expansion of built-up area. It is also noted that the expansion of cities to accommodate increasing population has global, regional, and local effects on weather and climate due to LULC changes. Now, there is an acute pressure on the available water and land resources in the proposed study area. The region has experienced one of the greatest rates of change in Land Use and Land Cover mainly due to urban expansion, reduction of cultivated land and increase in the built up area. The subsequent increase in urban land cover were found to be associated with increased scarcity of water, thus suggesting intensified watershed management strategies with time.It may be noticed that Land Use Land Cover information, along with other information on natural resources, such as water, soil, hydro-geomorphology, etc. is very useful for optimal planning at macro and micro levels. High resolution satellite data along with extensive field work might help inidentifying factors effecting water bodies in surrounding areas and highlight policies that can help arrest this trend. The existence of water bodies in this region,which is predominantly arid and semi-arid,is needed to support growing demands of ever increasing population but also to partly quench the water demands of the city through recharging the surface and ground water through proper management. Efforts must be made to preservethese water bodies, reduce/control the anthropogenic impacts, and enhance their ecological benefit for achieving a balance between urbanization and environmental conditions. The study is useful in identifying Land Use and Land Cover classes, and this data may be used in future to studyenvironmental issues, monitoring, and better watershed management practices. Thus, successful activities in small watershed regions may lead to integration of achievements in large river basins.

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Stream Flow Simulation by using Soil and Water Assessment Tool for Chotki-Berghi Watershed in Jharkhand

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ABSTRACT

Soil erosion due to accelerating runoff in various land cover types poses a serious threat to the long term sustainability of the fragile Chotanagpur landscape characterized by subsistence farming. Estimation of sediment yield is needed to study the reservoir sedimentation, river morphology and taking up any soil and water conservation measures. The study was aimed at delimitation of the zones of high runoff and consequently soil erosion in the agricultural dominated ChotkiBerghinala. Identification of such zones could help in the implementation of better land management practices.In this study, Soil and Water Assessment Tool (SWAT) and SWAT-CUP were used to calibrate and validate a hydrologic component on Chotki-Berghi stream. The model was calibrated for the period 2004–2006 and validated for 2007–2008 for stream water discharge and sediment loads. Nine highly sensitive parameters were identified of which base flow alpha factor was the most sensitive one. The results were satisfactory for the gauging station with R^2 = 0.75 and. NSE = 0.78 for calibration and R^2 = 0.62 and. NSE = 0.68 for validation period. Sub-basin 5 contributed highest sediment load to the outlet and thus need immediate attention. The SWAT model could be effectively used to predict stream flow and sediment yield in order to effectively design irrigation system and water related development in absence of gauged information.

Keywords: Hydrologic modeling, SWAT, SWAT-CUP, Stream flow, Sediment yield, Chotki-Berghi, Jharkhand.

INTRODUCTION

Many agricultural civilizations have declined due to land and natural resource mismanagement, and the history of such civilizations is a good reminder to protect our natural resources. Erosion is a serious problem for productive agricultural land. Controlling the sediment must be an integral part of any soil management system to improve water and soil quality. The economic and social impacts of soil erosion are more severe in the developing countries, compared to the developed, because of the direct dependence of livelihood of a large majority of their populations on agriculture and land resources. A systematic assessment of water resources availability with high spatial and temporal resolution is essential in Jharkhand for strategic decision-making on water resource related development projects. A comprehensive understanding of hydrological process in the watershed is the pre-requisite for successful water management and environmental restoration. Mathematical models are nowadays used to overcome the challenges of decision making. Several water quality computer simulation models have been developed and applied to simulate complex hydrologic processes within the agricultural watershed. These models are classified as lumped or distributed parameter models. Hydrological modeling linked with geographical information systems helps water resources managers in reaching to a decision more efficiently. A model provides the basis for developing policy intervention and efficient watershed management plan that ensures environmental protection, sustainable development and economic sustainability. Non point source pollutant modeling is the most widely used and effective approach for soil conservation planning and design due to the difficulty in monitoring the influence of each specific agricultural and land management practice in a diverse ecosystem(Goodchild 1992).

There are many hydrological models which have been developed so far but in the present study, Soil Water Assessment Tool (SWAT) was selected. SWAT is recognized by the US Environmental Protection Agency (EPA) and has been incorporated into the EPA's BASINS (Better Assessment Science Integrating Point and Non-point Sources) (Di Luzio et al. 2002). Several hydrologic components (surface runoff, ET, recharge, and stream flow) that are currently in SWAT have been developed and validated at smaller scales within the EPIC, GLEAMS and SWRRB models. Interactions between surface flow and subsurface flow in SWAT are based on a linked surface - subsurface flow model developed by Arnold et al. (1998).SWAT model has been chosen in this study due to its simplicity in handling, spatial inputs and independency of GIS platform after certain operations. The model interfaces with GIS facilitate pre and post processing such as watershed delineation, manipulation of the spatial and tabular data. Another reason for choosing SWAT is its ability to perform water quality modeling, which would be investigated in our further research work. Early origin of SWAT can be traced to previously developed models by United States Department of Agriculture. These models are the Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) model (Knisel 1980), the Groundwater Loading Effects on Agricultural Management Systems (GLEAMS) model (Leonard et al. 1987) and the Environmental Impact Policy Climate (EPIC) model (Izaurralde et al. 2006). Many researchers across the world have calibrated and validated the SWAT model for various watersheds and proved the effectiveness of the SWAT model in simulating hydrological processes (White and Chaubey 2005; Cao et al. 2006; Singh et al. 2013; Chandra et al. 2014).

Jain et al (2010) estimated runoff and sediment yield from an area of Suni to Kasol, an intermediate watershed of Satluj river, located in Western Himalayan region of India by using SWAT model. They determined the coefficient of determination for the daily and monthly runoff as 0.53 and 0.90, respectively for the calibration period, and 0.33 and 0.62 respectively for the validation period. Chandra et al. (2014) calibrated and validated the SWAT model for Upper Tapi catchment in India and found Nash-Sutcliffe efficiency (NSE) and RSR for sediment yield 0.85 and 0.36, respectively. Tyagi et al (2014) concluded that SWAT is capable of estimating the discharge and sediment yield from Himalayan forested watersheds and suggested it to be a useful tool for assessing hydrology and sediment yield response of the watersheds in the region.Wu and Chen (2015) compared the Sequential Uncertainty Fitting Algorithm (SUFI-2), Generalized Likelihood Uncertainty Estimation (GLUE) method and the Parameter Solution (ParaSol) method within the SWAT modeling frame-work. They observed the SUFI-2 method to provide more reasonable and balanced predictive results than the other two methods. Mohammad et al. (2014) simulated the yearly surface runoff and sediment load for the main three valleys on the right bank of Mosul Dam Reservoir. The simulation considered for the twenty one year begins from the dam operation in 1988 to 2008. They opined that in order to minimize the sediment load entering the reservoir, a check dams is to be constructed in suitable sites especially for valley one. The check dam can store the runoff water and trap the sediment load, and then the flow can be released to the reservoir. SWAT studies in India include identification of critical or priority areas for soil and water management in a watershed (Tripathi et al. 2003; Kaur et al. 2004; Singh et al. 2012, 2014; Chandra et al. 2014). Main objective of the study is to simulate the sediment yield in a watershed of Chotki-Berghi by using SWAT model. The uncertainty analysis of the model output was carried out by using SUFI-2 algorithm.

MATERIALS AND METHODS

Soil and Water Assessment Tool (SWAT)

The SWAT (Soil and Water Assessment Tool) model is a continuous-time, semi-distributed, process based river basin model. It was developed to evaluate the effects of alternative management decisions on water resources and nonpoint-source pollution in large river basins. Within the HRU approach, all areas in a sub-watershed with the same combination of soil, topography and land use are lumped to form an HRU. SWAT operates on a daily time step and is designed to predict the impact of land use and management on water, sediment, and agricultural chemical yields in ungauged watersheds. The model is process based, computationally efficient, and capable of continuous simulation over long time periods. Major model components include weather, hydrology, soil temperature and properties, plant growth, nutrients, pesticides, bacteria and pathogens, and land management. In SWAT, a watershed is divided into multiple sub watersheds, which are then further subdivided into hydrologic response units (HRUs) that consist of homogeneous land use, management, topographical, and soil characteristics. The HRUs are represented as a percentage of the sub watershed area and may not be contiguous or spatially identified within a SWAT simulation. Alternatively, a watershed can be subdivided into only sub watersheds that are characterized by dominant land use, soil type, and management. Physical characteristics, such as slope, reach dimensions, and climatic data are considered for each sub-basin. For climate, SWAT uses the data from the station nearest to the centroid of each sub-basin. Calculated flow, sediment yield, and nutrient loading obtained for each sub-basin are then routed through the river system. Channel routing is simulated using the variable storage or Muskingum method (Arnold et al. 1993). The model computes evaporation from soils and plants separately. Potential evapotranspiration can be modeled with the Penman–Monteith, Priestley– Taylor or Hargreaves methods, depending on data availability. Potential soil water evaporation is estimated as a function of potential ET and leaf area index (area of plant leaves relative to the soil surface area). Actual soil evaporation is estimated by using exponential functions of soil depth and water content. Plant water evaporation is simulated as a linear function of potential ET, leaf area index, and root depth, and can be limited by soil water content. More detailed descriptions of the model can be found in Arnold et al (1998).

Simulation of hydrology of a watershed is done in two separate components. One is the land phase of the hydrologic cycle that controls the water movement in the land and determines the water, sediment, nutrient and pesticide amount that will be loaded into the main stream. Hydrological components simulated in land phase of the Hydrological cycle are canopy storage, infiltration, redistribution, and evapotranspiration, lateral subsurface flow, surface runoff, ponds and tributary channels return flow. The second component is routing phase of the hydrological cycle in which the water is routed in the channels network of the watershed, carrying the sediment, nutrients and pesticides to the outlet. In the land phase of the hydrologic cycle, SWAT simulates the hydrological cycle based on the water balance equation.

$$SW_t = SW_0 + \Sigma\,(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw}) \qquad \textbf{………(1)}$$

where, SW_t is the final soil water content (mm), SW_0 is the initial soil water content for day I (mm), t is the days (days), R_{day} is the day precipitation (mm), Q_{surf} is the surface runoff (mm), E_a is the evapotranspiration (mm), Ws_{eep} is the seepage from the bottom soil layer (mm) and Q_{gw} is the groundwater flow on day i (mm).Once the runoff part is finished, soil erosion is assessed by Modified Universal Soil Loss Equation (Wischmeier and Smith 1978). Sediment generation from each HRU is calculated by the following equation

$$Sed = (Q_{sur}f.\ q_{peak}.\ area_{hru})^{0.56} K_{usle}.\ C_{usle}.P_{usle}.\ LS_{usle}.\ CFRG \qquad \textbf{……..(2)}$$

where, sed is the sediment generation (metric ton), $Q_{sur}f$ is the surface runoff (mm), q_{peak} is the peak runoff rate (m^3/s), $area_{hru}$ is the HRU area (ha), K_{usle} is the USLE soil erodibility factor, C_{usle} is the USLE cover and management factor, P_{usle} is the USLE support practice factor, LS_{usle} is the USLE topographic factor, and CFRG is the coarse fragment factor. Sediment generation will be calculated separately for each HRU and then summed to determine total sub-basin fluxes (Arnold et al. 1998).

Description of the study area

Chhotki-Berghi watershed is located under Damodar-Barakar Basin in the district of Giridih, Jharkhand and spreads over an area of 79,714 km^2. It is a plain region situated between 24°03'30" (N) - 24°08'00" (N) in latitude and 85°59'30" (E) - 86°04"10" (E) in latitude. Maximum rainfall occurs from July to September accounting for more than 1,400 mm spread across the whole region.This watershed has three types of topographical areas viz. central plateau having moderate elevation, lower plateau having lower elevation and the trough basin of Damodar. The lower plateau area has relatively rough terrain having an elevation of 390 meters. In the North and North West there is a table land having an elevation of 250 meters, where steep scarp is found. Geologically the area is comprised with Archean granites and gneisses with capping of laterites at some places. Location of study area is shown in Fig. 1. The mean temperature ranges from 7.80 ^{0}C in winters to 37.30 ^{0}C in summer. The hottest month is May, in which the mean maximum temperature goes up to 38^{0}C. The rainfall varies from 1600 to 2200 mm depending on elevations, most of which falls in the rainy season (June-August) with July being the wettest month.There are two main streams in the study area namely, Chotkinala (stream) and Berghinala. These two streams serve as the main source of water for irrigation and domestic purposes in Chotki-Berghi region. Agriculture is the mainstay of more than 75 per cent people in the study area. Most of farmers belong to small and marginal category (about 83.7%) and major food crops are rice, wheat, potato, seasonal vegetables etc.

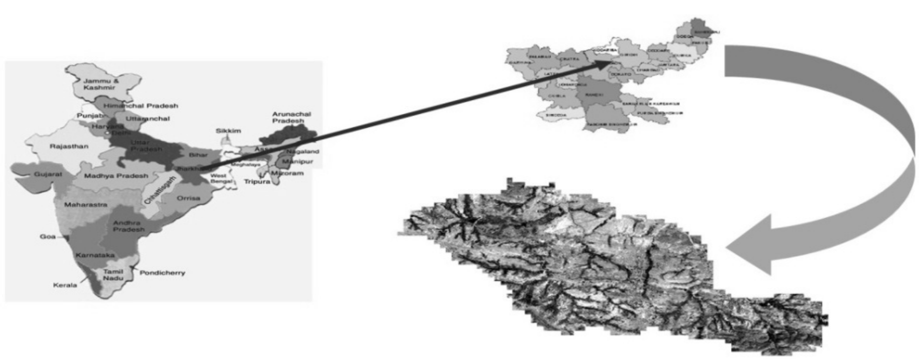

Figure 1 Location of the study area

SWAT model input

SWAT model is data driven, which requires several data ranging from topography, land use, soil, climate, etc. Digital elevation model (DEM) is one of the main inputs of SWAT Model. For preparation of DEM, the vector map with contour lines (from topographic maps) was converted to raster format (Grid) before the surface was interpolated. Grids are especially suited to representing geographic phenomena that vary continuously over space, and for performing spatial modeling and analysis of flows, trends, and surfaces such as hydrology. Raster data records spatial information in a regular grid or matrix organized as a set of rows and columns. The stream layer and watershed layer have been generated using above mentioned data set. Land use/land cover map was prepared using remote sensing data of Landsat ETM+. The classification of satellite data mainly follows two approaches *i.e.* supervised and unsupervised classification. The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes. This categorized data may then be used to produce thematic maps of the land cover present in an image. In the present study, the unsupervised classification method was used for preparation of the land use map. The soil map was collected from Damodar Valley Corporation (DVC), Hazaribagh. SWAT requires daily values of precipitation, maximum and minimum temperature, solar radiation, relative humidity and wind speed. Daily gridded rainfall for the period 2004-2008 and temperature values for the period 2004-2008 were collected by DVC Hazaribagh.

SWAT model implementation

Geographic information systems data for the SWAT model were preprocessed by two separate functions watershed delineation and determination of hydrologic response units (HRUs). SWAT uses DEM data to automatically delineate the watershed into several hydrologically connected sub-watersheds. The initial stream network and sub-basin outlets were defined based on drainage area threshold approach. The threshold area defines the minimum drainage area required to form the origin of a stream. The interface lists a minimum, maximum and suggested threshold area. The smaller the threshold area, the more detailed the drainage network delineated by the interface but the slower the processing time and the larger memory space required. In this study, defining of the threshold drainage area was done using the threshold value. Hydrologic response units (HRUs) are lumped land areas within the sub-basin that are comprised of unique land cover, soil, slope and management combinations. HRUs enable the model to reflect differences in evapotranspiration and other hydrologic conditions for different land covers and soils. The runoff is estimated separately for each HRU and routed to obtain the total runoff for the watershed. This increases the accuracy in flow prediction and provides a much better physical description of the water balance. The land use and the soil data in a projected Grid file format were loaded into the ArcSWAT interface to determine the area and hydrologic parameters of each land-soil category simulated within each sub-watershed. In order to utilize the calibrated model for estimating the effectiveness of future potential management practices, the model was tested against an independent set of measured data. This testing of a model on an independent set of data set was used. As the model predictive capability was demonstrated as being reasonable in both the calibration and validation phases, the model was used for future predictions under different management scenarios. In this study, the model was validated with independent validation period (2007-2008) in SUFI2.

RESULTS AND DISCUSSION

The model delineated watershed area as 32 km^2 which was much closer to actual area provided by DVC Hazaribagh. Whole watershed was divided into five sub-basins and 23 HRU's. The area coverage of each land use type is presented in Table 1. Most portion of the watershed is covered with agricultural land, which accounts for 89 percent of the watershed area. The dominant soil type in the watersheds is sandy loam soil. It was analyzed that 27.91% of the area in Chotki-Berghi had a slope less than 1% while 16.07% of the area had a slope less than 2% and 38.61% of the area has slope less than 4%, 6.07% area has slope less than 6%, and 11.35% area of Chotki-Berghi has slope more than 6%. Majority of the land mass is plain land having slope less 4%.

Table 1 Land use and land cover of the study area

Watershed	Land Use	Area km^2	% Area
Chotki-Berghi	Agricultural Land-Generic	29.14	88.95
	Indian grass	2.25	6.87
	Forest-Deciduous	0.34	1.05
	Residential	1.02	3.14

Results of sensitivity analysis with observed data showed that most sensitive parameters are base flow alpha factor (Alpha_Bf), curve number (CN_2), Gw_Delay, the delay time, which cannot be directly measured, gw_qmn a threshold depth of water in the shallow aquifer to allow for water flow. The flow of underground water into the river can occur if the water depth in the shallow aquifer is equal or greater than the value gw_qmn. Itis a significant parameter in a watershed that represent saturated zone which are located not far from the surface of the soil or vegetation which have roots deep enough. Gw_revap value approaching 0 indicates that the movement of water from the shallow aquifer to the root zone is limited. Gw_revap value close to 1 indicates that the movement of water from the shallow aquifer to the root zone close to the average potential evapotranspiration. The obtained value after the calibration was 0.01whichindicatesthe limited movement of water from the aquifer to the root. Soil evaporation compensation factor (ESCO), Sol_awc is the available water capacity of the soil layer (mm H_2O/mm soil), SOL_K is the saturated hydraulic conductivity and sol_z is the soil depth, the sensitive parameters which have effect on the runoff along with their ranking and their method of adjustment are presented in Table 2.

Table 2 Sensitive parameter ranking and final auto-calibration result

Rank	Aggregate Parameters	Min. Value	Max. Value	Fitted Value
1	Cn_2	-0.2	0.2	0.160
2	Alpha_Bf	0.0	1.0	0.500
3	Gw_Delay	30.00	450.00	324.000
4	GW_QMN	0.00	2.00	0.89
5	GW_REVAP	0.00	0.2	0.09
6	Esco	0.10	1.00	0.40
7	Sol_Awc	0.2	0.4	0.25
8	Sol_K	0.00	0.80	0.56
9	Sol_Z	300	500	450
10	RCHRG_DP	0	1.0	0.26

Water and sediment yieldand sediment distribution

The water yield was simulated for the year 2004 to 2008 on monthly time step. The result was summarized as intermediate (Feb-May), wet (Jun-Sep), dry (Oct-Jan) and on yearly basis after calibration of sensitive parameters for flow obtained during the auto-calibration of Chotki-Berghi station. The result is shown in Table 3. In this study the SWAT model which was calibrated and validated only for hydrological component of Chotki-Berghi station was used to estimate the sediment yield with their respective distribution among the sub-basins. Based on simulation, the annual sediment yield at the outlet of watershed was observed in the range of 9.259 to 30.451 tons/hectare during the year 2004 to 2008 with annual average yield of 23.8316 tons/ha. The detail is presented in Table 4. The spatial variability of sedimentation rate were identified and shown in Fig. 2 and based on which the potential area of intervention can identified. The output of model showed that Sub-basin 5 of Chotki-Berghi at the existing condition generates a maximum annual average sediment yield of 2.70 ton/ha. This is attributed due to the topographic slope and landuse of this sub-basin. It was an agricultural land with slope more than 4%. The minimum yield of less than 1.5 tons/ha was obtained for sub-basin 3, it has a slope <2% and it is covered by agriculture. Precipitation data is used as dominant climatic factor in the study of sediment yield, because it affects vegetation and runoff. However, the effectiveness of a given amount of annual precipitation is not everywhere the same. Variations in temperature, rainfall intensity, number of storms and seasonal and areal distribution can also affect the yield of sediment. The effect of temperature, which controls the loss of water by evapotranspiration, can also been taken into account.

Table 3 Simulated monthly water yield (t/ha)

Month	Year					
	2004	**2005**	**2006**	**2007**	**2008**	**Average**
Jan	5.45	4.66	8.56	0.98	7.98	5.76
Feb	2.66	12.38	0.91	12.77	2.08	6.16
Mar	7.51	7.40	22.24	1.01	0.74	7.78
Apr	5.36	1.93	0.39	1.59	0.43	1.94
May	1.02	0.76	19.77	3.78	1.91	5.45
Jun	40.76	3.00	116.49	10.83	184.47	71.11
Jul	66.91	89.14	193.70	287.48	283.84	184.21
Aug	177.27	131.12	144.96	252.44	288.71	198.90
Sep	155.71	166.59	286.76	217.17	133.21	191.89
Oct	135.96	60.07	80.16	119.35	67.53	92.61
Nov	44.63	30.36	46.75	58.85	32.85	42.69
Dec	23.23	13.83	22.42	28.89	13.19	20.31
Total	674.00	531.68	938.39	1000.82	1023.08	833.58

Table 4 Simulated monthly sediment yield (t/ha)

Month	Year					
	2004	**2005**	**2006**	**2007**	**2008**	**Average**
Jan	0.01	0.22	0	0	0.81	0.20
Feb	0	0.41	0	1.52	0.00	0.38
Mar	1.43	0	1.87	0.02	0	0.66
Apr	0.08	0	0	0.00	0.00	0.01
May	0.00	0	1.38	1.22	0.03	0.52
Jun	0.29	0.09	4.79	2.61	3.99	2.36
Jul	0.86	2.05	8.36	7.30	7.92	5.30
Aug	6.93	2.45	2.32	4.17	12.55	5.68
Sep	9.01	4.01	11.70	4.88	3.80	6.68
Oct	9.47	0	0	0.401	0	1.97
Nov	0	0	0	0	0	0
Dec	0.04	0	0	0	0	0.008
Total	28.15	9.25	30.45	22.16	29.13	23.83

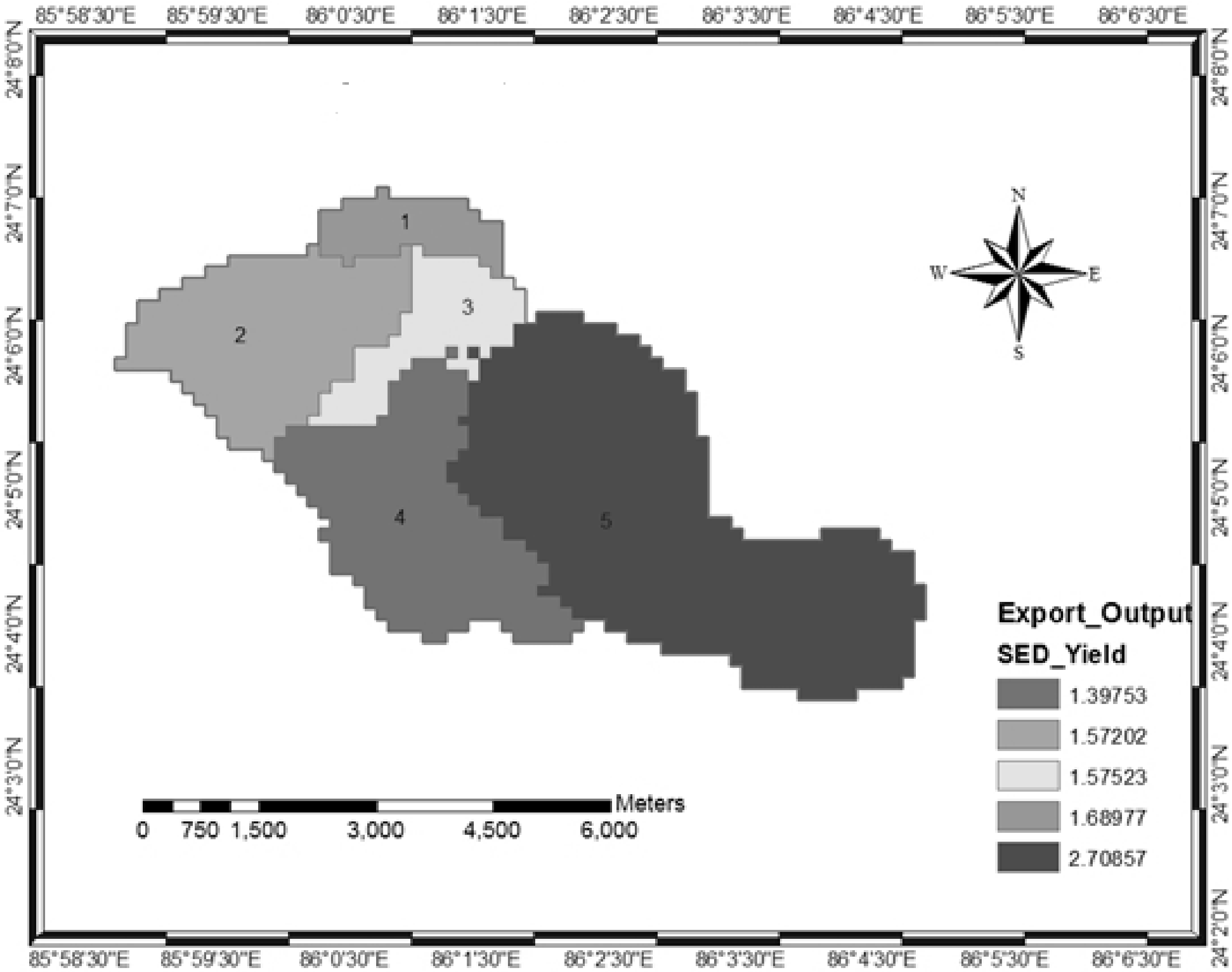

Figure 2 Sediment Distribution with respect to sub-basin

Model calibration

The SUFI-2 method was used for calibration, and with 500 simulation runs were conducted. Both NSE and$R^2$of the best simulation were selected to evaluate the simulation performance to improve the reliability of the analysis in this study. The scatter plots of simulated and observed runoff in the calibration and validation period are shown in Figs. 3 and 4, respectively. The NSE and $R^2$of the best simulation are 0.78 and 0.75 for the calibration period, and 0.68 and 0.62 for the validation period, respectively, indicating reasonable consistency between the simulated and observed runoff as well as responses to precipitation. After the acceptable simulation was obtained, uncertainly analysis can be further conducted. For the better comparison, P-factor and R-factor were used to compare the performance of different uncertainty analysis methods. It is observed from Fig. 4 that most of the lower values are closer to the line of best fit. Higher values of runoff have not been captured well by the model. The reason may be attributed to inconsistency in the input data or lack of proper base flow simulation

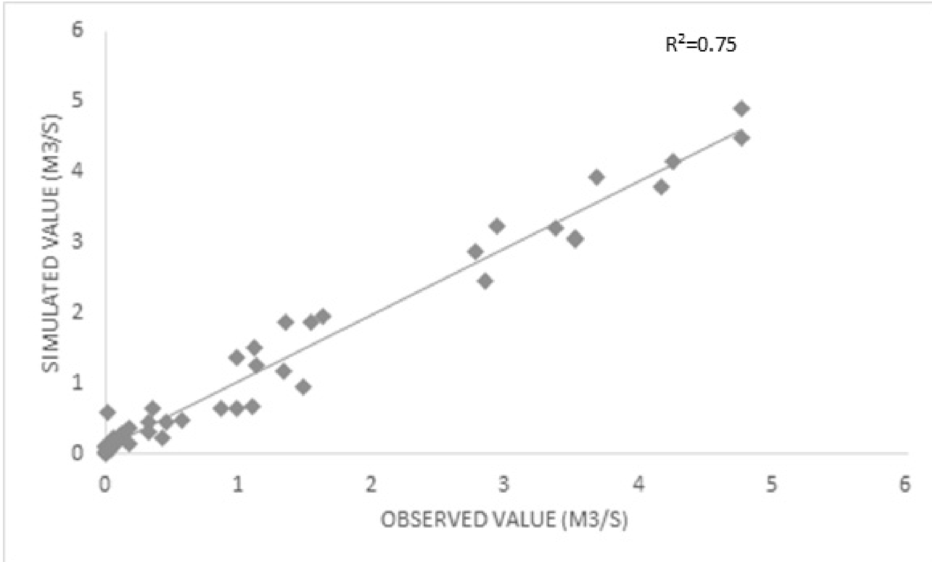

Figure 3 The scatter plot of monthly simulated and observed runoff for the calibration period

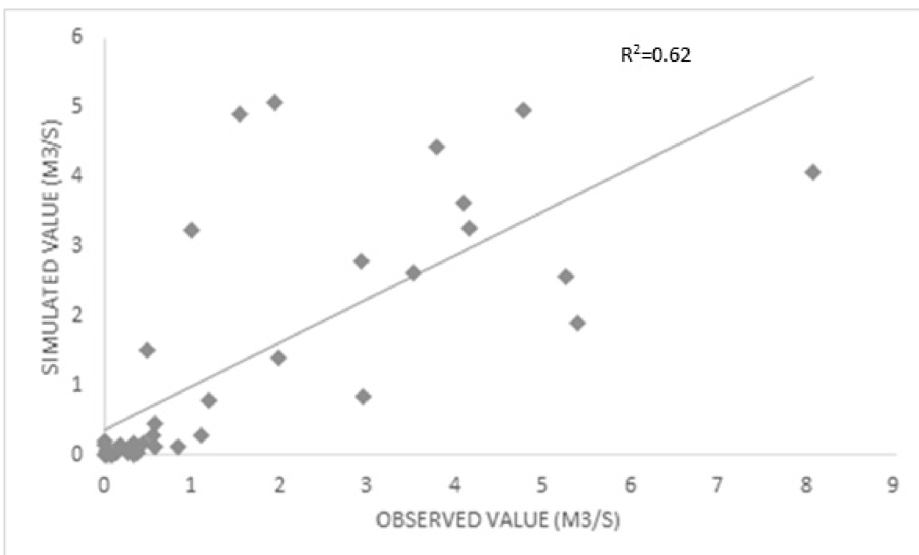

Figure 4 Scatter plot of monthly simulated and observed runoff for the validation period.

CONCLUSIONS

In this study, SUFI-2 was used for model calibration and to perform the uncertainly analysis for number of parameter. The SWAT model created HRUs from the combination of land use/soil types and runoff was modeled on the basis of Curve Number (CN) defined for HRU. SWAT model was highly sensitive to CN for the runoff; minor change in the value of CN affected the runoff amount significantly. Alpha_Bf was the second sensitive parameter, adjustment of the parameter resulted into better simulation of runoff. For sediment yield support practice factor was most sensitive because of the defining of the tillage practice for the crops in the watershed. Slope steepness and vegetation cover factor were the other important factor which affected the sediment yield.

Notwithstanding the data scarcity, the result is very satisfying and provides notable insight into the runoff availability and the associated uncertainties in this susceptible region. Sub-basin no.5 of Chotki-Berghi at the existing condition generates a maximum annual average sediment yield of 2.70ton/ha, this can be reduced by using sediment yield intervention strategies such as land slope stabilization, construction bench terraces, changing the land use of steepy area and afforestation. The model gives relatively good result in Chotki-Berghi basin. Given the complexities of a watershed and the large number of interactive processes taking place simultaneously and consecutively at different times and places within a watershed, it is quite remarkable that the simulated results comply with the measurements to the degree that they do. Based on the results obtained in this study, SWAT is assessed to be a reasonable model to use sedimentation and water quantity studies in the Chotki-Berghi watershed.

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Ridges and Furrow Method of in situ Moisture Conservation for Enhancing the Productivity of Rabi Sorghum under Dryland Condition – A Case Study of Narotewadi Watershed

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ABSTRACT

The National Innovations On Climate Resilient Agriculture project is functioning at Zonal Agricultural Resarch Station, Solapur and implemented its different activities in the adopted Narotewadi watershed, Tal. N. Solapur, Dist, Solapur in scarcity zone of Maharashtra from *Kharif 2011-2016*. One of the objective to demonstrate the impact of *in-situ* moisture conservation techniques *viz.,* ridges and furrow and compartmental bunds under farmers management condition and secondly to popularize the productive technology amongst farmers in the Narotewadi watershed, Tal. N. Solapur, Dist. Solapur during the period 2011-12 to 2015-16. Monocropping of *rabi* sorghum in medium deep soil with two harrowing in *kharif* season is the common practice of the farmers in Narotewadi village. the opening of ridges and furrow method of *in-situ* moistur conservation in *kharif* season followed by *rabi* sorghum was demonstrated on 53 farmers field on 0.20 ha area each at Narotewadi village. The cultivar M-35-1 of *rabi* sorghum was used as test crop with all recommended package of practices. The results revealed that, the average grain yield of sorghum was highest in ridges and furrow (10.22 q ha^{-1}) as compared to farmers practice i.e., two harrowing. The percent increase in grain yield was 20 per cent in ridges and furrow over farmers practice. Similar trend was also noticed in case of fodder yield of *rabi* sorghum. 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.

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, its 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. 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. 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. 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). In view of the above facts, to test the *in-situ* moisture conservation techniques on farmers fields, verification trials were conducted at NICRA DLA village Narotewadi , Tal. N. Solapur, Dist, Solapur (M. S.)

The National Innovations On Climate Resilient Agriculture (NICRA-DLA) Project was implemented at Narotewadi watershed, Tal. N. Solapur, Dist. Solapur (M. S.) from *Kharif* 2011. At the start, basic survey on soil, Socio-economic and natural resources was carried out. About 36.35 percent of the soils are very shallow having

During the period under report, out of five years severe drought was observed for one years (2015). A need based technical programme was formulated based on land capability, soil suitability and with PRA technique. 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.

MATERIALS AND METHODS

The verification cum demonstration trials on *in-situ* moisture conservation practices i.e., ridges and furrow method were assessed for population and refinement on farmers field at Narotewadi village during the year 2011-12 to 2015-16. The selected watershed is located at village Narotewadi, Tal. N. Solapur, Dist. Solapur in scarcity zone of Maharashtra.

The field trials treating individual farmer as a replication with two treatments viz., ridges and furrows in *kharif* followed by *rabi* sorghum and farmers practice (two harrowing in *kharif* followed by *rabi* sorghum) were conducted on fifty three farmers fields. The trials were conducted on 0.20 ha. area under each treatment. The maximum soil are black in colour and few of them are in ash in colour or grey brown colour. On the basis of depth, the soils are categorized in to three group viz. Shallow, Medium and Medium deep. The structure of soil is sandy loam to loam. The treatments i.e., opening of ridges and furrows were given 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 in *kharif* season.

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 grain and fodder yield data of *rabi* sorghum was recorded at harvest and presented in Table 1.

Table 1 Yield and economics of *in-situ* moisture conservation techniques on farmers field at Narotewadi village.

Year	Yield (q/ha)							
	Farmers Practice (Two Harrowing)		Ridges & Furrow		% increase over Farmers Practice		B:C Ratio	
	Grain	Fodder	Grain	Fodder	Grain	Fodder	Farmers Practice	Ridges & Furrow
2011-12 (Mean of 06 farmers)	7.86	23.29	9.04	27.88	15.01	19.70	1.27	1.49
2012-13 (Mean of 12 farmers)	7.02	18.44	8.57	20.74	22.07	12.47	1.20	1.42
2013-14 (Mean of 12 farmers)	12.91	24.68	15.72	31.94	21.74	29.42	2.63	2.94
2014-15 (Mean of 10 farmers)	8.40	22.12	10.85	27.89	29.16	26.08	1.24	2.17
2015-16 (Mean of 05 farmers)	6.02	15.00	6.92	17.80	14.95	18.66	1.14	1.27
Mean	**8.44**	**20.70**	**10.22**	**25.25**	**20.58**	**21.26**	**1.49**	**1.85**

RESULTS AND DISCUSSION

The observations revealed that the average grain and fodder yields of sorghum were higher in ridges and furrow (10.22 and 25.25 q ha^{-1} respectively) treatment than farmers practice of harrowing (8.44 and 20.70 q ha^{1} respectively). The overall per cent increase in grain and fodder yields under ridges and furrow treatment was to tune of 20.58 and 21.26 per cent respectively over farmers practice. Also the ridges and furrow method of *in-situ* moisture conservation showed more B:C ratio (1.85) than farmers practice of only harrowing (1.49). 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 famers practice. Ridges and furrow method of *in-situ* moisture conservation also helped in avoiding terminal moisture stress to some extent than farmers method. The other benefits of weed control, pest control due to pulverization of soil were also observed in ridges and furrow method of *in-situ* moisture conservation. Whereas, in case of farmers practice i.e., harrowing, due to less opportunity time for infiltration, the problems of soil erosion and formation of gully at high rainfall intensity was observed. 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. Similar results were reported by Upadhye *et al.* (2010) and Thorve *et al.* (2015).

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 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.

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Extemporizing Spectral Signatures using Spectroradiometer for Different Species of Family Graminaceae

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ABSTRACT

Vegetation has a unique spectral signature which enables it to be distinguished readily from other types of land cover. Spectral reflectance curve for healthy green vegetation exhibits the "peak-and-valley" configuration. The peaks indicate strong reflection and the valleys indicate predominant absorption of the energy in the corresponding wavelength bands. In general, healthy vegetations are very good absorbers of electromagnetic energy in the visible region. Vegetation has a unique spectral signature which enables it to be distinguished readily from other types of land cover. Using multi spectral remote sensing, plant species mapping has always posed a problem because of the discontinuous bands. This has lead to research into the use of electromagnetic energy continuously. Hyper spectral remote sensing is capable to record reflectance values at nanometers and acquire very narrow, many, contiguous spectral bands throughout the electromagnetic spectrum. In this present research work developed spectral libraries using SVC spectroradiometer for prominent species of Poaceae available at Rajendra nagar agricultural university, Hyderabad by measuring and analyzing their reflectance curves uses SVC software. The chlorophyll absorption bands are observed at 490nm and 670nm for the species of the Graminaceae. The red edge for all the spectral signatures is observed at the 720nm commonly. The different percentages of reflectance is observed for variety species as the type of chlorophyll and cell structures of the leaves which are reflected in visible and near infrared regions varies which is explained in detailed hyperspectral remote sensing by recording the reflectance in very narrow bands.

Keywords: Grass, Poaceae, Spectroradiometer, Spectral library, reflectance, electromagnetic Spectrum

INTRODUCTION

Vegetation is a fundamental element of the earth’s surface and has a major influence on the exchange of energy between the atmosphere and the earth’s surface . Accurate quantitative estimation of vegetation biochemical and biophysical characteristics is necessary for a large variety of agricultural, ecological, and meteorological applications. Likewise, the mapping and monitoring of vegetation biochemical and biophysical variables is important for the spatially distributed modeling of vegetation productivity, evapotranspiration, and surface energy balance. Hyperspectral analysis of vegetation involves obtaining spectral reflectance measurements in hundreds of bands in the electromagnetic spectrum. These measurements may be obtained using hand-held spectroradiometer or hyperspectral remote sensing instruments placed onboard aircraft or satellites. Hyperspectral remote sensing provides valuable information about vegetation type, leaf area index, biomass, chlorophyll, and leaf nutrient concentration which is used to understand ecosystem functions, vegetation growth, and nutrient cycling. Classifying vegetation is an important component in the management and planning of natural resources. Foundations are created through the mapping of vegetation which can provide useful information for classifying habitat and ecological diversity, prescribed burn planning, hazard management and disease/pest control. Traditional methods are still demanded and used, and include air photo interpretation, fieldwork, literature reviews, map interpretation, and collateral and ancillary data. Remote sensing is challenging to use in high relief area, but successfully performed, it will provide valuable land cover information. It is challenging as it is difficult to define vegetation classes based on their spectral responses alone, due to the common heterogeneity of the cover type and the factors affecting spectral responses. Remote sensing allows for characterization of vegetation classes by a spatially distributed pattern of spectral responses and determines a higher degree of vegetation classes in mountainous regions. In this paper the differentiation of the different species of the poaceae family are identified using the spectral signatures.

REVIEW OF LITERATURE

The study on hyperspectral data has been used to develop the spectral signatures and variability of the six forest species teak, chinpine, tropical pine, eucalyptus, ficus and grass by Dipanwita et al.(2008). Six temporal ERS-2 (SAR) and landsat-5 (TM) imager data sets has been used to identify the rice crop, general terrain types and land use classes in Thailand. Classification has done using maximum likelihood classifier in which the seven classes of rice are identified with 84.7% accuracy.

Rama Rao et al. (2007), investigated the utility of space borne hyper spectral imaging for the development of a crop specific spectral library and automatic identification and classification of 3 cultivars for each of rice, chilly, sugarcane and cotton crops. To be most useful in ecological studies, these relationships should be generalizable across species and leaf developmental stages. However, most of the relationships between leaf reflectance and pigment content have been developed and tested for only one or at most a few closely related species (e.g., Blackburn, 1998a, Blackburn, 1998b, Chappell et al., 1992, Gamon & Surfus, 1999 and Gitelson & Merzlyak, 1994a). Structural differences (i.e., leaf thickness, density, number of air water interfaces, cuticle thickness, and pubescence) between leaves may have significant effects on these relationships. Light reflected directly from the leaf surface never enters the leaf cells and thus is not influenced by pigment and water content. Surface reflection can be greatly enhanced by leaf hairs Billings & Morris, 1951 and Ehleringer et al., 1976 or surface waxes Cameron, 1970, Clark & Lister, 1975 and Reicosky & Hanover, 1978.

Hairs increase reflectance throughout the visible region of the spectrum but their effect in the near infrared is variable Grant, 1987 and Slaton et al., 2001. Waxes increase surface reflectance throughout the visible and NIR regions of the spectrum although the effect is often greatest at shorter wavelengths due to Rayleigh scattering Clark & Lister, 1975 and Reicosky & Hanover, 1978. Giridhar et al (2014a, 2014b) had developed the spectral signatures for different crops using hyperspectral remote sensing and the spectroradiometer.

The reflectance of the soil differs at different soil moisture contents by the study on red soils in the laboratory conditions (Giridhar et.al 2016). Red edge indices are based not on reflectance percentage but rather on the wavelength position of the transition between low reflectance in the red region of the spectrum and high reflectance in the near infrared (Horler, Dockray, & Barber, 1983). Fitting of reflectance in this region to an inverted Gaussian model results in two parameters with units of wavelengths in addition to the minimum and maximum reflectance parameters Bonham-Carter, 1988. The inflection point is the parameter most often used as a spectral index and is the parameter we chose for use in this study. The inflection point can also be estimated from linear and Lagrangian models(Dawson & Curran, 1998), polynomial models (Baret, Jacquemoud, Guyot, & Leprieur, 1992), or from determining the position of the peak in the first derivative of the spectrum when high spectral resolution data are available (Curran, Windham, & Gholz, 1995).

Estimation of leaf carotenoid content from reflectance is much more difficult than estimation of chlorophyll because of the overlap between the chlorophyll and carotenoid absorption peaks and because of the higher concentration of chlorophyll than carotenoid in most leaves. Consequently, reflectance indices have proved more successful for the estimation of the ratio of carotenoid to chlorophyll, than in the estimation of the absolute carotenoid content Merzlyak et al., 1999 and Peñuelas et al., 1995.Most indices for estimation of carotenoid/chlorophyll ratios are based on the comparison of reflectance in the region of the carotenoid absorption peak (400–500 nm) with reflectance in the red region, which is influenced only by chlorophyll. In this study, we tested the "structure-insensitive pigment index" (SIPI), which was developed by Peñuelas et al. (1995), the "plant senescence reflectance index" (PSRI), which was developed by Merzlyak et al. (1999) and the photochemical reflectance index (PRI), which was originally developed by Gamon, Peñuelas, and Field (1992) to estimate rapid changes in the relative levels of xanthophyll cycle pigments and thus serves as an estimate of photosynthetic light use efficiency , Gamon et al., 1997 and Peñuelas et al., 1995.

STUDY AREA

The reflectance of the different species of poaceae family is measured in study area which belongs to Ranga Reddy District of Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana State, India. This is enclosed with geographical regions of 17°19'17"N, 78°25'23"E. the boundary of the study area is delineated from BHUVAN website. The study area map is as shown in the fig 1. Sri Konda Laxman Horticultural University the crops are identified in which the research is to be continued. Different types of grasses are observed in the agricultural fields and the most seen species are selected for this study. Sri Konda Laxman Telangana State Horticultural University (SKLTSHU), a dedicated & splendid institute of horticultural learning. It is the first Horticultural University in the state of Telangana and fourth in the Country.

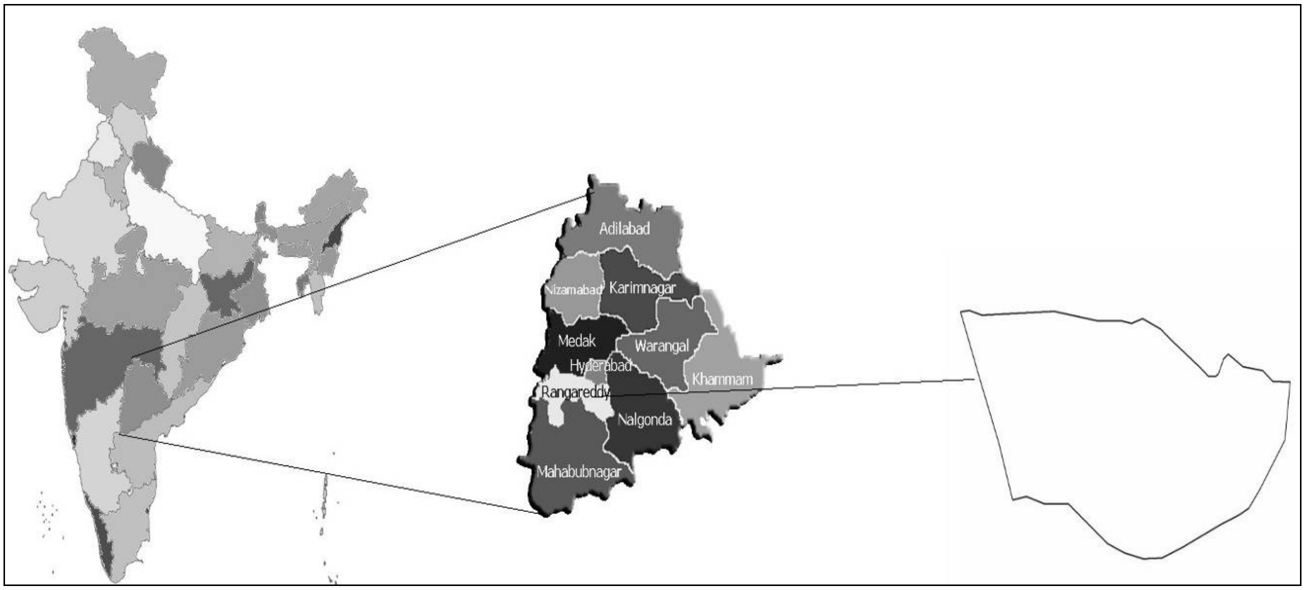

Figure 1 Study area map for the study

MATERIALS AND METHODOLOGY

Grasses make up one of the largest families of flowering plants, a family which plays a most important role both in man's economic activity and in the composition of natural plant communities. According to our figures it includes 898 genera and 10,300 species. Inasmuch as it is impossible to calculate the exact number of species for many genera, the overall number of species of grasses may be taken as about 10,000-11,000. Only three families surpass grasses in the number of species: composites (Asteraceae) about 1200 genera and 20,000 species; orchids (Orchidaceae) about 800 genera and 20,000 species; and legumes (Fabaceae sensu lato) about 700 genera and 17,000 species. The different grasses like the Cheat Grass, Indian Crowfoot, Crowfoot, Bermuda Paddy, Maize and Green Fox Tail type of grasses were selected for the present study. The different grasses have the different features in the leaf structure and the hairy structures on the surface of the leaf, their thickness and the color which affect the spectral response of the different species. The different types of the grasses selected for the study are as shown in the figure 2.

Cheat Grass

Cheat grass is an annual grass usually less than 60 cm tall, usually with 4 to 4 nodes. Leaf blades are up to 20 cm long, 2-4 mm broad, velvet-hairy. Cheat grass in Africa, Asia and Europe. The type I anatomy has a thick-walled mestome sheath, connected by sclerenchyma to the upper and lower epidermises, a poorly developed parenchyma sheath, and irregularly arranged chlorenchyma. In these grasses no starch is formed in the outer chlorenchyma, and the mesophyll is a darker green than the parenchyma sheath. In these festucoid species the plastids of both the mesophyli and the parenchyma sheath form starch, but in considerably smaller quantity than do the parenchyma sheath plastids of maize and sorghum. Sample for which the reflectance is collected is shown in Fig. 2a.

Bermuda Grass

Bermuda Grass is a grass native to north Africa, Asia and Australia and southern Europe. The blades are a grey-green colour and are short, usually 4-15 cm long with rough edges. In drought situations with penetrable soil, the root system can grow to over 2 m deep, though most of the root mass is less than 60 cm under the surface. The grass creeps along the ground and root wherever a node touches the ground, forming a dense mat. Sample for which the reflectance of Bermuda grass is collected is shown in Fig. 2b.

Indian Crow Foot

Indian Crowfoot Grass is an annual tufted grass. The plant is clump forming, branching from the base, culms are 40-95 cm tall. Leaf blades are flat or sometimes folded, 15-30 cm long, 4-6 cm wide. Flower spikes are mostly 2-6, usually 4-10 cm long. Spikelets are 4.5-5.5 mm long, the florets closely imbricated, dark green, disarticulating at maturity, leaving glumes overlapping in 2 rows on one side of the flattened rachis. Indian crow foot sample for which the reflectance is collected is shown in Fig. 2c.

Crow Foot

Crowfoot Grass is a slender to moderately robust, spreading annual herb, with wiry stems. Leaves are typically grass-like,2-30 cm long, 2-9 mm wide, with blades and sheaths that are without hair. Leaf margins have long, stiff hairs. Crowfoot Grass is native to Africa, but naturalized world-wide. Unverified information In Manipur, juice of fresh plants is prescribed in fevers. Decoction of the plant is given in small pox. Crow foot sample for which the reflectance is collected in the field is shown in Fig. 2d.

Green Fox Tail

Green Foxtail is an annual grass with prostrate or erect stems growing up to a meter long, and known to reach two meters or more at times. The leaf blades are up to 40 cm long and 2.5 wide and glabrous. Leaves and leaf sheaths of very young plants often densely hairy but with upward-pointing hair; upper leaf blades and leaf sheaths mostly without hair. Type II is characterized by the large size of the parenchyma sheath cells which separate the xylem from the sclerenchyma next to the upper epidermis, and by the radial arrangement of the chlorenchyma cells. The reflectance collected for green fox tail sample is shown in Fig. 2e.

Paddy

Rice is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years. The rice plant can grow up to 3.3–5.9 ft tall, occasionally more depending on the variety and soil fertility. It has long, slender leaves 50-100 cm long and 2-2.5 cm broad. The small wind-pollinated flowers are produced in a branched arching to pendulous inflorescence 30-50 cm long. Rice cultivation is well-suited to countries and regions with low labor costs and high rainfall, as it is labor-intensive to cultivate and requires ample water. Paddy sample for which the reflectance is collected is shown in Fig. 2f.

Maize

Maize is a cereal grain domesticated in the American continent. The stems superficially resemble bamboo canes and the internodes can reach 20–30 cm. Maize has a very distinct growth form; the lower leaves being like broad flags, 50–100 cm long and 5–10 cm wide. They grow about 3 cm a day. The ears are female inflorescences, tightly covered over by several layers of leaves, and so closed-in by them to the stem that they do not show themselves easily until the emergence of the pale yellow silks from the leaf whorl at the end of the ear. Maize crop for which the reflectance is collected is shown in Fig : 2g

a) Cheat grass | b) Bermuda | c) Indian crow foot | d) Crow foot

e) Green fox tail | f) Paddy | g) Maize

Figure 2 Different species of poaceae considered for the study

Reflectance measurements were acquired in a field using a range of 350–1050 nm SVC HR 512i spectrometer with a 4° FOV lens, with a resolution of ≤ 3.5 nm FWHM @ 700 nm with an integration speed of 10-1000ms. the total no of bands covered by the instrument is 512 bands. A reflectance measurement takes the scan of a reference (white plate) and calculates the ratio of the target scan to that reference the spectral measurements are taken using the laser point of the instrument. First the white plate reference is taken for the calibration o f the instrument. The spectral reflectance of the different species of the poaceae family is collected in the field. The spectroradiometer is a hyperspectral having 512 band between 350-1050nm width. The spectral signatures for the different types of grasses are collected in the field during shiny hours. The spectral signatures collected are further studied

RESULTS AND DISCUSSIONS

Spectral reflectance curve for healthy green vegetation exhibits the "peak-and-valley" configuration. The peaks indicate strong reflection and the valleys indicate predominant absorption of the energy in the corresponding wavelength bands. In general, healthy vegetations are very good absorbers of electromagnetic energy in the visible region. The absorption greatly reduces and reflection increases in the red/infrared boundary near 700 nm. On the other hand, reflection peaks for the green colour in the visible region, which makes our eyes perceive healthy vegetation as green in colour. However, only 10-15% of the incident energy is reflected in the green band. the reflected infrared portion (or near infrared, NIR) of the spectrum, at 0.7 μm, the reflectance of healthy vegetation increases dramatically. As the leaf structure is highly variable between plant species, reflectance measurements in this range often permit discrimination between species, even if they look same in visible wavelengths.

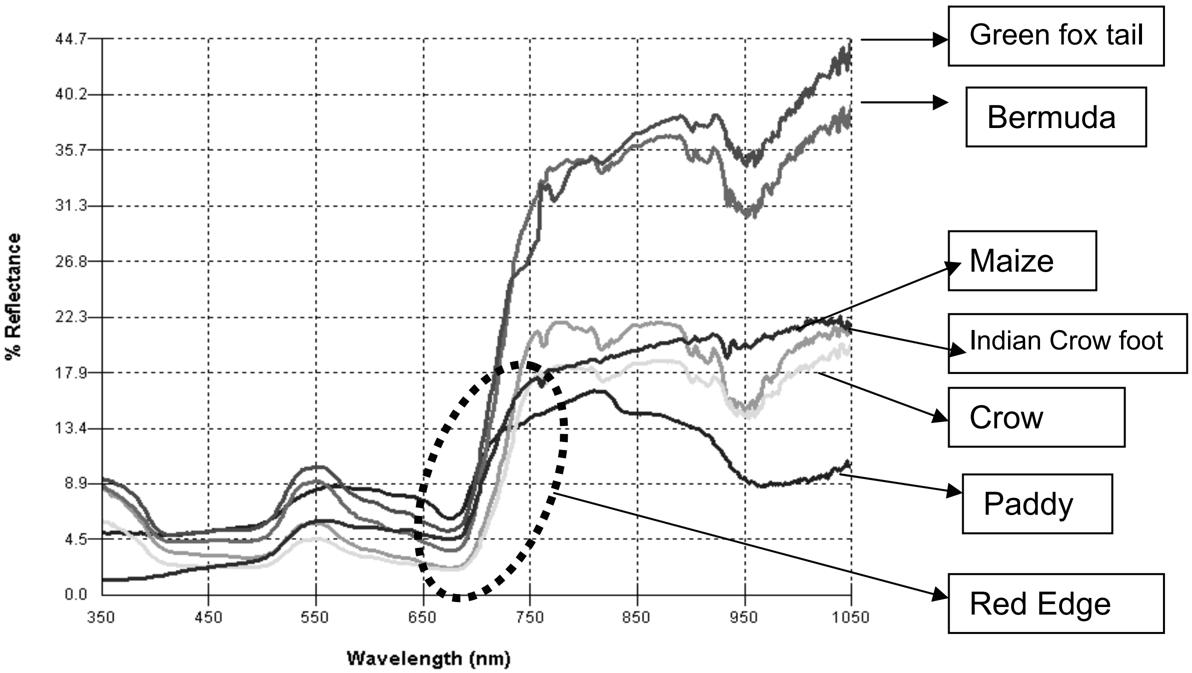

Figure 3 Spectral signatures of the different species of Poaceae family

CONCLUSIONS

The different types of vegetation can be identified using the hyperspectral remote sensing techniques. By observing the spectral signatures and by constant study of the spectral signatures the different species of the poaceae family are identified as the reflectance of the species vary due to the structural composition of the leaf, growing stage etc., In the study it was observed that the paddy is showing the less reflectance and the green foxtail is showing the high reflectance of the all selected species**.** All most all the species have the strong reflection at 550nm in common and the second strong reflection is different for different species when helps in the identification of the species. On an average the red edge of all the species is between 700-720nm, and the reflection percentage varies after the red edge to different species. The paddy shows the less reflection which is near to 15% and the maize and crow foot shows the same reflection near 780nm and later changes due to their internal structure changes. Indian crow foot and the crow foot species also show the similar type of reflection series with a slight change in the infrared region i.e from 700-1000nm. In the same way the Bermuda and green foxtail similar reflection is observed till 740nm and difference is reflection observed from 800-1000nm. The difference in the reflection may be of many reasons like the leaf structure, external parameters, which requires further more research on the leaf anatomy.

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Spectral Response of Cluster Beans Crop

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ABSTRACT

Spectroradiometer is an instrument which works based on principle of remote sensing, collecting data without making any physical contact with objects. Basically Spectroradiometer is used in many fields such as oil industry, food industry, Vegetative stress analysis, Surface color measurement. Spectral analysis is a fast, non-destructive and invasive method. If the reflectance is more than 26% then the crop is in healthy condition if it is less than 26% means crop is in stress condition. For any vegetation dips can be found at 400nm, 500nm, 550nm, 670nm, 770nm, 870nm and 920nm. There may be the same dips for a particular crop irrespective stages but percentage of reflectance will be vary because of chlorophyll , leaf internal structure and moisture content. In this paper study moved on cluster beans crop and variety of cluster beans for local names such as Meena and Rani at maturation stages. Objective of the study is to develop spectral library for Cluster beans for selected study area located in Sri Konda Laxman Horticultural University Rajendra nagar farmhouse using Spectroradiometer.

Keywords: Non-invasive, Reflectance, Spectroradiometer, Remote sensing, Non-destructive, Farmhouse.

INTRODUCTION

Spectroradiometer is an instrument by which one can used to detect or finding out the vegetation stress analysis, color measurements and many more fields. It is purely new technology to estimate the vegetation healthy or unhealthy conditions. Spectroscopy can be used to detect individual absorption features due to specific chemical bonds in a solid, liquid, or gas. Recently, with advancing technology, imaging spectroscopy has begun to focus on the Earth. The concept of hyper spectral remote sensing is being used most widely by geologists for the mapping of minerals. The Spectroradiometer which is used for analysis is Spectra Vista Corporation Company 512i, here 512 indicates the number of bands that have used in it. Plant parameters such as pigmentation, nutritional status, leaf architecture, internal structure of the leaves and water content affect spectral response of the leaves.Plants reflect less in visible portion whereas more reflects in infrared regions. The healthier plant will be greener due to higher content of chlorophyll in leaves resulting in higher absorption particularly in blue and red regions of the electromagnetic spectrum. The data generated from the proposed research shall be useful to make quantitative classification and identification of crop accurately, reliably, precisely and within short period of time. Collection of the data is very easy single personal can handled the instrument. Acquired data has to openin PC through USB cable. SVC 512i software is compatible for importing images. Reflectance of the surface of a material is its effectiveness in reflecting radiant energy. It's the fraction of incident electromagnetic power that is reflected at an inference. The reflectance spectrum or spectral reflectance curve is the plot of the reflectance as a function of wavelength. Spectral signature it is the difference in reflectance or emittance characteristics with respect to wavelength.

The total energy which can be reflected absorbed and transmitted with respect to type of crop or any objects. Black body can absorb 100% incident energy whereas white body reflects 100%. A graph of the spectral reflectance of an object as a function of wavelength is called a spectral reflectance curve. In general spectral reflectance graphs can be drawn four types such as vegetation, soil, water and snow. Which implies that with different objects reflectance values and pattern of graph varies because of internal structure, texture, chemical, physical, surface roughness, sun angle and finally type of material made up of. Larger the size or grains more the reflectance and vice versa.

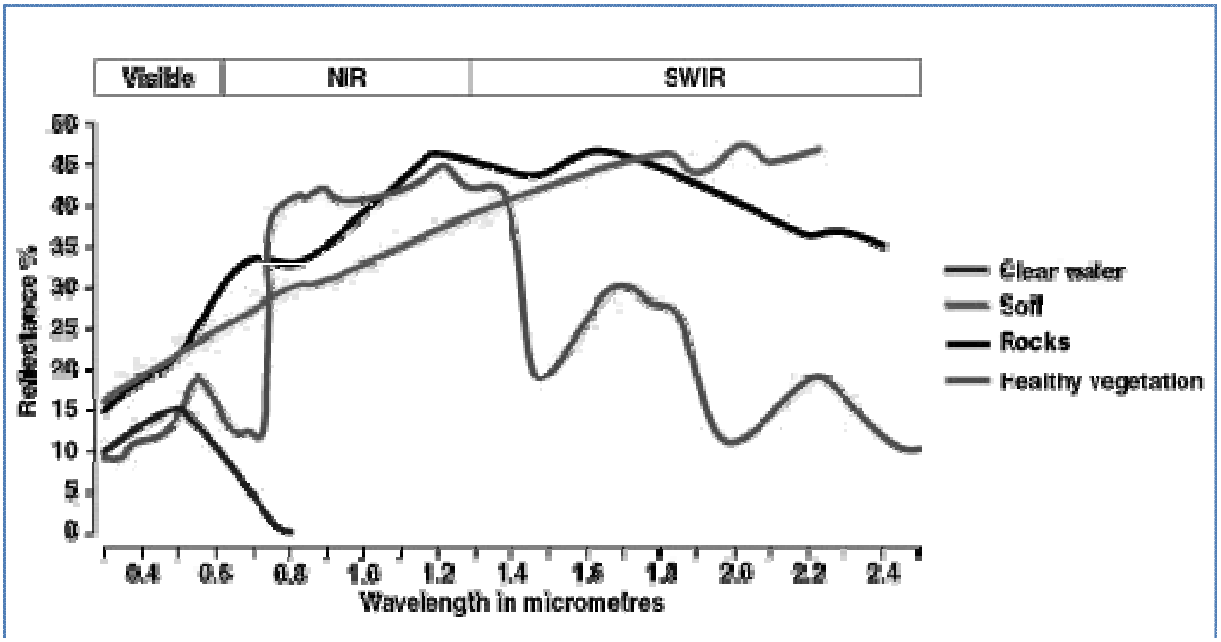

Figure 1 Spectral Signature of different materials

LITERATURE REVIEW

Hyper spectral remote sensing for LAI estimation in precision farming the ground based effective LAI (eLAI) measurements estimated with the LICORLAI- 2000 and eLAI values derived from probe-I hyperspectral surface reflectance data. The data was collected for corn and white beans canopies (Anna *et al.* (2001)). Development of hyper spectral data utilization technology for paddy field in Indonesia such as growth stage classification for estimating harvest time, in collaborate with agency for assessment and application technology, ground measurements are conducted and measured the LAI(Leaf Area Index), SPAD(Signal passed at danger) and growth stage. The airborne hyper spectral image was obtained by HYMAP developed by Hyvista. For classifying the growth stage, SAM (Spectral Angle Mapper) and space linear discriminate function are used (Atsushi *et al* (2012). Spectral analysis is carried out to acquire the spectral signatures using ASD and first derivative reflectance at fresh leaf scale only for ground based data. The correlations between spectral signatures, first derivative reflectance and three biochemical variables were established using curvefitting analysis (Adam *et al* (2010). Identification of the aphid infestation in mustard by hyper spectral remote sensing. Spectral reflectance was taken in healthy as well as in aphid-infested canopies of mustard in field as well as in laboratory. The filed experiments were conducted during 2009-2010 rabbi season at research farm of IARI New Delhi India. The spectral reflectance of the healthy as well as aphid-infested canopies was taken using Field Spec TM ground held Spectroradiometer on clear sunny days (Jitendra*et al* (2010)). Investigated the utility of space borne hyper spectral imaging for the development of a crop specific spectral library and automatic identification and classification of 4 cultivars for each of rice, chilly, sugarcane and cotton crops. The classification of crops at cultivator level using two spectral libraries developed using hyper spectral reflectance data at canopy scale (in-situ measurements) and at pixel scale (Rama Rao *et al* (2007)). Studied on method to extract a subset of individual bands from a hyperspectral data set of Hymap sensor, by performing the classification for previously mapped agricultural areas for which ground truth data had been collected in the same vegetation period in Germany, by applying the algorithms for feature extraction method (Sebastian *et at* (2006)). They had gone through between soil moisture content and soil surface reflectance. They minimize both the effect of time of day on the spectral data and the effect of drying time on the moisture data, every effort was made to perform the data collection within a consistent and minimal period (A.L.Kaleita *et al* (2005)).

METHODS AND MATERIALS

Spectroradiometer is an instrument for measurement of radiometric quantities in narrow wavelength intervals over a given spectral region. Spectra Vista Corporation proudly offers the SVC HR-512i. Here 512 indicate number of bands that are used in this instrument. This instrument combines the latest technology required to produce exceptional spectral datawhile capturing digital photographic, GPS and external sensor data. Hyper spectral hundredsto thousands number of spectral band and spectral resolution narrow, few nm; its capabilitydetects and identifies solids and liquids. One person by first setting up instrument parametersthrough the touch screen display and then initiating a measurement easily acquiresmeasurements. Spectral resolution and low noise ensure that the collected data is of thehighest quality and vice versa. A hyper spectral image provides each and every aspect can beanalyzing easily, spectral information to identify and distinguish between spectrally similarmaterials.

TAKING A REFERENCE

1. Check that the LED Power Indicator is illuminated, indicating that the power is enabled. On the LCD's "Setup Screen A", ensure that the trigger field is set to "Laser + Scan" by pressing the "TRIGGER:" button until the correct setting appears.
2. On the LCD's "Main Screen", ensure that the scan type is set to "Reference" by pressing the "SCAN:" button until the correct setting appears.
3. Press and hold the LASER/SCAN button to activate the sighting laser and verify the placement of the reference plate relative to the laser spot as required filling the field of view. Then LASER/SCAN button to record the measurement.
4. Repeat the Same process for Target measurement.

Downloading Stand-alone Measurements

Following steps are to data acquisition software in order to download the stand-alone measurements to the PC: See "Control->Setup Instrument…" for basic software connection instructions. See "Control->Setup Overlap/Matching…" for instructions on how to configure these settings, as they are applied to both downloaded and newly acquired spectral data. See "Control->Read Memory…" for downloading instructions.

STUDY AREA

For the purpose of study, area chosen which is belongs to Ranga Reddy district of Sri KondaLaxmanTelangana State Horticultural University Rajendranagar, Hyderabad, Telangana State, India. This is enclosed with geographical regions of 17°19'17"N,78°25'23"E. My study area boundary delineated from BHUVAN website for the study area using Arc Map 10.2 version. The study area map has been prepared and shown in Fig.4.1. Sri KondaLaxman Horticultural University the crops are identified in which the research is to be continued. Sri KondaLaxmanTelangana State Horticultural University (SKLTSHU), a dedicated & splendid institute of horticultural learning.

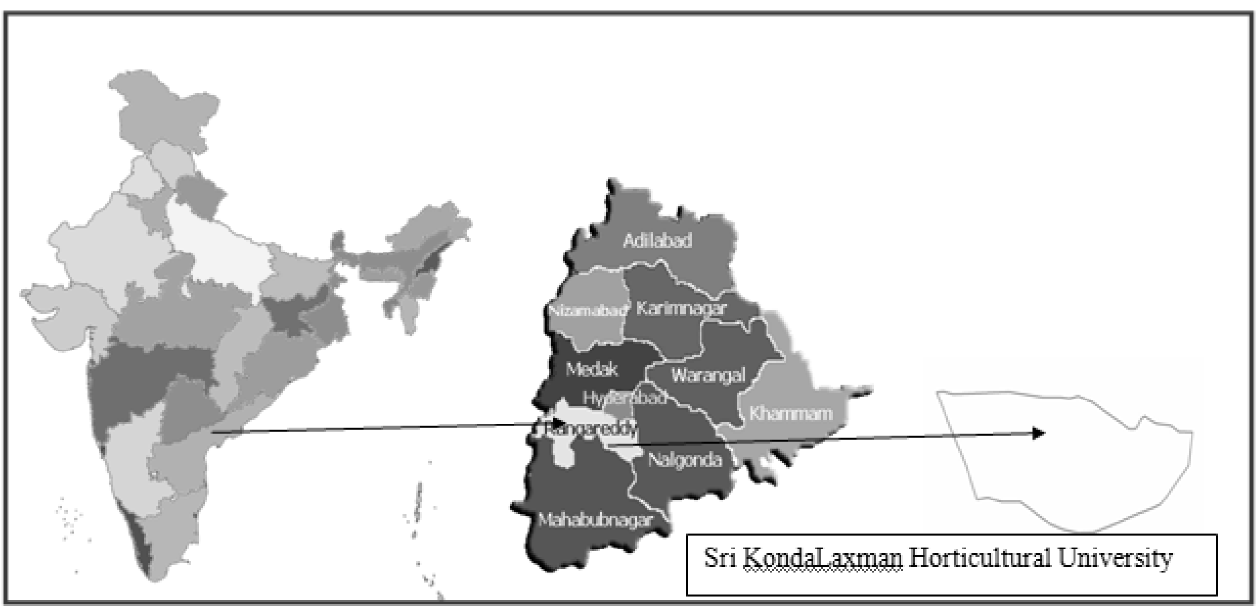

Figure 2 Sri KondaLaxman Horticultural University boundary Study Area Map

The spectral signature of following vegetation were studied in this research

- To develop spectral library for variety of cluster beans such as Chithrangi, Meena and Rani.

RESULTS AND DISCUSSIONS

The crop identification is done by direct visit to the study area and the direct analysis of the crops in direct view. The photographs of the crops are taken during the maturation stage of the crops. It is found that at the initial stage of crop the chlorophyll content is higher in amount due to that spectral reflectance is less in percentage at visible range, later chlorophyll content reduces due to aged crop so reflectance increases in near infrared regions after 920nm reflectance got disturbance.

Ground Truth Data for Cluster beans

Cluster beans were sowed on 23/07/2016 for the crop Cluster beans at maturation stage data only taken. Spectral response is at 450nm, 500nm down dip, 550nm up dip, 690nm down dip, 770nm up and finally at 920nm dips can be observed these dips are common with irrespective of stages. Spectroradiometer has the wide range of 350nm to 1050nm within this spectrum only data has analysis. Considered the wavelengths are 400nm and 920nm for simple understanding with respect to spectral reflectance.

