Two Day National Conference
on
Water, Environment & Society
(NCWES - 2014)
30th June and 1st July, 2014
Hyderabad, India

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Foreword

Water is indispensable for life and more so for man and society. The demand for water for irrigational and industrial uses also increased correspondingly to meet the requirements of the growing population. The world's water supply is a finite resource and the practice of water reuse helps to conserve it. In addition to the use of reclaimed water for non-potable purposes, water quality experts support the consideration and use of highly treated reclaimed water for indirect potable reuse. The reuse of municipal wastewater for beneficial purposes is an important aspect of the world's total water resources management.

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

The use of virtual water is an emerging concept in countries where the carrying capacity of a society is not sufficient to produce land and water intensive products itself. The closing of cycles should be realized at different spatial scales such as

- The rural scale, implying water conservation, nutrient and soil conservation, prevention of over-drainage and the recycling of nutrients and organic waste.
- The urban scale, both in towns and mega-cities, implying the recycling of water, nutrients and waste.
- The river basin scale, implying: soil and water conservation in the upper catchment, prevention of runoff and unnecessary drainage and enhancement of infiltration and recharge, flood retention, pollution control and the wise use of wetlands.
- The global scale, where water, nutrient and basic resource cycles are integrated and closed.

There is thus an urgent need to promote Research and Development, educational and training activities in the areas of water and environment by way of organizing seminars, workshops, conferences and training programs to bring about and development more awareness. The two day National Conference on “Water, Environment and Society (NCWES-2014)” is an appropriate step in this direction. Keeping this in view, the subject matter of the conference is planned to cover a wide range of topics spreading over six technical sessions.

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

Prof. Rameshwar Rao

Vice-Chancellor of JNTUH &
Chief Patron, NCWES-2014

Preface

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

It is well recognized that watersheds have an important role to play in the process of sustainable development. Watershed approach has proved its efficacy and watersheds have been considered to be the ideal, logical and scientific hydrologic units for effective and efficient management of water resources.

It is in this context and backdrop that the Centre for Water Resources, Institute of Science and Technology, JNTUH felt the need to organize a two day national conference on Water, Environment and Society (NCWES-2014) to take stock of the current status of applications in water resources development and management and also 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 two day national conference on NCWES will focus its attention on various themes in the form of technical sessions such as

1. Hydrologic parameter estimation & modeling
2. Climate change and environment
3. Hydropower, bio-diveristy, catchment treatment and EIA
4. Groundwater exploration, development, recharge and Modeling
5. Water quality, water treatment, pollution and society
6. Water and irrigation management

More than 120 delegates and about 80 technical papers are being presented in these six 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 – 2014.

Dr. M.V.S.S Giridhar

- Editor

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(Established by Andhra Pradesh Act No. 30 of 2008)

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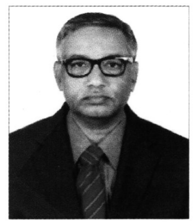

MESSAGE

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 two day National Conference on "Water Environment and Society – NCWES" during 30th June and 01st July 2014.

Our water supply and environment are in peril with increasing pressure from pollution, degradation and over exploitation.

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

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

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

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

Rameshwar Rao

(Prof. Rameshwar Rao)

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B.E.(Osm)., M.Tech (IIT-M), M.S., Ph.D. (Drexel, USA), PDF (SIU,USA)

Professor of Mechanical Engg &

R E C T O R

MESSAGE

I am glad to learn that the "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a two day National Conference on ***"Water, Environment and Society – NCWES"*** during 30th June and 01st July 2014.

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

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

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

T. Kishen Kumar Reddy

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B.E., M.Tech., PGDCS., Ph.D (UK) Post Doc. (UK).

Professor of Civil Engg., &

REGISTRAR

MESSAGE

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

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

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

Prof. N. V. RAMANA RAO,

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Dr. K. Vijaya Kumar Reddy
M.Tech., Ph.D., F.I.E.,
Professor of Mechanical Engg., &
Director, Academic & Planning

Date: June 21, 2014

MESSAGE

I am very glad to learn that the "Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a two day National Conference on "***Water, Environment and Society – NCWES***" during 30th June and 01st July 2014.

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

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

I wish the two day conference program a great success.

(Prof. K. Vijaya Kumar Reddy)

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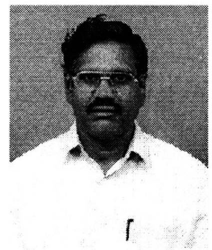

MESSAGE

I am pleased to note that the Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a two day National Conference on "***Water Environment and Society – NCWES***" during 30th June and 01st July 2014.

When a major fresh water crisis is gradually unfolding in India, it is quite appropriate to have chosen this topic. I am sure that this National Conference will be of immense use to all those, who move with high aspirations.

I hope that the learned member delegates would widely deliberate on various aspects of the theme at the conference and suggest cost-effective, environmental friendly and sustainable technologies.

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

Prof. K. Mukkanti, Ph.D

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Dr. K. Ramamohan Reddy,
B.Tech., M.S., Ph.D., MISTE, MIAH
Professor and Head

MESSAGE

It gives me immense pleasure to note that the “Centre for Water Resources, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad is organizing a two day National Conference on **“*Water, Environment and Society – NCWES*”** during 30th June and 01st July 2014.

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

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

I wish the program a grand success.

Prof. K. Ramamohan Reddy

Acknowledgements

The two day national conference on Water, Environment and Society NCWES-2014 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. Rameshwar Rao, 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 Prof. T Kishen Kumar Reddy, Rector, Jawaharlal Nehru Technological University Hyderabad for his precious support as Patron of this two day conference.

My sincere and special thanks to Prof N.V. Ramana Rao, Registrar, Jawaharlal Nehru Technological University Hyderabad as Patron of the conference for his cordial, time to time permissions and support.

I am deeply indebted to Prof K. Mukkanti, Director, IST, JNTUH and Chairman of this conference for having taken every responsibility for completing this task through various stages.

I would like to extend my very great appreciation to Prof K. Rammohan Reddy, Head, Centre for Water Resources for his valuable and constructive suggestions during planning, development and implementation of this task as a Co-chirman of this conference.

My grateful thanks are due to Prof. B. Venkateswar Rao, Director, SCDE and professor of water resources, and Prof. C. Sarala, Professor of water resources for their valuable support throughout the conference.

My sincere thanks to the officials of Technical Education Quality Improvement Program, Phase-II, IST, Pollution Control Board Hyderabad, Science and Engineering Research Board (DST) and JNTUH University 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.

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

I am thankful to Sri. P. Ravibabu, Sri. A. Sravana Kumar, Smt. Nazia Thabassum, Sri. Y. Siva Prasad, Sri. Shaik Khaja Mohiddin, Sri. K. Siva Prasad and Smt.K.Chandrakala of Centre for Water Resources who have worked untiringly for making various arrangements of this conference.

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

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

My sincere thanks to all my students Sri. V.T. Varuna Mithra, Sri. R. Anirudh, Sri. R. Chaitanya Kumar, Ms. S. Sri Divya, Sri. S.Sajan Ms.R.Sharmila and Ms. K. Divya for their continuous day and night support for this conference.

My special appreciation and sincere thanks to my student Smt. P. Sowmya, Junior Research Fellow, UGC Project, who stood as a pillar to organize this conference and taken all the burden of extra work.

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
Organising Secretary

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WATER QUALITY, WATER TREATMENT, POLLUTION AND SOCIETY

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HYDROLOGIC PARAMETER ESTIMATION AND MODELING

Computational Data Intelligence in Hydrological Modeling

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1. INTRODUCTION

The transformation of precipitation over a river basin into stream flow is the result of many interacting processes which manifest themselves at various scales of time and space. This is due to the variety and the heterogeneity of media in which water travels. The interaction of hydrology with other research disciplines such as atmospheric sciences, ecology and geology showcases just how diverse these media can be. The highly dynamic, nonlinear nature of most catchment systems is a reflection of the complex interaction between the various processes at different scales. Clearly, effective system descriptions are therefore not easily defined.

The issues of scale and heterogeneity make the definition of straightforward descriptions and models of hydrological processes very challenging, and also complicate the gathering of representative data from a catchment. Not only are measurements seldom without error, the difficult questions present themselves of how well observed data represent system behavior and how they translate to the quantities defined in the model representation of the system.

No laboratory experiment can be constructed in which the complexity of a natural hydrological system is adequately replicated, which is why researchers focus on simulation models of river basins. The challenge of hydrological modeling originates from the combination of the complexity of a catchment system and the difficulty to properly and quantitatively express the information that is available about it. For these reasons, hydrological modeling is considered one of the greatest challenges in hydrology, even after more than a century of research.

The hydrological transformation involves many processes that are at the very core of hydrology. Hydrological models that simulate these processes can therefore be used to advance the science, because the accordance or conflict with observed values of models based on existing hydrological theories can confirm or negate these theories.

Another, more practical reason to model the hydrological transformation is for prediction purposes, ultimately to improve the quality or effectiveness of decisions related to water management issues. Some examples of areas in which streamflow information is needed are water resources assessment, flood protection, mitigation of droughts, channel or hydraulic construction design, assessment of contamination effects, ecological studies, and climate change impact assessments.

2. HYDROLOGICAL MODELING

The first models that predicted runoff from rainfall were developed as early as halfway of the nineteenth century (e.g., the rational method by Mulvaney (1851). Engineers interested in design criteria for constructions based these theories on empirically derived relationships and largely ignored the nonlinearities in hydrological processes. Other methods were more focused on the routing of runoff such as the well-known unit hydrograph method. A large number of variations of this method exist that are all based on the idea of using a transfer function to calculate runoff from effective rainfall (e.g., the Nash-cascade model).

The problem of estimating how much of the rainfall effectively contributes to the runoff has always been the biggest challenge for modelers. As hydrological process understanding and the possibilities offered by digital computers grew, they turned to simulation of river basin behavior using so-called conceptual hydrological models. Such models are based on a simple mass balance and simplified descriptions of hydrological processes and media. Despite the physical foundations of conceptual models, their parameters still need to be calibrated.

A very large number of conceptual models exist, of which popular examples are the American Sacramento model, the Scandinavian HBV model, and the Japanese Tank model.

Physically-based and spatially distributed models of hydrological systems (e.g., SHE and IHDM models) became more popular in the 1970s and 1980s with the advancements in both computer power and accessibility. However, the large data demand and the complexity of calibration and simulation are important reasons for the lack of popularity of these models, even today. There are, however, simplified distributed models such as TOPMODEL that attempt to strike a balance between complexity and practicality.

In the last two decades, the hydrological model approaches mentioned above have still been under development. With the development and application of modern data analysis, modeling and calibration techniques, the empirical approach has broadened to what can be called as data-driven hydrological modeling. Conceptual models have also advanced because of better process and model understanding and improved calibration strategies. Finally, increasing computer power and new data sources such as remote sensing have helped to push the boundaries of physically-based models.

Having explored the various modeling possibilities in the past, the awareness that each model approach has its advantages and disadvantages has settled among hydrologists. Conceptual models often prove to be effective because they offer a combination of simplicity, transparency and good performance. Physically-based models are preferred when, for example, predicting the effect of changes in a river basin. Finally, for short-term streamflow forecasting, the accuracy of data-driven models is often unrivaled.

Nevertheless, the search for better hydrological models is ongoing. The main drivers for developments in this field are:

1. Improved insights into both small-scale and large-scale processes of river systems (and the interactions between them),
2. Increase in quantity and quality of data through new and enhanced measurement techniques, along with improved abilities to extract information from data,
3. New views and paradigms in hydrological modeling methodology and philosophy,
4. Development of new modeling, calibration and data assimilation techniques.

A generalized framework has been suggested in this paper to make better use of the knowledge and information that is contained in the data and the computational data intelligence techniques are discussed in detail.

The field that is nowadays commonly called Computational Intelligence (CI) in fact evolved from various research fields such as soft computing (Zadeh, 1994), machine learning (Mitchell, 1997), evolutionary computing (Jong, 2006). Nowadays, it also includes newer techniques from, for example, data mining, chaos theory and swarm intelligence, with more emphasis on knowledge embedded in the data, and thus the computational intelligence derived from mainly from data, which is henceforth referred as Computational Data Intelligence (CDI). In recent years, CDI has therefore increasingly become a generic term for a large diversity of techniques that use data intelligence in their approach. What prevents CDI from being merely a hotchpotch of algorithms is the collective trait of its techniques to intelligently solve complex computational problems in science and technology (Palit and Popovic, 2005). Solomatine (2005) discussed the similarities and differences between various research areas related to computational intelligence, with special reference to data intelligence.

CDI is an emerging field in which theoretical developments are still rapidly evolving and feedback from practical application is much needed. It is still unclear to what extent CDI will change the field of simulation modeling but both the similar and complementary aspects of CDI techniques and human problem-solving suggest a large promise. Examples of similarities include the way artificial neural networks mimic the functioning of the brain (albeit very rudimentary) and the use of fuzzy information such as words in a problem-solving framework (Zadeh, 1996). An important complementary aspect is the increased computational ability of digital computers compared to human brains. The fact that computer power increases still strengthens the belief that CDI can lead to significant developments in many fields of engineering and science.

In this paper, two typical current exponents of CDI are presented: artificial neural networks and evolutionary algorithms. Both techniques have been applied in hydrological modeling in recent years and prove to be valuable alternatives to traditional approaches. In the hydrological research community there exists a clear and urgent need to further investigate the application of such techniques in hydrological modeling in order to explore their potential value and pitfalls, and to formulate guidelines regarding their application.

3. HYDROLOGICAL MODELING FRAMEWORKS

In this section two important frameworks suggested by prominent researchers in hydrological modeling, namely, systems approach and top-down modeling are briefly presented below along with the issue of uncertainty in hydrological modeling.

3.1 Systems Approach

A system is a theoretically defined set of components that interact or are in some way interdependent. The system is defined by the choices of system boundaries, and of which components and interactions to consider. A hydrological catchment is classified as an open system, meaning that the system interacts with an environment (e.g., a meteorological system) in the form of exchange of mass and energy. After the system is defined, a model of it can be built. According to Gupta et al. (2008), a model is *a simplified representation of a system, whose twofold purpose is to enable reasoning within an idealized framework and to enable testable predictions of what might happen under new circumstances* where *the representation is based on explicit simplifying assumptions that allow acceptably accurate simulations of the real system*

In the systems approach to hydrological modeling, the modeler sees the hydrological catchment from a holistic instead of a reductionist viewpoint. The overall complexity of the system is considered a reason for not trying to separate its elements and processes but to regard the system as the only appropriate level of complexity on which to model or from which to deduce knowledge. Often this means that a so-called black-box approach is taken, in which the processes and elements of the systems are regarded unknown, although they not need to be. The only way of understanding the system is then to consider its input and output, and attempt to relate the two. From this point of view, building a model does not necessarily require knowledge of the physical principles involved.

3.2 Top-down Modeling

In the reductionist or bottom-up approach to modeling, a model is built starting from a detailed description of its basic elements. These elements are often specified on the basis of detailed experiments. A model can subsequently be built by linking the various (sub- systems of) elements together until the appropriate level of system detail. The bottom-up way of thinking has long been the dominant paradigm in hydrological modeling, but re- cent literature shows that the top-down paradigm is considered a promising alternative by many (e.g. Sivapalan et al. (2003b); Young (2003)). The top-down paradigm follows the opposite direction of bottom-up modeling, and is defined by Kleme˘s (1983) as the route that *"starts with trying to find a distinct conceptual node directly at the level of interest (or higher) and then looks for the steps that could have led to it from a lower level."*

This paradigm strongly relates to the systems approach, although the latter does not imply explaining the working of the system in terms of internal characteristics or processes at finer scales (Sivapalan et al., 2003b).

3.3 Model Evaluation

Historically, there have been several changes in what is implied when hydrological modelers stated that they want to improve their models. Compare, for example, the issues raised on numerical statistics raised by Nash and Sutcliffe (1970), the quantitative uncertainty framework by Beven and Binley (1992), the discussion on model accuracy, uncertainty and realism by Wagener et al. (2001), and the diagnostic framework by Gupta et al. (2008), which is discussed below.

The most common and straightforward approach to evaluate hydrological models is to quantitatively evaluate model behavior by examining the difference between model output and observed variables. A large variety of statistical measures can be calculated from this difference that expresses the accuracy of a model. However, since there is uncertainty in the measurements as well as in model, hydrologists have understood the value of providing the associated probability of model output. This information requires uncertainty in the data and model to be quantified and this has proven to be a great challenge for the hydrological community.

Qualitative evaluation of consistency in model behavior is another important aspect of model evaluation. Examples of this range from visual inspection of expected patterns in model output to model parameter sensitivity analysis. In recent years, several approaches have been suggested that combine quantitative and qualitative information into a more complete model evaluation framework. Examples are the GLUE method (Beven, 2006), the multi-criteria approach (Gupta et al., 1998), and DYNIA (Wagener et al., 2003b).

Finally, there is qualitative evaluation of consistency in model form (structure) and func- tion (behavior). This implies that certain model structures might be favored over others based on, for example, their performance on past problems or their similarity to the perceptual model (Beven, 2001b) of the system at hand. Although subjective, this can be a valuable contribution in model evaluation.

The above three forms of model evaluation are based on the framework presented by Gupta et al. (2008), who argue that evaluation should be diagnostic in nature, i.e. focusing on identifying which components of the model could be improved and how. It is for this reason that model evaluation should focus not merely on a simple comparison of series of model output and observed data of that variable, but on comparing signature information through which the essence of model and data is extracted.

3.4 Issues of Uncertainty

All components of a hydrological modeling application are subject to uncertainty. The three primary sources of uncertainty, as discussed by Liu and Gupta (2007), are as follows.

1. Data — Observations of model input, states and output inherently contain measurement errors, which can be divided into instrument errors (i.e., imperfect measurement devices or procedures) and representativeness errors (i.e., incompatibility between observed and model variables, for instance in terms of scale).
2. Model parameters — Parameters are conceptual aggregate representations of spatially and temporally heterogeneous properties of the real system. They usually cannot be easily directly related to observable real-world characteristics of a catchment. Model calibration is usually applied to let model output comply to observations in an acceptable manner, as a result of which errors and uncertainties are introduced.
3. Model structure — Models are assemblies of assumptions and simplifications and thus inevitably imperfect approximations to the true system. If these approximations are inadequate, large errors can be the result. Mathematical implementation issues can also add to model structural uncertainty.

Future research not merely calls for objective, quantitative, and accurate estimations of model output uncertainty, but also for a minimization of this uncertainty. Suggestions for uncertainty estimation are widespread in recent literature (e.g., Thiemann et al. (2001); Vrugt et al. (2003a, 2005); Kuczera et al. (2006). To accomplish the minimization of uncertainty, however, much more radical steps are needed that relate to the very fundamentals of hydrological modeling. Examples of this are acquiring new and better hydrological observations, finding improved methods of extracting and using information from observations, and improved hydrological models using better system representations and mathematical techniques.

4. COMPUTATIONAL DATA INTELLIGENCE IN HYDROLOGICAL MODELING

CDI methods have become and are still becoming increasingly common in hydrological modeling. A brief overview of typical applications of CDI, namely, hydrological system identification, hydrological parameter estimation, hydrological data mining, along with examples for each application are presented here. These applications have a long history (see) but with the emergence of CDI methods it is experiencing somewhat of a resurgence in the form of what is nowadays commonly termed data-driven modeling (Dooge and O'Kane, 2003).

4.1 Data-Driven Modeling

A common approach to simulate catchment systems is to model them based on process knowledge. This so-called knowledge-driven approach aims to represent the real-world hydrological system and its behavior in a physically realistic manner, and is therefore based on detailed descriptions of the system and the processes involved in producing runoff. The best examples of knowledge-driven modeling are so-called physically-based model approaches, which generally use a mathematical framework based on mass, momentum and energy conservation equations in a spatially distributed model domain, and parameter values that are directly related to catchment characteristics. These models require input of initial and boundary conditions since the flow processes are described by differential equations. Examples of physically-based hydrological modeling are the Syst`eme Hydrologique Europ´een (SHE) (Abbott et al., 1986) and the Representative Elementary Watershed (REW) (Reggiani et al., 2000; Reggiani and Rientjes, 2005; Zhang and Savenije, 2005, 2006) model approaches. Physically-based modeling suffers from drawbacks due to the complexity of the hydrological transformation process in combination with limitations in rep- resenting the small-scale spatial variability of meteorological inputs, physiographic characteristics, and initial conditions in the model (see Rientjes (2004)). Examples of drawbacks are excessive data requirements, large computational demands, and over-parameterization effects. This is what causes modelers to look for more parsimonious and simple model approaches that incorporate a higher degree of empiricism, but it is (still) not clear how far this empirical approach should be taken (cf. Nash and Sutcliffe (1970) and Beven (2001a)). Conceptual model approaches are a first step from physically-based model approaches in a more empirical direction. These approaches use the principal of mass conservation in combination with simplified descriptions of the momentum and energy equations. Conceptual modeling commonly implies that the model domain is represented by storage elements, either in a spatially lumped or semi-distributed manner. Well-studied examples of conceptual modeling are the HBV model (Lindstr¨om et al., 1997), the TOPMODEL (Beven et al., 1995b), and the Sacramento soil moisture accounting model (Burnash, 1995). De- spite their popularity, there has been much debate in the literature on how much model complexity is warranted (e.g., Beven (1989); Jakeman and Hornberger (1993)) and how their performance can be best evaluated (e.g., Kleme˘s (1986); Gupta et al. (1998)).

The data-driven approach to hydrological modeling, on the other hand, is based on extracting and re-using information that is implicitly contained in hydrological data without directly taking into account the physical laws that underlie the hydrological processes (of which the principle of mass conservation is the most commonly implemented). The data-driven modeling paradigm is strongly related to the systems approach and has been around since the very beginning of hydrological modeling. Basically, the first methods that tried to approximate the transformation from rainfall to runoff were empirical methods that relied on crude assumptions and subsequent fitting to data (Beven, 2001a) for a more complete historical perspective). Roughly since the beginning of the 1990s, interest in data-driven techniques has virtually exploded thanks to theoretical developments and an increase in available computational power. The field of data-driven modeling comprises a plethora of techniques, of which examples are discussed in this section. Nowadays, traces of the data-driven paradigm can be found in many hydrological studies, but the full power of its techniques (many of which are still rapidly evolving) is likely not yet exploited, and insights into and experience with practical applications remain limited.

4.2 Advantages and Disadvantages of CDI methods

Data-driven hydrological models are generally quickly and easily developed and implemented, and are less affected by the drawbacks of knowledge-driven models. Because of their relative simplicity, simulation times often remain within reasonable limits. Moreover, their flexibility requires little expert knowledge of the system or processes modeled.

The latter argument could also be used against them, because naturally the reliance on data alone poses some difficulties:

- Because of their low transparency, which results from the inability to interpret their internal workings in a physically meaningful way, data-driven models generally fail to give useful insights into the system under investigation.

- Data inherently contains (measurement and scale) errors, which can translate to serious model deficiencies.
- How to ensure that a data-driven model learns the correct relationships from the data? Fitting a flexible model structure to data does not assure a reliable model.
- The range of application can be limited because empirical models only have validity over the range of the speCDIfic sample of the hydrological records that is used for model calibration. Extrapolation results beyond this range are therefore often inaccurate and uncertain. The same argument applies to situations in which a system has changed.

For these and other reasons, physical insights should be incorporated into the model development procedure where possible. Still, one might not be able to overcome the inherent flaws of data-driven models. For an insightful discussion on the shortcomings and risks of the data-driven paradigm, see the article by Cunge (2003).

4.3 Artificial Neural Networks as Data-Driven Models

A data-driven technique that has gained significant attention in recent years is Artificial Neural Network (ANN) modeling. In many fields, ANNs have proved to be good in simulating complex, non-linear systems, while generally requiring little computational effort. This awareness inspired hydrologists to carry out early experiments using ANNs in the first half of the 1990s. Their promising results led to the first studies on the specific topic of ANNs for hydrological modeling (e.g., Halff et al. (1993) Karunanithi et al. (1994); Minns and Hall (1996)). Dawson and Wilby (2001) reported reviews on ANN modeling in hydrology. The majority of studies proved that ANNs are able to often outperform traditional statistical hydrological techniques (e.g., Toth et al. (2000); Huang et al. (2004)) and to also produce good results compared to conceptual hydrological models (e.g., Dibike and Solomatine (2001); de Vos and Rientjes (2007)). The field of hydrological modeling using ANNs is nevertheless still in an early stage of development and remains a topic of continuing interest. Examples of ANN hydrological modeling research in recent years include Gaume and Gosset (2003), Anctil et al. (2004), Rajurkar et al. (2004), Ahmad and Simonovic (2005), Srivastav et al. (2007), and de Vos and Rientjes (2008a). Still, more research is needed to support the discussion on the value of these techniques in this field and to help realize their full potential, especially since their black-box nature, their flexibility and their automatic adjustment to information makes them prone to the risk of producing results that lack consistency or plausibility.

4.4 Other Data-Driven Model Techniques

Five different methods of data driven models under the computational data intelligence methods are presented here.

(a) Regression

A multiple linear regression model such as the example presented in Equation 1, can be seen as a simple example of a data-driven technique. Regression is a so-called parametric approach, meaning it requires a priori formulation of the form of the relationship between the dependent variable Z and the independent variable X. This form is usually linear, but regression can be extended to non-linear cases. The parameters of the model need to be calibrated to best fit the observed data Z given the noise signal c.

$$Z = a_0 + a_1X + c \qquad \text{.....(1)}$$

Regression trees and model trees are variations on classical regression methods that consist of local regression models for separate parts of the complete data set. A hydrograph, for instance, can be classified into several categories, after which a separate regression model is built for each category (e.g. Solomatine and Dulal, 2003).