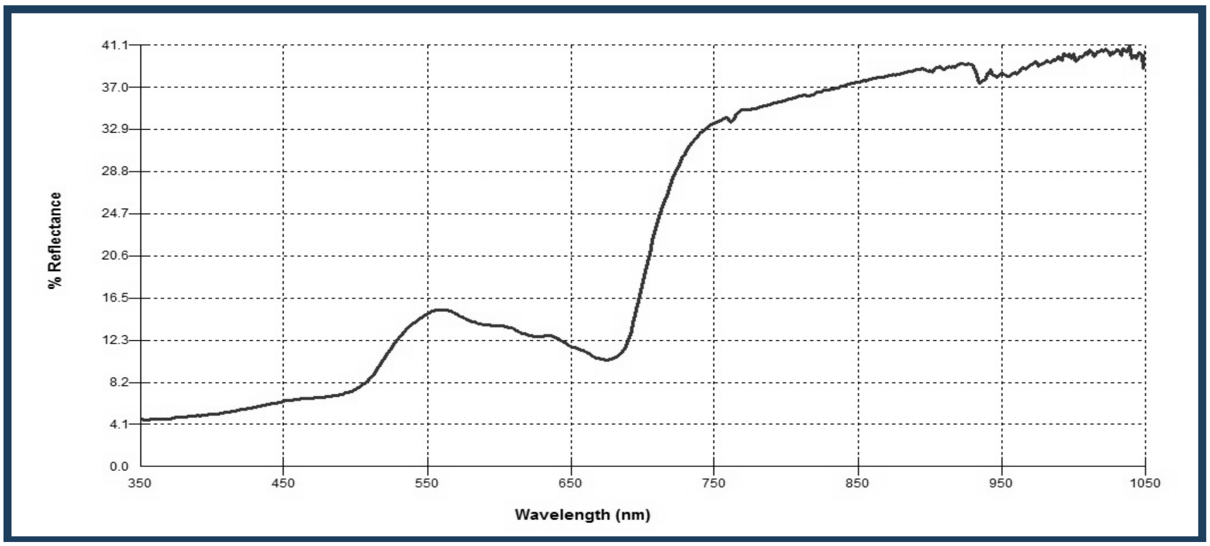

Figure 3 Spectral reflectance of cluster bean variety of meenaat maturation stage

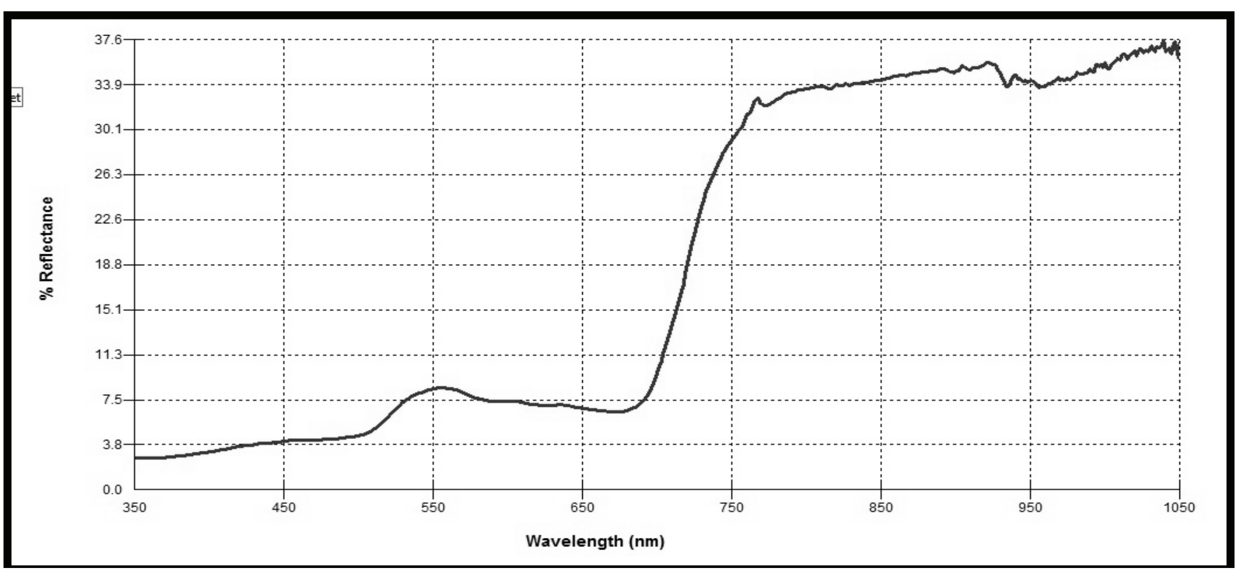

Figure 4 Spectral reflectance of cluster bean variety of Rani at maturation stage

- At 400nm wavelength reflectance is about 5.5% and at 920nm is about 37% at maturation stage for Meena variety of cluster beans.
- At 400nm wavelength reflectance is about 3.8% and at 920nm is about 33.9% at maturation stage for Rani variety of cluster beans.

From above reflectance response one can understand that reflectance is depends of the amount of chlorophyll present in the crop, leaf internal structure and types of crop within same variety also.

CONCLUSIONS

- The spectral reflectance curve of green vegetation one can observe that the spectral reflectance curve of green vegetation is not a uniform one. It varies from different regions of the electromagnetic spectrum.
- Low reflectance corresponds to chlorophyll absorption bands because chlorophyll present in the green leaf absorbs most of the incident energy.
- Variation in spectral reflectance is mainly due to internal structure of leaf and moisture content present in the leaf, thickness etc.
- The internal leaf structure controls the leaf reflectance in the near infrared region where nearly half of it is transmitted while the other half is reflected. In the middle infrared region, the total moisture content of the vegetation controls the reflection where much of the incident energy is absorbed by the leaves.
- Tomato spectral response analyzed in uncontrolled and controlled farming dips are at same wavelengths but only difference is spectral reflectance percentages this may be due to spraying the pesticides in controlled farming and absence in uncontrolled farming.
- In the near infrared portion of the spectrum, there is a marked increase in reflectance beyond 0.7nm as it passes from visible to infrared region. In this region, the green vegetation is characterized by high reflectance, high transmittance and low absorption.
- From the spectral response developed from the study, it has been found that at 500nm, 690nm and 920nm shows down dip and 550nm and 770nm is up dip has been observed irrespective of various stages of crop.
- At 400nm wavelength and 920nm wavelengths about 5.5%, 3.8% and 37%, 33.9% for Meena, Rani respectively.

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Effective use of Chemical Coagulants for Reducing Total Organic Carbon

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ABSTRACT

The Total Organic Carbon (TOC) is an index of the total amount of organic substances in water, playing a key role in assessing the efficiency of a wastewater purification process. It is used in a wide array of applications from management of wastewater treatment plant influent and effluent, to drinking water supply management, and monitoring of impurities in process and surface waters. In this respect, a key issue is to find the most efficient analytical method to determine the amount of TOC in the wastewater, both in terms of time, cost and accuracy of results. Ferric chloride and Alum, which are the most common types of coagulants in water treatment plants of Iran as well as many other countries, were investigated with the aim of determining their capabilities to reduce TOC of urban lake samples namely Durgam Cheruvu, Chinna Maisamma Cheruvu, Khajaguda Cheruvu, Sunnam Cheruvu, Timmidkunta Cheruvu and Malaka Cheruvu in and around HITEC city and Borabanda collected in the month of June 2016. In the present study, Jar tests were carried out to optimize coagulant dose and study the effect of Alum and Ferric chloride on TOC effectively using Alum and Ferric chloride tested within (50-100 mg/L) dose range. The highest TOC removal efficiency was within 5-15 % for Alum and Ferric chloride over applied range of dose. Both applied coagulants demonstrated promising performance in reducing total organic carbon content from the urban lake samples.

Keywords: Total organic carbon, Ferric chloride, Alum, Jar test

INTRODUCTION

The occurrence of organic contaminants in water usually occurs during heavyrains. Domestic and industrial activity also contributes to the organic contaminantsamounts in various wastewaters. As a result of accidental spills or leaks, industrialorganic wastes may not be completely removed by treatments processes and enterin waters sources. Therefore, it is important to know the organic content in a watersample.The determination of Total Carbon Organic (TOC) content in water is useful as a measure of pollution. Also, it is becoming increasingly important to have a reliable and rapid technique for determination of total carbon organic in wastewater used for better purification procedures by knowing the amount of TOC in the wastewater (Dolezal et al., 2003).

ENVIRONMENTAL IMPACT OF TOTAL ORGANIC CARBON

Capable of providing information regarding the organic character of water, the knowledge of carbon content in wastewater samples becomes an important element in water monitoring programs. Using TOC measurements, a number of compounds with carbon content could be determined. This is the sum of organically bound carbon present in water connected to dissolved or suspended matter. If the oxygen consumption is high, then the organic carbon content increases. An increased organic content is marked by a growth in microorganisms and thus more oxygen is consumed. That is why, to have efficiency in purification process of wastewater, information related to the total carbon organic content are determinant (Tepus et al., 2007).

PRINCIPLE OF TOTAL ORGANIC CARBON ANALYSIS

The measurements were performed using a Total Organic Carbon Analyzer TOC-L series made by Shimadzu Instruments. Two types of carbon are present in water: total organic carbon (TOC) and inorganic carbon (IC). Organic carbon binds with hydrogen or oxygen to form organic compounds. Collectively, the two forms of carbon are referred to as total carbon (TC) and the relationship between them is expressed as:

$$TOC = TC - IC$$

After acidifying the sample to pH 2 to 3, pure gas is bubbled through the sample to eliminate the IC component. The remaining carbon is measured to determine total organic carbon, and the result is generally referred to as TOC.

TOC represent non-purgeable organic carbon and refers to organic carbon that is present in a sample in a non-volatile form (Dolezal et al., 2003).

Sample is introduced in the combustion tube, which is filled with an oxidation catalyst and heated to 6800C. In the samples, carbon is first converted to CO_2 by the combustion furnace for TOC and TC analysis or by the IC sparger for IC analysis. Carrier gas flows to the combustion tube and carries the sample combustion products from the combustion tube to an electronic dehumidifier, where the gas is cooled and dehydrated. The gas then carries the sample combustion products through a halogen scrubber to remove chlorine and other halogens.

A carrier gas then sweeps the derived CO_2 thought a non-dispersive infrared (NDIR) detector. Sensitive to the absorption frequency of CO_2, the NDIR generates a non-linear signal that is proportional to the instantaneous concentration of CO_2 in carrier gas. That signal is then plotted versus the samples analysis time. The peak area is proportional to the TC concentration of the sample. Calibration curve equation that mathematically expresses the relationship between the peak area and the TC concentration can be generated by analyzing various concentrations of a TC standard solution. The TC concentration in a sample can be determined by analyzing the sample to obtain the peak area and then using the peak area in the calibration curve equation.

The resulting area is then compared to the stored calibration data of a sample with concentration in parts per million.

MATERIALS AND METHODS

The standard measurement procedure described in Water quality – guidelines for the determination of total organic carbon (TOC) (ISO 8245:2000) was followed which provides guidelines for the determination of TOC in wastewater. The procedure described in this international standard applies to wastewater samples containing concentrations of organic carbon of up to 1000 ppm, while higher concentrations can be determined after the appropriate dilution.

Figure 1 Durgam Cheruvu

Figure 2 Chinna Maisamma Cheruvu

Figure 3 Khajaguda Cheruvu

Figure 4 Sunnam Cheruvu

Figure 5 Timmidkunta Cheruvu

Figure 6 Malaka Cheruvu

Qualitative analysis of urban lake samples pre and post jar test study was successfully performed in water quality laboratory of JNTUH. The water sample was collected in the month of June 2016 using polythene cans of 10L capacity from a depth of 0.5 m below the surface of lake.Quality report was validated by comparing the current study results to BIS 10500 : 2012. Stock solutions of 1% Alum and Ferric chloride were prepared. All the chemicals used in the study were of Analytical grade. Total organic carbon of the samples were measured using Shimadzu TOC-L series analyzer by preparing standard reference solution of Potassium hydrogen Phthalate chemical of 1000 ppm concentration.Jar test experiments on the collected samples of 1L volume were used tostudy the performance of Aluminum Sulphate (Al2(SO4)3.18H2O) and Ferric Chloride (FeCl3. 6H2O) coagulants on a six stirrer DBK Flocculator Jar testing apparatus at room temperature with experimental characteristics as summarized in Table 1. At the end of Jar test after providing sufficient settling time leaving the settled flocs aside, 50 mL of supernatant was withdrawn from the jar of 1L capacity and thoroughly filtered using filter paper and stored for future analysis.

Table 1 Experimental characteristics for Jar test study

Characteristics	Description
Coagulants	Alum and Ferric Chloride
Coagulant dose range	50-100 (mg L^{-1})
Rapid mixing	2 min at 161 (rpm)
Slow mixing	30 min at 25 (rpm)
Settling time	2 hours

RESULTS AND DISCUSSIONS

Analysis was carried out for 6 lakes namely Durgam Cheruvu, Chinna Maisamma Cheruvu, Khajaguda Cheruvu, Sunnam Cheruvu, Timmidkunta Cheruvu and Malaka Cheruvu collected during June 2016. The coagulation efficiency of Alum and Ferric chloride at test doses 0 mg/L, 50 mg/L, 70 mg/L and 100 mg/L were evaluated under experimental conditions. Results indicated that addition of alum and ferric chloride to lake samples during jar test study reduced the TOC levels with increase in dose. It was found that performance of alum was slightly better than ferric chloride in reduction of TOC levels from raw lake samples. Though negligible reduction of TOC was observed in both the cases, TOC levels in raw and treated samples were found to be above the permissible limits as suggested by BIS 10500 : 2012 which can be considered as an undesirable effect.

Basic stoichiometric reactions occuring during the coagulation process for ferric chloride and aluminum sulfate (Alum) are given below:

$$FeCl_3 \cdot 6H_2O + 3(HCO_3^-) \rightarrow Fe(OH)_{3,am\downarrow} + 3Cl^- + 6H_2O + 3CO_2$$

$$Al_2(SO_4)_3 \cdot 14H_2O + 6(HCO_3^-) \rightarrow 2Al(OH)_{3,am\downarrow} + 3SO_4^{2-} + 14H_2O + 6CO_2$$

Table 2 Analysis results of different lakes

Para-meter	BIS 10500:2012 Permissible limits	Dose in mg/L	Coagulant	URBAN LAKES FOR THE STUDY AREA					
				Durgam Cheruvu	Chinna Maisamma Cheruvu	Khajaguda Cheruvu	Sunnam Cheruvu	Timmidikunta Cheruvu	Malaka Cheruvu
TOC (ppm)	< 10	0	Alum	77.37	64.63	59.94	46.98	69	64.66
			Ferric Chloride	77.37	64.63	59.94	46.98	69	64.66
		50	Alum	73.2	61.2	56.18	44.12	66.71	62.49
			Ferric Chloride	73.9	60.84	57.2	44.26	67.2	62.84
		70	Alum	70.26	59.7	52.92	42.64	66.12	60.22
			Ferric Chloride	70.41	61.2	53.14	43.1	66.32	60.4
		100	Alum	69.2	55.69	50.63	40.42	62.13	59.64
			Ferric Chloride	69.42	56.8	51.2	40.86	63.2	59.82

The highest TOC removal efficiency was within 5-15 % for Alum and Ferric chloride over applied range of dose. Both applied coagulants demonstrated promising performance in reducing total organic carbon content from the urban lake samples.

Moreover, Alum is widely available nontoxic material and it is proved to be cost-effective in water treatment process. Costs of alum application are primarily dependent on the form of alum used (wet or dry), dosage rate, area treated, equipment rental or purchase, and labor. Liquid alum has been used when large alum doses were needed.

Coagulation and flocculation process is a primary and cost-effective process in water treatment plants which can effectively remove TOC when operational condition is optimized. Optimization of pH and coagulant dose may increase the coagulation efficiency and reduce the sludge volume and subsequently sludge management costs.Coagulant aids may improve coagulation process and TOC removal. But it should be considered that coagulant aids should not increase water treatment costs significantly. Their accessibility and preparation procedure should also be considered when selecting a coagulant aid. It should be noted that rapid mixing parameters including time and intensity of mixing, as well as slow mixing parameters may also affect TOC removal efficiency in coagulation process.

CONCLUSIONS

It is evident that the test doses used in the study for reduction of TOC levels with alum and ferric chloride from raw lake samples was insufficient. TOC removal becomes difficult as alkalinity tends to be high, just adding the coagulants may not be sufficient thereby requiring addition of acids to lower the pH of samples. Hence, it is recommended to further increase the dosage of coagulants and alter the experimental conditions in order to obtain better removal efficiencies. TOC alone in raw water may not be harmful, but reaction with disinfectants leads to formation of disinfection byproducts that tend to be harmful. Hence, TOC analysis of lake samples is very much essential. It is essential to go for cost-effective and eco-friendly method of purification of water and consequently it is being recommended for large scale water treatment use in the rural industrially developed area where no facilities are available for the treatment of water bodies.

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Spectral Reflectance from the Tomato Crop Canopy under Controlled Condition by using Spectroradiometer

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ABSTRACT

The reflectance spectrum or spectral reflectance curve is the plot of the reflectance as a function of wavelength. Spectral signature is the difference in reflectance or emittance characteristics with respect to wavelength. Spectroradiometer is an instrument used for measurement of reflectance in percentage values from the objects. It has been using in many fields such asvegetative stress analysis, Forestry Analysis, Marine and Wetlands studies measurement etc. The graph given by Spectroradiometer is between percentages of reflectance on Y-axis and Wavelength in nanometer on X-axis. Graphs suggest how much percentage of energy reflects from incident energy and the drawn graph which is not a straight line or smooth curve. Rise and fall indicates the water absorption bands. Dips vary with material to materials which also depends on molecules present which them. Healthy vegetation will absorb more light than unhealthy or stress condition vegetation. If the reflectance is more than 26% then the crop is in healthy condition if it is less than 26% means crop is in stress condition. For any vegetation dips can be found at 400nm, 500nm, 550nm, 670nm, 770nm, 870nm and 920nm. There may be the same dips for a particular crop irrespective stages but percentage of reflectance will be vary because of chlorophyll , leaf internal structure and moisture content. In the present study, the spectral reflectance of tomato controlled conditions in Sri KondaLaxman Horticultural University of Telangana (Rajendra Nagar) farmhouse from the visible/near infrared spectra of sensitive spectral band was applied to develop a method for rapid detection of spectral reflectance.

Keywords: Spectroradiometer, Horticulture, Controlled condition, Spectral reflectance, Emittance.

INTRODUCTION

Remote sensing is the collection of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation. Remote sensing is used in numerous fields, including geography and most Earth Science disciplines for example, hydrology, ecology, oceanography etc. In Optical Remote Sensing, optical sensors detect solar radiation reflected or scattered from the earth, forming images resembling photographs taken by a camera high up in space. Spectroradiometer is basically emitting the light which has the properties such as electromagnetic radiation light exists as photons displaying both wave and particle properties, discrete quanta of energy wavelength measurements in 350nm-1050nm range of EM spectrum. The interaction of electromagnetic radiation with materials on a macroscopic level, including the refraction, diffraction and scattering effects formed the basis of traditional remote sensing theory. The hyperspectral spectral analysis is a fast and non-destructive method and has been used in many fields such as oil industry, food industry, Vegetative stress analysis, Surface color measurement. In most of the vegetation, dips can be found at 400nm, 450nm, 500nm, 550nm, 670nm, 770nm and 920nm wavelengths. This is due to presence of chlorophyll content in the leaves in visible region more chlorophyll present so lesser the reflectance whereas in near infrared region chlorophyll content is medium and in middle infrared and lesser the chlorophyll content so by observing that it is found that the spectral response is rising trend in vegetation with dips at specific wavelengths. For the purpose of study data captured for mainly, two stages at maturity stage. There were same dips for particular crop irrespective stages of the crop. Only difference is percentage of reflectance value varied because of chlorophyll content within the crop this change is due to leaf internal structure, moisture content etc. Rise and fall of trend can be noticed which provides the information about water absorption dips varies with material to materials which also depends on molecules present which them. There are various objects which can reflects different range of percentage mostly for simple study some of the major curves are scientifically drawn such as vegetation, water, soil and snow

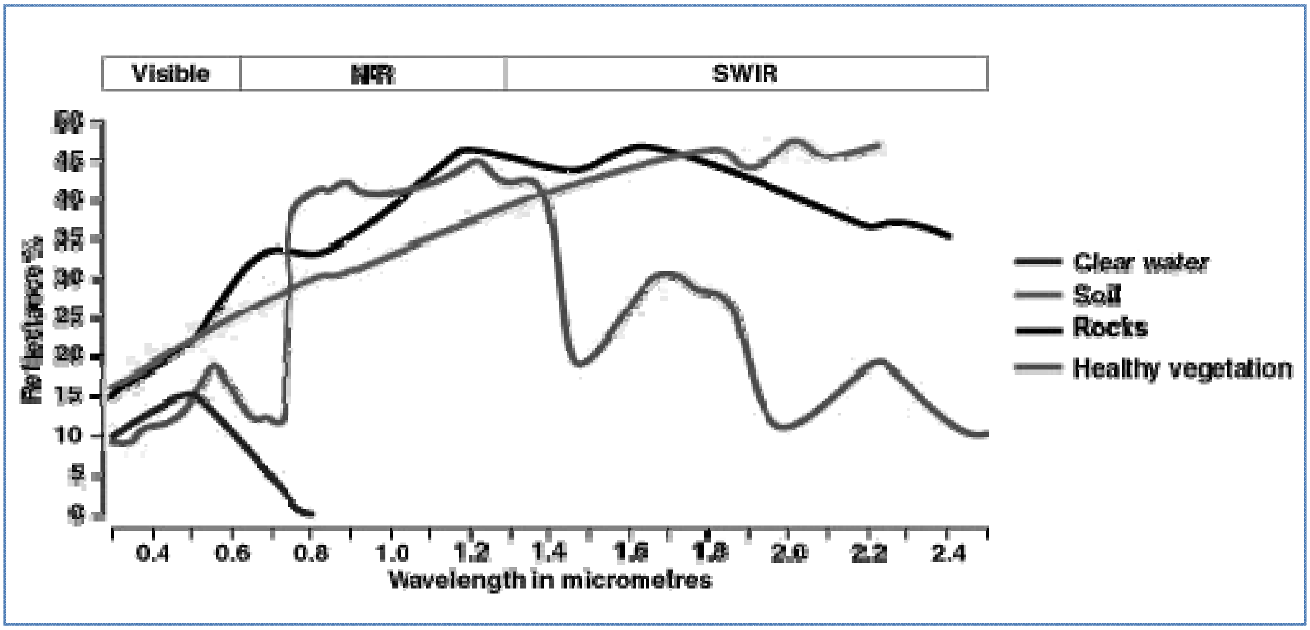

Figure 1 Spectral Signature of different materials

LITERATURE OF REVIEW

Dhaval*et al* (2013) had attempted to derive canopy level estimation of chlorophyll and Leaf Area Index (LAI) for tropical species using the Hyperion data. 50 leaves were picked up from different individuals. Leaf area and leaf dry weight were measured, SLA was calculated. Hyperion data was collected with cloud cover less than 25%. Atmospheric correction was carried out using ACORN 1.5 software. Subset extraction and image processing were performed using ENVI V.4.6 software.

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Adam *et al* (2010) he studied ground based hyperspectral analysis is carried out by to acquire the spectral analysis is carried out to acquire the spectral signatures using ASD and first derivative reflectance at fresh leaf scale. The correlations between spectral signatures, first derivative reflectance and three biochemical variables were established using curve fitting analysis.

Jitendra*et al* (2010) identified the aphid infestation in mustard by hyperspectral remote sensing. Spectral reflectance was taken in healthy as well as in aphid-infested canopies of mustard in field as well as in laboratory. The filed experiments were conducted during 2009-2010 rabbi season at research farm of IARI New Delhi India.

Rama Rao*et al* (2007) investigated the utility of space borne hyper spectral imaging for the development of a crop specific spectral library and automatic identification and classification of 4 cultivars for each of rice, chilly, sugarcane and cotton crops. The classification of crops at cultivator level using two spectral libraries developed using hyper spectral reflectance data at canopy scale (in-situ measurements) and at pixel scale (Hyperion data). The data has been collected from different sources such as Hyperion data, in situ hyperspectral data using field spectroradiometer (GER 3700, Spectra Vista Crop. New York, NY, USA) and other ancillary data.

Sebastian *et at* (2006) presented a method to extract a subset of individual bands from a hyperspectral data set of Hymap sensor, by performing the classification for previously mapped agricultural areas for which ground truth data had been collected in the same vegetation period in Germany, by applying the algorithms for feature extraction method.

A. L. Kaleita *et al* (2005) their study was relationship between soil moisture content and soil surface reflectance. They minimize both the effect of time of day on the spectral data and the effect of drying time on the moisture data, every effort was made to perform the data collection within a consistent and minimal period. Data collections were limited to approximately a 2hr window.

Zarco *et al* (2005) discussed the several new narrow band hyperspectral indices calculated from Air borne visible and near Infrared (AVNIR) hyperspectral sensor over a cotton field in California (USA) collected over an entire growing season at 1m spatial resolution. Within field variability of yield monitor spatial data collected during harvest was correlated with hyperspectral indices related to crop growth and canopy structure, chlorophyll concentration and water content.

METHODS AND MATERIALS

Spectroradiometer is an instrument for measurement of radiometric quantities in narrow wavelength intervals over a given spectral region. Spectra Vista Corporation proudly offers the SVC HR-512i. Here 512 indicate number of bands that are used in this instrument. This instrument combines the latest technology required to produce exceptional spectral data while capturing digital photographic, GPS and external sensor data. Hyper spectral hundreds to thousands number of spectral band and spectral resolution narrow, few nm; its capability detects and identifies solids and liquids. One person by first setting up instrument parameters through the touch screen display and then initiating a measurement easily acquires measurements. Spectral resolution and low noise ensure that the collected data is of the highest quality and vice versa. Hyper spectral images provide each and every aspects can be analyze easily, spectral information to identify and distinguish between spectrally similar materials.

Taking a Reference

1. Check that the LED Power Indicator is illuminated, indicating that the power is enabled. On the LCD's "Setup Screen A", ensure that the trigger field is set to "Laser + Scan" by pressing the "TRIGGER:" button until the correct setting appears.
2. On the LCD's "Main Screen", ensure that the scan type is set to "Reference" by pressing the "SCAN:" button until the correct setting appears.
3. Press and hold the LASER/SCAN button to activate the sighting laser and verify the placement of the reference plate relative to the laser spot as required filling the field of view. Then LASER/SCAN button to record the measurement.
4. Repeat the Same process for Target measurement.

Downloading Stand-alone Measurements

Following steps are to data acquisition software in order to download the stand-alone measurements to the PC: See "Control->Setup Instrument…" for basic software connection instructions. See "Control->Setup Overlap/Matching…" for instructions on how to configure these settings, as they are applied to both downloaded and newly acquired spectral data. See "Control->Read Memory…" for downloading instructions.

STUDY AREA

For the purpose of study, area chosen which is belongs to Ranga Reddy district of Sri KondaLaxmanTelangana State Horticultural University Rajendranagar, Hyderabad, Telangana State, India. This is enclosed with geographical regions of 17°19'17"N, 78°25'23"E. My study area boundary delineated from BHUVAN website for the study area using Arc Map 10.2 version. The study area map has been prepared and shown in Fig.4.1 Sri KondaLaxman Horticultural University the crops are identified in which the research is to be continued. Sri KondaLaxmanTelangana State Horticultural University (SKLTSHU), a dedicated & splendid institute of horticultural learning. It is the first Horticultural University in the state of Telangana and fourth in the Country. The mission goal & primary mandate of the University is to excel as Centre of Excellence in Education, Research and Extension Education in the field of Horticulture and allied sectors.

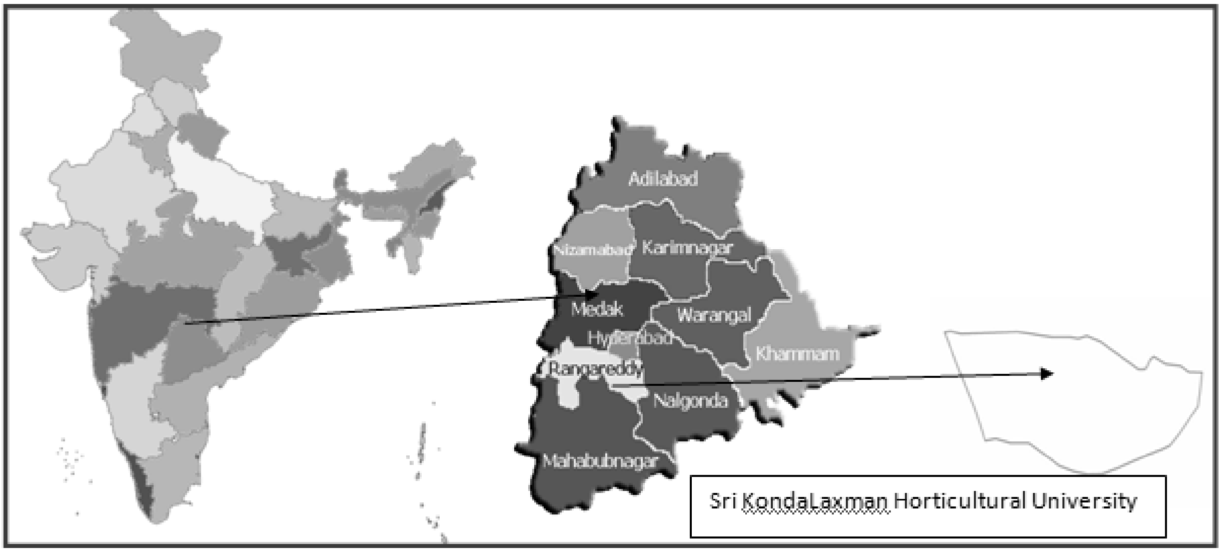

Figure 2 Sri KondaLaxman Horticultural University boundary Study Area Map

The spectral signature of following vegetation were studied in this research

- ✓ Tomato crop under controlled condition (maturation to harvesting stage)

RESULTS AND DISCUSSIONS

The crop identification and the village identification is done by direct visit to the study area and the direct analysis of the crops in direct view. The photographs of the crops are taken during the maturation and harvesting stages of the crops. Tomato crop taken for study under controlled conditions. Results drawn for at two stages of crop maturation and harvesting stage. It is found that at the initial stage of crop the chlorophyll content is higher in amount due to that spectral reflectance is less in percentage at visible range, later chlorophyll content reduces due to aged crop so reflectance increases in near infrared regions after 920nm reflectance got disturbance.

Ground truth data of tomato under Controlled conditions

Figure 3 Tomato under uncontrolled conditions farming at flowering stage

Tomato controlled farming sowed on 06/06/2016, planted on 27/06/2016, harvested on 01/09/2016. Controlled farming tomato grown in with spraying the pesticides and all other methods and fertilizers are common as like uncontrolled farming. For the crop Tomato spectral response is at 400nm, 450nm, 500nm down dip, 550nm up dip, 690nm down dip, 770nm up and finally at 920nm dips thereafter due to disturbance fluctuations occurs in response. Spectroradiometer wide range of spectrum is about 350nm to 1050nm only study took place within this range. Tomato spectral response analyzed in uncontrolled and controlled farming dips are at same wavelengths but only difference is spectral reflectance percentages this may be due to spraying the pesticides in controlled farming and absence in uncontrolled farming. At 450nm wavelength spectral response can be around 6.2% whereas at 920nm the spectral response about 77% at maturation stage.

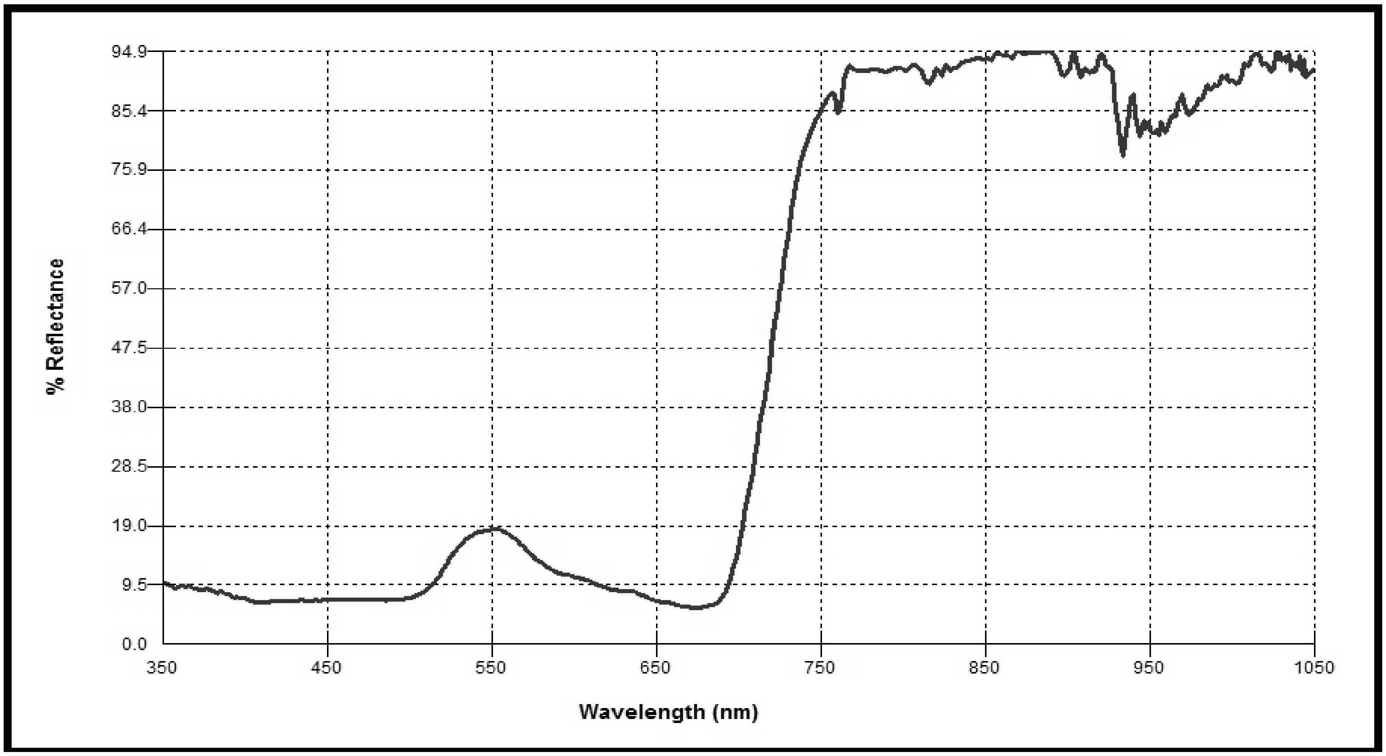

Figure 4 Spectral reflectance of tomato under controlled condition at maturation stage

CONCLUSIONS

- Data availability is an issue common to all approaches although optical remote sensing data are more easily obtained and typically costs less, availability is often limited bypoor weather conditions.
- Thermal remote sensing systems are uncommon and generally provide spatialresolution that is too coarse for watershed scale monitoring.
- Reflectance also understood that for a particular surface is more rough means lesser theamount of reflectance simply it can be decrease in surface roughness can increase thereflectance.
- Wetted area absorb more incident light than dry area and vice-versa
- The internal leaf structure controls the leaf reflectance in the near infrared region wherenearly half of it is transmitted while the other half is reflected.
- In the middle infrared region, the total moisture content of the vegetation controls thereflection where much of the incident energy is absorbed by the leaves.
- Optimum moisture content is main criteria increase in optimum moisture content willdecrease reflectance.
- **Tomato under Controlled Condition:** From the developed spectral reflectance studyhere crop grown with spraying pesticides**.**

- At 400nm wavelength reflectance is about 6% and at 920nm is about 76.2% atmaturation stage for Tomato under Controlled Condition.

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THEME – VII

WATER MANAGEMENT, RAINFALL AND RAINWATER HARVESTING

Water and Sanitation Utility Services for Mining Areas by Reusing of Mine Discharge – Challenges and Strategies

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ABSTRACT

People in rural mining areas are facing acute shortage of potable water supply But million gallons of mine water are being pumped out from mines and they are just being wasted. On the other hand additional costs are being made for the identification and collection of raw water from other sources for meeting the water demand in the area. This paper focuses on the threat of increasing hydrological extremes due to climate change and sea level rise. It examines the possibility of reusing the mine discharge for meeting the challenge of potable water supply in the area. It also examines the water resources, water quality criteria, quantitative and qualitative aspects of water resources available in the Raniganj Coalfield and identified its various sources, such as river water, mine water; ground water and from abandoned mines, and it discusses the water demand at present and in future in the Coalfield. This paper highlights the qualitative aspects of water for which it has become integral part in our living process. The study reveals that the acute need to supply water in the region can be addressed by using the million gallons of mine effluent that are being pumped out from the mines in the area. It is evident that mine water quality does not deteriorate to a great extent, and those can be reused for the purpose of improving water productivity in the agriculture, industrial use other than drinking. A low cost treatment scheme has been proposed for the mine discharge for public water supplies in mining areas.

Keywords: Water demand, potable, climate change, epidemics, treatment, disinfection,

INTRODUCTION

Developing countries such as India must continue to promote industrial development if they are to achieve a target of establishing 150,000MW-power generation capacity by 2010AD. This requires increased mineral fuel production (Ghose 1997, 2003a), and more specifically, to meet its proposed energy needs, producing nearly double the quantity of coal India is currently mining, as its fuel needs will be in the range 550 Mt/y by 2010 AD. Indian coal production, which is in the order of 330Mt/y, is currently supporting some 70,000 MW of thermal power generation (Ghose 2003b, 2003c). If the industrial development is to be emphasized the link between increased industrial production, energy demand and the need to provide potable water supply in the thickly populated rural coal mining areas cannot be overlooked. During the summer season drought like conditions prevail, compelling the mining community to use contaminated water, which affects the public health. Mining populations in most of the regions in India have been facing acute shortage of water supply and in some places people, particularly women folk have to walk a few kilometers to collect the water for their daily needs. Epidemics also occur due to water-borne diseases due to the non-availability of a properly treated water supply. Million gallons of mine water are being pumped out from coalmines in the areas (Singh 2004), which can be utilized for the public water supply in the area. But this water available from various sources may be contaminated with different industrial and domestic effluents and loose its acceptable value and subsequently is just being wasted incurring enormous costs in pumping requirements. On the other hand additional costs are being made for the identification and collection of raw water from other sources and treatment to meet the water quality criteria for the supply of potable water from the public water supply scheme The possibility of available mine for reusing needs a thorough investigation to fulfill the raw water demand in the area , which can save cost and water balance in the region. The National Water Policy 1987/2002 emphasizes the need to augment the water availability from such sources as well as to meet various water demands of local people (NWP 1987).

The objective of this paper is to investigate the water resources available and water demand in Raniganj Coalfield areas of Eastern India, water shortage as well as availability of mine water and to evaluate the possibility of reuse of mine discharge for public water supplies.

WATER RESOURCES

Since the day, life appeared on earth, water started the constituting of main life cycle. Of all liquids known to us, none of them can take the place of water in the great variety of life process (Ghose 1993). Many of the liquids- gasoline, alcohols, mineral oils, and vegetable oils- may appear similar to water, but because they are composed of chemically different substances, they do not have the combination of properties that make water unique. In this earth we are fortunate because it contains more oceans, lakes, streams and subterranean waters than landmasses. The earth's oceans are unique in sun's family of planets. It is so, only because the earth has surface temperature in the exceedingly narrow range within which water remains as a liquid. In the vast researches of the universe, temperature tend to extreme towards either near the absolute zero cold of interstellar space or the tens of million degrees found within stars. Our planet probably has the wrong name. Our planet should have been named ocean and not earth. Ours is the watery planet indeed, there is no other like it in the solar system.

The fresh water that is so essential to our lives is of only a small portion of the earth's water supply- about two percent. Nearly all of these two percent is locked in the masses of ice caps, glaciers and clouds. The remaining small fraction of fresh water is accumulated over centuries in the lakes and underground supplies of the world. Surprisingly, it is the salt water of the oceans is the main supplier of fresh water on the land. Almost eighty five percent of the rain falls directly into the sea and never reaches the land. The small remainder, which precipitates on the land, fills up the lakes and wells, and that keeps the river flowing. For every 50,000 grams of ocean water only one gram of fresh water is available to us making water a scarce and thus a precious commodity. Global water balance is given below:

Approx. total area of earth 1.49 x 108 km^2

Sea area on earth 3.61 x 108 km^2

Approx. total water on earth 1400 Mkm^3

Total water on sea's & oceans 1346 M. km^3 (97%)

Total water on land surface 54 M. km^3

Total water stored in ice caps 41 M. km3 (77%) and glaciers

Water stored as groundwater 12 M. km^3 (22%)

Water held in atmosphere 1890 km^3 (0.035%)

Total fresh water on surface 17820 km^3 (0.33%)

During 1985 the total consumption of the water on this earth has been estimated at about 3750 km^3 per year. Out of this irrigation uses amounted to 73%, industrial uses 21 %, domestic and recreational uses 6%.

Water resources and water quality criteria in Indian context

The annual rainfall over India based on the daily data from 2800 rainfall recording stations for a period of 50 years (190 I to 1950) is computed as 105 cms. It is the largest anywhere in the world for a country of comparable size. From precipitation alone, India receives 3000 million cubic meters. A good part of it is lost through the process of evaporation and plant transpiration, leaving only half of it on the land for us to use. Since independence the country has been planning to best utilize this water by prolonging its stay on the land by using engineering innovations such as dams and barrages. So long as we have been engrossed in the quantitative management of water resources to satisfy our demands for irrigation, power production, industries and for, drinking. Although we are aware that as a result of repetitive use of water, the quality of water deteriorates but we were not very serious in regard to the qualitative aspect of water resources. The Water (prevention and control of pollution) Act. 1974 is a positive step towards the quality control of water resources. This is to abate and control pollution of water. Almost all the states in India have already adopted this Act and has started functioning through the formation of State Boards.

Almost the entire country is cris-crossed by rivers. There are fourteen major rivers in this country who among them share eighty, three percent of total drainage basins, contribute eighty five percent of total surface flow, .and house eighty percent of the total population. They are Ganga, Brabmaputra, Indus, Godavari, Krishna, Mahanadi, Narmada, Cauvery, Brahmani, Tapi. Maht, Subarnarekha, Ponnar and Sabarmati. Three major divisions based on drainage basins are accepted for Indian rivers. There are a *few* desert rivers, which flow for some distance to get lost into deserts. There are complete arid areas where evaporation equals rainfall and no surface flow (Ghose 1993).

Each individual has vested interests in water for his particular use. The term quality, therefore, must be considered relative to the proposed use of water. From the users' point of view the water quality is used to define those physical~ chemical and biological characteristics by which users evaluate the acceptability of water: Thus, the use~ that have specific quality requirements which the manage-melt must seek to protect are:

1. Public water supplies.
2. Recreation and aesthetics
3. Fish; other aquatic life and wild life
4. Agricultural uses.
5. Industrial water supplies

Setting of water quality criteria, therefore, gets involved with epidemiology fish kills, sanitary and micro biological surveys, and aquatic system as well. Domestic water supply is generally considered the most beneficial use of water. Surface water bodies completely free from the deleterious influences of modern civilization are rarely available. Thus surface waters need treatment to meet the drinking water quality standard.

Waters should meet the drinking water standards as prescribed by the Central Public Health and Environmental Engineering Organization (CPHEEO), India, barring bacteriological quality only. The most common process used in this country for the treatment of surface waters for public use includes coagulation, sedimentation, rapid sand filtration and disinfection with –chlorine. Hence the management should seek to protect the quality of the resource pool at such a level that it can be upgraded to conform to drinking water standard by the conventional treatment or even lesser. The water balance in Indian scenario is given below:

Total geographical area 3.3 M. km^2

Total rainfall @ 1170 mm 3860 km^3

Average flow of water in the river system 1880 km^3

Usable water resources through surface structure 690-km^3

Usable groundwater availability 450 km^3

Evaporation from reservoirs and tanks 42 km^3

Evaporation from soil 600 km^3

By 2000 AD food production has been increased up to 240 Mt. So water requirement for irrigation in 2000 AD has been 630 km^3 and by 2025 AD it will be 770 km^3. For domestic uses water requirement in 2000 AD is 30 km^3 and in 2025 it will be 53 km^3. Comparatively for industrial uses water requirement is 30 km^3 and 120 km^3 respectively. For power plants water requirement has become 15 km^3.

Water resources in Raniganj Coalfield area

An investigation was conducted in Raniganj Coalfield area , which has an area of about 1600 km^2 (Figure 1). The average rainfall in the area is about 1180 mm. Three rivers surrounding the three sides of this coalfield form the major drainage channel of the area Damodar, Adjoy and Barakar (Ghose 1998). The Damodar is fed by Nunia, Singarar, Tumni, Tamp and Kunar Nullah and Adjoy is mainly fed by Tumni towards east. At present Damodar and Barakar rivers are the major water resources both for industrial and domestic uses. The uniform discharge of 194 MGD will be available for domestic and industrial consumption. Except for small withdrawal by means of intake wells, the river Adjoy system is not utilized properly.

In RCF there are about 120 collieries. They are discharging a substantial quantity of water out of which only a small portion is being utilized and the rest is being thrown out ,without any use. The total quantity of water pumped out from these mines is about 65 MGD in dry period and 104 MGD in monsoon period. There is a possibility of using this mine water for potable purpose after treatment and used water from the residential - colony could be discharged into open land for irrigation. In fact, mine water is actually being used in outlying collieries for domestic purpose after treatment. Therefore, if mine water from different collieries is locally used, it will reduce strain on general supply of water of RCF water supply scheme.

Ground water was not being trapped so far excepting a few dug wells and some deep tube wells in this region. Some shallow tube wells have recently been made for drinking water. It is evident that no detailed exploration work has been done to trap the ground water resources. As the Gondwanas are underlying the alluvium and all the three sides of the area are surrounded by perennial rivers and with the plenty of rainfalls, there appears to be substantial ground water potential in the area. There are innumerable abandoned underground workings mostly in the shallow seams in the upper horizons, which are all full of water. This may constitute a potential supply of water. . The aggregate area though not precisely known, may cover about 80-100 sq. km. with an average depth of water about 3-6 m. Thus there is a ready storage of 450 million cubic meter of water in the coalfield. As such there will be no scarcity of water in the near future and this situation is rather characteristic of RCF where mining has started since 1777

Water demand in the Coalfield

The total population in the RCF area was in the order of 32 lakhs by 2004 AD. This population needs about 130 MGD only for domestic consumption assuming per capita consumption of 40 gallons/day. According to the growth of these industries, about 40 MGD would be required for industrial use. So, for domestic and industrial use the water requirement was 170 MGD by 2004 AD. The use of water for the agricultural purpose should also be considered. A survey was conducted for coalmine water quality and those are of varying characteristics (APHA 1992). The range of water quality and requirement for drinking water standard are given below:

Characteristic	Requirements	Undesirable effects outside the limits	Desirable/ essential	Remarks
pH 6.0 to 9.0	6.5 to 8.5	Affects the mucus membrane and /or water supply	Essential	May be relaxes up to 9.2 in absence of alternative sources
Turbidity 20 to 130 JTU	10	Aesthetically displeasing, gastro intestinal irritation	Essential	May be extended up to 25 in absence of alternative sources
Total dissolved solids 250 to 1800 mg/1	500	Taste, gastro-intestinal irritation	Desirable	May be extended up to 1500 in absence of alternative sources
Iron (as Fe) Normally 0.5 but up to 3 mg/1	0.3	Taste/appearance are affected, promotes iron bacteria	Essential	May be extended up to 1.0 in absence of alternative sources
Total hardness 300 to 750 mg/l (as $CaCO_3$)	300	Excessive scale formation	Essential	May be extended up to 600 in absence of other sources
Sulphate (as SO_4) 150 to 1 000 mg/1	150	Gastrointestinal irritation when Mg or Na is present	Desirable	May be extended up to 400 if Mg does not exceed 30
Fluorides (as Fe) 0.6 to 3 mg/1	0.6-1.2	Low fluoride level may cause dental carries, above 1.5 may cause fluorisis	Desirable	May be extended up to 1.5 in absence of alternative sources

It has also been reported (Ghose 1990) that mine water is not having any major pollutant. Because of mining, the water quality does not deteriorate to a great extent, and the water can be used for the purpose other than drinking (CPCB 2000) It has also been reported that mine water can be used as a raw water source for public water supply and can be used for drinking purpose after certain conventional treatment and chlorination and a sustainable supply of water in the region can be maintained (Ghose 1999).

Reuse of mine water

The study reveals that there is an acute need to supply potable water in region. Underground mines developed below the ground water table usually produce mine drainage in a continuous basis. The ground water must be collected and pumped to the ground surface to develop the mine from flooding. Million gallons of mine water are being pumped out from the mines in the area, which is incurring huge pumpage cost On the other hand additional costs are being incurred for the identification and collection of raw water from other sources and treatment to meet the water quality criteria for the supply of potable water from the public water supply scheme. Reuse of mine water as raw water source for public water supply scheme and for irrigation can save huge cost. This also can maintain the ecological balance of water in the area.

A study was conducted in a project, which is located in the Eastern part of RCF. It is an underground project for mining coal of non-cooking type. The total mineale reserve is 52.38 Mt and total life of the project is 47 years. It is expected that the total make of water from u/g workings would be increased to 19.4 MLD at the end of 20th year. These would be pumped through boreholes, which in turn will go into the Adjoy river via zores. Present make of water is 3678 M^3/day during rainy season. During dry season, make of water is much more less. The part of this water is used for industrial as well as for domestic purposes. Rest of the water is being discharged to the Adjoy river through the jores. It is expected that total make of water from u/g workings would gradually increase to 19.4 MLD at the end of the 20th year. Water percolation into the mine would be increased as the caved out area in the mine would increase. U/g water would be pumped through boreholes, which in turn will go into the Adjoy river-via jores. Average daily requirement of industrial and township works out to (0.11 MLD and 1.03MLD respectively. Hence total wastewater discharge into the river would vary from 7.27 MLD to 20.54 MLD at the end of 20^{th} year.

The surface water analysis report also shows that the value of existing pollutant are within the tolerance limits. It is expected that with dilution of mine water with surface water there will be no appreciable change in the main watercourse. Liquid effluents from amenity centres and residential house (particularly from toilets) were found to be highly polluted. Those cannot be disposed off without appropriate treatment. These are proposed to be treated and disposed off in septic tanks and soke way, causing zero flow. Hence, there is no likelihood or any adverse: impact due to domestic effluents. Surface run off caused by precipitation may pass through stock piles All reject dumps thereby creating harmful effluents, unless suitable measures are adopted. While passing through the reject dumps it may carry solid suspensions al1d chemicals.

Sewage from different septic tanks located at different places and sewage is to be biologically treated in septic tanks under anaerobic conditions. The overflow of the effluent is then collected in a soak pit. The same will be followed for all domestic effluent and as such there will be no water pollution due to domestic effluent. From u/g workings mine water would gradually increase to 19.4 M LD at the end of the 20th year. Average daily requirement of industrial and township water works out to 0.11 MLD and 1.03 MLD respectively. Hence, total wastewater discharge would vary from 7.27 MLD to 20.54 MLD at the end of the 20^{th} year.

It is evident from the test results of water samples taken from the mine there is no major pollutant. Because of mining, the water quality will not deteriorate. The water can be used for purpose other than drinking. There are water treatment plants already in the mining area for daily use. In the CHP, water would be used only for dust suppression, so there would be very little wastewater from CHP. However this water along with the effluent from the store and workshop will have to be treated by a small sewage treatment plant before discharging it in the drain with the main water. Proper drain will have to be provided in the project site area, reject dump area and subsided area for quick draining *of* rain water during monsoon. Slope of the reject dump area will have to be provided with vegetative cover to prevent soil erosion during monsoon. The colony area would also to be provided with a network of surface drains For quick draining of run off. Toe pitching shou1d be provided at slopes of reject dumps to prevent toe failure of the slope and garland drain would be provided to reduce the seepage pressure in the slopes. The run off will have to be collected through a well-planned drain for ultimate discharge to Adjoy river through nail as and jores.

Treatment of mine discharge

Unit operations and processes are grouped together to provide what is known as primary, secondary and tertiary treatment (Metcalf and Eddy 2003). In primary treatment, physical operations such as screening, coagulation and sedimentation are used to remove the floating and settleable solids found in wastewater. In secondary treatment, biological and chemical processes are used to remove most of the organic matter(Ghose 2001a). In tertiary treatment, additional combinations of unit operations and processes are used to remove other constituents. such as nitrogen and phosphorous which are not removed by secondary treatment and refractory organics normally not amenable to biological degradation (Ghose 2002). Land treatment processes combine physical, chemical and biological treatment mechanisms and produce effluents of an order of quality similar to that from advanced wastewater treatment (Ghose and Roy 1999). Land treatment systems can also be used for the capture of solar energy and for the utilization of the nutrients in wastewater. This is now receiving serious attention because of the increasing emphasis in recent years on water reuse nutrient recycling and the use of water for crop production commensurate with safety (Ghose 1989).

Mine water is to be treated mainly by conventional methods using aeration followed by flocculation with rapid and slow mixing and sedimentation. The water is to be entered the rapid gravity filters after which it is disinfected by chlorination. In case of mine water with significant hardness (>300) softening by lime soda process is to be practiced additionally. The various steps involved I treatment include aeration which is to be provided for the removal of iron and dissolved gases Alum mixing chamber has been proposed for the treatment so that the clogging of the filter does not occur frequently. This process can remove the turbidity of the water easily (Ghose 2001b). The clariflocculator helps in flocculation and getting clarified water from the unit. The water is then passed through the pressure filters for the removal bacteria, color, taste odors and producing clear and sparkling water (McKay et.al 1980).

Non-carbonate hardness is usually removed more easily by the ion-exchange process than by a soda lime process. When the water does not contain a significant amount of harness , selective treatment can be done. The base exchange softening, which is being proposed, involves a number of reactions as given below:

$Ca^{++} + Na2R \text{------}\rightarrow CaR + 2Na^{+}$

In terms of hardness producing compounds the following reactions occur

$Ca\,(HCO_3)_2 + Na_2R \text{---}\rightarrow CaR + 2NaHCO3$

$CaSO4 + Na2R \text{---}\rightarrow CaR + Na2SO4$

$MgSO4 + Na2R \text{---}\rightarrow MgR + 2NaHCO3$

$MgSO4 + Na2R \text{--}\rightarrow MgR + Na2SO4$

R is being used to indicate the anionic portion of the of the material which does not enter into the reaction. As Base Exchange has removed the Na from the base material, regeneration is to be practiced to restore the Na by back flushing with sodium chloride (salt). The water coming out of the softener is extremely soft and it is proposed to be mixed with the filtered water by a bypass line as extreme soft water is not desirable for public water supply. The above mentioned treatment plant may require high cost and it may not be possible for the mining authorities to provide such treatment plant at the present such situation Thus a low cost treatment scheme has been proposed.

Disinfection of mine discharge

Chlorine is widely used for disinfections of water since it is a powerful oxidizing agent and it is cheaply available. Chlorine is applied to the water to be treated, through chlorinator or chlorine solution fed chlorinators, using liquid chlorine.(Ghose 1994) An ordinary solution fed chlorinator takes the liquid chlorine from the container, meters it, and mixes it with a small amount of water to form a strong chlorine solution. This solution is fed into the distribution mains by means of water injector. A typical solution feed chlorinator installation is shown in Figure 2. It can be used in its molecular form or in a hypochlorite form. For an effective disinfection it is needed to select the dose of chlorine to be added, optimum contact period required add the amount of residual chlorine to be present in water after the contact period. Minimum free chlorine residual of 0.2 mg/1, is to be maintained in all the parts of distribution system. Samples of water are to be collected rut estimation of residual chlorine present in the water samples. The residual chlorine present in a water sample is likely to decrease after collection, especially in hot weather. Hence the test for residual chlorine should be conducted in the spot where the sample is collected. If the sample contains suspended matter, allow-portion to stand for 15 minutes and test the supernatant. If bleaching powder is used for the purpose of disinfection, the available chlorine present in the bleaching powder *1s* to be estimated in order to select the dose bf bleaching powder to be added to the water for maintaining 0.2 mg/1 residual chlorine. When chlorine is added to water, if forms hypochlorous acid to hypochlorite ions; which have an immediate and disastrous effect oh must forms of microscopic organism. The hypochlorous acid is unstable and may break into hydrogen ions and hypochlorite ions

$$Cl_2 + H_2O \xrightarrow{pH > 5} HOCl + HCl$$

$$HOCl \longrightarrow H^{+} + OCl^{-}$$

It is cheap, reliable, easy to handle, easily measurable, and above all, it is capable of providing disinfecting effects for long periods, thus affording complete protection against future recontamination of water in the distribution system Its only disadvantage is that when used in greater amounts, it imparts bitter and bad taste to the water , which may not be liked by certain consumers.

The scheme proposed for the treatment of mine water for public water supply is broadly consist of the collection system involving pumping of raw water and its transmission through the pipes to the collection sump to the treatment plant. The treatment system including various stages of treatment so as to produce water of potable quality in terms of Indian standards (Ghose 1995). The clear water transmission and storage system which would involve pumping of treated water from the clean water sump to the zonal reservoirs and from the zonal reservoirs to the consumer points with help of primary main and secondary pipes. The schematic diagram of the proposed water treatment scheme for the collieries is given in Figure 3. It has been proposed to pump the mine water from the underground mines to the reservoir so that aeration has been achieved. The water is then pumped from the reservoir to the soda lime chamber. By adding lime and soda non-soluble carbonates are formed and those can be settled in the sedimentation tank .

CONCLUSION

If industrial development is to be emphasized the link between increased industrial production, energy demand; the need to provide potable water supply in the thickly populated rural coal mining areas cannot be overlooked. The study reveals that water storage as well as the availability mine water from various sources are found to be contaminated with different industrial and domestic effluents and looses its acceptable value and subsequently it is just wasted incurring enormous costs in pumping requirements. It is also causing lowering of ground water table and ecological imbalance in the region On the other hand additional costs are being made for the collection of raw water from other sources and treatment to meet the water quality criteria for the supply of potable water from the public water supply scheme. It appears that there is a substantial ground water potential in the area. Mine discharge as well water from the innumerable abandoned underground workings, which are all full of water can be utilized for public water supply scheme after some conventional treatment. As such there will be no scarcity of water in the near future and this situation is rather found to be characteristic of RCF. The available mine water can be reused to fulfill the raw water demand in the area which can save cost and water balance in the region A low-cost scheme has been proposed for the treatment of mine water, and for the supply of potable water in the coalfield area, which will make ensure the sustainable supply of water in the region. This study may have formed a guideline to reuse mine water, which can be utilized on an industrial scale for various sites.

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Water Balance Assessment of Micro-Catchment Treated with *In-Situ* Conservation Measures

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ABSTRACT

With uneven and low quantum of rainfall, often it is a challenge to dryland farmers to cope up for higher productivity under limited or no irrigated conditions. If adequate water is available, farmers would try to apply higher levels of irrigation whereas crop is lost frequently where water is not reaching. Therefore, we need to understand the crop water requirements in relation to water availability for increasing crop productivity in these drylands. Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention. For this purpose every piece of land should be treated as a micro-catchment and *in-situ* rainwater conservation techniques should be adopted and actual assessment in terms of water balance has to be done for accurate irrigation planning. Hydrological models are useful tools for quantification of water balance components. MIKE SHE model set up was developed and used for simulation of hydrological components in treated as well as untreated catchment at the experimental field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Vidarbha region of Maharashtra state. The results of the hydrological water balance of treated and untreated catchment are presented here. Evaluation of the existing CCT shows that its adoption results in about 100, 95.50 and 93.33% reduction in runoff in 2013, 2014 and 2015 respectively, leading to moisture conservation. During three years, *i.e.*, in 2013 the groundwater recharge for treated and control micro-catchments was estimated as 315mm (33.58% of input rainfall) and 262mm (27.93% of input rainfall), whereas in 2014 the corresponding values were 241mm (36.46% of input rainfall) and 200mm (30.26% of input rainfall), similarly in 2015 the corresponding values are 331mm (43.61% of input rainfall) and 274mm (36.10% of input rainfall).

Keywords: *In-situ*, Rainwater, Resources.

INTRODUCTION

Unplanned and uncontrolled groundwater extraction and use, with scant regard to the natural process of formation of groundwater, have disturbed the hydrological balance leading to a drop in groundwater table in many parts of the country. This also leads to decline in productivity of water bodies. For these reasons, groundwater recharge is identified as a critical component of small catchment management plans. Management of a catchment thus entails the rational utilization of land and water resources for optimum production but with minimum hazard to natural resources. Most applications of hydrology are depends upon monitoring and modelling of various hydrological processes for conservation and management of natural resources for groundwater recharge. Whenever rainfall-runoff event occurs, runoff begins and flows down from the slopes causing erosion giving not much chance for water to infiltrate into the soil. In such situations CCTs are adopted for reducing runoff and enabling the water to infiltrate in the soil. In order to know the effect of continuous contour trenches (CCTs), hydrological research needs to be conducted.

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. 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 *et al*., 2010). Intermittent trenches are adopted in high rainfall areas. The trenches are to be constructed strictly on contours irrespective of the category (Sussman, D., 2007). 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 conducted at the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.), India. The site is situated between latitude of 20° 43' 05.8" to 20° 43' 09.3" North and Longitude of 77° 02' 43.1" to 77° 02' 46.0" East with the altitude of 307m above MSL. It is located in the Western Vidarbha Zone, a part of the Central Maharashtra Plateau Agro-climatic zone. In the present study three types of soils were identified in the micro-catchment viz. Inceptisol, Entisol and Vertisol. The infiltration rate was determined by double ring infiltrometer. The infiltration rates for the soils under study were found to be 3.77, 4.4 and 1.2 cm hr^{-1} for Inceptisol, Entisol and Vertisol, respectively (Sarda Tariku, 2012).

Methodology

The experimental area of 1.0 ha was divided into two micro-catchments. The micro-catchment-1 (MC-1) is treated with Continuous Contour Trenches (CCTs) and has horticultural plantations of Atemoya (*Anona atemoya*) and Custard apple (*Anona squamosa*). The intercrop has been practiced along the continuous contour trenches in between plantation rows. The adjacent micro-catchment-2 (MC-2) has been kept without continuous contour trenches. This untreated micro-catchment also has horticultural plantations of Atemoya (*Anona atemoya*) and Custard apple (*Anona squamosa*). The intercrop of green gram has been sown in between the plantation rows of Custard apple and Atemoya in MC-1 and MC-2 during *kharif* season in every year. Model setup of MIKE SHE for treated as well as control (untreated) micro-catchment was prepared. For water movement model set up, different components were considered. Performance of the CCTs existing in the treated micro-catchment was evaluated by comparing the relevant components of the hydrological cycle. The results were used for the impact assessment purpose (Shinde, 2006 and Pendke, 2009). Other than hydrological monitoring, the physical observations and analysis of fruit production was also used for assessing CCT performance. Model setup of MIKE SHE for treated as well as control micro-catchment was prepared. For water movement model set up, saturated zone, unsaturated zone, evapotranspiration and overland flow were included.

RESULTS AND DISCUSSIONS

The treated and untreated micro-catchments were monitored and impact assessment was done based on the results obtained as below.

Soil Moisture

The soil moisture at the depths 0-15, 15-30 and 30-45cm is given in Table 1 and presented in Fig. 1. The soil moisture status in CCT treated catchment (T_2) was observed to be better as compared to the untreated catchment (T_1) at 0-15, 15-30 and 30-45cm depth in every recorded month. The prolonged moisture in the CCT treated catchment have enhanced the growth of perennial plantation of Custard Apple (*Annona squamosa*) and Hanumanphal (*Annona cherimola*).

Table 1 Soil moisture content (cm^3/cm^3) recorded at 0-15, 15-30 and 30-45cm depths in different months.

Treatments	Depth (cm)	Soil moisture content (Volumetric)			
		17.07.15	26.08.15	28.09.15	29.10.15
Untreated catchment, T_1	0-15	21.34	25.51	24.4	17.55
	15-30	22.13	27.43	25.66	20.17
	30-45	24.86	29.9	28.8	21.28
CCT treated catchment, T_2	0-15	22.53	27.2	26.52	19.06
	15-30	23.83	29.1	29.6	22.57
	30-45	25.72	31.34	32.06	25.82

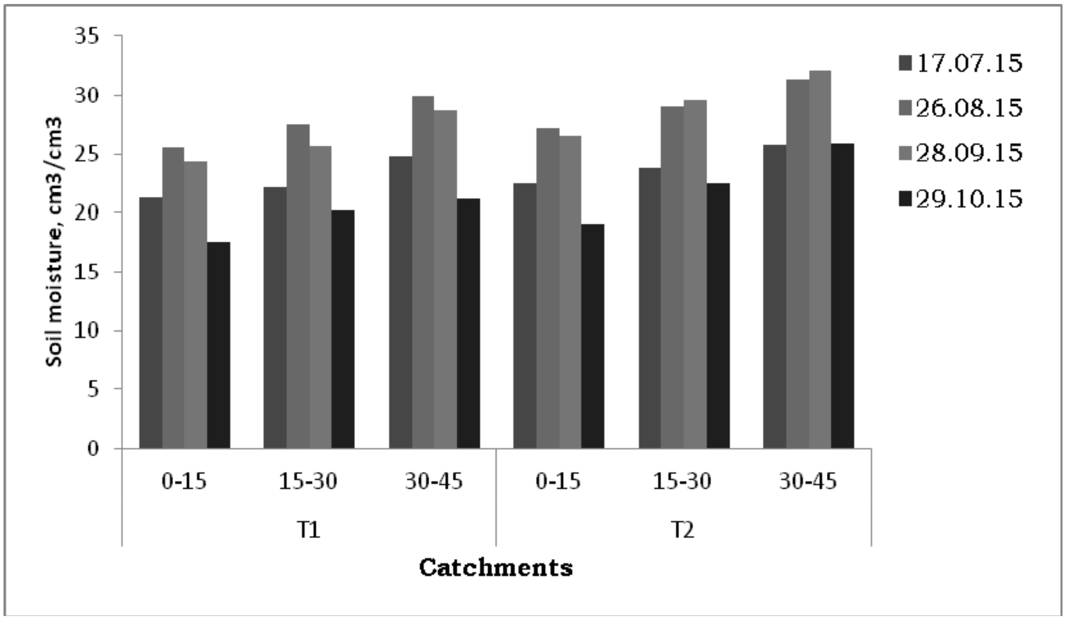

Figure 1 The soil moisture content at different depths in untreated and CCT treated Catchment recorded in different months.

Monitoring of ground water levels

The experimental area (1.0ha) was divided into two small catchments. One catchment was treated by constructing continuous contour trenches (CCTs) and other was without continuous contour trenches. The small catchments were again divided into two parts, thus in entire area there are four parts. In each part the observation wells were prepared for monitoring the ground water levels. The observation wells in all the four parts were monitored and the readings during the season are presented in the Table 2. From the table, it was observed that the percentage fluctuations in groundwater levels of CCT treated catchment over non treated catchment was more in the month of July (36.81%) followed by May (28.95%) and June (26.54%). It was also observed that the groundwater levels were more in CCT treated catchment compared to non treated catchment in all the months and this effect was depicted in figure 2 and 3. On an average during the twelve months the observed ground water recharge in the CCT treated catchment was more by 21.21% compared to the non treated catchment and this will clearly indicate the benefits of continuous contour trenches for small catchment.