(b) Time Series Modeling

Time series modeling is a linear data-driven technique, whose general framework is described by Box and Jenkins (1976). Most time series contain an autoregressive (AR) component that accounts for the delay in the series, and a moving average (MA) component of a time series that is an expression of its memory. A difference term (I) can also be added to account for trends in the series. In case the time series under investigation has a clear correlation with another time series (e.g. like streamflow depends on rainfall), the latter can be used as an additional exogenous (X) variable in the model. An example formulation for such an ARIMAX model is as follows.

$$Z_t - Z_{t-1} = \mu + b_1 Z_{t-1} + b_2 Z_{t-2} + ... + w_1 X_{t-1} + w_2 X_{t-2} + ... + c_t - a_1 c_{t-1} - a_2 c_{t-2} \quad .....(2)$$

where μ is the average difference in Z_t, and b, w and a are parameters.

The application of time series models for the forecasting of streamflow has a long history (Wang, 2006). Classical time series models like ARIMA, however, assume that the time series under study are generated from linear processes, which is generally not the case in hydrology. Some nonlinear regression-type time series models such as Autoregressive Conditional Hetero-scedasticity (ARCH) models have been tested in streamflow modeling (Wang et al., 2005).

(c) Support Vector Machines

An increasingly popular technique from CDI is the Support Vector Machine (SVM), developed by Vapnik (1998). This nonlinear classification and regression technique has a strong similarity to the ANN, and is theoretically reliable in extracting relationships from data while ignoring noise. Examples of successful applications to hydrological modeling include the works by Liong and Sivapragasam (2002), Bray and Han (2004) and Chen and Yu (2007).

(d) Fuzzy Methods

Fuzzy methods are based on a 'fuzzy' instead of the traditional 'crisp' representation of information. The idea is to express information as a degree of truth (not to be confused with uncertainty). Examples of application in hydrological modeling can be found in, for instance, B´ardossy and Duckstein (1995) and Vernieuwe et al. (2005).

(e) Genetic Programming

Genetic programming is an evolutionary method that can be used for regression purposes. So far, only a few applications to hydrological modeling have been reported in the literature (e.g. Khu et al. (2001); Babovic and Keijzer (2002)).

(f) Data-Based Mechanistic Modeling

In Data-Based Mechanistic (DBM) modeling (Young, 2003), a model is built from a general class of model structures. DBM is an example of a stochas- tic, top-down approach to modeling which is more parsimonious than most data-driven techniques. Most importantly, DBM allows for a physical interpretation of the model. This approach can be seen as trying to strike a balance between data-driven and knowledge- driven modeling.

4.5 Parameter Estimation

(a) Automatic Calibration Methods

Given the fact that hydrological models never perfectly represent the real world, the parameters of the model are fine-tuned in a calibration procedure to match the model output with observed data. The literature on this complex issue is vast, but a good overview of recent developments in hydrological model calibration is presented in the book of Duan et al. (2003). Nowadays, modelers often use the capabilities and speed of digital computers by applying automatic optimization algorithms to find well-performing parameter values. Table 1 introduces the five main characteristics that were found by Duan et al. (1992) that complicate the automatic calibration of conceptual hydrological models, the most important of which is considered to be the presence of many local optima.

Table 1 Major charzacteristics complicating the optimization in conceptual hydrological modeling.

S.No.	Characteristic	Reason for Complication
1.	Regions of attraction	more than one main convergence region
2.	Minor local optima	many small "pits" in each region
3.	Roughness	rough response surface with discontinuous derivatives
4.	Sensitivity	poor and varying sensitivity of response surface in region of optimum, and nonlinear parameter interaction
5.	Shape	non-convex response surface with long curved ridges

(*Source: Duan et al. 1992)*)

Traditional optimization algorithms usually search by starting at a randomized or cho- sen point in the parameter space and following a single path to find an optimum. Such algorithms usually depend on local search mechanisms (e.g. following the gradient of the response surface) and therefore run the risk of getting stuck in local optima or failing because of any of the other characteristics mentioned in the table. Global optimization algorithms have been developed in recent years that are claimed to search the parameter space more extensively and efficiently. Most CDI optimization algorithms have global optimization capabilities and are therefore promising in dealing with the problems related to hydrological model calibration. The following subsections address the two main families of such algorithms.

(b) Evolutionary Algorithms

Evolutionary algorithms are inspired by Darwin's theory of evolution. The main idea is to evolve a population of possible solutions to a given problem by applying principles of natural selection:

- Selection: only the 'fittest' members of a population are copied into the next generation
- Crossover: members produce offspring by exchanging characteristics
- Mutation: a population member will occasionally randomly mutate (some of) its characteristics

The population members are usually different models or model parameter sets, and the fitness is expressed by the difference between model output and observations. The algorithms use the rules mentioned above, and have their population size, the number of generations, and the probabilities of crossover and mutation as most important settings. Evolutionary methods have been shown to elegantly find globally optimal solutions to many problems.

The most common evolutionary algorithms is the Genetic Algorithm (GA), introduced by Holland (1975). Many different implementations of the natural selection rules mentioned above have been suggested for the GA. A popular example of an evolutionary algorithm developed in hydrology is the Shuffled Complex Evolution algorithm developed by Duan et al. (1992). An improved evolutionary algorithm is the so-called Differential Evolution (DE) algorithm by Storn and Price (1997). In this work, a variation of DE is applied for the calibration of a conceptual hydrological model.

In recent years, evolutionary algorithms have been applied frequently to a plethora of optimization problems including hydrological modeling. Well-known examples in hydrological model calibration include Mohan (1997); Wang (1991), Duan et al. (1992), and Franchini and Galeati (1997).

(c) Biologically-Inspired Algorithms

A new and developing field in CDI is the use of techniques inspired by the behavior of groups of animals (e.g., the flocking of birds or schooling of fish). Typically, a population of simple agents is modeled that are allowed to interact amongst themselves and with their environment. This can lead to the emergence of global behavioral patterns, which is often referred to as swarm intelligence. Groups of animals make use of this intelligence, for example in their search for food. Inspired by this, researchers have developed swarm intelligence techniques that search for optima on the response surface of functions. A well-known example of such an optimization technique is Particle Swarm Optimization (Kennedy and Eberhart, 1995). Another example of a biologically-inspired algorithm is Ant Colony Optimization (Dorigo and Stu¨tzle, 2004), which searches the parameter space in the way ants navigate using pheromone trails. Several successful applications of swarm intelligence techniques in hydrological modeling have been presented (e.g. Chau (2006); Goswami and O'Connor (2007)).

4.6 Data Mining

(a) Data Mining and Cluster Analysis

Data mining techniques are tools to facilitate the conversion of data into forms that pro- vide a better understanding of processes that generated or produced these data (Babovic, 2005). Mohan and Ramsundaram (2012) presented an overall view about data mining methods and its applications to water resources engineering. A variety of techniques can be used, but among the most common are clustering algorithms. These algorithms automatically categorize information by finding clusters in the data. This could be useful, for example when trying to find homogeneous parts of the data, compressing the information in the data into a small number of discrete values, or finding relationships in the data that were not foreseen.

(b) Clustering Algorithms

One of the simplest examples of a cluster algorithm is the k-means algorithm. It is dis- cussed in more details in Chapter 6, where it is used for temporal clustering of hydrological data. It has also been used in hydrological modeling for, for example, regionalization (Mazvimavi, 2003), and identification of spatial clusters with similar seasonal flood regimes (Lecce, 2000). Related to k-means clustering is its fuzzy c-means clustering variant, which uses the principle of fuzzy information to determine overlapping clusters. Choi and Beven (2007) use it for finding periods of hydrological similarity and subsequent model conditioning, and Xiong et al. (2001) for combining model outputs, for example.

Another interesting clustering algorithm is the Self-Organizing Map (SOM). It can be used for clustering but is also a unique method for visualizing information in data. The technique was used for clustering of watershed conditions by Liong et al. (2000), determi- nation of hydrological homogeneous regions by Hall and Minns (1999), for finding periods of hydrological similarity and subsequent local modeling by Hsu et al. (2002), and model evaluation and identification by Herbst and Casper (2007).

5. CONCLUSION

The complexity of hydrological systems, and the difficulty to properly and quantitatively express the information that is available about them, determine the challenge of hydrological modeling. Accurate and reliable R–R models, however, are important because they can be used for scientific hypothesis testing, or for making prediction that can improve the quality or effectiveness of decisions related to water management issues. Computational Intelligence (CI) has emerged as a promising field of research in hydrological modeling. It is proved from the results of various studies that the evaluation of a conceptual model can be improved to be more diagnostic in nature and how subsequent improvements to the model structure through computational data intelligence methods. It is also found that the choice of CI parameter estimation algorithms turns out to have large effects on model accuracy and uncertainty. Generally, it was concluded that CI parameter estimation methods are more effective compared to traditional techniques. The overall conclusion is that applications of CI in R–R modeling show a lot of promise, due to the fact that there are advantages to approaches in which models use the characteristics of both knowledge- driven and data-driven modeling using CID approached. This work shows that by correctly combining both process knowledge, modeling experience and intuition, it is possible to forge new model development and evaluation methods that combine the best of both worlds.

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Analysis of Sedimentation of Reservoirs and Fixing of Dead Storage using the Observed Rate of Sedimentation

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ABSTRACT

Sedimentation of reservoir / tanks is a natural process and therefore it cannot be stopped completely. There are instances of reservoirs that have got completely filled up by sediment. Important factors affecting sediment yield are rainfall characteristics like intensity, duration, quantity and distribution of rainfall over space and time. In India almost all reservoirs lose their storage capacity by about 0.50% to 1% every year. Design practices regarding provision for sedimentation in proposed new projects are derived from nearby major or medium projects. It is quite likely that the volume and pattern of sedimentation of such nearby projects may be different and may call for different design practice. With this aspect in view, sedimentation data of some of the existing projects constructed in Godavari & Krishna river basin portion of Andhra Pradesh are being studied and analyzed. Regression analysis of sediment load with respective period is being done for projects lying in a sub-basin portion of Godavari river basin in Andhra Pradesh and an equation / relationship is developed for arriving at the expected sediment load. This new sediment load may be used for fixing capacities of new contemplated reservoirs in the same sub-basin.

Keywords: sedimentation, regression, rate of sedimentation, reservoir.

INTRODUCTION

Sediment transport is either by wind or water. Factors affecting the erodability of soil are particle size of soil, land slope, vegetation, and presence of salt and colloidal material, soil compaction, human activities and rainfall characteristics. Results of sedimentation surveys for Indian reservoirs show that the rate of sedimentation varies from 1 to 14 Ha-m/100 sq. km/year. The sediment yield in a reservoir may be estimated either by sedimentation surveys of reservoir or by sediment load measurement of the stream. In reservoir sediment surveys, the sediment yield is determined by measuring the accumulated sediment in a reservoir for a known period, by means of echo sounders. The volume of sediment accumulated in a reservoir is computed as the difference between present capacity and original capacity after completion of dam. All the sediment carried by inflows is not deposited, some of it goes with surplus water and some of it goes through the water released through canals for crop.

Literature Review

There are various methods to assess the sedimentation of reservoir. Empirical and Mathematical methods to assess sedimentation of reservoir are very complex due to various factors affecting the process of sedimentation. Mathematical modeling of silting process in reservoir has at present become an extremely powerful means of determining and forecasting sediment distribution in reservoir. Chalachew Abebe Mulatu in 2012 have done analysis of reservoir sedimentation by using measured sample data, regional sediment yield equation, area reduction method, area increment method and based on trap efficiency. Sanjay K. Jain et al. in 2012 has studied estimation of soil erosion and sedimentation in Ramganga Reservoir (India) using remote sensing and GIS technique. Prabhat Chandra et al. in 2013 has studied sediment yield modeling for upper Tapi basin using SWAT model. It is reported that SWAT model is capable tool for simulating hydrologic component and erosion in sub-basin.

Analysis of sedimentation patterns in some the projects

The data of rate of sedimentation of different reservoirs are collected from APERL, Hyderabad. The hydrographic surveys are conducted by means of echo soundings. The volume of sediment accumulated in a reservoir is computed as the difference between present capacity and original capacity after completion of dam. The sedimentation pattern of following projects lying in each sub-basin of Godavari river basin is shown in Table 1.

Table 1 Sedimentation pattern of projects lying in each sub-basin of Godavari river basin

S. No	Name of the Project	No. of years	Rate of sedimentation in Ha-m/100 sq km/year
I	**G-4 Sub-basin:** 1. Pocharam project	25	14.378
		45	2.861
		8	5.384
		78 (Overall years)	6.811
	2. Manjira Barrage	11	1.02
	3. Nallavagu project	17	2.75
		16	5.567
		33 (Overall years)	4.118
	4. Koulasnala Project	9	8.824
II	**G-5 Sub-basin:** 1. Swarna Project	9	6.199
		16	6.701
		25 (Overall years)	6.52
	2. Kadam Project	19	9.16
III	**G-6 Sub-basin:** 1. Shanigaram Project	81	4.524
		34	0.151
		115 (Overall years)	3.204
	2. Boggulavagu Project	26	5.056
	3. Ramappa Lake	56	2.58
IV	**G-7 Sub-basin:** Sathnala Project	20	5.496
V	**G-9 Sub-basin:** 1. Vattivagu Project	8	5.625
	2. P. P. Rao Project	4	5.492
VI	**G-10 Sub-basin:** 1. Lakhnavaram Lake	100 (Overall years)	4.716
	2. Taliperu Project	21	2.58

From the above data of rate of sedimentation, it is observed that in case of Pocharam project the rate of sedimentation during first 25 years which before independence is very high. This may be due to very less number of minor tanks in its catchment area. In the next 45 years the rate of sedimentation is reduced up to 2.861, this is because of number of minor schemes are taken up after independence. In the next 8 years the rate of sedimentation has slightly increased to 5.38, this may be due to high intensity and erratic rainfall taking place for short duration thereby carrying more soil particles in sudden inflows.

In case of Manjira Barrage, the rate of sedimentation is very low due to forest, rocky areas and number of minor, medium and major projects existing in its catchment area. In case of Nallavagu project, the rate of sedimentation is very low in first 17 years and it is increased in next 16 years due to high intensity and erratic rainfall taking place for short duration thereby carrying more soil particles in sudden inflows. In case of Kaulasnala project, the rate of sedimentation is very high in 9 years which is due to black cotton soil and no forest area in its catchment. Moreover it also due to high intensity and erratic rainfall taking place for short duration thereby carrying more soil particles in sudden inflows. In case of Swarna project, the rate of sedimentation is moderate and almost same since its completion.

In case of Shanigaram project, the rate of sedimentation is high in first 81 years which is due to very less number of minor tanks in its catchment area. In the next 34 years, the rate of sedimentation is reduced up to 0.151, this is because of number of minor schemes are taken up after independence in its catchment area. In case of Boggulavagu project there is forest area and hilly terrain, hence rate of sedimentation is moderate. In case of Ramappa Lake there is rocky area and hard soils like morrum in its catchment area, hence rate of sedimentation is very less. In case of Sathnala project the rate of sedimentation is moderate due to partly forest (about 30%) in its catchment area. In case of Vattivagu and P.P. Rao projects lying in G-9 sub-basin, the rate of sedimentation is moderate due to about 30% forest in their catchment area. In case of Lakhnavaram lake the rate of sedimentation is moderate i.e., 4.715. But where as for Taliperu project the rate of sedimentation is less due to almost forest and rocky areas in its catchment. The sedimentation pattern of following projects lying in each sub-basin of **Krishna river** basin is shown in Table 2.

Table 2 The sedimentation pattern of projects lying in each sub-basin of Krishna river basin

S. No	Name of the Project	No. of years	Rate of sedimentation in Ha-m/100 sq km/year
I	**K-6 Sub-basin:**	36	11.406
	Kotipally vagu project	6	1.838
		42 (Overall years)	10.039
II	**K-7 Sub-basin:**		
	Dindi Project	33	0.1708
III	**K-10 Sub-basin:**		
	Himayathsagar Reservoir	49	4.467
IV	**K-8 Sub-basin:**		
	Gajuladinne project	14	9.53
V	**K-11 Sub-basin:**		
	Palair Reservoir	74	0.792
VI	**K-12 Sub-basin:**		
	Pakhal lake	85	3.745

From the above data of rate of sedimentation, it is observed that in case of Kotipally vagu project the rate of sedimentation during first 36 years is very high. This is due to very less number of minor tanks in its catchment area. In the next 6 years the rate of sedimentation is reduced up to 1.838, this is because of number of minor schemes are constructed in its catchment area.

In case of Dindi project the rate of sedimentation is low in first 33 years of construction. This is due to hard soils, forest and very low ground slopes in its catchment area. In case of Himayathsagar Reservoir the rate of sedimentation is moderate. In case of Gajuladinne project, the rate of sedimentation is very high in 14 years which is due to black cotton soil and no forest area in its catchment. Moreover it also due to high intensity and erratic rainfall taking place for short duration thereby carrying more soil particles in sudden inflows. In case of Palair Reservoir the rate of sedimentation is very low. This is due to hard soils, rocky area, forest and very low ground slopes in its catchment area. In case of Pakhal Lake, the rate of sedimentation is low i.e., 3.745. This is due to forest area and hard soils in its catchment area.

Arriving rate of sedimentation by regression analysis

As per IS 5477 (Part 2) : 1994, the sedimentation rates observed in adjacent reservoirs also serve as guide while designing dead storage capacity for new reservoir, the rate of sedimentation observed in similar reservoirs and/or adjacent basin should be suitably modified keeping in view the density of deposited material and sediment yield from the catchment. Several methods are in use for predicting sediment distribution in reservoirs for design purpose. As per above IS code either the empirical area reduction method or the area increment method may be used for fixing the dead storage and minimum drawdown level (M.D.D.L). Normally regression analysis is being adopted for arriving yield series of un-gauged catchments utilizing data of adjacent gauged catchments. Similarly rate of sedimentation arrived by regression analysis can be utilized for fixing of dead storage and M.D.D.L of reservoirs in same sub-basin where observed data at proposed dam site is not available. Regression analysis is done for the rate of sedimentation versus no. of year for the data of projects lying in G-4 sub-basin is shown in Fig.1.

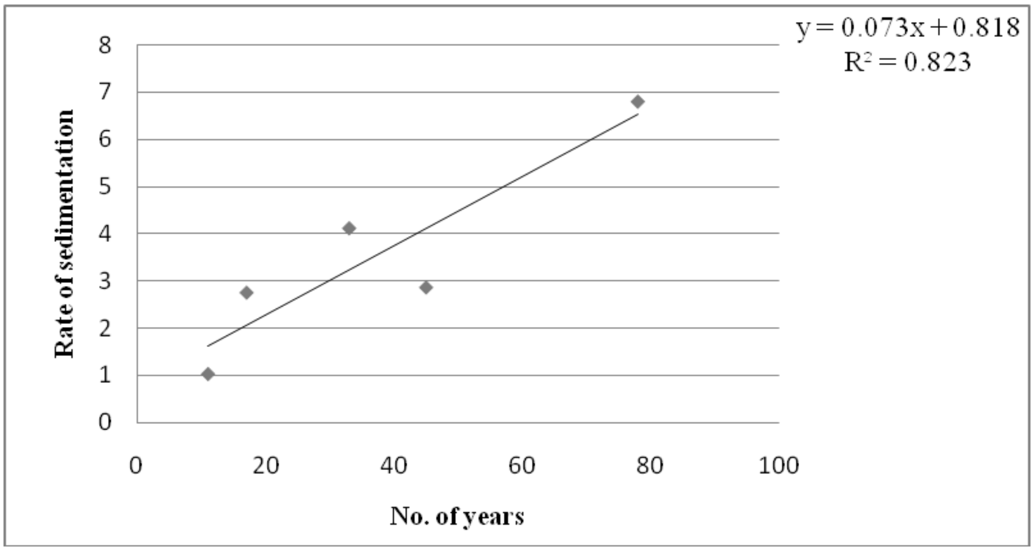

Fig. 1 Regression analysis for the rate of sedimentation versus no. of year

In the above regression analysis stray values are removed so that, R value is more than 0.70. This regression equation can be used to arrive the rate of sedimentation for 50 years and 100 years life of reservoirs as per Central Water Commission, Government of India, norms. Regression analysis is also done for the rate of sedimentation versus no. of year for the data of projects lying in G-5 sub-basin. The graph is as shown below.

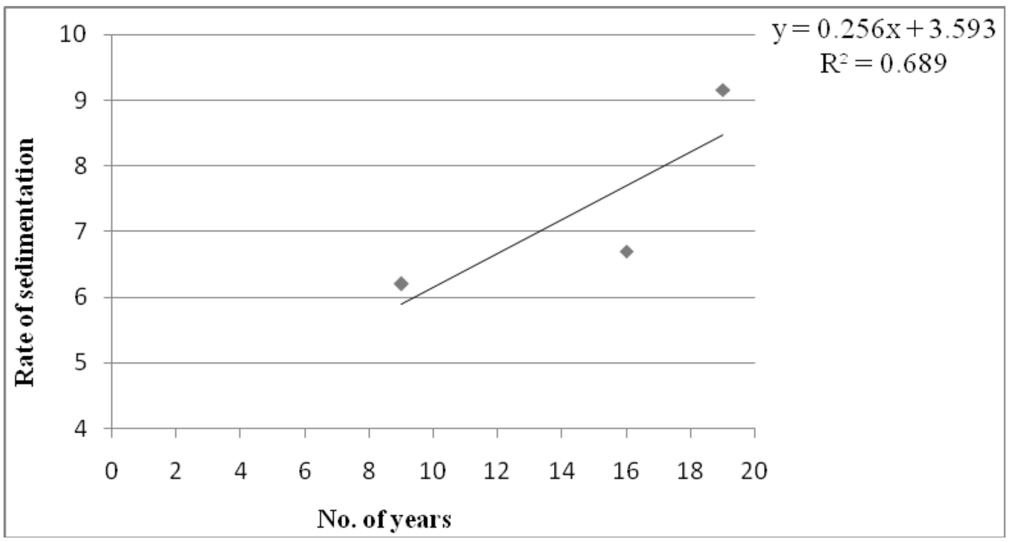

Fig. 2 Regression analysis for the rate of sedimentation versus no. of year

In the above regression analysis stray values are removed so that, R value is more than 0.70

CONCLUSION

- It is observed that the rate of sedimentation before independence is very high. This may be due to very less number of minor tanks in its catchment area.
- In the next few decades the rate of sedimentation is reduced, this is because of number of minor schemes are taken up after independence. This means that the sediment is trapped by upstream tanks.

- In some of the reservoirs (i.e., Kadam project and Kaulasnala project) the rate of sedimentation is more since last two decades due to high intensity and erratic rainfall taking place for short duration thereby carrying more soil particles in sudden inflows into reservoirs.
- The rate of sedimentation in some of reservoirs is very less due to almost forest and rocky areas in its catchment area.
- Instead of using empirical values of rate of sedimentation of nearby reservoir during project formulation, the above rate of sedimentation obtained from regression equation which is based on observed data can be utilized so that, capacities fixed for proposed reservoirs will be more realistic.

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Economic Appraisal of Watershed Programmes in Kadapa District – A Case Study

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ABSTRACT

Watershed development activities in drought prone are essential for development and improve living standards of people through enhanced environmental quality. The Government of India and international agencies are spending huge finance resources for establishing sustainable development in low rainfall areas in India without conducting proper analysis of environmental and economic impact. Research studies indicate significant change in economical conditions and environmental quality due to implementation of watershed management programmes. However, economic feasibility studies on shed management activities are scanty. Hence, an attempt has been made to study economic feasibility of various watersheds in Kadapa district; Andhra Pradesh using Benefit cost analysis, project appraisal techniques and sensitive analysis. The present study reveals that Benefit cost ratios of all watershed is greater than 1.5 and internal rate of return on project cost is ranging from 10% to 28%.

INTRODUCTION

The watershed programme has lot of impacts on economic status of the people and environmental quality. Large number of studies indicate that there is a significant change in family income due to the participation in watershed development activities (Jonathan, I., et al 2002). At the same time, the environmental quantity parameters such as, moisture content, groundwater level, crop yield, area brought into cultivation, milk-yield have enhanced which ultimately improve the ecological balance in particular ecosystem. However any project economic feasibility has to be studied in terms of Benefit cost ratio and rate of return on investment over the duration of the project. To get approval from any sanctioning authority. Hence, an attempt has been made to study economic feasibility of various watersheds.

OBJECTIVES OF THE STUDY

- Detailed study of existing watershed management practices in Kadapa district.
- Cost of each watershed are estimated.
- To estimate the economic values of the benefits.
- Benefit cost ratio will be calculated using 12% discount factor.
- Present values costs are estimated and discounting these costs.
- Feasibility of watershed is assessed by using project appraisal techniques and sensitivity.

LITERATURE REVIEW

Hans M. et. al (1984) conducted studies on watershed management. The study reveals that economic analysis of watershed management projects requires a comprehensive evaluation of many resources both at the site of implementation and at downstream sites.

Southgate & Wynders (2000) review the current initiatives on paying for watershed environmental services in some of the developed countries. Interest in the approach is substantial.

Ninan, K.N. and Lakshmikanthamma, K., (2001) conducted social cost-benefit analysis of a watershed development project in Karnataka by using alternate viability measures i.e., Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) and rigorous tests and sensitivity analysis and the results revealed that the expected benefits are realized the benefits derived from the watershed project are quite high with the IRR's ranging from 19 to 96%. The findings of this study suggested that watershed development projects initiated to improve the economy and ecology of India's dry and semiarid regions are economically viable and socially desirable.

Saravan, V.S., (2001) study reveals that Community Based Watershed Management (CBWM) has gained prominence in developing world towards integrated resource management for livelihood enhancement of the poor due to failure of large scale river valley projects.

Jonathan, I., et. al (2002) had done the Benefit cost analysis of water equality protection in the Catawba basin. The resulting cost-benefit analysis indicated that the potential benefits of this management plan outweigh the costs by more than $95 million.

Gligor Delia et.al (2004) developed a model by reducing the positive and negative impacts of a project to their equivalent money value, the Benefit cost analysis determines whether on balance the project is worthwhile.