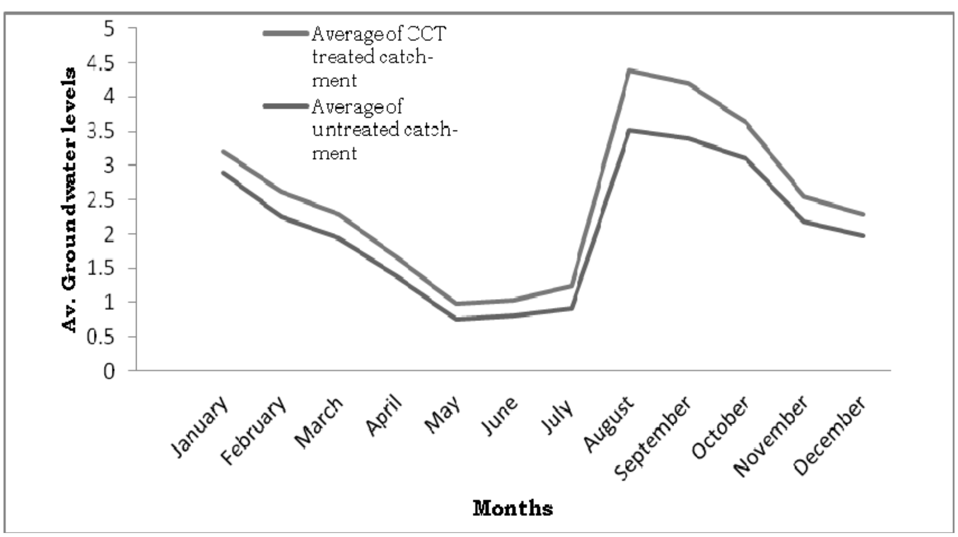

Figure 2 Ground water levels in different months in the catchment

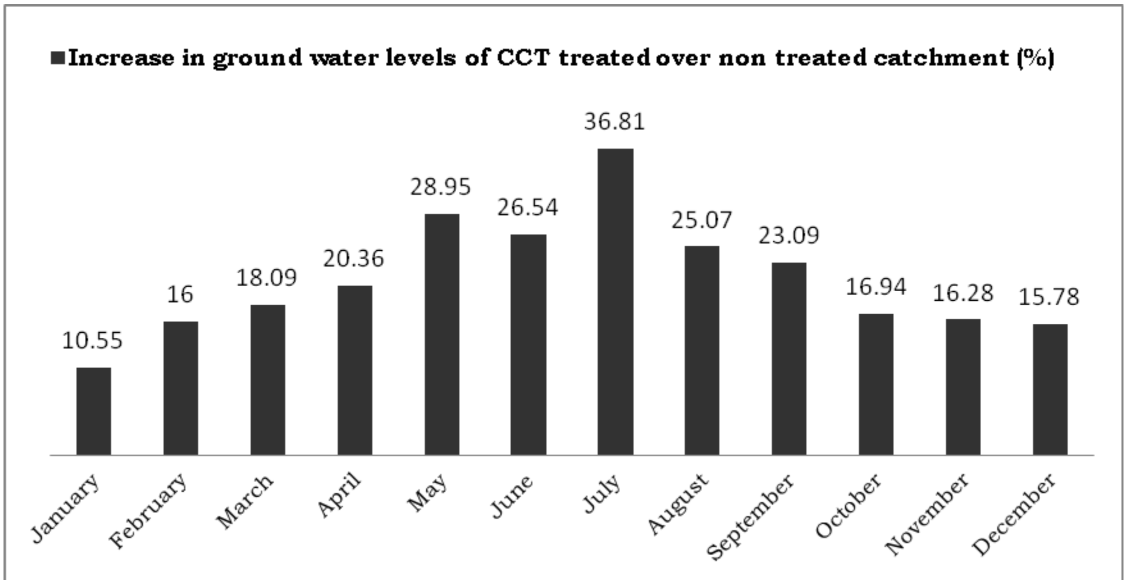

Figure 3 Increase in groundwater recharge in CCT treated catchment

Table 2 Average monthly ground water levels (m) in the observation wells at AICRPDA, Dr. PDKV, Akola during 2015

S. N.	Month	Average ground water levels, m						Increase in GW levels of CCT treated over untreated catchment (%)
		CCT treated catchment (T_2)		Untreated catchment (T_1)		Average of CCT treated catch-ment	Average of untreated catch-ment	
		OW-1	OW-3	OW-2	OW-4			
1	January	2.78	3.61	2.68	3.10	3.20	2.89	10.55
2	February	2.31	2.91	2.22	2.28	2.61	2.25	16.00
3	March	1.88	2.69	1.68	2.19	2.29	1.94	18.09
4	April	1.26	2.05	1.18	1.57	1.66	1.38	20.36
5	May	0.58	1.38	0.51	1.01	0.98	0.76	28.95
6	June	0.55	1.5	0.50	1.12	1.03	0.81	26.54
7	July	0.65	1.84	0.57	1.25	1.25	0.91	36.81
8	August	3.99	4.79	3.45	3.57	4.39	3.51	25.07
9	September	3.81	4.56	3.32	3.48	4.19	3.40	23.09
10	October	3.51	3.74	3.18	3.02	3.63	3.10	16.94
11	November	2.10	2.97	2.0	2.35	2.54	2.18	16.28
12	December	2.03	2.52	1.91	2.02	2.28	1.97	15.78

CONCLUSIONS

The validated model of the treated and control micro-catchment was used to work out simulation for the hydrological water balance during 2013 to 2015 (1st January to 31st December). The impact of the conservation measure adopted in the treated micro-catchment, i.e., existing CCT, was evaluated. It was observed that during 2013 in the CCT treated micro-catchment the runoff (100%) was recharged into the soil and ultimately reached to the groundwater. This will demonstrate the usefulness of CCT's for small catchment to in-situ conservation of the rainfall. The water uptake from unsaturated zone was more by 16.82% by the plantation in the CCT treated micro-catchment over control (untreated) and this reflects into evapotranspiration. It was observed that during 2014 the runoff was less by 95.50% in the CCT treatment micro-catchment over control. The water uptake from unsaturated zone was more by 17.77% by the plantation in the CCT treated micro-catchment over control and this reflects into evapotranspiration. It was observed that during 2015 the runoff was less by 93.33% in the CCT treated micro-catchment over control. The water uptake from unsaturated zone was more by 17.14% by the plantation in the CCT treated micro-catchment over control and this reflects into evapotranspiration. During three years, i.e., in 2013 the groundwater recharge for treated and control micro-catchments was estimated as 315mm (33.58% of input rainfall) and 262mm (27.93% of input rainfall), whereas in 2014 the corresponding values were 241mm (36.46% of input rainfall) and 200mm (30.26% of input rainfall), similarly in 2015 the corresponding values are 331mm (43.61% of input rainfall) and 274mm (36.10% of input rainfall). Thus, on an average CCT enhances groundwater recharge by about 20.51 per cent in the treated micro-catchment over control (untreated). Furthermore, CCT provides favorable environment for plant growth, which is evident from about 10.51% increase (498mm, 363mm and 380mm compared to 451mm, 327mm and 345mm in control micro-catchment during 2013, 2014 and 2015 respectively) in the ET in the treated micro-catchment compared to control (untreated).

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Studies on Rainfall Variations at Chas for Analysis of Droughts and Extreme Events in Scarcity Zone of Maharashtra

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ABSTRACT

Drought is a normal recurring feature of climate, it occurs in virtually all climatic regimes and very important feature in case of dry land or scarcity region. In present study, one of the most important climatic variable i.e. rainfall at Chas (Dist: Ahmednagar) in the scarcity zone of Maharashtra. Rainfall trend is among the important characteristics of rainfall that varies both in time and space. An investigation was undertaken to identify trends in rainfall time series of Chas(Dist: Ahmednagar) station in the scarcity zone of Maharashtra. The Mann-Kendall test was applied to detect the rainfall trends in weekly, seasonal and monthly basis. The test is non parametric. The daily rainfall data of 40 years from 1971 to 2010 has been processed to find out the rainfall variations. It is observed that the annual rainfall, southwest monsoon in case of seasonal rainfall June, August, September in case of monthly rainfall, meteorological Week No.24 and 36 (2 weeks) in case of weekly rainfall showed increasing trend. The rainy days in case of monthly values of in the months of August and September and meteorological week No. 36 (1 week) in case of weekly rainy days value of variance showed increasing trend. The analysis of the rainfall showed that for Chas the maximum probability of 20% is in the range of 501-600 mm rainfall. Hence , due attention should be given on planning of rain water harvesting, in-situ rainwater conservation and contingent crop planning for sustainable agriculture.

Keywords: Scarcity zone, Mann- Kendall test, droughts

INTRODUCTION

Water is the essence of life on the earth, without which living organisms cannot survive. Water resource play vital role for any development and planning including food production, flood control and natural resource management. Management and conservation of water resources require hydrological investigations related to storage capacity of reservoirs, flood magnitude and its frequency of occurrence, runoff peak and seasonal variations in strearm discharge. Rainfall plays an important role in crop planning in scarcity zone. The common pecurality 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 one third area of the state comprising 114 tahsils of 18 districts. The rainfall has key position in success of dry farming. 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 important characteristics which plays main role in rainfed farming. The daily rainfall data at Chas, Dist: Ahmednagar for 40 years (1971 to 2010) has been analyzed to study weekly, monthly and yearly meteorological drought. The average annual rainfall of Chas is 532.83mm in 29-31 rainy days.

The trend component is represented by an equation , and is described as a regular or long –term movement in a time series, on an average basis, which could either be in an increasing order or in a decreasing order. It has been observed that an annual data time series gives better results for computation of the trend component, because annual data suppresses the effect of periodic components in the series (Kottegoda,1980). Generally, Kendall's rank correlation test is conducted to test for the presence of any trend component in the time series. If the Kendall's correlation test static is within the limits +_1.96, then it is assumed that there is no trend present in the series. Sometime, a two-tailed test is also applied to test the presence of trend component in the series. When the presence of trend is established, that is when the time series is not random, then a suitable equation of type $T_t = f_n(t)$ is developed.

An attempt has been made in this study, to assess the meteorological drought occurrence at Chas(Dist: Ahmednagar, Maharashtra under scarcity zone), based on analysis of daily rainfall data. Soil varies from reddish brown to dark gray and commonly grouped as light to medium black soil. In very few places deep black soil is also observed. Erratic nature of rainfall affects the moisture content in the soil, therefore, this zone is commonly known as drought prone area. Major crops grown in this zone are pearl millet, sorghum, safflower, Bengal gram, wheat, sugarcane etc.

STUDY AREA AND DATA ACQUISITION

The place , Chas (Dist: Ahmednagar) coming under scarcity zone of Maharashtra is located at 19^0 09’ N Latitude and $74^0$75’ E longitude . The rainfall is characterised by erratic nature and prolonged dry spells. The average annual rainfall of Chas is 532.83 mm and maximum amount of rainfall occurs during monsoon period i.e. June to October.

The daily rainfall data of Chas station for 40 years (1971-2010) was obtained from AICRP on Agro Meteorology, Zonal Agricultural Research Station, Solapur.

METHODOLOGY

The trend component is represented by an equation , and is described as a regular or long –term movement in a time series, on an average basis, which could either be in an increasing order or in a decreasing order. Trends in data can be identified by using parametric or non-parametric methods. The non-parametric tests are more suitable for non- normally distributed, censored data, including missing values, which are frequently encountered in hydrological time series (Hirsch and Slack, 1984).

MANN-KENDALL TEST

- The daily rainfall and rainy days data of ARS, Chas, Dist. Ahmednagar for the period 1971 to 2010 (40Years) was taken for the study.
- The daily rainfall and rainy days data is converted to weekly, monthly, seasonal and annual rainfall.
- Compared first year data point with 2nd, 3rd, ..., 40th year data point. Assign +1 if X1 < X2, -1 if X1 > X2 and 0 if X1 = X2
- Sum of assigned values will give Mann-Kendall Statistic (S) A very high value of Mann-Kendall Statistic is an indicator of an increasing trend and a very low negative value indicated a decreasing trend.
- However, it is necessary to compute the probability associated with Mann-Kendall Statistic and the sample size, n, to statistically quantify the significance of the trend.
- Calculate Variance (S) by the following equation,

$$\text{Variance (S)} = \frac{\big(n(n-1)(2n+5)\big) \; - \sum_{p=1}^{p=g}(tp\,(tp-1)(2tp+5))}{18}$$

Where,

n = number of years,

g = number of tied groups (a tied group is a set of sample data having the same value)

tp = number of items in the tied group.

- Calculate a normalised test statistic Z by the following equation,

$Z = \frac{(S-1)}{\sqrt{\text{Variance }(S)}}$	If $S > 0$
$Z = 0$	if $S = 0$
$Z = \frac{(S+1)}{\sqrt{\text{Variance}(S)}}$	if $S < 0$

Where,

$S = p - q$ [where, p = number of (+1) values and q = number of (-1) values]

- The Microsoft Excel function *NORMSDIST (Z)* is used to calculate the probability.
- Probability level of significance was considered as 95 %.
- The trend is said to be
    - Decreasing if Z is negative and computed probability is more than 95 %
    - Increasing if Z is positive and computed probability is more than 95 %
    - No Trend if computed probability is less than 95 %
- The annual rainfall data of Chas is analyzed for 40 years and probability of occurrence and percent probability is found out.
- From the criteria of Indian Metrological Department, for analysis of rainfall, no drought years, mild drought years, moderate drought years and severe drought years were found out.

RESULTS AND DISCUSSION

The Mann-Kendall test was applied to weekly, seasonal and monthly rainfall data using the methodology explained above. The Z statistic for each week, season and month was computed and considering the criteria stated above the trends in weekly, seasonal and monthly rainfall were decided. The summary of results is presented in Table 1-3 and shown in figures 1-3.

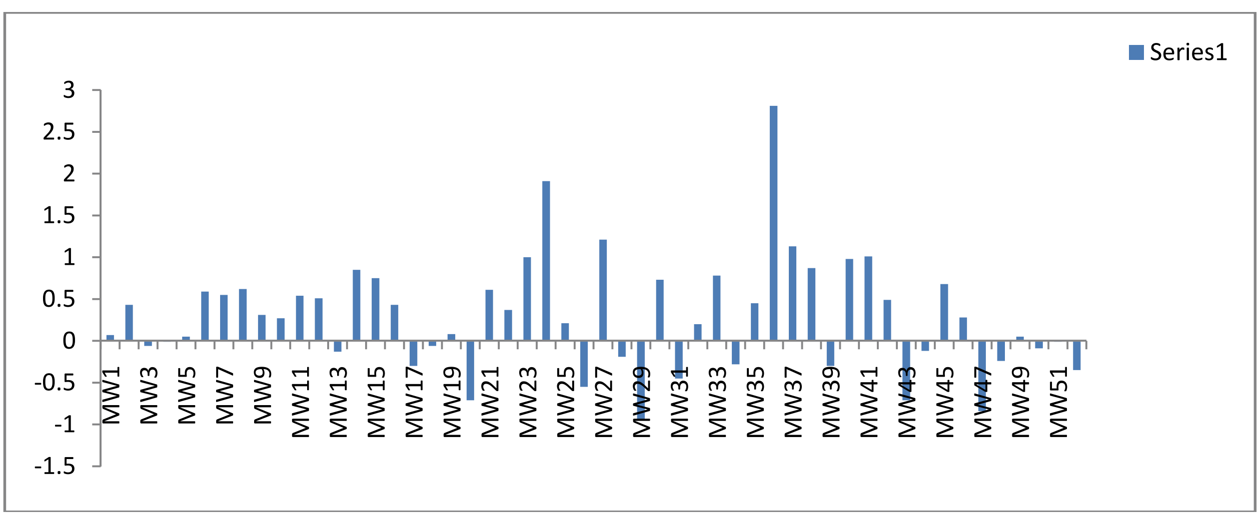

Figure 1 Weekly rainfall trend at Pandharpur for 40 years (1973-2012)

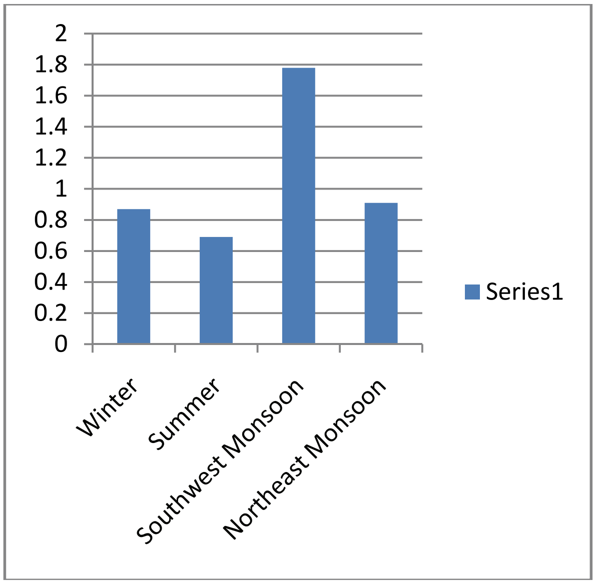

Figure 2 Seasonal rainfall trend at Pandharpur for 40 years (1971-2010)

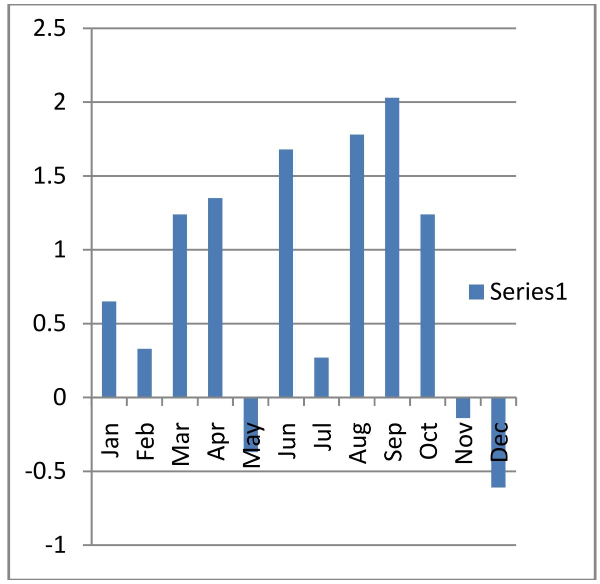

Figure 3 Monthly rainfall trend at Pandharpur for 40 years (1971-2010)

Weekly trends

From weekly rainfall trend analysis (Table 1), decreasing trend was observed for the 24th and 36th meteorological week at 10 percent level of significance, while no trend was observed for rainfall during rest of the weeks at Chas. Out of 18 weeks of monsoon, only one weeks i.e. 36th MW showed increasing trend and rest of 17 weeks showed no trend. There is no trend during crop growth period and thus we can expect normal rainfall during most of the weeks in monsoon period. Also, it can be observed from Table 1 and Fig.1 that, out of 18 weeks of monsoon (23 MW to 40 MW), the Zcal values are negative in 6 weeks. From this it can be said that the rainfall is showing decreasing trend. Hence, there is need of planning of *in situ* rainwater conservation, rainwater harvesting techniques and contingent crop planning for sustainable agriculture.

Seasonal trends

In the seasonal rainfall trend analysis (Table 2) ,increasing trend observed for the Southwest Monsoon at 10 percent of significance. While no trend observed for Winter, Summer and Northeast monsoon Season rainfall at Chas.

Monthly trends

From the monthly rainfall trend analysis (Table 3), ,increasing trend observed for the months June, August and September , while no trend observed rest of months during the year 1971-2010 at Chas. If the four months viz., June, July, August and September are considered, the Zcal values are positive and approaching towards the increasing trend (Table 3 and Fig.3).

Table 1 Trends in Weekly rainfall along with calculated Z statistic. (1971-2010)

Week	Zcal	NORMSDIST	Trend	Week	Zcal	NORMSDIST	Trend
MW1	0.07	0.53	No Trend	**MW27**	1.21	0.89	No Trend
MW2	0.43	0.67	No Trend	**MW28**	-0.19	0.43	No Trend
MW3	-0.06	0.48	No Trend	**MW29**	-0.94	0.17	No Trend
MW4	-0.01	0.50	No Trend	**MW30**	0.73	0.77	No Trend
MW5	0.05	0.52	No Trend	**MW31**	-0.45	0.32	No Trend
MW6	0.59	0.72	No Trend	**MW32**	0.20	0.58	No Trend
MW7	0.55	0.71	No Trend	**MW33**	0.78	0.78	No Trend
MW8	0.62	0.73	No Trend	**MW34**	-0.28	0.39	No Trend
MW9	0.31	0.62	No Trend	**MW35**	0.45	0.68	No Trend
MW10	0.27	0.61	No Trend	**MW36**	2.81	1.00	**Increasing**
MW11	0.54	0.70	No Trend	**MW37**	1.13	0.87	No Trend
MW12	0.51	0.70	No Trend	**MW38**	0.87	0.81	No Trend
MW13	-0.13	0.45	No Trend	**MW39**	-0.30	0.38	No Trend
MW14	0.85	0.80	No Trend	**MW40**	0.98	0.84	No Trend
MW15	0.75	0.77	No Trend	**MW41**	1.01	0.84	No Trend
MW16	0.43	0.67	No Trend	**MW42**	0.49	0.69	No Trend
MW17	-0.30	0.38	No Trend	**MW43**	-0.71	0.24	No Trend
MW18	-0.06	0.48	No Trend	**MW44**	-0.12	0.45	No Trend
MW19	0.08	0.53	No Trend	**MW45**	0.68	0.75	No Trend
MW20	-0.71	0.24	No Trend	**MW46**	0.28	0.61	No Trend
MW21	0.61	0.73	No Trend	**MW47**	-0.84	0.20	No Trend
MW22	0.37	0.65	No Trend	**MW48**	-0.24	0.40	No Trend
MW23	1.00	0.84	No Trend	**MW49**	0.05	0.52	No Trend
MW24	1.91	0.97	**Increasing**	**MW50**	-0.09	0.46	No Trend
MW25	0.21	0.58	No Trend	**MW51**	-0.01	0.50	No Trend
MW26	-0.55	0.29	No Trend	**MW52**	-0.35	0.36	No Trend

(*, **, *** - significant at 10, 5 and 1 per cent level of significance)

Table 2 Trends in Seasonal rainfall along with calculated Z statistic (1971-2010).

	Z Cal	NORMSDIST	Trend
Winter	0.87	0.81	No Trend
Summer	0.69	0.75	No Trend
Southwest Monsoon	1.78	0.96	**Increasing**
Northeast Monsoon	0.91	0.82	No Trend

(*, **, *** - significant at 10, 5 and 1 per cent level of significance)

Table 3 Trends in Monthly rainfall along with calculated Z statistic (1973-2012).

Month	Zcal	NORMSDIST	Trend	Month	Zcal	NORMSDIST	Trend
Jan	0.65	0.74	No Trend	**Jul**	0.27	0.61	No Trend
Feb	0.33	0.63	No Trend	**Aug**	1.78	0.96	**Increasing**
Mar	1.24	0.89	No Trend	**Sep**	2.03	0.98	**Increasing**
Apr	1.35	0.91	No Trend	**Oct**	1.24	0.89	No Trend
May	-0.37	0.35	No Trend	**Nov**	-0.14	0.44	No Trend
Jun	1.68	0.95	**Increasing**	**Dec**	-0.61	0.27	No Trend

CONCLUSION

The present study analyzed the daily rainfall data for 40 years from 1971 to 2010 of Chas in Ahmednagar district for determination of trend of precipitation. The Mann Kendall test is used for trend detection. Considering the weekly, monthly and seasonal rainfall trend, it can be concluded that the rainfall is showing no trend for Chas. From the analysis of the rainfall it is observed that for Chas the maximum probability of 20% is in the range of 501-600 mm rainfall. From the criteria for analysis of drought based on rainfall, out of 40 years for Chas 19 Years were drought years. Hence, due attention should be given on planning of *in situ* rainwater conservation, rainwater harvesting techniques and contingent crop planning for sustainable agriculture.

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Estimation of Trends in Rainfall and temperature at *Mohol* for Sustainable Agriculture

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ABSTRACT

The effort in this study has been made to analyze one of the most important climatic variable i.e., rainfall, minimum and maximum temperature for trend detection at ARS, Mohol, Dist. Solapur (M.S.) in scarcity zone of Maharashtra. The impact of climate change is projected to have different effects within and between countries. Information about such change is required at global, regional and basin scales for a variety of purposes. Rainfall trend is among the important characteristics of rainfall that varies both in time and space. An investigation was carried out to identify trends in rainfall time series of Mohol station in the Scarcity zone of Maharashtra. The non-parametric Mann-Kendall test was applied to detect monotonic trends in weekly, seasonal and monthly rainfall. The daily rainfall data of 40 years from 1972 to 2011 has been processed to find out the rainfall variability. It is observed that there is increasing trend in rainfall only for the month of May. There is no trend in rest of the months. It is observed that there is no trend in minimum temperature for all of the months. There is increasing trend in maximum temperature in the month of January to April, July to September and November to December. There is no trend in rest of the months (May, June and October). From the analysis of the rainfall it is observed that maximum probability of 25% is in the range of 701-800 mm rainfall followed by 17.5% probability in the range of 501-600 mm and 601-700 mm rainfall . Hence, due attention should be given on planning of *in situ* rainwater conservation, rainwater harvesting techniques and contingent crop planning for sustainable agriculture.

Keywords: Rainfall, Trend detection, Mann-Kendall test, Scarcity zone.

INTRODUCTION

Drought is a normal recurring feature of climate; it occurs in virtually all climatic regimes. It is the consequence of a natural reduction in the amount of precipitation received over an extended period, usually a season or more in length. The effects of drought accumulate slowly and its impacts are spread over a larger geographical area more than damages that result from other natural hazards.

Out of several element of weather, rainfall has a key role to play in the success of dry farming. Occurrence of dry spells during rainy season is a common feature in dry land situation. Dry spells are observed particularly during the months of July and August. These dry spells may extend up to two months and hence management of *kharif* crops during drought situation is serious concern. The rainfall analysis with five year moving average along with analysis of corresponding temperature can help in deciding whether the rainfall is deviating from normal value. Hence, the present study is undertaken.

Methodology: Trends in data can be identified by using either parametric or non-parametric methods. In the recent past, both methods have been widely used for the detection of trends.

MANN-KENDALL (MK) TEST

- The monthly rainfall, maximum temperature, minimum temperature data of ARS, Mohol from 1972 to 2011 (40 years) is taken for the study.
- Compare first year data point with 2nd , 3rd, ..., 40th year data point

- Assign
  - +1 if X1 < X2
  - -1 if X1 > X2
  - 0 if X1 = X2
- Sum of assigned values will give Mann-Kendall Statistics (S)
- A very high value of Mann-Kendall Statistic is an indicator of an increasing trend and a very low negative value indicated a decreasing trend.
- However, it is necessary to compute the probability associated with Mann-Kendall Statistic and the sample size, n, to statistically quantify the significance of the trend.
- Calculate Variance (S) by the following equation,

$$\text{Variance (S)} = \frac{(\mathrm{n}\ (\mathrm{n}-1)(2\mathrm{n}+5) - \sum_{\mathrm{p}=1}^{\mathrm{p}=\mathrm{g}}(\mathrm{tp}\ (\mathrm{tp}-1)(2\mathrm{tp}+5)\ \ )}{18}$$

Where,

n = number of years,

g = number of tied groups (a tied group is a set of sample data having the same value,

tp = number of items in the tied group.

- Calculate a normalised test statistic Z by the following equation,

$$\mathrm{Z} = \frac{(\mathrm{S}-1)}{\sqrt{\text{Varience (S)}}} \qquad \text{If } \mathrm{S} > 0$$

$$\mathrm{Z} = 0 \qquad \text{if } \mathrm{S} = 0$$

$$\mathrm{Z} = \frac{(\mathrm{S}+1)}{\sqrt{\text{Varience}}(\mathrm{S})} \qquad \text{if } \mathrm{S} < 0$$

Where,

S = p - q [where, p = number of (+1) values and q = number of (-1) values]

- The Microsoft Excel function *NORMSDIST (Z)* is used to calculate the probability.
- Probability level of significance was considered as 95 % .
- The trend is said to be
  - Decreasing if Z is negative and computed probability is more than 95 %
  - Increasing if Z is positive and computed probability is more than 95 %
  - No trend if computed probability is less than 95 %
- The annual rainfall data of ARS, Mohol, Dist. Solapur is analyzed from 1972-2011 i.e. 40 years and probability of occurrence and percent probability is found out.

From the criteria for analysis of rainfall, no drought years, mild drought years, moderate drought years, severe drought years are found out.

Table 1 Probability of occurrence of rainfall for Mohol

Rainfall, mm	Number of events	Probability of occurrence	% probability
0-100	0	0.00	0.0
101-200	0	0.00	0.0

201-300	2	0.05	5.0
301-400	2	0.05	5.0
401-500	6	0.150	15.0
501-600	7	0.175	17.5
601-700	7	0.175	17.5
701-800	10	0.25	25.0
801-900	2	0.05	5.0
901-1000	2	0.05	5.0
1001-1100	1	0.025	2.5
1101-1200	0	0	0.0
1201-1300	1	0.025	2.5

Table 2 Criteria for analysis of rainfall

Sr. No.	**Description**	**Rainfall deficit from normal**	**Rainfall, mm**
1	No Drought	--	> 653
2	Mild Drought	0-25 %	489.8 – 652.0
3	Moderate Drought	26 – 50 %	326.5 – 489.7
4	Severe Drought	> 50 %	< 326.50

(Normal rainfall of Mohol = 653 mm)

Table 3 Rainfall analysis for Mohol

No Drought years	**Mild Drought years**	**Moderate Drought years**	**Severe Drought years**
1974, 1975, 1978, 1981, 1983, 1987, 1988, 1989, 1990, 1996, 1998, 2000, 2004, 2005, 2007, 2008, 2010	1973,1979, 1984, 1985, 1986, 1991, 1993, 1995, 1997, 1999, 2001, 2002, 2009, 2011,	1976, 1977, 1980, 1982, 1992, 1994	1972, 2003, 2006
Total 17 years	Total 14 years	Total 6 years	Total 3 year

Table 4 Monthly values of Variance (S), Mann-Kendall Statistic (S), normalised test statistic Z, probability and trend of Rainfall at ARS, Mohol (1972-2011)

Month	**NORMSDIST**	**Trend**	**Month**	**NORMSDIST**	**Trend**
Jan	0.56	No trend	Jul	0.91	No trend
Feb	0.69	No trend	Aug	0.82	No trend
Mar	0.79	No trend	Sep	0.48	No trend
Apr	0.79	No trend	Oct	0.38	No trend
May	0.99	Increasing	Nov	0.44	No trend
Jun	0.50	No trend	Dec	0.37	No trend

Table 5 Monthly values of Variance (S), Mann-Kendall Statistic (S), normalised test statistic Z, probability,and trend of Minimum Temperature at ARS, Mohol (1972-2011)

Month	NORMSDIST	Trend	Month	NORMSDIST	Trend
Jan	0.18	No trend	Jul	0.03	No trend
Feb	0.10	No trend	Aug	0.01	No trend
Mar	0.03	No trend	Sep	0.03	No trend
Apr	0.02	No trend	Oct	0.00	No trend
May	0.02	No trend	Nov	0.01	No trend
Jun	0.01	No trend	Dec	0.06	No trend

Table 6 Monthly values of Variance (S), Mann-Kendall Statistic (S), normalised test statistic Z, probability,and trend of Maximum Temperature at ARS, Mohol (1972-2011)

Month	NORMSDIST	Trend	Month	NORMSDIST	Trend
Jan	0.99	Increasing	Jul	1.00	Increasing
Feb	1.00	Increasing	Aug	1.00	Increasing
Mar	0.99	Increasing	Sep	0.99	Increasing
Apr	0.99	Increasing	Oct	0.92	No trend
May	0.94	No trend	Nov	1.00	Increasing
Jun	0.93	No trend	Dec	1.00	Increasing

RESULTS AND DISCUSSION

1. From Table-4, it is observed that there is increasing trend in rainfall only for the month of May. There is no trend in rest of the months.
2. From Table-5, it is observed that there is no trend in minimum temperature for all of the months.
3. From Table-6, it is observed that there is increasing trend in maximum temperature in the month of January to April, July to September and November to December. There is no trend in rest of the months (May, June and October).
4. From the analysis of the rainfall it is observed that maximum probability of 25% is in the range of 701-800 mm rainfall followed by 17.5% probability in the range of 501-600 mm and 601-700 mm rainfall (Table 2).
5. From the criteria for analysis of drought based on rainfall, out of 40 years, 17 years are no drought years, 14 years are mild years, 6 years are moderate drought years and 3 years are severe drought years (Table 3).

CONCLUSION

There is increasing trend in rainfall only for the month of May. It is observed that there is no trend in minimum temperature and increasing trend in maximum temperature in the month of January to April, July to September and November to December. There is no trend in rest of the months (May, June and October).

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Facts & Fictions on Krishna River Water Sharing

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ABSTRACT

In India still around 60% of the cultivated land is at the mercy of "Rain God". Thousands of tmc ft of water is going in to the Seas on an average; as we are unable to use this water. The basic reasons for such scenarios are political apathy towards irrigation and irrigation projects; and delays in resolving inter-state disputes by Tribunals and Courts. The tribunals are filled with retired judges to tackle the major technical issues. This, many a time led biased awards that leads to adjudication in courts that take again several years. A classical example to these is the award presented by the 2nd Krishna River Water Distribution Tribunal headed by Justice Brijesh Kumar. This award is a major "Technical Fraud" enacted to favour Karnataka at the cost of undivided AP. I proposed in my latest book "a permanent technical body" to resolve such disputes in future. In fact Central Government announced to establish such permanent tribunal. With all these, there must be political will to start and complete the projects in time. By delaying, the cost escalations will further delay the fruits reaching the people. A classical example to this is the Polavaram multi-purpose project. Government must, give top priority for collecting basic data on water availability in all river systems; and assessment of variations with the respective natural variability in precipitation.

Keywords: AP, Krishna river, Tribunals.

INTRODUCTION

India being an agrarian state, in the agriculture production and thus improving the economy of the farmers and the states, irrigation and irrigation projects played major role for hundreds of years. Immediately after Independence, the First Prime Minister (late) Pundit Jawaharlal Nehru gave importance to irrigation sector wherein he considered Dams as Modern Temples. Yet around 60% of the cultivated area is at the mercy of Rain God. This basically because of the changes that took place in Indian political set up with bifurcation of states to meet vested interests of politicians and political parties. This resulted the regional parties ruled the roots of the states and nation. They neglected irrigation and agriculture resulting rapid increase in farmers' suicides and hunger and at the same time destruction of water resources. Thousands of tmc ft of water is going in to the Seas on an average as we are unable to use this water.

Facts of Krishna Water Sharing

General

The 1st Tribunal headed by Justice Bachawat presented simple award and till to date this is in operation. For the purpose of water distribution, the Tribunal used the amount of water at 75% probability level, known as "dependable" water. This is 2060 tmc ft [here after referred as tf]. To this added return flow of 70 tf, that is the sum 2130 tf of water was distributed among Maharashtra, Karnataka and AP respectively 585, 734 and 811 tf -- 5.0 tf each was allocated to Chennai drinking water. AP will get less than 811 tf in 25% of the years being lower riparian state after the upper riparian states using their allocations -- locally available in AP is 350-400 tf on an average. To minimize the risk, the Tribunal allowed AP to use the surplus water with 150 tf as carryover capacity.

Government of India appointed 2nd Tribunal headed by Justice Brijesh Kumar, which started its work in August 2006 and submitted its final order in 30 November 2013 to Government of India. Supreme Court with AP's petition stayed the award publication in Gazette. Though the tribunal used 75% probability, the Tribunal used 65% probability level as dependable and this is 163 over 2130 tf in which AP share is 45 tf . The tribunal also distributed additional water between 65% and the Mean [58%], 285 tf in which AP share is 145 tf. That means, the total water allocated to AP is 1005 tf. Karnataka share is 911 and Maharashtra share 666 tf. Thus, the total water distributed is 2578 tf, which is in excess by 448 over 2130 tf. In all the three stages, the upstream riparian states are given right to first use their allocated water. Yet, the reality is not as simple as this for AP.

Importance of River Water Flow data Series

Justice Brijesh Kumar Tribunal [hereafter referred it as "the Tribunal"] enacted a Technical Fraud in its award to favour Karnataka at the cost of undivided AP. There are several scenarios in the "Technical Fraud". These are presented under data manipulations, probability manipulations and thus finally its implications on two Telugu states. The first Tribunal used 78 years data set that was available to him at that time, namely 1894-95 to 1971-72 which was agreed by the three riparian states. Though Justice Brijesh Kumar Tribunal has 114 years data series [1894-95 to 2007-08] but used selected data series of 1961-62 to 2007-08 of 47 years only, which was not agreed by AP; and yet, the Tribunal used five different data sets to prove their unethical arguments. The average of 47 years data series is higher than 78 data series by 185 tmc ft.

The Tribunal put forth several subjective, unscientific and illogical arguments without giving scientific reasoning for doing so. The tribunal argued that "They [*47 and 78 years data series*] do not match hence cannot be integrated"; "Such increase [*185 tf*] as reflected seems to be quite natural & obvious ---"; "The longer the time series [*114 years data series*], however, greater the chance that it is neither stationary, consistent nor homogeneous"; and "we are of the opinion that 47 years length of the series should be considered sufficient to assess water availability of river. It more than fulfils the minimum requirement of IS Code ---".

The AP rainfall data series since 1871 presented a 132 year cyclic pattern in which 66 years each form part of below & above the average pattern in successive periods. The period prior to 1935 presents below the average pattern and the same is now started from 2001; and from 1935 to 2000 presents above the average pattern [Figure 1a]. The water availability data of 114 years follow the rainfall pattern [Figure 1b]. That is 78 years and 47 years data sets form part of below and above the average patterns only. Thus the average of 78 years data set is lower than the average of 47 years data set and as well under sine curve pattern [cyclic variation] they both form a continuum. In fact in the below the average period even delta area did not receive its share of 181.2 tf of water even when all the major projects were not ready to use their share of water on many years – the Tribunal presented this data in its report. In the present below the average part, N'sagar hasn't reached to its full capacity on many years.

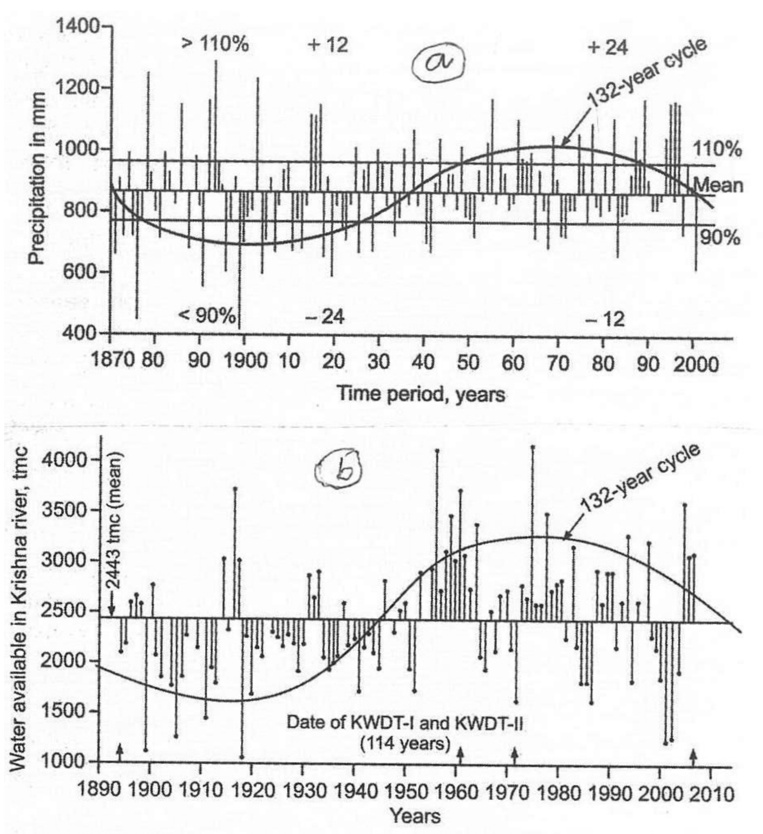

Figure 1 Annual march of annual data of (a) Precipitation of Andhra Pradesh and (b) Water flows in Krishna River (observed & predicted)

The accuracy of the minimum expected amounts derived at a given probability level depends up on the representativeness of the data used and the degree of skewness in the data set. When a given data series with least skewness follow normal distribution.

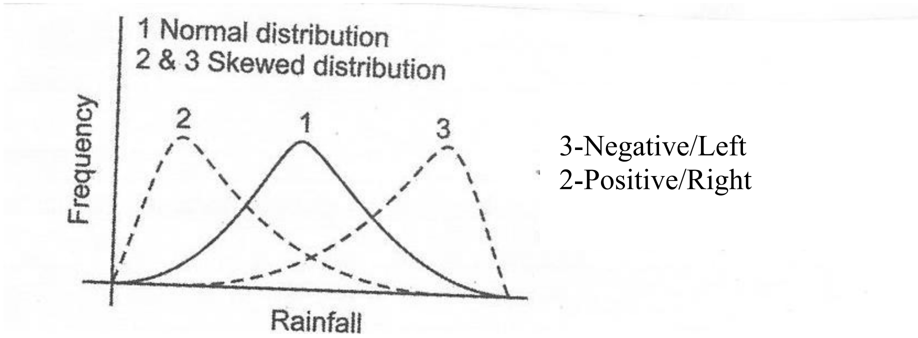

Figure 2 Schematic presentation of Normal and Skewed distributions

Figure 2 presents the Normal [Gaussian] -- symmetrical -- and skewed -- asymmetric or asymmetrical distribution schematically and the same with observed data series are presented in Figure 3. Symmetry means that one half of the distribution is a mirror image of the other half. A left [negatively] skewed distribution has long left tail and a right [positively] skewed distribution has long right tail. Data with Normal distribution, the Mean and the Median are the same – the Median is the numeric value separating the upper half of the sample data set from the lower half of the plot from the lowest to the highest, in other words, the Median refers to the value of 50% probability level. In the case of right skewed distribution, the Mean is to the left of the Median; and in the left skewed distribution, the Mean is to the right of the Median. To get unbiased estimates of water availability at a given probability level, the data series thus must follow the Normal distribution. Then such data series are termed as stationary, consistent and homogeneous. The Tribunal did not apply this test.

In the three data sets of 47, 78 and 114 years, the Mean coincides respectively at 58%, 42% and 48% probability levels [Figure 3]. This clearly suggest that 114 years data series is very close to the Normal distribution with the Mean at the 48% probability level; and the other two are following skewed distribution with 78 years data showing lesser skew over that of 47 years data series. 114 years data is the best data series for probability study over the other two with 47 years data set on the lower side [poor]. This negates the inferences made by the Tribunal on longer data series and choosing shorter data series of 47 years for the Study.

Importance of Probability Estimates

From the above discussion, the choice of data defines the quality of probability estimates. Justice Brijesh Kumar Tribunal used a subset of high rainfall period, a biased choice. Also, the Tribunal distributed water at three probability levels, namely: 75%, 65% and 58% [the Mean] using probability curve built by plotting the lowest to the highest values using 47 years data set, a subset of 114 years data series. They are 2130, 2293 & 2578 tf [Figure 3]. On the probability curve built using 114 years data set, for these three water limits the probability levels changed as 75% [fixed], 55% and 41.5% respectively [Figure 3]. That means as for as the award is concerned 2578 tf of water is available in 58% of the years but in reality it is available to AP in 41.5% of the years only as 114 years data series cover both better and poor rainfall periods. Similarly, 2293 tf of water is available to AP in 55% of the years only in reality but not in 65% of the years.

AP will get less than 811 tf in 25% of the years as the locally available water on an average is only 350 – 400 tf. Also, under less than 25% probability levels on probability curves [Figure 3] large part of water enters into the Sea as the water holding capacity of Prakasham Barrage is very low. This is more so in cyclonic activity periods. For example, 13 & 12 tf of water entered the Sea during 2002-03 & 2003-2004 with 1239 & 1252 tf of water availability; and 1273 & 944 tf of water entered the Sea during 2005-06 & 2006-2007 with 3624 & 3186 tf of water availability.

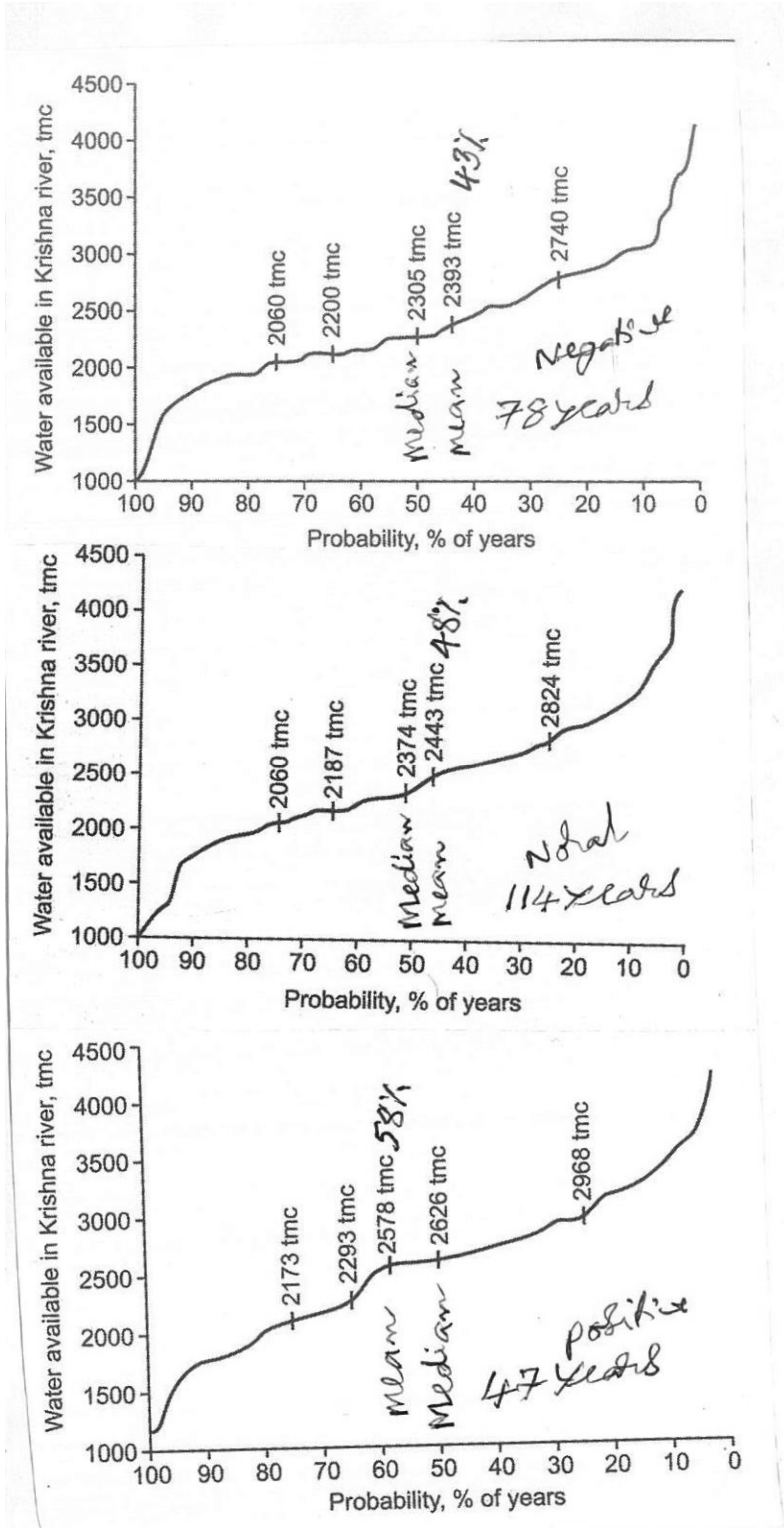

Figure 3 Actual data presentation of Normal and Skewed distributions

The tribunal allocated extra water to Karnataka on fictitious grounds. They include around 40 tmc ft of water to three illegal projects from Tungabhadra River; and 230 tf of water to Almatti Dam from Krishna-Bhima River. These are direct allocations but they create indirect allocations by 25% of 270 [= 230 + 40] tf of water through seepage in to the ground [creates groundwater] and through evaporation loss to the atmosphere by increasing the water spread area. Thus, the Tribunal allocated around 337.5 tf of water to Karnataka on fictitious grounds. Even if

230 are only 130, even then allocation on fictitious grounds is 212.5 tf of water. The Tribunal justified the former by saying that it is in drought prone zone. Drought prone zones of AP, Karnataka & Maharashtra are part of rain shadow zone of Western Ghats is a continuum. So, the argument of the Tribunal is biased to favour Karnataka only. The Tribunal justified the later, through mathematical jugglery by showing that AP will be getting on an average 1530 tf of water. The Tribunal arrived at this figure by adding 932 tf from Krishna-Bhima Basin estimated using 26 years data series [1981-82 to 2006-07] to 190 tf from Tungabhadra Basin and 350-400 tf locally available in AP. Here the important question is *at what probability level AP will be getting 1530 tf of water?*

To answer this, we need to add the water allocations to Maharashtra and Karnataka at the mean, namely 1518 [= 877+641] tf of water [return flows are not included] to 1530 tf. This water of 3018 [= 1530 + 1518] tf is available at 24% and 17.5% probability levels, respectively under the 47 & 114 years data sets. That means AP will get 1530 tf of water in less than 25% of the years only. All these clearly present the Tribunals bias towards Karnataka at the cost of AP.

Importance of Political Power

The 811 tf was divided among Rayalaseema, Telangana and Coastal Andhra with around 1 : 2 : 3 ratios [with 5 tf to Chennai]. In the case of surplus water, 150 tf goes as carryover in the dams to use in deficit years. AP government allocated 227.5 tf of surplus water [when available only] to 7 projects in the three regions. In 2013 the AP irrigation minister released project-wise allocations. However, these allocations will be drastically affected by the Justice Brijesh Kumar Tribunal Award of 2013. Also, the two Telugu states will be getting its share of water at the "will and pleasure" of Karnataka as the Tribunal distributed more water to two upper riparian states and as well allowed Karnataka to store more water on fictitious grounds. If the Justice Brijesh Kumar Tribunal award is implemented the dry regions of AP and four districts [old] of Telangana will turn in to deserts in no time with coming 50 years being in the frequent drought prone period. We must remember the fact that rainfall is seasonal and highly variable with years. We can see this openly with N'Sagar wherein only in few years the water reached to its full capacity after 2001. Under this scenario the two Telugu states must get succor from Godavari River water, though there are politics involved in it.

Though Telangana has sustainable water resources from Godavari River, stopped all major plans of utilizing Godavari waters in Krishna Basin such as Pranahita-Chevella, wherein the water use is limited to Godavari basin only. At the same time proposed projects in Krishna basin on fictitious water availability [150 tf] saying that undivided AP government initiated them, forgetting the fact that they were designed for not even 10% of the present project designs. Government planned to convert the existing drinking water reservoirs in Hyderabad in to real estate ventures and as a result even the groundwater will be turned in to polluted water. In fact the two reservoirs provide water directly and indirectly [through groundwater].

Though the AP government says it will divert Godavari waters to projects in dry areas but in reality it is planned to use this water in Krishna & Guntur districts wherein the new capital city and industrial & other infrastructure projects are planned, as part of this Pattiseema lift irrigation was introduced instead of completing the main Polavaram projects with right and left canals are nearly ready to carry water. Also government spent lavishly on Pushkaralu. Under this scenario completion of Polavaram project and the basic infrastructure to take water to dry areas in Krishna basin may take more than two Pushkaralu time.

There is a need that both the Telugu states must give priority, by keeping politics aside, to utilization of Godavari water in Krishna basin to meet both the drinking and irrigation needs. This is the only solution on long term basis with growing population and urbanization. To supplement, there is a need to use wastewater generated in urban areas – around 75% of the water used in urban areas goes as waste water.

Also, both the Telugu states must come together and fight in the Supreme Court against the injustice done by the Tribunal on technical grounds and not on legal grounds by asking the court to appoint a technical committee to review the "Technical Fraud" enacted by the Tribunal to favour Karnataka. In fact I myself submitted this to the three successive CJs of SC and as well brought to the notices of the Prime Minister & the President of India along with the two Telugu states irrigation departments.

Effect of Cost Escalations & Public Hearings on projects progress: An example

General

Let me present the issues of cost escalations & public hearing aspects with reference Polavaram Project in AP as an example. *I always used to wonder: Will Polavaram a Varam to People or Varam to Contractor-Politicians nexus?* Initially it looked like a Varam to people and with the changed political scenario it shows that it is a Varam to Contractor-Politicians. Polavaram project is a multi-purpose projects that includes, irrigation, drinking, navigation, power production, industry and interlinking with the Krishna River. The project works under gravity. Before Dr. YSR death in 2009, the project received majority of the statutory clearances/approvals from different central government departments. In 2009 just before presenting to Cabinet meet to get national status to the Project, CWC asked AP government to present the revised estimates with 50 lakh cusecs of extreme floods instead of 38.2 lakh cusecs based on 2006 floods.

Cost escalations

The Project estimates under the 38.2 lakh cusecs of maximum floods in 2005 were Rs. 10,271 crores for which Planning Commission has given clearance in February 2009 and the same for 50 lakh cusecs in 2011 were Rs. 16,000 crores, which was also cleared by the central government. The contractor slowed down the construction activities and government initiated Pattiseema lift irrigation by spending few thousand crores. Here they used the Polavaram Right Canal built during (late) Dr. YSR government. On 11th October 2015, AP Cabinet decided to raise the cost to around Rs.32, 000 crores though the project is supposed to be built by the Central Government and for which a Committee was also constituted by the Center. As a political game, the project was transferred to AP government and with that again the cost of the project was raised to more than Rs. 40,000 crores.

When Polavaram project was planned in 2005, it was the most cost effective multipurpose project. Now the present government transformed this in to cost-ineffective project. There is a doubt whether this raise only for copper dam part or inclusive main dam along with the power plant and other activities as envisaged in the original plan? It appears that it may cross one lakh crores at the end. However, these estimates were not cleared by the Central Government as they stated that they will provide funds as per the clearance of Rs. 16,000 crores only, even though granted national status to the project.

From the cost escalation estimates created by AP government in the last two and half years Central government acting as a silent spectator and without allocating funds for the completion of the project, clearly shows that Polavaram is not a Varam to People of AP but a Varam to Contractor-Politician Nexus. Unfortunately people have no knowledge on such intricacies but believe gimmicks of ruling party politicians.

Public hearings

Even before bifurcation, public hearings were conducted and project works stated during (late) Dr. YSR time itself in 2006. Also announced R & R packages and in fact the first batches of villages were happily moved to rehabilitation centers even when NGOs and vested groups including political parties tried to stop them.

As per the EIA Notification 1994, AP Government conducted Public hearings at five places in AP and accordingly obtained Environmental Clearance [EC] from MoEF in 2005. As per the Tribunal order, MP [Chhattisgarh is part of MP] & Orissa [present name Odessa] signed for 150 ft of dam height and to avoid submergence building of embankments [in Odessa & Chhattisgarh, be built with 10-30 ft height over 30.2 km in Odessa and 29.12 km in Chhattisgarh for which Rs.600 crores were allocated by AP Government] – in 2009 CWC ratified for embankments & MoEF gave forest clearance on July 28, 2010 with a condition that AP will construct Embankments to avoid submergence & displacements in Odessa & Chhattisgarh. CWC increased the extreme flood level to 50 lakh cusecs. To avoid any more submergence over the 38.2 lakh cusecs, the height of the dam was kept at 150 ft only. With this there will not be any additional submergence in the neighbouring states but the dam will have more spillways for outflow to maintain the water level at 150 ft. With reference to a case filed by the neighbouring states, the Supreme Court appointed a technical committee to look in to the matter whether AP followed the Tribunal order of 150 ft or not. The committee submitted its report saying that there was no change in Tribunal Order.

MoEF brought an EIA Notification 2006 and published the same in Gazette in September 2006. According to this the public hearing has to be conducted in the neighbouring states also. Project is already got EC and work was in progress with all the above mentioned orders/approvals and thus the retrospective implementation is not valid.

Yet some NGOs hobnobbed with the MoEF and neighbouring states filed a case in National Green Tribunal [NGT]. NGT stayed the work but this was vacated by the High Court.

However, MoEF asked AP Government to conduct public hearings in the two states as per EIA Notification 2006. Also MoEF issued stop order, a political game. However, as directed by the MoEF, AP Government wrote letters to the two governments to conduct public hearings in the respective states and the cost will be borne by AP Government. They did not respond on them. In such scenario, it is mandatory of MoEF to conduct public hearing in those states through their regional office in Bangalore. But, they did not do that and on the contrary MoEF ordered AP Government to stop work. It is a political game. Now, the NDA Government lifted the ban imposed by MoEF by granting national status to the project. This shows how the politics affect the progress of the project and may contribute to escalation of the project cost and delay in completion of the project.

Permanent Tribunal to address River Water Disputes

Presently, there are eight tribunals functioning to resolve disputes over sharing water of eight rivers. Some of these are over 50 years old. Three of them were set up in 1969 to deal with disputes over Godavari, Krishna, and Narmada. Ravi & Bias Tribunal was constituted in 1986, Cauvery water tribunal in 1990, and second Krishna water Tribunal in 2004, and Vamsadara water Tribunal & Mahadayi Water Tribunal in 2010. The Government of India is reported to have decided to set up a single statutory permanent tribunal to adjudicate all Inter-State river water disputes. A bill is to be introduced in Parliament. This is a major decision coming in the context of protracted disputes and long standing court cases in various parts of the country involving almost all major rivers and many states. The main intension is sad to be to speed up the process of settlement. The proposed permanent tribunal is to be headed by a retired Supreme Court judge. The move will not make adjudication a purely legal issue. For, provision for setting up Dispute Resultion Committee (DRC) comprising experts and policy makers will be included for investigation and examination of dispute before they are sent to the tribunal.

The same was announced at a press meet few months back by the Water Resources Minister and as well later by the Finance Minister. In fact even before that I presented under “Recommendations” section of my book (Reddy, 2016a) on page xii “To avoid such catastrophic awards, the Central Government should enact a Law to replace the tribunals with a technical body headed by a sitting Supreme Court Judge and a member from CWC will be the member Convenor, assisted by a 15 member team from different Central Government Departments. All will have a fixed two year term – they may hire temporary experts to resolve specific issues. In this connection, the government must formulate guidelines clearly so that nobody uses his or her vested interests in to that to vitiate justice”. Very simple and less controversial award was delivered by Justice Bachawat and very complicated highly controversial and biased award was delivered by Justice Brijesh Kumar. To avoid such variations, the basics must be clearly defined without giving a scope to tribunal to manipulate to serve the vested interests.

SUMMARY & CONCLUSIONS

It is common knowledge that many a times people without understanding basic intricacies of the situation make statements that harm some states. Research Institutions, Universities must give importance to unravel deficiencies in such systems to benefit people in general and Governments in specific. Without such efforts, executive and judiciary to meet their selfish interests, they not only destroy the nature but destroy the very framework on which they were employed.

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GO111: Protecting Water Resources of Hyderabad

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ABSTRACT

GO111 lists mandatory steps to protect Osmansagar and Himayatsagar, the two drinking water lakes of Hyderabad. These lakes were established with a noble cause by the then rulers. Three successive governments along with the Supreme Court and the AP High Court brought out Laws/Acts & Orders to protect the two water bodies. These two lakes present a living testimony of how the human greed attempts to kill the noble cause. The article presents the historical sequences of GO111 which includes efforts to save and attempts on to weaken the GO111. This includes both executive and judiciary actions. Unfortunately the precautionary principle turned into post-mortem reports. From all these, the story of GO111 presents a classical case of actions and counteractions between environmental groups and government departments, judiciary, violators in relation to Acts/Laws & Orders to protect natural resources. It became a common practice to attribute such destructions to climate change, a false propaganda to justify their inactions. A classical example to this is regularization schemes; and negating the principle of "prevention is better than cure". Failure to act on violators of Laws/Acts & Orders amplify the destruction of natural resources and thus also increase the hazards from the resulting impacts on natural resources, humans and environment.

Keywords: GO111, Osmansagar, Himaytsagar, regularization schemes.

INTRODUCTION

Importance of Alternate Site Selection

When dealing with the natural resources, as per the Environmental Acts prevailing in the country, alternate site selection with minimal damage to Environment and Ecological Sensitive Zones is to be adapted. Though it is mandatory, unethical political powers outplay this objective many a times. Human greed plays a major role in the destruction of natural resources.

Around the world Environmental Impact Assessment (EIA) is one of the successful policy innovations of the 20th Century for environmental conservation. EIA as a mandatory regulatory procedure originated in the early 70s, with the implementation of the National Environmental Policy Act (NEPA), 1969 in the US. Some rudiments of EIA are implicit even in early examples of environmental legislations. Napoleon in 1910 issued a decree which divided noxious occupations into categories: those which must be far removed from habitations, those which may be permitted on the outskirts of towns, and those which can be tolerated even close to habitations, having regard to the importance of the work and the importance of surrounding dwellings. In India it started in 1976-77 when Planning Commission asked the Department of Science & Technology to examine the river valley projects from environmental angle. Subsequently it was extended to cover those projects which required approval of the Public Investment Board. Till 1994, environmental clearance from the Central Government was an administrative decision and lacked the legislative support.

In India, the environmental action formally started with the participation of late Smt. Indira Gandhi, Prime Minister of India in the UN Conference on Human Environment in Stockholm in 1972. A National Committee of Environmental Planning & Coordination (NCEPC) was established to be the apex body in the Department of Science and Technology. On 27th January 1994, the Union Ministry of Environment and Forests (MoEF), Government of India, under the Environmental (Protection) Act, 1986 promulgated EIA Notification making Environmental Clearance (EC) mandatory for expansion or modernization of any activity or for setting up new projects listed in Schedule I of the notification. The government of India in a retrograde motion replaced this with EIA Notification 2006 Gazette on 14th September 2006 and subsequent amendments to it.

Of late, ad-hoc decisions for developmental projects/activities have led to an adverse impact on the local environment at costs, which are much higher than the benefits actually accrued. The development and analysis of alternatives form the very core of EIA. An EIA is actually a comparative analysis of alternatives. The analysis should consider potential consequences, which are long-term and short-term; direct and indirect; or secondary; individual and cumulative; beneficial and adverse. Even with more than 100 years history for EIA, it hasn't got its place. A classical example of violation of this is glaringly seen in the case of Shamshabad Airport and Outer Ring Road Phase-I site selections in Hyderabad. Government gave more importance to vested interests. That means we frame the laws/acts but we refuse to adhere or implement them to meet the selfish interests of politicians at the cost of environment/natural resources.

Of late governments are acquiring lakhs of acres of land including from fertile agriculture belts and ecologically sensitive zones to serve the vested interests. Central government brought out an act in this direction but states are not using this but using their own acts to maneuver easily while acquiring the lands. Here EIA has zero roles.

Who is Responsible for illegal Constructions?

It has become a ritual, allow violations and come up with regularization schemes for a price at the cost of environment and natural resources. This is glaringly seen in and around Hyderabad, more particularly in the last two decades. In this the major casualty is traffic and greenery and at the same time infringing a citizen's right to live. Governments have been responsible for the major violations so as to meet their vested interests and thus creating massive violations as secondary components like that in the case of Samshabad Airport and Outer Ring Road Phase-I. Also the government itself in the name of building new structures while appeasing "Vastu God" with the public money creating new traffic hurdles, butchering thousands of grown up tress – one tree is equivalent to 1000 new samplings --, destroying water bodies including drinking water reservoirs and water channels; polluting the atmosphere and whereby people are deprived of the life saving oxygen.

Forgetting the fact by regularizing the violations, what will be the impact on environment-biology, transport, etc governments brought out Building Regularization Scheme [BRS] – Penalization Scheme [BPS]. The simple argument is, if demolished the illegal structures the poor buyers will suffer – as the violators sell and wash their hands. Then why the government waited for such things happening. The BRS-BPS has a life of more than two decades. On every occasion public knocked the doors of the High Court when ever government announced BRS-BPS, starting from 1998 questioning the validity of G.O.Ms.No, 419 dated 30-6-1998. Again in 2008 on G.O.Ms.No.901 dated 31-12-2007 and now on the G.O.Ms.N.146 dated 31-10-2015 & G.O.Ms.No.152 dated 2-11-2015. This is the legacy of executive and judiciary under modern socio-political conditions.

Historical Perspective of GO111

General

For the last few days, the hot topic in media had been the NGT [National Green Tribunal] order on GO111 with reference to a petition asking for easing of the GO111. The GO111 relates to "twin lakes", namely Osmansagar and Himayatsagar. It is a "Gold Mine" for violators of GO111. Telangana Government is reported to have informed the NGT that it is in favour reviewing it.

Hyderabad gets its drinking water from Krishna, Godavari, Singuru-Manjeera and twin lakes respectively supply 270 MGD [million gallons per day], 172 MGD, 120 MGD & 40 MGD respectively. Twin lakes, in addition, provide more than 40 MGD from groundwater. The twin lakes water is available at Rs.2 per kilolitre but the same from Godavari is more than 30 and from Krishna it is more than 18. In the case of twin lakes we not only get 40 MGD directly but also get more than 40 MGD from groundwater indirectly.

GO111 and Precautionary Principle

Following the 1908 September floods to river Musi, on the advice of the legendry Engineer, Sir, Mokshagundam Visveswarayya constructed Osmansagar (1913-1918) on the river Musi and Himayatsagar (1920-1927) on Easi, a tributary to Musi River to contain floods and to provide drinking water to twin cities, spread over 10,000 acres. Since 1930 this water is used for drinking as Hussainsagar Lake (built in 1561 – though Hyderabad formed in 1592) hither to serving the drinking water needs to twin cities was contaminated by domestic sewage.

A view of Osmansagar Lake

A view of Himayatsagar Lake

Later, Government noticed affecting the quantity and quality of flows in to the two lakes. To address them, Government issued a series of GOs. The first one G.O.Ms.No.50 MA dated 28.01.1989 was issued to protect the hydrological regime as envisaged in the original reservoirs construction plans of the catchment areas through prohibiting the interception of any inflows of water into the lakes, removal of unauthorized check-dams, prohibiting tapping of groundwater in these catchment areas; preventing unauthorized occupation of land, etc. The second one, G.O.Ms.No.192 MA dated 31-03-1994 was issued prohibiting the establishment of any polluting industries, major Hotels, residential colonies or other establishments that generate pollution in the catchment within 10 km radius from the Full Tank Levels [FTLs] of the two lakes based on Technical Committee's interim report. The third one G.O.Ms.No.111 MA dated 08-03-1996 was issued by combining the two GOs based on the second report of the expert committee after detailed discussions and field visits.

That means GO111 relates to protection of both quantity and quality of flows in to the lakes. The land use of about 90% of the area is classified as agriculture which is inclusive of horticulture and floriculture. In the remaining 10% of the zone, identified 84 villages and were notified as prohibited zones wherein polluting industries, major hotels, residential colonies or other establishments that generate pollution are prohibited; and polluting industries are prohibited within the 10 km radius from FTLs, i.e., both upstream and downstream side to prevent acidification of lakes (due to air pollution).

Based on the reports from EPTRI [appointed by the government as per G.O.Rt.No.952 MA&UD dated 29-11-2005] and a Technical Committee [appointed by APPCB], Government issued regulatory measures for downstream zone such as no development will be allowed up to 500 m from the bunds/FTLs and the same shall be declared as prohibited zone; beyond 500 m and up to 1000 m, only low rise residential development (ground + 2 floors) will be allowed, etc similar to those allowed in 84 villages.

After issuing GO111, the very same government in violation of GO111 permitted hazardous industry in the prohibited zone. Environmental groups approached AP High Court but in its July 1997 order supported the government's action. Then environmental groups approached the Supreme Court, which in its land mark judgment dated 01-12-2000 [APPCB versus (Late) Prof. M.V.Naiudu] set aside the AP High Court order and brought in precautionary principle. Precautionary principle means "prevention measures" rather than "control measures". On this order the government constituted high power committee and identified polluting industries and issued closer orders. (Late) Prof. Naiudu and I were the members of the APPCB's Task Force Committee, which executed this Task; and later stopped coming up new industries in this zone as a member of CFE committee of APPCB.

Efforts to save GO111

In Environmental Impact Assessment [EIA] looking for an alternate site is an important component but this was not followed in the case of Shamshabad Airport and Outer Ring Road Phase-I (ORR-I) though they have alternate solutions to achieve the said goals. To serve the vested interests government has chosen environment-destruction path. This, thus, laid the foundation for the destruction of Osmansagar & Himayatsagar Lakes [same is the case with the Pharma-City in Vishakhapatnam & new AP Capital] in violation of GO111. Unfortunately AP High Court supported this [with reference to our two PILs].

Encroachment of Shamshabad Airport in to Himayatsagar catchment would have been avoided by shifting the airport as there were plenty of lands. On ORR-I, officials approached me for my opinion; and I suggested them to build expressway from Airport to Miyapur. Though they implemented partially [PVNR Expressway], they went ahead with ORR Phase-I that drastically reduced inflows in to Himayatsagar Lake. With my intervention in CFE committee of APPCB one Hotel within the Airport was located outside the 10 km radius line and the second one was withdrawn. However, with the Airport and ORR Phase-I, illegal layouts & structures surfaced. HADA published a list of such violations through a notification No. 248/HADA/01/2001 dated 14-08-2002. EPTRI & NGRI submitted a list of violations against GO50 of 1989 and list of Farmhouses – out of 200, large number are part of resorts -- to MA&UD in September 2005.

AP government allotted land [and as well changed the land use] 500 meters from Osmansagar Lake on 12.3.1998 to CDFD. As per the GO 111 there is no clause to permit the change of land use in the prohibited zone. APPCB rejected the consent order for wet operations; Appellate Authority dismissed appeal; AP High Court sent it back to APPCB. On this APPCB reiterated its earlier order rejecting the wet operations. Important point here is that the High Court hasn't negated the grounds – "polluting activity" as "polluting industry", on which consent for wet operation was rejected by APPCB and upholding the same by Appellate Authority.

In this connection, Advocate General and Technical committee opinion was taken by APPCB. They stated that "area within 10 km there is an absolute ban on polluting activity"; and "coming up of any such polluting establishment in the prohibited area such as Engineering, Technical Institutions, Chemical Labs and Resorts and Cottages for Commercial purposes are not desirable and appropriate and preventive steps must be taken by all the concerned authorities". On the same lines APPCB rejected establishment of Golf-Course very close to Osmansagar Lake that has a pollution potential to cause pollution to the lakes with chemical fertilizers and pesticides.

On the 25th April 2006, the Hon'ble High Court judgment (W.P.No. 3367 of 2006) says "we direct the state government and all its functionaries that no permission shall henceforth be granted for establishment or locating any industrial unit within 10 km of these lakes". The water sample analysis results submitted to the court in this connection by EPTRI suggest the presence of domestic sewage component – biological pollution. This component is more hazardous than even industrial pollution, because of which Hussainsagar Lake water became unsuitable for drinking. As against all these, most unfortunately, now the Hyderabad High Court allowed to establishment of Sewage Treatment Plants in the catchment area to serve the violators of GO111 interests.

After AP High Court order in support of Shamshabad Airport, I approached CBI in 2006 "to enquire on this issue" but they expressed their inability to do so. Then I, on behalf of environmental groups, filed a PIL in AP High Court [W.P.No.9386/07]. Government [MA&UD] issued a Memo No. 14046/I_1/07 dated 12.10.2007, which ratified GO111. The court also directed the government to create "Lake Protection Authority" but brought out a toothless "Lake Protection Committee"– G.O.Ms.No.157 dated 06-04-2010. The Memo was widely circulated in media. Though the government and court responded positively in my PIL, but failed to stop violations at the same time. The government submitted a list of violations to NGT with reference to a petition by Thakur Rajkumar Singh – 426 layouts and 12,442 structures – which are more than ten times to those submitted in 2007 to AP High Court in my case. Also government departments could not stop mining of black soil, granite crushing operations, etc even after court's directions under different PILs.

Attempts on to weaken GO111

The major casualty for human greed in urban areas under the existing socio-political set is the natural resources. A classical example to this is the two drinking water lakes in Hyderabad, namely Himayatsagar and Osmansagar. Without the efforts of environmental groups, highly polluting industries would have made the people's life in the Osmansagar & Himayatsagar Lakes catchment area miserable with polluted groundwater, air, and soil like in Patancheru. Noor Mohammed Kunta presents the live example. Yet a dozen bureaucrats got a report from EPTRI [committee of EPTRI, IICT & NGRI] under G.O.Ms.No.952 M.A. dated 29-11-2005 for suggesting amendments to GO111. On this report I submitted my comments to Chief Minister on 9-11-2007. As a result, the government did not pursue on the matter further. Later Government on 9-4-2010 unsuccessfully moved the AP High Court asking for amending the GO111 wherein to take out from GO111 a piece of land in Vattinagulapally.

Under the Mission Kakatiya, Cyberabad Police Commissioner has proposed to adapt these two lakes. The police proposed to fence the FTLs and lay cycle track - walk way around the lakes. Citizens groups rejected this proposal as this helps only the violators to legalize their illegal activities, though the BRS excluded this zone from regularization. We told them, if the government fences along the 10 km boundary we support them but not their proposal. As a result police department withdrew from this project but the irrigation department went ahead with the fencing of FTLs. Every now and then some groups under some pretext or the other are approaching the AP High Court with a request of easing the GO111. Now they approached National Green Tribunal [NGT]; and NGT asked the government on this. Government appointed three bureaucrats to give their report on this.

GO111 is not prohibiting agriculture activity but in reality 90% of the area is demarcated as agriculture–horticulture-floriculture zone. Also, our beloved Chief Minister has shown the path of earning Rupees one crore per acre/hectare with greenhouses and announced to fund such schemes. The farmers could utilize this facility. Also, the farmers of this zone can fight to get Godavari water for irrigation, instead asking for easing GO111 if they are really interested in continuing on agricultural activity. By easing the GO111 the beneficiaries are none other than the violators of GO111 holding commercial establishments, such as Resorts-farm houses, educational institutions, etc who have been behind all the activities around easing of the GO111 for the last one decade. Now the Government is saying what the violators used to say all along, that "we get water for drinking from Krishna and Godavari." They forget the fact that the quantity and quality of groundwater is going to be polluted severely in this zone by easing GO111. Getting water from Godavari and Krishna cost more than ten times to that from two lakes. It will also deprive people of the state their right to get fair share of water from Godavari & Krishna. If the upper riparian states follow the same, then there is no guarantee that we get water from those rivers.

SUMMARY & CONCLUSIONS

Though by spending large sums of money and experts/officials time governments brings out Acts/Laws to protect the natural resources of vital importance to human survival. While at the same time they rarely give the same importance in implementing Acts/Laws or protecting natural resources from destruction. Unfortunately, it became ground for playing for both the executive and judiciary to amass wealth and thus it turns out to be a goldmine to violators of laws/acts and orders. There is a need to change this scenario to protect natural resources of vital importance to future generation livelihood.

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Post Tsunami Salinity Rise in a Small Inhabited Island in Nicobar, A&N Islands: Need for Large Scale Rainwater Harvesting and Artificial Recharge

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ABSTRACT

Small, remote inhabited Chowra island, population 1500(2011 census), in Nicobar district (7^0 $01^/37^{//}$ latitude and $93^0 55^/ 09^{//}$ longitude),occupies a geographical area of 8.28 sq. km. The atoll island suffers from perennial scarcity of fresh ground water. Studies revealed typical geomorphology and low altitude forms root causes of evacuation of fresh groundwater by means of outflow, vertical dispersion as also through transpiration mostly by the coconut trees and the other forestry. Thus the island becomes water scarce since time immemorial and rainwater harvesting forms the main source of drinking water. A conceptual ground water model of the island was built up to facilitate a pilot project, designed in June, 2004, involving rainwater harvesting and artificial recharge. The project could not be implemented due to tsunami devastation on 26.12.2004. The water scarcity situation further aggravated post tsunami. A recent study revealed rise in water level and ground water salinity in the island. Many saline water pools are generated. Rise in salinity facilitated the water scarcity further as also the productivity of coconut plantation, its growth and mortality. All these are hitting severely on sustainable livelihood of people. The study explores the plausible causes of problem. Three types of solution i.e. Short, medium and long term solution as envisaged are discussed in the paper.

Keywords: Small, remote inhabited island ,tsunami, low altitude, fresh water lens, rainwater harvesting, artificial recharge, conceptual model, Salinity rise, Short, medium long term solution.

INTRODUCTION

Chowra (Fig-1) is one of the most remote inhabited island fall in Nicobar district situated nearly 80 km South Car Nicobar island, the district headquarters. The geographical area of island is 8.28 sq, km. this island. The population as per 2011 census was 1500. It is dwelled by Nicobari tribes. The island was severely devastated after the tsunami

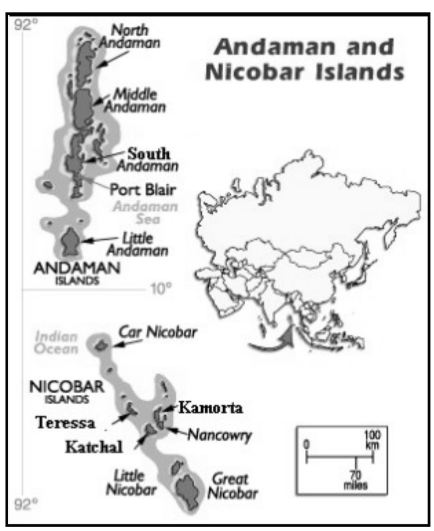


Figure 1 Location Map.

and the entire population was rehabilitated to Teresa Island. However, the islanders returned back to their island in 2007 .It's a remote Island as the mainland ship never touches the jetty and to reach the island one has to get down in open sea on small boats. However, after tsunami weekly twice Helicopter service is started by Pawan Hons under the sponsorship of A&N Admn. The islanders live in Nicobari hut.

The traditional round house (local name Gol ghar) was many before the tsunami. Tsunami had destroyed bulk of the traditional houses including many other civil structures, Church and claimed more than 70 lives. The island face tremendous scarcity of fresh water since time immemorial and rainwater harvesting is the main means of fresh water supply to the island. Case study of such small inhabited atoll islands with similar problem is unavailable in the literature. The outcome of the research may form a showcase studies for its future application elsewhere in the globe.

Geomorphology

Typical tortoise back topography and low altitude is the characteristic of the island. The Island forms a low height coralline-foraminifer limestone islands i.e. atoll. The average and maximum height of the bulk of the area is nearly 5 to 6m and 10m from mean sea level respectively. However, there is an abrupt uplifted part located in the southern tip of the island. From a distance the profile of the island looks like a tooth brush. Although the island ultimately have a gentle slope towards sea in all directions, there are numerous depressions, having depth sometimes below mean sea level or close to MSL, occur inside the island. This accentuates movement of ground water in various directions which is ultimately being mingled with the saline water inside the island itself. Forthis, fresh water lens of somewhat appreciable thickness can never form in the island. Because of high porosity of limestone drainage system is absent in the island.

Agriculture and Land use

Although agriculture is the mainstay of people, the Chowrans only produce Coconut, Tuber crops and few other green vegetables. Only two type of land use are prevalent in the Island: 1. Forest with settlement. 2. Agricultural plantation with settlement.

Geology and Hydrogeology

The Island is underlain by foraminiferal and coralline limestone (Fig-2). However, marl deposits are also encountered at the island. The porosity and permeability of the organic limestone formations are relatively good. During the detailed study in april-may, 2004, daily monitoring of water level and electrical conductivity used to be conducted. Besides, the change in water quality during and after rainfall was also closely studied to understand the recharge and discharge mechanism operative in the island. In the southern part of the island near the village Raiheon, two dug wells were existent near the beach. The depth of the wells was nearly 4m. It was observed that perched freshwater lens of nearly 15cm used to be developed in the area which could be observed from the wells during low tide while the thickness of ground water lens used to increase up to 25-30 cm during high tide.

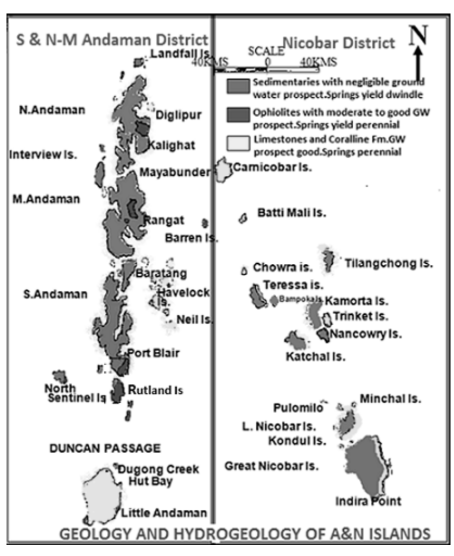


Figure 2 Geology and Hydrogeology of Chowra Island.

To adjudge the aquifer parameter one bailing test of one of the dug wells yielding freshwater were done. The permeability and transmissivity of the formation was deduced as 32m/day and 240m^2/day.

Hydraulic connectivity of ground water with ocean tide and Recharge-discharge mechanism

Peer studies in 2004 unraveled the recharge-discharge mechanism and its hydraulic connection with ocean tide prevailing in the island. Those are briefly discussed in the following paragraphs.

To understand the behavior of water table and its relation with ocean tide, Electrical conductivity of water and rainfall was correlated and the following observations were made

1. Observation: Following (Fig-3) is the hydrograph of a ringwell of Kuitasuk Village in Chowra Island. The well water was brackish (EC >8500µs/cm). During the study period it was rainy for two days. After the event well water turned fresh. It continued for some time and again it turned brackish. The well was situated in a depressed land. The water level, EC and tide level was recorded and those are plotted in fig-3 together to adjudge the influence of tide and rain on water level and salinity of ground water.

   Inference: As the well was in a depression, lot of rainwater accumulates around it. A local freshwater lens /mound develop around the well. With rainfall recession the lenses get mixed with saline water and gradually disappear. Had there been a closed impermeable barrier/membrane then that could make the fresh water existing in the aquifer for a long period till it was utilized or evaporated. The water level and ocean tide shows keen correlation as also the EC.

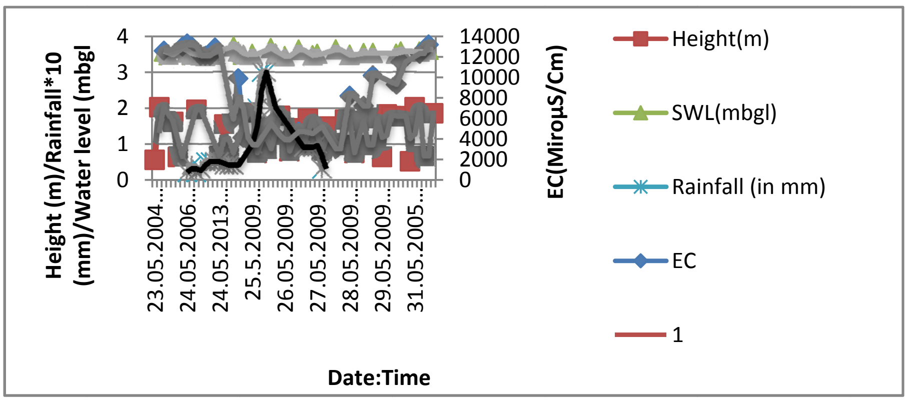


Figure 3 Hydrograph and its relation with tide level(shown as depth/height), variation of of EC (blue line) with rainfall (black) at Kuitasuk Ring well, Chowra Island.

2. Observation: Here the well yields fresh water (Fig-4).Thickness of lens varies with tide. Tides, water level, EC all are correlated. Water level shows e rise after rainfall esp. during high tide.

   Inference: The water is immediately recharged and forms a mound which further rises with high tide.

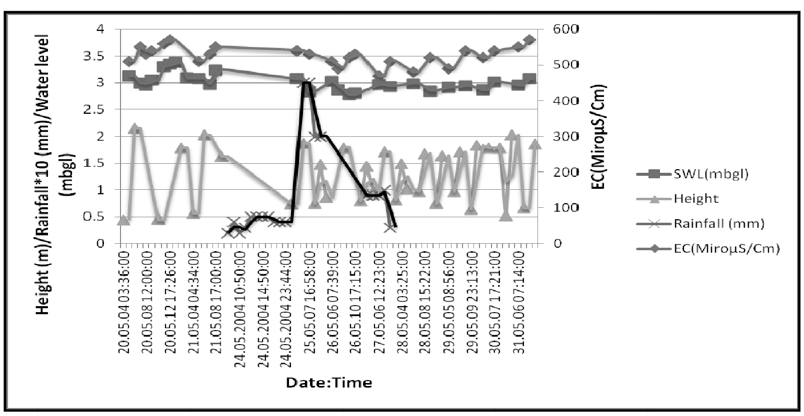


Figure 4 Hydrograph and its relation with tide level(shown as height), variation of of EC (blue line) with rainfall (black) at Raiheon, Jetty fresh water well, Chowra Island.

3. Observation: Here the well too yields fresh water (Fig-5). Thickness of lens varies with tide. Tides, water level, EC all are correlated. Water level shows rise after rainfall especially during high tide.

   Inference: Results are same as the other fresh water well. The water is immediately recharged and forms a mound which further rises with high tide.

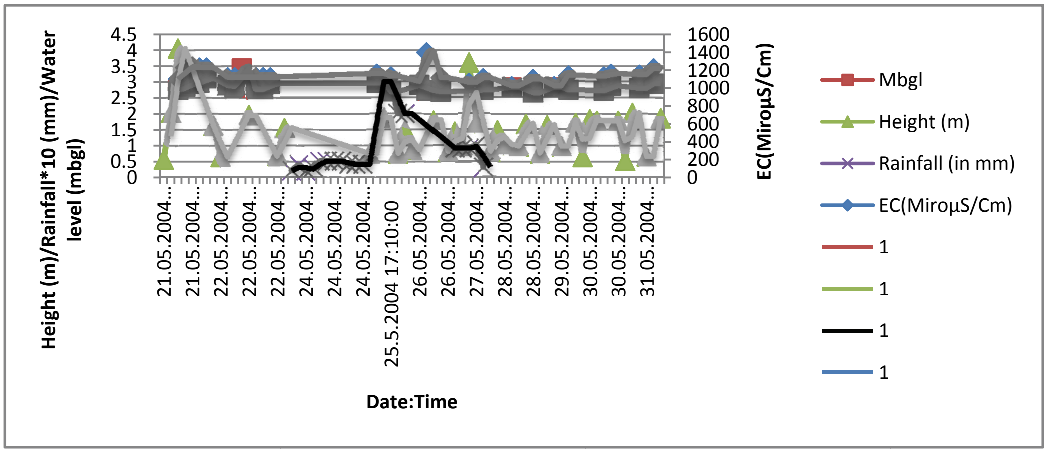


Figure 5 Hydrograph and its relation with tide level (shown as height), variation of EC with rainfall (Police station well, Chowra Island)

Ground water quality

The quality of the two beaches well as observed pre-tsunami was fresh. The Kuitasuk well turns fresh after rainfall. So all these fresh water, rainwater samples were analyzed and the cations and anions were plotted in piper diagram (Fig-4). The plot shows that the fresh water samples are Ca-HCO_3 type while the mixed water from the wells is of NaCl type.

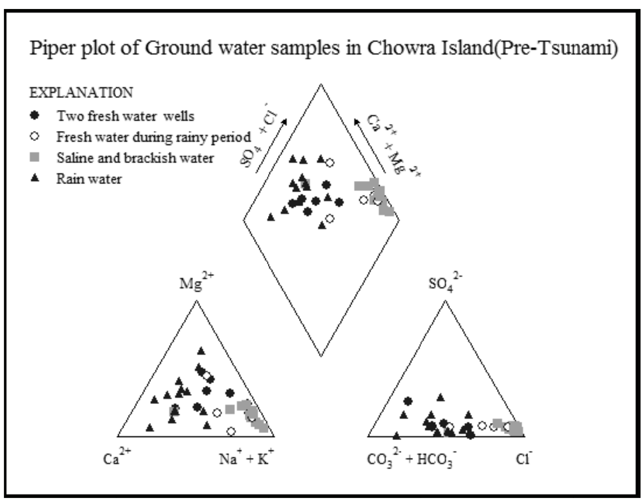
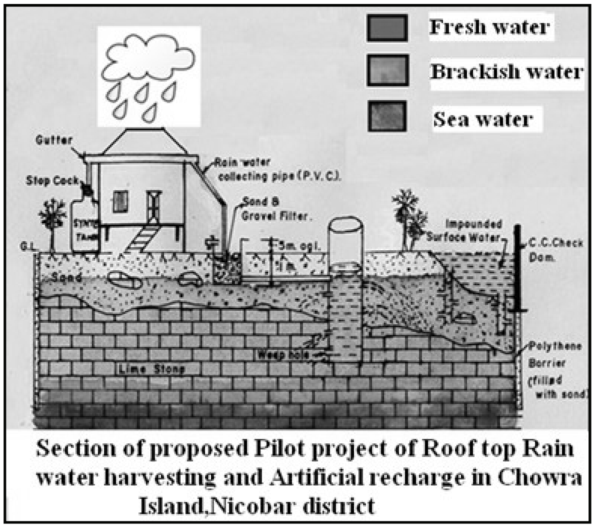


Figure 6 Piper plot shows the quality of ground water.

Design of pilot project on artificial recharge and rainwater harvesting

From these observations as enumerated above the actual mechanism of recharge and discharge characteristics in the island and the root causes of non occurrence of continuous fresh water lens in the island was revealed. The detailed chemical output of water samples of groundwater and rainwater from the islands (Fig-6) indicates the chemical behavious of groundwater samples in various hydro geochemical environments in the island. Propelled with all these observations, a recommendation of rainwater harvesting and recharge was put forward. It was so envisaged that if the rainwater is recharged inside a closed boundary, no recharged water can move out of the aquifer system. The following constructions were proposed.



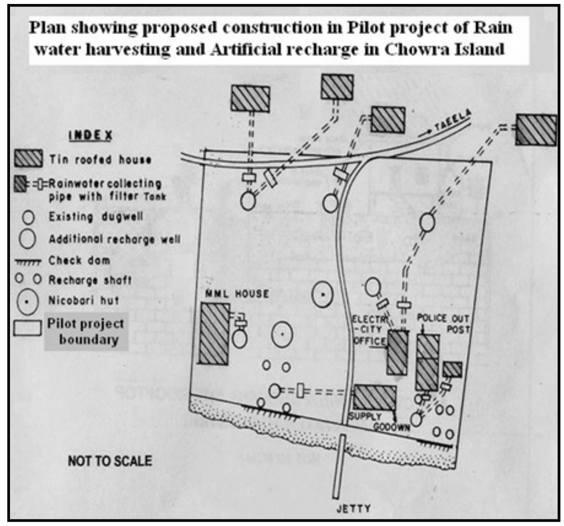


Figure 7 Plan of Pilot project, Chowra Island

Figure 8 Section of Pilot project, Chowra Island

It was recommended to dig out a trench along the outer periphery of an area having dimension 200mx200m in village Raiheon, keeping the two existing wells inside (Fig-7). The depth of the trench was recommended as 4.5m. In the trench good quality polythene sheet was recommended to be wrapped so that the dig out sand can be put in between the void portion of the side walls of the polythene sheets. The sand packing would be made so that it would look like a wall. Now the arrangement inside the project area was made so that whatever may be rainfall in the area optimum quantity would be recharged into the closed aquifer. It was proposed that all the roof top rain tapped in the Nicobari huts falling in the catchment would be poured into five new recharging dug wells (proposed to be constructed) as also into the two existing dug wells for recharge. For accentuating recharge, infiltration galleries in the top portion of the aquifer would be constructed packed by gravels and weep holes were recommended in the lower part of the recharge wells. In addition to the groundwater recharge, to capture considerable rain in the project area, recharge shafts were recommended to be constructed inside the land area. Similarly in the natural depressions existing along the shore line, two low height check dam of maximum 0.5m height was recommended for construction(Fig-8). From the plan and sections it may be well conjectured that lot of rainwater could be recharged in to the aquifer through the recharge media and the fresh water will be gradually be accumulated over the relatively denser saline water forming the third imaginary boundary of the closed aquifer system. The conserved groundwater may further be retrieved through the recharging wells itself by means of bucket and rope. In no case ground water pumping should be there which may facilitate the intermixing of saline and fresh water through turbulence. Unfortunately the project work could not be started due to the devastating tsunami of 26.12.04.

Recent studies in the Post Tsuami

Prompted by the keen initiation of A&N Administration a special appraisal of Chowra Island was undertaken during early June'16 and November'16 and the island has been revisited. The special mission has also been termed by the Administration as "Mission Chowra". The study has revealed the following.

1. A general rise in water level all around the island (Fig-9)
2. Steep rise in ground water salinity.The salinity condition somewhat lowers during continuous rainfall and it again shoots with recession of rainfall (Fig-10).
3. Many saline water pools are created in the island which did not exist prior to the tsunami (Fig-9&10).
4. The overall salinity rise has not only facilitated the water scarcity further, it has started affecting the productivity of coconut plantation as also its growth and mortality.
5. All these are hitting severely on sustainable livelihood of people.

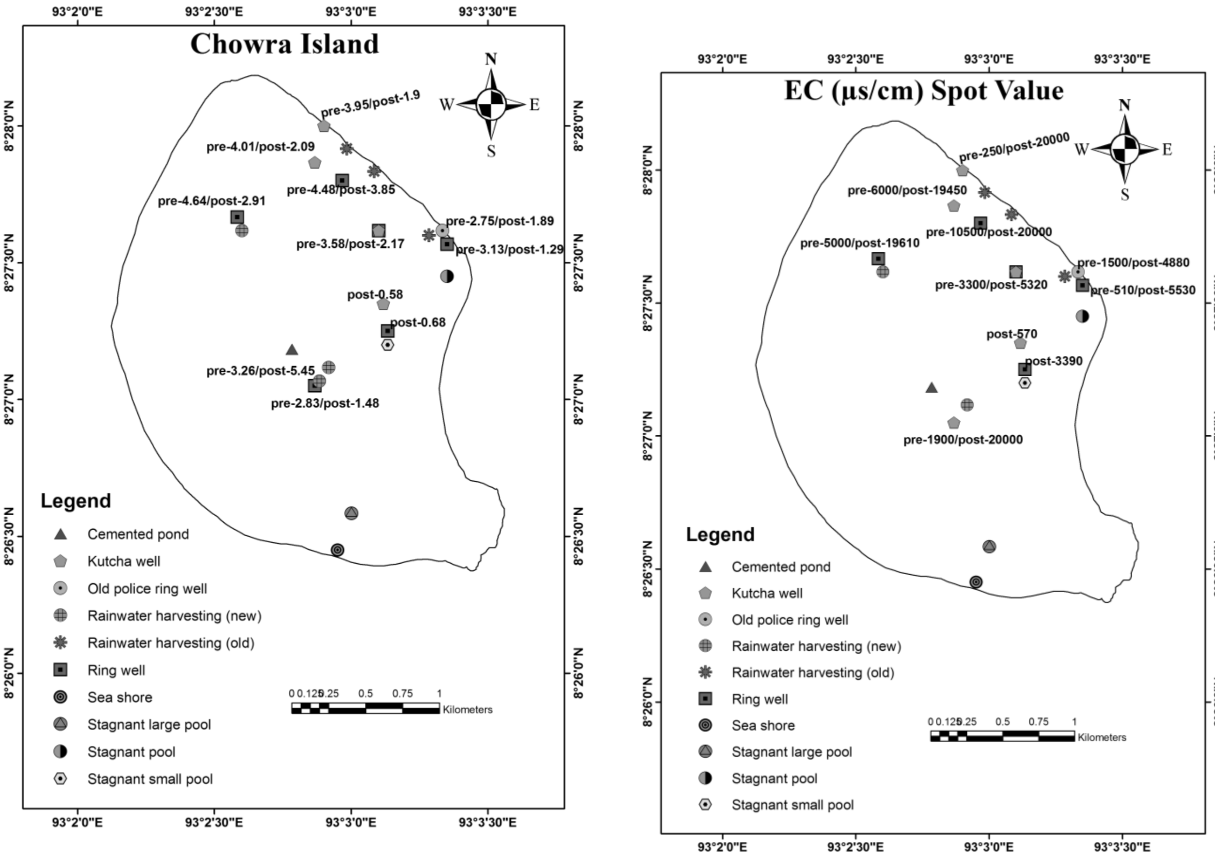


Figure 9&10 Comparative water level and salinity (EC) rise of ground water in Pre and Post Tsunami

Based upon previous experience and the current studies, the plausible root causes of up rise in salinity have been envisaged. However, to mitigate the drinking water scarcity various solution measures are proposed as follows.

To alleviate the problem, three types of solution i.e. (1) Short term (2) Medium term and (3) long term have been advocated. The measures considered under various options are enumerated below.

1. **Short term measure:** The islanders face acute drinking water shortage during lean months. It has been contemplated to make arrangement to carry fresh water from the spring near shore during the lean period, from contiguous Teresa Island.
2. **Medium term measure:** This option will cover the sustainable management of drinking water supply through various measures like enhancement of rain water harvesting arrangement and installation of Desalination plant.
3. **Long term measures:** As already mentioned that the water ecology has been amply affected after tsunami. Apart from up rise in salinity level of ground water,it is likely to impact badly to the coconut plantation and forestry in the island. In this regard besides the study on groundwater, a research study on soil and water salinity and impact on coconut plantation needs to be initiated forthwith.

CONCLUSION AND RECOMMENDATION

The tiny inhabited island of Chowra in Nicobar district of UT of Andaman and Nicobar Islands ails with perennial crisis of fresh water since time immemorial. The fresh water scarcity prevails due to various intricate causes such as complex geomorphology, recharge and discharge governed by the ocean in its all sides. After a keen study a pilot project was designed in June, 2004 before tsunami involving rainwater harvesting and artificial recharge. The project could not be implemented due to tsunami devastation. A recent study in 2016 revealed that the water salinity and also water level in the island has further increased and many saline water pools are generated. The situation is not only jeopardizing the fresh water availability, it is hitting hard to the coconut product growth and its mortality. The latter is likely to affect the livelihood of the islander. In this regard a short, medium and long term measures are advocated which needs to be implemented forthwith.

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Sector Specific Ground Water Management: A Case Study from Paschim Medinipur District, West Bengal

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ABSTRACT

Ground water management plan based on local terrain condition is a tool for sustainable development of this precious resource. The availability of ground water and its strategic management is a function of local terrain conditions and is also influenced by anthropogenic factors (land use pattern, irrigation practices etc.). Hydrogeological studies in parts of Paschim Medinipur district, West Bengal comprising six adjacent administrative blocks in two sectors reveal the contrasting ground water development and management practices for sustainable use of available resource. The western sector, comprising Medinipur Sadar, Kharagpur I and parts of Kharagpur II blocks is represented by undulating uplands of laterite covered platform sediments and marginal alluvium. A considerable area is under forest cover with average cropping intensity around 155% with inadequate irrigation coverage. A thick persistent laterite capping followed by a granular sand zone characterizes the upper quaternary aquifer in the region. Ground water occurs under phreatic condition in shallow aquifer and semi confined to confined condition in deeper aquifer and is developed by dug wells and tube wells with yield of 14-80 m^3/hr. The phreatic aquifer represents stable ground water regime. On the other hand, the eastern sector, comprising parts of Kharagpur II, Debra, Pingla and Sabong blocks is represented by flat alluvial terrain, less forest cover area, 195% cropping intensity and 75% irrigation coverage. The near surface lithology is dominantly soil and clay. The absence of shallow phreatic aquifer in the area confines ground water development from the semi confined and confined aquifer. Ground water development is accomplished by both shallow and deep tube wells with yield 118-250 m^3/hr. However, the hydrograph analysis of the piezometric level depicts both pre and post monsoon falling trend, hence, unstable ground water regime. The contrasting hydrogeomorphic environment and anthropogenic influencesin two sectors lead to adopt region specific ground water management practices. The design of effective ground water management techniques in the western sector includes large scale development of shallow phreatic aquifers by large diameter dug wells / dug cum bore wells, analysis of lineaments pattern, geo-electric, demarcation of auto flow zones, identification of paleochannel courses and lastly micro watershed development. On the contrary, in the eastern sector, apposite and judicious development of semi confined/ confined aquifer with strict adherences to ground water legislation is adjudged as most effective measures for effective curb in depletion of piezometric level.

Keyword: Ground water, development and management, western sector, eastern sector, aquifer, yield.

INTRODUCTION

Water is an indispensable resource which plays a pivotal role in almost all the facets of civilization viz., agricultural development, industrial growth, drinking and domestic uses, protection of environment and ecology etc. The state of West Bengal, is blessed with plenty of surface and sub-surface (ground) water resources. The erratic and undistributed rainfall coupled with increased demand of water in domestic, agricultural and industrial sphere has resulted in enlarged dependence on directly available ground water resources which in turn, has caused overexploitation and depletion of ground water level. Natural toxic contamination and also man made pollution of ground water has become an added quandary. Therefore, a planned and deterministic approach has to be adopted on the basis of proper scientific studies for judicious development and management of available ground water resources. The present studies emphasizes that the availability and the management of the ground water resources largely depends on the local terrain condition and is also influenced by anthropogenic factors. The present paper deals with necessitate for the contrasting development and management practices in six adjacent administrative blocks of the Paschim Medinipur district ,W.B. Sector wise anthropogenic and hydrogeomorphic influences on ground water set-up have been unearthed and based on that apposite management measures have been advocated.

In the present study Medinipur Sadar, Kharagpur I and western parts of Kharagpur II blocks are designated as *western sector* and Debra, Pingla, Sabang and the parts of Kharagpur II blocks are designated as e*astern sector* (Figure 1).

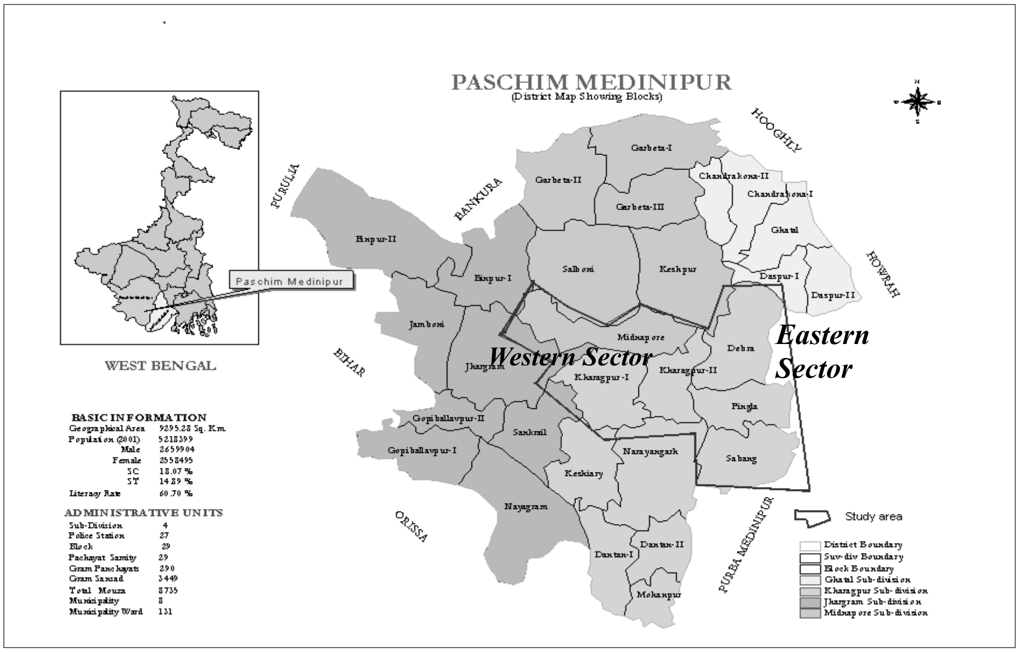


Figure 1 Study Area.

ANTHROPOGENIC INFLUENCES

2.1 Land use pattern

In Medinipur and Kharagpur I blocks 50-60% of net cropped area are under more than one crop whereas in the eastern and southern part in Kharagpur II, Debra, Sabang and Pingla block 75 to 98% of net cropped area get at least two cultivation. The forest covered land is comparably higher in Medinipur and Kharagpur I blocks

Table1 Land use pattern in two sectors block wise data (area under ha).

Sl. No.	Block	Geo Area	Net Cropped area	Area under pasture & orchard	Cultivable waste land	Forest land	Resid-ual area	Area under more than one crop
1.	Medinipur	33300	17700	950	570	5940	304	9927
2.	Kharagpur I	32600	18500	825	300	4000	4311	11327
3.	Kharagpur II	26587	20440	618	300		680	15066
4.	Debra	34231	29287	499	1308	540	207	25376
5.	Pingla	22148	18600	300	300	-	85	18377
6.	Sabang	30075	21083	372	-	-	3100	20526

It is evident from the above detail that the cropping intensity, is around 150% in Medinipur sadar and Kharagpur I whereas in the other four blocks in the eastern sector it ranges between 187-199%.

2.2 Irrigation

Since last 2-3 decades considerable thrusts have been put for development in Minor Irrigation Sectors based on both surface and as well as ground water resources. Development in Minor Irrigation sectors is principally aimed at sinking of more numbers of High Duty Tube Wells (HDTW), Medium Duty Tube Wells (MDTW), and Shallow Tube Wells (STW), use of more surface water through different water harvesting structures, excavation /re-excavation of farm ponds, installation of River Lift Irrigation (RLI) on River, Canal, *Khal*, rivulets, etc. A brief account of source of irrigation and area irrigated by different sources is given in Table 2

In Miedinipur Sadar, Kharagpur I & II blocks (western sector) ground water irrigation depends on dug wells and shallow tube wells. HDTW or MDTW are rare in these blocks. In Medinipur Sadar block >50% of the irrigated area is generated by 1860 STW. Irrigation potential of 6945 ha and 5000 ha is created so far in Medinipur Sadar and Kharagpur I blocks whereas 22110 ha in Debra, 16700 ha in Sabang and 15274 ha in Pingla block in the eastern sector has been brought under irrigation.

Table 2 Irrigation coverage

Block	Net cultivated area (ha)	Area under assured irrigation (ha)	% of irrigation
Midnapore Sadar	17700	6945	39%
Kharagpur I	18500	5000	27%
Kharagpur II	20440	14495	71%
Debra	29287	22110	75%
Pingla	18600	15275	82%
Sabang	21083	16700	79%

The cultivation of *boro* paddy which solely depends on irrigation water is more in Sabang and Debra blocks; 19330 Ha and 15470 Ha respectively are under boro cultivation. However, the boro cultivation is observed low in Medinipur Sadar and Kharagpur I block in the western sector of the study area.

3. CONTRASTING TERRAIN CONDITION: REFLECTION OF DIVERSE HYDROGEOMORPHIC ENVIRONMENT

3.1 Physiography and Landforms

The western sector constitutes the eastern most fringe of Chhotonagpur plateau with erosional remnants of small isolated hillocks (Gopgarh hillock in Medinipur block) exhibits highly dissected pediments and laterite covered platform sedimentary area forming undulating topography. The laterite terrain is underlain by older alluvium deposits. Laterite cover in Medinipur block is about 42% and in Kharagpur block is more than 80% of total geographical area. The area depicts gentle slope from west to east and north to south. The elevation decreases towards east and the undulating terrain of western sector merges to flat alluvial terrain in the eastern sector. Elevation decreases to 20 m above MSL in Debra and 10 m above MSL in Pingla and ultimately drops down to 3-4 m in further east.

3.2 Drainage

The western sector falls in Kangsabati sub basin and a few area of the eastern sector is in Kalighai-Kapaleswari subbasin. The drainage density per 2 sq km grid area varies between 0.019 to 0.21 in eastern part whereas it is reasonably high in parts of Medinipur and Kharagpur I block of western sector, >0.21 to 0.65 (Bhunia et al. 2012)

3.3 Soil profile

The soil characteristics is also of diverse nature and based on the terrain condition is broadly divided into lateritic soil and alluvial soil. In Medinipur and Kharagpur I block more than 50 % of the total geographical area is covered by lateritic soil and rest sandy soil. The eastern sector on the other hand is dominated by clay loam and clayey soil.

3.4. Surface and Subsurface Geological Dispositions

The area is characterised by diverse geological formations ranging from upper Tertiary to Recent. The unconsolidated sediments include laterite and older and newer alluvium forming the flat terrain. Number of lineaments trending NW-SE and NE-SW traverse Medinipur sadar and Kharagpur I block in the western sector. The subsurface geological disposition of the study area is represented by E_W section, (Figure 2). 10-20m thick laterite cappings occur almost persistently in Medinipur sadar and Kharagpur I block. The laterite bed pinches out towards east and the near surface zone in the eastern sector is represented by thick yellow clay. The first occurrence of significant thick gray clay bed separates two major aquifer systems in the area, Quaternary and Upper Tertiary aquifer. The Q/T boundary, in general are found at greater depth in eastern sector that the west.

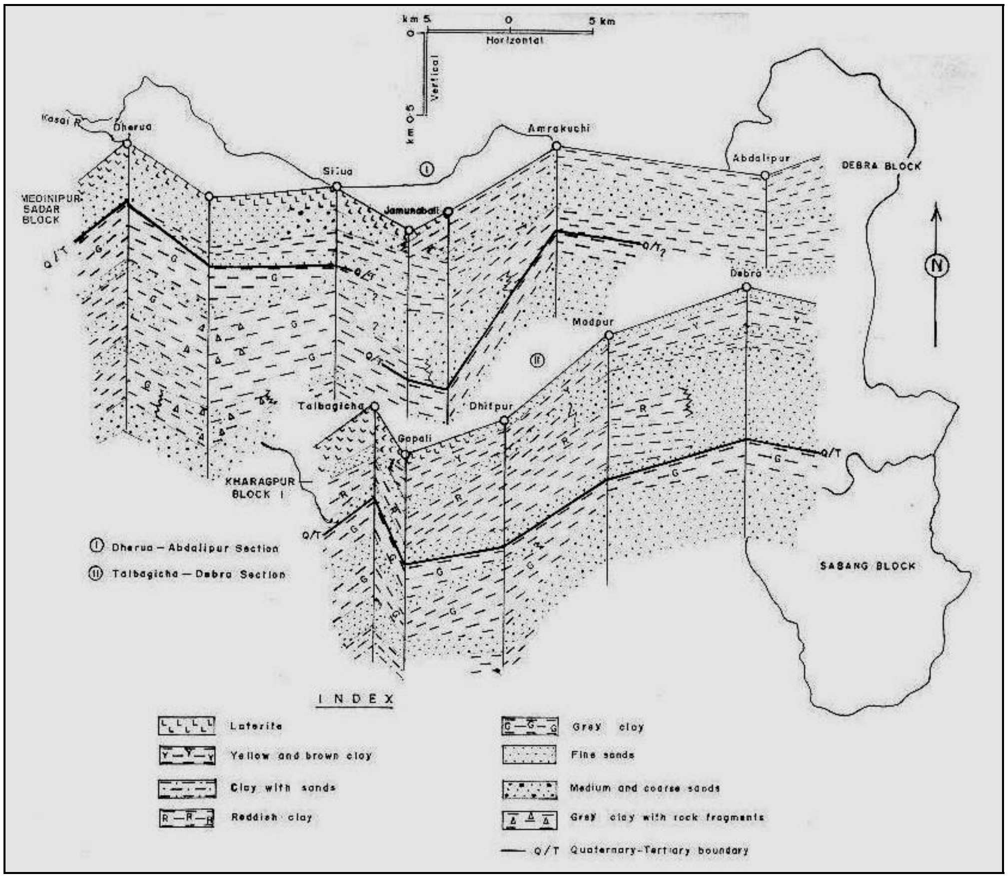
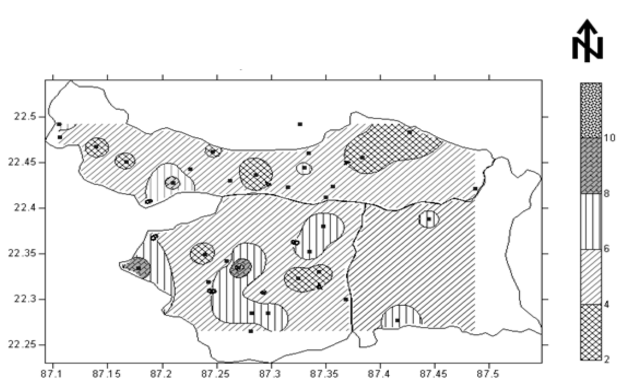


Figure 2 Subsurface Geology.

3.5 Hydrogeological Setup

Occurrences of shallow phreatic aquifer followed down by semi confined to confined aquifer characterize the western sector. The depth of water level of phreatic aquifer in premonsoon ranges between 3-11 mbgl whereas the post monsoon SWL lies at 1.2-7 mbgl (Figure 3). The fluctuation is moderate to high, maximum being recorded at



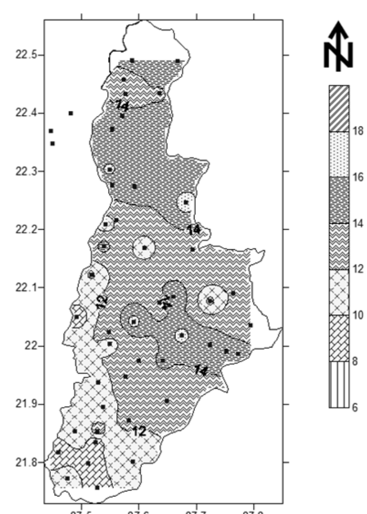


Figure 3,4 Premonsoon depth to ground water level in Western and Eastern sector.

Nimpura and Khemasuli area in Kharagpur I block to the tune of 4-4.5 m. This constitutes the recharge area. The shallow aquifers are developed by dug wells and STW at favorable locations. Long term ground water trend analysis of the phreatic aquifers in Medinipur sadar and Kharagpur I block show post monsoon rising trend of 0.35-0.9 cm /yr indicating stable ground water regime over the years. Dug wells and large diameter dug wells are used for irrigation in small command area with limited yield prospect of 5 m^3/hr. Potential shallow tube wells are found along the flood plain zone of the Kangsabati river. The MDTW and HDTW, although rare essentially tap Quaternary and Upper tertiary aquifer yield at 14-80 m^3/hr for drawdown of 3-13 m. Transmissivity ranges between 22 -530 m^2/day.

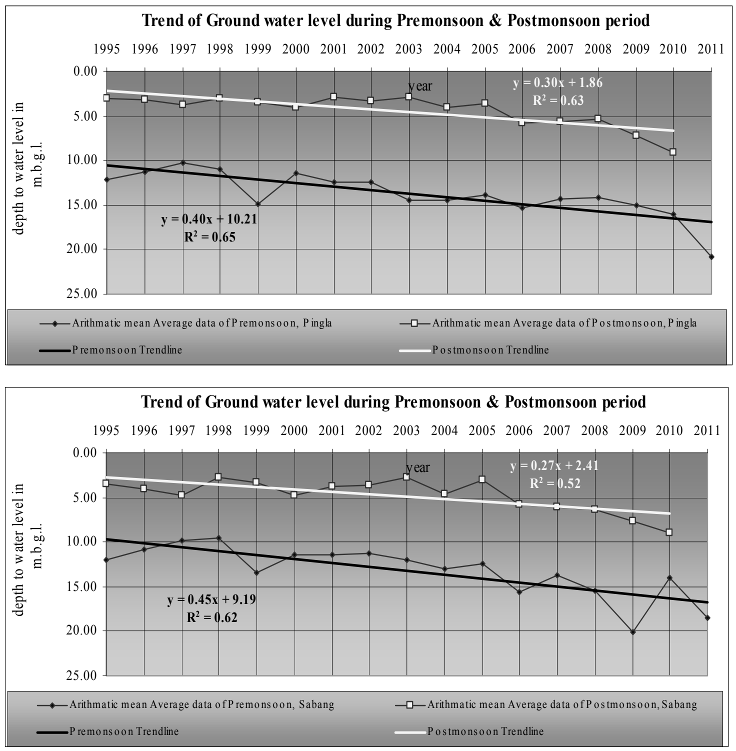


Figure 5,6 Long term water level trend of piezometric surface in Pingla and Sabang.

On the other hand, occurrences of thick blanket of sandy clay and clay overlying sand-clay cyclothem characterize subsurface geology in Debra, Pingla and Sabang block. No significant shallow phreatic aquifer is reported in the eastern sector and ground water occurs under semi confined to confined condition. The aquifers in this sector are developed by STW, MDTW, HDTW. The piezometric water level is very deep at 12-20 mbgl in premonsoon and 4-8 mbgl in post monsoon (Figure 4). Long term hydrograph analysis of piezometric level in Debra, Pingla and Sabong block reflecting both pre and postmonsoon falling trend to the tune of 40-45 /yr and 27-30 cm /yr respectively (Figure 5,6). Therefore, the semi confined and the confined aquifers in the eastern sector are under stress; draft and natural discharge exceeds the recharge. Absence of dug wells is observed with large number of irrigation shallow tube wells with moderate to high yield. Deeper aquifer within the depth range of 100-150 m tapping 30 m of cumulative thickness are found to yield at 118-250 m^3/hr. Transmissivity is high, around 400-2934 m^2/day.

4. TERRAIN SPECIFIC GROUND WATER MANAGEMENT

The ground water management is the efficient and judicious utilization of the available resource. The management of ground water resource requires a comprehensive evaluation of ground waters as well as surface water condition in relation to regional /local perspective. The critical review of anthropogenic signatures and existing geomorphological, geological and hydrogeological setup demands sector specific contrasting strategies of ground water development and management in west to east in the study area.

4.1 Management in Western Sector

A close review of the irrigation potential created by ground water and surface water resources (3rd MI and 4th MI census, 2001 & 2011) clearly brings out limited development of surface irrigation network in the entire study area. In the western sector, where, the scope for ground water development is limited, surface water management through micro watershed development should be encouraged. Construction of check dam, nallah bunds across small perennial streams and percolation tanks/rain water harvesting tanks in favorable catchment area may be useful to conserve as well as to recharge ground water. The water supply in Medinipur and Kharagpur town is very much dependent on the sub terrain flow in the Kasai river and are extracted by series of river bed tube wells. Assessment of seasonal base flow helps in predicting scope of for further development of sub terrain flow for water supply solutions.

Analysis of number of N-S, NW-SE and NE-SW lineaments in Medinipur sadar and Kharagpur I block and field verification guides to *pin* point the ground water worthy sites. The E-W trending lineaments are not favorable for ground water localisation (Chakraborty, Nag, 2009). However, N-S, NW-SE and NE-SW lineaments singly or intersecting are more or less characterized by presence of shallow (3-5 mbgl) depth to water level in premonsoon time. The VES survey in this area is very much useful to determine the cost effective potential sites.

Based on the available resource for future irrigation approximately 1770 dug wells /dug cum bore wells, 5200 STW, 381 dug wells and 1040 STW are recommended in Medinipur and Kharagpur I block respectively. These large diameters dug wells may be constructed in the topographic low and in the valley area.

In micro water shed development the 'Auto Flow' wells may play facilitator role to increase local irrigation potential. A number of free flowing tube wells/auto flow wells are found in topographic lower area in Kasai river valley. The wells are located in north of Kasai river in Medinipur Sadar block. The auto flow condition was observed in the tube wells and hand pumps at Bailasole, Astara, Illaboni, Jadavpur (Illaboni), Bhatpara villages. The depth of the wells varies from 60-120 m bgl with discharge 2 m^3/hr to 7.20 m^3/hr. The free flowing wells are essentially tapping the Tertiary aquifer the depth of which varies from place to place. The tertiary aquifer is in confined condition and is overlain by thick grey clay beds. An auto flow zone of about 28 sq.km is demarcated in north of Kasai river along Gurguripal-Dherua stretch. It is also observed that all the auto flow wells at Bailasole, Choiphur, Illaboni, Bhatpara etc., are found to occur in NW-SE alignment, which is almost parallel to the reported lineament (NW-SE) in this area (Figure 7).

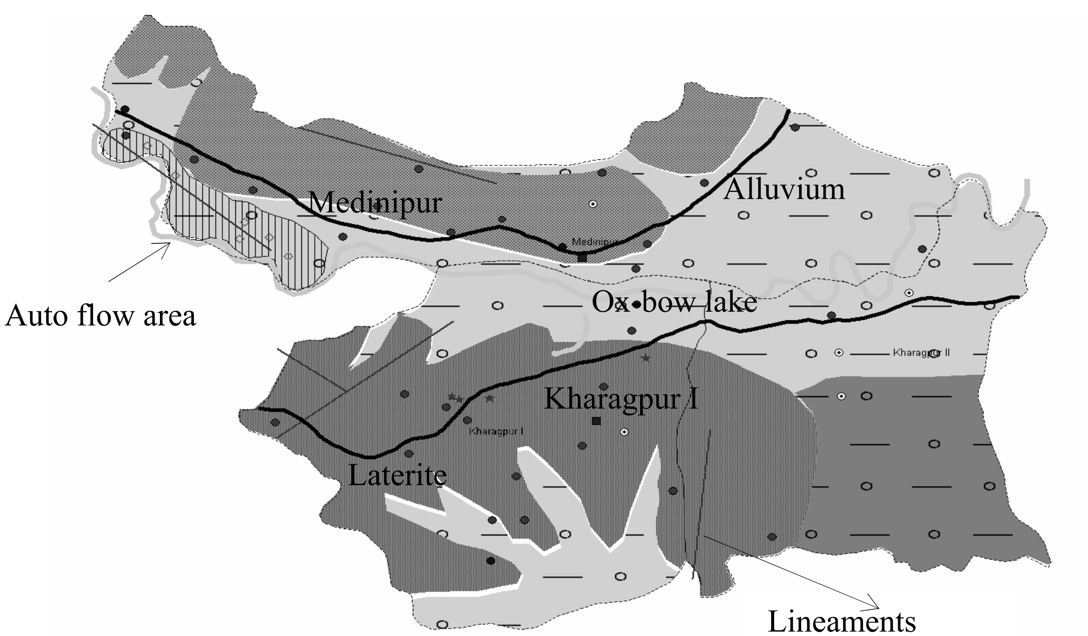


Figure 7 Ground Water Management Options in Western Sector

Identification of abandoned channel courses or Paleochannel across Borgai- Barkhola village in Kharagpur I block influences the local ground water development. An ox bow lake/cut off channel is found along the boundary of these villages. Barkhola village, lying north of water body is blessed with highly potential shallower aquifer within 10-15 m bgl. Both dug as well as the shallow tube wells (10-12 m depth) are highly productive, yielding at > 20 lps. The static water level rests within 3-4 m bgl. On the other or southern side of the oxbow lake, in Borgai village shallow tube wells work beyond 25 m depth. The discharge is around 10 lps i.e., less as compared to Barkhola village. The SWL lies at 6 m bgl. In and around Borgai village and further south, close to NH – 6, shallow tube wells do not work in summer. Therefore, across the paleochannel, even within a limited spatial stretch the water management options may differ based on local condition.

4.2 Management in Eastern Sector

In general, the eastern sector represented by flat alluvial terrain with huge thickness of alluvium is a good repository of ground water. Surface irrigation may not be effective solutions in this area due to occurrences of thick near surface clay. This may lead to water logging in the shallow zone causing adverse affect to the crops. On the other hand, ground water irrigation is highly developed in the area. Both pre and post monsoon falling trend of long term water level has been recorded in Debra, Pingla and Sabang block indicating the ground water development has started exceeding the recharge. The extraction from the particular stressed (60-120 mbgl) aquifer should be regulated to avoid further decline of piezometric level. The strict implementation of “West Bengal Ground Water Resource and Development Act, 2005” to restrict indiscriminate sinking and registration of the wells may be followed in the area. The safe distance criteria, to avoid mutual interference of pumping among the tube wells should be adhered to. Artificial recharge to ground water by existing or abandoned wells or by recharge shafts/tube wells to that particular depleted aquifer may help to raise water table to some extent. The programme of aquifer mapping to locate alternate potential aquifer and development of suitable management plan for each individual aquifer systems may be effective management options for eastern sector.

CONCLUSIONS

The landform and the terrain condition are the signatures of the hydrogeological set up in the area which in turn depending on the nature of anthropogenic influences governs the availability of both surface and ground water resources. The development and management should be sector or terrain specific and planned in a systematic manner depending on the particular watershed and region. The present study reveals a wide variation of hydro geomorphic and hydro geological set up of Medinipur, Kharagpur I block in the west and Debra, Pingla and Sabong block in the east. Sector specific constraint like depletion of ground water level and advantages like occurrences of auto flow zones or paleochannel etc should be mapped to devise sector specific comprehensive management plan of ground water resource for sustainable development.

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Increasing Water Productivity, Yield, Income and Employment Generation for Small Farmers through Adoption of Integrated Farming

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ABSTRACT

An Integrated Farming Systems Model (IFS) of "Crops + Goat + fruits and vegetables + Poultry + Rabbit + Boundary plantation + Compostwas studiedon 1 ha area at Akola, during 2012-13 to 2014-15, in irrigated situation for Western Vidarbha region with average annual rainfall of 847 mm. The model was tested against the conventional cropping systems. Among five cropping systems of Cotton + pigeon pea – summer sesame; soybean + pigeon pea; sorghum-wheat; soybean – chickpea and cow pea – fenugreek were grown on 0.65 ha for grain purpose,custard apple on 0.25 ha and other components on 0.05 ha area tried,the average gross and net returns of ₹162748 and 86354 were realized from all the components of one ha IFS model. The highest gross profit of ₹733053 and average net profit of ₹40180 was received from goat component. This was followed by the receipts from the crop component (GMR and NMR of ₹ 54510 and ₹ 31531 respectively). The comparison showed that the farmer can get higher returns by adoption of integrated farming systems over cropping systems. In addition to this the, man-days also increased to 270 than in cropping systems (112). The data of soil analysis indicated that, there was decrease in pH and electrical conductivity, increase in organic carbon content and available nitrogen, phosphorus and potassium content. This indicated that the recycling organic waste of crop and animal in the model resulted in improvement in the chemical properties of soils.

Keywords: Integrated farming systems, cropping systems, goat, back yard poultry, rabbit, compost, recyclingand boundary plantation.

INTRODUCTION

The Indian sub-continent has already crossed the human population of 1.21 billion. It is 11.3 and 2.7 million in Maharashtra and Vidarbha respectively. The bulging population has created tremendous pressure on all natural resources. In India, per capita annual water availability of 5177m^3 in the year 1951 has reduced to 1340 m^3 in 2015. It is expected to shrink the water availability further to 1140 m^3 during 2050. In India, 86% of total available water is used for agriculture, 6% for domestic and 8% for industrial use. More than 70 per cent area in rain fed farming has less than 100% cropping intensity, which has direct co-relation with agriculture production, productivity and income. The Irrigated area in Maharashtra is 13 and that of Vidarbha region is only 11 percent which is quit less than national average of 30%. The percentage of small farm holders up to 2 ha is more than 85. Due to non-availability of assured irrigation, the resource poor small farmers can grow only one crop during monsoon season and to some extent one more during winter or *rabi*season on residual moisture or under protective irrigation.

An Integrated farming system (IFS) is growing of grain crops, fruit and vegetable crops along with agriculture based supplementary and complementary enterprises like goat keeping, poultry, rabbit, fishery (if farmer has pond in the field), compost or manure preparation through the recycling of organic waste. The IFS can be more remunerative than growing grain crops alone. Surve *et al* (2015)reported that both on-station and on-farm integrated farming systems (IFS) models at Rahuri, Maharashtra were found more remunerative than cropping systems in terms of net returns (₹ 199848) water productivity (₹991/ha-cm) and employment generation (1275man-days per ha per year).Cropping systems equivalent yield (SEY), land equivalent ratio (LER), total production, monetary gains and water productivity can be higher inIFS than intercropping and crop rotations of crop component alone.Shekinath and Sankaran (2007) also reported increase in productivity, profitability and employment generation in IFS over cropping systems in the rain fed vertisols of western zone of Tamil Nadu. Similar results were also reported by Korikanthimathand Manjunath (2009) and Ramrao et al (2005).

MATERIAL AND METHODS

A field experiment was conducted to develop region specific Integrated Farming Systems (IFS) Model of "Grain Crops + Goat + Fruits and Vegetable + poultry + Rabbit + Compost + Boundary plantation" on one hectare area in irrigated situation at Dr. Panjabrao Deshmukh Krishi Vidyapeeth at Akola, during the year 2012-13 to 2014-15. The assured rainfall region of western Vidarbhazoneis included in the 9th agro-climatic zone of Western plateau and hills. The objective of testing the model was to enhance system productivity, profitability, to assess efficiency in terms of economics and resource use to optimize the individual component in regional perspective. The existing farming systems adopted by the local farmers is mainly soybean, red gram, green and black gram, sorghum or cotton based intercropping either sequenced with wheat, gram, safflower that are grown on residual moisture or in protective irrigation in winter. The small and marginal farmers are found to rare the goat, back yard poultry and cow as livestock along with some local dry land fruit crops grown on field bunds.

The soil of the site of experiment was *vertisol* with initial values of pH 7.82, Electrical conductivity of 0.31 dsm^{-1}and organic carbon content of 4.62 gkg^{-1}. The available nitrogen, phosphorus and potassium contents in the soil at the start of the experiment were 166.8, 12.7 and 252.1 kg ha^{-1}. The actual rainfall received during the years of experimentation was 721, 961 and 691 mm during 2012-13, 2013-14 and 2014-15 respectively. Total rainfall during 2012-13 (22-13 MW i.e. meteorological week) was 721 mm within 54 rainy days which was deficit by 126.3 mm as against the average rainfall of 847.3 mm per annum. Actual rainfall received in the year 2013-14 was 961.3 mm (22-11 MW) in 53 rainy days. This year rainfall was surplus by 114 mm as against the average rainfall. Total rainfall of 2014-15 (22-13 MW) was 691.3 mm received within 39 rainy days. This year the rainfall was deficit by 82.7 mm over the average rainfall. The experimental site is at 300 meters from mean sea level.

Table 1 Information (package of practices) of crops, variety, spacing, RDF, sowing and harvesting dates.

Sr. No	Treatment	Variety	Spacing (cm)	NPK (kg ha^{-1})	Sowing Date	Harvesting / Picking Date
1	Soybean + Pigeonpea (5:1)	TAMS 38	45 X 5	30:75:00	2.7.2012	16.10.12 (S)
		PKV Tara	45X30			26.12.12 (P)
2	Cotton + Pigeonpea (6:2)-Sesame	AKH 8828	60 X 30	50:25:00	2.7.2012	2.11.12 (i) 5.11.12 (ii) 1.1.13 (iii)
		PKV Tara	60 X 15			27.12.12 (P)
		AKT 101	30 x 5	25:25:00	2.2.2013	31.5.13
3	Sorghum – Wheat	CSH 14	45 X 15	80:40:40	2.7.2012	8.10.12 (S)
		AKW-3722	22.5	120:60:60	3.11.2012	(W) 18.2.13
4	Soybean – Chickpea	TAMS 38	45 X 5	30:75:00	2.7.2012 (S)	(S) 16.10.12
		Jaki 9218	45 X 5	25:50:00	21.11.12 (C)	(C) 22.2.13
5	Custard apple + Black gram – Safflower	Balanagar grafts	5 m X 5 m	30 kg FYM + 150 g N+ 75g P+ 75g K /plant	22.9.10 (C) Gap filling 3.7.11	
		TAU – 1	45 X 5	20:40:00	(Bg) 2.7.12	(BG) 26.9.12
		AKS-207	45 x 20	40:40:00	(Sf) 18.10.12	(Sf) 23.2.13
6	Cowpea - Fenugreek (Vegetable)	PusaKomal	45 X 30	25:50:00	(C) 2.7.2012	28.9.12 (i) 29.9.12 (ii)
		Local	20	50:00:00	(F) 5.11.12 21.7.12	(F) 22.2.13

Seventy per cent of 1 ha area was allotted to grain crops, 25% to custard apple and remaining 5% to animal component, kitchen garden and compost/manure pit. Five cropping systems of grain and vegetable crops in varied row ratios of intercropping and seasonal sequence cropping were studied. Balanagar grafts of custard apple were planted at 5x5m^2 *spacing.* Black gram in *Kharif* and safflower in *Rabi* season were sown as intercrops during initial two years in the custard apple in order to harness the solar radiation in to grain yield. *Gliricidia* seedlings for fodder and green leaf manure and *Carissakaronda* as live fencing were planted on all around the four sides of model as boundary plantation.Goat component was started with twelve*Usmanabadi* adult goats (10 females plus 2 males). The goats were partially stall fed and grazed within 1 ha IFS model on the crop waste, residue and with recommended amount of dry and fresh fodder (leaves and twigs of G*liricidia*). Excess goats produced in the model were disposed periodically by open auction maintaining 10+2 number. The animals were periodically vaccinated and dewormed. The back yard poultry was introduced with 10 birds each of *Giriraj, Vanraj* and *Kadaknath* local breeds. De-beaking of poultry was done in order to avoid injuries to the birds. The poultry birds were fed with vegetable and crop waste and lower grade grains produced in the model. A small unit of rabbit was initiated with a pair of White Giant breed for sale as aesthetic purpose. Rabbit were fed with kitchen garden vegetable waste. The daily dropping, litter and urine from goat, poultry and rabbit were decomposed in to valuable compost which was used as organic manure for the crops grown in the model. The recommended package of cultivation for different crops is given in table 1.

Table 2 Monetary Returns of IFS model (Average of 2012-13, 13-14 and 2014-15)

S.N	Components	2012-13		2013-14		2014-15		Average of 3 years	
		GMR	NMR	GMR	NMR	GMR	NMR	GMR	NMR
1	Soybean + Pigeonpea	16910	11894	9866	5066	4200	3012	10325	6657
2	Cotton + Pigeonpea –Sesame	13871	8046	22842	14206	11253	7681	15989	9978
3	Sorghum - Wheat	14073	6815	9679	3017	6364	3917	10039	4583
4	Soybean –Chickpea	19808	12465	13548	5842	5849	4289	13068	7532
5	Cowpea – Fenugreek	4596	1855	6700	3844	3970	2645	5089	2781
Total of grain crops		69258	41075	62635	31975	31636	21544	**54510**	**31531**
6	Custard apple	8096	1678	3974	1474	4235	2897	5435	2016
7	Goat unit	56,200	20108	101460	59560	61500	40873	**73053**	**40180**
8	Kitchen garden	1900	1400	3066	2066	1121	632	2029	1366
9	Backyard poultry	505	312	16131	6092	16046	10573	10894	5659
10	Rabbit	--	--	2900	1011	7800	5246	5350	3129
11	Compost	14000	1000	12000	1000	8432	5420	11477	2473
	Total	**149959**	**89785**	**202166**	**103178**	**130770**	**87183**	**162748**	**86354**

Table 3 Comparison between cropping systems and Integrated Farming Systems

Particulars	GMR		Average	Man days		Average
	2012-13	2013-14		2012-13	2013-14	
A) Cropping systems	85918	74010	79964	102	122	112
B) Integrated Farming System	149959	202166	176062	195	345	270
Increase in GMRand man-days due to adoption of IFS	74.5%	173%	120%	93	223	158

CONCLUSION

It is concluded that, the yield and income of small farmer can be sustained by adoption of integrated farming systems model of one ha area in western Vidarbha region. The IFS model can generate consistent employment for rural youth through integrating grainscrops with fruit and vegetable and animal components like goat, poultry and rabbit. Regular recycling crops and animal waste and its reuse as valuable plant nutrient source can help in its safe disposal and for improvement of soil fertility.

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The Assesment of Sedimentation of Nagarjunsagar using Spaceborne Chronosequential Images

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ABSTRACT

Loss of the storage capacity of multi-purpose reservoir due to sedimentation is a major concern in optimization of reservoir operations. The analysis of sedimentation data of Indian reservoirs show that the annual siltation rate has been generally 1.5 to 3.0 times more than the designed rate and the reservoirs are generally losing the storage capacity at the rate 0.30 to 0.92 % annually. Large reservoirs are constructed with the assumption of certain level of siltation based on rainfall, inflow and outflow and terrain conditions in the catchment. Timely and reliable information on the quantum of sediment and its deposition pattern in various zones of a reservoir is very essential to ascertain the current live storage capacity of the reservoir for efficient and productive management of water resources. A case study on sedimentation in the Nagarjunsagar reservoir of Telangana state, southern India using chrono-sequential space borne multispectral digital data is presented herewith. Thresholding and various water indices like Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), etc. were used for delineation and monitoring of water spread in the reservoir. The regression analysis was subsequently carried out to study the relationship between water spread and storage capacity of the reservoir. The results indicate a decreasing trend in water spread with the passage of time indicating thereby a significant loss in the water storage capacity of the reservoir.

Keywords: Storage capacity, sedimentation, NDWI.

INTRODUCTION

Reservoirs, created by dams on rivers, lose their storage capacity due to sedimentation. A large proportion of the silt transported in the rivers eventually gets deposited at different levels of a reservoir and causes reduction not only in dead storage but also in live storage capacities. The consequence of loss in storage due to sediment accumulation precludes the intended long-term usages of reservoir such as irrigation, hydro-power generation, water supply, flood control, recreation, etc. and may even cause operational problems. Periodic capacity survey of reservoir is, therefore, essential to ascertain the rate of sedimentation and reduction in storage capacity for efficient and productive management of water resources. The conventional technique such as hydrographic survey and inflow-outflow approaches, for the estimation of capacity of a reservoir are cumbersome, labour-intensive, time-consuming and expensive.

There are broadly two methods for measurement of sedimentation in reservoirs, namely (i) stream flow analysis, and (ii) capacity survey. *Stream flow analysis* is a continuous observation process consisting of measurement of inflows and outflows with sediment sampling. In this method, the sediment inflow into the reservoir including estimated bed load and the outflow there from is measured at all significant points of entry and exit. The difference gives the quantity of deposit during the period of analysis. The analysis consists of two main parts (1) measurement of water inflows and outflows and (2) simultaneous measurement of sediment concentration.

The methods commonly used for *capacity survey* include traditional method, bathymetric method and the use of geospatial technology. The conventional method of conducting sedimentation surveys in the reservoirs involves the use of conventional equipments e.g. theodolite, plane table, sextant, range finders, sounding rods, echo-sounder and slow moving boat etc. The depths of the reservoirs are recorded with the help of echo. With the help of data collected from the site by the above surveys the volume of silt deposited in the reservoir is calculated between the two successive surveys. In bathymetric survey a boat equipped with the bathymetric equipment, the GPS system mounted on board and a lap-top computer is used for bathymetric survey while its reference station is positioned in a known geographical benchmark. The data collected is then processed and analysed using specially developed software to obtain the results in various forms e.g. point plots contour and three dimensional maps of reservoirs bed, area capacity elevation tables and cross-sections of reservoir. Remote sensing approach for reservoir sedimentation surveys are essentially based on mapping of water-spread area at the time of satellite overpass.

Multi-date satellite data is needed which covers the operating level of reservoirs at close interval. Water spread area is the water level contour at that level. Using different contours, capacity between them is calculated. With the sedimentation, the water spread area of the reservoir reduces at different levels. The water spread area and the elevation information is used to calculate the volume of water stored between different levels. These capacity values are then compared with the previously calculated capacity values to find out the change in capacity between different levels.

Spaceborne multispectral measurements by virtue of providing synoptic coverage at regular interval offer immense potential in assessment and management of water resources (Jain et al.,2002). Chronosequential spaceborne multispectral measurements provide information on elevation contours, in the form of water-spread area, at different water levels of a reservoir. For quantification of the capacity of a reservoir, the water-spread area at different water levels of the reservoir is estimated (Morris and Fan 1998, Peng 2006). Water-spread area, thus derived from multispectral measurements, is used as an input in a simple volume estimation formula to estimate the capacity of a reservoir. Several researchers : Vibulsresth (1988) for Ubolratana reservoir in Thailand, Peng (2006) for the Fegman Reservoir in Chinathe, Manavalan (1990), Goel et al. (2002) and Jain et al. (2002) for Malaprabha reservoir, Bargi reservoir and Bhakra Reservoir, India, respectively have reported the utility of per-pixel classifier for estimating the capacity of a reservoir. Jeyakanthan and Sanjeevi (2013) used a sub-pixel or linear mixture model (LMM) approach has been chosen for classifying the boundary pixels of water-spread area from different water levels of Nagarjuna Sagar reservoir located in Andhra Pradesh state of India. In the above mentioned approach *in situ* water level measurements are used to estimate the capacity of a reservoir. Abileah1 and Vignudelli (2011) used a standalone approach wherein optical sensor data from Landsat was used to estimate the water spread of a reservoir and water levels derived from spaceborne radar altimeter data for assessing the capacity of a reservoir.

TEST SITE

Nagarjuna Sagar dam has been built across the Krishna river at Nagarjuna Sagar where the river is forming boundary between Nalgonda district in Telangana and Guntur district in Andhra Pradesh, southern India. The construction duration of the dam was between the years of 1955 and 1967. The dam created a water reservoir whose gross storage capacity is 11.472 billion cubic metres (405.1×10^9 cu ft). The dam is 150m tall from its deepest foundation and 1.6 km long. The dam provides irrigation water to the Prakasam, Guntur, Krishna, Khammam, West Godavari and Nalgonda districts along with hydro electricity generation. Nagarjuna Sagar dam is designed and constructed to utilise up to the last drop of water impounded in its reservoir of 405 TMC gross storage capacity. This region experiences hot and dry summer throughout the year except during the South-west monsoon season. The monsoon season is from June to September and retreating monsoon or the post monsoon season is during October to November. The mean annual rainfall in the district is 772 mm. An estimated 71% of the annual rainfall is received during southwest monsoon. The mean daily maximum temperature is about 40^o C and the mean daily minimum is about 28^o C. The soils in and around the study reservoir mainly comprise loamy sands, sandy loams and sandy clay loams.

DATABASE

For estimation of water-spread areas multi-temporal Landsat-TM and Resourcesat -2A AWiFS data covering the Nagarjuna sagar reservoir and its environ were uitlized (Table-1). The reservoir water level data and the hydrographic survey details required for capacity estimation were collected from the Nagarjuna sagar reservoir authority responsible for the maintenance and operation of the reservoir.

Table 1 Details of satellite data used

Sl.No	Name of the sensor	Date of satellite overpass	Reservoir elevation (foot)
1.	Landsat-TM	24-05-2013	519.4
2.	Resourcesat-2 AWiFS	26-02-2013	510.8
		05-10-2012	529.8

APPROACH

Estimation of Waterspread area

The approach involves estimation of water-spread areas at different water levels in reservoir, and capacity estimation. The estimation of water-spread areas encompasses co-registration of chronosequential images, resampling the resultant images to a common pixel dimension, radiometric normalization and image classification. The image co-registration was performed using image-to-image registration tool available in geometric correction module of ERDAS/IMAGINE version2015 system. Changes in illumination and atmospheric conditions were accounted for during radiometric normalization using dark pixel or pseudo-invariant features. The per-pixel Gaussian maximum likelihood classification was then carried out to classify water bodies and to estimate the water-spread area of the reservoir. The steps involved in classification include (i) identification and decisions relating to the set of classes/cover types into which the image is to be segmented, (ii) choice of the representative pixels for each of the desired set of classes (i.e., construct the training data), (iii) estimation of the parameters (eg. class signatures) of the classification algorithm from the training data, (iv) use of the classifier to label (or 'classify') every pixel in the image into one of the desired/predetermined cover types, (v) preparation of thematic maps which contain the results of the classification, and (vi) determination of the accuracy of the classification by comparing the output to ground truth data.

Capacity Estimation

This step involves computation of volume between two consecutive reservoir water levels, using the prismoidal formula, (the Simpson formula) and the trapezoidal formulae (Patra 2001), estimation of storage capacity of the reservoir based water volume between consecutive water levels . Of these, the trapezoidal formula has been most widely used for computation of volume (Goel and Jain 1996, Rathore 2006). The water-spread area estimated using supervised classification approach was used as an input in the volume estimation formula to find out the, volume at different water levels of the reservoir. In this study the volume between two consecutive reservoir water levels was computed using the following trapezoidal formula:

$$V = H/3\ (A_1 + A_2 + \_A_1*A_2) \qquad \text{........(1)}$$

where V is the volume between two consecutive water levels. A_1 and A_2 are the water-spread area at the reservoir water level 1 and 2 respectively and H is the difference between these two water levels.

The volume, thus computed, between different water levels (i.e from Minimum Draw Down Level to Full Reservoir Level) was added up to compute the cumulative or storage capacity of the reservoir.

RESULTS AND DISCUSSION

The reservoir capacity was estimated by deriving water spread area from Landsat-TM and Resourcesat-2 AWiFS data. Water spread area of the reservoir as on October 05, 2012 was estimated at 223979394 sq.km^2 whereas the value for February 26, 2013 was 211435394 sq.km^2. Water spread area during October, 2012, February, 2013 and May2013 as delineated from digital satellite data is appended as Fig.1.Using trapezoidal formula (Eq.1) volume of water during this period was estimated. A value of 138.37 TMC was arrived at.