Joshi, P.K., et. al (2004) assessed the performance of watershed programs by using meta-analysis in 311 case studies in India. The mean-Benefit cost ratio of watershed programme in the country was quite modest of 2.14. The internal rate of return was 22%. The watershed programmes generated enormous employment opportunities augmented irrigated area and cropping intensity and conserved soil and water resources.

Yitbarek, T.W., Satish Kumar et.al (2010) carried out watershed rehabilitation programs in Ethiopia. The results clearly indicate that investment in watershed rehabilitation may be an economically viable short-term and long-term proposition. Hence there is a strong case for sustainable management of rehabilitated watersheds in view of the very high economic benefits from the rehabilitation.

METHODOLOGY

The study was conducted on both primary and secondary data. Primary data collection involves two hundred households randomly selected from the villages and also experts.

The primary data was collected through questioners. The data were collected during December 2004 to February 2006. The head of the households were interviewed for the household questionnaire. Memory recall method was adopted to record the past experience of the respondents about their cultivation practices, income, expenditure etc. Participatory Rural Appraisal (PRA) was conducted to observe the level of awareness of the people in the villages.

Assumptions

A: Cost of the Project

The secondary data provide cost of the watershed which was collected from DWMA office and farmers for Kadapa watershed. The maintenance and other cost of the project will be the mean cost of the watershed for the relative years.

B: Benefit of the Project

In the identification of the project impact, the possible benefit of the project to the village economy. The sustainability of the project will be considered for minimum period of 10 years.

C: The Discount Rate

The discount rate to be considered as 12% per year.

MONITORY VALUATION OF THE BENEFIT

The benefit of the project is the increase in post project output in comparison to its pre project scenario. In this study, 20 different indicators have been identified for asserting the total benefits, which is calculated as:

Total benefit of the project

$$= (x_1 t_{past} - x_1 t_{pre}) + (x_2 t_{past} - x_2 t_{pre}) + ... + (x_{20} t_{past} - x_{20} t_{pre})$$

$$= Bx_1 + Bx_2 + ... + Bx_{20}$$

$x_1 t_{past}$ is the variable (crop/item x_1 at the post-project period, and $x_1 t_{pre}$ represents the corresponding variable of x_1 at the pre-project period. Thus the benefit from the project i.e., Bx_1 is $(x_1 t_{past} - x_1 t_{pre})$.

Now, the benefits in real terms are to be converted in values, by multiplying their respective prices which can be written as

$$(Bx_1 \times Px_1) + (Bx_2 \times Px_2) + ... + (Bx_{20} \times Px_{20}) = Vx_1 + Vx_2 + ... + Vx_{20}$$

where, Px is the price of x and Vx is the value of the benefit.

From equation we can calculate the value of the benefit for one household (R). The total benefit for hundred sample households in monetary term will be

$$(Vx_1 + Vx_2 + ... + Vx_{20})R_1 + (Vx_1 + Vx_2 + ... + Vx_{20})R_2 + ... + (Vx_1 + Vx_2 + ... + Vx_{20})R_{100} = VB$$

where, VB is the total value of the benefit.

The estimated economic values of the benefits of the watersheds are presented in Table 1.

Discounting of Benefit and Cost values and calculate the Net Present Value

The Benefit Cost Analysis is presented here with the assumption that the benefit out of the project will remain same for the next 10 years. Now the monetary values of the benefits and costs are to be calculated for next 10 years. The benefit-cost ratio will be derived assuming a discount rate of 0.12.

The cost of the Project

The cost of the project is derived from secondary source. The Present Values (PV) of costs are estimated by discounting these costs, which is calculated from the following form

$$TPVC = [C_{2005}] + [C_{2004} \times (1+\delta)^1] + [C_{2003} \times (1+\delta)^2] + ... + [C_{1998} \times (1+\delta)^7]$$

where TPVC = Total Present Value of Cost, and C_{Year} is the cost of the project during a particular year.

The cost of the project in different heads for the Kandlopalli watershed presented in table 2.

Benefit of the Project

The next present value of the benefit for the next 10 years can be obtained from the formula

$$TPVB = \sum VB_1 + VB_2\left(\frac{1}{1+\delta}\right)^2 + VB_3\left(\frac{1}{1+\delta}\right)^3 + ... + VB_{30}\left(\frac{1}{1+\delta}\right)^{10}$$

where TPVB = Total present of benefit, δ = discount rate

The value of the benefit of Kandlopalli watershed is presented in Table 1 converting the values in present value by applying above equation.

The Benefit Cost Ratio

$$Benfit\ Cost\ \ Ratio = \frac{Total\ Present\ Value\ Benefit}{Total\ Present\ Value\ Cost}$$

Sensitive Analysis

The Net Present Value (NPV) test described above tells us about the relative efficiency of the project, given the data input to the calculations. A sensitivity analysis is attempted to ascertain the sensitivity of the Benefit Cost Ratio to the three assumed parameters of the Benefit Cost Analysis, such as the discount rate, lifetime of the projects and the set of prices. For this neither the cost data nor the benefits scenario is tempered. Only the parameters are modified. All the parameters are raised in one set and lowered in another. The precise modifications are as follows:

- The discount rate is 0.012 in the Benefit Cost Analysis (BCA) analysis and it is changed to 0.01 in case one and 0.015 in case two.
- The lifetime of the project is taken as 10 years in the original analysis, in the first case it is assumed to be 15 years and in the second case it is modified to 20 years.
- The prices of the commodities in the study are added with 10 percent in one case and a deduction of 10 percent is done in the second case.

Hence the new parameters for the sensitivity analysis are:

1. Prices of the indicators are raised by 10 percent, discount rate is taken as 0.01 and lifetime of the project is 15 years.
2. Prices of the sources of benefits are lowered by 10 percent, discount rate is 0.015 and lifetime of the project is 20 years.

RESULTS & DISCUSSIONS

The results of economic feasibility analysis of various watersheds are presented in table 5 to 7. For the major projects including the irrigation projects desirable Benefit cost ratio is 1.5 and rate of return value on investment should be on par with existing market rate. The Benefit Cost Ratio of Kandlopalli watershed in Muddanur mandal is more than standard stipulated value by world bank because the same results cannot be expected in future because of varying the assumptions and variation of climate conditions due to change in global environmental and socio-economic conditions.

THE BENEFIT-COST RATIO

The details of present value of benefits and costs with discount factors given in table 1 and the cost of expenditure details and the benefits of each parameters are given table 2.

The present value of the benefit for 10 years in Kandlopalli watershed project is calculated to be Rs.29.03 lakhs. The present value of the cost in 2007 of the project of Kandolopalli watershed is Rs.15.18 lakhs.

$$Benfit\ Cost\ \ Ratio = \frac{Total\ Present\ Value\ Benefit}{Total\ Present\ Value\ Cost}$$

The Benefit Cost ratio for watershed is presented in table 3

From the table 1, it is observed that the Benefit cost ratio of the project is more than 1.5. Hence, the watershed programme is economically feasibility.

SENSITIVITY ANALYSIS

The IRR method, Net Present Value (NPV) gives the idea of relative efficiency of watershed for given data of inflows and outflows. However, the assumed parameters varies from time to time due to the change in socio-economic conditions and political conditions in the study area. It needs sensitive analysis to find the sensitive of Benefit cost ratio value by varying the assumed parameters such as discount factors, life of the project, price of the commodity. The sensitive analysis of the watershed is given in table 3. The results of sensitive analysis of Benefit cost ratio indicates that higher project duration enhances Benefit cost ratio because total desirable benefits of the project can be achieved due to establishment of stabilized man-made ecosystem in the watershed even though discount factor for calculating present value of project cost and benefits enhanced from 10% to 15%. Benefit cost ratio of this project in increased from 1.91 to 3.64 due to higher beneficial duration of project. This indicates that period of project is vital factor to assess economic feasibility studies of a project.

The IRR & Benefit Cost for various watershed are given in the table 4. Benefit cost ratio of various watershed programme varies from 1 to 3.1 and internal rate of return on investment from 10 to 28% among all is ranging watersheds, the highest Benefit cost ratio is 3.7 for Pemmada palli due to additional net area brought under cultivation and increase in crop yield, horticulture and afforestation area increased and also percentage increase of agricultural productivity and lowest cost-benefit ratio 1.0 for Reddypalli and due to less crop yield minimum area brought into cultivation and also people participation is less. Cetimapuram-I, Settyvaripalli-2 and Vempalli-4 are economically feasible programme as per World Bank standards.

Table 1 Benefit Cost Ratio of Kandlopalli watershed

S. No.		**Amount (Rs.) in Lakhs**
1.	Present value of the benefit	29.03
2.	Present Value of the cost	15.18
3.	Benefit Cost Ratio	1.91

Table 2 Benefit Cost Analysis of Kandlopalli (Expenditure details)

Total Expenditure incurred : Rs.15.18 Lakhs Cost Input																Benefit					
S. No.	Item / Work / Activity	1997-98			1998-99			1999-2000			2000-01			Total		2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
		Physical	Financial	Benefit	Physical	Financial	Benefit	Physical	Financial	Benefit	Physical	Financial	Benefit	Physical	Financial						
1	Contour Bunding Ha	1	0.1	0.121										1	0.13	0.12	0.12	0.12	0.12	0.12	0.12
2	Stone Terracing (ha)																				
3	GCW (RFD'S) (Nos)				10	0.23	0.09	10	0.20	0.07				20	0.43	0.1	0.1	0.1	0.1	0.1	0.1
4.	Diversion drains (Kms)																				
5.	Live Fencing (Ha)																				
6.	Check dams (Nos)				2	1.32	0.51	3	1.96	0.62	2	1.08	0.43	7	4.35	0.7	0.7	0.7	0.7	0.7	0.7
7.	Dugout ponds (Nos)				2	0.43	0.17							2	0.43	0.2	0.2	0.2	0.2	0.2	0.2
8.	Repairs to percolation tanks (Nos)				3	0.73	0.43	3	0.66	0.16				6	1.39	1.10	1.20	1.30	1.40	1.50	1.60
9.	Horticulture (Ha)	18	0.47											18	0.47	0.17	0.20	0.30	0.45	0.55	0.70
10.	Block Plantations (Ha)	8	3.80																		
11.	Nurseries (Nos)																				
12.	Avenue plantations (KM's)																				
13.	Continuous contour trenches (Ha)																				
14.	Gabian Structures (Nos)																				
15.	Entry Point Activity (EPA)	3	0.8	0.40										3	0.81	0.4	0.4	0.4	0.4	0.4	0.4
16.	Village Wood lot (Ha)																				
17.	Feeder Channels (Kms)										1	0.09	0.03	1	0.09	0.12	0.12	0.12	0.12	0.12	0.12
	TOTAL		5.2	0.52		5.99	1.2		2.82	0.85		1.17	0.458		15.18	3.61	3.84	4.14	4.49	4.79	5.14

S. No.	Item / Work / Activity	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
1	Contour Bunding Ha	0.14	0.14	0.16	0.18	0.17	0.16	0.16	0.19	0.19	0.19
2	Stone Terracing (ha)										
3	GCW (RFD'S) (Nos)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4.	Diversion drains (Kms)										
5.	Live Fencing(Ha)										
6.	Check dams(Nos)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
7.	Dugout ponds (Nos)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3		0.3
8.	Repairs to percolation tanks (Nos)	2.3	3.5	3.7	3.8	3.9	4.0	5.2	6.3	7.4	8.6
9.	Horticulture (Ha)	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.8
10.	Block Plantations (Ha)	1.8	2.0	2.2	3.3	4.4	5.5	6.6	7.7	8.8	9.9
11.	Nurseries (Nos)										
12.	Avenue plantations (KM's)										
13.	Continuous contour trenches (Ha)										
14.	Gabian Structures (Nos)										
15.	Entry Point Activity (EPA)	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
16.	Village Wood lot (Ha)										
17.	Feeder Channels (Kms)	0.13	0.13	0.13	0.12	0.12	0.14	0.14	0.14	0.14	0.14
	TOTAL	6.17	7.87	8.39	9.7	10.99	12.3	14.7	17.29	19.23	21.53

Table 3 Economic Feasibility of Kandlopalli watershed Benefit cost ratio under different scenario's Cost-Benefit Ratio values

S. No.	Indicators	Case	Kandoloapalli, Kadapa in A.P.
1.	$\delta = 0.012$ T = 10 years P = Actual	Base case	1.91
2.	$\delta = 0.010$ T = 15 years P = 10% above the case	Raised case	2.18
3.	$\delta = 0.015$ T = 20 years P = 10% below base case	Lowered case	3.64

Table 4 Salient features of economic feasibility status of different watershed in study area, Discount factor = 12%; Period = 10 years

S.No.	Name of the Watershed	IRR (%)	B/c value
1.	Velpula –2	21	2.18
2.	Nawabpet & Duggannapalli	18	1.7
3.	Yerragudipalli & Bakarapuram	23	2.4
4.	Diguvalkalavakatta-1	19	1.8
5.	Nandyalampalli	28	3.1
6.	Kondapayapalli	26	2.7
7.	Pemmadapalli	28	3.7
8.	Cetimapuram-I	14	1.2
9.	Settyvaripalli-2	15	1.3
10.	Vempalli-4	10	1.0
11.	Reddypalli	27	1.5

Table 5 The present value of cost and benefit at 12% discount factor of life period 10 years

Year	Present value of cost (in lakhs)	Present value of benefit (in lakhs)	At 12% discount factor
1997-98	4.64	0.46	0.89
1998-99	4.77	0.95	0.79
1999-2000	2	0.6	0.71
2000-01	0.744	0.29	0.63
2001-02		2.04	0.56
2002-03		1.94	0.50
2003-04		1.87	0.45
2004-05		1.79	0.40
2005-06		1.72	0.36
2006-07		1.65	0.32

Table 6 10% increment both in the cost of the project and benefit of the project, 10% discount factor, life period 15 years

Flow type	Year	Cost	Flow type	Year	Cost
Outflow	1997-98	5.72	Inflow	1997-98	0.57
	1998-99	6.58		1998-99	1.32
	1999-2000	3.1		1999-2000	0.93
	2000-01	1.28		2000-01	0.49
				2001-02	3.97
				2002-03	4.22
				2003-04	4.55
				2004-05	4.93
				2005-06	5.26
				2006-07	5.65
				2007-08	9.81
				2008-09	17.98
				2009-10	31.81
				2010-11	54.53
				2011-12	90.88

IRR = 21%

Table 7 10% decrease in rate at discount factor of 15%, Life period 20 years

Flow type	Year	Cost	Flow type	Year	Cost
Outflow	1997-98	4.68	Inflow	1997-98	0.46
	1998-99	5.39		1998-99	1.08
	1999-2000	2.53		1999-2000	0.76
	2000-01	1.05		2000-01	0.41
				2001-02	3.24
				2002-03	3.45
				2003-04	3.72
				2004-05	4.04
				2005-06	4.31

Table 7 *Contd…*

Flow type	Year	Cost	Flow type	Year	Cost
				2006-07	4.62
				2007-08	5.55
				2008-09	7.08
				2009-10	7.55
				2010-11	8.73
				2011-12	9.9
				2012-13	11.07
				2013-14	13.3
				2014-15	15.56
				2015-16	17.3
				2016-17	19.37

IRR = 17%

CONCLUSION

The Benefit cost ratio varies from 1 to 3.1 and rate of return ranges from 10% to 28%. The watershed programmes are economically feasible because the predicted Benefit cost ratio of watersheds is viable even though assumed project duration and cost of the price change in future.

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Integrated Water Resources Management in Upper Thurinjalar Sub Basin of Ponnaiyar River Basin in Tamilnadu

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ABSTRACT

Water Planning includes assessing surface and ground water potential, estimating sectoral demands like domestic, agriculture, industrial, livestock and power sectors, and arriving at the balance water potential for further use. Development and management of water resources is essential to meet out the increasing demands. For this objective Integrated surface water and groundwater resources management should be implemented. TamilNadu is occupied by 73% of hard rock formation. Even though in east 27% sedimentary formation occurs there is sea water intrusion problem. Groundwater occurrence is very much limited in hard rocks. Surface water is almost harnessed. Due to indiscriminate pumping of groundwater, water level is declined and many Panchayat unions were declared as Over Exploited blocks. Tamilnadu is drained by 17 river basins, 127 minor basins and 1047 sub basins. Upper Thurinjalar sub basin is one of 39 sub basins of 19 minor basins of Ponnaiyar river basin in Tamilnadu. This sub basin was selected for study as parts of 5 Panchayat unions lie in this sub basin are over exploited, due to deficit rainfall, drought prone area, occurrence of hard rock terrain, seasonal river flow etc. Development and management of water resources is essentially required for this study area. Development of surface water can be done by construction of more anicuts in Thurinjalar and Olaiyar which are draining the area. Desilting and deepening of suitable tanks selected based on geomorphological and lineament studies, construction of sub surface dykes in streams, formation of new recharge tanks, can improve the present status. Groundwater can be developed by construction of percolation ponds, recharge pits, formation of dykes in hilly elevated rocks, drilling bore wells in highly favorable suitable sites, forming trenches in sloping terrain. Based on lineament fault plane and geomorphology maps interpreted from satellite data were used for this purpose. If development of surface and groundwater is done properly, management can be easily made. By Roof water harvesting water will be saved in syntex tanks where hard massive rocks occur in surface. Less water consuming crops may be planned instead of wet crops depending upon soil conditions.

***Keywords*:** Water Management, over draft, Remote Sensing, Artificial Recharge

1. INTRODUCTION

River basin water planning requires both development and management. Only by proper management, domestic, agricultural, industrial and power demands can be easily met out fully. In a river basin or sub basin, assessing surface and groundwater potential, estimating sectoral demands and arriving at the balance for future use will be done based on watershed approach

The area selected for study is Upper Thurinjalar minor basin which is one of the 19 minor basins of Ponnaiyar river basin of Tamilnadu. The issues in this area are:

1. Area comprises of hard rock terrain,
2. All five (5) panchayat unions lie in the sub basin are declared as over exploited
3. Declination of groundwater level and
4. Droughtprone area with deficit rainfall.

For better management of the sub basin, it is essential to understand the physiography, geology, geomorphology, drainage pattern, land use, structures, trend of rainfall, groundwater level, surface water sources, water quality and depth to bedrock.

2. MATERIALS AND METHODS

2.1 Study area and data source

Index map

Upper Thurinjalar sub basin is one of the 19 sub basins of Ponnaiyar river basin, Tamil Nadu. Total geographical area is 323.31sq.km. This watershed is bounded in North by Cheyyar river basin, South by Lower Thurinjalar minor basin, West by Aliyar watershed and East by Varaganadhi sub basin. 5 Blocks/ Panchayat unions lie in the area namely Thiruvannamalai, Kilpennathur, Thurinjapuram, Chengam and Thandrampattu blocks of Thiruvannamlai District. 155 villages lie in this sub basin area within the coordinates East longitude 78.57´23´´ E to 79.09´23´´E and North latitude 12.09´8´´ N to 12.23´27´´ N. as shown in Fig 1.

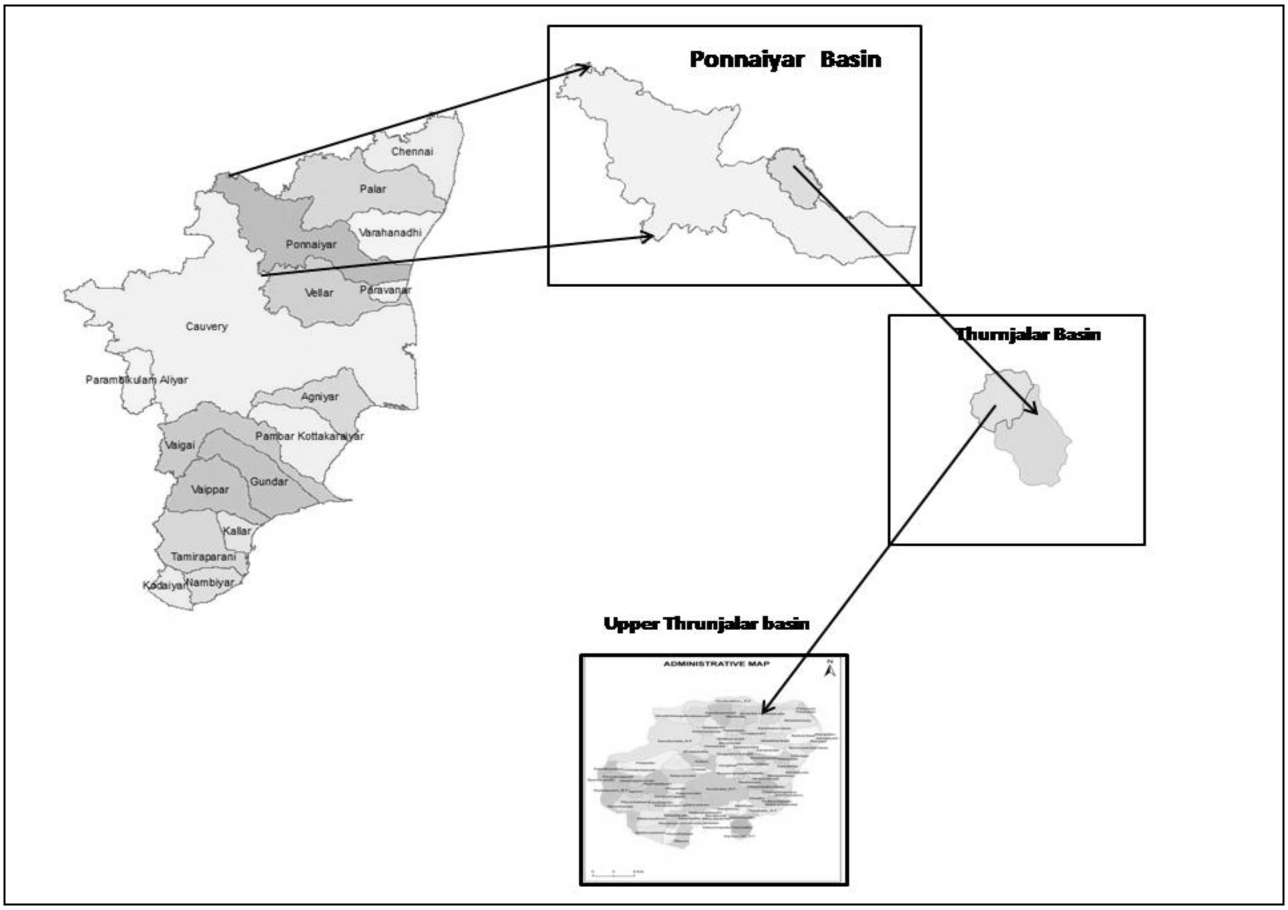

Fig. 1 Study area map

2.2 Geology

The Archean crystalline rocks of the area has charnockite group with pyroxene granite and magnetite quartzite. The ultra basic rocks occur as detached patches. Pegmatite and Quartz occur as lenticular bodies. Weathered rocks occur up to 15 m, partially weathered formation extends down to 28 m and fractured and jointed formation occurs as 40 m to 70 m below ground level as shown in Fig 2.

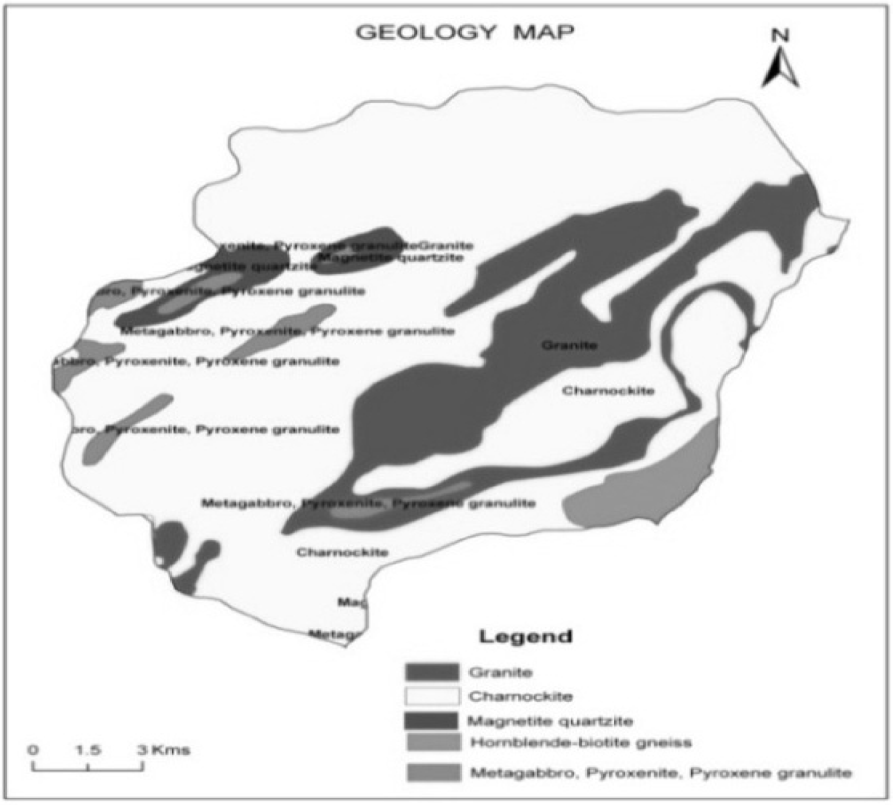

Fig. 2 Geology map

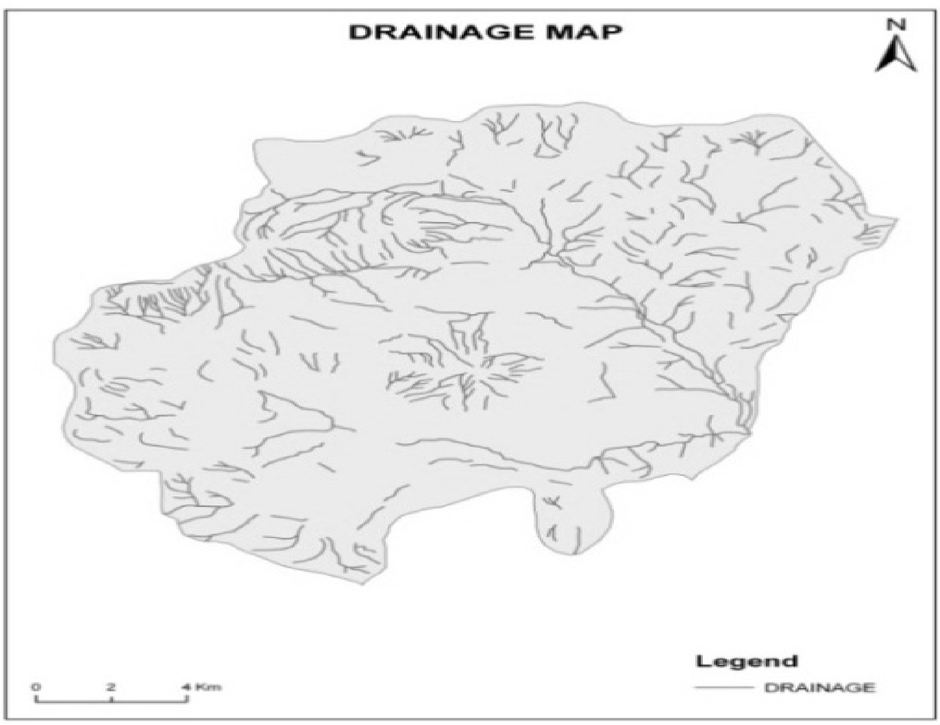

Fig. 3 Physiography map

2.3 Physiography

The highest altitude is 818 m above MSL located in Thiruvannamalai reserve forest area and lowest altitude is 145 m above MSL. Hills and forest land occupy 39 sq.km, tanks occupy 85 sq km. Thurnjalar river orginates from Kavuttumalai hills and forest in Chengam taluk, in western part of sub-basin. It flows in southern direction. Totally there are 97 tanks as shown in Fig. 3.