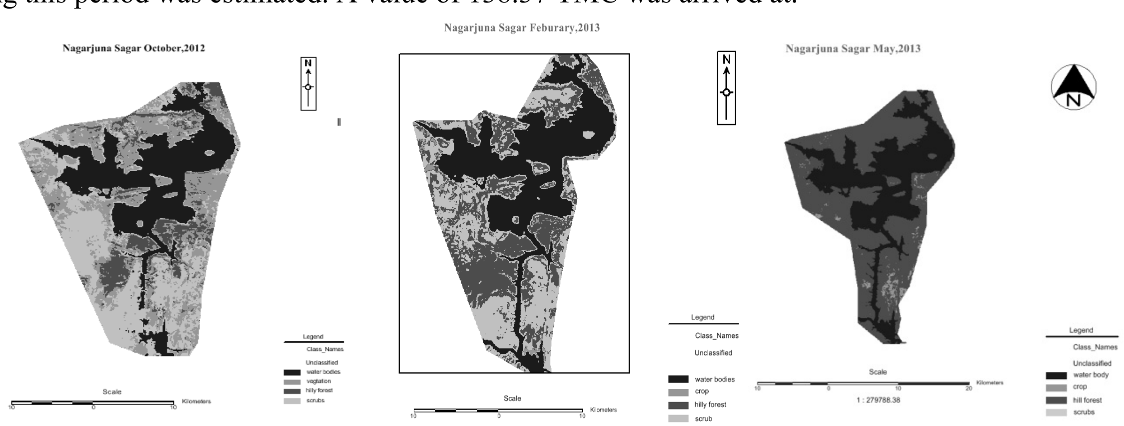

Figure 1 Satellite derived water spread area for October 2012, February 2013 and May 2013.

The reservoir level information for computing the water volume was taken from cadarsms.cgg.gov.in.

CONCLUSIONS

The study clearly demonstrated the potential of spaceborne multispectral data in estimation of water volume in the reservoir between two periods. Further study is intended to utilize closely - spaced time-period data for estimation of reservoir's capacity.

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Enhancing of Water Availability for Irrigation through Recharging Wells with Recharge Technique in Watershed Area

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ABSTRACT

The paper presents in detail about a case study of water harvesting structures and their impact on water availably and their utilisation for rainfed crops through recharging wells with recharge technique in water shed area methods of irrigations. Notable finding is that water harvesting systems prevented farmers from deepening of their wells thus saving investments in artificial recharge is the process of spreading or impounding water on the land to increase the infiltration through the soil and percolation to the aquifer or of injecting water by wells directly into the aquifer.

Keywords: Water harvesting, Recharge, Wells, Watershed, Artificial recharge aquifer.

INTRODUCTION

In initial PRA and baseline survey, it was observed that groundwater level was go on declining season by season and some of the open and bore wells were defunct. Even crops under irrigation get affected by this scenario. In initial period of monsoon season, after sowing operation, if any dry spell occurred, crops got suffered from moisture stress even under open wells because it required some time to recharge naturally mean time the crops got affected. In the cluster of villages, some of the bore wells which have either gone dry or whose water levels have declined considerably. These could be recharged directly with surface run-off. Rainwater that was collected from surrounding area was diverted by approach channel to a settlement or silt trap, from which it was diverted by conduit into the open well. Under these circumstances, it was proposed to recharge the open well and bore well with runoff water yielding nearby water ways or surrounding catchment area. This initiative served immediate need of water requirement of crops as well as improving ground water levels.

An alternative simplified and economic design was made to recharge wells with rainwater. In areas where considerable de-saturation of aquifer have already taken place due to over-exploitation of groundwater resources resulting in the drying up of dug wells and lowering of piezometric heads in open/bore wells. It is important to increase awareness at the field level on the usefulness of open and bore well-recharge structures even though they are constructed at the cost of productive land.

Methodology

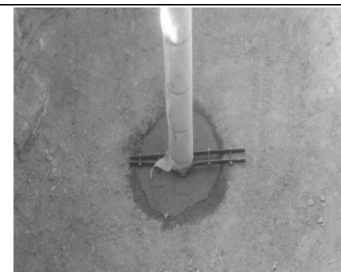
The study was carried out in five farmers' fields, located in the lands at KVK-Watershed area lies in between Longitude 78º 40' 44" to 78º 42' 28" and latitude 17º 04' 54" to 17º 07' 08" and its covered with geographical area of 520 sq.km of Gadda Malliah Guda Village, Yacharam Mandal of Rangareddy district. The soil and water conservation structures in the village silted up and some of the structures are damaged. After discussion with the farmers it was proposed to enhance the storage capacity by de-silting the structures strengthening the structures were proposed in the KVK-Watershed activities for the year 2015. With the provision, it is express to increase the groundwater level in wells located surrounding areas and increase the availability of drinking water for livestock. The designed watershed area is surrounded open wells and bore wells of which some of them are defunct. CRIDA watershed team two locations were identified in Phase-I for developing Soil and Water Conservation activities as mentioned below, after the renovated of the structures all the wells would get recharged and cropping intensity. Could be enhanced 50 to 60 farmers may get benefited from this interventions.

Artificial Recharge Techniques and Designs of wells

A Wide spectrum of techniques is in vogue to recharge rain water. Similar to the variations in hydrogeological framework, the artificial recharge techniques too vary widely.

1. Artificial Bore Well Recharge Technique





Design and operational procedure for open well:	
Procedure Dig upto 3m depth, width and height. The pit is cleared. A clamp is fixed tightly to the casing pipe at bottom. Holes of size 4-6 mm are made on the pipe. Holes are covered with a nylon mesh. The pit is now ready to be filled with stones. Bottom 30 cms is filled with 15-20 cm sized stones. Further 15 cms is filled with 7.5 cm sized stones. Next 15cms is filled with 2-4 cms gravel. A Strong nylon net is spread over the gravel. Nylon net allows silt free water to enter. 60 cms is filled with sand over the nylon net. A protection wall of 30 cms is built Pit protection wall with inlets on the upstream side .	• Low cost • Simple Technique • More recharge in shorter time • Local Material • Improve the water quality • Silt and bacteria free • Quick Recharge • Improvement in Water Levels • Evaporation loss in Minimized

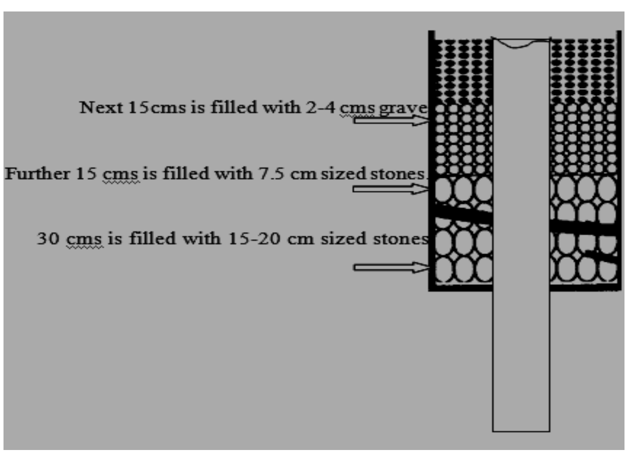


Figure 1 Design and operational procedure for open well

2. Artificial Dug Well Recharge Technique

Design and operational procedure for dug well:

1. Selection of dug wells in such a way that, the catchment area should be agricultural land which yields lesser siltaion. In other hand, if the catchment is a barren land that results more silt in the runoff water so the designed silt trap may not be work efficiently.
2. Wells with higher yields before getting dried up due to the de-saturation of aquifers should be selected for recharge as they prove to be more suitable for ground water recharge when compared to low yielding wells.

3. Wells with larger diameter are more suitable than smaller ones as the designed system has problem with silt
4. The approach channel to the silt trap should be enough capacity to accommodate the runoff from catchment area or a water way.
5. RR stone pitching should be provided to sides of silt trap.
6. RR stone pack should be provided at conduit inlet
7. Silt trap should be de-silted after every runoff event occurred. As the silt trap designed for one runoff event.
8. Most of the wells are unlined so that PVC conduit one end should be enough length to carry the runoff water in to well without causing erosion of walls of the dug well.
9. Periodical de-silting of well should be carried out as the silt trap could not be trap the suspended silt.

Table 1 Cost estimation for dug well recharge with rainwater (runoff)

S.No.	Particulars	Length	Width	Depth	Volume (m3)
1	Earth work excavation by JCB Machine means in construction of water ways	3 m	3 m	3m	27
2	Total volume of work by JCB	Excavation duration 27 cu.m / 15 cu.m per hrs = 1.80 = say 2 hrs			27 cu.m
3	Nylon mesh	Open well casing pipe covered with Nylon mesh			
4	Holes to the casing pipe	Holes required of recharging of well			
5	Pit protection wall with inlets on the upstream side(wall of 30 cm surrounding)	Construction of wall Local available stone = farmer contribution Cement=3 bags Sand= one mini truck			

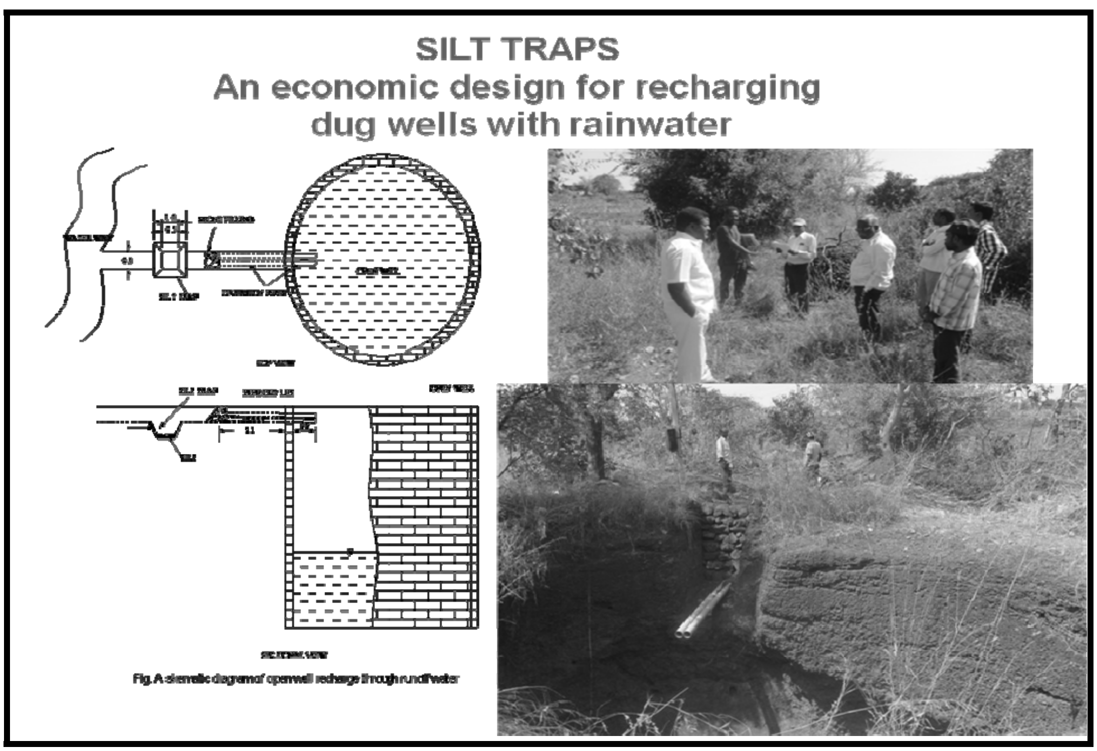


Figure 2 An economic design for recharge dug wells with rainwater

Monitoring of Ground water levels in the village

The total village agricultural wells are divided in the three parts and named in like Zones and each zone has the 10 observation wells and out of 10 wells from each zone one is open well and other 9 as bore wells, the total observation wells from the three zones is 30 (3open wells and 27 bore well as indicated in table 2)

Zone-I	
No of Bore wells	**: 9**
No of Open wells	**:1**
Zone-II	
No of Bore wells	**: 9**
No of Open wells	**:1**
Zone-III	
No of Bore wells	**: 9**
No of Open wells	**:1**

Figure 3 Zone wise divided the recharge wells

Water Level Monitoring

During the feasibility study stage the monitoring of surface water and ground water levels greatly help in identifying the method of artificial recharge. Net work of observation wells is used to study the ground water flow pattern and temporal changes in potentiometric head in the aquifer.

Table 2 Well Inventory in the village divided into 3-Zones for collecting the well data

Zones	S.No	Farmer Name	Father Name	Survey No.	N	E	well	Area	msl	Total Depth
Z - I	1	Achhan Bhirappa	Lakshmaiah	335	17° 05' 46"	78° 42' 16"	Bore Well	1	1985	450
	2	Anjireddy	Yadagiri reddy	329	17° 05' 54"	78° 42' 13"	Bore Well	1	2024	210
	3	Yara Jangaiah	Sivaiah	357	17° 05' 51"	78° 42' 04"	Bore Well	2	2016	300
	4	Yara Narisimha	Ramulaiah	358	17° 05' 52"	78° 41' 55"	Bore Well	1	2005	200
	5	Jemma Anjiiah	Lakshmaiah	326	17° 06' 07"	78° 41' 58"	Bore Well	2	2039	300
	6	G.Janareddy	Bhalaram reddy	322	17° 06' 05"	78° 41' 46"	Bore Well	5	2028	350
	7	Yara Anjiiah	Naraiah	352	17° 05' 41"	78° 41' 59"	Bore Well	1	1979	230
	8	Bhadu Srisailam	Naraiah	364	17° 05' 35"	78° 41' 46"	Bore Well	1	2006	330
	9	Gouwar Jangaiah	Naraiah	412	17° 05' 03"	78° 41' 20"	Bore Well	5	1998	300
	10	B. Panthulu	Surya narayana	376	17° 05' 15"	78° 41' 29"	Open Well	2	2017	71
Z - II	11	Yara Anjiiah	Muthyamma	259	17° 05' 56"	78° 41' 29"	Bore Well	2	1962	300
	12	Ch.Mallareddy	Bhadra reddy	267	17° 06' 06"	78° 41' 19"	Bore Well	1	1950	400
	13	Ravula Yellaiah	Jangaiah	451	17° 05' 56"	78° 40' 55"	Bore Well	2	1997	360
	14	Gouwar Naraiah	Mallaiah	423	17° 05' 14"	78° 41' 03"	Bore Well	1	2059	250
	15	Swamureddy	Bhera reddy	405/3	17° 05' 41"	78° 41' 17"	Bore Well	2	2014	700
	16	Narre Parvathalu	Jangaiah	444	17° 05' 34"	78° 41' 05"	Bore Well	2	2028	400
	17	Narre Maraiah	Jangaiah	441	17° 05' 26"	78° 40' 50"	Bore Well	1	1992	300
	18	Prathapureddy	Ramchandrareddy	382	17° 05' 31"	78° 41' 25"	Bore Well	2	2020	180
	19	Bhapuravu Panthulu	Surya narayana	376	17° 05' 19"	78° 41' 20"	Bore Well	1	2013	150

Contd...

	20	Achhan Yellaiah	Bhuchiiah	395	17° 05' 48"	78° 41' 26"	Open Well	1	1991	60
Z - III	21	Dandu Mallaiah	Bhiraiah	247	17° 06' 19"	78° 41' 52"	Bore Well	1	1999	250
	22	Ch.Madhava reddy	Malla reddy	254	17° 06' 12"	78° 41' 35"	Bore Well	1	2022	200
	23	Narre Mallaiah	Narisimha	220	17° 06' 42"	78° 41' 51"	Bore Well	2	1950	300
	24	Ava Bhiraiah	Jangaiah	224	17° 06' 33"	78° 41' 43"	Bore Well	1	1987	350
	25	Gouwar Peddalu	Poshaiah	203	17° 07' 04"	78° 41' 28"	Bore Well	2	1942	180
	26	Nayini Venkatreddy	Narisimha reddy	205	17° 06' 51"	78° 41' 28"	Bore Well	1	1922	420
	27	Achan Narisimha	Ramachadraiah	233	17° 06' 33"	78° 41' 23"	Bore Well	2	1972	600
	28	Narre Sankaraiah	Bhuchiiah	242	17° 06' 17"	78° 41' 24"	Bore Well	1	1987	250
	29	Ravula Parvathalu	Bhiraiah	179/1	17° 06' 24"	78° 41' 07"	Bore Well	2	1954	300
	30	Yara Maraiah		271	17° 06' 08"	78° 41' 07"	Open Well	1	1956	30

Increased water levels in wells

On the basis of the data collected from observation wells and perception of farmers, it was found taht the water levels rose to the tune of 4 to 10 meters by using of recharge technique. A total of 25 to 30 wells (20 to 30 %) were found to be partly or fully influenced by the water conservation measures in the watershed.

Increased Duration of Water Availability in Wells

The duration of water availability was taken as a measure to examine as to how the water conservation measures helped in improving the groundwater. Data on the duration of water availability in a number of wells i.e., number of months in a year was collected before and after the interventions. The duration of water availability in the wells was limited to 2-3 months earlier. After the water conservation interventions, it increased to 6-7 months. Due to increased period of water availability in the wells, the farmers could afford a greater number of irrigations to crops.

Increased Well Yield

Data with regard to duration of pumping hours before well goes dry and time it takes to recuperate to the same level were collected from sample wells. Water yield/recuperation rate before and after interventions for different wells indicate that recharge rate increased. This may be attributed to enhanced groundwater augmentation as a result of water conservation measures.

Figure 4 Recharging dug and bore wells with runoff water from the fields

Impact of artificial recharge of wells with rainwater harvesting

These bore wells may not be yielding enough water to meet the requirements of farm operation during early monsoon. The recharged water from rainfall requires a few weeks time to bring the water level up the wells.

Farmers cannot store runoff water separately in the field itself. In these circumstances the idea of artificial recharge of wells was introduced. This technique not only helps recharge of wells but also contributes groundwater development. Mean time, farmers can use the water collected from rainfall for their immediate need for agriculture.

Increased water-output: Bore-wells recharged using our technique have an increased water-output. Completely dry bore-wells can be revived too.

Better water-quality: Sending back of naturally filtered rainwater into the groundwater tables results in a decrease in the proportion of impurities in the water. The bore-well's water thus loses its hardness with time.

Cost-effective: The use of locally procured natural materials enables us to deliver the bore-well recharge service at an extremely low cost.

Permanent: Once recharged a well never goes dry. Year after year, underground water-tables and aquifers are replenished thus keeping your well up and running.

Customizable: It doesn't matter if you're a farmer with your well on a farm-land or if your well lies on the site of an industry / farm-house / educational institute or any other urban site. Our technique can be customised to meet your needs.

Eco-friendly: Apart from resolving your water-scarcity issue, our well recharge technique also ensures the storage of naturally filtered rainwater in natural water-reservoirs i.e. aquifers and water-tables for use by future generations.

CONCLUSION

This technique was proposed to open/bore wells covering the KVK adopted villages of Pudur Mandal and Yacharam Mandal, Rangar Reddy Dist cluster of CRIDA-KVK Watershed project. For the year of 2015-16 farmers filed structures were completed Md.Usif Ali, Mr Ravi Chandra Reddy and Charmanda from that villages and Volume of water recharged or collected on individual wells basis was not calculated as it required detailed catchment area/contributing area. Based on some assumptions (ten percent runoff against rainfall and contributing area is 1 ha) the system has the potential of recharging volume of 650 m3 for each of open well and the overall rainwater trapped among the 15 open wells around 9750 m^3. Depth of well increased by 21.3% through de-silting in two consecutive years. Productivity of crops increased by 20%, respectively due to recharge of wells through de-silting, the average cropping intensity across farmers increased by 17%.

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THEME – VIII

GEOSPATIAL APPLICATIONS IN WATER RESOURCES

Morphometric Analysis of Ungauged Watershed and Prioritization of Palar Sub Watershed using Rs & GIS

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ABSTRACT

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of land forms. Remote sensing and GIS technology helps in creation of the digital data of the drainage network. Morphometric parameters were studied under three categories namely linear, aerial and relief factors. Due to improper land, soil and water management practices, land and water resources getting degraded and eroded, water getting polluted. In this regard present study is profoundly concerned to prioritization of palar sub watershed which is small tributary of pennar River in river chittoor district. The prioritization of this sub watershed has been carried out on the basis of morphometric analysis for land reclamation and soil erosion prevention. The other analysis carried out for certain significant areal, linear and relief morphometric parameters vis stream length, stream frequency, bifurcation ratio, Length of overland flow, perimeter of basin, drainage density etc. have been assessed. These studies are very useful for planning rainwater harvesting and watershed management.

Keywords: Morphometric Analysis, Ground Water Potential, Remote Sensing, Geographical Information System, Dem, linear parameters, aerial parameters, Relief parameters.

INTRODUCTION

The Morphometric analysis of the chandragiri watershed of chittor district , Andhra Pradesh coupled with remote sensing and GIS techniques helps us to understand the geological and geo morphological history of drainage basin development of this region. According to Naithani & Rawat (1984), the morphometry parameters could be categorised into two major groups namely; the measured parameters and calculated parameters. The Morphometric analysis study coupled with remote sensing and GIS techniques evaluate different valuable parameters for the watershed development plan of chittoor district, Andhra Pradesh. A watershed is a natural hydrological unit, which is demarcated by the topographic highs and regulates the movement and occurrence of its surface water and also the subsurface water/groundwater.The watershed development plan has become mandatory for developing surface and subsurface water resources of this area. For preparing a proper watershed development plan, it becomes necessary to understand about the geological and geomorphological factors, which effect on the occurrence and movement of surface and subsurface water of this region. In the present study an attempt has been made to evaluate the above said controlling factors by morphometric analyses of chandragiri Watershed. Morphometry makes it possible to generate descriptive statistics of the shape of the surface or assigns a location in a landscape to an exhaustive set of features based on the local form of the landscape to an exhaustive set of features based on the local form of the land surface. Morphometric studies in the field of hydrology were first initiated by Horton (Horton, 1932 and 1945) and Strahler (Strahler 1952 and 1957). The drainage basin analysis helps in the assessment of groundwater potential and management and, environmental assessment. Various hydrologic phenomena can be correlated with the physiographies characteristics of a drainage basin such as size, shape, slope of drainage area, drainage density, size and length of tributaries. Due to advancement in satellites and sensing technology, it is possible to map finer details of the earth's surface and provide scope for micro level planning and management. The present study aims at for the identification of ground water potential zones by prioritization of micro watershed based on Morphometric analysis using Remote sensing data and GIS overlays techniques. This study is mainly helpful for the increasing agricultural based livelihood and also for supplying the greater level of irrigation facilities.

Study Area

The major part of study area is covered by Chandragiri mandals, Pulicherla – Chinnagottigallu mandals on NorthWest, Pakala- Puthalapattu on South West, Ramachandrapuram on South East and Tirupati (Urban & Rural) on North East. It is located 13°26' to 13° 45' N and 79° 6' to 79° 22' E and covering an area of 545.79 Sq.Km. It is included in the Survey of India Topographical sheets of 57 $\frac{o}{2}$, 57 $\frac{o}{4}$ and 57 $\frac{o}{6}$on a scale of 1:50,000. The study area lies in a morphologically transitional zone between the interior Plateau of Karnataka in the west and the Coastal plain of Bay of Bengal in the east which is about 150 Km. from the study area. The Mandal slopes down from west to east from an average elevation of about 750 mts. On the west to about 150 mts. On the east Tirupati railway station which is hardly 10 Km from the study area is situated at an elevation of 120 M above MSL.

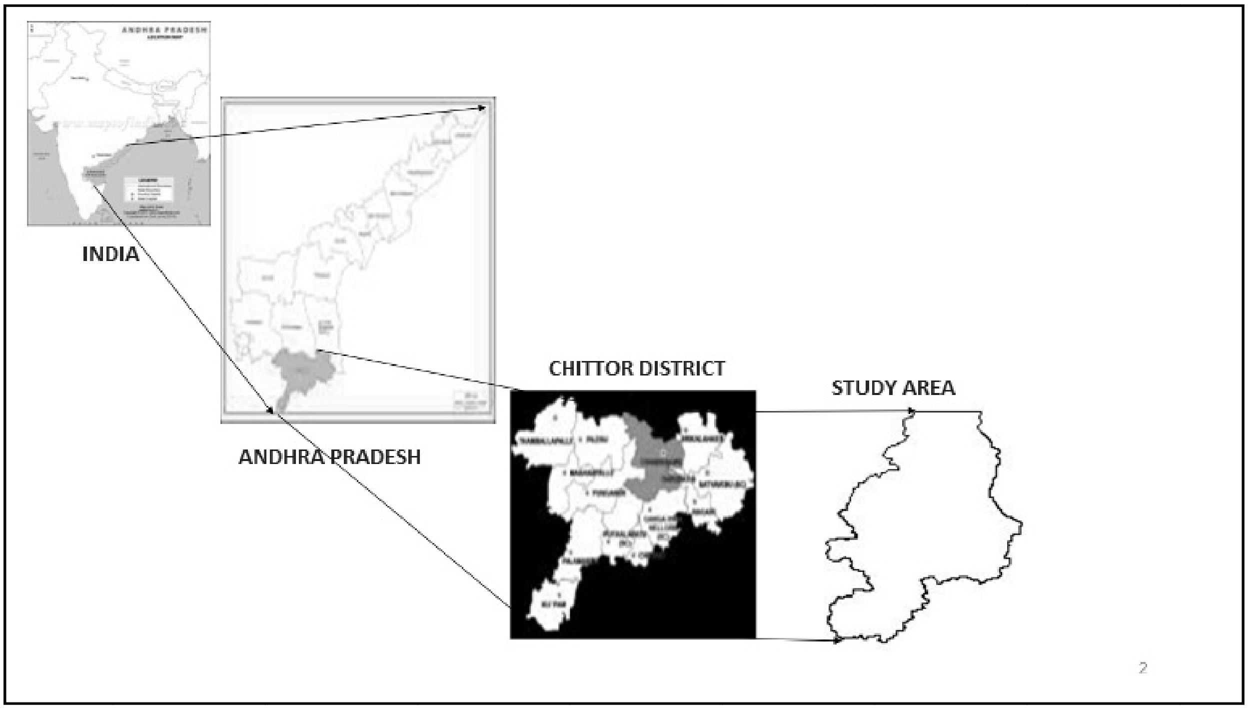

Figure 1 study area map

Methodology

Morphometric analysis consists of morphometric parameters which contains Linear, Areal and Relief parameters

Table 1 Methods for Calculating Morphometric Parameters

	Morphometric parameters	Method	References
Linear parameters	Stream order(U)	Hierarchical order	Strahler, 1964
	Stream length(L_u)	Length of the stream	Horton, 1945
	Mean stream length(L_{sm})	$L_{sm} = L_u/N_u$ where, Lu=Stream length of order 'U' N_u=Total number of stream segments of order 'U'	Horton, 1945
	Stream length ratio(R_l)	$Rl=L_u/L_{u-1}$, where L_u=Total stream length of order 'U', L_{u-1}=Stream length of next lower order.	Horton, 1945
	Bifurcation ratio(R_b)	$Rb = N_u/ N_{u+1}$, where, Nu=Total number of stream segment of order 'u', N_{u+1}=Number of segment of next higher order	Schumn,1956
Relief parameters	Basin relief(B_h)	Vertical distance between the lowest and highest points of watershed.	Schumn,1956
	Relief ratio(R_h)	$R_h=B_h/L_b$, Where, B_h=Basin relief, L_b=Basin length	Schumn,1956
	Ruggedness number(R_n)	$R_n = B_h \times D_d$ Where, B_h =Basin relief; D_d=Drainage density	Schumn,1956

Table 1 *Contd...*

	Morphometric parameters	Method	References
Aerial parameters	Drainage density(D_d)	$D_d = L/A$ where, L=Total length of streams, A=Area of watershed	Horton, 1945
	Steam frequency(F_s)	$Fs = N/A$ where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio(T)	$T = N_1/P$ where,N_1=Total number of first order streams, P=Perimeter of watershed	Horton, 1945
	Form factor(R_f)	$Rf=A/(L_b)^2$, where, A=Area of watershed, L_b=Basin length.	Horton, 1945
	Circulatory ratio(R_c)	$Rc=4\pi A/P^2$, where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
	Elongation ratio(R_e)	$Re=2\sqrt{(A/\pi)}/L_b$, where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn,1956
	Length of overland flow(Lof)	$Lof = 1/2D_d$ where,D_d=Drainage density	Horton, 1945
	Constant channel maintenance (C)	$L_{of} = 1/D_d$ where,D_d=Drainage density	Horton, 1945

Linear parameters

The linear parameters generally considered in morphometric studies are stream number, stream order, stream length, mean stream length, stream length ratio, and bifurcation ratio.

Areal parameters

The aerial aspects include various morphometric parameters like drainage density (D_d), drainage texture (T), stream frequency (Fs), elongation ratio (R_e), circulatory ratio (R_c), form factor (F_f), and length of overland flow (L_o).

Relief parameters

Relief is an important parameter for drainage basin analysis. It reflects the elevation difference between the highest and lowest point of a region. Relief aspects deal with the structural elevation of a basin. The relief measurements like basin relief (R), relief ratio (R_r) and ruggedness number (R_n).

RESULTS AND DISCUSSIONS

The Hydrology tools can be applied individually or used in sequence to create a stream network or delineate watersheds. Stream ordering is a method of assigning a numeric order to links in a stream network. This order is a method for identifying and classifying types of streams based on their numbers of tributaries. Some characteristics of streams can be inferred by simply knowing their order**.** Study area is of 5^{th} order stream and divided into sub watersheds.

The number of streams of various orders in the sub-basins is presented in that 490 streams are of first order, 228 streams are of second order, 85 streams are of third order, 168 streams are of fourth order, 91 streams are of fifth order. It may also observed that the number of streams decreases as the stream order increases following Horton’s law of stream numbers.

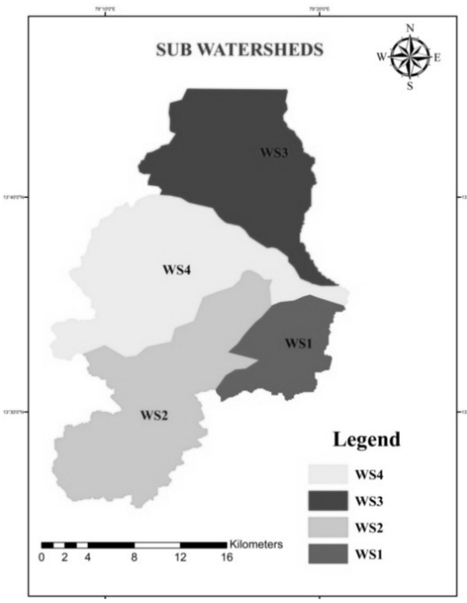

Figure 2 Sub watersheds of study area

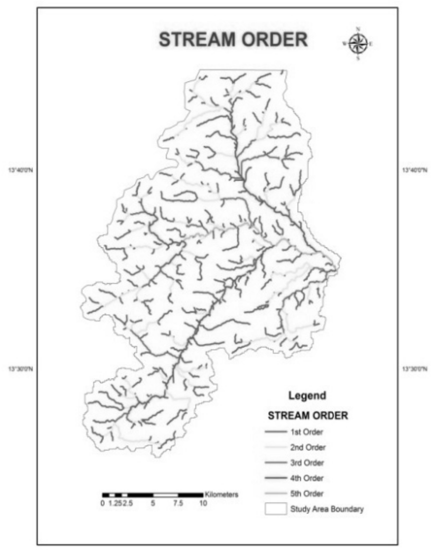

Figure 3 Stream orders of stream order

Table 2 Linear parameters of sub-basin

sub-basin	Total no of streams Nu					Total	bifurcation ratio R_b (N_u/N_{u+1})				mean R_b
	1	2	3	4	5	Nu	1/2	2/3	3/4	4/5	
WS_1	42	30	14	1	*	87	1.4	2.143	14	*	4.386
WS_2	167	75	10	80	*	332	2.227	7.5	0.125	*	2.463
WS_3	102	59	22	57	12	252	1.729	2.681	0.386	4.75	2.386
WS_4	179	64	39	30	79	391	2.797	1.641	1.3	0.379	1.529
Total	490	228	85	168	91	1062				Mean	2.691

Bifurcation ratio (Rb) of successive orders of sub-basins WS_1 to WS_4 of palar basin as presented in table 6.1 show that the mean bifurcation ratio is high for WS_1(4.386) and low for WS_4 (1.529).

The higher Rb for WS_1 sub-basin may be due to large variations in frequencies between successive orders indicating the matured topography. The mean Rb of palar basin was observed to be 2.691 indicating that the sub-basin is less affected by structural disturbances with drainage pattern, not much influenced by geological structures.

Table 3 Basic parameters of sub-basins

sub basin	Basin area, A (km²)	Basin length L (km)	perimeter P (km)
WS_1	57.6275	13.224	44.0756
WS_2	162.409	25.194	93.1507
WS_3	141.68	20.971	65.3971
WS_4	166.575	23.793	82.1731

The mean stream length ratio between the streams of different orders of the study area changed from 0.49 to 1.10. This change may be attributed to variation in slope and topography.

Table 4 Aerial parameters of sub basin

Sub Basin	Drainage Density D_d	stream frequency F_s	drainage texture T	elongation ratio R_e	Circulatory ratio R_c	Form factor F_f
WS_1	0.01063	1.50976	0.9529	0.178122	0.372771	0.32952
WS_2	0.00989	2.04422	1.7927	0.113713	0.235205	0.255866
WS_3	0.00911	1.77865	1.5597	0.139854	0.416295	0.322155
WS_4	0.00963	2.34729	2.1783	0.125477	0.309999	0.29422

The areal aspects for the basin such as drainage density(D_d), streamfrequency(F_s), drainage texture ratio(T), circularity ratio(R_c). The drainage texture(T) of the sub-basins varied from 0.952 to 2.17, low T values indicate very coarse drainage texture. R_e less than 0.7 of sub-basins.

The watersheds WS_1, WS_2, WS_3, WS_4 indicated elongated shape of sub-basins. R_c less than 0.5 of WS_1, WS_2, WS_3, WS_4 indicate elongated sub-basins with moderate relief, low runoff an high subsoil permeability. Low F_f values of sub-basins indicate elongated shape resulting in longer flow duration with flatter peak leadng to more groundwater recharge.

Table 5 Relief parameters of sub-basin

Sub-basin	Basin relief R (m)	Relief ratio R_r	Ruggedness number R_n
WS_1	611	0.0462	0.00049
WS_2	701	0.0278	0.00027
WS_3	965	0.0460	0.00041
WS_4	770	0.0323	0.00031

The groundwater potential zones identification of sub-basins of palar basin was carried out through compact factor analysis of morphometric parameters.

Table 6 Compact factors and groundwater potential availability

Sub-basin	Rank										compact factor	groundwater potential availability
	linear parameter		Areal Parameter						Relief parameter			
	R_b	R_l	D_d	F_s	T	R_e	R_c	F_f	R_r	R_n		
WS_1	1	4	1	4	4	1	2	1	1	4	2.3	poor to moderate
WS_2	2	1	2	2	2	4	4	4	4	3	2.8	good to very good
WS_3	3	3	4	3	3	2	1	2	2	1	2.4	moderate to good
WS_4	4	2	3	1	1	3	3	3	3	2	2.5	moderate to good

CONCLUSION

The drainage pattern of the study area varied from dentric to sub-dentric at higher elevations to parallel in the lower elevations. It may also observed that the number of streams decreases as the stream order increases. The mean R_b of palar basin was observed to be 2.691 indicating that the sub-basin is less affected by structural disturbances with drainage pattern, not much influenced by geological structures. The mean stream length ratio between the streams of different orders of the study area changed. This change may be attributed to variation in slope and topography. Low F_s values indicate a very coarse drainage structure with low relief and high infiltration capacity and, the existence of favorable sites for groundwater recharge. Low relief ratios and ruggedness numbers of sub-basins indicate the existence of promising groundwater zones. The morphometric analysis of linear, areal and parameters of sub-basins presented in tables indicate that WS_1 possesses high bifurcation ratio with short streams. It is less elongated with high stream frequency causing less infiltration rate, moderate drainage density and low ruggedness number.

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Geomorphological Parameters on Gauged Watershed in Swarnamukhi River Basin by using GIS and RS

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ABSTRACT

Rainfall intensity- frequency-duration equations are required for design of soil and water conservation and runoff disposal structures and for planning flood control projects. The rainfall intensity-duration-return period relationship as $I = (KT^a) / (t+b)^d$ has been developed for Solapur region under scarcity zone of Maharashtra. The constants K, a, b and d in this equation are location specific. The values of parameters a and b were determined by using graphical method and the values of K and d by least square method. The daily automatic rain gauge charts of Solapur were analyzed in the form of annual maximum series of various durations viz. 5, 10, 15, 30 minutes, 1, 3, 6, 12 and 24 hours. The constants K, a, b and d for Solapur were found as 11.08 0.1892, 1.01 and 1.2066 respectively by analyzing 17 years daily automatic rain gauge charts of Solapur (Barai, 2004). These constants K, a, b and d were now modified to 6.96, 0.2313, 1.00 and 1.1081 respectively by analyzing 28 years daily automatic rain gauge charts.

Keywords: Rainfall intensity-frequency-duration relationship, IFD, Rainfall intensity)

INTRODUCTION

The Morphometric analysis of the Swarnamukhi sub-watershed of Nellore district, Andhra Pradesh coupled with remote sensing and GIS techniques helps us to understand the geological and geo morphological history of drainage basin development of this region. The Morphometric analysis study coupled with remote sensing and GIS techniques evaluate different valuable parameters for the watershed development plan of Nellore district, Andhra Pradesh. A watershed is a natural hydrological unit, which is demarcated by the topographic highs and regulates the movement and occurrence of its surface water and also the subsurface water/groundwater. The watershed development plan has become mandatory for developing surface and subsurface water resources of this area. For preparing a proper watershed development plan, it becomes necessary to understand about the geological and geomorphological factors, which effect on the occurrence and movement of surface and subsurface water of this region. The role of basin geomorphology in controlling the hydrological response of a river basin is known for a long time. It is advantageous in case of laying out the urban drainage and irrigation canal system, aqueducts, study the physiographic impacts on environment, and selection of silt disposal site, hydropower site (Sarkar and Gundekar, 2007), recharge zone, percolation tank, retention tank, dam site, etc. This drainage network of the river basin can provide a significant contribution towards flood management and water logging program (Jain and Sinha, 2003)**.** Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998; Obi Reddy et al., 2002). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945; Leopold & Maddock, 1953; Abrahams, 1984). The source of the watershed drainage lines have been discussed since they were made predominantly by surface fluvial runoff has very important climatic, geologic and biologic effects e.g. The morphometric characteristics at the watershed scale may contain important information regarding its formation and development because all hydrologic and geomorphic processes occur within the watershed (Singh, 1992). Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). GIS techniques are now a day used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information.

Study Area

The area of investigation in this research study is the major part covers Naidupeta and remaining area covers Venkatagiri, sullurupeta in Nellore district, Andhra Pradesh. It is located 13°90' and 14° 25' N and 79° 89' and 80° 12' E and covering an area of 957.92 sq.km. The Study area falls under Palar Sub-basin the area was delineated from India Water Resources Information System (IWRIS) C18PAL41. The study area it is a part of east flowing river between pennar and caurey basin and the river draining into the bay of Bengal. In the study area main river is Swarnamukhi and the length of the river as 56.90 km. In the study area has one hydro observation station and 11 rain gauge stations are located. The hydro observation site is located in naidupeta in Nellore district.

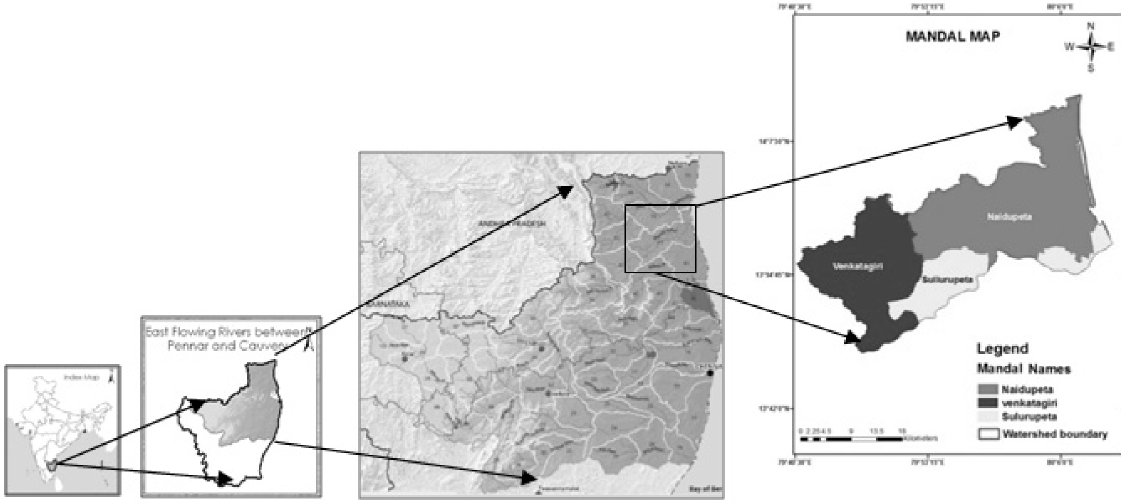

Figure 1. Location map of the study area

Methodology

The methods adopted for calculating morphometric parameters are given in Table 1. Linear parameters analyzed include: stream orders (Nu), stream length (Lu), mean stream length (Lsm) and bifurcation ratio (Rb). Results of the morphometric analysis are Bifurcation ratio (Rb) is the ratio of the number of stream segments of a given order to the number of segments of the next higher order (Shumn 1956).

Table 1 Method of calculating morphometric parameters

	Morphometric parameters	Method	References
Linear parameters	Stream order(U)	Hierarchical order	Strahler, 1964
	Stream length(L_u)	Length of the stream	Horton, 1945
	Mean stream length(L_{sm})	$L_{sm} = L_u/N_u$ where, Lu=Stream length of order 'U' N_u=Total number of stream segments of order 'U'	Horton, 1945
	Stream length ratio(R_l)	$Rl=L_u/L_{u-1}$, where L_u=Total stream length of order 'U', L_{u-1}=Stream length of next lower order.	Horton, 1945
	Bifurcation ratio(R_b)	$Rb = N_u/ N_{u+1}$, where, Nu=Total number of stream segment of order 'u', N_{u+1}=Number of segment of next higher order	Schumn,1956
Relief parameters	Basin relief(B_h)	Vertical distance between the lowest and highest points of watershed.	Schumn,1956
	Relief ratio(R_h)	$R_h=B_h/L_b$, Where, B_h=Basin relief, L_b=Basin length	Schumn,1956
	Ruggedness number(R_n)	$R_n = B_h \times D_d$ Where, B_h =Basin relief; D_d=Drainage density	Schumn,1956

Aerial parameters	Drainage density(D_d)	D_d = L/A where, L=Total length of streams, A=Area of watershed	Horton, 1945
	Steam frequency(F_s)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio(T)	T = N_1/P where,N_1=Total number of first order streams, P=Perimeter of watershed	Horton, 1945
	Form factor(R_f)	$Rf=A/(L_b)^2$, where, A=Area of watershed, L_b=Basin length.	Horton, 1945
	Circulatory ratio(R_c)	$Rc=4\pi A/P^2$, where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
	Elongation ratio(R_e)	$Re=2\sqrt{(A/\pi)}/L_b$, where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn,1956
	Length of overland flow(Lof)	Lof = $1/2D_d$ where,D_d=Drainage density	Horton, 1945
	Constant channel maintenance (C)	$L_{of} = 1/D_d$ where,D_d=Drainage density	Horton, 1945

RESULTS AND DISCUSSION

Digital elevation model is taken from the SRTM 30 M data. The DEM of the study area shows the elevation value between 163 m to 10 m.

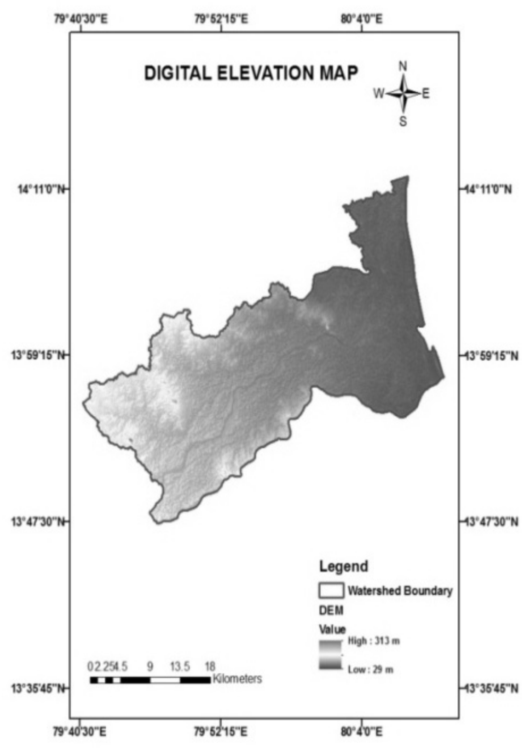

Figure 2 DEM map of the study area

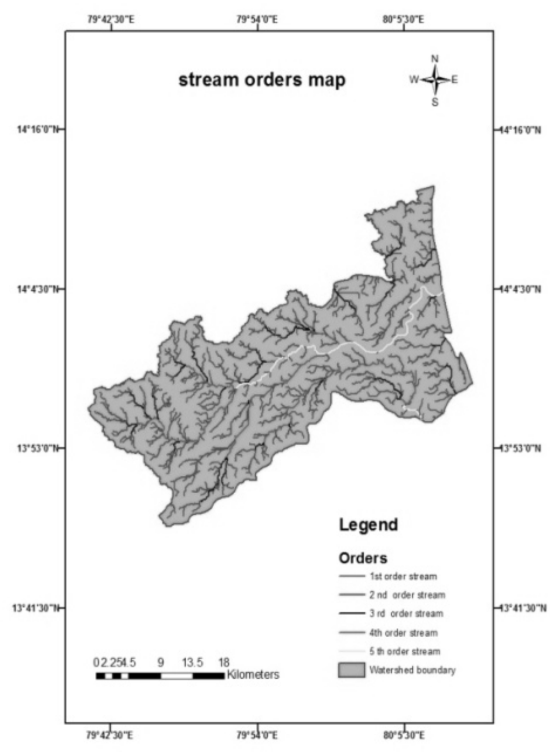

Figure 3 Stream order map of the study area

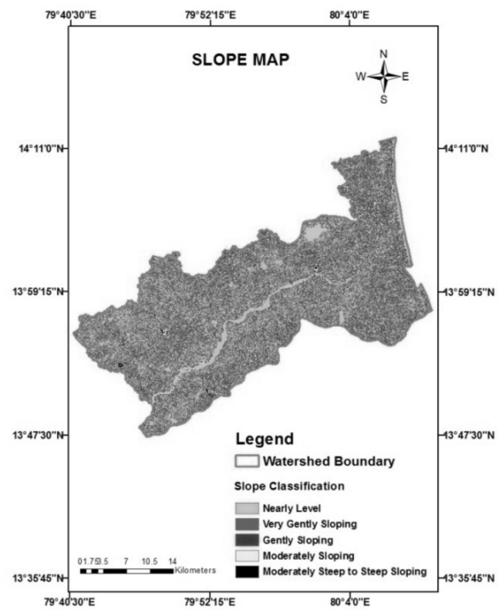

Figure 4 Slope map of the study area

This order is a method for identifying and classifying types of streams based on their numbers of tributaries. Some characteristics of streams can be inferred by simply knowing their order**.** Study area is of 5th order stream.

The number of streams of various orders in the basins is presented in table 2 that 318 streams are of first order, 75 streams are of second order, 15 streams are of third order, 4 streams are of fourth order, 1 streams are of fifth order. It may also observed that the number of streams decreases as the stream order increases following Horton's law of stream numbers.

Table 2 Mean stream length (L_{sm}) of swarnamukhi sub-watershed

Name	Stream order	L_u	N_u	L_{sm}
Swarnamukhi sub-water shed	1	423.783	318	1.332
	2	236.784	75	3.157
	3	92.825	15	6.188
	4	53.11	4	13.27
	5	42	1	42
L_u=stream length of order 'U'(km), N_u=Total number of stream segments L_{sm}=mean stream length				

These parameters were used to determine the stream-lengths ratio (R_L) is unique representative parameters for a given watershed and are fixed values for a watershed system. Values of bifurcation ratio, the length ratio, and the area ratio in nature are normally 1.5 and 3.5 for R_L.

The present study area the watershed length ratio has 2.289 the value has with in the limits. The basic parameters of watershed length (L), perimeter(P) and area(A), the areal aspects for the basin such as drainage density(D_d), stream frequency(F_s), drainage texture ratio(T), circularity ratio(R_c) were computed and presented in Table 3.

The stream length ratio indicates the surface flow characteristics of the basin. The stream lengths, mean stream lengths and their ratios for the sub-basins of palar basin are presented in tale 2. A decrease in the stream length with increased stream oder for WS_1 to WS_4 sub-basins may be observed. The mean stream length ratio between the streams of different orders of the study area changed from 0.49 to 1.10. This change may be attributed to variation in slope and topography.

Table 3 Results of morphometric analysis of swarnamukhi sub-watershed

Morphometric parameters	Results
Area (km^2)	957.24
Perimeter(km)	243.861
Basin order	5
Basin length(L_b)(km)	56.793
Relief ratio(R_n)	2.6939
Basin relief(B_h)(km)	153
Ruggedness number(R_n)	135.69
Bifurcation ratio(R_b)	4.24
Drainage density(D_d)(km^2)	0.8864
Stream frequancy(F_s)(km^2)	0.43
Texture ratio(T)(km)	1.30401
Form factor(R_f)	0.2967
Circulatory ratio(R_c)	0.2022
Elongation ratio(R_e)	4.632
Length of over land flow(L_{of})(km)	0.4432
Constant channel maintenance(C)(km)	1.12815

CONCLUSION

Drainage morphometry of a sub-watershed reflects hydro-geologic maturity of that river. Satellite remote sensing has an ability of obtaining the synoptic view of a large area at one time, which is very useful in analyzing the drainage morphometry. GIS has proved to be an efficient tool in drainage delineation and this drainage has been used in the present study. Variation in the values of R_b among the micro-watersheds is ascribed to the difference in topography and geometric development. Further, the morphometric parameters evaluated using GIS have helped us to understand various terrain parameters such as nature of bedrock, infiltration capacity, surface runoff, etc. The present study will be of assistance in watershed development and management.

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Land use and Land Cover Mapping of Mauxi Village (North Goa District, Goa State) using Remote Sensing and GIS Technology

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ABSTRACT

Spatial information on Land use and Land Cover mapping is a necessary prerequisite in planning, utilizing and management of environmental impact analysis and natural resources management. The present study involves remote sensing and GIStechnology and integration of digital data and field data, quality result and map composition. In this paper an attempt is made to study the changes of Land Use and Land Cover mapping in SattariTaluk over 30 years period. The Land Use Land Cover analysis has been done through Remote Sensing technology approach which involves suitable planning for satellite data, Toposheet and field data of the area followed by image rectification techniques, image classification and mapping with the help of visual interpretation techniques and ground truth verification of this area. Further approach involves analysis, integration and efficient spatial modeling for observing the data using multi-resolution of satellite images for land use land cover change detection mapping. The land use land cover analysis were used for World-View-2, Resource sat LISS-IV, Cartosat and Toposheet of 1:25,000 scale data. The study is on screen visual interpretation of different LU/LC classes based on the standard visual interpretation by giving attributes and area calculation with output by using Arc GIS10.1. The present study has brought to light that forest area that occupied about 70 percent of the Taluk's area in 1969 has decreased to 33 percent in 2011. Agricultural land, Harvested land and Wasteland also have experienced change. Built-up lands (settlements) have increased from 3 percent to 23 percent of the total area. In present study land use land cover planning is essential for a sustainable development of SattariTaluk. These remote sensing and GIS techniques can easily interpret the suitable soil and water conservation structures to that particular area and maintains vegetation, forest and also we can able to suggest water managing systems.

Keywords: Remote sensing, GIS, GPS, Satellite image.

INTRODUCTION

The land use/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use/ land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change. An accurate forest cover-type and/or land-classification system is essential to providing information for effective management of natural resources (Schriever and Russell, 1995). The remote sensing technology in integration with Geographical Information System (GIS), helps in extracting maximum amount of vegetal information that describe vegetation diversity i.e. extent, structure, composition and condition. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

Land use relates to the human activity or economic function associated with a specific piece of Land (Lillesand et al. 2004). Examples of land use include agriculture, urban development, grazing, logging, and mining. In contrast, land cover relates to the composition and Characteristics of land surface elements (Cihlar 2000). The term land cover originally referred to The kind and state of vegetation, but it has broadened in subsequent usage to include human Structures such as buildings or pavement and other aspects of the natural environment, such as Soil type, biodiversity, and surface and groundwater (Meyer 1995). Land cover categories Generally include cropland, forests, wetlands, pasture, roads, and urban areas.

Study Area

Location: Mauxi Village, SattariTaluk, North Goa District, Goa State.

Area of Mauxi: 6.381 Sq.kms, **Rainfall:** 2932mm, **Temperature:** 26.9°C.

Latitudinal and Longitudinal extension of Mauxi village: 74°6′55.567″ E to 15°32′49.584″ N.

Grid numbers of Mauxi: D43CO2Q-SE, D43CO2R-SW, D43CO2R-SE, D43CO2W-NE, D43CO2W-NW, and D43CO2V-NE.

The Goa state area is about 3,702 Sq.km.It has 213 villages, 27 towns and 7 municipalities. It is divided into two districts that are North Goa and South Goa. Geographical area of North Goa district is about 1,736 Sq.kms. Again it subdivided into four municipalities that are Panaji, BIcholim, Mapusa, Ponda and six Taluks that are viz, Tiswadi, Bardez, Pernem, Bicholim, Sattari and Ponda.

Goa has estuary entrance and rocky capes along palm-fringed beaches and has long coastline with a length of 105 Km. The principal perennial rivers are Madei River, RagadaNadi. The geomorphology of the study area is occupied with lateritic soil, alluvial soil are the major. The principal crops are paddy, cereals, millets pulses and oil seeds, sugarcane, coconut, arecanut and cashew etc.

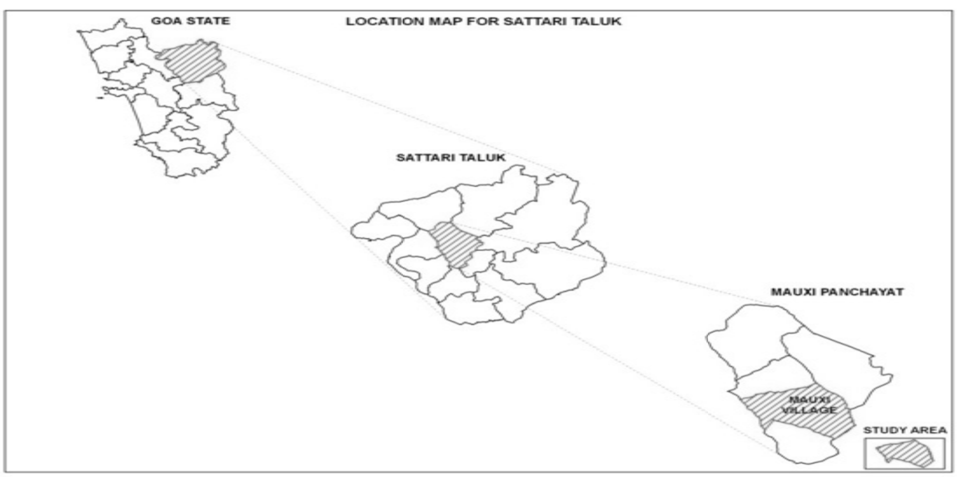


Figure 1 Location Map of Study Area

Aim and Objective

- Preparation of various thematic data such land use and Land cover using LISS-4 image Data.
- To Create Land Use Land Cover mapping from satellite images.
- To determine the trend, nature, rate, location and magnitude of land use / land cover change.

Data Used

The study has made use of various primary and secondary data. These include Survey of India (SOI) topographic sheets of 1:50,000 scale and satellite imagesWorld view-2 satellite imagery, Resourcesat-1, Cartosat-1**,** These data were visually and digitally interpreted by using the Arc GIS 10.1 Software (for processing, analysis and integration of spatial data) to reach the objectives of the study.

Methodology

In the present study Image processing and visual interpretation technique are carried out to Land use / Land cover classification using digital data and standard False Colour Composite (FCC) satellite image. The classification is adopted to prepare land use and land cover map. Standard False Colour Composite (FCC) for satellite image LISS-III and Landsat TM image is used for mapping land use/land cover . The interpretation is based on shape, size, tone / colour, texture, and pattern, and location aspects of the particular feature on the satellite imagery. Using the above interpretation keys, a thematic layer of Land use/land cover for the year 2014 is prepared. The topographic map is obtained from the Survey of India, Hyderabad, which was surveyed and prepared in 1976; it is converted to digital mode using scanning. The topographic map isgeoreferenced with longitude and latitudes using the Arc GIS software and spatial analyst tools and demarcated the boundary of study area. The feature classes were identified based on the visual interpretation of the satellite imagery coupled with field checks.

Mapping of Base layers, Land Use/ Land Cover and Soil Classification details are being carried out by using Remote Sensing and GIS techniques on 1:25,000 scale by using multi-spectral and multi-temporal satellite imagery with Level III classification system in Arc GIS environment.

The Geomatics technology is used to identify the land use/land cover units, forest types and canopy density using satellite remote sensing data and other collateral data in the complex GIS environment.

Data Processing

Analysis and interpretation of satellite data will be done by digital image processing asDepicted.

Image Processing

Remote sensing satellite orbit the earth from pole to pole and continuously scan the earth's surface, convert the reflection from it in to digital numbers. This information will be sent to earth's receiving station (shadnagar-India). The collected information (Data) is stored in High density magnetic tapes and is sent to NDC (NRSC Removing the errors and preparing the data for use in applications is called image processing.

Image processing will be carried out by using ERDAS Imagine software. In this process, correction for Distortions, Degradations and Noise, removing of radiometric errors, contrast enhancement etc., will be carried out.

Geo-referencing

Correlating the image to the real world co-ordinates with a specific projection and specified units is called geo-referencing. Raw data from NRSC Data Centre is supplied as scenes with reference to path & row.

Data Merging

Quick bird/world view data will have 0.5m spatial resolution, with which we can see the information clearly up to 1:5,000 scale. As the information in this data is from panchromatic camera, it cannot be used individually for all analysis. Like, wise IRS P6 LISS-IV data will have multi spectral data but with a spatial resolution of 5.8m only. Upon data merge we can obtain multi spectral data with the spatial resolution of 5m. so, in this project, we will merge the PAN and LISS-IV data by using Erdas Imagine software.

Mosaicking

The joining if the abjactent image s called mosaicking. As the districts in the study area cover in more than one scenes, all the scenes of the merged data will be mosaicked. While mosaicking the scenes, care will be taken such that the fe3ature should be ontinuous in edge matching of sid-by-side scenes, as they come from different paths and time.

Image Interpretation

Image interpretation is defined as the examining images for identifying abjects and judging their significance. It will be carried out by either visual interpretation techniques or digital interpretation techiniques. In this project the mapping will be carried out by visual interpretation.

Visual Interpretation

In the Visual Interpretation, interpreters will study remotely sensed data by the elements of image interpretation and attempt through logical processes in detecting, recognizing and identifying, analyzing, classifying, measuring and evaluating the significances of physical and cultural objects, their patterns and special relationship.

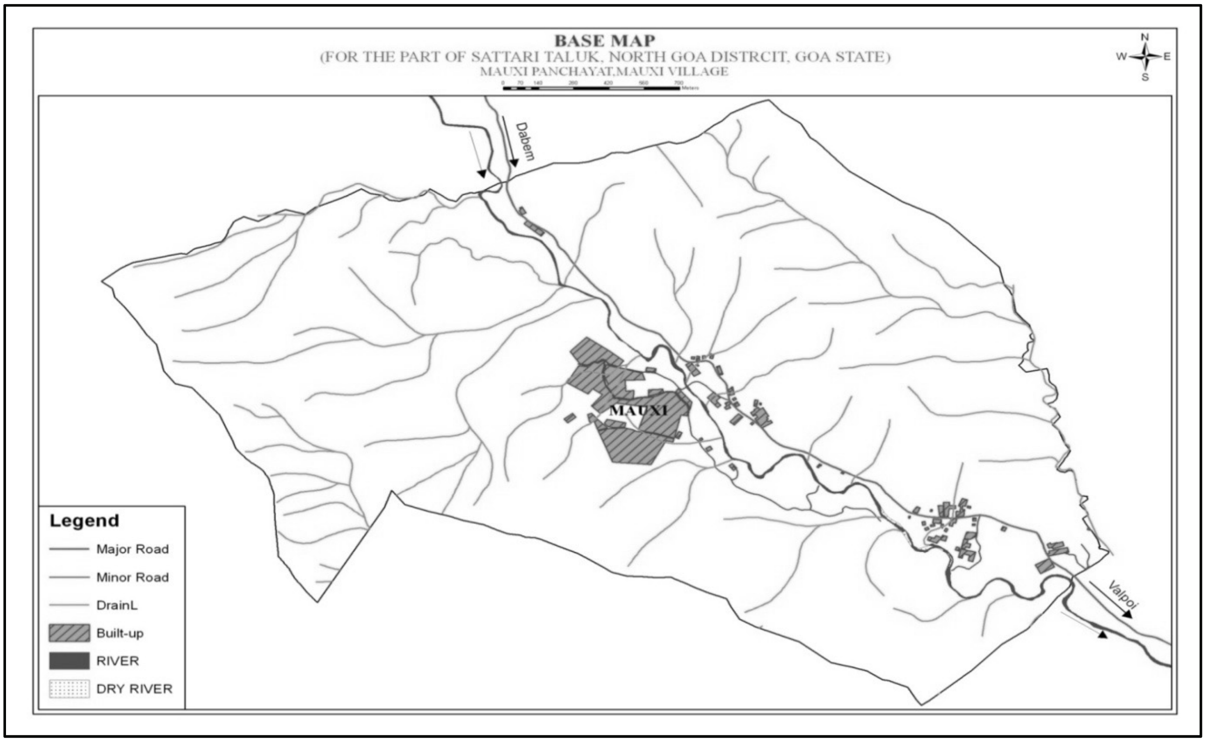


Fig 2: Base Map of Mauxi village

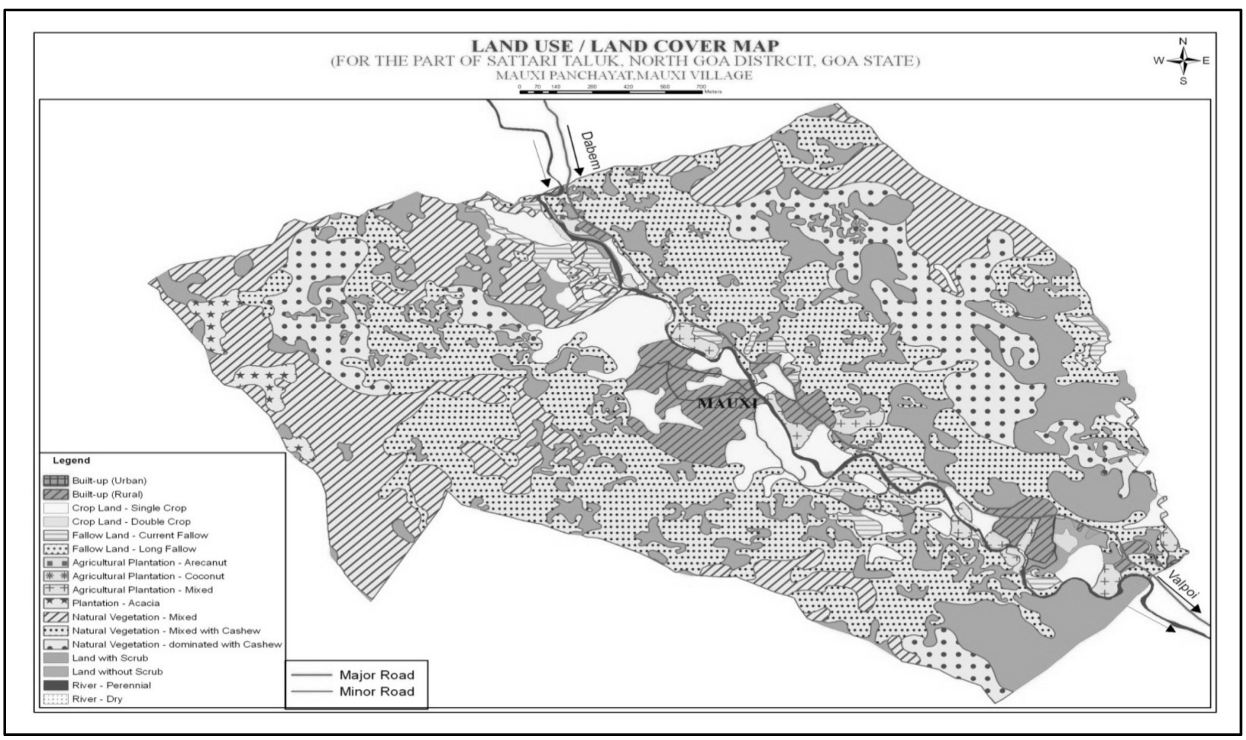
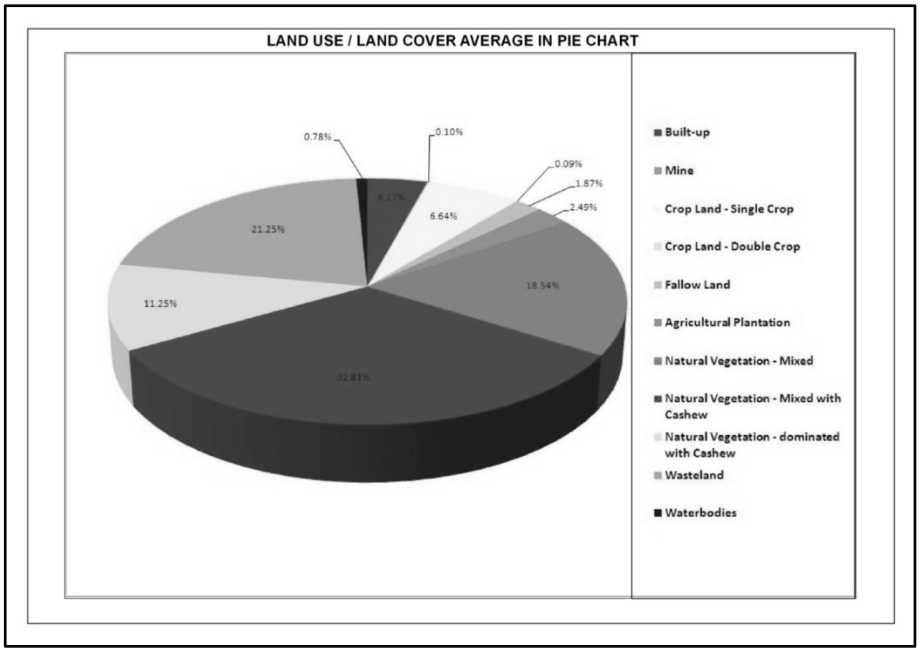


Fig 3 Land Use/Land Cover of Mauxi village

Field surveys

Field surveys will be conducted within the study areas to determine the major types of land use and land cover. Such data would be used in two aspects of the mapping of land use land cover. Firstly it will aid in land use and land cover classification, by associating the ground features of a specific type of land use and land cover with the relevant imaging and spectral characteristics. Secondly, ground data will be used for accuracy assessment of the developed land use and land cover maps.

Results



Pie-Chart1: Land Use/ Land Cover area percentages of Mauxi village

The land use and land cover map clearly shows that area of natural vegetation mixed with cashew is higher than others. Open Land/Waste land has 1.36 km^2 area it occupies second place in this village, natural vegetation mixed getting third place has 1.18 Km^2 area.

Table 1 Data showing total land cover

LAND USE / LAND COVER LEGEND			
S. NO.	**Description**	**Area(Km^2)**	**Percentage (%)**
1	Built-up	0.27	4.17
2	Mine	0.01	0.1
3	Crop Land - Single Crop	0.42	6.64
4	Crop Land - Double Crop	0.01	0.09
5	Fallow Land	0.12	1.87
6	Agricultural Plantation	0.16	2.49
7	Natural Vegetation – Mixed	1.18	18.54
8	Natural Vegetation - Mixed with Cashew	2.09	32.81
9	Natural Vegetation - dominated with Cashew	0.72	11.25
10	Wasteland	1.36	21.25
11	Water bodies	0.05	0.79
Total		6.38	100

CONCLUSION

Base Layers, Land use and land cover of the study area, Soil mapping are carried out by using Remote Sensing and GIS techniques. In this satellite images of world View -2, Cartosat-1, and Resourcesat-2 are used. The final result shows that 4.17% by built-up area, 0.1% of area is covered by mine, 6.73% is covered by crop land, in which the single crop is covered by 6.64% of the study area. 1.87% of area is covered by Fallow Land, 2.49% area covered by Agricultural Plantation, 62.60% area covered by natural vegetation, Waste land covered by 21.25% and 0.79% of area covered by Water bodies. It may help to further planning of watershed management planning effectively to development of that watershed area.

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Estimation of Soil Erosion in a Semi Arid Watershed by Revised Universal Soil Loss Equation (RUSLE) using Remote Sensing and GIS

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ABSTRACT

Soil is one of the most important natural resources on the earth upon which everyone's livelihood, well being and future prosperity depends. But in recent years, these resources are being subjected to rapid deterioration due to soil erosion. Vast areas of land now being cultivated may be rendered economically unproductive if the erosion of soil continues unabated. In order to protect the land from being degraded, it is very essential to estimate the soil loss and identification of critical areas for implementation of best soil conservation practices. The present study aims to estimate the soil erosion in a semi-arid watershed in Adilabad district of Telangana by RUSLE using Remote Sensing and GIS. The erosivity factor (R) was calculated using daily rainfall data of the period from 2001 to 2016. The soil erodibility (K) and conservation practice factor (P) were selected based on watershed features. Slope steepness factor (LS) was generated from flow accumulation and slope map. For detecting and interpreting the vegetation cover the MODIS NDVI images were used and then monthly C factor maps were generated. Considerable variation of C values was observed and corresponding soil loss was noted. The value of C factor was observed maximum during summer season (0.60) and minimum during mid *kharif* season (0.08). The annual soil loss varied from 2.31 t ha^{-1} yr^{-1} in 2007 to 35.02 t ha^{-1} yr^{-1} in 2013 with mean annual soil loss of 8.37 t ha^{-1} yr^{-1}. The spatial map of mean annual soil loss revealed that, considerable portion of the study area falls under the slight erosion category with the annual soil loss less than 15 t ha^{-1} yr^{-1} and very little portion falls under severe erosion category with the annual soil loss greater than 15 t ha^{-1} yr^{-1} and suitable soil conservation interventions were recommended.

Keywords: C-factor, NDVI, RUSLE, Soil loss.