2.4

A. Climate: Generally semi arid climate prevails over the Upper Thurinjalar sub-basin area without any sharp variation. The climate of the area is characterized by four distinct seasons namely Southwest monsoon (Jun-Sep), Northeast monsoon (Oct- Dec), Winter season (Jan-Feb) and hot summer season (Mar-May). Hydrometeorological data were collected from Kilnatchipattu weather station. Thiruvannamalai maintained by State Ground & Surface Water Resources Data centre, W. R. O, P. W. D.

B. Temperature: The maximum and minimum temperature varies between 41°C and 21.6°C in general.

C. Relative humidity: Average relative humidity was recorded as 72.4% during southwest monsoon, 78.4% during northeast monsoon, 75.2% during winter and 70.6% during summer seasons

D. Potential Evaporation: Mean potential evaporation is found to be more (189 mm) during May and less (99.8 mm) in December. Generally it ranges from 100 to 170 mm.

2.5 Rainfall

Rainfall data is being collected from Thiruvannamalai Rain gauge station (IMD)

Table 1 Rainfall Distribution in Thiruvannamalai

Rainfall Distribution in Thiruvannamalai		
Season	**Normal Rainfall**	**Percentage**
Southwest Monsoon	392.70 mm	40.1
Northeast Monsoon	418.16 mm	42.7
Transitional Period	168.44 mm	17.2
Annual (Mean)	979.30 mm	100

Monthly rainfall data for the past 17 years from 1995 to 2011 and daily rainfall data from Jan 2002 to Dec 2011 were collected from IMD. Data was grouped season wise as Southwest, Northeast, Winter and Summer.

Dependable rainfall

For Thiruvannamalai Rain gauge station (IMD): 75% dependable annual rainfall is 794.7 mm While analyzing daily rainfall from 2002 to 2011 and monthly rainfall from 1995 to 2011, it is found out that in seven years Southwest monsoon rainfall is more than North East monsoon rainfall and in 10 years northeast monsoon rainfall is more than southwest monsoon rainfall. Annual rainfall is more than mean annual rainfall in 6 years, equal in one year and less in ten years.

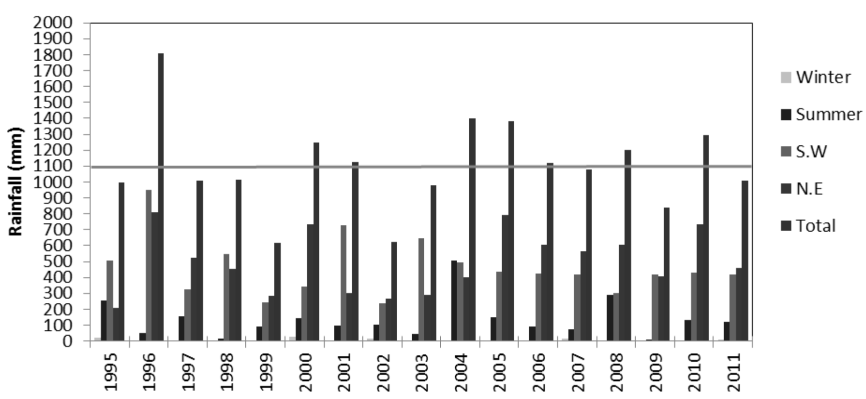

Fig. 4

Three years moving average rainfall method

By adapting three years moving average rainfall method normal, drought and flourishing years were identified

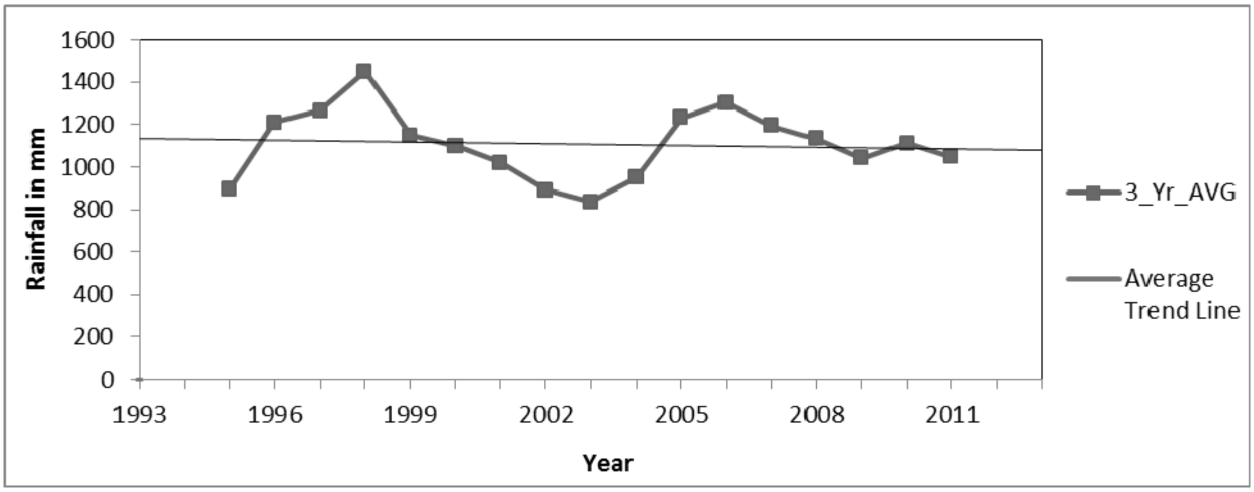

Fig. 5 Trend line of three years moving average rainfall method

3years moving average rainfall prediction of normal, drought and flourishing year (1995-2011)

(i) Normal years are 1999, 2000 and 2010 (3 years)

(ii) Deficit drought years are 1995, 2001, 2002, 2003, 2004, 2009 & 2011 (7 years)

(iii) Surplus flourishing years are 1996, 1997, 1998, 2005, 2006, 2007, 2008(7 years)

Trend line shows decreasing trend

3. GROUNDWATER LEVEL

PWD Ground water Department is monitoring shallow observation wells for studying water level fluctuation by collecting monthly water levels and collecting water samples twice in a year in the pre monsoon and post monsoon periods. In the study area two observation wells 23112 Polagunam and well no 23141 Pichanadal were selected for analysis. Monthly water level data from January 2002 to December 2012 were collected and analyses was made as shown in Fig 6,7.

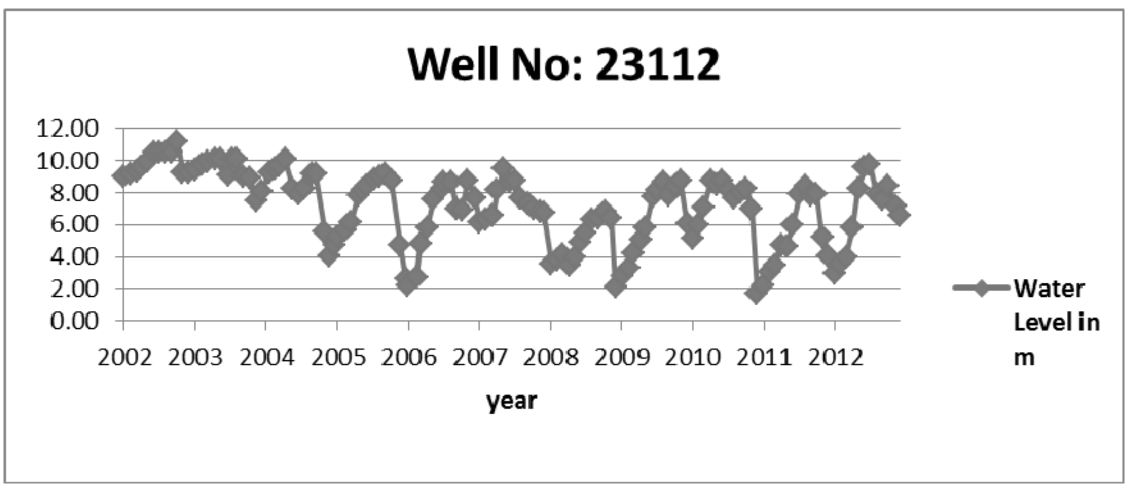

Fig. 6 Analysis of observation well 23112 Polagunam.

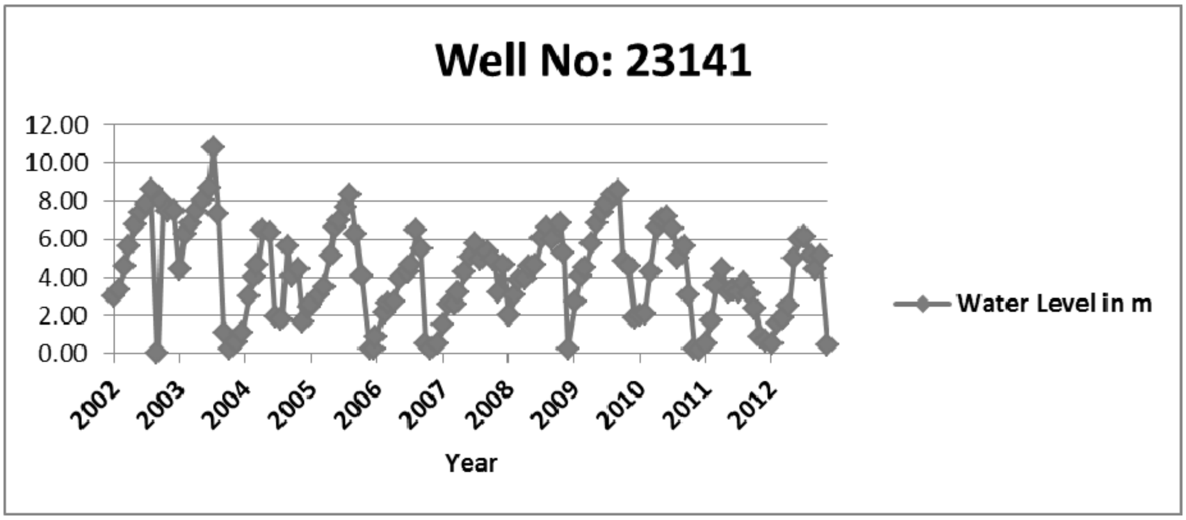

Fig. 7 Analysis of observation well 23141 Polagunam.

Table 4 Minimum and Maximum water levels for observation wells 23112 and 23141

Well No: 23141 Location: Pichanandal				
Year	**Month**	**Max Water Level in m**	**Month**	**Min Water Level in m**
2002	Aug	8.6	Jan	3
2003	Jul	10.8	Oct	0.25
2004	Apr	6.45	Nov	1.65
2005	Aug	8.35	Dec	0.25
2006	Aug	6.45	Nov	0.25
2007	Jul	5.75	Jan	1.5
2008	Oct	6.85	Dec	0.25
2009	Sep	8.55	Dec	1.85
2010	Mar	7.2	Dec	0.2
2011	Apr	4.45	Jan	0.5
2012	Jul	6.15	Nov	0.45

Well No: 23112 Location: Polagunam				
Year	**Month**	**Max Water Level in m**	**Month**	**Min Water Level in m**
2002	Oct	11.18	Jan	8.98
2003	Jul	10.08	Nov	7.48
2004	Apr	10.08	Nov	4.08
2005	Sep	9.18	Jan	5.18
2006	Nov	8.78	Jan	2.23
2007	May	9.48	Jan	6.18
2008	Oct	6.83	Dec	2.08
2009	Nov	8.78	Jan	2.78
2010	Jun	8.78	Jan	5.13
2011	Oct	7.88	Jan	2.18
2012	Jul	9.78	Jan	2.98

Maximum and Minimum Water Level in metre for 10 years (2002-2012)

By analyzing the water level fluctuation of two control wells 23112 and 23141 it is found that in well no 23141 minimum water level ranges between 0.2 m to 1.85 m in case of well no 23112 minimum water level ranges 2.08 m to 8.98 m. In the flourishing years 2005, 2006, 2007, 2008 in well no 23141 the minimum water level is 0.25 m to 1.5 m and in well no 23112 after the flourishing years water level ranges in between 2.08 m to 6.18m Maximum water level in 23141 following flourishing rainfall years ranges 5.75 m to 8.35 m, in the well 23112 it ranges in between 6.83 m and 9.18 m. Definitely if rainfall is more, water level rises and rainfall is less water level decreases. There is declining trend in general.

4. WATER QUALITY

The geochemical results of water samples collected from well no 23141 and well no 23112 obtained from geochemical lab were analyzed (Table 5). The cations and anions are found to be well within standard limits (Standard Limits for TDS 1050 mg/lit, for Chloride 250mg/lit). Quality of water is highly suitable for domestic agricultural and industrial uses. For comparative purposes total dissolved solids and chloride values for the period of 11 years from (2002 to 2012) were taken. Results indicate that both chloride and TDS have values within safe limits . Hence quality of water did not affect the crop pattern even though there is increase in crop pattern and waste land from 1998 to 2008 there is decrease in forest land. But quality had no effect on this forest lands.

5. LAND USE

Land use refers to man's activities and varied uses which are carried in over land and land cover refers to natural vegetation water bodies, rock/soil and others noticed on the land (NRSA 1989)

5.1 Landuse is classified into different categories as follows.

- Built-up land – settlement
- Crop land – wet crop (Paddy & sugarcane)
  Dry crop - (Groundnut, Flori culture, cholam)
- Forest land – Hills and forest
- Wasteland – Barren land, Land covered by scrubs
  Land covered by shrubs
  Rocky Outcrop
  Stony waste
  Stony waste covered by scrubs
- Water bodies- tank, rivers and streams
- Each category of land use is furnished in sq.km and percent in Table 3.

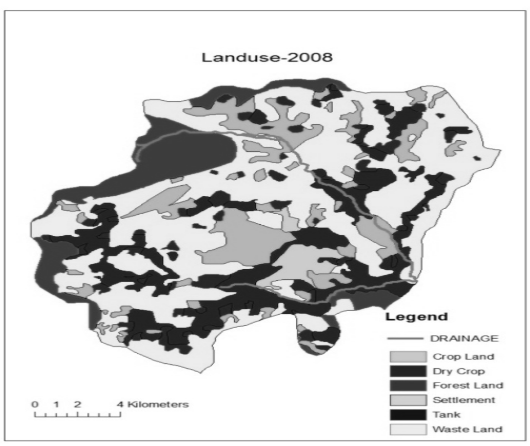

Fig. 8 Land use Classification of study area in 2008

Table 3 Total Geographical Area of the study area

2008_data	Area in sq km	Percentage
Settlement	8.99	2.78
Wet crop	47.73	14.76
Waste land	150.19	46.46
Forest land	39.28	12.15
Dry crop	59.05	18.27
Tank	18.04	5.58

TOTAL GEOGRAPHICAL AREA ; 323.28 sq.km

6. WATER RESOURCES PLANNING

Water planning includes

1. Assessment of surface water potential in the sub-basin is 77.6 Mcm (MRS model, PWD Groundwater).
2. Assessment of ground water potential is 34 Mcm (GREC Norms)
3. **Total water potential** is **111.6 Mcm**.
4. The demands of following sectors are

   Domestic: 5.65 Mcm

   Livestock: 3.40 Mcm

   Industrial: 18.35 Mcm

   Irrigation: 98.11 Mcm

   Total demand: **125.5 Mcm**

   No balance of water and this sub basin is over drafted

7. CONCLUSIONS

As the sub basin area is over drafted as per water planning calculations it is essential to increase water potential to meet out the sectorial demands for better management. Water level fluctuation indicates that there is declination of water level. To improve the condition artificial recharge arrangements are to be done. To select rainwater harvesting structures following thematic maps are essentially needed.

A. ISO RESISTIVITY CONTOUR MAP

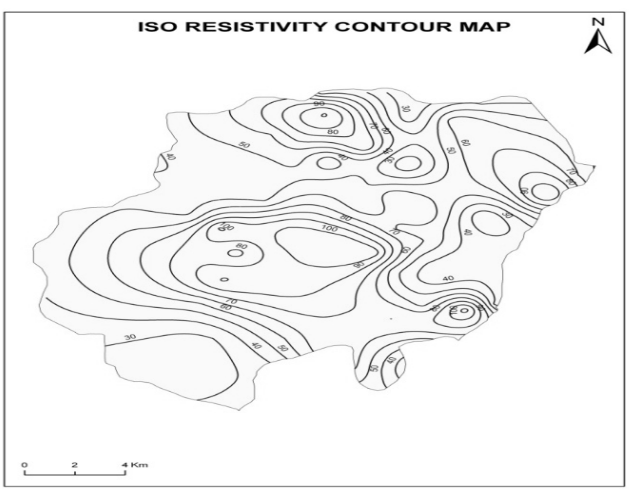

Fig. 9 resistivity contour map

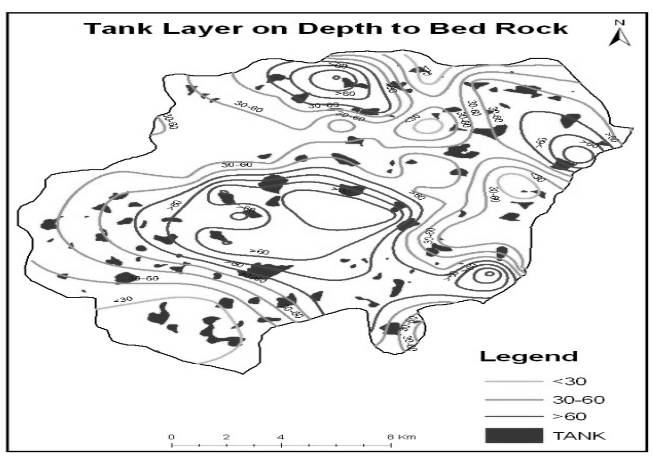

Fig. 10 Tank layer on depth to bed rock

By conducting electrical resistivity survey, ISO resistivity contour map was prepared. The depth to bedrock can be known in the study area. In 70 locations resistivity survey was conducted. Due to tectonic disturbances, fractured and jointed rock occurs to depths of 60 to 90 metres. Depth to bedrock occur 60 to 90 metres bgl. Weathered thickness varies in between 15 to 30 metres. When the tank layer was superimposed on ISO resistivity layer by using GIS techniques, it was found out that highly favourable zones which have depth to bed rock more than 60 metres bgl, in central, north western and north eastern portion of the sub basin have 18 tanks. These tanks are suitable for desilting and modernization

B. GEOMORPHOLOGY MAP

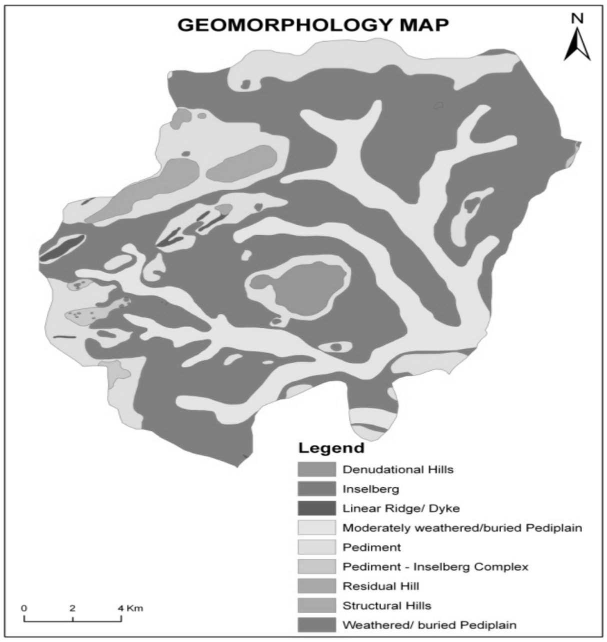

Fig. 11 Geomorphology map

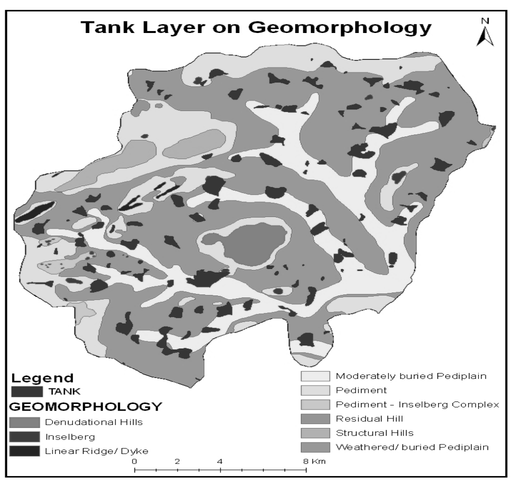

Fig. 12 Tank layer on geomorphology

While geomorphology map was generated, it was noted that only favourable land form suitable for rainwater harvesting was moderately buried pediment. Other land forms are not favourable. By super imposing tank layer on the Geomorphology layer suitable tanks for artificial recharge were selected as shown in Fig. 11, 12 . The thickness of soft disintegrated formation is found as 15 to 18 metres bgl. 21 tanks in the moderately buried pediment were selected for desilting and modernization for Recharge purposes.

C. LINEAMENTS /(FAULT FRACTURE ZONE MAP)

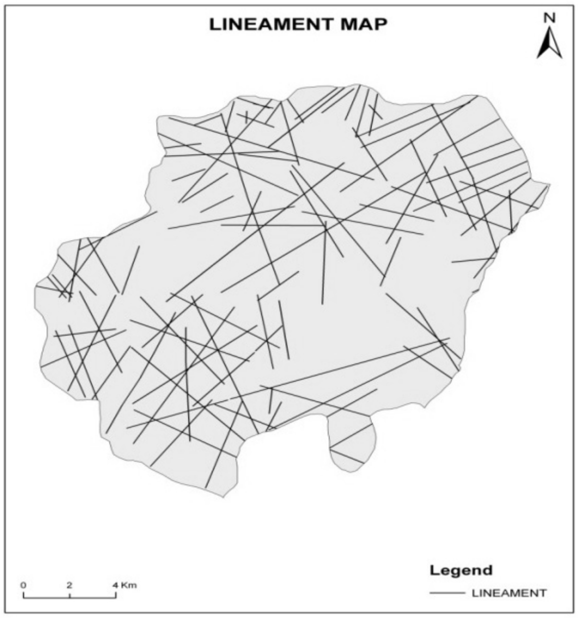

Fig. 13 Lineament map

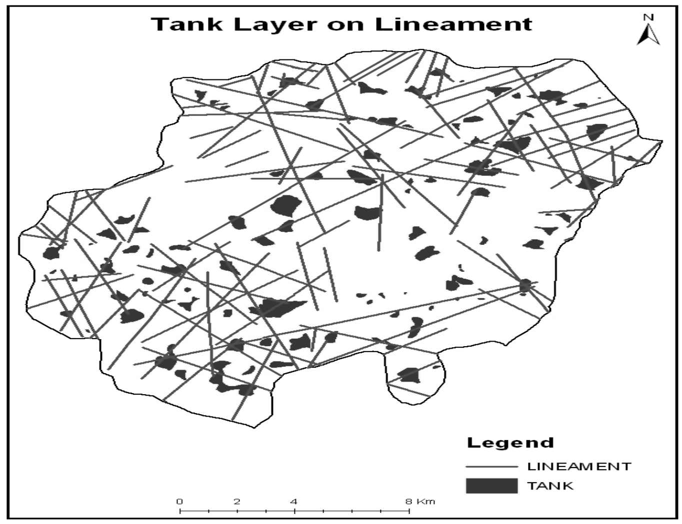

Fig. 14 Tank layer on lineament

Based on Remote sensing interpretation Lineament map of the area was generated and fault/fractured zone map was generated. Intersection of fault zones were marked and identified in the field. By GIS overlay analysis 15 tanks located in the intersection of fault planes were identified and selected for desilting and modernization shown in Fig. 13,14.18 locations were found highly suitable for establishing recharge structures like Percolation Ponds, Sub surface dykes, recharge pits, check dams in channels.

TECHNICAL RECOMMENDATIONS

For best management of water resources in Upper Thurinjalar sub basin following technical recommendations are suggested.

1. Due to availability of space and already existing water source, tanks are selected for augmenting Ground water Recharge based on overlay analysis. As an evidence two borewelss drilled in the foreshore of Samudram tank which lies in the moderately buried pediments and inter section point of faults sustain pumping of 200 GPM and 150 GPM and 50% of Tiruvannamalai Town domestic water supply is met out from the water supplied from these two wells. One open dug well sunk in the foreshore of Usambadi Tank which lies in the moderately buried pediment and inter section point of faults yield 250 GPM for 6 hours pumping per day even during peak drought period. 16 Tanks in the sub basin are recommended for desilting and modernization.
2. It is recommended to drill bore wells in the inter section of faults, to establish recharge pits, percolation ponds, sub surface dykes in the places on the fault zone which lie moderately buried pediment.
3. It is suggested to form Trenches in the sloping terrain of mountains.
4. It is recommended to select check dams in the drainage channels which lie in the fault plane and moderately buried pediments which has fractured thickness above 30 m.

5. After referring ISO resistivity contour, Geomorphology, fault zone maps, on the spot hydro geological investigation and resistivity survey have to conducted before finalizing the site.
6. To save water Micro irrigation Techniques like drip, sprinkler irrigation method have to be adopted.
7. Awareness should be created among the Agriculturists for judicial and economical utilization of water and conservation of tanks.

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Classification of Rain Fed Micro-watersheds Based on Physical and Hydrological Parameters using Clustering Analysis and Geospatial Techniques

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ABSTRACT

Classification of micro-watersheds based on hydrological response is crucial to formulate appropriate strategies for suitable conservation and management practices within the watershed. In this study physical, morphometric, land use and dynamic hydrological characteristics are considered for classification. Characterization and analysis of micro-watersheds with hydrological and morphological parameters is carried out using GIS and Remote sensing techniques and Soil and Water Analysis Tool (SWAT). Three clustering analysis techniques including Kohonen Neural Networks (KNN), Principal Component Analysis (PCA) and K-means Cluster Analysis (KCA) are employed for classification of micro-watersheds to a rainfed watershed namely, Kaddam watershed of G-5 sub-basin of Godavari river basin in India. H- Statistic based Hosking and Wallis homogeneity test is performed to assess the homogeneity of clusters formed by three clustering techniques based on the monthly surface run off values of 1996 to 2010. Optimal number of groups is chosen based on two cluster validation measures namely, Davies–Bouldin index and Dunn's index. The results show that physical and geo-morphological parameters alone should not be basis for classification because factors such as climate, land use, and soil properties introduce variability in hydrological functionality of watersheds. From the comparative results of homogeneity tests (H- Statistic) and distance measures, it is observed that KNN and KCA algorithms performance is better than PCA. It is also noticed that both KNN and KCA produce approximately similar kind of classification of micro-watersheds but KNN produced clusters with more compactness. The obtained results for Kaddam watershed suggests that the cluster-1 consisting of south east and north central micro-watersheds should be given top priority and requires immediate conservation measures.

Keywords: *micro-watersheds classification, GIS, K-means Cluster Analysis, Kohonen Neural Networks, Principal Component Analysis, hydrologic modeling, H- statistic.*

INTRODUCTION

Classification of watersheds based on similar hydrological behavior is needed for different purposes. Each watershed may not require the same conservative measures. So, instead of analyzing each watershed for its rehabilitation and/or improvement, watersheds that are similar can be grouped so that problem can be tackled in the form of groups instead of individually for conservative measures (Rao and Srinivas, 2008). Classification of watersheds has been also used in the prediction or extension of shorter records of flow characteristics such as floods or low flows in watersheds (e.g. Cavadias et al., 2001; Natahan and McMahon 1990), regional flood frequency analysis (e.g. Rao and Srinivas, 2006; Castellarin et al., 2008), generalization of hydrologic system understanding (Sawicz et al., 2011), and to generate streamflow hydrographs in ungauged watersheds (e.g. Chiang et al., 2002a, 2002b; Kahya et al., 2008).

Watersheds classification is generally based on watershed physiographic characteristics or its hydrologic behavior e.g. runoff characterstics. watershed parameters/ attributes considered for classification are different across various studies, and it seems that an initial hypothetical judgment is required to identify which potential watershed parameters would have an impact on the hydrological responses of interests. Merz and Blöshl (2004) and Parajka et al. (2005), for example, use the help of expert judgments to take into account the interaction between the runoff regime, climate, and physiographic attributes. According to Howard (1967) and Jhon et al. (2000) morphological characteristics like stream order, drainage density, aerial extent, watershed length and width, channel length, channel slope and relief aspects of watershed are important in understanding the hydrology of the watershed. Rao and srinivas (2008) pointed out that watershed attributes used for classification/ regionalization purposes should characterize the factors that drive the hydrological response of a watershed and should be representative of physical and critical hydrological parameters. When the goal of watershed classification is to cluster catchments according to hydrological responses then, Sawicz et al. (2011) introduced six signatures defined as hydrologic response characteristics and possible universal metrics to identify homogeneous groups of hydrologically similar watersheds. The signatures include: runoff ratio, baseflow index, snow day ratio, slope of flow duration curve, drainage density and relief ratio. Razavi et al (2012) defined 10 parameters for watershed classification including physiographic and monthly runoff and sediment yield for clustering similar watersheds in Arizona, USA. Ssegane et al (2012) examined 42 published papers and identified 72 unique topographic variables, 66 climatic variables, 98 soil variables, and 15 land use and land cover variables used by different researchers. This study suggested that integration of physical, land use and dynamic hydrological characteristics results in effective classification/ regionalization of watersheds. In this study physical, morphometric, soil, land use and dynamic hydrological parameters are considered for classification of micro-watersheds into homogenous groups.

On the other hand clustering algorithms can be useful for watershed classification to form homogenous groups, particularly if many criteria are associated with watersheds. Burn and Boorman (1993) applied k-means clustering on the flow response variables of watersheds and classified the watersheds according to the hydrological similarity. Chiang et al. (2002a) used 16 stream flow parameters estimated by a time series model to classify 94 watersheds into 6 regions in Alabama, Georgia, and Mississippi (USA) and using Fuzzy Cluster Analysis (FCA). The limitation of these classification techniques is that they may not capture the nonlinear patterns in data, hence, it should not be considered as the only option. Rao and Srinivas (2008) discussed important issues related to clustering such as choice of clustering algorithm, choice of appropriate attributes for clustering, selection of suitable objective function, choice of dissimilarity (or distance) measure, appropriate initialization of the clustering algorithm and selection of appropriate number of clusters in the data. ASCE Task Committee (2000a,b) discussed the use of Kohonen Neural Networks (KNN) for classification purpose and its applications in water resources. Sewailam et al. (2000) presented an approach for clustering homogenous areas based on river basin planning alternatives using Principal Cluster Analysis. Jingyi and Hall (2004) applied PCA, Fuzzy c-means method, and KNN to 86 sites in the Gan River Basin of Jiangxi Province and the Ming River Basin of Fujian Province in the southeast of China to delineate homogeneous regions based on site characteristics and it was concluded that PCA and KNN methodology is the preferred approach. Raju and kumar (2011) compared three classification techniques, namely, K-means Cluster Analysis (KCA), FCA, and KNN to group 25 watersheds based on ten hydrological parameters. This study reported that KCA and KNN methodology can be used as the basis for clustering environmental data entities for natural resources conservation due to its advantage of less field data requirement and its wider concurrence with other clustering techniques. In this study, three clustering analysis techniques including K-means Cluster Analysis (KCA), Kohonen Neural Networks (KNN) and Principal Component Analysis (PCA) are employed for classification of micro-watersheds in the study region.

According to Ssegane et al (2012) use of physical, land use and dynamic hydrological characteristics to gether is fruitful for effective classification of watersheds. Besides physical characteristics , the hydrologic modeling are necessary to characterize the watersheds with critical hydrological parameters which involve simulation of hydrologic processes such as rainfall, evapotranspiration, infiltration, surface runoff, sediment yield, percolation and subsurface flow. A wide range of watershed models are available to simulate the hydrological process accouring in the watershed. Examples of these models are: the physically based event model ANSWERS (Beasley, 1991), the empirically based SWATCATCH model (Holman et al., 2001), the physically based DWSM model (Borah and Bera, 2003), and the semi-empirical SWAT model (Arnold et al., 1998; Arnold and Fohrer, 2005; Gassman et al., 2007). All these models can simulate the hydrological variables like runoff, sediment yield, water yield at the watershed scale. Among all the hydrological models, Soil and Water Assessment Tool (SWAT) is the most capable model for long-term simulations in watersheds dominated by agricultural land uses and has been widely used in various regions and climatic conditions on daily, monthly and annual basis is employed in this study.

This study aims to characterize and classify the micro-watersheds into homogeneous groups based on physical, morphometric, soil, land use and dynamic hydrological parameters using GIS, SWAT, KCA, KNN and PCA. In specific the objectives of the study includes

(i) Characterization and analysis of micro watersheds with hydrological and morphological parameters using SWAT and GIS

(ii) To classify the micro-watersheds into homogeneous groups using KCA, KNN and PCA based on selected critical hydrological and morphometric parameters and to compare the homogeneity results of different methods

(iii) To identify critical and homogenous regions in the study region for effective planning and management of conservation practices.

2. STUDY REGION AND ANALYSIS OF DATA

2.1 Study Region

The study region, Kaddam reservoir catchment lies in the central part of middle Godavari (G-5) sub-basin of Godavari river basin in India, which lies between latitudes $17^{\circ}04'$-$18^{\circ}30'$ North and longitudes $77^{\circ}43'$ – $79^{\circ}53'$ East. The G-5 sub-basin has a catchment area of 35723 km^2, which constitutes 11.38% of the total Godavari river basin area and entirely lies in the state of Andhra Pradesh. The study area of Kaddam reservoir catchment lies between latitudes $19^{\circ}05'$-$19^{\circ}35'$ N and longitudes $78^{\circ}10'$-78° $55'$ E. The areal extent of the study area is 2617.56 km^2, which constitutes 7.4% of the sub-basin area. The climate in the study area is semi-arid with an average annual rainfall of 715 mm and is a typical rainfed watershed characterized with dry land crops, i.e., cotton (majorly) and pigeon pea. It is observed that the monthly minimum and maximum average temperature recorded in summer ranges from 26^{o}C to 42.5^{o}C and the monthly average temperature recorded in winter ranges from 16^{o}C to 29^{o}C. The highest wind speed is 136 km/hr. The study area is drought prone and regional government (Government of Andhra Pradesh) has declared the administrative boundaries of the watershed as drought prone in the years 1994-1997, 2000, 2003, 2005, 2006 and 2009 (APWALMTARI, 2010). In this context, LULC assessment and analyzing its implications on watershed hydrology is having high importance to formulate appropriate strategies for suitable conservation and management practices.

2.2 Morphometric Analysis of Data

The present study area of Kaddam watershed boundary has been delineated from the Survey of India (SoI) toposheets. Stream network of the study area is digitized from toposheets of 1:50000 scale. Kaddam watersheds have been delineated into 35 micro-watersheds based on stream network behavior and a vector layer of stream network is developed. Strahler system (Strahler, 1964) of ordering stream segments is followed to classify the stream segments. These delineated 35 micro-watersheds are individual hydrological units and boundaries are earmarked based on intersection of common drain point. The delineated micro-watersheds are designated with codes 1, 2, 3….., 35.

Morphological parameters, namely, drainage density (D_d), bifurcation ratio (R_b), stream frequency (F_s), length of overland flow (L_o), form factor (R_f), relief Ratio (R_h), elongation ratio (R_e), circulatory ratio (R_c), compactness coefficient (C_c) and texture ratio (T) are chosen for classification (or grouping) based on the recommendation of past studies (Chakraborti 1993; Biswas et al. 1999; Chopra et al. 2005; Ratnam et al. 2005; and Garde, 2006). Detailed description of these parameters can be found in past studies (e.g., Garde 2006).

2.3 General Prioritization of Micro-watersheds

In general prioritization methodology, ranks have been assigned to each micro-watershed with respect to each parameter based on their significance to a specific purpose. Then, based on every single parameter, the ranking values for all the parameters of each micro-watershed are used to arrive at compound value (C_p). This C_p values are used to assign the priorities. The sediment yield and linear parameters have a direct relationship with erodability, whereas shape parameters have inverse relationship with erodability (Biswas et al, 1999). Based on average value of these parameters, the micro-watersheds having the least rating value is assigned highest priority, next higher value is assigned second priority and so on. This method gives the priority ranking of micro-watersheds for conservation measures in the study region.

3. SOIL AND WATER ASSESSMENT TOOL

SWAT is a physically based semi-distributed hydrological model that was developed to predict runoff, erosion, sediment and nutrient transport from agricultural watersheds under different management practices (Arnold et al., 1998). SWAT is a continuous simulation macro scale hydrologic model and is most versatile model that has been widely used in various regions and climatic conditions on daily, monthly and annual basis (Santhi et al., 2001). SWAT provides physically based mathematical relationships as an option to describe many of the important components of the hydrologic process occurring in the watershed through script files. The hydrological components of SWAT is driven by the soil water balance of a river basin.

The SWAT model requires a digital elevation model (DEM), soil and LULC spatial maps and climate data for modeling a watershed. In the present study, DEM is generated from 20 m contour map and deterministic eight-neighborhood algorithm is used to improve the flow tracing along flat areas. The DEM of the study region is presented in Fig 1. The LULC classification of Kaddam watershed is carried out using LANDSAT 7 ETM (Path / Row - 99/58) satellite imageries (30m spatial resolution) by employing NDVI classification method. Land use and Land cover map generated based on NDVI using LANDSAT imagery of 01-10-2010 is presented in Fig 2. The spatial database of soil is developed by geo-referencing the scanned soil map of study region and a vector layer of soil map was delineated in GIS environment describing soil physical properties of Kaddam watershed. Daily climate data on rainfall, minimum and maximum air temperature, relative humidity, wind speed and sunshine hours for the period 1996- 2010 is given as input to the SWAT model.

3.1 SWAT Simulation Results

The SWAT model was applied to simulate surface runoff and sediment yield in Kaddam watershed for monthy and daily time scales. The SWAT model was calibrated for time period of (June 1999-October 2002) and validated for time period (June 2003- October 2006). The simulated values of surface runoff were greater than observed values during low flow periods of months September and October, whereas simulated values of surface runoff were lower than observed values during high flow periods of July month. The SWAT model predicted runoff well during the high flow period i.e., in the months of June to August, but tends to over-predict the runoff in the winter months i.e., during September- October months. The model was validated with performance statistics of Nash-Sutcliffe efficiency (*NSE*), coefficient of determination (R^2), and Percent bias (*PBIAS*) for simulation of runoff and sediment yield for three monitoring stations at monthly and daily time step. The values of performance measures of SWAT model was within the permissible results and satisfactory.

4. CLASSIFICATION METHODOLOGY

4.1 Kohonen Neural Networks (KNN)

The KNN is a learning algorithm that was originally proposed and developed by Kohonen (Kohonen, 1982a; 1982b and 1998) and due to its un-supervised it is also called as self organizing map (SOM) neural networks. The KNN is a neural network model that is based on Kohonen's discovery that the topological information prevalent in high dimensional input data can be transformed into a one or two dimensional layer of neurons (Kalteh and Berndtsson 2005). The main advantages of the KNN algorithm are that it is non-linear and has an ability to preserve the topological structure of the data (Corne et al. 1999 and ASCE 2000a). In general, the KNN algorithm clusters the samples (or patterns) into predefined number of classes and also orders the classes into meaningful maps with topology preservation. The typical structure of a KNN consists of two layers: an input layer and a Kohonen or output layer. The input layer contains one neuron for each variable (e.g., precipitation, temperature, watershed parameter etc) in the data set. The Kohonen layer neurons are connected to every neuron in the input layer through adjustable weights or network parameters. The weight vectors in the Kohonen layer gives a representation of the distribution of the input vectors in an ordered fashion. The weight vectors define each cluster. Input patterns are compared to each cluster, and associated with the cluster it best matches. The KNN output emphasizes the salient features of the data and subsequently leads to the automatic formation of clusters of similar data items (Herrero et al. 2000).

4.2 K-means Cluster Algorithm (KCA)

For comparative analysis and to validate the results of KNN, the K-means Cluster Algorithm (KCA) is employed for classification of micro-watersheds in the study region. The KCA method is chosen because it has the advantage of less parameter requirement and its wider applicability (or acceptability). The KCA partitions data sets into relatively homogeneous groups and used to minimize intra-cluster sums of squares of differences to obtain the final classification (Jain and Dubes 1998). In KCA, each cluster is represented by its mean of feature vectors within the cluster (Rao and Srinivas 2008). In this technique, data sets are grouped so that each data set is assigned to one group of the K (fixed number) groups. The sum of the squared differences of each element from its assigned cluster mean is used as the objective function. Detailed explanation and application of KCA can be found in Hyjeoo et al. (2011).

4.3 Principal Component Analysis (PCA)

PCA based clustering finds combinations of the original variables (known as latent variables or principal components- PCs) which describe the dominant patterns and the main trends in the data (Jackson, 2003). In datasets with multiple variables, usually more than one variable determine the same driving principle which controls the behavior of the system. In this case, replacing a group of variables with a smaller set of new variables can make the analysis simpler. This new set of variables, are principal components. Each principal component is a linear combination of the original variables. PCA is done through an eigenvector decomposition of the covariance matrix of the original variables. The extracted latent variables are sorted according to their eigen value. With PCA the high dimensional space described by matrix X is modeled as (Aguado et al., 2008):

$$X = TP^T + E \qquad \text{.....(1)}$$

where, T is the score matrix (composed by the PCs), P the loadings (composed by the eigenvectors of the covariance matrix) and E is the residual matrix. Principal Component Analysis (PCA) maximizes the rate of decrease of variances (Haykin, 1999). Detailed explanation and application of PCA can be found in Jackson , 2003.

4.4 Cluster Validation Indices

Cluster validation indices are used to determine the optimal number of clusters in a data set. These are computed based on the outcome of clustering algorithms. Two cluster validation indices namely, Davies-Bouldin Index and Dunn's Index are applied to determine the optimal number of clusters or groups (Lin and Chen 2006).

Davies-Bouldin (DB) Index: The DB index (Davies and Bouldin 1979) is a function of the ratio of the sum of intra-cluster (within-cluster) scatter to inter-cluster (between-clusters) separation. The scatter within i^{th} cluster, S_i , is computed as $S_i = \frac{1}{|C_i|}\sum_{x\in C_i}\left\{\left\|x - z_i\right\|\right\}$ and the distance between clusters C_i and C_j , $d_{ij} = \left\|z_i - z_j\right\|$. Here z_i is *i*th cluster center. A similarity measure R_{ij} between the clusters C_i and C_j is defined as $R_{ij} = \left\{\frac{S_i + S_j}{d_{ij}}\right\}$.

Let $R_i = \underbrace{\max}_{\substack{j=1,\ldots,K \\ i\neq j}} \left\{R_{ij}\right\}$. The DB index can be computed as:

$$DB = \frac{1}{K}\sum_{i=1}^{K} R_i \qquad \text{.....(2)}$$

In this case, it is desirable for the clusters to have minimum possible similarity to each other, hence a smaller DB index value represents good performance of clustering. The cluster configuration that gives most minimum *DB* is taken as the optimal number of clusters *K*.

Dunn Index (ν_D): It is proposed by Dunn (1974) as a metric for evaluating the performance of clustering algorithms in terms of identifying compact and well separated clusters. For any partition, the Dunn index is computed as:

$$\nu_D = \min_{1\le i\le K}\left\{\min_{\substack{1\le j\le K\\ j\ne i}}\left[\frac{\delta(C_i,C_j)}{\max\limits_{1\le k\le K}\{\Delta(C_k)\}}\right]\right\} \quad \text{.....(3)}$$

where $\delta(C_i,C_j)$ is the distance between two clusters C_i and C_j, which is given by $\delta(C_i,C_j)=\underbrace{\min}_{x,C_i,y\in C_j}\{d(x,y)\}$ and $\Delta(C_k)$ is the diameter of cluster k, which is given by $\Delta(C_k)=\underbrace{\max}_{x,y\in C_k}\{d(x,y)\}$. Here $d(x,y)$ is the distance between points *x* and *y*.

Here the aim is to identify sets of clusters that are compact, with a small variance between members of the cluster, and well separated, where the means of different clusters are sufficiently far apart, as compared to the within cluster variance. Larger values of Dunn index correspond to good clusters, and the optimal number of clusters (*K*) is chosen based on cluster configuration that result in maximum value of Dunn index.

4.5 Homogeneity Test

An examination of homogeneity is normally used to assess whether a proposed group of sites is homogeneous or not. Tests for the homogeneity of regions/pooling groups are usually based on a statistic that relates to the formulation of a frequency distribution model, e.g. the coefficient of variation (CV) (Wiltshire, 1986; Fill and Stedinger, 1995). Hosking and Wallis (1993, 1997) proposed homogeneity tests based on L-moment ratios such as L-CV alone (H_1) and L-CV & L-skewness jointly (H_2) which are widely used in regionalization and flood frequency analysis although the former one is recommended by these authors for having better power to discriminate between homogeneous and heterogeneous regions. A group of watersheds is considered to be homogeneous if $H < 1$, probably homogeneous if $1 \le H \le 2$, and heterogeneous if $H > 2$. In this study, for each supposedly homogenous set of watersheds formed by KCA, KNN and PCA, the homogeneity tests were computed on monthly surface runoff values from 1996 to 2010.

5. RESULTS AND DISCUSSION

5.1 Classification of micro-watersheds

For the classification of micro-watersheds, physical, geo-morphological, soil, land use and critical hydrological parameters that can represent various key characteristics of watershed are chosen for input layer as shown in Fig 1. These parameters were chosen according to the suggestion of Ssegane et al (2012 a, b) and Razavi et al (2012) that integration of physical, land use, soil and dynamic hydrological characteristics results in effective classification/regionalization of watersheds. The watershed parameters such as, drainage density (D_d), bifurcation ratio (R_b), stream frequency (F_s), length of overland flow (L_o), form factor (R_f), relief Ratio (R_h), elongation ratio (R_e), circulatory ratio (R_c), compactness coefficient (C_c) and texture ratio (T) can cover almost all morphological and physical aspects of a watershed. Sediment yield index represents the physical soil properties influencing runoff and sediment yield. Forest cover greatly influences the runoff process and is the widely used land use parameter for classification of watersheds (Ssegane et al 2012 a, b). Critical dynamic hydrological components i.e., run off, sediment yield, and evapotranspiration on a daily basis for 1996 to 2010 are considered. These parameters are selected as they are found to have profound influence on physical process of watershed hydrology (Kenneth, 2003; Tracy et al., 2013).

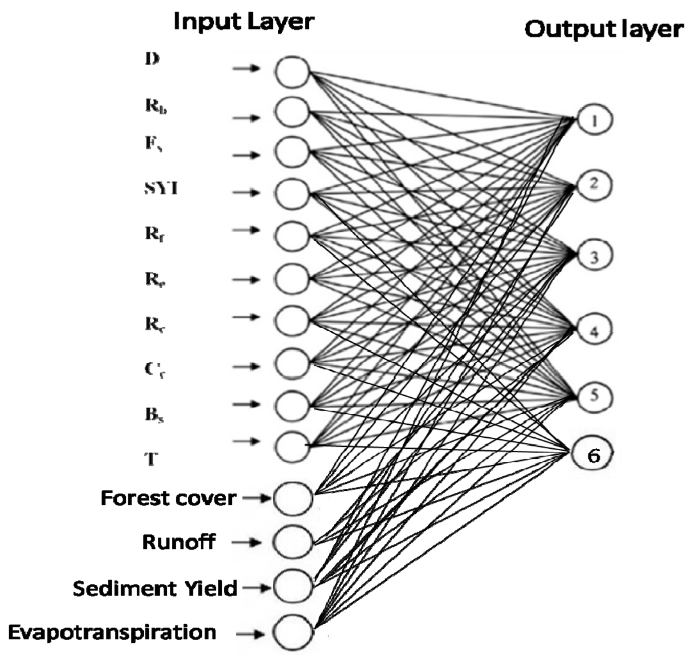

Fig. 1 Schematic diagram of Neural Networks applied for the micro-watershed zonation

5.2 Determination of Optimal Number of Clusters

Determining the number of clusters is necessary before applying classification algorithms. To evaluate the sensitivity of number of clusters to be chosen for the micro-watershed classification, the analysis is performed by varying number of clusters (K) ranging from 4 to 7. This range is chosen based on the consideration of having at least 4 and maximum 7 micro-watersheds in a cluster. DB Index and Dunn's Index are computed to determine the optimal number of clusters or groups. DB and Dunn index is calculated by using the outputs or clusters formed by KNN algorithm. The optimal value i.e., minimum value for DB and maximum value for Dunn index, corresponds to 6 number of clusters. In previous studies, it was suggested that these indices can be used as the basis to make an informed choice about the number of clusters (Rao and srinivas, 2008). Thus, based on DB Index and Dunn's Index values, the micro-watersheds in the study region are to be classified into 6 clusters.

5.3 Classification Results

The individual classification results of KCA, KNN and PCA is presented in table 1. It can be observed that different micro-watersheds have classified into six groups (more or less uniformly) by KNN, KCA and PCA. The obtained results help in identifying the groups of micro-watersheds that should be given top priority (i.e., those require immediate conservation measures). From KNN and KCA based classification, it is noticed that micro-watersheds that are having similar priority (as per general prioritization methodology) are clustered together. The cluster-1 consisting of micro-watersheds 2, 4, 15, 31, 34, 35 are having priorities 1, 1, 2, 3, 5 and 6 respectively. When closed examined these are also the watersheds which have under gone vegetative stress (i.e., change in the vegetative vigor from 1996 to 2010 land use scenario). Thus cluster-1, consisting of south east and north central micro-watersheds should be given top priority and requires immediate conservation measures.

From the comparative analysis of KCA, KNN and PCA, indicates that 16 micro-watersheds out of 35 are commonly classified by KNN, KCA and PCA. About 10 micro-watersheds maintain similar associativity, even though they classified into different clusters by KCA, KNN and PCA. It is also observed that 25 micro-watersheds out of 35 i.e., 71% are suggested by both KCA and KNN, whereas these are 22 in the case of PCA and KNN (62%); and 21 in the case of PCA and KCA (60%).