INTRODUCTION

Soil and water are the two basic natural resources on which everyone's livelihood, well being and future prosperity depends. But in recent years, these resources are being subjected to rapid deterioration due to soil erosion. The removal of fertile soil from the upper layer resulting in the loss of soil nutrients and makes the soil unproductive, which in turn reduces the agricultural productivity at imperceptible rates over extended periods (Lal, 2003). The eroded soil particles from the catchment area increases the deposition of sediments in canals, farm ponds, lakes, rivers and reservoirs and thus reduce their storage capacity and water quality by contaminating the water with suspended soil, toxic materials and pesticides (Reddy *et al*., 2005). Soil erosion in India has a major effect on the agricultural sector, siltation of reservoirs, etc. About 85 % of land degradation in the world is associated with soil erosion. It has been estimated that in India about 5,334 Mt (16.4 t ha^{-1} yr^{-1}) of soil is being eroded annually due to various reasons and about 113.3 Mha of land is subjected to soil erosion due to water (Narayan and Babu, 1983), about 29% is carried away by the rivers into the sea and 10% is deposited in rivers resulting the considerable loss of the storage capacity. Hence, it is essential to control the rate of soil erosion. For planning interventions to conserve soil and water needs quantification of runoff and soil loss. But in India, these data are available only from limited sites, where gauging stations are installed. The major factors influencing the rate of soil erosion are climate, soil, vegetation and topography and cultivation practices.

Several models such as USLE/RUSLE, WEPP (Water Erosion Prediction Project), SEMMED (Soil Erosion Model for the Mediterranean Region), ANSWERS (Areal Nonpoint Source Watershed Environment Response Simulation), LISEM (Limburg Soil Erosion Model), EUROSEM (European Soil Erosion Model), SWAT (Soil and Water Assessment Tool), SWRRB (Simulator for Water Resources in Rural Basins), AGNPS (Agricultural Non-Point Source Pollution), etc., each with its own characteristics were developed to estimate the soil loss at catchment, regional and global scales (Rao *et al*.,2016; Rejani *et al*.,2016). The RUSLE has become dominant model applied for soil loss assessment at watershed scale because of its convenience in computation and applicability over large areas. This study was carried out to estimate the C- factor from NDVI and soil loss by RUSLE using remote sensing and GIS.

MATERIALS AND METHODS

Study area

The semi-arid watershed covering an area of 7756 ha is located in Adilabad district, Telangana and extends from 19°12′39″N to 19°18′57″N latitudes and 79°26′29″E to 79°34′53″E longitudes with elevation ranges from 123 to 259 m above mean sea level (Fig.1). It falls under Godavari River basin and receives an average annual rainfall of 1083 mm with 85 % of its contribution during southwest monsoon. The watershed is characterized by clayey textured soils with undulated topography having slope ranging from 0 to 26 degrees. The high intensity precipitations during south west monsoons over the undulated topography make the study area prone for soil erosion.

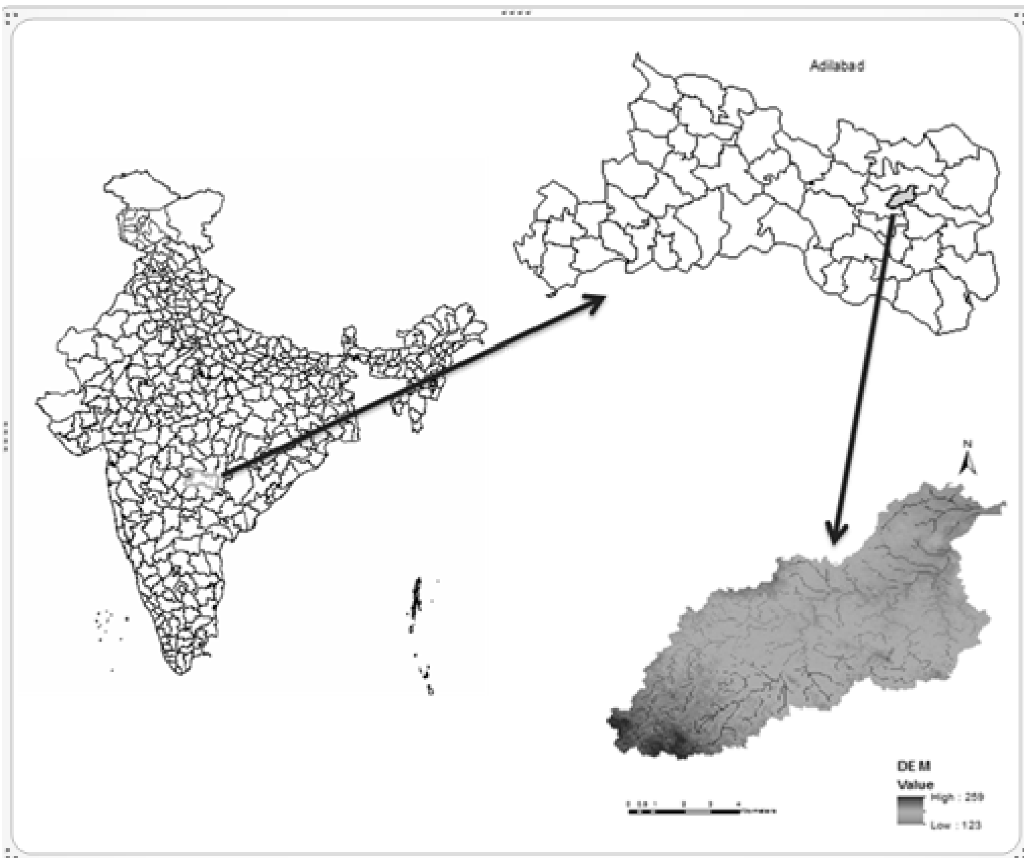

Figure 1 Location and digital elevation maps of the study area

Methodology

The spatial and temporal variation of soil loss from the semiarid watershed over 16 years was estimated using the Revised Universal Soil Loss Equation (RUSLE) combined with Remote sensing and GIS. RUSLE, which is a function of five factors: rainfall erosivity (R), soil erodibility (K), slope steepness (LS), cover management (C) and conservation practice (P). These factors vary over space and time (Prasannakumar *et al*., 2012). RUSLE (Renard *et al*., 1997) can be expressed as:

$$A = R*K*LS*C*P \quad \textbf{.....(1)}$$

where, A = Average annual soil loss ($t ha^{-1} yr^{-1}$)

R = Rainfall erosivity factor ($MJ\ mm\ ha^{-1}\ h^{-1}\ yr^{-1}$)

K = Soil erodibility factor (t ha h $ha^{-1}MJ^{-1}mm^{-1}$)

LS = Slope length-steepness factor (dimensionless)

C = Crop cover management factor (dimensionless)

P = Conservation practices factor (dimensionless)

Rainfall erosivity factor (R)

For this study, the daily rainfall data for the period from 2001 to 2016 collected from DES (Directorate of Economics and Statistics), Hyderabad. It was used to calculate R-factor from daily rainfall (Rejani *et al*., 2016).

Soil erodibility factor (K)

In this study, soil texture map was derived from the soil map prepared by NBSSLUP, Govt. of India and the soil texture was found to be clay and the corresponding soil erodibility factor (K) was selected based on the report of Reddy *et al*., 2005.

Topographic factor (LS)

The LS factor map was generated from slope and flow accumulation maps which are derived from ASTER DEM using the following equation (Rahaman *et al*., 2015; Rejani *et al*., 2016):

$$LS = [(\text{Flow accumulation} * \text{Cellsize})/22.13]^{m} * (0.065+0.045*S+0.0065*S^2) \quad \textbf{.....(2)}$$

where, S is the value of slope grid in percentage, cell size is the resolution of the DEM and m is dimensionless constant which depends upon slope.

Cover management factor (C)

The value of C factor depends on the type of vegetation and percentage of vegetation cover, which protects the soil by dissipating the raindrop energy before reaching soil surface (Patil *et al*., 2013). It varies from 0 for soils fully covered by vegetation to 1 for barren lands without any vegetation (Tirkey *et al*., 2013). Normalized Difference Vegetation Index (NDVI) is a best indicator for detecting and interpreting the vegetation cover and in the present study, MODIS NDVI images having spatial resolution of 250 m (MOD13Q1) was used. Then C factor maps were generated using the following expression in spatial analyst raster calculator.

$$C = \exp\left[-\alpha * \frac{NDVI}{(\beta - NDVI)}\right] \quad \textbf{....(3)}$$

where, α and β are dimension less parameters that determine the shape of the curve relating NDVI and the C factor and taken as 2 and 1 respectively from the literature (Lulseged Tamene and Quang Bao Le, 2015; Rejani *et al*., 2016). Monthly C factor maps were generated by taking the mean of every two composites of that corresponding month. Likewise, it was done for the period from 2001 to 2016 in order to estimate the spatial and temporal variation of C factor within the study area.

Conservation practice factor (P)

For the proposed study, the P factor was derived from the land use land cover map and the support practices followed in the selected area (Reddy *et al*., 2005; Rejani *et al*., 2016).

RESULTS AND DISCUSSION

Spatial and temporal variation of C-factor

From the land use land cover map (NRSC, Hyderabad) of the study area, it was found that major portion of the study area was classified under *kharif* crops followed by current fallows, plantations, scrubs and grass lands. Higher NDVI values were observed during the mid *kharif* season (i.e., in the months of August to September) and lower NDVI values were observed during summer season (March to June). The C factor varied spatially and temporally with corresponding variation in vegetation cover. The mean values of the C factor were ranged from 0.08 to 0.60. The lower C values (Fig. 2) were observed during mid *kharif* season (September to November) and higher C values (Fig.3) were observed during summer season (March to June).

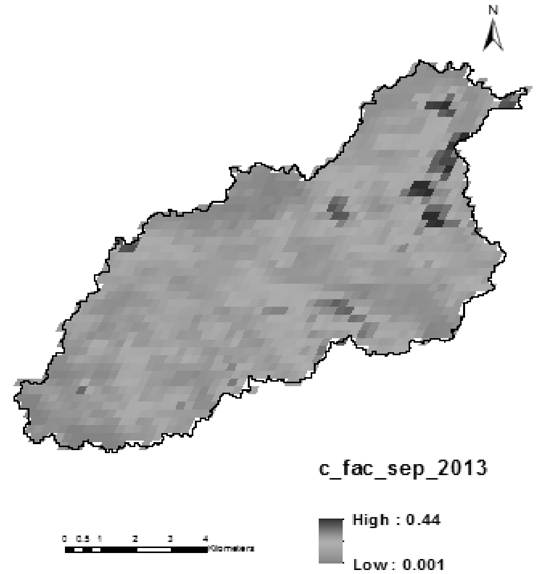

Fig. 2. C-factor map for the month of September

Spatial and temporal variation of soil loss

The annual rainfall was observed minimum as 701 mm in 2002 and maximum as 1959 mm in 2013. Results inferred that, the values of erosivity increases with increase in annual rainfall and vice-versa (Fig.4). The annual erosivity of the study area varied from 5956.65 to 63,446 MJ mm $ha^{-1}h^{-1}yr^{-1}$ in the years having lowest (2002) and highest rainfall years (2013) with a mean erosivity of 16,864.35 MJ mm $ha^{-1}h^{-1}yr^{-1}$. The soil erodibility factor (K) was taken as 0.032 t ha h ha^{-1} MJ^{-1} $mm^{-1}$and the slope of the study area varied 0 to 26^{o}. Major part of the watershed is having flat slopes less than 5^{o}. The steepness factor (LS) map was derived using the equation (2) by considering the value of dimensionless constant 'm' as 0.3 and it was found that LS factor varied from 0 to 4.62. In the study area contour bunding is under practice as soil conservation measure and hence, the conservation practice factor (P) was taken as 0.28. Then, spatial and temporal variation of the soil loss over the period of 16 years was estimated and results indicated that the annual soil loss varied from 2.31 t ha^{-1} yr^{-1} in 2007 to 35.02 t ha^{-1} yr^{-1} in 2013 with mean annual soil loss of 8.37 t ha^{-1} yr^{-1} (Fig.5).

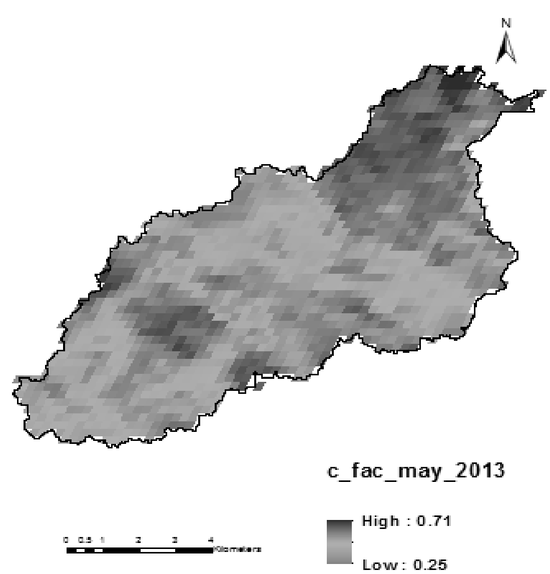

Fig. 3 C-factor map for the month of May

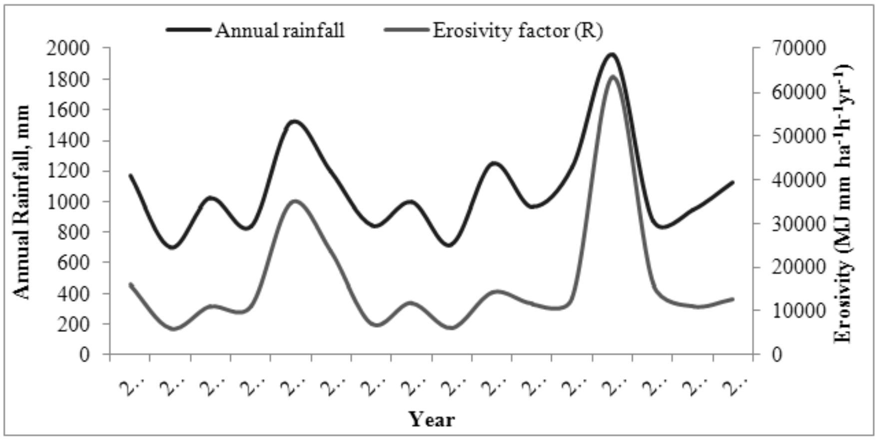

Fig. 4 Temporal variation of annual rainfall and erosivity over the period from 2001 to 2016

Considerable portion of the study area is having the annual soil loss less than 15 t ha^{-1} yr^{-1}which falls under the slight erosion category and very little portion is having the annual soil loss greater than 15 t ha^{-1} yr^{-1} and falls under severe erosion category due to undulated topography and high intensity precipitations.

CONCLUSION

From the study, it can be concluded that major portion of the catchment area fall under soil loss less than 15 t ha^{-1} yr^{-1} and very little portion is under severe erosion, which has to be arrested for sustainable management of watershed. It can be achieved by adopting soil conservation interventions such as graded bunds, vegetative bunds and drop structures to check the erosion and to conserve soil moisture, water harvesting structures like farm ponds can be adopted.

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Investigating the Effect of Size of the Training Sample on SVM, ANN and SAM Algorithms on Hyperion Data for LULC Classification

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ABSTRACT

Digital image classification has an important role in extracting the categorical information from the image resulting in thematic maps which act as primary inputs for many land related studies. However the accuracy of the thematic map produced from digital classification depends on many factors like classification algorithm, parameters used in the classifier, size of the training samples etc. The spectrally rich images obtained from space borne hyperspectral sensors contain many mixed pixels due to their moderate spatial resolution and narrow band widths. Acquiring too many pure pixels from the hyperspectral image for training these datasets is a challenging task. In the present work, the space borne hyperspectral data - Hyperion has been tested with four well known classifiers Spectral Angle Mapper(SAM), Support Vector Machine(SVM) and Artificial Neural Networks(ANN) with training samples of various sizes - 5, 10, 20, 30 and 50. The test was conducted twice - initially for classifying 5 classes and later for classifying 15 classes. The purity of the training samples collected was tested using Jaffari's Mathusita transformed divergence method. Analysis of the results obtained have shown that Support Vector Machine classifier gave accurate thematic maps with higher accuracies with minimum number of training samples. This shows the superiority of statistical learning theory based SVM classifier over MLC and ANN classifiers in complex and heterogeneous environments where many pure pixels are not available for training the dataset.

Keywords: Image classification, Training sample size, SVM, ANN, SAM, Statistical analysis.

INTRODUCTION

The advent of space borne hyperspectral(HS) sensors brought a substantial change in the classification levels of land use land cover maps. These HS sensors cover a considerable swath area with moderate spatial resolution and narrow contiguous spectral bands. This combination of spectral and spatial properties leads to high correlation between the values in the neighboring pixels and neighboring bands. Many new advanced classification techniques like Spectral Angle Mapper, Artificial Neural Networks(ANN), Support Vector Machines(SVM), Spectral Informed Divergence(SID), linear and non-linear unmixing(LUM) have been developed which can efficiently classify the HS datasets compared to the conventional classifiers The SAM, SVM,ANN and SID classifiers fall in the category of per pixel classifiers which assign each pixel into one and only one class. On the other hand sub-pixel classifiers like fuzzy C-means, linear unmixing give the proportions of each class within a pixel. However the performance of sub pixel and per pixel classifiers varies with the purity and size of the training sample. It is a general consideration that there exists a strong relationship between the accuracy of the classified map and the training samples used in the learning stage of the supervised classification method (Zhuang et al., 1994; Foody, 2006; Pal and Foody, 2010). Selection of pure pixels from a space borne hyperspectral image is a challenging task due to the high spectral variability and moderate spatial resolution which leads to mixed pixels in the image.

Mahesh and Mather 2006 have studied the sub-pixel classification of hyperspectral DAIS and Landsat-7 ETM+ data applying four algorithms (such as, maximum likelihood, decision tree, artificial neural network and support vector machine) and made the comparison of accuracy assessment, for the area of La Mancha Alta, South of Madrid, Spain. They conclude that no reduction in classification accuracy was observed as the number of bands was increased, even with the small training data set of 100 pixels per class. However, classification accuracy starts to stabilize once a threshold number of bands are reached. The SVM produce higher classification accuracies than others with small training data setsT. Kavzoglu et.al 2012. The effect of using different sampling plans was investigated and it was found that ML classifier produces higher classification accuracies when the training data were sampled randomly than those achieved using a systematic sampling plan. Both sampling plans produced similar results with SVM, SAM and ANN.

Aziz, M.A. 2004 has evaluated the soft classifiers for multispectral remote sensing data, and this study has focused on two statistical classifiers; maximum likelihood classifier (MLC) and linear mixture model (LMM), two fuzzy set theory based classifiers; fuzzy c mean (FCM) and probability c mean (PCM) and two neural network classifiers; back propagation neural network (BPNN) and competitive learning neural network followed by learning vector quantizers (CLNN-LVQ).

Mahesh and Mather 2003 have done support vector classifiers for land cover classification. They have studied for two project areas. The classification involved a multispectral ETM+ data and Hyperspectral DAIS datafor classifying seven and eight classes respectively. A radial basis kernel with penalty value C=5000 is used for both data sets. The parameters were chosen after a number of trials. Results obtained using ETM+ data suggests that the SVM classifier performs well in comparison with ANN and MLC. Further the training time taken by SVM is 0.3 minutes in comparison of 58 minutes by the ANN on a dual processor machine. The performance of SVM is statistically significant in comparison with ANN and MLC classifiers. Results obtained from analysis of hyperspectral data suggested that the accuracy of SVM classifier increases almost continuously as a function of number of features, with the size of training data set held constant, whereas the overall classification accuracies produced by the ML, DT and ANN classifiers decline slightly once the number of bands exceeds 50 or so. The level of classification accuracy achieved by SVM classifier is better than both MLC and ANN classifiers when used with small number of training data.In the present study three different per pixel classifiers SAM, ANN and SVM were tested using varying sizes of training samples -5, 10, 20, 30, 50 and 100. The parameters of all the three classifiers were optimized using trial and error method.

Study Area and datasets

The area chosen for this study is a part of Dehradun city which is situated in the south central part of Dehradun district of Uttarakhand State, India. The area falls between 30°20"N and 77°05"E. The entire study area has an average elevation of 709km with 50% covered by various vegetation species like sal, mango, tea, shrubs, fallow landsand different croplands in the northern part, 30% occupied by urban area covered in the southern part and the remaining encompassed by river bed, water bodies etc (Fig. 1). The urban pattern in Dehradun city is rather scattered and irregular. A seasonal river named Tons flows from North East to South West direction.

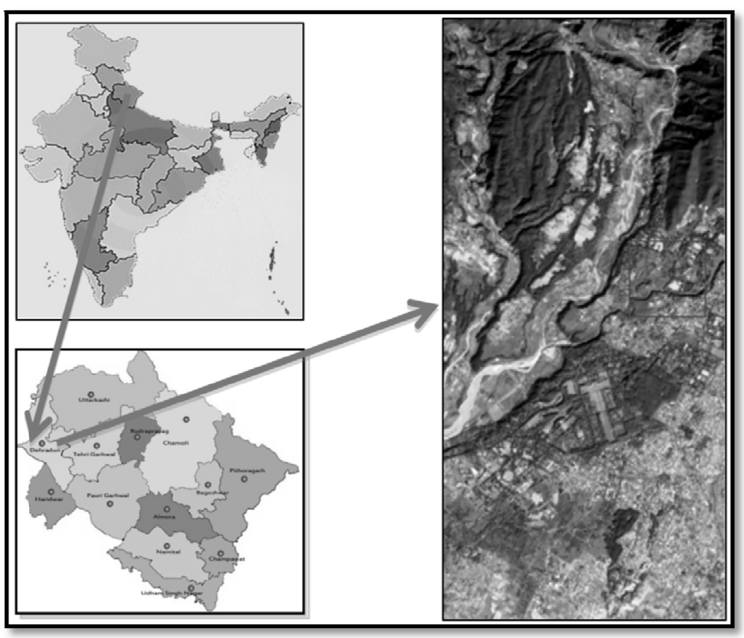


Fig. 1 Study area

The Hyperion Hyperspectral data of NASA was used for the current study. Hyperion is push broom sensor on board the EO -1 platform. It has a spatial resolution of 30m with a spectral resolution of 10nm and a radiometric resolution of 14bits.

Table 1 Technical specifications of Hyperion data

Specifications	Hyperion
Sensor	Push broom
Date of pass	2 Dec 2009
Spatial Resolution	30m
Spectral resolution	242 bands (400-2500nm)
Swath	7.5km
Temporal resolution	209days
Radiometric resolution	14bit
Sensor altitude	705km
Band width	<10nm

Methodology

The present study focuses on analyzing the performance of three different classifiers on Hyperion data with varying size of the training sample. The Hyperion image was initially pre-processed to correct the radiometric errors like bad lines and band removal. The bad lines observed in the image are replaced by the average of the neighboring columns. The radiometrically corrected image contained 143 bands and is used as input into FLAASH tool for converting into reflectance. The atmospheric model was set to tropical and aerosol model to rural. Visibility was kept at 40.0km and water absorption band of 1135nm was used. The image thus obtained is dimensionally reduced using Minimum Noise Fraction method. Equal number of training samples were randomly collected from the image. Care was taken that the samples were distributed throughout the image. The collected training samples were used as input for classification. The parameters for each of these classifier were fined tunedto give the best results. The accuracies of the each of the classified maps were tested using confusion matrix method. The flowchart for the study is given in fig. 2.

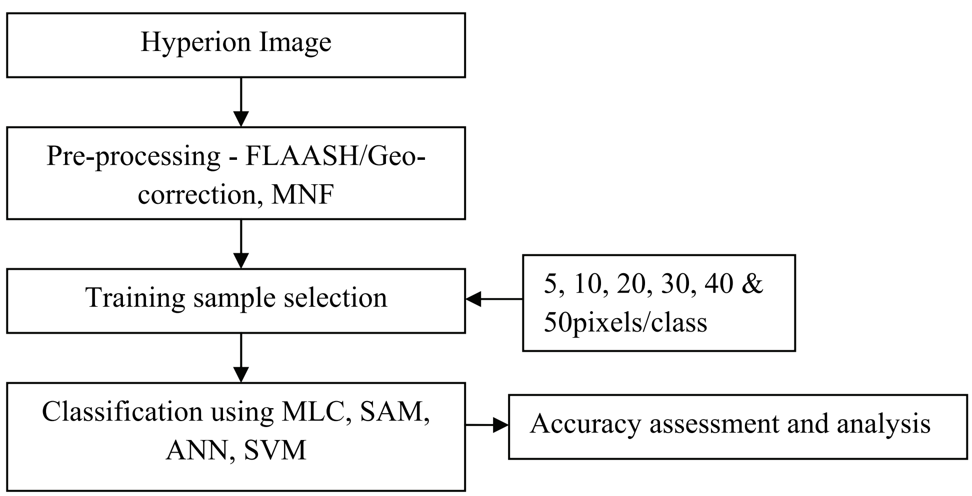


Fig. 2 Methodology

Optimum parameter identification for SVM, ANN and SAM classifiers

The algorithms chose in the present work are based on different principles like - one learning algorithm (ANN), one statistical learning theory based algorithm (SVM) and one statistical algorithm (SAM). Each of these classifier depends on different parameters which require fine tuning based on the study area and image properties. The ANN algorithm requires proper selection of training parameters which are taken from Azim M.A.2004 (Azim M.A. 2004 unpublished Ph.D thesis, IIT Roorkee) and A.Kumar et.al., 2008 (Table 2). SVM algorithm has four different kernels - linear, polynomial, Radial Basis and Sigmoid kernels and requires fine tuning of the penalty parameter value *C*. The penalty value allows certain error in the classification results. Hence, a kernel that yields a good accuracy with minimum penalty is considered to be the best kernel. A standard penalty value of 100 is used for all the four SVM kernels and tested.

Table 2 Parameters used for ANN classifier

Training threshold	0.9
Hidden layers	1
Training momentum	0.5
Training rate	0.2
RMSE Exit criteria	0.01
No. of training iterations	100

RESULTS AND DISCUSSIONS

Fig. 3 shows the results from FLAASH atmospheric correction model. The results obtained were compared with field spectra obtained using ASD field spec spectroradiometer. The minimum fraction dimensionality reduction method reduced the unwanted noise in the image. The first 17 bands were used for inverse MNF transform. The SNR has increased from 0.765 to 0.844 after MNF transform.

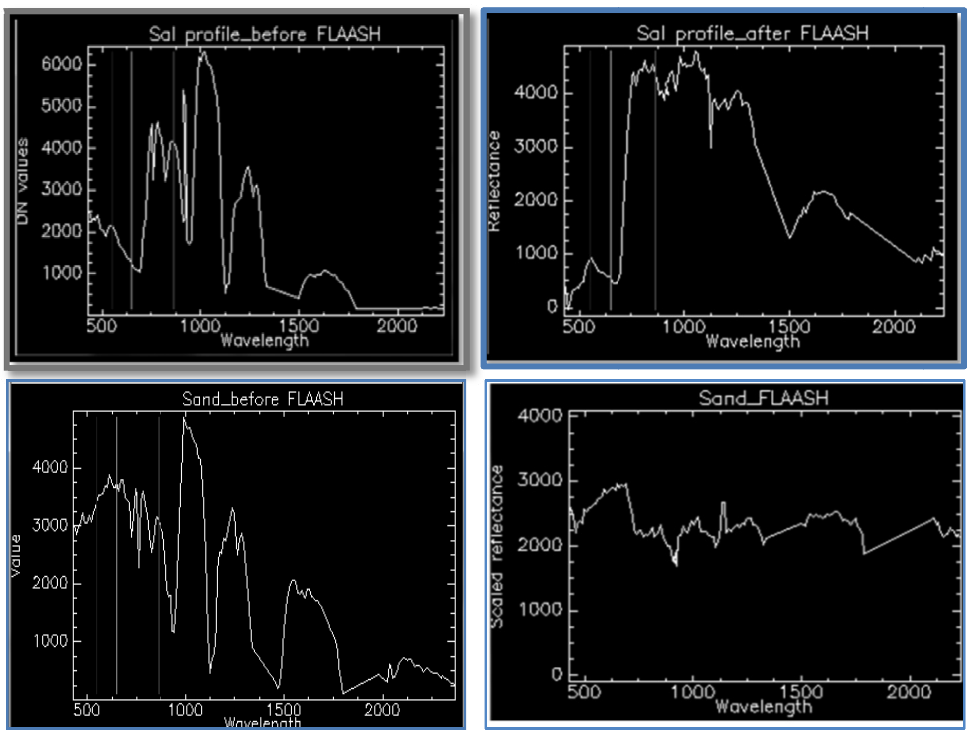


Fig. 3 Spectra profiles of Sal and Sand before and after atmospheric correction.

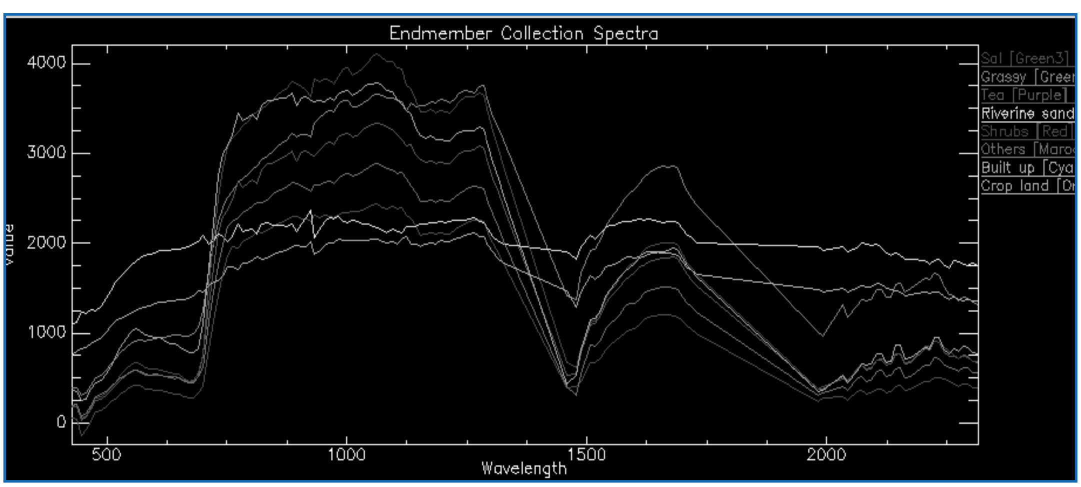


Fig. 3 End member spectra

Fig. 4 shows the spectral profiles of various end members collected from the image. Six different classes were considered for the study and the training pixels were collected from the image. Only a few classes were selected in order to avoid confusion in analyzing the results.

SAM results for 5,10,20,30,50 and 100 training pixels

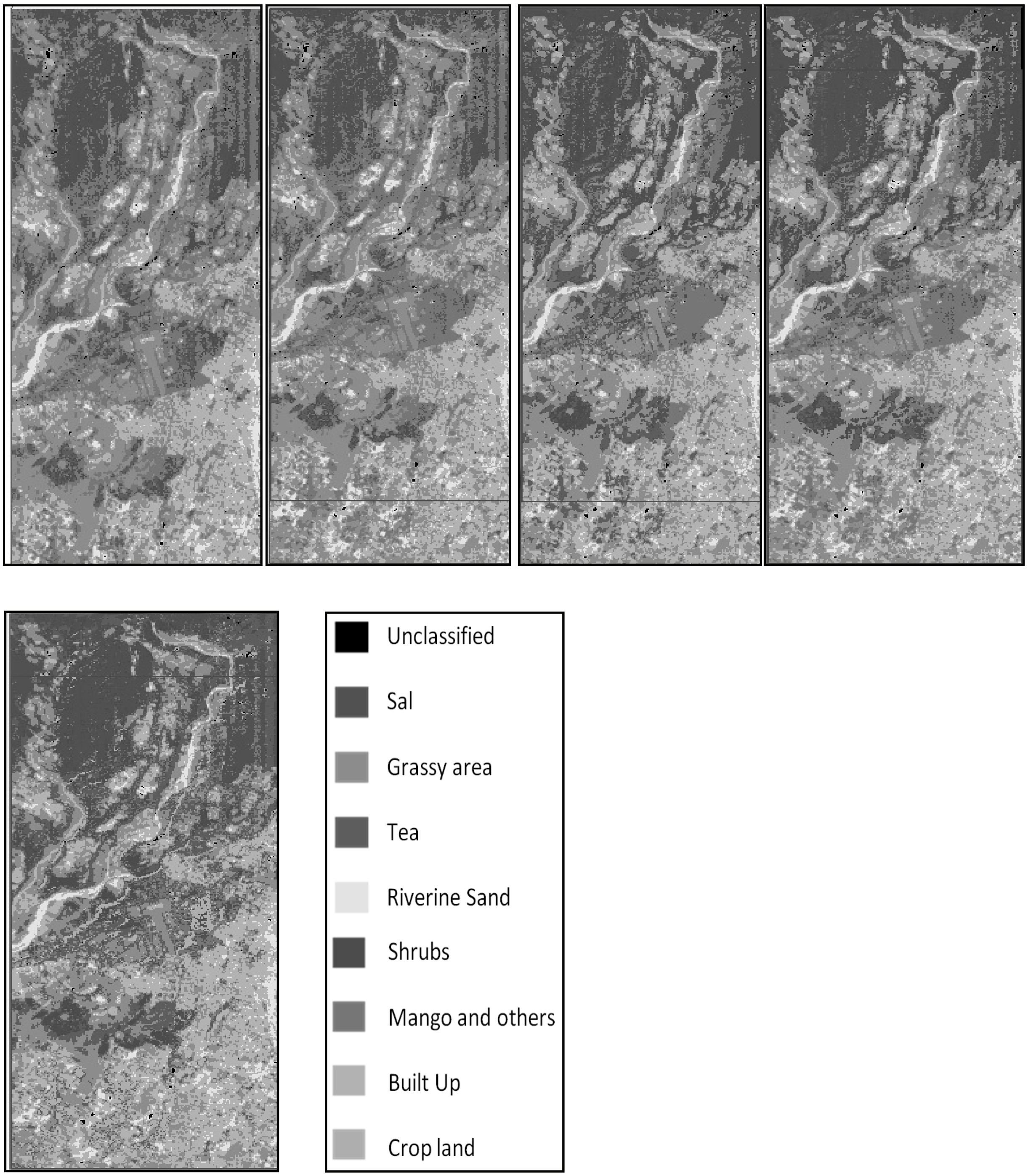
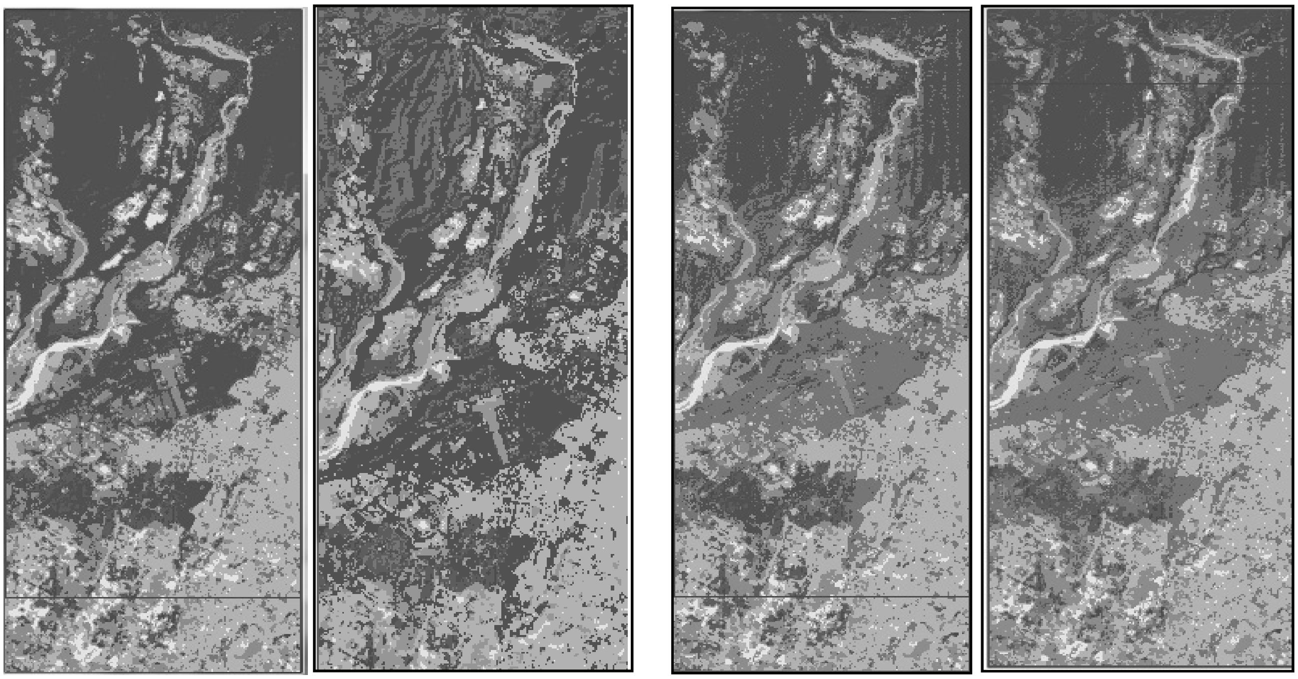


Fig. 4 Classification of the image using SAM classifierfor 5, 10, 20, 30, 50 and 100 training samples

SVM results for 5,10,20,30,50 and 100 training pixels



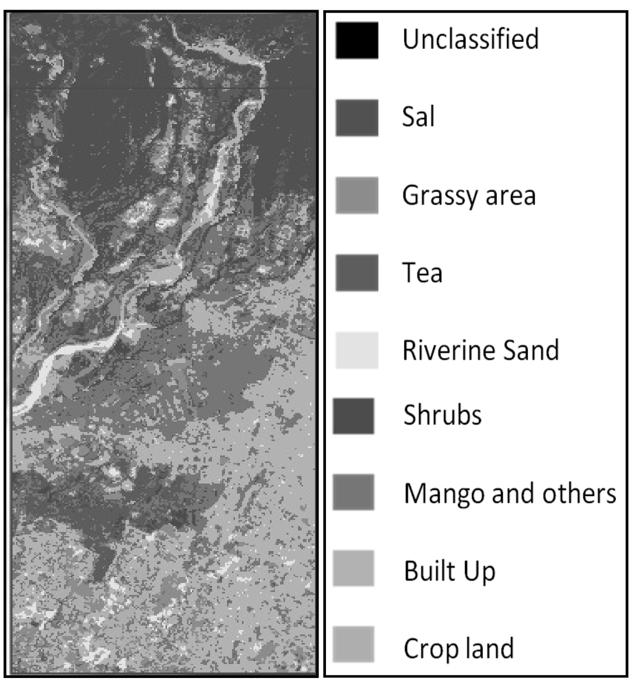
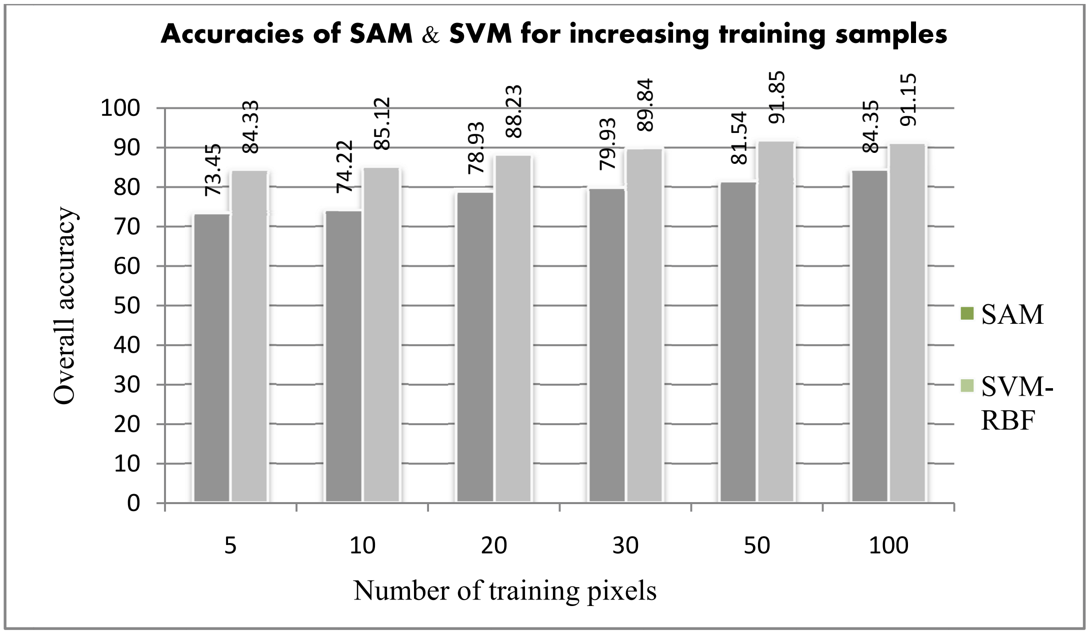


Fig. 5 Classification of the image using SVM classifiers with RBF kernel for 5, 10, 20, 30,50 and 100 training samples

CONCLUSIONS

The study evaluates the performance of SAM, ANN and SVM classifiers with increasing size of the training samples. SVM classifier with RBF kernel gave an accuracy ranging from 88.33% to 91.85% while SAM gave an accuracy of 73.45% to 84.35% (Table 3). The Artificial Neural Network classifier failed to train the neural network with very few training samples and requires more number of training samples for classification. The MLC classifier requires a minimum of 10*n (n number of bands) of training samples which is not possible to acquire using Hyperion data. The performance of the SAM classifier increased with increasing size of the training sample. The SVM classifier also showed a similar trend but gave higher accuracies than SAM classifier. Confusion were mostly seen between sal, shrubs and mango classes. The river sand and urban classes also had few confusions in SAM classification and SVM with 5 training pixels. However, it was observed that, since Hyperion data does not contain too many pure pixels, an increase in training sample size for SVM algorithm lead to confusions and slight decrease in the overall accuracy due to increased mixed pixels in the training samples.

Table 3 Overall accuracies of SAM and SVM classifier with increasing training samples.



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Satellite Remote Sensing of the Impact of Aquaculture on Environment

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ABSTRACT

Aquaculture, also known as fish or shellfish farming refers to breeding, rearing and harvesting of plants and animals in all types of water environments including ponds, rivers, lakes and the ocean. It has deleterious effects on the environment by way of altering the nutritional regime and incorporation of unutilized feeds and excreta of the aquatic animals. An approach termed as Ecosystem Approach to Aquaculture (EAA) has been advocated and being implemented by the Food and Agriculture Organizations of the United Nations (FAO) for sustainable development of aquaculture. The implementation of this approach calls for the use of a host of methodologies and tools including EIA and risk analysis. The satellite remote sensing by virtue of providing synoptic coverage of an area in discrete spectral bands of electromagnetic radiation at regular interval offers the immense potential in deriving the desired information for EAA. Realizing the role of remote sensing in this endeavor, time series Landsat data were used to monitor the spatio-temporal behavior of aquaculture in part of coastal Andhra Pradesh, southern India. The approach involves database preparation including geo-referencing and radiometric normalization, on-the-screen visual interpretation of space borne multispectral and multi-temporal images. The results indicate the exponential growth of aquaculture in the region over a period of time.

Keywords: Aquaculture, Landsat, Radiometric normalization, Ecosystem Approach to Aquaculture (EAA).

INTRODUCTION

Aquaculture, the farming of aquatic organisms, particularly fish and shell fish, represents some 25% of food fishery supply, and is expected to contribute an increasing share to meet the world's future food needs. In India, brackish water aquaculture is widespread in the East Coast, in the States of West Bengal (traditional *bheries*), Andhra Pradesh, Orissa and Tamil Nadu. Along the West Coast, Kerala has dominant traditional system of paddy-cum-shrimp culture, followed by traditional systems in Karnataka and Goa. Rapid expansion of coastal aquaculture has serious environmental and socio-economic consequences, namely large-scale removal of valuable coastal wetlands, salinization of ground water and agricultural lands, and subsequent loss of goods and services generated by natural resource systems (Chua, 1992). In addition, concentrations of copper and barium tended to be higher in freshwater than in brackish waters. The chemical constituents tended to be more abundant in the soils of brackish water ponds than in those of freshwater ponds (Boyd et al., 1994). Corea et al. (1995) have observed relatively high concentrations of sulfides, nitrites and ammonia in the effluents discharged from prawn farms. Precipitation of iron pyrite in anaerobic soil layers was the apparent cause of sulphur accumulation in older ponds. In addition, the accumulation of phosphorus in older ponds has been observed where heavy doses of fertilizer were applied (Munsiri et al., 1996). Practices that are environmentally safe, technically appropriate, economically viable and socially acceptable should, therefore, be promoted through integrated planning and management within the framework of sustainable coastal zone management.

Shrimp and prawn farming have grown rapidly in recent years in many tropical and sub-tropical countries, but there have been setbacks resulting from diseases and the growing awareness of the environmental and social impacts of shrimp farming. Inventory and monitoring of shrimp farms are essential tools for decision-making on aquaculture development, including regulatory laws, environmental protection and revenue collection. In the context of government's aquaculture development policy, the attention has to be focused on identification and monitoring of the expansion of shrimp farms, often located in remote areas. However, reliable and timely information on the nature, extent, spatial distribution pattern and temporal behavior of degraded lands including those subject to aquaculture, which is a pre-requisite for their reclamation and management, is not available. The study was taken up to study the feasibility of delineating to assess the feasibility of generating the information on aquaculture in part of coastal Andhra Pradesh, southern India using Landsat-TM, Landsat-8 Operational Land Imager (OLI), SPOT-MLA and IRS-1C/-1D-LISS-III and PAN data.

ROLE OF REMOTE SENSING

Initially, aerial photographs have been used for detection of wetlands. Carter et al. (1979) concluded that seasonal colour infrared photographs provide sufficiently detailed information to delineate wetland areas as small as 0.5ha in size and 20m in width. Carter and Stewart (1977) and Moore and North (1974) have reported the use of high altitude colour infrared photographs to document surface water boundaries. In Bangladesh both black and white and infrared colour aerial photographs have been used for delineation and monitoring the spatial extent of shrimp farming (aquaculture) areas (Quader *et al.,* 1986; Shahid et al., 1992). Additionally, spaceborne multispectral data from Multispectral Scanner System (MSS), Thematic Mapper (TM) aboard Landsat series of satellites, and Multispectral Linear Array (MLA) aboard SPOT-1 covering parts of Bangladesh have also been used to identify the clusters of shrimp farming and concluded that the area under shrimp farming registered an increasing trend. While inventorying and monitoring shrimp cultivation using aerial photos, Landsat MSS and SPOT data**,** Shahid *et al* (1992) observed an increase in the spatial extent of shrimp cultivation areas which is extending into paddy lands. Li et al. (1995) showed that wetland identification is possible using either Landsat TM or multi-temporal European Remote Sensing satellite (ERS-1) data, but that the accuracy increases when the two image types are used in combination.

The temporal behavior of aquaculture has also been studied by various researchers. In Thailand, using temporal Landsat data, Vibulsresth *et al*. (1993) reported a decreasing trend on the order of 1.49 % in the area under mangroves during the period 1991 and 1992 due to sudden spurt in shrimp farming**.** In India, Venkataratnam *et al*. (1997) analysed temporal satellite data for the periods 1973, 1985, 1990 and 1992 over coastal Andhra Pradesh, southern India, and noted an increasing trend in the area under prawn cultivation. Honhoulis and Michener, (2000) delineated wetlands through a rule- based approach using ancillary information, such as National Water Inventory (NWI) and SPOT-XS data. Tripathi et al. (2000) found the Landsat-TM data useful for delineation of active and abandoned shrimp farming in Thailand.

STUDY AREA

The vicinity of Kaikalur town of Krishna district, coastal Andhra Pradesh, southern India, extending between 15^{o} 53' 53" to 16^{o} 05' 03" N and between 80^{o} 53' 05” to 81^{o} 03' 57” E was selected for realizing the objectives of the study. Earlier, the major portion of the test site was under paddy cultivation and the rest supported mangroves that have been subsequently converted into aquaculture ponds.

3.1 Database

The Landsat-TM and Landsat-OLI (Operational Land Imager), SPOT-MLA and IRS-1C LISS-III digital data were used to delineate and monitor the temporal changes in the spatial extent and distribution pattern of aquaculture. Besides, IRS-1C LISS-III and PAN-merged digital data were used to study the details within the areas where aquaculture is practiced.

Table 1 Details of Remote Sensing data used

Sl. No.	Satellite - sensor	Path - Row	Date of Acquisition
1	Landsat-TM	142/48	19-3-1986
2	SPOT-MLA	219/324	22-2-1989
3	IRS-1C LISS-III	103/61	29-5-1996
4	IRS-1C PAN	103/61B	29-5-1996
5	IRS-1D LISS-III	103/61	09-2-2001
6	Landsat-OLI	142/49	19-2-2016

APPROACH

The approach essentially involves database preparation and systematic on-the–screen visual interpretation of both concurrent as well as historical space-borne multispectral and multi-temporal digital data. Various steps involved are discussed hereunder:

4.1 Database Preparation

Preparation of database involves generating of sub-set of satellite data covering study area, geo-referencing, radiometric normalization and data fusion.

4.2 Geo-referencing

To begin with, the IRS-1C LISS-III data of the test site acquired during May, 1996 was digitally co-registered to Survey of India topographic maps at 1:50,000 scale and resampled to 24m spatial resolution using first-order polynomial transform on a Silicon Graphics work station using ERDAS/ IMAGINE version 2015 software. The digital data, thus generated, was used as a reference for geo-referencing other satellite data sets of 1986, 1989, 1996, 2001 and 2016 periods.

4.3 Radiometric Normalization

Initially, the Digital Numbers (DN's) values were converted into radiance values using the gain settings and saturation radiance values provided in the satellite data header / supplied by the NRSA Data Centre (NDC) for IRS-1C LISS-III and SPOT-MLA sensors. For Landsat-TM images, the values provided by Markham and Barker (1986) were used. Later, corrections for sun elevation angle variations using cos θ correction (where θ is the sun elevation angle) were made. Subsequently, all the radiance values were re-scaled using a common linear scaling factor.

$$L_{\lambda} = LMIN_{\lambda} + \left(\frac{LMAX_{\lambda}}{QCALMAX}\right) QCAL \qquad \text{.....(1)}$$

Where,

QCAL = Calibrated and quantified scaled radiance in units of DN, digital numbers

$LMIN_{\lambda}$ = Spectral radiance at QCAL=0

$LMAX_{\lambda}$ = Spectral radiance at QCAL= QCALMAX

QCALMAX = Range of rescaled radiance in DN

L_{λ} = Spectral radiance

4.4 Preliminary Visual Interpretation

On-the-screen visual interpretation approach was employed for delineation of aquaculture areas. Not only image elements but also the associations in terms of terrain conditions were taken into consideration while delineating aquaculture areas. In general, both prawn as well as fish cultivation, involve stocking of water. Such areas are clearly discernible on the image with a characteristic spectral response of water girdled by well-laid regular- shaped field bunds, and are associated with field channels and drains.

4.5 Ground Truth Collection

The field validation studies carried out by national Remote Sensing (NRSC) agency to prepare aquaculture map and to study there spatio-temporal behavior was taken as a reference for our study.

4.6 Map Finalization

Initially, the spaceborne multispectral data of 1986 were displayed onto colour monitor of Silicon Graphics workstation and the areas where aquaculture is practiced were delineated manually as the vector coverage vis-a-vis ground truth. Subsequently, the coverage has been duplicated and overlaid onto the 1988 data and the changes in the spatial extent of aquaculture areas, if observed, were made. Similar exercise was carried out for other period datasets too. These vector coverages were then suitably annotated and topologically corrected.

RESULTS AND DISCUSSION

The results of the study are reported in the following two sections. The first section addresses the delineation of aquaculture from satellite data and the second with their temporal behavior.

5.1 Delineation of Aquaculture Ponds

As mentioned earlier, since aquaculture ponds contain water and have a regular shape, using satellite images, such areas could be easily delineated by their characteristic spectral response pattern. As evident from the LISS-III image (Fig.2-c), the clusters of aquaculture ponds are seen in different shades of the blue color. Croplands are seen in different shades of red colour. Settlements and fallow lands appear as irregular-shaped cyan color features. However, further categorization of aquaculture areas into prawn farming areas and fishponds could not be achieved owing to similarity in their spectral response patterns.

5.2 Temporal Behavior of Aquaculture Ponds

As mentioned earlier, the areas with aquaculture ponds were delineated through on-the-screen visual interpretation as a vector layer and labeled as aquaculture. The rest of the land use/land cover categories were merged into one category, which was labeled as "other areas". As could be seen from Landsat-TM standard False Color Composite (FCC) print of 1986, aquaculture is confined to north-west and west of Kaikalur town and to bottom right of the image (Fig-1: a). With the advancement of time from 1986 through 1988, 1997 and 2001, the growth of the aquaculture has been both south and south-eastward in case of the area north-north-west and west of Kaikalur whereas it has been towards north and north-westward in the bottom right of images (Fig-1).

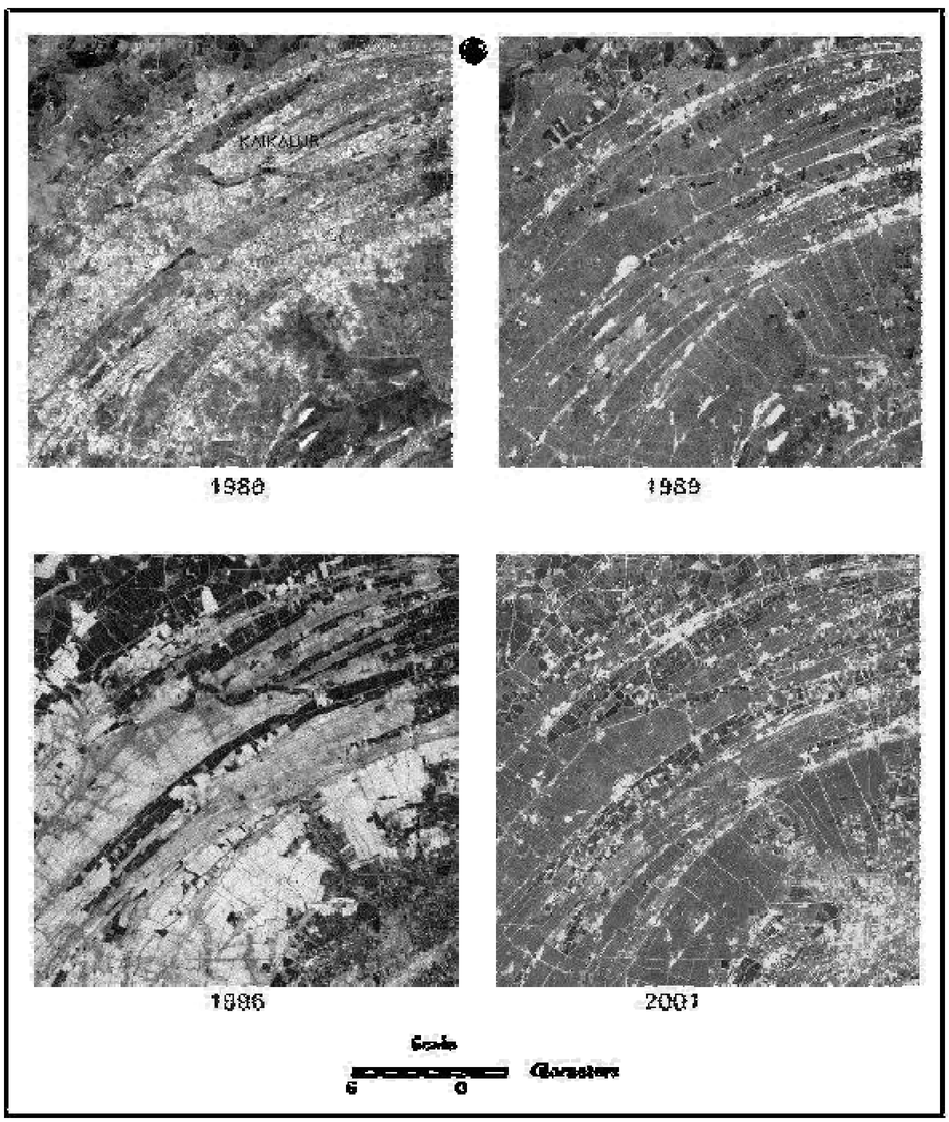

Figure 1 Illustrates the satellite images of aquaculture a) 1986, b) 1989, c) 1996 d) 2001.

The area statistics of aquaculture areas was subsequently generated for all the four periods. It is amply clear from the satellite images that a very large chunk of crop land especially paddy lands have been converted into aquaculture. A comparison of the area under aquaculture during the period 1986 to 2001 reveals more than five-fold (3,250 ha in 1986 versus 17,674 ha in 2001) increase in its spatial extent during 15 years period as 18,910 ha in 2016. The increase, as pointed out earlier, has been at the cost of paddy lands. Such a phenomenon is highly deleterious to the environment especially surface and ground water apart from soils.

Table 2 Temporal behavior of aquaculture

Sl. No.	Year	Area (ha)
1	1986	3,250
2	1988	4,789
3	1997	15,531
4	2001	17,674
5	2016	16,689

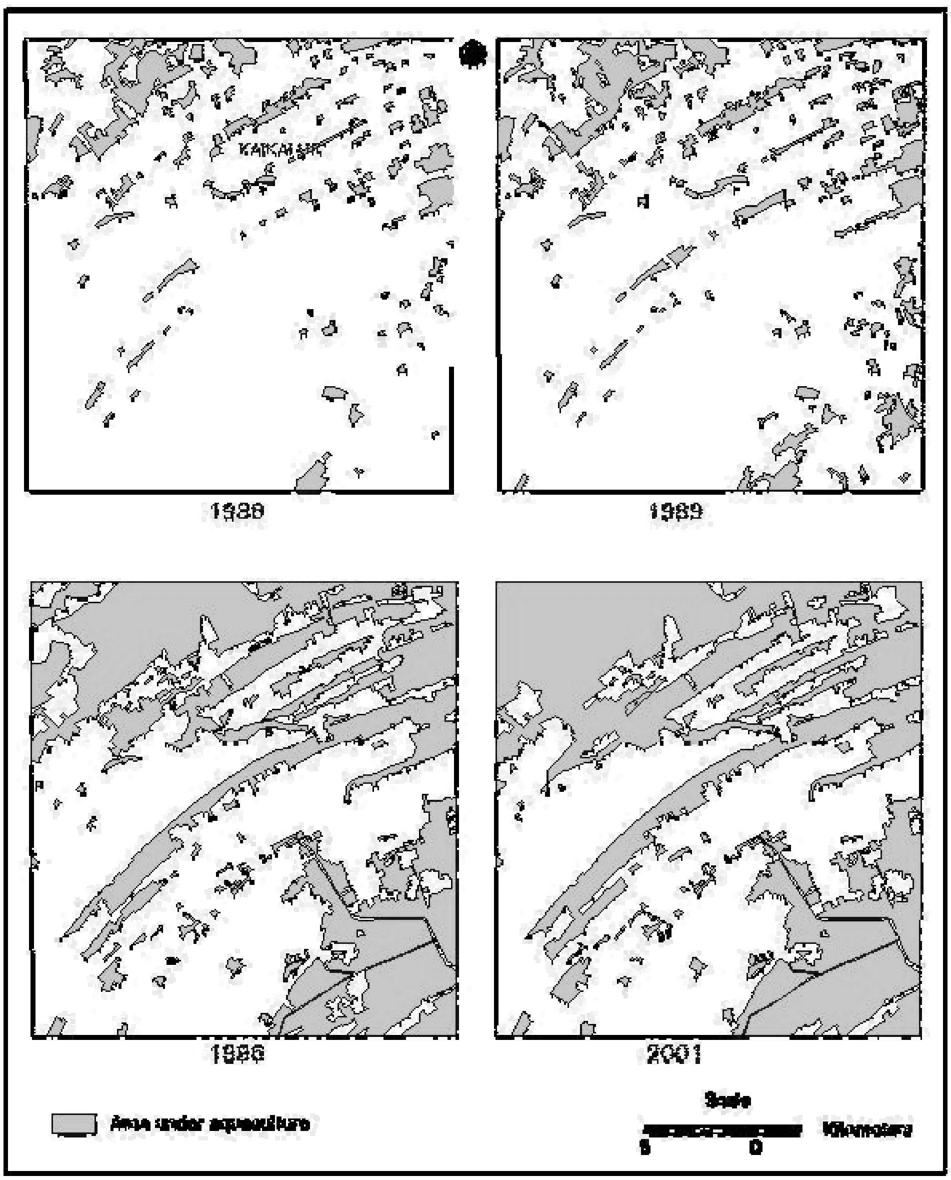

Figure 2 Illustrates the area under aquaculture (a) 1986, (b) 1989, (c) 1996 (d) 2001

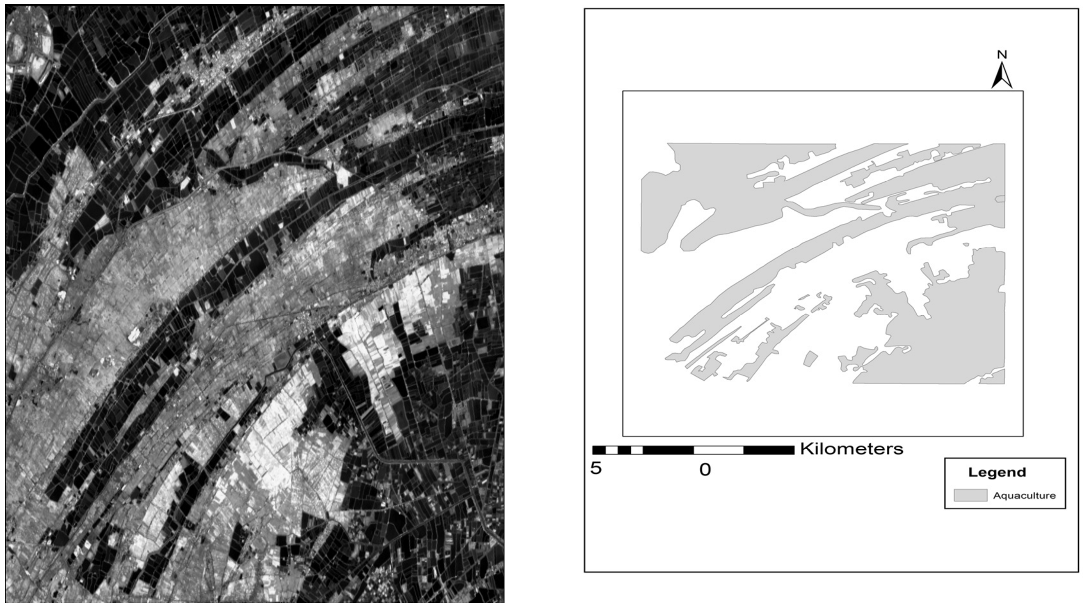

Figure 3 Aquaculture in 2016 in a Landsat 8 OLI satellite image

CONCLUSIONS

By virtue of characteristic spectral response pattern and association with the channels/ drains and mangroves, the aquaculture areas are amenable to detection using spaceborne multispectral data. The multi-temporal spaceborne multispectral data enable studying the temporal behaviour of aquaculture areas. In the current study the ponds are delineated based on digitization and labeling of pond boundaries. The temporal study of the extent of spatial distribution of aquaculture during the period of 1986-2016 shows an increasing trend in the area under aquaculture till 2001 and thereafter due to awareness of the public about its ill effects has been shrinkage in the area under aquaculture ponds. However, developments in edge detection and object delineation based on shape could help automated detection of the fish and prawn ponds. The Geographic Information System (GIS) may facilitate integration of spatial and attribute information on soil properties for modelling the impact of aquaculture on environment.

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Spatio-Temporal behavior of Waterlogging using Multi-Temporal Satellite Data

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ABSTRACT

Waterlogging refers to a soil condition whereby excess water in the root zone inhibits gas exchange with the atmosphere. Waterlogging and consequent salinization and alkalization are the major land degradation processes operating upon in the arid and semi-arid regions of the world. With an increase in area under irrigated agricultural land, and with the adaptation of flooding system of irrigation, and poor sub-surface drainage, there is a significant increase in the spatial extent of water logged areas. The water table which affects adversely the yield of agricultural crops, varies depending upon rooting zone of crops for shallow rooted crops like rice, potato, cauliflower, cabbage, lettuce, onion, etc., the root zone depth is taken as 60 cm whereas for moderately deep rooted crops like wheat, groundnut, musk melon, carrot, peas, beans, chillies, etc., it is 90 cm. For deep-rooted crops like maize, cotton, sorghum, pearl millet, soybean, sugarbeat, tomato, etc., it is 120 cm, and for very deep-rooted crops like sugarcane, citrus, coffee, apple, grape, wine, sunflower, lucern, etc., it is 180 cm. The water table within above mentioned depths may have adverse effects on crop growth and yield. Taking into account the details of norms followed by different states, rooting depths of different crops under different soil and fringe areas of water table which affect the upper layer of the soil due to capillary action/evaporation, the Working Group of the Ministry of Water Resources (Anonymous, 1991) has adopted the following norm for irrigated lands as: Waterlogged areas - for Water table within 2 meters of the land surface, Potential areas - for Water table between 2-3 m below land surface, Safe areas - as Water table below 3 meters of the land surface. Taking advantage of spaceborne multispectral measurements which provide reliable information on spatial patterns of waterlogged areas in a timely and cost-effective manner a study was taken to delineate and monitor the spatial distribution pattern of waterlogged areas in part of Mahanadi stage-1 command area, Odisha, India using spaceborne multi temporal and multi spectral data. The multi spectral and multi temporal data was initially georeferenced and radiometrically normalized. Subsequently a systematic on-screen visual interpretation approach was followed for delineation of waterlogged areas. Results point to a significant increase in the spatial extent of waterlogged areas with the passage of time.

Keywords: Waterlogging, Radiometric normalization, Water table, Spaceborne multi spectral data.

INTRODUCTION

Excess water in the root zone disturbs the delicate balance between oxygen and carbon dioxide that manifests its effect on physiological processes of the plants and nutrient status of soils which ultimately affects the crop growth and yield. The extent of damage to crops depends, largely, on frequency and duration of waterlogging and the nature and type of crops grown. Waterlogging may --either be due to surface ponding or rise in ground water table owing to excess inflow as compared to run-off, which may be either on account of excess rain or over-irrigation and the congestion of drainage. In the arid and semi-arid regions, prolonged and frequent waterlogging may lead to salinization and/alkalization. The introduction of canal irrigation has been found to accelerate the process of salinization /or alkalinization in areas already affected, and to initiate the development of salinity and/or alkalinity in the otherwise normal productive lands. At national level there is no universally acceptable figure of the extent of land affected by waterlogging available today. The estimates given by the National Commission on Irrigation (1972); National Commission on Agriculture (1976) and the Ministry of Water Resources (Anonymous, 1991) are 4.84 million ha, 6.00 million ha and 2.46 million ha, respectively.

The Working Group constituted by the Ministry of Water Resources, Government of India (Anonymous, 1991) has reviewed the criteria adopted by various institutions for considering a given piece of land as waterlogged. For this purpose, the depth of ground water table and yield of affected crop have been considered. Several criterions have been adopted by various organizations/institutions for delineating waterlogged areas. The National commission on Agriculture (National Commission on Agriculture, 1976) had laid emphasis on yield of the crop affected by water table. Ground water tables at '0'm below ground level (bgl) has been taken for rice crop, and

1.5m for other crops in order to qualify a land for waterlogging. The Working Group has defined it as "An area is said to be waterlogged when the water table rises to an extent that soil pores in the root zone of a crop become saturated, resulting in the restriction of normal circulation of the air, decline in the level of oxygen and increase in the level of carbon dioxide" (Anonymous, 1991). The water table, which is considered harmful, would depend upon the type of crop, type of soil and the quality of water, etc. The Working Group adopted the norm of waterlogged areas for the irrigated land, as follows:

(i)	Waterlogged areas (Due to rise in water table)	Water table within 2m of land surface.
(ii)	Potential areas for waterlogging	Water table between 2 – 3m below land surface
(iii)	Safe area	Water table below 3m of land surface.

Both Central Ground Water Board as well as State Ground Water Departments regularly records the fluctuation in ground water table before and after monsoon in some selected areas. Such observations are, however, point-specific and any generalization with respect to ground water table requires an intimate knowledge of the terrain conditions as well as precipitation pattern. Waterlogging problem in the command areas of our country has been investigated by several workers (Agarwal and Malik, 1982; Rao, 1986; Sondhi and Sharma, 1987; Bouwer et al., 1990; Sarma et al., 1990; Agarwal, 1991; Chitale, 1991) through conventional approach.

ROLE OF REMOTE SENSING

Remote sensing data acquired in the visible, near infrared (IR) and short-wave infrared (SWIR) regions have shown encouraging results in providing information on spatial pattern of waterlogging (Kalubarme et al., 1981, Sahai et al., 1985; Sharma and Bhargava, 1988; Chaubey and Chaubey, 2000). Such studies have, however, enabled detection of waterlogged areas with either standing water (surface ponding) or a thin film of water at the surface or the land with wet surface, using Landsat-MSS and TM; and Indian Remote Sensing Satellite IRS-1A/-1B/-1C/-1D Linear Imaging Self-scanning Sensor (LISS-I, -II and -III) data. In Australia, conjunctive use of spectral measurements made by a Portable Field Spectroradiometer and a thirteen-channel airborne scanner covering 0.45 to 12.0µm region of the electromagnetic spectrum and the Landsat-TM data, helped in segregation of crops suffering from waterlogging, from those which are normal (Wallace et al., 1993). In another study, dynamics of waterlogging has also been studied in the Sharada Sahayak and Periyar-Vaigai command areas (National Remote Sensing Agency, 1995, 1997) in parts of Gandak command in Bihar (Dwivedi, 1997) and eastern Uttar Pradesh (Sujatha et al., 2000) using multi- temporal multispectral data.The study was taken up to delineate waterlogged areas and to monitor their spatial extent and distribution using mutlitemporal spaceborne multispectral data

STUDY AREA

Covering an area of 6,031sq km which is spread over in 27 blocks, the command area is bound by geo-coordinates $20^0$01' to $20^0$47'N and $85^0$53' to $86^0$45'E and forms parts of Cuttack, Jagatsingapur, Kendrapara and Jajpur districts of Orissa (Fig.-1). Further, the maximum area of the command is in Jagatsingapur (1,83,721 ha) followed by Cuttack (1,54,018ha), Jajpur (1,01,129ha) and Kendraparha (78,675ha) districts. Lithologically, the area comprises mainly of deltaic alluvium. Marine sediments and coastal alluvium characterise coastal plains. Physio graphically, the command comprises mainly of deltaic plain with an average slope of 0.1% towards Bay of Bengal, which is girdled by coastal plains, beach ridges/swales, mangrove swamps, and dotted with back swamps, palaeo-channels, filled up lagoons, etc. The river Mahanadi and its distributaries, namely, Chitrotpala, Luna, Birupa, Kathajuri, Devi and Bramhani rivers, drain the command.

Both pre-monsoon and post-monsoon period data are required for delineation of seasonally or temporarily waterlogged areas, and perennially or permanently waterlogged areas respectively. In a study carried out earlier, Indian Remote Sensing satellite (IRS-1A) Linear Imaging Self-scanning Sensor (LISS-II) data for October 1988 and March 1989 data were used. Similarly, for another historic period (1998-1999), IRS-P3 WiFS data acquired during October 1998 and IRS-1D LISS-III data of May 1999 were used (Dwivedi R.S. et al, 1999). We have used Landsat TM data for pre- and post-monsoon area data for delineation of waterlogged areas.