Table 1 Classification of micro watersheds by KCA, KNN and PCA.

Cluster	KCA	KNN	PCA
1	2,31, 4,15,34,35	2, 4, 15, 31,34 35	4,15,34,35, 12,30
2	5,33, 6, 8, 24,25	5, 6, 8, 24,25, 33	6, 8, 24,25, 7,16
3	1 ,11,14,19,20,2	1,10,11,14,19,20,28	14,19,20,28, 2,31,
4	12,30, 18,21,26, 29	12,18,21,26,30	18,21,26, 29,32
5	7,16, 17,23	7,16,17,23	17,23, 1,10,11
6	29,32,13,22,27	3, 9,13,22,27,29,32	3,13,22,27,5,33

The homogeneity tests of *H*-statistic is performed among the set of homogenous clusters formed by different methods based monthly surface runoff values of 1996 to 2010. The comparative results of *H*- statistic and distance measures is presented in table 2. From the comparative results, it can be stated that H-static measure is good for KNN and almost equal with KCA, which states that clusters formed with KNN and KCA are having homogeneity distribution of runoff values. From the comparative results of distance measures (DB and Dunn index) values, the clusters formed with KNN are more compact and the clusters are well separated when compared to clusters formed with KCA and PCA. It is observed that both the KNN and KCA algorithms produce approximately similar kind of classification of micro-watersheds but KNN produces clusters with more compactness. It can also be stated that KNN can be used as a better classification algorithm if many criteria (dynamic parameters) is associated with classification due its unsupervised and dimensionality reduction nature.

Table 2 Homogeneity and distance measures for different clustering methods

Clustering Method	H-statistic	DB index	Dunn index
KCA	1.101	1.214	0.252
KNN	1.998	1.113	0.261
PCA	1.291	1.542	0.219

For a comparative study, the classification is done for a scenario, considering only first 10 geo-morphological parameters for classification and homogeneity tests were computed on the clusters formed. The homogeneity test results of classification with 10-geo-morphological parameters (scenario-I) and classification with 14- hydrological parameters (scenario-II) were compared. The H-statistic measure for scenario-1 resulted in 1.24 and for scenario-II about 0.91, which concludes that scenario-II has better homogeneity of clusters than scenario-I. The homogeneity tests proved that clusters formed based on integration of hydrological, land use, and physical characteristics are more homogeneous than clusters formed with considering physical and geo-morphological parameters. The results shows that physical and geo-morphological parameters alone should not be basis for classification because factors such as climate, land use and evapotranspiration introduces variability in hydrological functionality of watersheds. The study suggests that identifying homogeneous regions can be helpful for effective planning and management of watersheds, and KCA and KNN can be applied effectively for micro-watershed zonation.

6. CONCLUSIONS

This study characterized the micro watersheds with hydrological and morphological parameters using GIS and SWAT and classified the micro-watersheds into homogeneous groups using KCA, KNN and PCA. This study evaluated the ability of variables selected and also the capability of different classification methods to identify the hydrologically similar watersheds and also suggested micro-watersheds which should be given top priority for conservation measures. The results shows that physical and geo-morphological parameters alone should not be basis for classification because factors such as climate, land use, evapotranspiration and soil properties introduces variability in hydrological functionality of watersheds. The homogeneity tests proved that clusters formed based on integration of hydrological, land use, and physical characteristics are more homogeneous than clusters formed with considering physical and geo-morphological parameters. From the comparative results of homogeneity tests (H- statistic) and distance measures (DB and Dunn index), it is observed that both the KNN and KCA algorithms produced approximately similar kind of classification of micro-watersheds but KNN produces clusters with more compactness. It can also be stated that KNN can be used as a better classification algorithm if many criteria (dynamic parameters) is associated with classification due its unsupervised and dimensionality reduction nature.

The obtained results help in identifying the groups of micro-watersheds that should be given top priority (i.e., those require immediate conservation measures). The obtained results for Kaddam watershed suggests that the cluster-1 consisting of south east and north central micro-watersheds should be given top priority and requires immediate conservation measures. The study suggests that micro-watershed zonation based on similar hydrological response can be helpful for effective planning and management of watersheds.

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Surface Flow Measurement using Large Scale Particle Image Velocimetry

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ABSTRACT

Large-scale particle image velocimetry (LSPIV) is a nonintrusive approach to measure velocities at the free surface of a water body. The raw LSPIV results are instantaneous water surface velocity fields, spanning flow areas up to hundreds of square meters. Measurements conducted in typical conditions in conjunction with appropriate selections of parameters for image processing resulted in mean velocity errors of less than 3.5%. Large-Scale Particle Image Velocimetry (LSPIV) is an extension of a quantitative imaging technique to measure water surface velocities using inexpensive equipment. This study describes the implementation of imaged-based LSPIV in eight different environmental flow and hydraulic engineering applications for the investigation of complex configurations with and without sediment transport (bed and suspended loads). These applications include the investigation of sedimentation in shallow reservoirs, run-of-river hydropower plants, side weirs used to control bank overflow, oil spills with flexible and rigid barriers, groin fields, river confluence, and sediment flushing in reservoirs. The potential of LSPIV is used to measure surface flow velocities in the context of river and dam engineering projects. Despite significant variations of natural and artificial illuminations and seeding tracers in the laboratory, field, wind, and water surface elevation, LSPIV was applied successfully to obtain velocity measurements. LSPIV has proven to be a reliable, flexible, and diagnostic tool that can be employed successfully in many engineering applications. Flash-floods that occur in regions result in significant casualties and economic impacts. The remote image-based techniques such as Large-Scale Particle Image Velocimetry offer an opportunity to improve the accuracy of flow rate measurements during such events, by measuring the surface flow velocities.

Keywords: *Large Scale Particle Image Velocimetry for surface flow measurement, Matlab Analysis.*

1. INTRODUCTION

Large scale particle image velocimetry (LSPIV) is a field application of PIV used to measure the 2d velocity of the surface of flowing water, e.g. the surface of a river. With the increasing need to monitor river flows, due to climatic changes LSPIV has the advantage that it is relatively cheap to implement and that even under conditions that endanger human life such as floods images can be obtained automatically delivering information that could be life saving. The initial idea was developed by Fujita in 1994. It uses image patterns at the water surface as tracers. These can be any floating pieces of wood, ice, and foam or surface waves seen under specular reflection. These waves can result from turbulent structures within the flow. Other authors actually seed the flow with floating particles. However, no matter what type of tracer is used "The most challenging problem for implementing LSPIV in field conditions, is attaining a good visualization of the stream free surface". Normally images at river locations are taken during the day when illumination conditions are more favorable. Especially if specular reflections are used to utilize the natural tracers of the water surface the illumination conditions are a matter of luck. The advantage of using undulations of the surface is that they, if present cover most of the surface under surveillance allowing an efficient image evaluation.

2. METHODOLOGY

2.1 LSPIV System

The LSPIV system used in this study was comprised of six elements: a camera, tracer particles, a tracer distributer, an illumination system, a computer for data acquisition as well as analysis, and software (images recording, pre-processing, and post-processing with PIV packages). Depending on the flow velocity, a suitable camera characteristic has been chosen to record images of the flow at a suitable rate with adequate image resolution. The sampling frequency of the recorded images has a significant influence on the accuracy of the LSPIV velocity estimates. In recent years, methods have been developed for using an LSPIV system to measure discharge in open channels (Bradley et al., 2002; Cruetin et al., 2003). The USGS procedure for evaluating emerging open-channel discharge measurement technologies was used in this study (Melcher et al., 2002). In general, the methods developed in this study follow the steps shown in Fig. 1.

2.1.2 Image Acquisition

Good image acquisition is crucial for obtaining accurate measurements with LSPIV. Generalised steps in LSPIV are shown in Fig., 1. There are three key components to image acquisition using LSPIV. First, there must be adequate features on the stream surface to capture velocity measurements across the image plane. A homogeneous distribution of particles at a medium seeding density is optimum for image evaluation (Raffel et al., 1998), and the tracers must occupy at least one pixel.

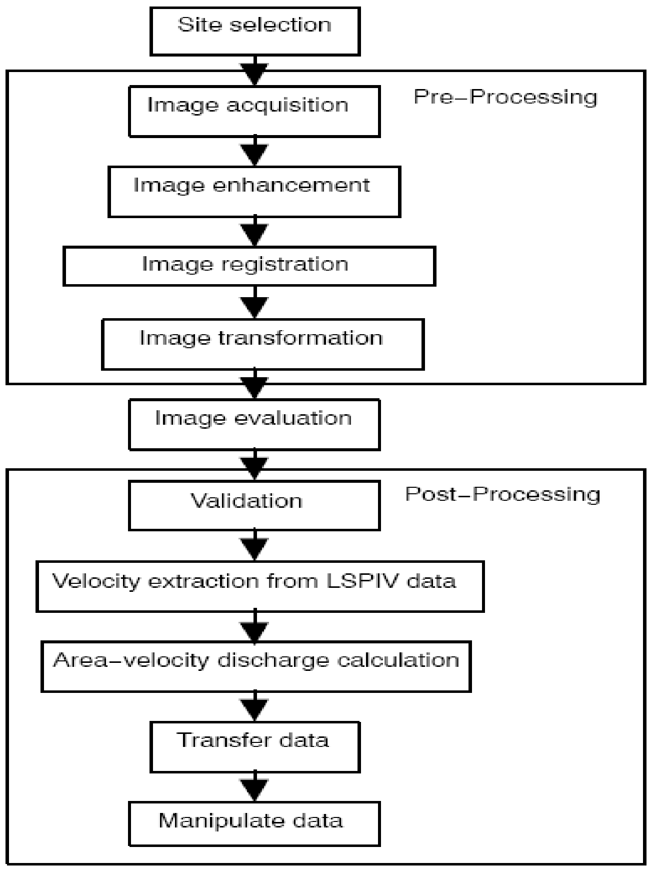

Fig. 1 Flowchart showing the generalized steps involved in LSPIV.

Second, the stream must be sufficiently illuminated to create contrast between the tracers and the water surface. Finally, the camera must be able to capture the image field at the desired frame rate, field of view, and resolution. Appropriate incorporation of all of these components is a prerequisite for the development of a functioning LSPIV system.

2.1.3 Image Enhancement

Several aspects of image acquisition can introduce error, such as poor illumination, glare, and shadows. Image enhancement methods can remove some of these errors prior to image evaluation. Image enhancement is performed by altering the pixel values of the recorded image using image-processing software. Typical image enhancement methods used in LSPIV include increasing the signal-to noise ratio, attenuating background noise, and improving the contrast and brightness of the image (Etterma et al., 1997). Many commercial image-processing software packages can perform these common image enhancement techniques. However, image enhancement techniques are image specific and depend on the camera, lighting conditions, and image size. Matlab image enhancement tools were used in both the laboratory and field images.

2.1.4 Registration and Transformation

In LSPIV field applications, the camera is usually at an oblique angle to the stream, which introduces spatial distortion (Bradley et al., 2002). The distortion is corrected through image transformation, which relates the pixels to their physical locations. The transformation can be corrected through implicit parameters of the camera. However, in LSPIV applications, the transformation is explicit, as ground reference points (GRP) are used to numerically optimize the parameters. In the field experiments, GRPs were surveyed prior to the collection of images. Temporary GRPs were identified by acquiring a single image of the measurement area and identifying features at the water surface. The features identified were rocks, exposed bedrock, trees, and roots. The features were marked on the image, within ±1 pixel, using an image editing program. Subsequently, the point was surveyed with laser survey equipment. A total of 10 to 12 GRPs were taken at each site, depending on the identifiable features.

2.1.5 Image Evaluation Using DPIV

Image evaluation techniques use image intensity fields to measure tracer displacements and estimate a surface velocity field Image evaluation is a critical step in LSPIV, requiring the most specialized techniques. Most LSPIV research has used correspondence techniques to determine particle displacement.Correspondence techniques, such as cross-correlation, search for the correlation of pixels (patterns and individual tracers) between frames. Cross-correlation algorithms work well for the velocities and the low seeding densities found in open-channel applications (Fujita et al., 1998). Careful implementation of the algorithm and corresponding parameters is essential for accurate velocity measurements. The PIV analysis software used in this study (FlowIQ, Piv lab etc.,) was developed by P. Vlachos (Abiven and Vlachos 2002a, 2002b) of Virginia Tech in collaboration with Aeroprobe Corporation. The PIV algorithms are some of the most robust available and well-tested in laboratory settings (Abiven and Vlachos, 2002a, 2002b; Brady et al., 2002). The DPIV algorithm is based on a hybrid scheme that integrates a dynamically adaptive cross-correlation method with a particle tracking velocimetry algorithm. However, in this study, seeding densities were sufficient (between two and five tracers per interrogation window) to use only the cross-correlation methods. Cross-correlation compares an interrogation area (small area of the stream surface) in one image to many interrogation areas in the corresponding image. A cross-correlation coefficient is calculated for every interrogation window in the search area or region of interest (ROI). The highest correlation coefficient in the ROI is taken as the probable particle location. Effective calculation of the cross-correlation coefficients is imperative for accurate displacement measurements. Several successful LSPIV research projects (Bradley et al., 2002; Cruetin et al., 2003) have used the equation given by Fujita et al. (1998) to calculate the correlation coefficient:

$$R_{ab} = \frac{\sum_{i=1}^{MX}\sum_{j=1}^{MY}\left\{\left(a_{ij}-\bar{a}_{ij}\right)\left(b_{ij}-\bar{b}_{ij}\right)\right\}}{\left\{\sum_{i=1}^{MX}\sum_{j=1}^{MY}\left(a_{ij}-\bar{a}_{ij}\right)^2\sum_{i=1}^{MX}\sum_{j=1}^{MY}\left(b_{ij}-\bar{b}_{ij}\right)\right\}^{1/2}} \quad \text{.....(1)}$$

where R is the cross-correlation coefficient, and MX and MY are the sizes of the interrogation area in each image. The variables aij and bij are the distributions of the gray-level values in the two interrogation areas separated by time interval dt.

2.1.6 Image Processing

Several parameters must be specified prior to image evaluation, including the interrogation window size, region of interest (ROI), window-offset scheme, and grid spacing. Optimization of the interrogation window size and location is a principal means of acquiring accurate displacement measurements. The window size must be small enough to preserve the spatial scale of interest (any scale smaller than the window size is lost) and avoid second-order effects (e.g., displacement gradients). However, interrogation windows that are too small may suggest that many pixels show high correlation and will increase the computation time (Raffel et al., 1998). The dynamically adaptive local cross-correlation method used in this study (FlowIQ) reduces the need to precisely identify the optimum interrogation window size. The DPIV program estimates a displacement field for every point in the grid during a first pass. In subsequent passes, the size of the interrogation window is reduced and the location of the window is refined using a single-order discrete window offset; the last operation is repeated until the user-specified minimum interrogation window size is reached. The iterative nature of this process significantly reduces the spatial averaging effects and can capture multiple length scales often present in open-channel flow.

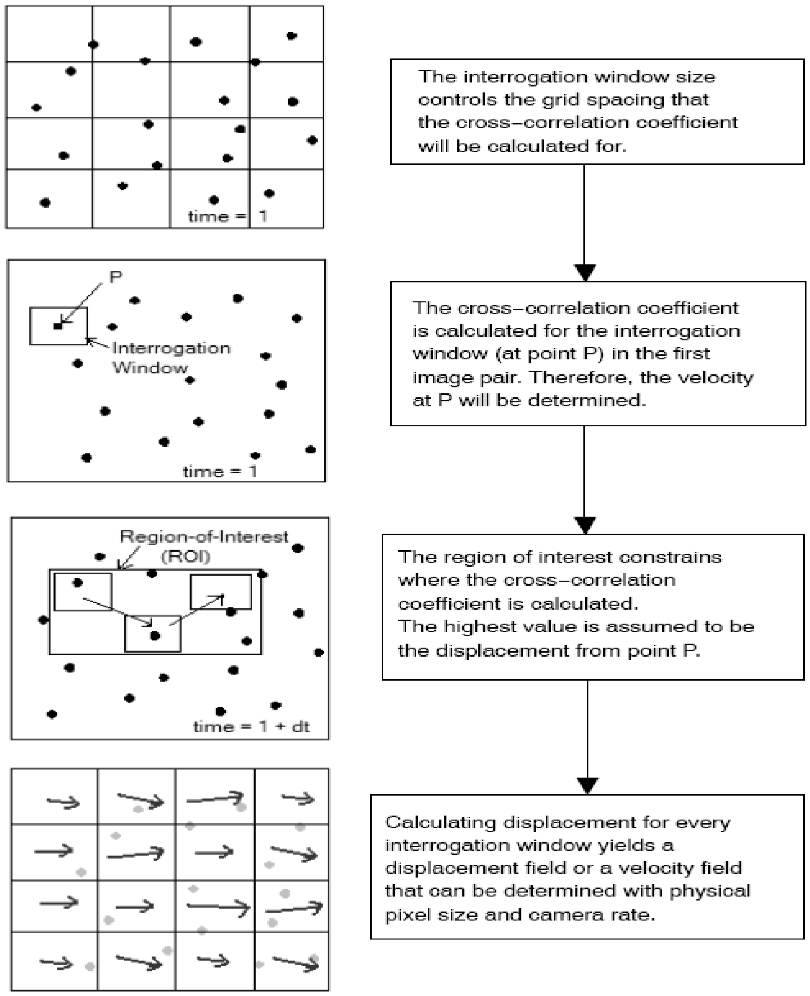

Fig. 2 Flowchart for a typical cross-correlation algorithm.

2.1.7 Discharge Estimation

The LSPIV velocity measurements are used to calculate discharge using the same area-velocity procedures as other devices (e.g., current meter). The most common method is to divide the measuring cross-section into several smaller sections or segments and measure velocity at each vertical. The midpoint method was used in this study; this method assumes that the depth and velocity measured at a given vertical is representative of the velocity for the partial area centered on that vertical. To properly use the midpoint area-velocity method, the stream dimensions must be surveyed (repeatedly in very dynamic systems), and stage must be measured for each discharge measurement. An upstream and downstream cross-section was surveyed, and the average of the cross-sections was used to estimate channel dimensions over the stream reach; the cross-sections used a minimum of 20 survey points. Points were collected at approximately 0.3 m intervals across the channel, unless changes in slope were encountered. Cross-section intervals always contained less than 10% of the total stream discharge. The midpoint method also requires the instantaneous LSPIV velocity values to be averaged temporally and spatially. The mean velocity in time was determined by averaging velocities over a set number of images (with known time intervals). Additionally, it was necessary to average velocity streamlines parallel to the flow into single-point velocities (Fig. 2). Velocity also varies with depth because of the frictional forces of the bed-water and air-water interfaces. For this reason, the ISO (1997) recommends correlating the surface velocity with the velocity at 0.6 of the total water depth using correction coefficients (between 0.84 and 0.92 in natural channels). The use of a correction coefficient introduces error (see the Uncertainty Estimation section later in this article) but modifies the velocity data into the necessary form for calculating discharge. The depth-averaged velocities were determined following ISO (1997) guidelines for the field measurements, with minor modifications showed that a trend of increasing correction factors is necessary for higher stages. Therefore, a method was developed to determine the correction coefficient as a function of stage. The method assumes that the correction coefficient is 0.85 at base flow and is 0.93 at high-flow conditions (bank full discharge). Linear interpolation between these values was used to derive correction factors at both field sites. Additionally, the velocity data were averaged parallel to the flow into between 6 and 15 velocity vectors, depending on stage. Subsequently, the cross-section velocities were averaged temporally across all 39 image pairs. These velocity vectors were used in the area-velocity method to calculate discharge.

3. CASE STUDY (EXPERIMENTAL STUDY IN AN OPEN CHANNEL)

This study is organizing in Fluid mechanics Laboratory in an open channel (Tilting Flume). The channel has 20m length, 0.5 m width, 0.6 m depth and two adjustable gauging stations. The flume is operated at different conditions and readings are recorded as given in table 1. Based on the recorded data velocity, discharge, roughness is found. These detailed observation is compared with the new technique called LSPIV (Large Scale Particle Image Velocimetry) using the PIV tool in Matlab. LSPIV reads the additional matter such as vorticity, shear, turbulence etc, The flume has the following manual adjustments.

Table 1 Tilting Flume data

Rise	Reducing	Slope
1	0.565	1:1200
2	0.638	1:600
3	0.703	1:400
4	0.775	1:300
5	0.847	1:240
6	0.916	1:200
7	0.983	1:171

4. CONCLUSION

The paper presented a suite of experiments conducted with free-surface PIV techniques in shallow flows for documenting various hydro- and morpho-dynamic aspects of shallow flows. The non-intrusive, non-contact features of these techniques enable them to acquire velocity measurements where other techniques are difficult or impossible to employ. The techniques complement numerical simulations and other analytical tools that have provided most of the knowledge of shallow flows. The good performance of the techniques in laboratory flows indicates that their use in field conditions is potentially as successful as it is expected that the Shallow flows in the field are scaled up in the natural conditions such that the measurement environment is less challenging. The techniques provide two-component velocity over the entire imaged area, with high frequency and spatial resolution that can be continuously improved if initial tests show unsatisfactory results. For this purpose, the size of the images can be gradually reduced to address image-recording concerns such as illumination or seeding visibility. The reduced size will require acquisition of more experimental runs, which can be subsequently integrated to provide the information for the area of interest.

The experiments in this study demonstrate the promise of free-surface PIV for hydrodynamic and morpho-dynamic measurements in shallow flows. The technique is relatively new and continues to evolve. Several cautions are needed for the user of the technique. First, the user needs to fully understand the flow nature and behavior in order to adapt the measurement protocol accordingly. Second, and equally important, is that the user should garner a sufficient understanding of the measurement technique to take advantage of its components' capabilities and accelerate the measurement process. Fortunately, the image-based techniques are more robust than the conventional ones, because the measurement process is staged (image recording, image processing) and weakness in one phase can be compensated for by use of alternative procedures in the other phase.

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Downscaling the Precipitation using SDSM

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ABSTRACT

Climate change refers to any systematic change in the long term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer time periods. General Circulation Models (GCMs) are tools designed to simulate time series of climate variables globally, accounting for effects of greenhouse gases in the atmosphere resulting global climate change. Downscaling relates local and regional climate variables to the larger scale atmospheric forcing. The present study focuses on statistical technique of downscaling the global climate models (GCM) for Godavari river spanning 75 degrees latitude and 20.41 degrees longitude. Statistical downscaling model SDSM is applied to the GCM to downscale large scale atmospheric variables into localized weather variables. Using SDSM daily precipitation data for A1 and A2 scenarios downscaled using CGCM3 (GCM). Comparing both observed and downscaled shows equivalent results.

Keywords: *Climate change, SDSM*

INTRODUCTION

Climate change describes changes in the global temperature over time (increase in global temperature global warming) and its consequences on other climatic variables such pressure humidity wind etc. The latest assessment report of IPCC projects that global average temperature in 2100 will be between 1.8 to 4.0 ^{o}C higher than the 1980-2000. Climatic changes are expected to cause increase in temperatures and changes in precipitation patterns and other climatic variables across the globe .The tremendous importance of water in both society and nature underscores the necessity of understanding the impacts of changes in global climate over water resources at local regional scales.

The General Circulation Models (GCMs) have indicated a change in the climate due to increasing concentration of Greenhouse gases in the atmosphere. This may result in serious regional impact on the hydrological cycle, especially on runoff, precipitation, evapotranspiration and soil moisture and their spatial and temporal redistribution. This in turn, may result in serious consequences of global warming would be changes in the extreme values of runoff both high and low. Changing high flow extremes may attenuate the problem of flood, whereas low flow extremes may cause droughts problems

Climate Change Scenario

Climate Change scenario refers to a plausible future climate that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change and natural climate variability. Intergovernmental Panel on Climate Change (IPCC) gives 4 storylines describe the way world population, land use changes, new technologies, energy resources, economies and political structure may evolve over the next few decades (Fig 1).

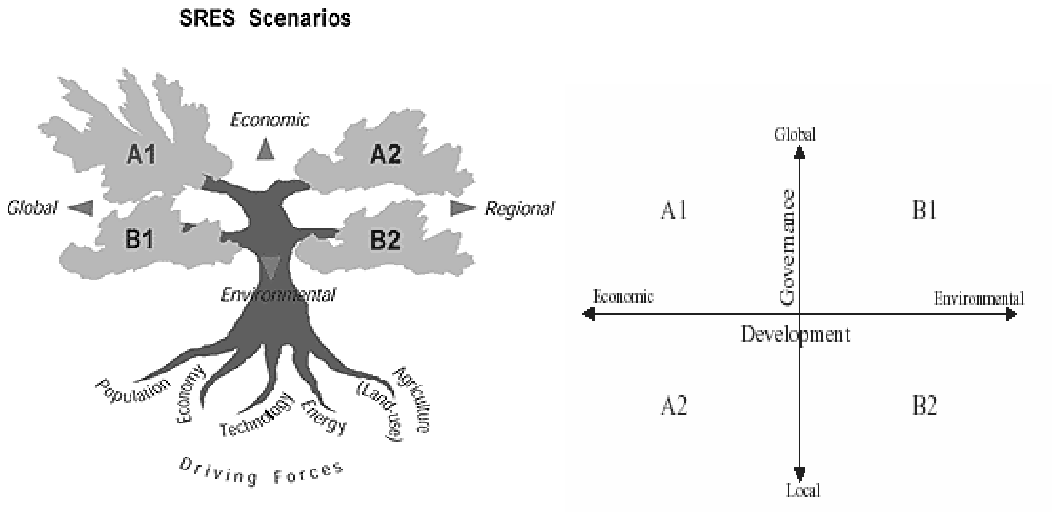

Fig. 1

IPCC Scenarios

Four different narrative storylines: A1, A2, B1, B2. These scenarios describe consistently the relationships between emission driving forces and their evolution and add context for the scenario quantification. It also represents different demographic, social, economic, technological and environmental developments.