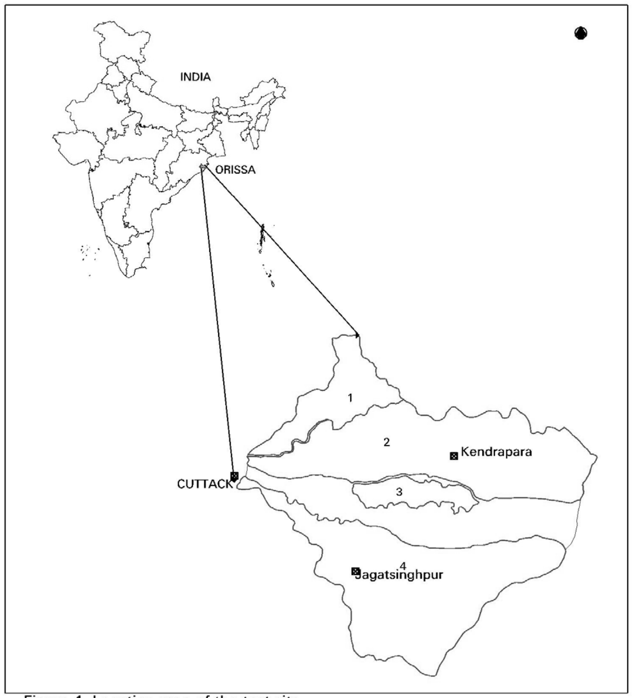

Figure 1 Location map of the test site

METHODOLOGY

The approach essentially involves data base preparation and a systematic on-the–screen visual interpretation of both concurrent as well as historical spaceborne multispectral and multi-temporal digital data. Various steps involved are discussed hereunder:

Preparation of Database

Preparation of database involves geo-referencing, radiometric normalization and analysis and the interpretation and the details of the steps involved are given hereunder:

Geo-referencing

To begin with, the Landsat TM data of the command area acquired during October 2002 was digitally co-registered to Survey of India topographical maps at 1:50,000 scale and resample to 30m spatial resolution using first-order polynomial transform on a Silicon Graphics work station using ERDAS/ IMAGINE software version 2015. The digital data, thus generated, was used as a reference for geo-referencing other satellite data sets. Subsequently, the Landsat-TM digital data co-registered to reference database and resample to 30mx30m pixel. Similar exercise was carried out for digitally geo-referencing other dataset too.

Radiometric Normalization

In our study, we have radiometrically normalized Landsat-TM and ETM+ using the values provided by Markham and Barker (1986) were taken. Later, corrections for sun elevation angle variations using cos θ correction (where θ is the sun elevation angle) were made. Subsequently all the radiance values were scaled using a common linear scaling factor.

$$L_\lambda = LMIN_\lambda + \left(\frac{LMAX_\lambda}{QCALMAX}\right) QCAL \qquad \textbf{...... (1)}$$

where

QCAL = Calibrated and quantified scaled radiance in units of DN, digital numbers

$LMIN_\lambda$ = Spectral radiance at QCAL=0

$LMAX_\lambda$ = Spectral radiance at QCAL= QCALMAX

QCALMAX = Range of rescaled radiance in DN

L_λ = Spectral radiance

Preliminary Visual Interpretation

Waterlogged areas are, generally, confined to low-lying areas in the vicinity of the canal, local depressions and lower element of the slope. Such areas have either standing water or a thin film of water or surface wetness. And the areas subject to waterlogging due to rising ground water table do not manifest such surface features. Such areas support a healthy vegetation stand during summer when the evapo-transpiration is very high and the vegetation in the neighboring areas virtually whither. This feature along with the observations on the depth of ground water table could be used as a surrogate measure for delineation of areas subject to waterlogging due to rising ground water table.

In the false color composite (FCC) image generated from green, red, and near IR bands of TM data, waterlogged areas appear in different shades of blue/cyan/and sometimes even in different shades of gray with in the normal cultivated lands which is manifested in different shades of red color indicating density and vigor of the crop. Cropping pattern, occasional absence of crop/vegetation cover/crop yield and supporting chemical analysis data help in their delineation. After geo-referencing Landsat-TM data, the areas likely to experience waterlogging were broadly identified, based on their spectral behavior, and ancillary information and the terrain conditions by displaying it onto a colour monitor of the Silicon Graphics work station. Subsequently, the sample areas to be verified in the field were identified and precisely located on the Survey of India topographical maps of 1:50,000 scale.

Ground Truth Collection

The correlation between image elements and water logged areas established during study carried out by NRSC (Dwivedi R.S. et al, 1999) was used for delineation of waterlogged areas.

Map Finalization

The areas, which were delineated as waterlogged during preliminary visual interpretation, were then located in the image. Boundaries of waterlogged areas were then drawn in the vector layer which was already superimposed over satellite image, vis-a-vis field observations, relief information from topographical maps and ground water table data from Command Area Authority, Mahanadi Stage-1. Due care was, however, taken to avoid inclusion of water bodies in the waterlogged areas. The waterlogged areas, thus delineated, were basically, seasonally or temporarily waterlogged and were used as a reference for mapping of waterlogged areas from pre-monsoon period satellite data. Similar exercise was carried out for delineation of perennially waterlogged areas from Landsat TM data of October 2002 and October 2016.The areas which exhibited waterlogging conditions during both the periods i.e. pre- and post- monsoon was categorized as permanently/perennially waterlogged while those experiencing waterlogging condition only during post-monsoon period were categorized as seasonally / temporarily waterlogged. Similar approach was followed for delineating waterlogged areas from historical period data too.

Change Detection

For monitoring the spatial extent and distribution of waterlogged areas Landsat TM data of October 2002 and October 2016 were used as a reference**.** Areas subject to waterlogging were then delineated from corresponding period historical satellite data following aforesaid approach. Subsequently, the change in the spatial distribution of waterlogged areas and salt-affected soils during the periods 2002 and 2016 was brought out.

RESULTS AND DISCUSSION

The results of the study are reported in the following two major Sections, namely current status and temporal behavior of waterlogged areas.

Current Status

The detection of waterlogging which in strict sense is defined as the saturation of root zone for a considerable long period of time affecting the growth of most of the mesophytic plants, does not seem feasible using optical sensor data since the spectral response pattern of non-waterlogged area and those with sub-surface drainage congestion is almost similar. For deriving information on current status of waterlogging, post-monsoon satellite data acquired during October 2002 and post-monsoon satellite data of October 2016 are used. The areas experiencing waterlogging during post-monsoon season are considered as seasonally or temporarily waterlogged, whereas those, which remained waterlogged during pre-monsoon period also, are categorized as perennially waterlogged areas. Fig.6 illustrates the delineation of seasonally and perennially/ permanently waterlogged areas from satellite data. It is evident that waterlogged areas are associated with the patches of bluish gray/greenish blue /bluish green/cyan color within the standing vegetation mostly crops, which are seen in different shades of red color in the false colour composite (FCC) image. Further, a close look at waterlogged areas delineated from October 2002 and October 2016 reveals that the seasonally waterlogged areas have more spatial coverage as compared to perennially waterlogged areas due to relatively low evapotranspiration and high precipitation during monsoon season. Following this approach waterlogged areas of entire command have been delineated at 1:50.000 scales.

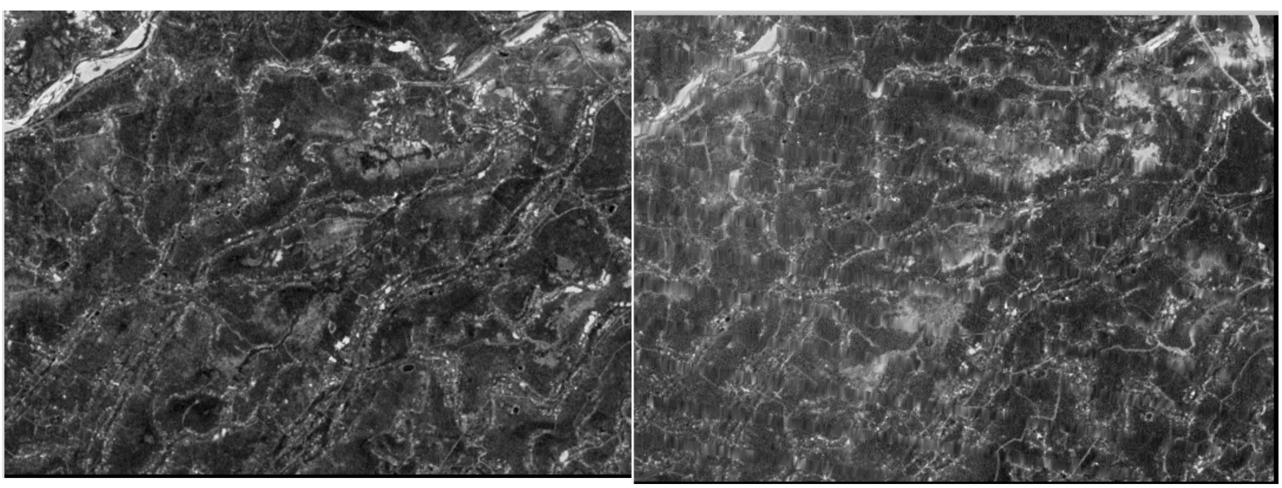

Figure 2 Satellite image showing the waterlogged areas for October 2002 and 2016

Due to scale limitation, individual patches of waterlogged areas with smaller spatial extent could not be portrayed. Nevertheless, it does provide the spatial distribution pattern of waterlogged areas in the entire command area at a glance.

Temporal Behavior

Being highly dynamic phenomenon, the extent and duration of waterlogging depends, to a large extent, on intensity, duration, spatial distribution and quantum of rainfall, release of water from canals, and surface and sub-surface drainage conditions. The spatial distribution of pattern of waterlogged areas in the command area during the periods October 2002 and October 2016 is depicted. An objective comparison of the area figures for waterlogging during this period October 2002 and October 2016 reveals that there is substantial decrease in the spatial extent of waterlogged areas.

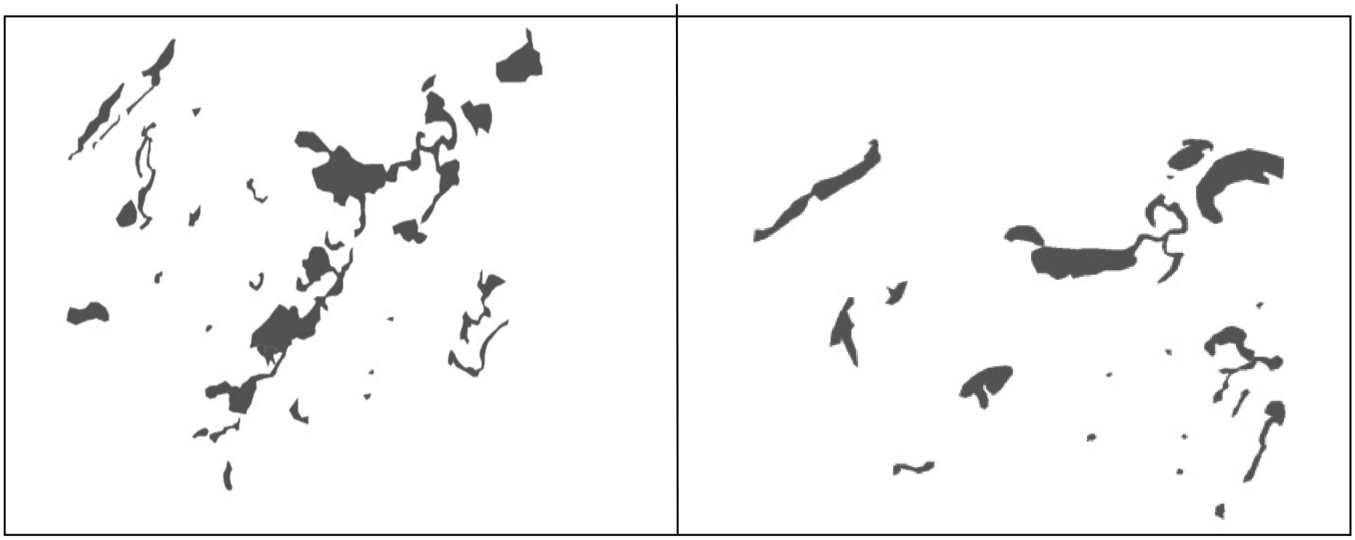

Figure 3 Waterlogged areas during (a) October 2002 and (b) October 2002

CONCLUSIONS

A systematic on-the-screen visual interpretation of spaceborne multispectral data enabled generation of information on the nature, extent, spatial distribution and temporal behavior of waterlogged areas. In the command area, waterlogging has been found to be associated with local depressions and lower elements of the slope with fine-textured soils having poor surface and sub-surface drainage. Furthermore, temporal variation in the extent and spatial distribution of waterlogged areas are associated with the hydrological conditions of the terrain which, in turn are, governed by the quantum, duration and spatial distribution of rainfall, inflow in the canals. There has been a decrease in the spatial extent of waterlogged areas during the period 2002, and 2016. Being a sub-surface phenomenon with hardly any surface manifestation, waterlogging to rising ground water table could not be detected. Spectral measurements in thermal region of electromagnetic spectrum capturing emitted radiation, the measurements made by Ground penetrating Radar (GPR) with sub-surface penetration capability may offer potentials in detection of sub-surface waterlogging.

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Application of M-M-F Model for Estimating Sediment Yield by using GIS

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ABSTRACT

Soil erosion in catchment areas reduces soil productivity and causes a loss of reservoir capacity. Several parametric models have been developed for predicting soil erosion at drainage basins, hill slopes and field levels. This study includes the estimation of average annual soil loss by using Morgan - Morgan - Finney (M-M-F) model at the outlet of watershed. Rampur watershed, Chhattisgarh was selected as the study area. A recent emerging technology represented by Geographical Information System (GIS) was used to generate, manipulate and spatially organize disparate data for soil loss modeling. The main objective of this study was to evaluate the performance MMF models for soil erosion assessment. The input data of model was provided Landsat-7 ETM+ (2003) data, of the study area, previous research reports, meteorological and statistical data and the information obtained from field studies. Further, the MMF model was validated by comparing the estimated Sediment yield for all the years with the observed values. The differences between the predicted and observed Sediment yield from MMF model are reinforcement of the knowledge that erosion predictions is nearly good (i.e. r^2=0.71). This erosion model can be used to predict the sediment as a preliminary estimation of a catchment area to develop good management practices.

Keywords: GIS, Soil Loss, M-M-F and ASTER.

INTRODUCTION

Soil erosion is a worldwide problem which has various impacts on environment. The top layer of the soil gets eroded by the natural geomorphical processes such as air, water, storm etc. These natural calamities erode the top surface of the soil which leads to the loss of fertility and rich nutrients soils.Nowa days, Soil erosion by water is the basic and important parameter which leads to the soil loss. When water flows over the earth's surface, small size particles are transported by the water which gets collected in the reservoir, results in decreasingtheir capacity, damages the structures and affecting their operational life.For restoring the productivity of soil and to prevent it from further damages, planning, conservation and management of the watersheds are vital. Therefore, an attempt to assess the erosion hazard and soil loss of watersheds for treatment would aid in better planning to combat this menace.The negative changes in soil quality are a worldwide concern, particularly in developing countries where soil erosion is becoming a limiting factor in increasing or even sustaining agricultural productivity (Arekhi, 2008).There are various erosion prediction models – USLE (Universal Soil Loss Equation), MUSLE (Modified Universal Soil Loss Equation), RUSLE (Revised Universal Soil Loss Equation) etc that are used to evaluate the soil erosion in the watershed.The basic aim of this study is to predict thesediment yield in the watershed for several years by M-M-F (Morgan-Morgan-Finney) model. The various thematic layers of map are created by using GIS. This project will give highlights on the general MMF/GIS approach for Rampur. The model will be derived from available data such as soil maps, rainfall records, land use maps and satellite images. Interpretation of such a map will provide the information required to take measures to prevent soil erosion. However the main purpose of this project is oriented to applications of the MMF/GIS approach for estimation of sediment yield.

Description of the study area

The Hilly and Forested area, Rampur Watershed of Chhattisgarh with an area of about 3409 sq km has been taken up as the study area. The district extends between 20° 49′30'' to 21° 33' 14" North latitudes and 81°59′ 31"to 83°16′37" East longitudes and is bounded on north and west by Raipur, South and east by Orissa state. It lies between 20°30'00" - 21°30'00"N and 83°04'50" - 83°11'36" E falling in Survey of India top sheet. Basically four types of soil are presented in the watershed i.e. Silt, clay, sandy clay and silt loam.

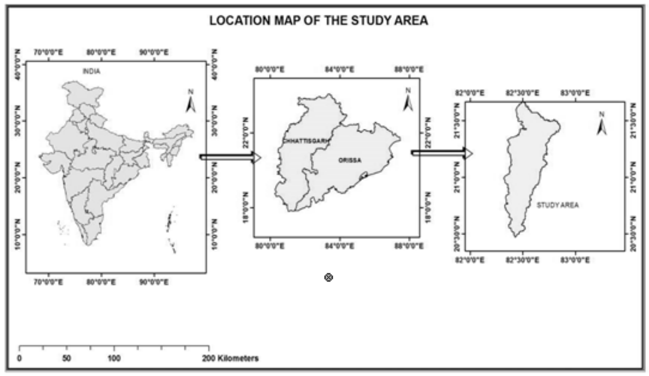

Figure 1 Study area

The State of Chhattisgarh is blessed with good rainfall of 700-1400 mm per annum and out of which around 15-20% is during the winters. The number of rainy days also varies from 40 to 65 and evaporation from free water bodies is around 1.5 - 2.0 m per annum.

Materials and Methods

Generation of the thematic layers

Shuttle Radar Topography Mission (SRTM) data was used for generation of the Digital Elevation Model (DEM) of the Rampur watershed (fig.1). The elevation data were processed and graphic simulation was carried out in which an elevation (or Z value) was recorded at each X, Y location to make topographic data usable. Surfacing function in "Image Interpreter" was used to generate a DEM and to represent as a surface or one- band image file where the value of each pixel was a specific elevation value. Slope map was generated in ERDAS IMAGINE software by using DEM.

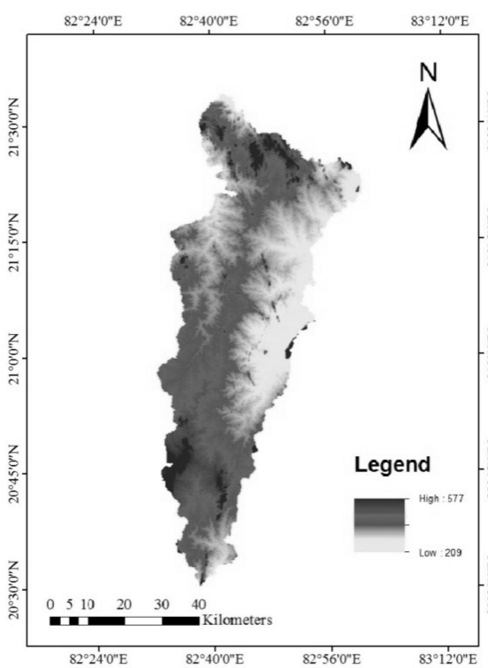

Figure 2 DEM of the study area

Morgan et al. (1984) developed a model to predict annual Sediment yield, which endeavors to retain the simplicity of USLE and encompasses some of the recent advances in understanding of erosion process into a water phase and sediment phase. Sediment phase considers soil erosion to result from the detachment of soil particles by overland flow. Thus, the sediment phase comprises two predictive equations, one for rate of splash detachment and one for the transport capacity of overland flow. The model uses six operating equations for which 15 input parameters are required. The model compares predictions of detachment by rain splash and the transport capacity of the run-off and assesses the lower of the two values as the annual rate of Sediment yield, thereby denoting whether detachment or transport limiting factor.

Water phase

In the water phase, the annual precipitation is used to determine the rainfall energy available for splash detachment and the volume of runoff. The rainfall energy is computed from the total annual rainfall and the hourly rainfall intensity for erosive rain, based on the relationship established by Wischmeier and Smith (1978). The annual volume of overland flow is predicted using the model by Kirkby (1976). In this model, the runoff is assumed to occur whenever the daily rainfall exceeds a critical value corresponding to the storage capacity of the surface soil layer.

Estimation of rainfall energy

Kinetic energy of rainfall (E) in J/m^2 is dependent on the amount of annual rain (R) and the rainfall intensity (I). It can be derived by the following equation, established by Wischmeier and Smith (1978):

$$E = R(11.9 + 8.7\log_{10} I) \quad \text{.....(1)}$$

Where, E = kinetic energy of rainfall (J/m^2) and I = typical value for intensity of erosive rain (mm/hr).The study area falls under strong seasonal climate. In this study the typical value of intensity of erosive rain is 30 mm/hr.

Estimation of the rate of soil detachment

Soil detachment is a function of soil detachability index defined as the weight of soil detached from the soil mass per unit of rainfall energy.It can be computed by using the following equation:

$$F = K \times (E \times \exp(-a \times P)) \times b \times 10^{-3} \quad \text{.....(2)}$$

Where, F = rate of detachment by raindrop impact (kg/m^2); K = soil detachability index defined as the weight of soil detached from soil mass per unit of rainfall energy;

A = percentage of rainfall contributing to permanent interception and stem flow (%);

Values of exponents: a = 0.05 and b = 1.0.

Sediment phase

In the sediment phase, splash detachment is modeled as a function of rainfall energy, soil detachability and rainfall interception effect by crops. The transport capacity of the overland flow is determined using the volume of overland flow, slope steepness and the effect of vegetation or crop cover management (Kirkby, 1976). The equations used are as follows:

Estimation of overland flow

Overland flow (Q) is dependent on moisture storage capacity (MS) of surface soil, which can be derived from field capacity. It is also dependent on the soil bulk density (BD), rooting depth (RD) of various cover types, the ratio of actual to potential evapotranspiration (E_t/E_0), the amount of annual rain (R) and the number of rainy days (R_n) as shown in Table 1. It can be explained by the following Equations:

$$Q = R \times \exp(-Rc \div Ro) \quad \text{.....(3)}$$

$$Rc = 1000 \times MS \times BD \times RD \times (Et/Eo)^{0.5}$$

$$Ro = R/Rn$$

where, Q = volume of overland flow (mm);

R = annual rainfall (mm);

R_n = number of rainy days in the year;

E_t/E_o = ratio of actual (E_t) to potential (E_o) evaporation;

MS = soil moisture content at the field capacity or 1/3 bar tension (% or w/w); BD = bulk density of the top layer (Mg/m^3) and

RD = topsoil rooting depth (m) defined as the depth of soil from the surface to an impermeable or stony layer, to the base of A horizon, to the dominant root base.

Estimating the transport capacity

Transport capacity of overland flow (G) is dependent on the volume of overland flow (Q), the crop cover management factor (C) and the topographic slope factor (S). It can be calculated by using the following equation:

$$G = C \times Q^2 \times \sin s \times 10^{-3} \quad \text{.....(4)}$$

where, G = transport capacity of overland flow (kg/m^2);

C = crop cover management factor and

S = steepness of the ground slope expressed as slope angle.

Estimation of soil loss using Morgan- Morgan- Finney model

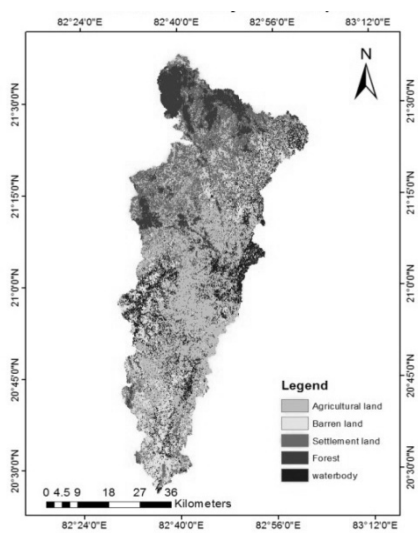

Figure 3 Land use/ Land cover map of the study area

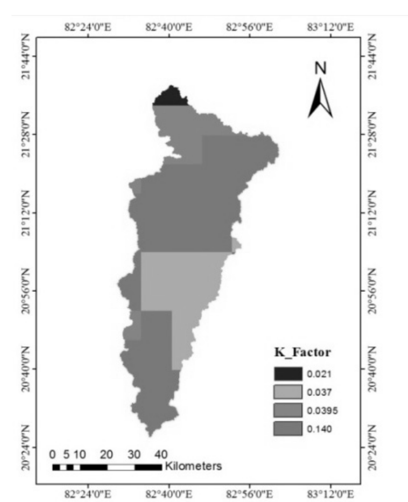

Figure 4 Soil Detachability (K) map of the study area

The parameter E_t / E_o and RD for land use/land cover map (Fig. 2) were calculated by using typical values of plant parameters as suggested by Morgan, Morgan and Finney table (Morgan *et al.*1984).

The parameters R and R_n was calculated from the seasonal rainfall data. Individual columns were added to the soil texture map for calculating MS and BD. Attribute maps were prepared for MS and BD. Rooting depth (RD) and E_t / E_o column was added to land use/land cover and an attribute map was prepared in GIS environment. All these were used as input to calculate final R_c.

Table 1 Typical value of plant parameters for use in Morgan's Model

S.No.	Land use/land cover	E_t/E_o	P	C	RD
1.	Water body	1.0	25	0.001	0.05
2.	Agriculture	0.67	39	0.2	0.1
3.	Forest	0.98	30	0.002	0.1
4.	Barren Land	0.05	5	1.0	0.05
5.	Settlement	0.1	25	0.1	0.05

R_o was calculated using annual rainfall (R) and number of rainy days (R_n). Thus, for each input parameter to the soil erosion model were prepared using weighted values for the whole year.The Soil detachability (K) maps were prepared in GIS environment (Fig. 3). The value of detachment rate (F) and transport capacity of Runoff (G) was then compared for different pixel sizes. In these two maps the minimum value is the soil erosion map.

RESULTS AND DISCUSSION

The analysis for the years 1979-2010 shows the highest Sediment yield is 12.902 t $ha^{-1}yr^{-1}$ in 1990, the year of highest rainfall (2932.842 mm). The lower value of Sediment yield was 4.242 $tha^{-1}yr^{-1}$ in 1979, the year of lowest rainfall (828.75 mm). The average annual Sediment yield for all the years at outlet of the watershed was determined.

Table 2 Estimation of soil detachment, overland flow and sediment yield

S. No.	Year	G (t $ha^{-1}yr^{-1}$)	F (t $ha^{-1}yr^{-1}$)	Sediment yield (t $ha^{-1}yr^{-1}$)
1.	1979	9.06	4.242	4.24
2.	1980	39.03	8.673	8.67
3.	1981	30.19	7.646	7.64
4.	1982	26.00	7.126	7.12
5.	1983	38.40	8.607	8.60
6.	1984	24.28	6.889	6.88
7.	1985	23.02	6.693	6.69
8.	1986	18.03	5.959	5.95
9.	1987	15.05	5.426	5.42
10.	1988	37.51	8.508	8.50
11.	1989	50.40	9.818	9.81
12.	1990	86.77	12.902	12.90
13.	1991	51.62	9.967	9.96
14.	1992	13.41	5.128	5.12
15.	1993	41.28	8.907	8.90
16.	1994	47.16	9.530	9.53
17.	1995	26.42	7.199	7.19
18.	1996	22.88	6.688	6.68
19.	1997	46.97	9.528	9.52

20.	1998	47.48	9.607	9.60
21.	1999	29.06	7.489	7.48
22.	2000	11.15	4.674	4.67
23.	2001	23.28	6.714	6.71
24.	2002	18.66	5.994	5.99
25.	2003	50.55	9.864	9.86
26.	2004	16.78	5.727	5.72
27.	2005	17.39	5.826	5.82
28.	2006	22.87	6.666	6.66
29.	2007	39.20	8.683	8.68
30.	2008	50.44	9.839	9.83
31.	2009	31.18	7.745	7.74
32.	2010	32.37	7.907	7.90

The wide variation in variation in Sediment yield for different years is mainly due to variation in rainfall pattern. Since the MMF Model considers the minimum values of Sediment yield between the splash detachment (F) and overland flow (G) from Table 2, therefore for a year Sediment yield due to splash detachment (F) was considered as it is the minimum of the two (between F and G).

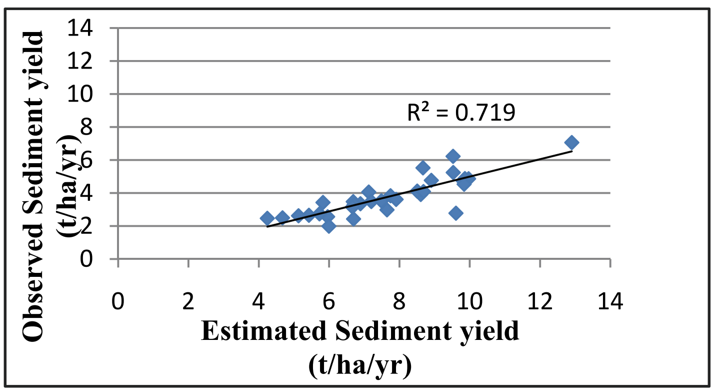

Fig. 5 Comparison between the observed and estimated Sediment yield

It can be seen from figure 3 that the points obtained by plotting the estimated values against the observed values are close to 1:1 line indicating that their differences are not significant. The best fit lines between the above data have high coefficient of determination of 0.71 which shows that they are closely related by a straight line. The differences between the predicted and observed Sediment yield from MMF model are reinforcement of the knowledge that the erosion predictions in generalcan be used to predict the sediment as a preliminary estimation of a catchment area to develop good management practices.

CONCLUSION

Soil erosion is the most serious type of land degradation, occuring in all climatic regions. For predicting its magnitude various empirical and process-based models are available. Soil erosion can never be stopped completely but it can be reducedto some extent.The Rampur watershed mainly consists of light textured unstable soils with prevalent practice of shifting cultivation which makes the whole watershed prone to the soil erosion. For the present study the Morgan-Morgan-Finney model is used for the estimation of Sediment yield using satellite data and Geographic Information System.The average annual Sediment yield for all the years at outlet of the watershed was determined. The wide variation in Sediment yield for different years is mainly due to variation in rainfall pattern. Since, the MMF Modelpresented reasonable accuracy in the predictions.Best management practices suggested for Rampur watershed are afforestation, terracing, and different types of bunds (upper, middle and lower reaches), sediment detention structures, water harvesting structures and masonary conservation measures for drainage line treatment.

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Estimation of Water Spread Area in a Region using RS and GIS

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ABSTRACT

Surface water bodies are the major source for irrigation in India. Information on surface water bodies such as water spread area, volume of water stored in a water body is useful for understanding the availability of water resources for the crop season in a river basin / sub basin. Satellite based techniques provide the surface water spread at spatial and temporal scale and also facilitate mapping, monitoring visualization of the dynamics unlike conventional methods. Hence, the dynamics of surface water bodies in and around Nagarjunasagar Dam is studied through geospatial analysis for extraction of water body layers for the month of October, 2015, February, and May, 2016.

Geospatial database on water bodies information has been created from the landsat 8 image of path/row 143/49 (LC81430492015294LGN00.tar, LC81430492016041LGN00.tar and LC81430492016121LGN00.tar) The water bodies where water is stored for irrigation purpose such as reservoirs, tanks and ponds are taken into consideration excluding rivers. ERDAS Imagine and Arc GIS software were used for extracting spatio- temporal water body layers in the study area. The model was used for the estimation of water spread area were NIR-RED (Band 5-Band 4). Quantitative estimates on water spread area (WSA) of water bodies are obtained for analyzing inters / intra seasonal / annual analysis. The WSA calculated for each of three seasons is 25766.47 ha, 26808.369 ha and 22653.328 ha. The water spread area is higher in February, 2016 because the amount of rainfall received in the month of October and November, 2015 is more. The present study has brought out geospatial database on WSA and provided scope for sub regional / regional analysis. The information can be used in deciding the cropping pattern in the study area.

Keywords: *Water spread area, Water bodies, Remote sensing, GIS.*

INTRODUCTION

Mapping of natural resources like forest and water bodies using satellite imagery has gained much importance in the recent past. Both forest and water resources are subject to intense exploitation and monitoring them at regular intervals is imperative for their sustainable management. Water bodies, which play a key role in the global carbon cycle and climate variations, are mapped in spatiotemporal domain to analyze and assess the extent and rate of their degradation and disappearance. Geospatial tools are proving to be advantageous for such impact assessment for the implementation of conservation measures. Researchers across the globe have used different satellite data varying in spatial, spectral, and temporal characteristics to generate thematic maps of land use land cover or maps with special emphasis on water bodies. At the same time, various techniques have been adopted to extract these features from satellite imagery and each method has its own merits and demerits. Visual interpretation of satellite data provides the best delineation of water bodies of varied sizes but is time consuming, especially when working with high resolution data. The simple and common approach of unsupervised classification which uses an interactive self-organizing data analysis technique provides results with very low accuracy, when there is spectral overlap between water bodies with other classes. In contrast, supervised classification presents more accurate and reliable outputs than unsupervised method but may vary when used for high resolution data. Moreover, the supervised technique requires sufficiently large spectral training data sets and is not a fully automated method. Further it does not take into account the spatial features of the objects.

The method of fractal characterization classifies the features based on their texture either smooth or rough. Since water bodies exhibit a smooth texture compared to the other landscape features like vegetation and buildings in the satellite imagery, they can be easily extracted using the fractal method. However the method does not take into account the spectral features of the objects; hence different classes with varied spectral characteristics but with similar textures are classified as one class. Further, the results may also differ significantly with image resolution. The use of the normalized difference water index (NDWI) method maximizes the reflectance properties of water by minimizing the low reflectance of near infrared (NIR) and maximizing the reflectance in the green wavelength.

Studies show that this method yields better results for deeper and worse for shallower parts of the water body. Whatever be the approach, generally the user is interested in a method which is fast, accurate, and automated. Towards this objective, a simple model was developed for the extraction of water bodies.

This paper presents an approach to extract the water body from a Landsat 8 satellite imagery using a simple model was developed for the extraction of water bodies. The feature vectors, combined with the weights, sum up to provide an input to the output function which is a binary hard limit function. The feature vector in this study is a set of characteristic properties shown by a pixel of the water body. The model was carried out with the difference of near infrared and red (NIR-RED).

MATERIAL AND METHODS

Study Area

Nagarjuna Sagar Dam was built across the Krishna river at Nagarjuna Sagar where the river is forming boundary between Nalgonda District in Telangana and Guntur district In Andhra Pradesh states in India.Nagarjuna sagar and surrounding area occupies an area of 37304 km2 and average rainfall is 772 mm. This dam lies between lat: 16 33’45” log: 79 14’ 00. The Map of the study area are shown in the following figure 1.

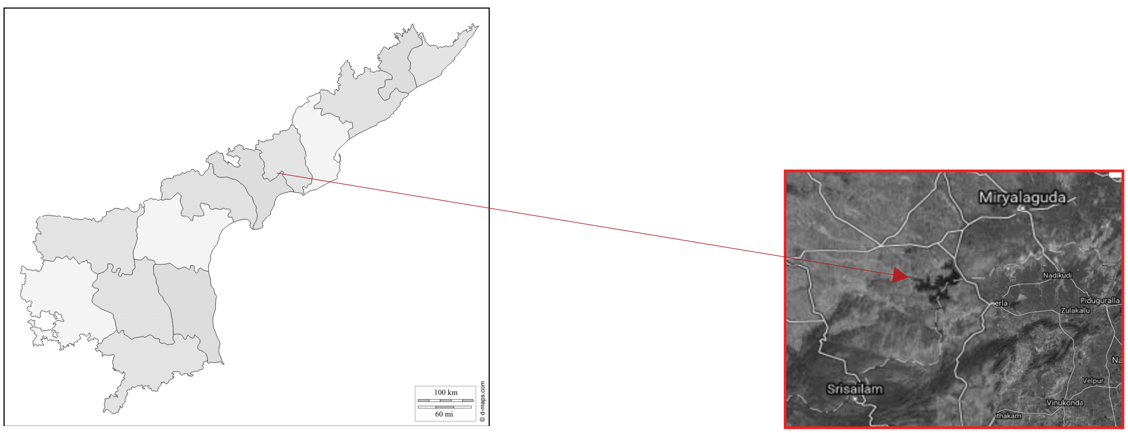

Figure 1 Location map of the study area.

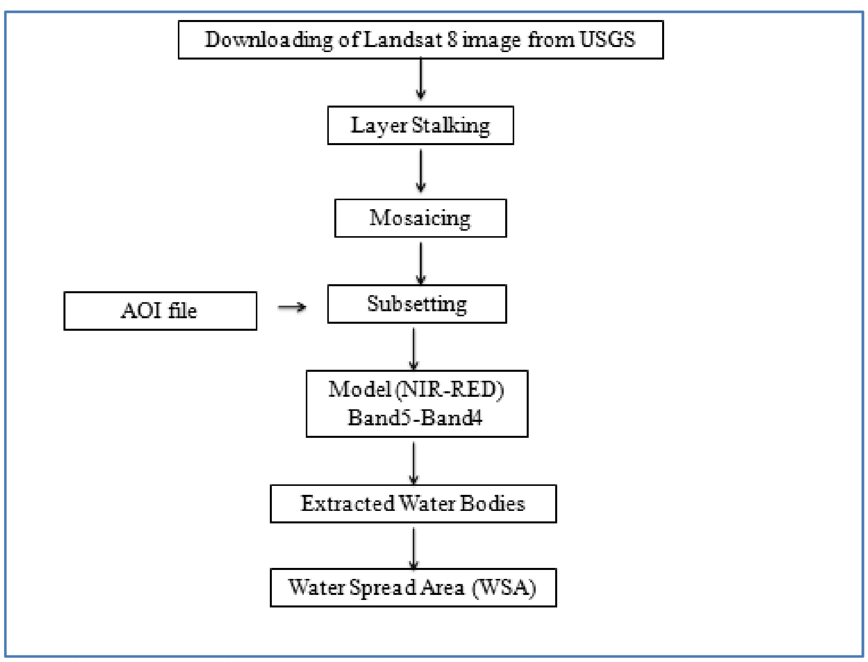

Figure 2 Over view of Methodology.

The above fig 2.2 was the overall methodology for the extraction of the water bodies.

Data used for study

US Geological Survey (USGS) Landsat-8 OLI images were employed. These images are in the World Geodetic System (WGS 84) datum in GeoTIFF format and projected using the Universal Transverse Mercator system. Three OLI images from Landsat-8, which were acquired over the Nagarjunasagar reservoir of Telangana. The three OLI images were acquired on Oct 2015 (path/row 143/49), Feb, 2016 (path/row 143/49) and May, 2016(path/row 143/49). The study sites contained several water bodies, including small ponds, rivers, reservoirs and lakes, with different environmental conditions such as different depth, turbidity and surface appearances (Figure 1 and Table 1).. The test sites were deliberately selected so that the sub-scenes consisted of complex surface features as the background features for the water features.

Table 1 List of data used for study area

S.No	Path/row	Date of pass Satellite	Image ID
1.	143/49	Oct,2015	LC81430492015294LGN00 .tar
2.	143/49	Feb, 2016	LC81430492016041LGN00.tar
3.	143/49	May, 2016	LC81430492016121LGN00.tar

It's difficult to obtain accurate ground-truth reference data because the water body changes over time (Ouma and Tateishi 2006). One acceptable option is to use the higher resolution images collected simultaneously with the multispectral images to minimize anytime-dependent effects. Hence, the 30-m resolution OLI landsat 8 images that were acquired at the same time as OLI multispectral images were selected for the ground-truth reference data.

Model for Water Bodies Extraction

The new model was developed for the extraction of bodies from the Landsat image, so the condition of the model which was tested for the landsat image of path/row which was 143/49 and 142/49 are to be tested for the model. The condition of the new model was Band 5-Band 4 (NIR-Red).

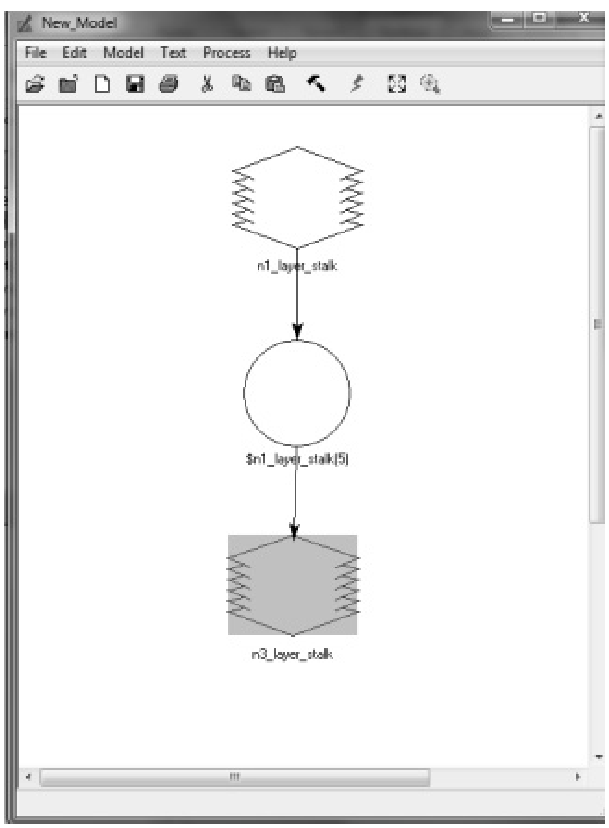

Figure 3 Model for extraction of water bodies.

RESULT AND DISCUSSION

This chapter describes the results obtained from the analysis of spatio-temporal satellite derived water bodies information of Nagarjunasagar reservoir, model framework for the extraction of surface water bodies from the landsat 8 image of nagarjuna sagar reservoir of Telangana. The discussion is made from the satellite derived water bodies area with the help of figures. Water body layers derived from landsat 8 sensor through the model for extraction of water body information for Nagarjunasagar reservoir.. The anlysis is focussed on the surafce water bodies.

Extraction of water bodies from satellite image

Water bodies were extracted from the land sat 8 satellite data. The waster spread areas of the three seasons *Kharif, Rabi* and *summer* of 2015-2016 crop years. The WSA calculated for each of three seasons is 25766.47 ha, 26808.369 ha and 22653.328 ha. The water spread area is higher in February, 2016 because the amount of rainfall received in the month of October and November, 2015 is more.

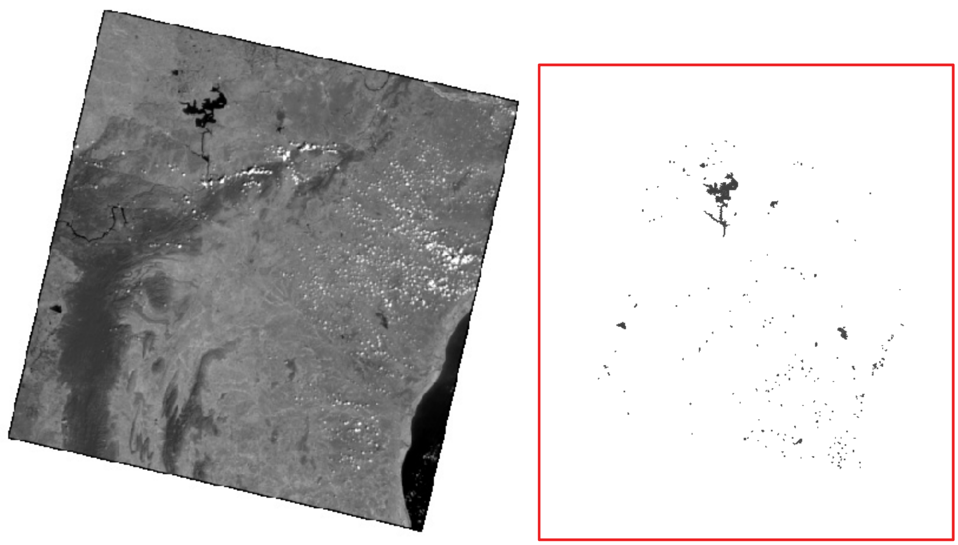

Figure 4 Water Spread area of Oct, 2015

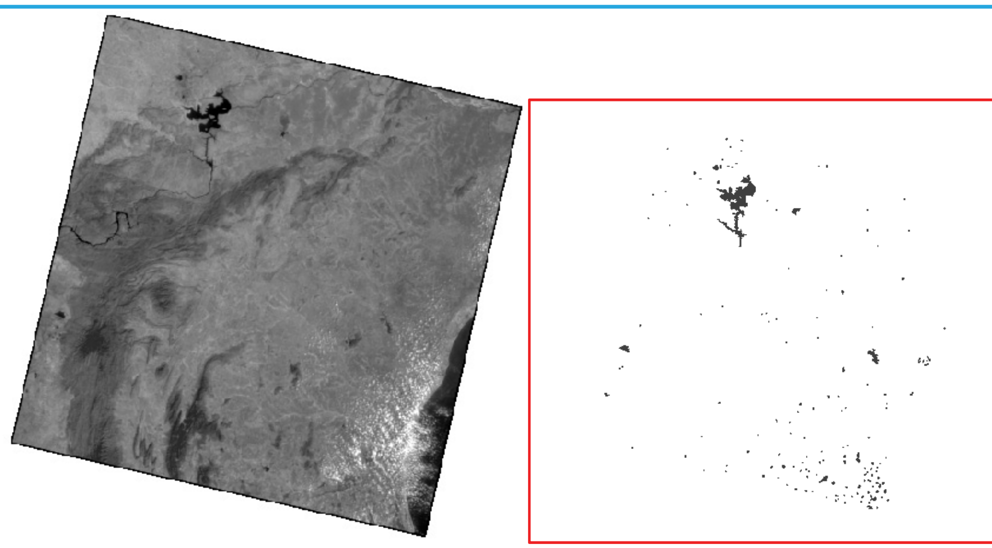

Figure 5 Water Spread area of Feb, 2016

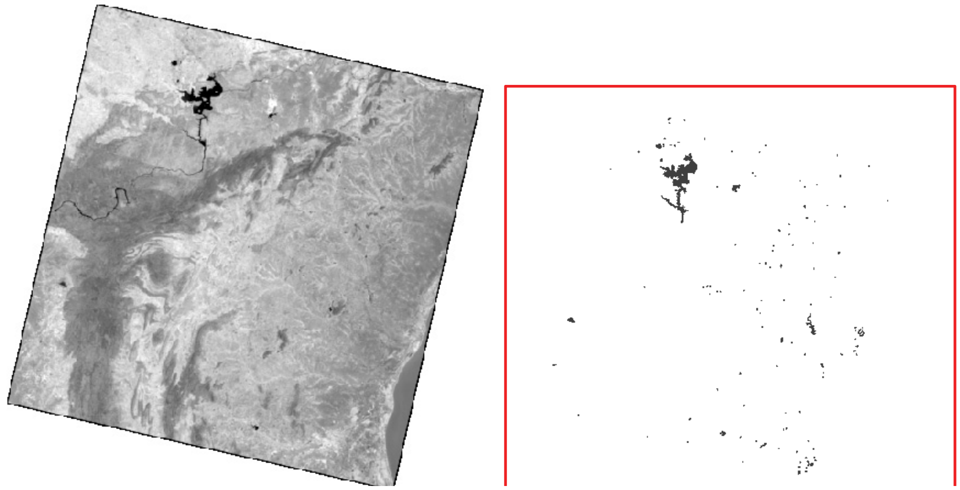

Figure 6 Water Spread area of April, 2016

The above figures was shows that the water spread area of the individual water bodies. The total water spread area of the nagarjunasagar and surrounding. The model was extracted by pixel wise analysis has been done for the identification of water and non water bodies.

CONCLUSION

1. The remote sensing and GIS application tools are very useful for the extraction of surface water body's information and analysis.
2. Water spread area is analysed in Oct, 2015, Feb, 2016 and May, 2016 satellite derived total WBA, number of water bodies categoried by size as observed from satellite data.
3. The water spread area is higher in February, 2016 because the amount of rainfall received in the month of October and November, 2015 is more.

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Spatial and Temporal Estimation Runoff under Changing Climate Scenarios at Indore

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ABSTRACT

Indore district of Madhya Pradesh is prone to groundwater over-exploitation and needs precise estimation of runoff for planning soil and water conservation structures for rainwater harvesting and groundwater recharge. In this study, a spatial runoff estimation model was developed for daily runoff using SCS-CN method coupled with GIS. The model was validated using observed data (R^2 = 0.9). Spatial and temporal variability of rainfall and runoff over the years was analyzed. Rainfall is the important factor governing runoff and the mean annual runoff from major portion of the district varied spatially from 21.4 to 26.2% of annual rainfall. The runoff corresponding to different land use land cover was determined for the baseline period (BL) (1976-2005), 2020's (2010 to 2039), 2050's (2040 to 2069) and 2080's (2070 to 2099) using Ensemble data pertaining to RCP 2.6 (low emission), RCP 4.5 (medium emission), RCP 6.0 and RCP 8.5 (high emission) scenarios. The rainfall is predicted to increase from 963 mm (BL) to 1000, 1048 and 1077 mm by 2020's, 2050's and 2080's respectively under RCP 4.5. The corresponding runoff from agricultural land with clayey soil is estimated to increase from 24.5 (BL) to 29.2% of annual rainfall under RCP 4.5. The rainfall is predicted to increase from 963 mm (BL) to 1018, 1083 and 1161 mm by 2020's, 2050's and 2080's respectively under RCP 8.5. The runoff from clayey soil is estimated to increase from 24.5 (BL) to 31.6% of annual rainfall under RCP 8.5. Considerable increase in future runoff is predicted especially under higher emission scenarios.

Key words: Climate change, ensemble, runoff

INTRODUCTION

Accurate estimation of runoff resulting from rainfall is very important for water resources management. In India, the runoff and sediment loss data is available only from limited areas where gauging stations are available (Patil *et al.,* 2008).

Hence, development of accurate runoff estimation techniques for ungauged watersheds is relevant in Indian conditions due to non availability of data. In recent years, estimation runoff using Geographic Information System (GIS) and remote sensing is very common especially for agricultural areas. Runoff depends upon spatially variable parameters like rainfall, topography, soil characteristics, and land use land cover. Among different methods, SCS-CN is widely used for quick and accurate estimation of runoff from ungauged watersheds (Jain *et al.,* 2006; Patil *et al.,* 2008). The SCN-CN methodology in its original form is embedded in many hydrological models like CREAMS (Knisel, 1980), EPIC (Williams *et al.,* 1990), SWAT (Arnold *et al.,* 1996; Narsimlu *et al.,* 2013; Tripathi *et al.,* 2003) etc. Many researchers used modified NRCS-CN method to identify runoff generation process in catchments (Geetha *et al.,* 2005; Mishra *et al.,* 2005; Mishra *et al.,* 2008). SCS-CN method coupled with GIS helps to estimate runoff spatially and temporally (Nandgude *et al.,* 2014; Rejani *et al.,* 2015). The spatial variability of runoff is very essential for planning *in-situ* interventions (Rejani *et al.,* 2015b) and water harvesting structures (Saptarshi and Raghavendra, 2009; Kadam *et al.,* 2012; Rejani *et al.,* 2017) in watersheds.

Climate change and global warming impacts all sectors of human life and agriculture is particularly vulnerable to it (Srnivasarao *et al.,* 2016). Increase in atmospheric and surface temperature increases evaporation rates at the earth's surface (IPCC, 2007; Chattopadhyay and Hulme, 1997). This leads to more vigorous hydrologic cycle, influences precipitation, its intensities, frequencies, extreme events and changes in soil moisture status (Srinivasarao *et al*., 2014). In India, the impact of climate change is predicted to increase the average surface temperature by 2 to 4 ^{0}C, changes the distribution and frequency of rainfall, decrease in number of rainy days by more than 15, increase in high intensity rains and the frequency and intensity of cyclonic storms (Ranuzzi and Srivastava, 2012). Under changing climatic scenarios, the potential for rainwater harvesting due to increase in high intensity rains may be more for many regions in India (Srinivasarao *et al.,* 2017). Hence, an attempt is being carried out to estimate the runoff spatially under changing climatic scenarios in the groundwater over-exploited drought prone area, Indore.

Methodology

Study area

The selected study area, Indore district lies in the Malwa region of Madhya Pradesh. It covers an area of 3898 sq km and it is located between $22^0$31' to $23^0$05' N latitudes and $75^0$25' to 76^0 15'E longitudes. Out of four blocks in the district, three blocks are over exploited and one is in semi-critical state.

Figure 1 Location map of Indore district

Mhow block of the district is categorized as semi critical and Depalpur, Indore and Sanwer are over exploited. The highest stage of ground water development is 148 % in Indore block. The net ground water availability is 52,314 ham and ground water draft for all uses is 65,620 ham, making stage of ground water development 125 % in the district. After making allocation for future domestic and industrial supply for next 25 years, balance available ground water for future irrigation would be negative (CGWB, 2013). Major crops are wheat and soyabean. The district is predominant with medium black soil and source of irrigation is mainly using tube wells. Indore district is prone to groundwater over-exploitation and needs precise estimation of runoff for planning soil and water conservation structures for rainwater harvesting and groundwater recharge.

The runoff corresponding to different land use land cover was determined using SCS-CN method coupled with GIS for the baseline period (BL) (1976-2005), 2020's (2010 to 2039), 2050's (2040 to 2069) and 2080's (2070 to 2099) using Ensemble data pertaining to RCP 2.6 (low emission), RCP 4.5 (medium emission), RCP 6.0 and RCP 8.5 (high emission) scenarios. The daily rainfall grid data (Ensemble), land use land cover map of NRSC and soil map of NBSS&LUP was used in the present study. Soil and LULC data was intersected to generate new polygons associated with soil type and LULC. The runoff was estimated using the SCS CN method given below.

SCS-CN Method

The SCS-CN method is an empirical equation predicting runoff from rainfall, using a shape parameter S based on soil, vegetation, land use, and soil moisture prior to a rainfall event

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \text{ for P > 0.2 S} \quad (1)$$

$$Q = 0 \text{ for P} \leq 0.2 \text{ S} \quad (2)$$

where P = total precipitation (mm); Q = surface runoff (mm); and S = potential maximum retention or infiltration (mm). The value of S is given as

$$S = \frac{25400}{CN} - 254 \qquad (3)$$

The potential maximum retention storage (S) is related to a curve number (CN), which is a function of land use, land treatments, soil type and antecedent moisture condition of the area. In this study, CN estimation based on real data from local or nearby similar watersheds. The entire area was classified in terms of areas under crops, scrub/degraded forest, current fallow, other waste land and scrub land etc using LULC map. The selected area is characterized by clayey soil.

The three levels of antecedent moisture condition (AMC) was used. Hence, the different thematic layers were prepared in ARCGIS, intercepted and corresponding curve number values corresponding to three AMC conditions namely, CN_2, CN_3 and CN_1 were assigned for each new polygon and the runoff was estimated spatially and temporally. The daily runoff corresponding to different land use land cover conditions were estimated and annual runoff was derived spatially.

RESULTS AND DISCUSSION

Generation of slope

The ASTER DEM of Indore was used and slope map was generated using GIS. Majority of the study area falls under very gentle to gentle slope class with clayey soil indicates the need of water retention for longer time to enhance the chance of infiltration and recharge. The slope of the area influences the runoff, recharge and flow direction of surface water. The slope map derived showed that major portion of the area have slope less than 5% (Fig.2). Hence, SCS CN model can be directly applied in this area without slope adjustment in the curve number.

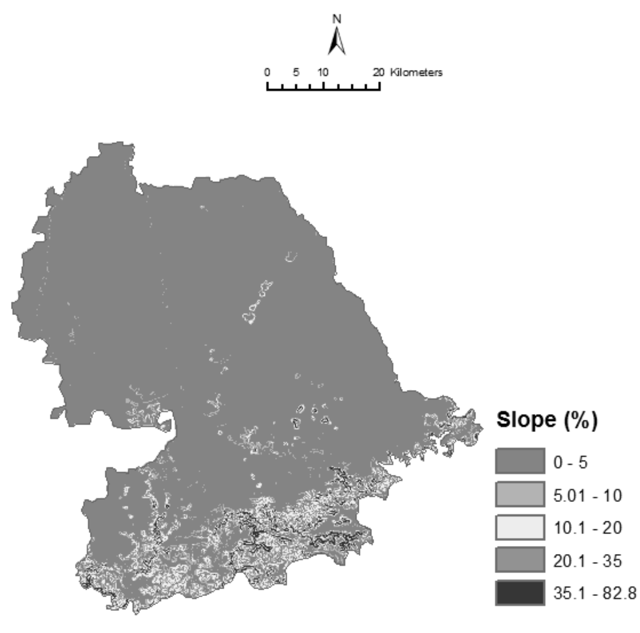

Figure 2 The slope map (%) of Indore district

Variation of land use land cover

Land use pattern of a watershed influences its runoff and evapotranspiration. The land use land cover of the selected study area consists of area under crops, degraded forest, current fallow, other waste land, scrub land and water bodies. Major portion of the area is under crop followed by scrub/degraded forest (Fig.3). The change in area under the crops significantly influences the runoff.

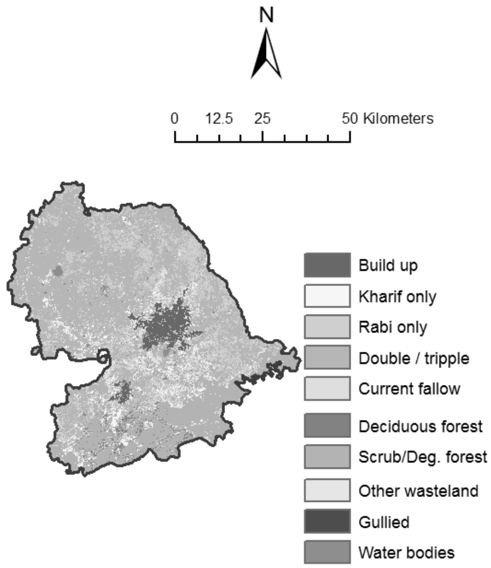

Figure 3 LULC map of Indore district

Temporal and temporal variation of runoff from crop land over the years

In this study, a spatial runoff estimation model was developed for estimating the daily runoff using SCS-CN method coupled with GIS and the model was validated using recorded data ($R^2 = 0.9$) (Fig.5).

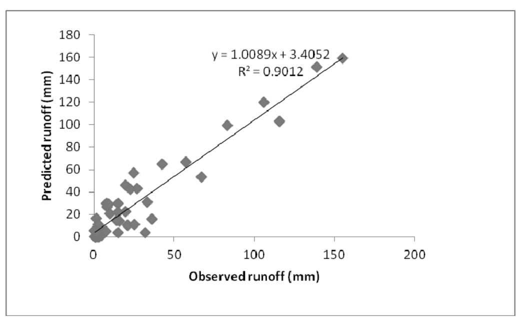

Figure 4 Observed and predicted runoff at Indore

Rainfall is the important factor governing runoff and the mean annual runoff from major portion of the district varied spatially from 21.4 to 26.2% of annual rainfall (Fig.6).

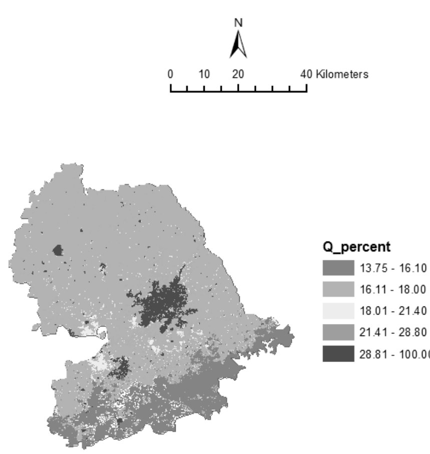

Figure 5 Spatial variation of runoff (% of annual rainfall) at Indore.

The runoff corresponding to different land use land cover was determined for the baseline period (BL) (1976-2005), 2020's (2010 to 2039), 2050's (2040 to 2069) and 2080's (2070 to 2099) using Ensemble data pertaining to RCP 2.6 (low emission), RCP 4.5 (medium emission), RCP 6.0 and RCP 8.5 (high emission) scenarios.

The rainfall is predicted to increase from 963 mm (BL) to 1000, 1048 and 1077 mm by 2020's, 2050's and 2080's respectively under RCP 4.5. The corresponding runoff from agricultural land with clayey soil is estimated to increase from 24.5 (BL) to 27.3, 28.6 and 29.2% of annual rainfall under RCP 4.5. The rainfall is predicted to increase from 963 mm (BL) to 1018, 1083 and 1161 mm by 2020's, 2050's and 2080's respectively under RCP 8.5. The runoff from clayey soil is estimated to increase from 24.5 (BL) to 27.8, 29.3 and 31.6% of annual rainfall under RCP 8.5. Considerable increase in future runoff is predicted especially under higher emission scenarios. This methodology can be adopted for estimating the runoff potential from similar areas under changing climatic scenarios.

Spatial variation of runoff in the catchments

The mean annual runoff corresponding to each land use land cover was estimated spatially using the daily runoff. This mean annual runoff was intercepted and dissolved with the catchments generated from DEM and the runoff volume was generated catchment wise (Fig.7).

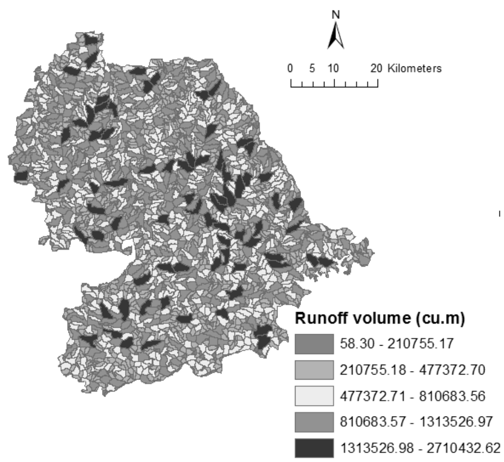

Figure 6 Runoff volume generated in the area

These runoff volumes estimated catchment wise for the micro-watershed could be utilized for planning the site specific water harvesting structures needed for the sustainable management of the micro-watershed.

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Information Content Analysis of Landsat-8 Oli Data for Water Resources Managemnt-A Case Study of Nagarjuna Sagar Reservoir

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ABSTRACT

Remote sensing sensors operating in the optical region of the spectrum capture reflected & / or emitted electromagnetic radiation from the object /features, which facilitates their identification / detection. Beginning with a few spectral bands in early 1970s, for example, in Landsat MSS, now the user community has access to remote sensing images with hundreds of spectral bands, viz. Hyperion image with 232 spectral bands. The challenges faced by image analyst is how to minimize the data analysis time without sacrificing the information content of remote sensing images. The information present in remote sensing imagery depends to a large extent on various factors like spatial, radiometric resolutions and amount of noise present in the imagery. It points to minimizing the number of spectral bands by using appropriate image processing techniques into a few spectral vectors/ indices. Towards this end, several spectral indices/ spectral transformation approaches, namely image entropy, Principal Component analysis (PCA), canonical analysis, Optimum Index Factors (OIF), etc. have been developed and used for inventory and monitoring of water resources, extent, distribution and temporal behaviour of water bodies, snow cover, optimal allocation of available water resources, performance evolution of canal command areas, etc. required for water resource management . The focus of the article is on selection of spectral features using the image processing tools available in ERDAS / IMAGINE which are indicative of the information content of Landsat-8 operational Land imager (OLI) for water resource management.

Keywords: Remote sensing, Landsat, PCA and OLF

INTRODUCTION

Remotely sensed data are widely used for deriving information on natural resources and environment. Spatial information/thematic maps are generated from remotely sensed data through the process of visual interpretation and/or digital image classification. The cost and complexity of classification depends on the number of spectral bands at different wavelengths and band size, while classification accuracy depends on factors like type of classifier used, noise in the bands and the information carried by each band. With increasing number of bands, cost of classification increases exponentially though accuracy saturates after increase to a certain number of bands. In order to bring down the cost of digital classification and to maximize the separability between classes a subset of the remotely sensed data needs to be selected (Novak and Soulakellis, 2000). For visualization of remotely sensed data a colour composite image with three spectral bands which are exposed through blue, green and red colours is generated. The choice of spectral bands for digital classification in case of sensors having very limited number of spectral bands is simple. But if the sensor is having more number of bands it is quite difficult to choose the minimum number of bands which gives unique information that are present in image. We have used Landsat Operational Land Imager data with 11 bands of different resolutions like 30 metres and 15 metres.

The PAN data is available with 15 metres spatial resolution. thermal Infrared(TIR) initially it is collected with 100 meters but it is resampled to 30 metres . As the satellite data used in this work contains 11 bands choice of selecting minimum number of bands is difficult for deriving information on natural resources and environment.In order to avoid such kind of problems there are certain unique transform procedures for retrieving unique data among the different bands of sensor. In this method we have used two methods such as Principal Component Analysis & Optimum Index Factor for selecting the minimum number of bands which gives unique information present in the image. Principal component analysis produces a new uncorrelated vector space from a set of correlated datasets in which data has most variance along its first axis, the next largest variance along a second mutually perpendicular axis and so on. The optimum index factor (OIF) helps us selecting a three-band combination representing the maximum variance in a multispectral which is a surrogate measure of its information content.

METHODS OVERVIEW

The methods developed by Chavez (1982) and Sheffield (1985) are discussed below

Chavez:

The Optimum Index Factor (OIF) was introduced by Chavez to select a three-band combination that displays the greatest details among a maximum of 20 bands. The index is given by SD_i it is the standard deviation of band i and ABS (CC) is the absolute value of the correlation coefficient between any two of the possible three pairs. According to Chavez the highest values of OIF should be a three band combinations having the most information content. This measure favours the selection of those bands having high variances and low pair-wise correlation. The measure can obviously be extended to any subset of arbitrary size p.

OIF is defined as

$$\text{OIF} = \sum_{i=1}^{3} SD_i \,/\, \sum_{j=1}^{3} ABS\left(CC_j\right)$$

Sheffield

Sheffield (1985) proposed a method based on the size of the hyperspace spanned by the data bands. The square root of the product of the eigen values of the three principal components defines the significant volume spanned by the image bands in the hyperspace. Sheffield suggests that those bands with the biggest hyper volumes be selected. According to Sheffield, the above approach would discourage the selection of those pairs having high correlation coefficients, the rationale being that highly correlated image band pairs will have the eigen value of one of the two image bands close to zero. Therefore, if a highly correlated pair is chosen, the resultant (hyper) volume, which is the product of the eigen values, will be small. Because the product of the eigen values (principal axis system) is equal to the determinant of the original covariance matrix, it is sufficient to rank in decreasing order the value of the determinant of each p by p sub-matrix generated from the original covariance matrix.

TEST SITE

The area around Nagarjun sagar was chosen as a test site. Nagarjuna Sagar Dam was built across the Krishna river at Nagarjuna Sagar where the river is forming boundary between Nalgonda District in Telangana and Guntur district in Andhra Pradesh states in India. The dam created a water reservoir whose gross storage capacity is 11.472 billion cubic metres .Height of the dam is 490 feet tall. It is also one of the earliest multi-purpose irrigation and hydro-electric projects in India. The dam provides irrigation water to the Prakasam, Guntur, Krishna, Khammam, West Godavari and Nalgonda districts along with hydro electricity generation. The Latitude and Longitude values of test site is as fallows 16.575967 N & 79.312402 E.

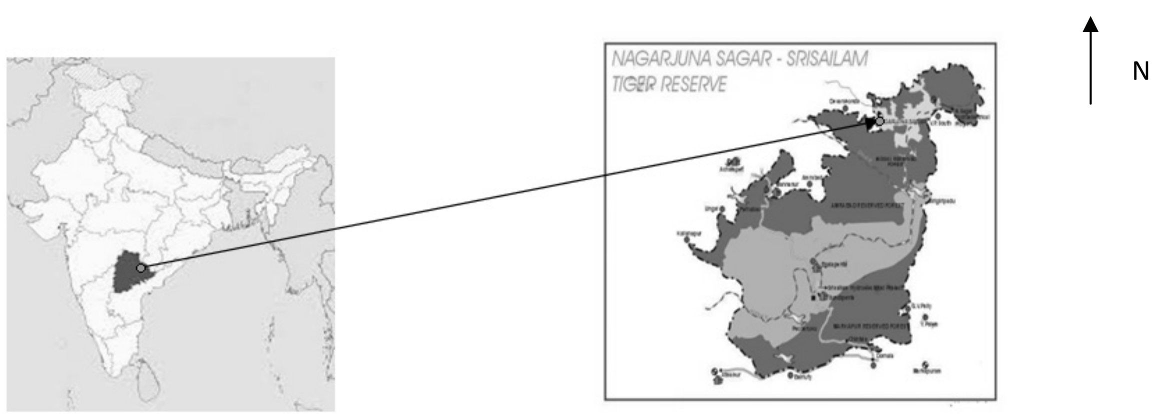

Figure 1 Location Map of Test site

DATA USED

Land sat OLI

The Land sat OLI data with path- row numbers 143-49 covering the test site used in the study. The Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) are the two instruments onboard the Land sat 8 satellite, which was launched in February of 2013. The satellite collects images of the Earth with a 16-day repeat cycle. The approximate scene size is 170 km north-south by 183 km east-west.

The spectral bands of the OLI sensor are similar to Land sat 7's ETM+ sensor with the addition of two new spectral bands: a deep blue visible channel (band 1) specifically designed for water resources and coastal zone investigation, and a new infrared channel (band 9) for the detection of cirrus clouds. Two thermal bands (TIRS) capture data with a minimum of 100 meter resolution, but are registered to and delivered with the 30-meter OLI data product.

Land sat 8 Level 1 data products typically include data from both the OLI and TIRS sensor; However, there may be OLI-only and/or TIRS-only scenes in the USGS archive. In scene identified on details given in the USGS website the first two values of the Landsat 8 scene ID designates the data provided in each scene:

LC80290302014084LGN00 = Combined (both OLI and TIRS data)

LO80810202014064LGN00 = OLI data only

LT81172002013314LGN00 = TIRS data only

Table 1 Salient features of Landsat 8 OLI imager

Channel	Spectral Range	Spatial Resolution	Electro Magnetic Region
Band1	0.43-0.45	30	Ultra Blue
Band2	0.45-0.51	30	Blue
Band3	0.53-0.59	30	Green
Band4	0.64-0.67	30	Red
Band5	0.85-0.88	30	Near Infra Read (NIR)
Band6	1.57-1.65	30	Shortwave Infrared (SWIR) 1
Band7	2.11-2.29	30	Shortwave Infrared (SWIR) 2
Band8	0.50-0.68	15	Panchromatic
Band9	1.36-1.38	30	Cirrus
Band10	10.69-11.19	100 (30)	Thermal Infrared sensor-1
Band11	11.50-12.51	100 (30)	Thermal Infrared sensor-2

The first 8 spectral bands of OLI data were used to realize the objectives.

METHODOLOGY

For deriving the information related to water bodies with multi spectral data in our study Erdas Imagine 15 was used. The approach involves generation of principal component transform of OLI multispectral data and deriving information of water related features. Information extraction is done using the Principal Component Analysis (PCA) which is an existing module in Erdas Imagine. Another software ILWIS is used for carrying out Optimum Index Factor(OIF).