A1 storyline: It describes future world of very rapid economic growth, Global population that peaks in mid-century and declines thereafter and rapid introduction of new and more efficient technologies. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system: fossil-intensive (A1FI), no fossil energy sources (A1T), and a balance across all sources (A1B).

A2 storyline: It describes a very heterogeneous world, continuously increasing global population, economic development is primarily regionally oriented. Per capita economic growth and technological change are more fragmented and slower than in other storylines.

B1 storyline: It describes convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy with reductions in material intensity and the introduction of clean & resource-efficient technologies.

B2 storyline: It describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. The world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines

Assessing the impact of climate change on hydrology essentially involves projections of climate variables (e.g. temperature, humidity, mean sea level pressure etc) at global scale, downscaling of global scale climate variables into local scale hydrologic variables and computations of risk of hydrologic extremes in future for water resources planning and management. Projections of climatic variables globally can be performed by General Circulation Models (GCMs)

The spatial scale on which a GCM can operate (e.g. 3.75^{o} longitude x 3.75^{o} latitude for coupled Global climate model CGCM3) is very coarse compared to that of hydrologic process(e.g. precipitation in a region, stream flow in a river basin etc) to be modeled in the climate change impact assessment studies. Downscaling in the context of hydrology is a method to predict the hydrologic variables (e.g. rainfall and stream flow) at a smaller scale based on large scale climatological variables(e.g. mean sea level, pressure) simulated by GCM. Since GCMs are run at coarse resolutions, the output climate variables from these models cannot be used directly for impact assessment on a local scale. Hence in the past two decades, several downscaling methodologies have been developed to transfer information from the GCM simulated climate variables to local scale like SVM, ANN etc.

Downscaling techniques

Downscaling techniques can be broadly classified in to dynamic and statistical downscaling.

(i) *Statistical Downscaling:* Statistical Downscaling produce future scenarios based on statistical relationship between large scale climate variables and local scale climate as well as hydrologic variables. A major assumption in the statistical downscaling is that the statistical relationship will hold good in future for climate change scenarios.

(ii) *Dynamic Downscaling:* Dynamic downscaling approach does not depend on static regression relationship between the observations and GCM outputs but on the relationship among physical processes of the Earth. A major drawback of dynamic downscaling which restricts its use in climate change impact studies is its complicated design and high computational cost.

Statistical downscaling methodologies have several practical advantages over dynamical downscaling approaches. In situations where low–cost, rapid assessments of localized climate change impacts are required, statistical downscaling (currently) represents the more promising option. The software is named SDSM (Statistical Downscaling Model) and is coded in Visual Basic 6.0. SDSM was the first tool of its type freely offered to the broader climate change impacts community. It is the best hybrid of the stochastic weather generator and transfer function methods.

Downscaled models if bias corrected can be used to obtain corrected daily precipitation.These bias corrected daily precipitations simulate runoff for current and future scenario using Soil and Water Assessment Tool (SWAT) model [1]. Many spatial distributed hydrological models (WetSpa) are used to study the effect of climate change on stream flow and soil moisture and these are used then in the hydrological model WetSpa [2]. General Circulation Models (GCM) performance is limited to simulate at finer spatial scale. These GCM predicted values can be corrected to multiple timescales and rainfall can be predicted over different regions. This can be done using Nested Bias correction [3]. Some authors have used SDSM for downscaling the daily precipitation, maximum and minimum temperature data. Using SDSM prediction of climate change can also be done [4].

Statistical Downscaling Model (SDSM)

SDSM predictors may be obtained online for any global land area of data portal maintained by the Canadian Climate Impacts Scenarios Group. The website can be accessed from Data access integration (DAI) website. For downscaling climate scenarios four sets of GCM output are available HadCM2, HadCM3, CGCM2, and CSIRO. Three emission scenarios are available, the greenhouse gas only experiment with CO2 compounded annually by 1% per year (HadCM2 only), the two SRES scenarios A2 and B2 produced by greenhouse gas, sulphate, aerosol, and solar forcing (HadCM3, CSIRO, CGCM2).

Table 1 Large scale atmospheric variables (predictors)

Predictors	Description	Predictors	Description
msl	Mean Sea Level Pressure	p_fas	Surface Airflow Strength
p_uas	Surface Zonal Velocity	p_vas	Surface Meridional Velocity
p_zas	Surface Vorticity	p_thas	Surface Wind Direction
p_zhas	Surface Divergence	p5_f	500hpa Airflow Stength
p5_u	500hpa Zonal Velocity	p5_v	500hpa Meridional Velocity
p5_z	500hPa Vorticity	p500	500hPa Geopotential
p5th	500hPa Wind Direction	p5zh	500hPa Divergence
p8_f	850hPa Airflow Strength	p8_u	850hPa Zonal Velocity
p8_v	850hPa Meridional Velocity	p8_z	850hPa Vorticity
p850	850hPa Geopotential	p8th	850hPa Wind Direction
p8zh	850hPa Divergence	2temp	Mean Temperature at 2m
r850	Specific Humidity[1] at 850hPa	r500	Specific Humidity at 500hPa

SDSM performs seven key functions

1. *Quality control and Data transformation*: Quality control checks the identification of gross data errors and specification of missing data. Transformations to the data files can be applied using data transformation.
2. *Screening of downscaling predictor variables*: selection of predictors determines the character of downscaled climate scenario. Hence SDSM provides screen variables assisting user the appropriate selection of variables.
3. *Model calibration*: It takes user specified predictand along with a set of predictor variables and computes the parameter. Model structure and the process can also be specified. In case for downscaling the precipitation conditional process is selected.
4. *Weather generator* generates ensembles of synthetic daily weather series for observed (NCEP) atmospheric predictor variables.
5. *Scenario generation* produces daily weather series given by atmospheric variables supplied by climate model (CGCM2 or HadCm3).
6. *Data analysis* can be done using summary statistics and frequency analysis screen.
7. *Graphical analysis* for all the downscaled variables can be done using frequency analysis, compare results and time series analysis screens.

Climate Dataset

Godavari River rises near Trimbakeshwar near Nasik, northeast of Mumbai in the state of Maharashtra at an elevation of 1067 m and flows for a length of about 1465 km (910 miles) before out falling into the Bay of Bengal. IMD data for daily precipitation of Godavari, latitude of 19^0N and longitude of 75^0E is used as predictand file.

CGCM3 data set was downloaded from the site which consisted of two scenarios of CGCM3 and observed variables NCEP for latitude of 20^0 N and longitude of 75^0 E. The file in Zip format (BOX_21X_19Y) consisted of CGCM3A2_1961_2000, CGCM3A2_2001_2100, CGCM3A1B_2001_2100, and NCEP_1961_2003.

Downscaling Precipitation

Working out with these data files a year length of 366 days for NCEP and 365 days for CGCM3 should be selected. While downscaling for precipitation conditional process is checked. Screen variables screen assists the user for predictand and predictor relationship. Analyzing we get percentage of variance explained by predictor-predictand pair. Strongest correlating pairs were then used in model calibration with fourth root transformation for predictand and 0.8 bias corrections. The weather generator was used to downscale observed (NCEP) predictors and Scenario generator for GCM (CGCM3). Downscaled scenarios were evaluated using summary statistics.

RESULT AND DISCUSSION

Among all the available predictors five predictors (mean sea level pressure (msl), 500hPa Geopotential ht (p500), surface meridional velocity (p_v), 850hPa Geopotential ht (p850), near surface specific humidity (pshum)) showing strongest correlation and partial correlation were used for downscaling. A monthly model using NCEP from 1961-2000 using the predictors were processed. Model is calibrated from 1961-1980 and validated for 1981-2000. Validation model when compared with observed data for the same periods shows equivalent results for the downscaling GCM predictors.

Scenario generator is implemented using CGCM3 for time period of 1961-2000 and then compared with observed data 1961-2000. The results here are equivalent with a percentage difference of 18% and 20% in the month of June and July respectively.

Table 2 CGCM3 and observed (OBS) mean values for period of 1961-2000

	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CGCM3	0.101	0.061	0.088	0.503	4.154	4.281	4.296	5.991	2.864	1.244	0.310	0.251
OBS	0.073	0.099	0.182	0.216	2.412	5.267	5.433	5.557	5.112	2.057	0.529	0.273

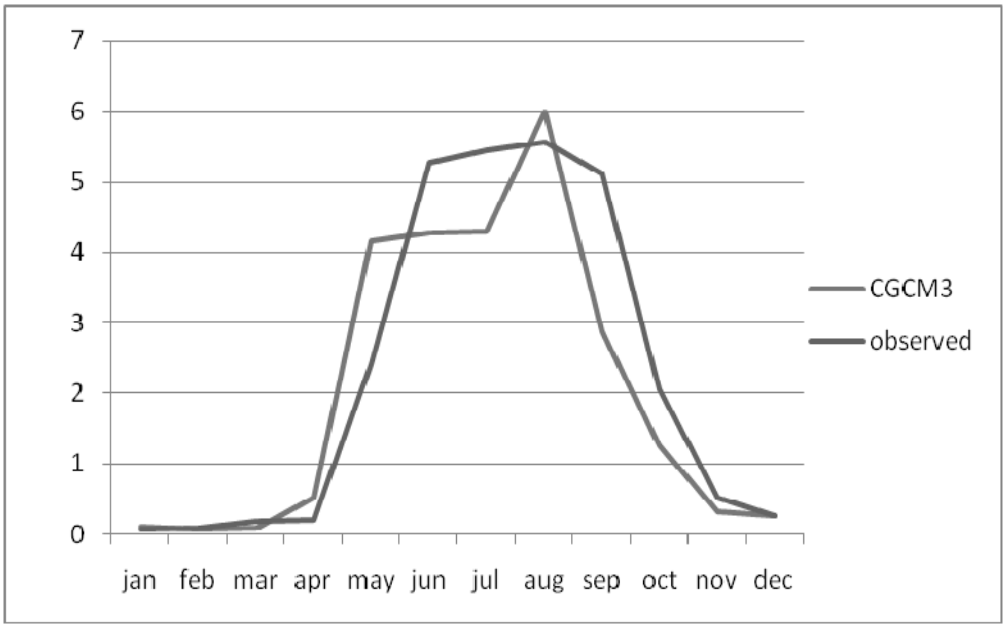

Fig. 2 Chart showing results compared for CGCM3 (1961-2000) and observed (1961-2000)

The scenario generator operation was implemented for a second time using CGCM3 predictors under future (2001-2100) climate forcing. The file was then used to obtain results for three time periods 2011-2040, 2041-2070, 2071-2100. Results show a consistent rise of 1%, 4%and 22% in rainfall in the month of July, June and May respectively.

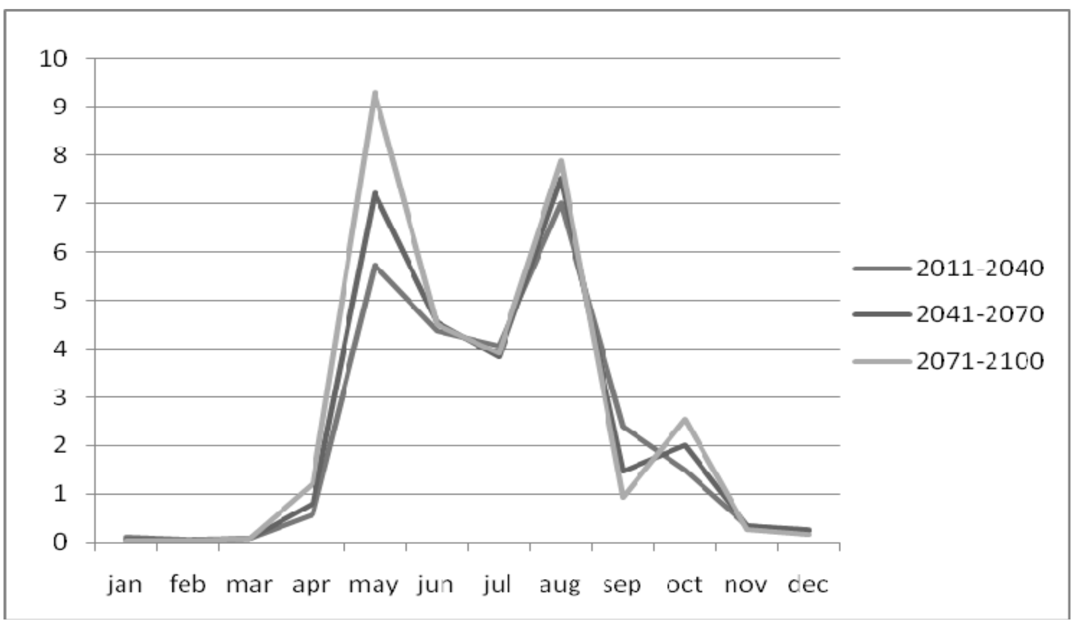

Fig. 3 Downscaled and compared projections for three time periods 2011-2040, 2041-2070, 2071-2100

CONCLUSION

In this paper precipitation data is downscaled and thus compared with the observed data using Statistical Downscaling Model (SDSM). SDSM values differed and in some cases are greater than observed data. Downscaling accuracy depends on the assumption of predictor-predictand relationship.

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Quantification of Morphometric Characterization and Prioritization of Watersheds using Multi Criterion Decision making and GIS Approaches

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ABSTRACT

Planning of watershed at micro-level is indispensable for sustainable development, particularly in the fragile environments, and drought conditions. Morphometric characterization is important to recognize hydrological behavior of the basin for carrying out management strategies. Previous prioritization methods suffer from cavities in which uncertainties were associated with morphometric variables of watershed ecosystem. Keeping this in view, geospatial–statistical techniques were used for identifying critical and priority sub-watersheds in water scarce region of India. Multi-Attribute Theory (MAUT), a Multi criterion Decision Making (MCDM) technique is employed for ranking of each hydrological unit concerning the weightages obtained from morphometric parameters. Considering MAUT approach, sub-watersheds were alienated into very high, high, medium, low and poor priority zones. The results illustrate that 51.66% of sub-watersheds are in the moderately to highly susceptible zones, which shows potential areas for preferential conservation works planning. The MAUT is viable approach and will be useful to different stakeholders such as agriculturists and natural resources managers for better decisions making.

Keywords: *Multi-Attribute Theory, GIS, Morphometric characterization, Watershed prioritization.*

1. INTRODUCTION

Watershed is an important basic planning unit for any hydrologic analyses and designs. Watersheds vary in size from a few hectares in urban areas to several thousand square kilometers for large river basins. Each watershed shows distinct characteristics, in such a way that no two watersheds are identical. Certain physical properties of watersheds significantly affect the characteristics of runoff and are critical for hydrologic analysis. Morphological characteristics like stream order, drainage density, aerial extent, watershed length and width, channel length, channel slope and relief aspects of watershed are important in understanding the hydrological aspects of a region. Runoff response of the watershed is different for various slopes, shapes, lengths, widths and areas of watershed. Response is also affected by the factors like drainage density, length of overland flow, stream frequency, relative relief and relief ratios.

A detailed analysis of the drainage network in a watershed can provide valuable information about watershed behaviour which will be useful for further hydrological analysis. The order, pattern, and drainage density have a profound influence on watershed as to influence runoff, infiltration, land management etc. They also influence the flow characteristics and thus erosional behaviour (Murthy, 2000). The Geographic Information System (GIS) has unique features to relate to the linear, areal and relief features in terms of the topology as well as connectivity (Kar, 2008). In recent times many studies are being directed to the mapping of hydro-geomorophological characteristics using GIS and Remote Sensing techniques (Epstein et al., 2002). Walsh (1998) applied remote sensing and GIS techniques for geomorphic analysis of watershed. Vittala et al. (2004) conducted study for morphometric analysis of sub-watersheds in the Pavagada area of Tumkar district in South India, using remote sensing and GIS techniques. Akar (2009) conducted studies related to drainage network morphometry, in which topographical maps, Landsat Images and Reflection Radiometer images of satellite and terrain observation were integrated for hydrological analysis of the Kastro Gulf River. In the present study watershed boundary delineation, drainage network digitization and contour map are prepared in GIS environment and utilized for computation of the morphological characteristics of the watershed using Arc GIS 9.2.

2. STUDY REGION

To demonstrate the applicability of Multi-Attribute Theory (MAUT), technique, a watershed located at of middle Godavari (G-5) sub-basin in semi-arid tropics of India is selected. The study region between latitudes $17^{0}04^{'}$ - $18^{0}30^{'}$ North and longitudes $77^{0}43^{'}$ - $79^{0}53^{'}$ East. The G-5 sub-basin has a catchment area of 35723 km^2, which constitutes 11.38% of the total Godavari river basin area and entirely lies in the State of Andhra Pradesh. The climate in the study area is semi-arid with an average annual rainfall of 715 mm. It is observed that the monthly minimum and maximum average temperature recorded in summer ranges from 26^{0}C-42.5^{0}C and the monthly average temperature recorded in winter as 16^{0}C-29^{0}C. Daily mean relative humidity ranges from 10 to 100%. The highest wind speed 136 km/hr.

3. METHODOLOGY

3.1 Morphometric Characterization

A common task in hydrology is to delineate a watershed from a topographic map.The collected topographic sheets were scanned, geo-referenced and rectified using Arc Map of Arc GIS 9.3 software. The following local information was used as an input data in the geo-referencing of the toposheet. Projection: WGS 84, Zone : 44 (78^{o} E to 84^{o} E),Rows : R (16^{o} N to 32^{o} N), Datum: Spheroid Everest, Re sampling method: Nearest. The ten individual rectified maps were clipped using ERDAS 9.2 software to extract spatial features of the map and to remove the miscellaneous information on topographic map such as legend, scale etc. Further all the clipped topographic maps were mosiaced using ERDAS 9.2 to extract the spatial layer of study area and the rectified maps were projected and merged together as a single layer. The present study region of G-5 sub basin of Godavari River Basin was delineated in GIS environment . Stream network of the study area is digitized from SOI toposheets of 1:50000 scale, which are geocoded in ERDAS IMAGINE software. One of the first attributes to be quantified is the hierarchy of stream segments according to an ordering classification system based on ranking of streams proposed by Strahler (1964). In this system, channel segments are ordered numerically from a stream's headwaters to a point somewhere down stream. Numerical ordering begins with the tributaries at the stream's headwaters being assigned the value 1. A stream segment that resulted from the joining of two first order segments was given an order of 2. Two second order streams formed a 3rd order stream, and so on. The trunk stream through which all discharge of water passes is therefore the stream segment of the highest order. Fig. 2 shows the drainage network map of the study region. The number of stream segments present in each order along with their lengths is recorded in the topology built by GIS. Formulae used for the computation of the morphometric parameters are listed in Table1.

Table 1 Formulae used for the computation of the morphometric parameters

Morphometric Parameter	Formula/Relationship
Mean Stream length (L_{sm})	$L_{sm} = \frac{\sum_{i=1}^{N_u} L_i}{N_u}$
Stream length ratio (R_{Lu})	$R_{Lu} = \frac{L_u}{L_{u-1}}$
Bifurcation ratio (R_b)	$R_b = \frac{N_u}{N_{u+1}}$
Relief ratio (R_h)	$R_h = \frac{H}{L_b}$
Drainage density (D)	$D = \frac{\sum_{i=1}^{w} \sum_{j=1}^{N_i} L_{ij}}{A}$

Table 1 *Contd…*

Morphometric Parameter	Formula/Relationship
Stream frequency (F_s)	$F_s = \frac{N_u}{A}$
Drainage Texture (R_t)	$R_t = \frac{N_u}{P}$,
Form factor (R_f)	$R_f = \frac{A}{L_b{}^2}$
Circularity ratio (R_c)	$R_C = \frac{4*\Pi*A}{P^2}$
Elongation ratio (R_e)	$R_e = \frac{2\sqrt{\left(\frac{A}{\pi}\right)}}{L_b}$
Length of overland flow (L_g)	$L_g = \frac{1}{2D}$
Relative relief (R_p)	$R_p = \frac{H}{P}$
Ruggedness number (R_n)	$R_n = H \times D$

where, L_u is total stream length of order'u', N_u is Total number of stream segments of order u, H is the total relative relief of the basin, L_b is basin length. a is the total area of the basin, P is the perimeter of the basin and D is the drainage density.

3.2 Multi-attribute utility theory (MAUT)

The focus of this paper is to examine prioritization of sub-watersheds and incorporate significance of morphometric parameter value judgments in choosing critical sub-watersheds for conservation and planning using MAUT. MAUT is based upon expected utility theory (Savage, 1954; Fishburn, 1970). Expected utility theory states that if an appropriate utility is assigned to each possible consequence and the expected utility of each alternative is calculated, then the best course of action is the alternative with the highest expected utility. The expected utility of an event is calculated as the sum of utilities of the payoffs weighted by their probabilities. Keeney (1971) provided a theoretical framework and a set of assumptions, namely preferential and utility independence, which decompose the multi-attribute utility function into a more practical form for elicitation. Preferential independence implies that the order of a given attribute does not depend on the levels of the other attributes. It concerns preferences for consequences rather than lotteries. Utility independence (risk independence) implies that the risk attitude of a parameter for a given attribute does not depend on the levels of the other attributes.

The aim of MAUT is to connect the morphometric parameter value of alternative management options that represents the stakeholders' (watershed planner) preference, taking into account all the criteria. The simplest and most used aggregation method in MAUT is the additive model (Belton and Steward, 2002 and Hostmann et al., 2005):

$$V_\alpha = \sum w_i \times V_i \times (a_i)$$

where: $V(\alpha)$: the total value of the alternative α; $v_i(\alpha_i)$: the simple attribute value function reflecting alternative α's performance on attribute i; and w_i: the importance weight for each criterion assigned by the watershed planner.

One of the advantages of MAUT method is that it provides a structured approach to address the problem using both quantitative and qualitative data. The clarification of alternatives, objectives and attributes helps the user to understand the watershed problem and participate in its solution. Another advantage is that MAUT helps to conclude in accepted solutions and policy recommendations as the value function considers the user's preference. Sensitivity analysis is also applicable to test the robustness of the results. The performance assessment of each alternative strategy in the achievement of the prioritization of sub-watersheds goal is based on both the aggregation of the value of each criterion under each alternative scenario and its average weight

4. RESULTS AND DISCUSSION

4.1 Prioritization of Sub-watersheds

The crucial watershed morphometric parameters such as, drainage density (D), bifurcation ratio (R_b), stream frequency (F_s), form factor (R_f), elongation ratio (R_e), circulatory ratio (R_c), compactness ratio (C_c) texture ratio (T) and Basin length (B_s) have been computed in GIS environment taking the inputs from personal geo-database of respective watersheds and are calculated as per the methodology presented in sub section 3. The values are displayed in Table 2

Table 2 Morphometric characteristics with respect to micro-watersheds

Sl.No	Micro watershed code	Bifurcation ratio	Compactness ratio	Circulatory ratio	Drainage density	Elongation ratio	Form Factor	Stream Frequency	Texture ratio	Basin length
1	4E3C4a	5.352	2.201	0.206	2.829	0.569	0.254	4.604	12.382	41.65
2	4E3C4b	6.405	1.435	0.485	2.883	0.607	0.290	5.164	13.112	24.00
3	4E3C4c	4.730	1.739	0.330	3.424	0.604	0.287	7.255	15.819	25.11
4	4E3C4d	4.470	1.248	0.642	3.510	0.654	0.336	6.036	10.195	12.88
5	4E3C4e	5.993	2.047	0.238	2.974	0.635	0.317	4.215	5.390	16.48
6	4E3C4f	10.772	1.549	0.417	3.063	0.670	0.352	5.593	6.433	10.64
7	4E3C4g	6.525	1.576	0.402	3.073	0.687	0.371	5.468	5.092	8.54
8	4E3C4h	6.558	1.319	0.575	3.406	0.668	0.351	6.086	8.327	10.80
9	4E3C4i	6.049	1.887	0.281	2.105	0.629	0.310	3.627	5.433	17.98
10	4E3C4j	6.667	1.277	0.613	2.435	0.678	0.361	3.693	4.707	9.60
11	4E3C4k	8.073	1.322	0.572	3.144	0.602	0.284	5.098	15.059	25.96
12	4E3C5a	11.952	2.460	0.165	2.821	0.564	0.250	5.251	13.385	44.46
13	4E3C5b	4.338	1.511	0.438	2.454	0.624	0.305	3.703	7.352	19.24
14	4E3C5c	4.835	1.801	0.308	2.979	0.612	0.294	4.604	8.778	22.43
15	4E3C5d	5.365	1.771	0.319	3.257	0.676	0.359	5.006	4.673	9.78
16	4E3C5e	2.000	1.283	0.607	3.049	0.601	0.284	5.055	15.534	26.24
17	4E3C5f	4.285	1.463	0.467	2.943	0.639	0.320	4.724	8.149	15.81
18	4E3C5g	4.191	1.418	0.497	2.646	0.595	0.278	4.909	14.749	28.65

Ranks have been assigned to each parameter based on their significance to a specific purpose and the rank values of all parameters have been cumulated as per MAUT methodology given section 3 . Priorities are arrived based on based upon expected utility theory. The linear parameters have a direct relationship, where as shape parameters have inverse relationship and sediment yield has direct relationship with erodability (Nookaratnam, 2005). After the ranking has been done based on every single parameter, the ranking values for all the parameters of each micro-watershed were used to arrive at expected utility value. Based on expected utility e of these parameters, the micro-watersheds having the least rating value was assigned highest priority, next higher value was assigned second priority and so on as shown in the Table 3. The Table 3 demonstrates the prirority ranking of micro-watersheds for conservation measures. It is found that 4E3C4d and 4E3C4h micro-watersheds should be given top priority and 4E3C4a should be given low priority for conservation measures.