Principal Component Analysis

In order to derive information on various water bodies multispectral images captured from space in different portions of the electromagnetic radiation are used. A close look at the multispectral images reveals the redundancy of information in the images of different spectral bands. That is to say that the spectral response patterns of the earth's surface features in different spectral bands are highly correlated.

Principal component analysis aims at transforming the original multispectral data with correlated spectral bands into a new uncorrelated transforms called principal components (Kumar, 2004). In the transformed (principal component image) the maximum variance lies along its first axis (components), followed by a second mutually perpendicular axis and so on. The process is implemented in two steps (Jensen, 1996). Firstly n × n covariance matrix from the bands is derived. In second step, eigen values and eigen vectors of the covariance matrix which are related as

$$\Sigma_Y = \Phi^T \Sigma_X \Phi = \begin{vmatrix} \lambda_1 \, 0 \ldots\ldots\ldots\ldots 0 \ldots \\ \ldots \lambda_2 \\ \ldots\ldots\ldots \lambda_3 \\ . \\ .0 \ldots\ldots\ldots\ldots\ldots \lambda_n \end{vmatrix} \longrightarrow \quad \textbf{....(1)}$$

are computed. Here ΣX is covariance matrix of original image bands, Σ*Y* is uncorrelated covariance matrix of uncorrelated bands, Φ is eigen vector matrix and λ_i's are eigenvalues such that $\lambda_i > \lambda_j$ for $i > j$. Eigen values are axes of the vector space and variances of the PC's their length. The percent of total variance carried by the each principal component can be calculated using the formula

$$\mathrm{var}_i = \frac{\lambda_i}{\sum_{k=1}^{n} \lambda_k} \times 100 \longrightarrow \quad \textbf{.....(2)}$$

Optimum Index Factor (OIF)

For analysis of multispectral images as those from Operational Land Imager (OLI) aboard Landsat-8 satellite with several spectral bands, the analyst wishes to select a set of few spectral bands that may provide maximum information about the image. Optimum index factor (OIF) addresses this issue by determining a set of three spectral band combination that may carry maximum variance (information) amongst all possible three-spectral band combinations.It is a statistical computation of most favorable band combination (Jensen, 1996) and rank the band subsets according to their information (Beaudemin and Fung, 2001) based on the amount of total variance and correlation between various bands (Ehsani et al., 2010; Gupta, 2003).

OIF can be computed as

$$\mathrm{OIF} = \frac{\sum_{i=1}^{i=n} \mathrm{Std}_i}{\sum_{i=1}^{i=j} \mathrm{Corr}_{ij}} \longrightarrow \quad \textbf{.....(3)}$$

Where Std_i refers to standard deviation and Corr_{ij} is the absolute value of correlation coefficient.

Normalised Difference Water Index(NDWI):

The NDWI image was generated by using green and NIR bands of OLI-8 data using the following formula(McFeeters,1996) S.K. The use of Normalised Difference Water Index (NDWI) in the delineation of open water features. Int.J.RemoteSens.1976, 17,1425-1432.

$$\mathrm{NDWI{=}GREEN{-}NIR/GREEN\ {+}NIR} \longrightarrow \quad \text{.....}\textbf{(4)}$$

Results and Discussions

The section is divided into two sub sections namely Principal component Analysis and Optimum Index factor dealing with minimum number of band combinations which gives unique information that is present in image.

Optimum Index Factor

The OIF value ranges from for three band combination to of band combination. A visual comparision is made for highest band priorities against standard FCC and FCC derived from combination of OLI bands reveals a good improvement in water content analysis.

Table 2 Optimum Index factor for various Band combinations

S.no	Combination	ΣSD	ΣR	OIF= ΣSD/ ΣR
1	123	43.297	2.8908	14.97751487
2	124	39.826	2.8081	14.18254336
3	**125**	**40.599**	**1.8964**	**21.40845813**
4	126	38.691	2.5188	15.36088614
5	127	37.943	2.6417	14.36309952
6	134	24.228	2.7203	8.906370621
7	135	25.001	1.8086	13.82339931
8	136	23.093	2.431	9.49938297
9	137	22.345	2.5539	8.749363718
10	145	21.53	1.7259	12.47465091
11	146	19.622	2.3483	8.355831878
12	147	18.874	2.4712	7.637584979
13	156	20.395	1.4366	14.19671446
14	157	19.647	1.5595	12.59826868
15	167	17.739	2.1819	8.130070122
16	234	30.817	2.8075	10.97666963
17	235	31.59	1.886	16.74973489
18	236	29.682	2.5331	11.71765821
19	237	28.934	2.6479	10.92714982
20	245	28.119	1.8121	15.51735555
21	246	26.211	2.4592	10.65834418
22	247	25.463	2.574	9.892385392
23	256	26.984	1.5377	17.5482864
24	257	26.236	1.6525	15.87655068
25	345	12.521	2.1285	5.882546394
26	346	10.613	2.7253	3.894250174
27	456	7.915	1.9739	4.009828259
28	457	7.167	2.0577	3.483015017
29	467	5.259	2.7872	1.886839839
30	567	6.032	1.7474	3.451985807

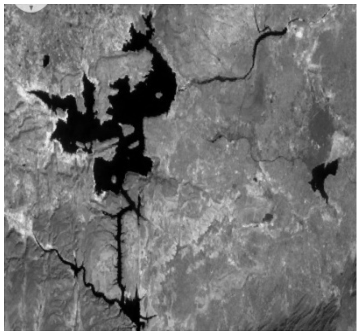

Figure 2a Standard false colour composite of test site

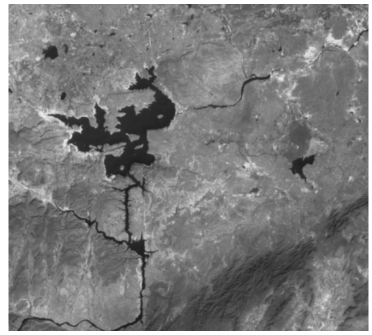

Figure 2b Standard false colour composite of bands 1,2,5 with maximum OIF

Figure 2 FCC of raw image and highest band combination image with maximum OIF value

Principal Component Analysis:

The details of training site, covariance, eigen vectors are shown in below tables

As evident from the Table 4, the spectral band-2 of Landsat-8 OLI accounts for maximum variance (8938785.00) indicating thereby the maximum information available in band-6 (Table 4). Eigen values and eigenvectors were computed for 7x7 matrix and are appended in Table 5. The variance measured along the first PC is 19378300.18which accounts for 73.57% of the image variance. The remaining variance is distributed amongst the other 6 PCs. Among these, the second PC contains maximum variance (24.05%), the seventh PC accounts for only (0.00003%) of the variance. While PC1 exhibits overall brightness of the image in which water resources are identified clearly.

Table 3 Statistics of Test site

Band	Min	Max	Mean	Standard deviation
1	0	255	84.038	15.239
2	8	252	145.743	21.828
3	42	255	155.904	6.23
4	49	255	76.166	2.759
5	68	255	126.125	3.532
6	89	146	114.015	1.624
7	107	133	117.126	0.876
				SUM 52.088

Table 4 Covariance matrix

Band	Band1	Band2	Band3	Band4	Band5	Band6	Band7
1	157406.06	195793.54	260603.1	433450.8	-99787.5	628247.3	701939.6
2	195793.54	248822.56	341909.73	576919.3	-73886.7	883729.8	956527.3
3	260603.1	341909.73	530800.79	922782.2	353758.6	1690814	1659500
4	433450.84	576919.31	922782.23	1780187	441708.1	3397712	3384458
5	99787.52	-73886.65	353758.61	441708.1	7330105	3943399	1910281
6	628247.27	883729.84	1690813.61	3397712	3943399	8938785	7746818
7	701939.55	956527.31	1659499.61	3384458	1910281	7746818	7351069

Table 5 Eigen Vector data

Eigen vector	Band1	Band2	Band3	Band4	Band5	Band6	Band7
1	0.0502	-0.0775	0.3464	-0.1568	0.4651	-0.4477	-0.6554
2	0.07	-0.0958	0.4176	-0.206	0.4256	-0.2155	0.7357
3	0.1331	-0.0923	0.5104	-0.1925	0.06054	0.8025	-0.1683
4	0.2618	-0.2192	0.5114	0.0914	-0.716	-0.3173	0.003
5	0.3266	0.9097	0.1917	0.1663	0.01273	-0.0306	0.0088
6	0.6746	-0.0489	-0.3674	-0.6338	-0.0671	0.03301	-0.01031
7	0.5869	-0.3132	-0.1077	0.6768	0.2852	0.0785	0.0119
E value	19378300.18	6334683.762	477525	97392.24	40269.48	8098.037	906.0802
Percent variance	73.57	24.05	1.8	0.3	0.15	0.0005	0.00003

Principal component Transform of 7 bands of OLI data:

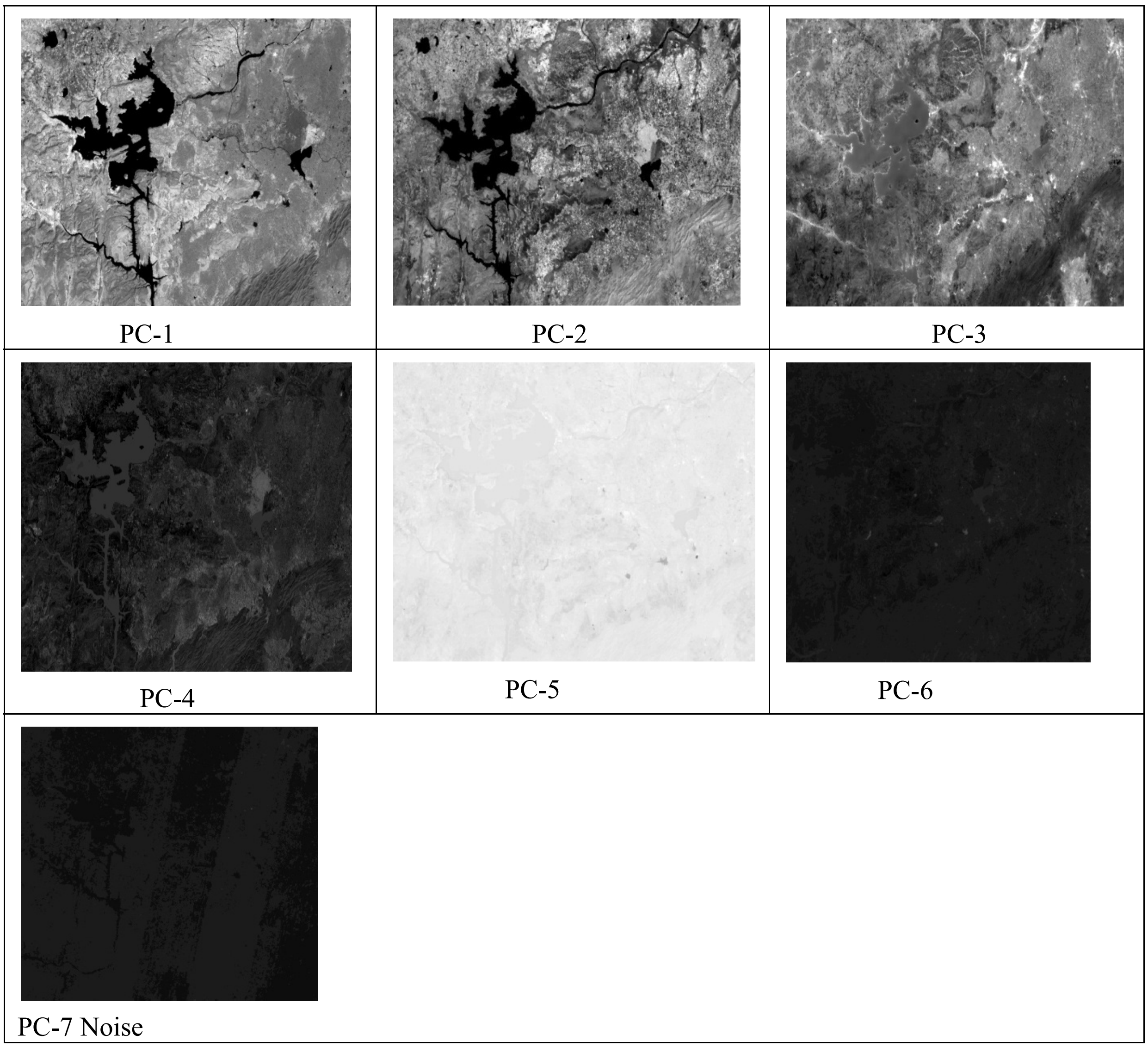

Figure 3 Principal Component Transform of Landsat-OLI data

Detection of Terrain features:

A qualitative evaluation of transformed images with respect to delineation of terrain features is given below

Optimum Index Factor

As evident form Table 2 the band combination 1, 2, & 5 accounts for a maximum OIF value

(21.40) indicating thereby the availability of maximum terrain information. With respect to information on water resources and other terrain features, a comparison of FCC prepared from band 4,3,2 with the one generated using bands 1,2,5 reveals that the overall image contrast amongst various terrain features is more in case of FCC prepared using spectral band with maximum OIF value. Furthermore in contrast between crops and forest is appreciably better in FCC of maximum OIF value images as compared to standard FCC image.

Principal Component Transform

Water bodies stand out very well in PC1 image. In addition drainage network required for various hydrological studies including modelling is very clear. However, the contrast between forest and crop land is relatively poor. In PC2 image paddy crop has come out very well incidentally the contrast between land and water bodies is very poor. In PC3 the contrast between land features and land water boundary is equally poor.

Normalised Difference Water Index (NDWI)

Since the focus of study was on delineation of water and its related features, the NDWI image has served as very good database for detection of water bodies. The water bodies are seen as bright white features. The pixel values varies from -0.196 to 0.724. As evident from figure-4 the water bodies-both Natural as well as manmade are exhibited vividly in very light gray tone. Interestingly, the coastal water in the lower right of the image is seen as white colour. This area is part of Bay of Bengal. Vegetation over hills (Forest) is manifested as dark to very dark gray tone. Crop lands along the coastal plains could be seen as medium gray tone.

Figure 4 Identification of water resources

Conclusion

With an objective of optimizing the number of spectral bands data for detection of Water resource management three datasets, namely original Landsat-8 OLI bands data, a band triplet with maximum OIF value, and the first three principal components of Landsat-8 OLI bands were analyzed. All the water resources are highlighted which provides an easy view for identifying them. Interestingly, a band triplet with the maximum optimum index factor (OIF) value 21.40845813 (Landsat-8 OLI band 1, 2 and 5) showed clear identification of water resources with fewer number of bands. Similarly the PC's 1,2,3 showed maximum amount of covariance data for identifying of water resources. The results clearly indicate the potential of using data transforms for detection of water resources using space borne multispectral data.

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Rainfall Analysis with Reference to Spatial and Temporal in Kaddam Watershed using Geomatics

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ABSTRACT

In the present study, a rainfall map of the study area was prepared by Thiessen polygon method for years 2000-2014 and the rainfall data for daily was obtained from which normal average monthly, yearly was analyzed. GIS is used to explore spatial patterns of the trends over the entire Kaddam basin. GIS software can easily handle, store, analyze, manipulate and retrieve spatial data map preparation can be easily implemented using GIS environment. The rainfall data over the years was collected and maps were obtained with the help of GIS. Yearly and monthly rainfall is analyzed along the Kaddam watershed quantifying aspects as the anomaly of rainfall amounts and the spatial distribution of rainfall data. A trend analysis for Monthly average rainfall is done for year 2000-2014 which shows a very high rainfall in the region of Inderavelly and comparatively very low rainfall in Khanapur. Average rainfall shows a decreasing rainfall trend in the basin during the period 2000-2004, which is reversed during the period 2004–2005 resulting in increasing rainfall trend in the basin. The most probable year of change was found to be 2004 in annual and monsoonal rainfall which proved to be a drought year and year 2013 showed a considerable increase in rainfall.

Keywords: *Precipitation, Rainfall analysis, GIS, Kaddam.*

INTRODUCTION

Analysis of the precipitation phenomenon as one of the most vital meteorological elements straightforwardly influencing access to water resources is of fundamental significance. Variation in precipitation and other forms of precipitation will be one of the most critical factors deciding the general effect of environmental change. Precipitation is a great deal harder to predict than temperature. It is the adjustments in weather patterns that make foreseeing precipitation especially troublesome. Precipitation is one of the critical climatic parameter impacting the cropping pattern, productivity, flooding and drought hazards, disintegration and sedimentation. Irrigated system likewise requires rainfall precipitation to renew surface water or the aquifers. Changes in the intensity of the rainfall and its seasonal distribution would influence the spatial and temporal distribution of runoff, soil moisture and groundwater reservoir, and would affect the frequency of droughts and floods. Information of spatial and temporal rainfall pattern is necessary for planning suitable measures for mitigating the problems. Three main characteristics of rainfall are its amount, frequency and intensity, the values of which vary from place to place, day to day, month to month and also year to year.

Kaddam watershed mostly lies in the Adilabad district. The climate of the district is characterized by hot summer and in generally dry except during the south-west monsoon season. The rainfall in the district, in general increases from the south-west towards the north east. About 85% of annual rainfall is received during the south-west monsoon season, July being the peak rainy month. The variation in the Annual rainfall from year is not large. The relative humidity is high generally during the south-west monsoon season. The air is generally dry during the rest of the year, the district part of the year being the summer season when the humidity in the afternoon is 25%. During the south-west monsoon season the sky is heavily clouded. There is rapid decrease of clouding the post-monsoon season. In the rest year the sky is mostly clear of light clouded. Winds are light to moderate with some strengthening in the period from May to August. During the post-monsoon and cold season, winds blow mostly from the east or north-east. By March, south westerlies and westerlies start blowing and continue during the rest of summer. The sought west monsoon season winds are mostly from directions between south-west and North West.

Rainfall is one of the climatic variables that affect both the spatial and temporal patterns on water availability. The Geographical Information System (GIS) is an effective tool for mapping the spatial distribution and its trend. GIS have been used worldwide by number of researchers for spatial mapping. GIS is a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the Earth. Jagannadha Sarma (2005) analyzed the spatial distribution pattern of annual, monsoon and non monsoon rainfall in the coastal zone of Andhra Pradesh. Vennila (2007) studied the rainfall variation in the Vattamalaikarai sub basin in Tamil Nadu. Rathod and Aruchamy (2010) have done a study on spatial analysis of rainfall variation in Coimbatore District of Tamil Nadu using GIS tool. Similarly, the present study is made to understand the spatial variation of different data series such as annual, monthly, rainfall for the Kaddam watershed.

STUDY AREA

The Study area selected is Kaddam watershed present in the G-5 sub basin which is the 'Middle Godavari' Sub basin of Godavari River Basin. The Godavari basin extends over an area of 3, 13,812 Sq.km. Godavari catchment is divided into eight sub basin in which G-5 sub basin is one of the basin, it lies between latitudes 17° 04' N and 79° 53' E longitude. The study area selected in the Middle Godavari sub basin is considered up to Kaddam reservoir watershed which lies between 19° 05' E and 19° 35' N latitudes and 78° 10' and 78° 55' E longitudes. The watershed covers a total of twelve mandals of which eight mandals are taken Khanapur, Boath, Ichchoda , Narnoor, Utnoor, Indervelly, Bazarhatnoor and Kaddam all of which fall under Adilabad district.

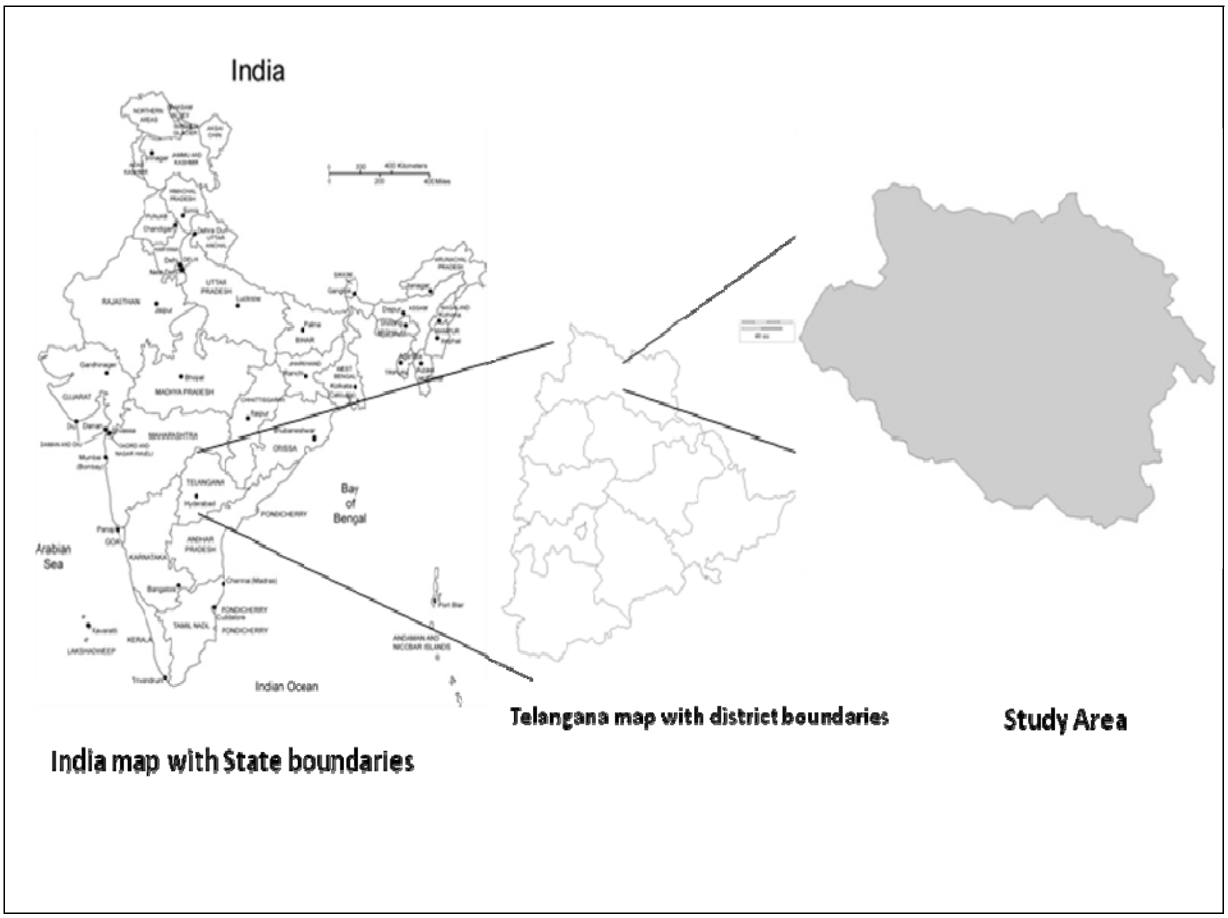


Figure 1 Location map of Kaddam Watershed.

MATERIALS AND METHOD

Data

Every day Rainfall Data for a period of 14 years from 2000 to 2014 of eight gauge stations are collected and processed on Excel sheets as indicated by the prerequisites to acquire interpretative area map. Arc GIS software version 9.3 was used for creating, managing and generating maps.

Methodology

For the preparation of rainfall maps, the monthly rainfall data is collected for the years 2000 to 2014. The rainfall data is from the eight rain gauge stations viz., Boath, Khanapur, Bazarhatnoor, Kaddam, Ichchoda, Utnur, Indervelly, Narananoor. Mapping point data usually involves some sort of interpolation. There are many point-interpolation methods as well as non-interpolation methods for displaying point values. The Thiessen Polygon method is an interpolation method commonly used for precipitation. Thiessen Polygons are Voronoi Cells, a geometric means of dividing up an area given a set of known values at a relatively small number of points.

The latitude and longitude were assigned to the eight stations which are then imported to the ArcGis in which these are converted into point feature. There are various steps taking place in this process. The point feature is taken as input and duplicated points are removed. TIN structure is created which generates perpendicular bisectors for each tin edge and builds the Thiessen polygons. The Thiessen polygon are clipped to the extends of the input features. The resulting feature class is clipped with the polygon of study area to get the desired shape. Annual average, monthly average rainfall maps for the period of 14 years are generated.

Table 1 Rain Gauge Stations in Study Area

Sl. no	Station ID	Longitude	Latitude	Area (Km. sq.)
1	Ichoda	78.455300	19.427600	578.44
2	Bazarhatnoor	78.352200	19.458300	122.26
3	Naranoor	78.846869	19.504998	70.617
4	Boath	78.321600	19.339900	521.99
5	Kaddem	78.780200	19.097800	410.20
6	Khanapur	78.648400	19.041400	636.28
7	Utnoor	78.778800	19.371800	568.73
8	Inderavelly	78.671100	19.494100	288.27

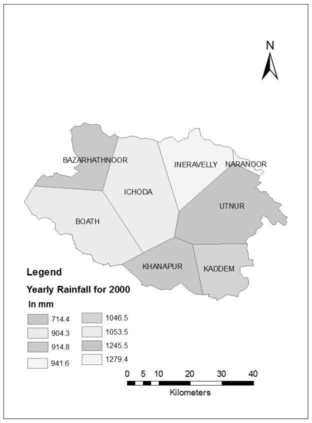
RESULTS AND DISCUSSION

Average Monthly analysis (shown in Table 2) of rainfall indicated that the majority of the polygons have very little or no changes in months of January, February, March, April, May, November and December. In seasons other than monsoon the magnitude of change was quite small; as rainfall in these seasons is much smaller than in the monsoon season. In the month of October there was a generous increase in the rainfall in most of polygons. The monsoon months June, July and August showed a diverse trend in rainfall. The maximum increase out of eight stations was experienced by Inderavelly in the month of August (388.89 mm/year) and Ichoda in the month of August (350.25 mm/year). The maximum reduction was found in Khanapur (140.72 mm/year) in June which showed the lowest peak and Kaddam (154.59 mm/year) in June.

Table 2 Monthly Average Rainfall in mm for the study area

S.No.	STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Inderavelly	9.51	2.13	10.45	10.86	12.79	190.87	339.48	388.81	139.97	63.42	9.72	0.21
2	Ichoda	12.97	3.79	17.26	13.41	15.57	209.65	261.16	350.25	173.10	57.79	14.41	0.00
3	Bazarhathnoor	7.75	3.53	20.27	8.47	11.17	218.23	297.75	342.65	179.99	57.97	12.80	0.08
4	Boath	12.95	8.13	19.25	5.60	14.55	181.46	267.46	307.76	164.00	55.11	17.97	0.27
5	Nananoor	11.69	9.51	10.55	9.09	10.40	175.30	281.56	306.70	165.24	62.11	13.81	1.29
6	Khanpur	13.72	8.33	11.93	16.01	8.87	140.72	245.26	278.17	178.74	60.24	9.41	3.11
7	Kaddam	8.99	7.89	14.15	21.01	6.83	154.59	273.77	285.23	147.80	49.20	9.24	4.68
8	Utnur	12.24	8.41	19.78	9.85	12.35	185.31	327.41	335.02	170.63	62.93	10.42	0.21

The spatial analysis of rainfall on monthly and yearly basis has been carried out for all eight stations of Kaddam watershed. Spatial analysis of rainfall and the results obtained have been presented for all the different stations (shown in fig 3).



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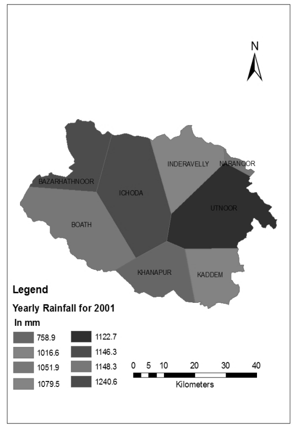

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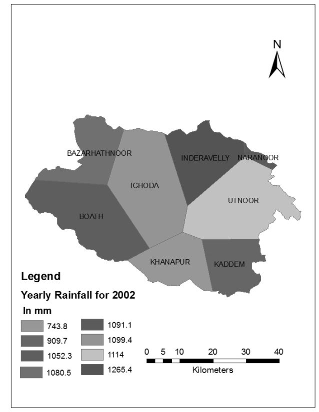

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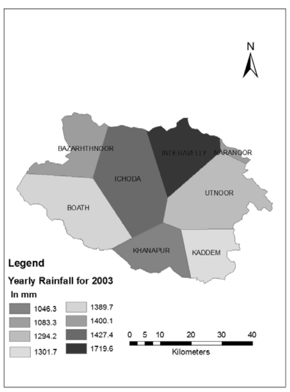

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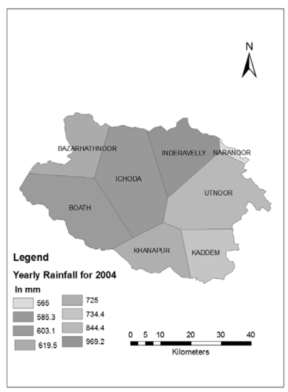

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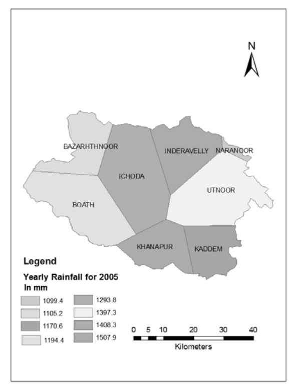

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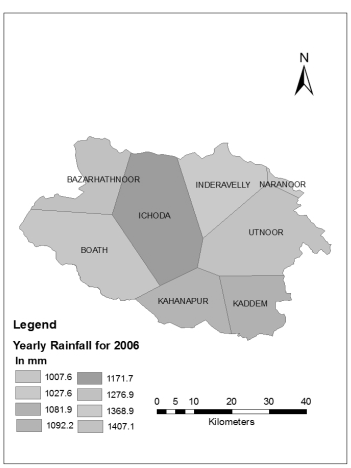

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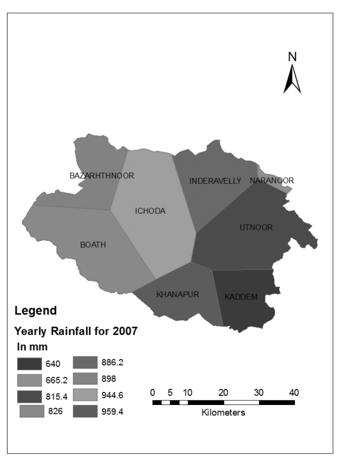

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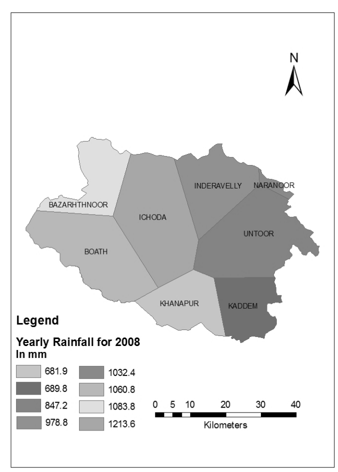

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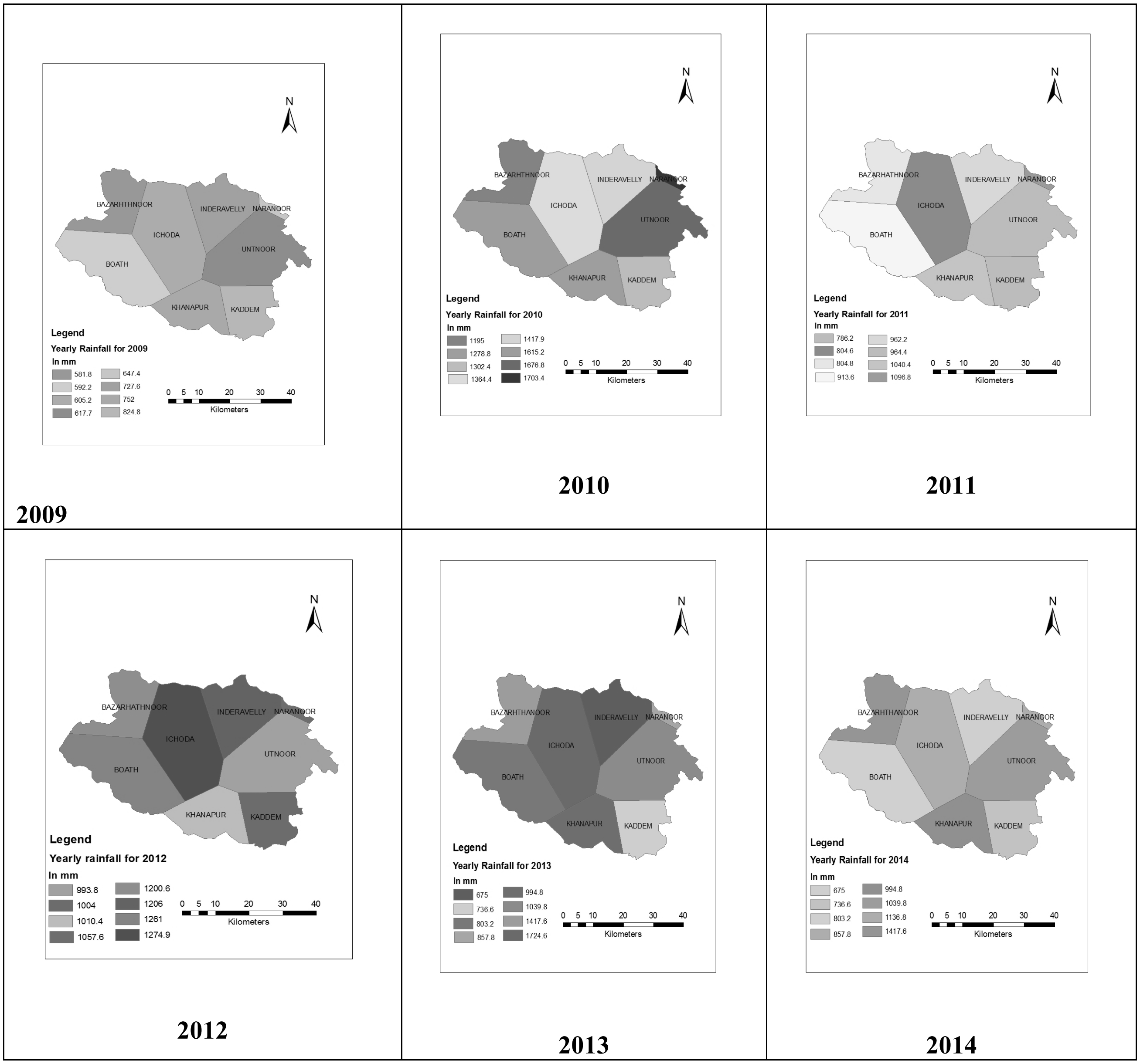

Figure 2 Annual Rainfall of Kaddam watershed for the years 2000 to 2014.

Linear regression analysis has been done in Excel which uses the method of least squares to find a line that best fits the points. The trendline of yearly average from 2000-2014 for the eight stations have been produced. Out of eight stations negative trend has been shown in the stations Inderavelly and Kaddam. Indervally showed a decrease in the trend through years 2000-2014 whereas Kaddam showed no change in trend throughout the years. The rest of six stations showed a positive trend, among which the maximum increase was shown in Bazarhathnoor.

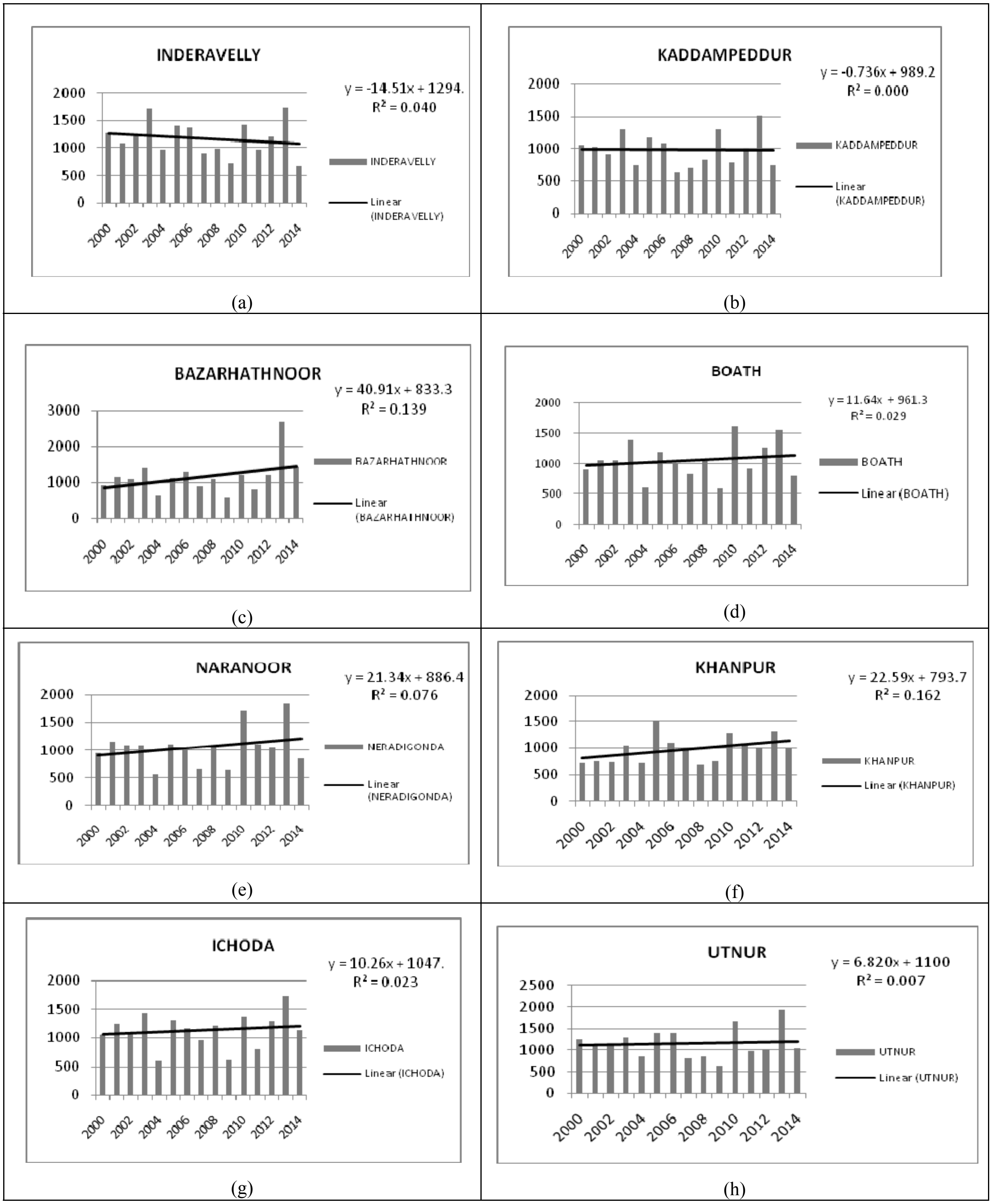

Figure 3 Normal Rainfall showing Negative Trend (a & b) and Positive trend of Rainfall Station

Normal rainfall analysis of sub-divisional varied over eight stations along the years. Maximum rainfall is shown in the year 2013 in the area Bazahathnoor. The lowest rainfall is seen in the year 2004 in the area Naranoor. Annual rainfall is seen decreasing in trend from 2003 -2004 and 2005-2007 whereas increase in the trend seen from years 2002-2003, 2009-2010 and 2012 -2013.

CONCLUSION

Arc GIS is a useful tool in mapping the spatial distribution of rainfall data. Rainfall map preparation helps to identify the spatial variation of rainfall across different parts of the study area and to identify areas with high and low rainfall. This information about precipitation intensities can be utilized in the design of storm water drainage systems, calculation of irrigation water requirements and design of irrigation water supply systems etc. GIS helps in modeling these spatial variations into an effortlessly interpretable frame which can be put into utilization for other related purposes. The aim of present study was analysis of monthly and annual rainfall for the area of Kaddam watershed using Arc Gis. The eight substations for the whole of watershed have been analyzed for trend detection .The trendline showed both positive and negative trend. The negative trend was found in polygon of Inderavelly which shows decrease in rainfall through years 2000 to 2014 and Kaddem which showed little decrease. The annual rainfall was calculated for 14 years and the year 2004 showed low rainfall for stations Inderavelly, Ichoda, Bazarhathnoor, Boath, Naranoor, Khanapur, Kaddam and Utnur as 969.2, 585.3, 619.5, 603.1, 565, 725, 734.4, and 844.4 (mm/year) respectively. The maximum annual rainfall was calculated in the year 2013 for stations Ichoda, Bazarhathnoor, Boath, Naranoor, Khanapur, Kaddam, Utnur and Inderavelly as 1724.6, 1417.6, 803.2, 1039.8, 994.8, 736.6, 1039.8 and 675 (mm/year) respectively.

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Identification of Potential Agricultural Lands in Urban Environment using Space-Borne Multispectral Data

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ABSTRACT

As a consequence of urbanization the agricultural land in the peri-urban region of most of the cities is gradually transformed into urban settlements. In order to ensure food security such a transformation needs to be prevented. By virtue of spectral measurements at regular interval space-borne multispectral measurements hold great promise in delineating such lands in timely and cost-effective manner. We report here a study that was taken up in Serilingampally mandal of Rangareddy district, Telangana state which forms the peri-urban areas of Hyderabad city, to identify potential agricultural lands. In order to realize the objectives Landsat-TM data collected in 2005 and Resourcesat 2 LISS-IV data over state acquired in 2015 was interpreted through heads-up/on-screen visual interpretation approach to delineate current land use pattern. Land use/cover pattern, thus delineated, was utilized to identify the pockets of land which can support agriculture based on terrain and soil characteristics. The results indicate that an estimated 2,841ha spread across the *mandal* has ample potential to support agriculture. Furthermore, estimated area of 1,597ha could be used for floriculture, olericulture and horticulture.

Keywords: Spectral measurements, Landsat-TM, Resourcesat 2 LISS-IV, Urbanization, Agriculture, Floriculture, Olericulture.

INTRODUCTION

In the next four decades, all of the world's population growth is expected to take place in urban areas most of which will happen in developing countries, where the urban population is expected to double i.e. from 2.6 billion in 2010 to 5.2 billion in 2050 (United Nations,2011). Rapid urbanization has resulted in conversion of agricultural lands to residential and commercial uses worldwide (Boudjenouia et al., 2008; Fazal, 2001; Yan et al 2009), and often this conversion results in a net loss in prime agricultural land and ultimately threatening food security. In this context Urban and Peri-urban Agriculture (UPA) can make significant contributions by acting as a (i) Source of livelihoods for a range of urban and peri-urban beneficiaries, (ii) Means of addressing urban and periurban food and nutritional security, (iii) Means of utilizing bio-degradable urban waste thus facilitating an improvement in the urban environment and the return of recyclable nutrients to UPA production systems, (iv) Means of re-cycling urban wastewater, and (v) Source of urban micro-ecosystems and ecology by providing green zones and carbon sinks as a means of mitigating Climate Change. Information on spatial extent and distribution of such land is a pre-requisite for coordinated, community efforts to set and meet local food and bio-fuel production goals.

BACKGROUND

Conventionally, agriculture is defined as the process of producing food, feed, fiber and other desired products by the cultivation of certain plants and the raising of domesticated animals. The agriculture practiced in the Urban and Peri-urban areas is termed as Urban and Peri-urban Agriculture (UPA). The definition of UPA varies on a project basis and as dictated by institutional mandates, policy opportunities and restrictions and, on individual perceptions. According to (FAO-COAG, 1999), urban and peri-urban agriculture are agriculture practices within and around cities which compete for resources, namely land, water, energy and labour that could also serve other purposes to satisfy the requirements of the urban population. Furthermore, Mougeot (2000) defines urban agriculture as the growing of plants and the raising of animals for food and other uses within urban and peri-urban areas, as well as the related production.

The most important characteristic of urban agriculture is not its location, but the fact that it is part of and interacts with the urban ecological and economic system. UPA is embedded in and interacting with the urban ecosystem. Such linkages include the use of urban residents as labourers, use of typical urban resources (like organic waste as compost and urban wastewater for irrigation), direct links with urban consumers, direct impacts on urban ecology (positive and negative), being part of the urban food system, competing for land with other urban functions, being influenced by urban policies and plans, etc.

ROLE OF REMOTE SENSING

By virtue of synoptic view and spectral measurements of a fairly large area at a regular interval digital remote sensing data have been found very useful for analysis of the urban and suburban environment: urban land-use and infrastructure mapping and monitoring (Barnsley et al, 1993; Jensen and Cowen, 1999; Meaille and Wald, 1990).

Furthermore, most urban land-use studies have employed data from optical remote sensing satellites including Landsat Thematic Mapper (TM), Systeme Probatoire d'Observation de la Terre (SPOT), Indian Remote Sensing (IRS 1C)] where an effective delineation of vegetation, water, and built-up land-cover categories has been made on a purely spectral basis (Ridd, 1995; Sadler et al, 1991). Besides, remotely sensed data have been found to very useful in developing soil resources maps and in generating derivative information such as land capability, land irrigability and land suitability (Mulder et al., 2011 Dwivedi et al., 2016a and 2016b).

STUDY AREA

Serilingampally is part of Hyderabad Urban Agglomeration (HAU) which is located within Ranga Reddy district of Telangana state.. Bound by geo co-ordinates 17.414 to 17.517^0N and 78.283 to 78.414^0E Serilingampally municipality covers an area of approximately 101 km^2 spread over 24 wards (Fig.-1). Lithological the test site consists of granite-gneiss complex. Hills, pediment, pediplain and valley the physiographic units encountered in the area. Coarse-textured red soils predominantly occur with inclusions of black soils in local depressions and low lying areas. The area enjoys semi-arid sub-tropical climate with average daytime temperature ranging from 25-30^{o}C during November to February and 40-45^{o}C during April-June. Annual precipitation is between 700-1000 mm yr-1 which is received mostly during July to October. According to the 2001 Census, the total population of Serilingampally was 153,364 exhibiting an increase of over 112% over the 1991 value. Main crops grown include sorghum (35.53%), paddy (36.84%) and pigeon pea (22.37%). The remaining 5.26% was recorded as sorghum/paddy (IWMI, 2007).

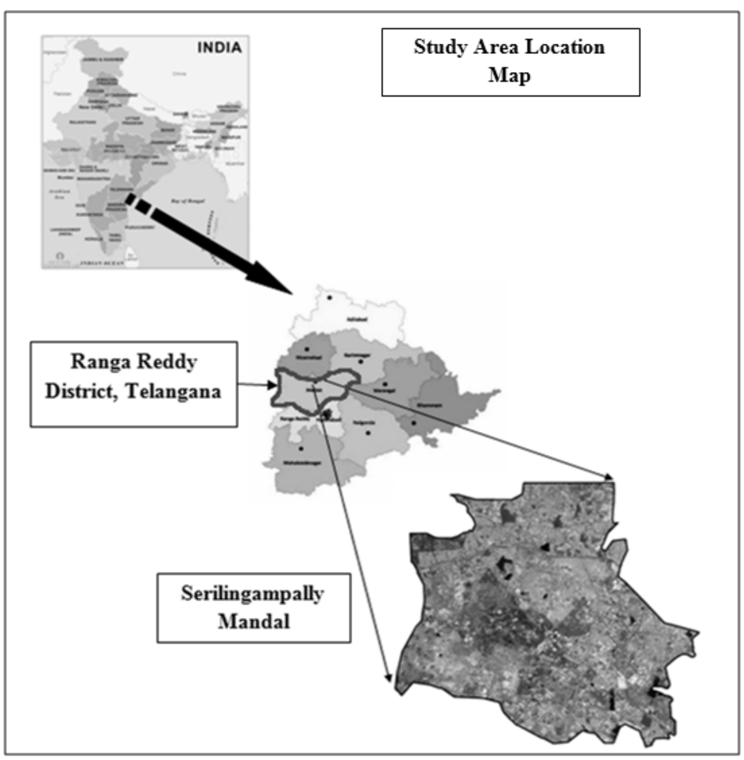

Figure 1 Location map of the study area.

DATBASE

Landsat-TM data acquired on November 17, 2005 and Resourcesat-2 LISS-IV data collected on March15, 2015 were used for developing land use/ land cover maps of the test site. Ancillary information consists of Survey of India topographical maps at 1:50,000 and 1:25,000 scales, soil map prepared by Telangana State Remote Sensing Centre, Hyderabad and other published reports on Serilingampally.

METHODOLOGY

To begin with, Landsat-TM data was georeferenced to Survey of India (SOI) topographical maps at 1:50,000 scales on a Silicon Graphics (Octane)-based system by identifying adequate ground control points by using ERDAS/IMAGINE software by identifying well distributed ground control points identifiable on Landsat-TM digital image and topographic maps. Landsat-TM data was resampled to 30m resolution with sub-pixel accuracy using second order polynomial transform and the nearest neighbor sampling approach. Similar exercise was done for geo-referencing Resourcesat-2 LISS-IV data with 6m spatial resolution using ground control points from 1:25,000 scale topographic maps. The digital output, thus generated, was used for land use/ cover mapping.

PRELIMINARY VISUAL INTERPRETATION

Based on our experience, image elements, namely tone/ colour, texture, pattern, association and ancillary data and the terrain conditions, the areas likely to correspond to various land use/land cover categories viz. agriculture, forest, wastelands, settlements, water bodies etc. were tentatively delineated Resourcsesat-2 LISS-IV digital image of the area following heads-up visual interpretation approach. Subsequently, the sample areas to be verified in the field were identified and precisely located on the Survey of India topographical maps of 1:25,000 scales. Similar approach was followed for preliminary visual interpretation Landsat-TM image and 1:50,000 scale.

GROUND TRUTH COLLECTION

The parcels of land representing various land use/land cover classes as delineated during preliminary digital analysis in each sample strip and located onto topographical maps, were physically located on the ground. Subsequently observation on various land use categories in each sample strip was made to correlate the image elements and their correspondence with land use categories. The location of each observation was recorded with help of a GPS.

MAP FINALIZATION

To begin with, the digital Resourcesat-2 LISS-IV data was displayed onto colour monitor of the Silicon Graphics (Octane) - based system using ERDAS IMAGINE software and a blank vector layer was overlaid onto the image. The areas which were delineated as having tentative land use/ land cover categories during preliminary visual interpretation were then located in the image and the boundaries were modified *vis-a-vis* ground truth collected during field visit. The vector coverage was generated for and use/land cover categories delineated from Landsat TM and LISS-IV data delineated on the colour monitor of the Silicon Graphics (Octane) system using ERDAS/ IMAGINE software and its topology built. The area statistics for each land use/ land cover categories was generated.

DATA INTEGRATION AND GENERATION OF DERIVATIVE INFORMATION

As the objective of the study was to identify agriculturally potential land, the land use/land cover map prepared from LISS-IV data was integrated with available soil map in a GIS environment (Arc-GIS version 10.1). The suitability of each land use categories available for use for various purposes (temporarily/ permanently) was assessed vis-a-vis potential and limitations of the land as deciphered from soil map (Fig.2). Subsequently the areas with varying degree of limitations for agriculture were delineated.

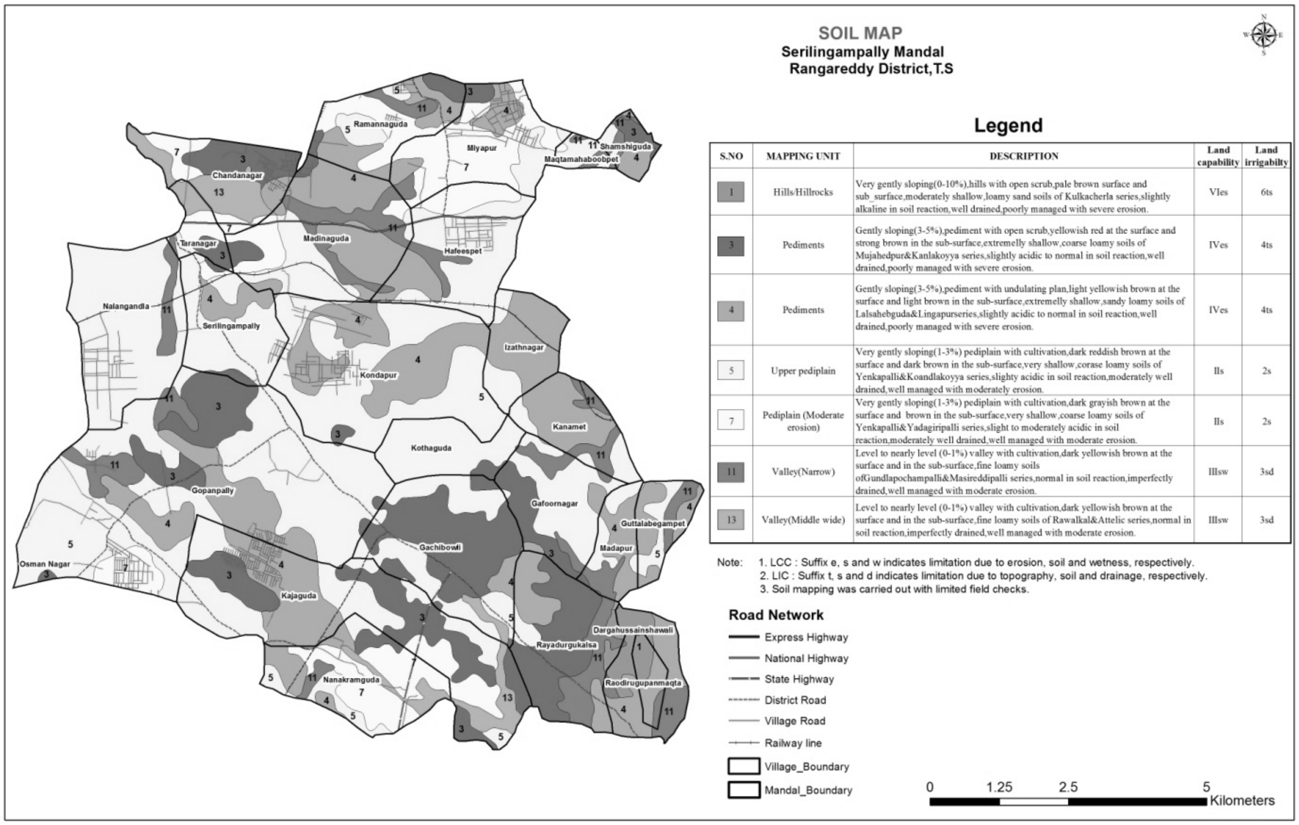

Figure 2 Soil Map of the study area.

ACCURACY ESTIMATION

For quantitative estimates of classification accuracy of land use/land cover maps generated from Landsat-TM and Resourcesat-2 LISS-IV data sample areas representing different land use/land cover categories were selected (Congalton, et al., 1983). Within each sample areas 20 sample points representing different land use land cover categories were identified. A one-to-one comparison of the categories mapped from all the data sets and available ground truth data, was made and the percent correct points was estimated. Accuracy estimation in terms of overall accuracy and Kappa coefficient (K) was subsequently made after generating confusion matrix. The Kappa coefficient (K) was computed as follows (Bishop et al., 1975).

$$K = \frac{N \sum_{i=1}^{r} xii - \sum_{i=1}^{r} (xi+)(x+i)}{N^2 - \sum_{i=1}^{r} (xi+)(x+i)} \qquad \text{.....(1)}$$

where `r' is the number of rows in the matrix, xii is the number of observations in row i and column i (the ith diagonal elements), xi+ and x+i are the marginal totals of row 'r' and column i, respectively; and N is the number of observations.

RESULTS AND DISCUSSION

Land use/land cover pattern as delineated from Landsat-TM and Resourcesat-2 LISS-IV data were used to study its temporal behavior. And potential of a particular land use land cover unit was assessed to provide the information to planners and decision makers for utilizing the available land for agriculture.

LAND USE/LAND COVER SCENARIO

Landsat-TM data could afford delineation of broad land use/land cover categories, namely agriculture, forest, scrubs, layouts recreational and water bodies (Fig-3).Out of the total area of the *mandal* an estimated 2617 ha has been under agriculture during 2005. During the gap of a decade (2005-2015) a fairly large area under agriculture has been converted into urban settlements. The area under agriculture has been shrunken from 2617 ha to 409 ha, a loss of 2208 ha in agriculture land.

The land use/land cover map derived from LISS-IV data is appended as Fig. 4.As evident from the map several sub-divisions within each land use/ land cover category delineated from Landsat_TM data could be made. For example, within settlements medium dense settlements, dense settlements, apartments, and villas could be identified on LISS-IV image (Fig.-3) with 6m spatial resolution.

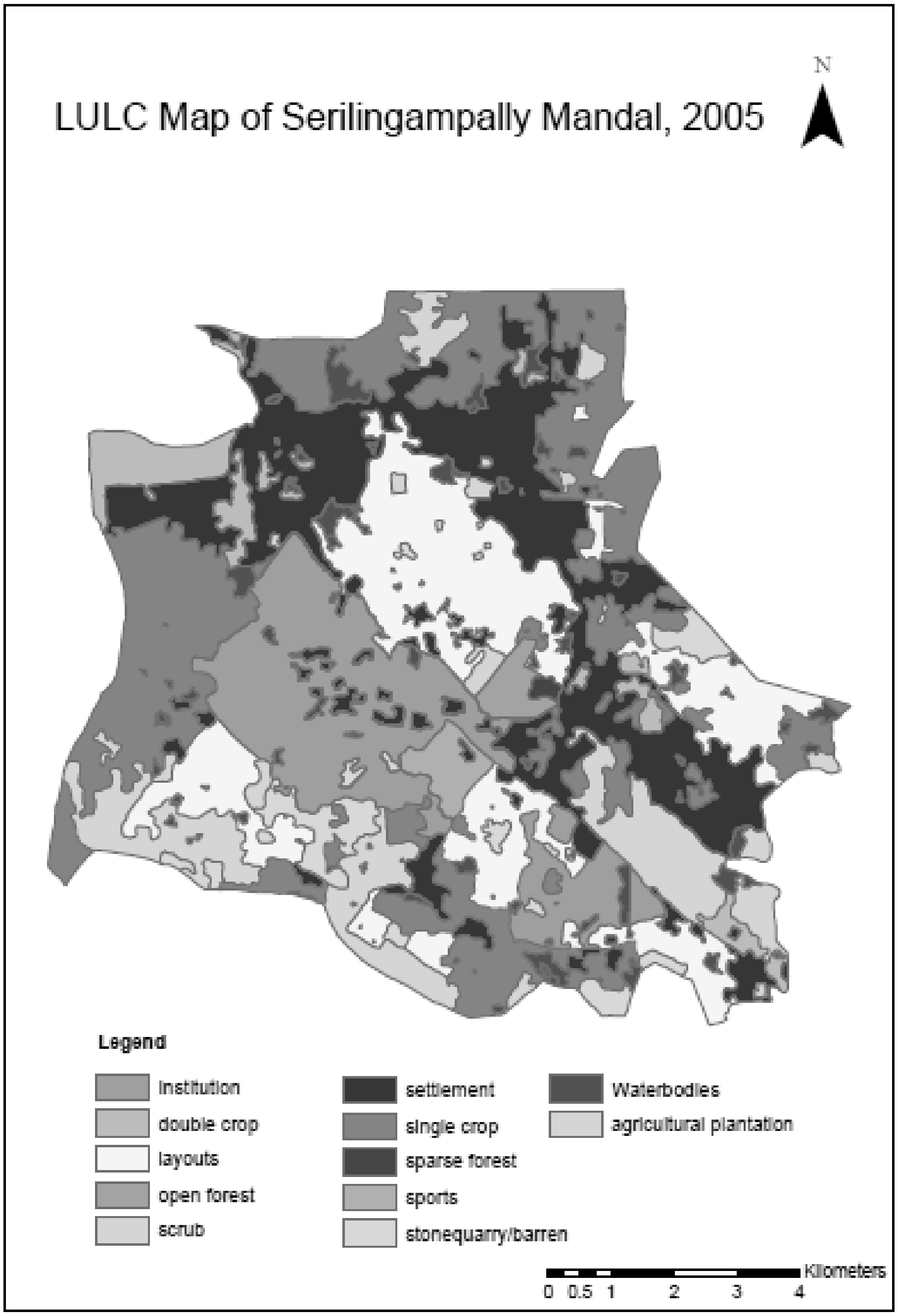

Figure 3 LULC Map of the study area derived from Landsat-TM imagery.

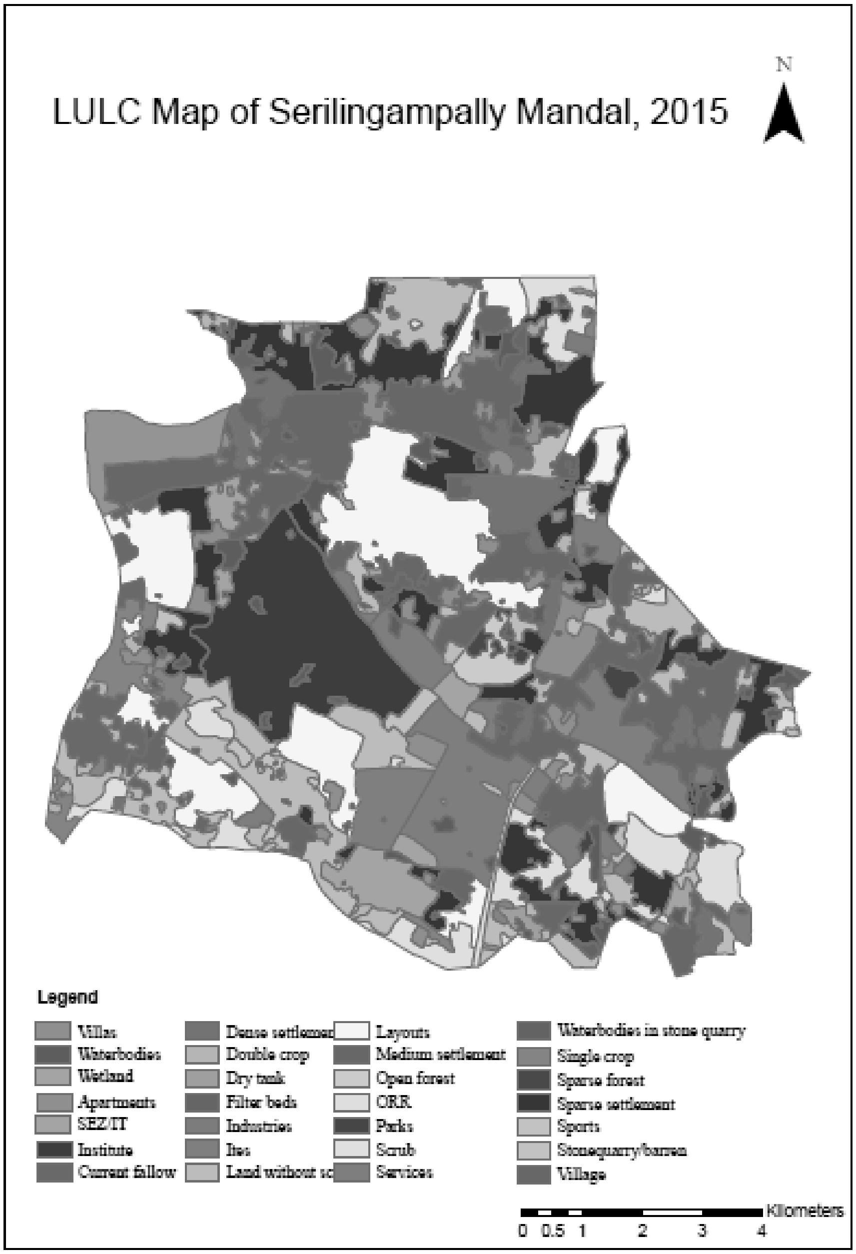

Figure 4 LULC Map of the study area derived from LISS-IV imagery.

AREA SUITABLE FOR AGRICULTURE

Of the several land use land cover categories delineated from LISS-IV data, layouts, scrubs, land without scrubs and wetlands have been considered for evaluating their potential for agriculture. As mentioned in Section 6.4 the vector layer of Land use/land cover derived from LISS- IV was overlaid on to the vector layer of soil map using overlay module of ArcGIS. Soil map portrays land capability class IV each soil unit. By overlaying, Land use/land cover the potential of each Lulc category could be assessed. That is to say, entire polygon or part has potential for agriculture (Fig.5). As evident from the figure within layouts near or around Kondapur village the major unit that qualifies for land capability class is IIs. However, inclusion of other land capability units, IVes, and IIIs has also been observed. The area under each land capability class with a potential for agriculture is appended as table-1. An estimated 1,597ha of land qualifies for land capability class IIs, 169ha for class IIIsw, and 1,075ha for class IV es (Table 1).

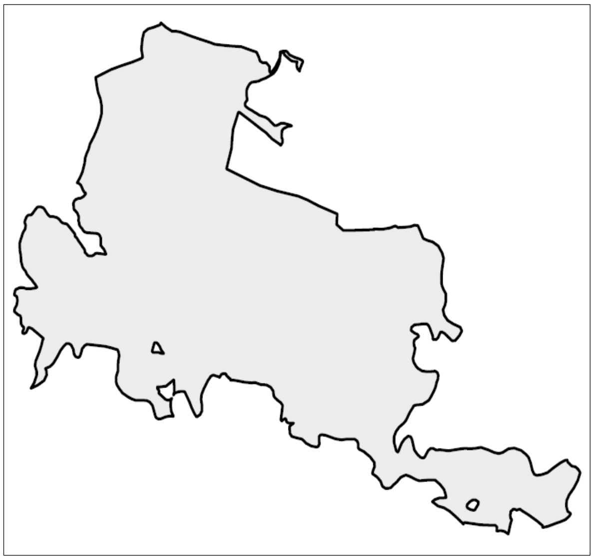

Figure 5a. Part of Kondapur layouts indentified for agriculture.

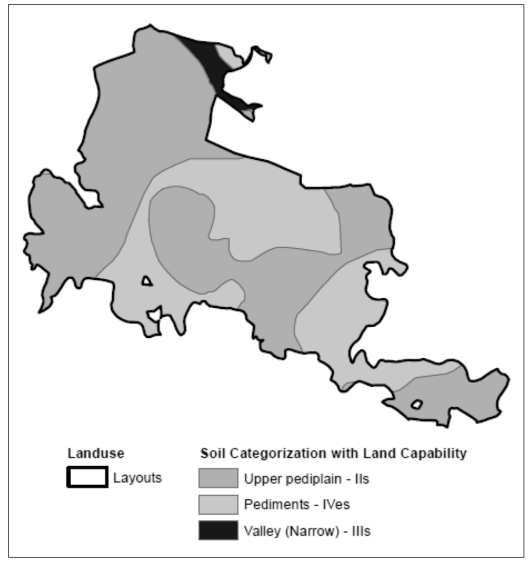

Figure 5b. Integrated Map (LULC & Soil) of part of Kondapur.

Table 1 Land capability class with a potential for agriculture

Soil Mapping Unit	Landuse Type	Land Capability	Area (ha)
Hills/Hillocks	Scrub	VI es	39.83
Pediments	Land without scrub	IV es	502
	Layouts		458
	Scrub		98
	Wetland		17
Upper Pediplain	Land without scrub	II s	433
	Layouts		596
	Scrub		145
	Wetland		46
Pediplain(moderate erosion)	Land without scrub	II s	83
	Layouts		131
	Scrub		156
	Wetland		7
Valley(narrow)	Land without scrub	III sw	32
	Layouts		22
	Scrub		41
	Wetland		39
Valley(middle wide)	Land without scrub	III sw	24
	Layouts		3.4
	Scrub		8

CONCLUSIONS

For ensuring food security to urban population, potential agricultural land is to be identified. It calls for analyzing the existing land use pattern using remotely sensed data and evaluation of each land use land cover unit hitherto unutilized, for its potential for agriculture using information on the terrain and soils. Although moderate spatial resolution data (Landsat-TM) could afford delineation of broad land use land cover categories, it does provide information on overall LULC pattern and its temporal behavior. The analysis of bi-temporal space borne multispectral data provides the dynamics of fast changing land use/land cover scenario. Higher spatial resolution LISS-IV data could afford preparation of detailed land use/ land cover map. When integrated with the information of terrain and soils, the potentiality of these lands for agriculture could be assessed.

ACKNOWLEDGEMENTS

The authors are extremely thankful to Prof. A. Jayasree, Director, Institute of Science and Technology, Jawaharlal Nehru Technological University, Hyderabad for providing necessary facilities during the course of investigation

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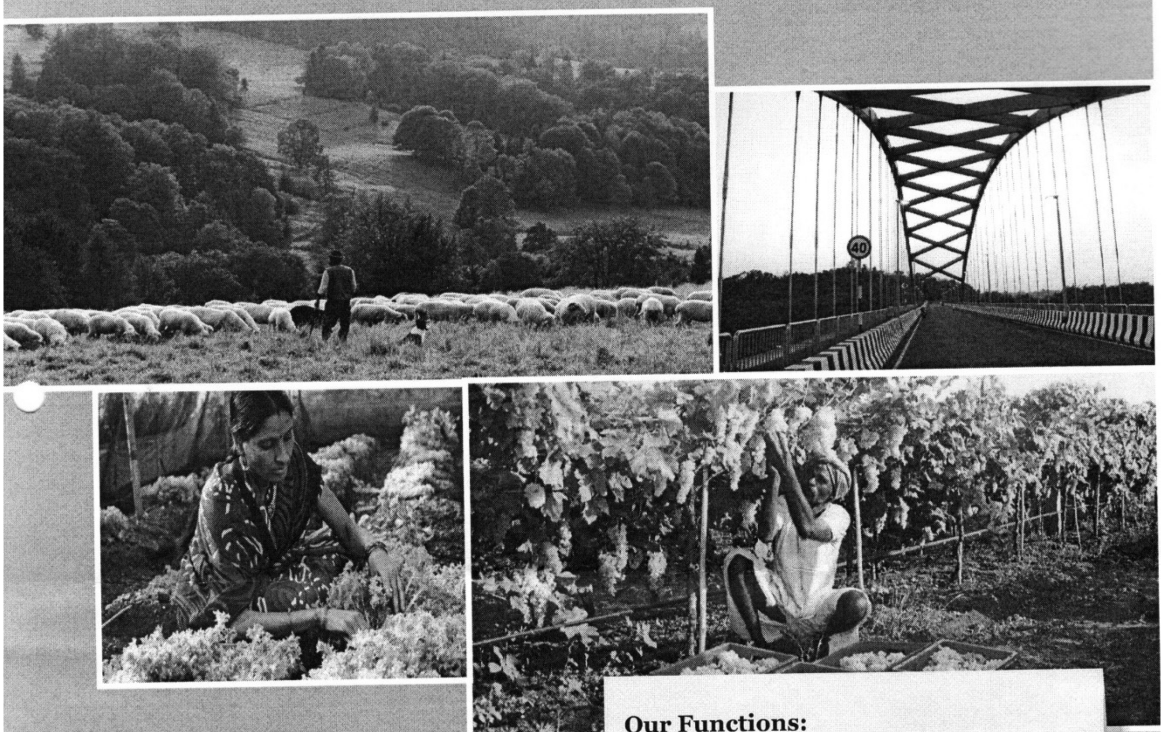

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