Table 3 Prioritization of micro-watersheds based on morphometric parameters using MAUT

Micro watershed code	Bifurcation Ratio	Compactness Ratio	Circularity ratio	Drainage Density	Elongation Ratio	Farm Factor	Stream Frequency	Texture Ratio	SYI	Priority based on MAUT
4E3C4a	11	2	17	13	17	17	13	7	15	16
4E3C4b	7	12	7	12	12	12	7	6	17	10
4E3C4c	13	7	12	2	13	13	1	1	3	2
4E3C4d	14	18	1	1	6	6	3	8	2	1
4E3C4e	9	3	16	10	8	8	15	15	6	9
4E3C4f	2	9	10	7	4	4	4	13	16	4
4E3C4g	6	8	11	6	1	1	5	16	13	3
4E3C4h	5	15	4	3	5	5	2	10	10	1
4E3C4i	8	4	15	18	9	9	18	14	1	12
4E3C4j	4	17	2	17	2	2	17	17	11	8
4E3C4k	3	14	5	5	14	14	8	3	18	6
4E3C5a	1	1	18	14	18	18	6	5	7	7
4E3C5b	15	10	9	16	10	10	16	12	4	14
4E3C5c	12	5	14	9	11	11	14	9	12	13
4E3C5d	10	6	13	4	3	3	10	18	5	5
4E3C5e	18	16	3	8	15	15	9	2	8	11
4E3C5f	16	11	8	11	7	7	12	11	14	13
4E3C5g	17	13	6	15	16	16	11	4	9	15

5. CONCLUSION

In this paper, efforts were made to demonstrate the imperative role of remote sensing, GIS and Multi Criteria decsion approaches in morphometric characterization as well as assigning priorities to all the sub-watersheds of the study area. Morphological characterization carried out through the measurement of linear, areal, and relief aspects illustrated their correspondence with hydrologic behavior of the watershed and considered as an accomplished contrivance for prioritization of hydrological units. In the study, a MCDA approach, Multi-attribute utility theory (MAUT) technique has been formulated and demonstrated successfully in prioritization of Sub-Watersheds.

The results show that 4E3C4d and 4E3C4h micro-watersheds should be given top priority and 4E3C4a should be given low priority for conservation measures.. Priority wise classification map will be useful in classification of conceivable zones for management over the prevailing hydro-geomorphologic conditions. Prioritized classification conferred in the highly susceptible zones, which indicates potential areas considered for preferential provision of soil and water conservation works for the efficient watershed management planning. Thus, identification of prospective zones for planning and management of conservation measures at micro-level to conserve available natural resources leads towards sustainable development and establishment of control measures over the entire watershed at similar instance. Coupling of geospatial tools with MCDA method resulted in demonstration of MAUT as one of the viable and significant technique, particularly over the data hungry prioritization approaches.

The application of MAUT technique in sub-watershed prioritization, or judicious planning and management of conservation measures at micro-level to conserve available natural resources, will be helpful to various stakeholders such as water resources managers, conservation measures planners and decision policy makers for better decisions making, particularly, in the data scarce areas. A MAUT method offers dynamic, effective and sustainable approach over traditional prioritization methods in which significance of several characterization parameters were considered equally and in a complex way. Furthermore, the technique can be improved through adopting the correlation matrix in other classification techniques such as analytical hierarchy process, fuzzification, and clustering for conservation planning of critical zones

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Shoreline Change Rate Prediction using Statistical Methods – WLR and EPR

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ABSTRACT

A Shoreline is idealistically defined as the interface of land and water. Shoreline change is considered as one of the most dynamic processes in the coastal areas. The shoreline rate is calculated by End Point Rate (EPR) for short term and Weighted Linear Regression (WLR) for long term period. Several sources of error impact the accuracy of historical shoreline position. It is necessary to accurately estimate the errors and uncertainties associated with each shoreline. To calculate Weighted Linear Regression Rate (WLR) it is necessary to estimate the errors of each shoreline separately. Here five errors are considered such as Rectification Error, Pixel Error, Seasonal Error, Tidal Error and Digitizing Error. The present paper attempts to describe in detail about the Statistical Methods used for predicting the Shoreline Change Rate. Coastal erosion studies by this group and others employ historical shoreline positions that are digitized from aerial photographs and survey charts (t-sheets) (Fletcher et al., 2003; National Academy of Sciences, 1990). Historical shorelines may be derived from several shoreline change reference features (SCRF's), such as, the vegetation line, high water line, or low water line. We utilize the low water line (indicated by the beach toe or base of the foreshore) as the SCRF for all photo and t-sheet years. The historical shorelines are displayed together on a map for comparison and their relative distances are measured along shore-perpendicular transects spaced 20 m apart. It is one of the most indented coasts with numerous river mouths, lagoons, bays, creeks, cliffs, spit, sand dunes and long braches. Sea erosion, migration of river mouths, siltation of ports and harbors are the prominent problems along the coast. However, the information does not have any systematic historical records to understand the nature of shoreline change. The main purpose of the work is to provide a systematic historical information on shoreline change along Karnataka coast using multi resolution satellite data (Landsat (MSS, TM & ETM+) and Geographic Information System (GIS) for past 33 years period i.e. from 1973 to 2006. The six historical shorelines (1973, 1989, 1992, 2000, 2005 and 2006) were used in Arc GIS for computing the shoreline change rate along the coast. Two statistical methods i.e., Weighted Linear Regression (WLR) and End Point Rate (EPR) were employed in analyzing the shoreline changes. The entire coast was splitted in to 5600 transects at 50 m spacing to depict the changes at finer scale. The analysis revealed that about 70% of the coastline was either stable or accreting in nature, whereas remaining 30% region was experiencing varying magnitude of erosion. The change rate was classified in three categories indicating the accretion, low erosion and high erosion locations. The erosion and accretion pattern observed along the coast is influenced mainly by the coastal process and river line inputs. Whereas, the same area shows erosion pattern during the period of 2000-2006. This may be due to variation in coastal processes, land runoff and geomorphologic units influencing the coast. About 168 km of coastline was found to be accreting in nature with an average rate of 1.5 m/yr followed by 71 km coastal stretch with mild erosion of an average rate of 1.0 m/yr. It was also observed that the erosion was found in isolated pockets throughout the coast. The variation in river mouth morphology was quite significant. The present study demonstrates that combined use of satellite imagery and statistical method such as weighted linear regression can be a reliable method for shoreline change analysis.

INTRODUCTION

A shoreline is idealistically defined as the interface of land and water. Shoreline change is considered as one of the most dynamic processes in the coastal area. The evolution of coastal systems is controlled by various factors viz., morphology and geology of the catchment, the size of the catchment area, nature of sedimentation basin, climate leading to rainfall and river discharge at coastal zone, freshwater input and coastal hydrodynamics - waves, tides and currents.

Wind, waves and currents are natural driving forces that easily moves the unconsolidated sand and soils in the coastal area, resulting in rapid changes in the position of the shoreline. The coastal systems have also been affected by several developmental activities such as ports, industries, aquaculture farming and other human intervention in the form of coastal defenses. Thus, it is not possible to ascertain the complex morpho-dynamic pattern of any coast by hydrodynamic modeling alone.

The main purpose of the work is to provide a systematic historical information on shoreline change along the Karnataka coast using multi-resolution satellite data (Landsat (MSS, TM & ETM+) and Geographic Information System (GIS). Digital Shoreline Analysis System (DSAS) version 4.2 (Thieler. et al., 2009), an extension of ESRI ArcGIS software was used to calculate shoreline rate of change statistics from a time series of multiple shoreline positions. Both long term period and short term period shorelines were analyzed. For long term shoreline analyses, LRR and WLR were selected as they are most statistically robust quantitative methods when a limited number of shorelines are available (Crowell et al., 1991). In the present study, WLR statistical method is used for long term change analysis because it takes uncertainty field into account to calculate the long-term rates of shoreline change. For short term, EPR method is adopted.

STUDY AREA

The coast has one major and ten minor ports in their coastal belt. It is one of the most indented coasts with numerous river mouths, lagoons, bays, creeks, cliffs, spits sand dunes and long beaches. Sea erosion, migration of river mouths, siltation of ports and harbors are the prominent problems along this coast.

MATERIALS AND METHODS

ST Method

Shoreline change rates are calculated from the time series of historical shoreline positions using a variety of statistical methods. Our group and other coastal research groups (e.g., Theiler, et al., 2005) have utilized the single-transect (ST) method to calculate shoreline change rates. ST calculates a shoreline change rate and uncertainty at each shoreline transect. ST uses various methods (e.g., End Point Rate, Average of Rates, Least Squares) to fit a trend line to the time series of historical shoreline positions. We employ weighted least squares (WLS), which accounts for the uncertainty in each shoreline position when calculating a trend line (see: Fletcher et al., 2003; Genz et al., 2007). Shoreline positions with higher uncertainty will have less of an influence on the trend line than data points with smaller uncertainty. The slope of the line is the shoreline change rate.

Remote sensing satellites images have been used effectively for coastal shoreline change monitoring along the coast. Interpretation of shoreline position is a difficult task due to the fact that coastal environment are dynamic in nature and many other distortions associated with the images are to be rectified.

End Point Rate

The EPR method uses only two data points to delineate a change rate the earliest and most recent shoreline positions. Given that only the end data points are used, the information contained in the order data points is entirely omitted, preventing the observation of variations in rate through time. The main disadvantage of this method is that if one or both end points are erroneous, the calculated erosion rate will be inaccurate. (CROWELL, DOUGLAS, and LEATHERMAN, 1997; CROWELL, HONEYCUTT, and HATHEWAY, 1999; DOLAN, FENSTER, and HOLME, 1991).

Weighted Linear Regression

One of the common assumptions underlying most process modeling methods, including linear and nonlinear linear regression is that each data point provides equally precise information about the deterministic part of the total process variation. In other words, the standard deviation of the error term is constant over all values of the predictor or explanatory variables. This assumption, however, clearly does not hold, even approximately, in every modeling application. For example, in the semiconductor photo mask line spacing data shown below, it appears that the precision of the line spacing measurements decreases as the line spacing increases. In situations like this, when it may not be reasonable to assume that every observation should be treated equally, weighted linear regression can often be used to maximize the efficiency of parameter estimation. This is done by attempting to give each data point its proper amount of influence over the parameter estimates. A procedure that treats all of the data equally would give less precisely measured points more influence than they should have and would give highly precise points too little influence.

Advantages of Weighted Linear Regression

Like all of the linear regression methods discussed so far, weighted linear regression is an efficient method that makes good use of small data sets. It also shares the ability to provide different types of easily interpretable statistical intervals for estimation, prediction, calibration and optimization. In addition, as discussed above, the main advantage that weighted linear regression enjoys over other methods is the ability to handle regression situations in which the data points are of varying quality.

Disadvantages of Weighted Linear Regression

The biggest disadvantage of weighted least squares, which many people are not aware of, is probably the fact that the theory behind this method is based on the assumption that the weights are known exactly. This is almost never the case in real applications, of course, so estimated weights must be used instead. The effect of using estimated weights is difficult to assess, but experience indicates that small variations in the the weights due to estimation do not often affect a regression analysis or its interpretation. However, when the weights are estimated from small numbers of replicated observations, the results of an analysis can be very badly and unpredictably affected. This is especially likely to be the case when the weights for extreme values of the predictor or explanatory variables are estimated using only a few observations. It is important to remain aware of this potential problem, and to only use weighted linear regression when the weights can be estimated precisely relative to one another [Carroll and Ruppert (1988), Ryan (1997)].

WLS assumes hetero scedastic uncertainties. This means that the variance associated with each Y component (shoreline position) is not necessarily the same a teach X component (time) (e.g., KLEINBAUM et al., 1998). If the variances are the same, WLS reduces to OLS (GRAYBILL and IYER, 1994). In many studies it may be difficult to quantify the uncertainties for WLS; however, if the variance (_2) or standard deviation (_) for each Y component is known, the weight (w) is equal to 1/_2. In matrix form, solving for b, a column vector with unknown parameters of intercept and slope, results in which Y is a column vector containing shoreline positions, X is a matrix composed of a column of ones and a column of time data, and XT is the transpose of the matrix X, (e.g., DRAPER and SMITH, 1998). The weight matrix, W is

Where wi _ 1/_ and n is the total number of data points (e.g., 2i GRAYBILL and IYER, 1994).

Data points with large variance will have less of an influence on the trend line than data points with smaller variance (GRAYBILL and IYER, 1994). For example, early shoreline data have larger uncertainties associated with them than recent shorelines. WLS will put more weight on the recent data. The resulting trend line incorporates the uncertainty at each position as well as the uncertainty of the model.

CONCLUSIONS

The main purpose of the study was to investigate the application of Remote Sensing data to understand the behaviour of shoreline change along the coast. The study observes both erosion and accretion in isolated pockets all along the coast. The analysis revealed that about 70% of the coastlines were under stable or accretion, whereas remaining 30% region was experiencing varying magnitude of erosion. High rate of erosion was observed all along the river mouth of northern side of Sharavati Rivers. While the Southern side of the Kalinadi River is noticed with high accretion. The erosion and accretion pattern observed along the coast is influenced mainly by coastal process and river line inputs. The variation in river mouth morphology was quite significant. Hence the study reveals that shoreline change is mainly due to variation in coastal process, land runoff and geomorphologic units influencing the coast.

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Estimation of Confined Aquifer Parameters from Residual Drawdowns – A Genetic Algorithm Approach

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ABSTRACT

Reliable and accurate estimation of aquifer parameters is vital for groundwater modelers and managers of a region in effectively managing the resources. Estimating aquifer storage and hydraulic parameters from recovery drawdowns is proved to be less erroneous. This research aims at estimating confined aquifer parameters using heuristic Genetic Algorithm (GA) approach. A generalized MATLAB code to estimate aquifer storage coefficient (S) and transmissivity (T) considering recovery drawdowns alone was presented in this study. A total of 10 chromosomes each with 16-bit length were considered in the initial gene pool. Fitness of each chromosome was evaluated using roulette wheel diagram. Model sensitivity to cross over method, mutation rate, and cross over probability was evaluated. The optimal model parameters were selected considering the propagation of error between successive iterations. Applicability of the developed code was tested on the synthetic dataset developed by Singh (2006). A total of two datasets, one with small errors, and one with large errors were considered for the analysis, and the results were compared with previous research. Statistical analysis on the estimated parameters concludes that, GA is effective in estimating aquifer parameters over conventional least-squares optimization methods.

Keywords: Aquifer parameters, Optimization, Genetic Algorithm, Residual Drawdown.

NOTATIONS

i	index for counting residual drawdowns [-]
N	number of observed residual drawdowns [-]
p	number of estimated parameters [-]
Q	constant pumping rate [L3 T-1]
r	distance to observation well from pumping well [L]
S	storage coefficient of aquifer during pumping phase [-]
Sp	drawdown after time t (t > tp) due to a hypothetical continuous pumping at constant rate [L]
sr	drawdown after time t due to a hypothetical continuous injection at constant rate [L]
T	transmissivity of aquifer [L2 T-1]
t	time measured since commencement of pumping [T]
t'	time measured since pump shut-off [T]
tp	duration of pumping [T]
u	argument of well function during pumping [-]
u'	argument of well function during recovery [-]
ui	argument of well function during pumping for i^{th} residual drawdown [-]
ui'	argument of well function during recovery for i^{th} residual drawdown [-]

Units

L	m
T	s

1.0 INTRODUCTION

A prior knowledge of aquifer parameters is essential for accurate and reliable modeling results, and thereby ensuring proper management of vital groundwater resources. Pumping tests are the most widely used technique for estimating different hydraulic parameters of the aquifers. Conventionally the graphical approach is adopted to analyze the steady or unsteady drawdown pumping test data by using several nonlinear analytical models. These analytical models depend on the type of the aquifer and the hydraulic conditions. It must be noted that when the graphical approach matching with observed data is poor, the estimated aquifer parameters are not reliable. Calculated drawdown data based on optimal aquifer parameters must simulate the observed data as close as possible. Consequently, a nonlinear optimization technique must be adopted, instead of the graphical method, to minimize the differences between calculated and observed drawdown data.

With the advent of soft computing tools simulation-optimization techniques which can optimize aquifer parameters have become an area of active research. In this study, Genetic Algorithms (GA) is used to estimate aquifer storage coefficient (S) and transmissivity (T) considering recovery drawdowns alone. GA is a global optimization algorithm derived from evolution and natural selection. Although GA cannot always provide optimal solution, it has its own advantages and is a powerful tool for solving complex problems

The basic thought of Genetic algorithm:

1. Randomly producing a original population whose number of individuals is a constant (N).
2. Producing next generation by crossing over and mutation among individuals.
3. Forming the new population of N individuals
4. Producing the next population by repeating the step 2) and 3) until obtaining the individual that satisfies the objective function.

2. METHODOLOGY

Synthetically generated pumping test data with $T = 8.33 \times 10^{-3}$, $S = 5.5 \times 10^{-4}$, $Q = 0.025$, $r = 150$ and $tp = 12000$ was used to illustrate the application of the proposed method obtained from Singh(2006). Random errors were introduced in proportion to the drawdown to the synthetically generated data (Singh 2006). The main purpose of the present research is to find a more adequate and representable magnitudes for the unknown aquifer parameters. In case of pumping test the logical objective function is to minimize the differences between the observed field drawdown and the corresponding calculated ones from using the analytical models. In the present work, the objective function was selected to minimize the summation of the square differences between observed and calculated drawdown in piezometric heads. The adopted objective function can be represented as follows:

$$\text{Min Obj} = 0.5 * \sum_{i=1}^{N} (S_{sim} - S_{obs})^{\wedge 2}$$

where Obj. represents the objective function (L^2), N is the total number of observed data (dimensionless), **i** is the rank of the observed data (1 to N), sobs is the observed filed drawdown data in piezometric head due pumping (L), ssim is the simulated drawdown by using a pre-specified computational model (L). The simulated drawdown ssim is a function of the unknown aquifer parameters (decision variables). Consequently the objective function implicitly depends on the aquifer parameters.

Unknown aquifer parameters must be restricted in a bounded region within upper and lower limits. The lower and upper limits are appropriately specified in the proposed model. Lower and upper magnitudes of these parameters can be estimated reasonably by taking into consideration, the probability of all aquifer materials from soft clay to coarse gravel. The following analytical model(Jacob) was used to calculate the simulated drawdown.

$$s(r,t) = sp(r,t') + sr(r,t)$$

$$sp(r,t) = (Qw / 4\pi T)*W(u)$$

$$sr(r,t) = -(Qw / 4\pi T)*W(u')$$

$$u = (r^{2*}S)/(4Tt)$$

$$u' = (r^{2*}S)/(4Tt')$$

$$W(u) = -0.5772 - \text{Ln } u$$

$$W(u') = -0.5772 - \text{Ln } u'$$

Where s(r, t) is the total residual drawdown in piezometric head at a radial distance ‘r’ and time ‘t’. sp(r,t’) is piezometric head at radial distance ‘r’ and time ‘t’’ due to pumping. sr(r,t) is piezometric head at radial distance ‘r’ and time ‘t’ due to recovery. T and S are the unknown parameters of the model, Qw is the constant well discharge, W(u) and W(u’) are the well functions during pumping and recovery phase respectively.

Genetic Algorithm

Genetic Algorithm is a search technique developed by Holland and Goldberg that uses the mechanism of natural selection to search through the decision space for optimal solution. The following are the main steps adopted in this research to formulate the present problem.

MATLAB programming for genetic algorithm

Generation of initial population: The Genetic Algorithm randomly generates an initial population of chromosomes, which consist from number of genes equal to number of unknown aquifer parameters The generation process starts with creating a uniform random number for every gene between 0 and 1. By setting the lower and upper limit of a variable the decision variable can be calculated by linear interpolation. The real value coding is an efficient code in representing continuous decision variables like the unknown aquifer parameters. Any value between upper and lower limits of the decision variable has a uniform chance to be created.

Computation of the objective function: For every string in the initial population consequent magnitudes of drawdown in piezometric heads must be calculated for the suggested aquifer parameters.

Computation of fitness: The fitness of each string must be taken as a function of the objective function.

Encoding: In Genetic Algorithm, coding is representing the individual by the binary strings of 0s and 1s. It randomly produces an encoded original population. Pop in the function encoding is a matrix whose every row indicates an encoded individual and the total number of rows is denoted by popsize. Dimension is the number of dimension of an individual, stringlength is the number of bits of binary string of encode individual.

Selection: The Roulette wheel principle was selected here. The size of the segment is proportional to the probability of selection of the associated chromosome. Fitter chromosomes have larger segments and therefore a greater probability of being selected.

Cross Over: Randomly choosing two individuals from population, and changing the bits of the same section of the two individuals is considered in cross over operation. For every two subsequent neighborhood strings within the mating pool a crossover is permitted only if a generated uniform random number is lower than or equal to a pre-specified ratio of the crossover.

Mutation: Mutation also simulates biologic evolution mechanism. For the individual to mutate, randomly choose the point to mutate which means the bit of the individual encoded binary string, then change 0 to 1 and 1 to 0. ‘pm’ is the probability of mutation and a value of 0.05 is considered in the present analysis. For every individual, a number of probabilities of mutation are randomly given by the program. If the giver number is not greater than 'pm', the individual mutates, otherwise not

Decoding: Decoding changes the encoding binary strings into decimal number, and then computes fitting values for individuals.

Result: Every mathematical optimization method needs a stopping criterion to terminate the solution process. GA creates a subsequent generations of solutions till a pre-specified number of generations is reached. The program must be terminated with a final solution resulting in the fittest solution in last generation. The sequence of operations considered is represented in figure I

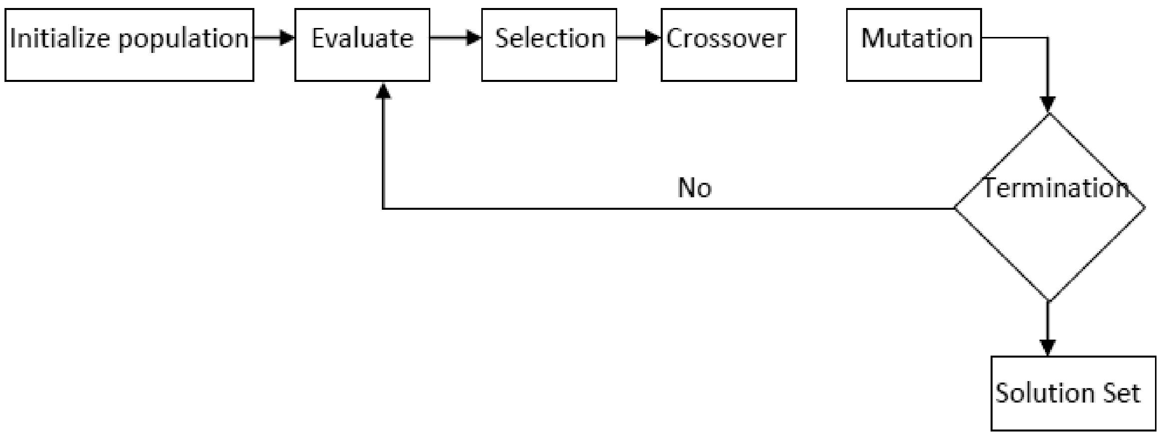

Fig. 1 General Flowchart of GA operations

3. RESULTS AND DISCUSSIONS

Statistical parameters like RMSE, SEE and BIAS are selected to evaluate the performance of the Model. The parameters of the model are estimated as

$$\mathrm{RMSE} = \left\{(1/N) * \sum_{i=1}^{N} (S_{sim} - S_{obs})_i^2\right\}^{0.5}$$

$$\mathrm{BIAS} = \left\{(1/N) * \sum_{i=1}^{N} (S_{sim} - S_{obs})_i\right\}$$

$$\mathrm{SEE} = \left\{1/(N - p) * \sum_{i=1}^{N} (S_{sim} - S_{obs})_i^2\right\}^{0.5}$$

In the present case, p=2 is considered since the present model is used for the optimization of two parameters. The RMSE criterion is used to evaluate the model performance by finding the differences between values predicted by the model and the values observed form the specified data set. The SEE criterion can be used to compare models having a different number of parameters. The BIAS criterion is a measure of the model estimating the true values. A model with positive bias will consistently over-estimate and it is said to be unbiased if BIAS = 0. The data set considered for the evaluation of the above statistical parameters form the proposed model is given in Table I.

Table 1 Residual Drawdown set

t'	t	Residual Drawdown (m) - No Error	Residual Drawdown (m) - small Error	Residual Drawdown (m) - large Error
120060	60	0.7	0.698	0.696
120120	120	0.694	0.688	0.682
120180	180	0.68	0.685	0.689
120240	240	0.664	0.659	0.654
120300	300	0.646	0.647	0.647
120360	360	0.628	0.61	0.591
120420	420	0.611	0.614	0.617
120540	540	0.58	0.592	0.603
120600	600	0.566	0.571	0.576
120900	900	0.505	0.503	0.501
121200	1200	0.458	0.446	0.434
121500	1500	0.42	0.415	0.409
121800	1800	0.388	0.389	0.39
122400	2400	0.338	0.337	0.336
123000	3000	0.3	0.302	0.305
123600	3600	0.269	0.269	0.269
124800	4800	0.222	0.226	0.23
126000	6000	0.188	0.185	0.182
127200	7200	0.161	0.161	0.161
128400	8400	0.14	0.139	0.139
129600	9600	0.122	0.121	0.12
130800	10800	0.107	0.108	0.109
132000	12000	0.095	0.095	0.095

Data set considered for the proposed method is taken from the synthetically generated data (Singh 2006) with Q = 0.025, r = 150 and tp = 12000. Using the proposed method the optimized parameters along with their corresponding statistical parameters based on which the performance of the model is given below.

Data Type	$T * 10^3$	$S * 10^4$	RMSE	SEE	BIAS
Data with small errors	9.1	4.0	0.4191	0.1924	0.0874
Data with large errors	9.12	4.2	0.4207	0.1939	0.0877

The observed drawdown data was plotted against the simulated drawdown for both the cases (i.e., for data with small errors and the data with large errors) and is represented in figures II and III. Further the propagation of error along with the observed drawdown values is plotted and is represented in figures IV and V

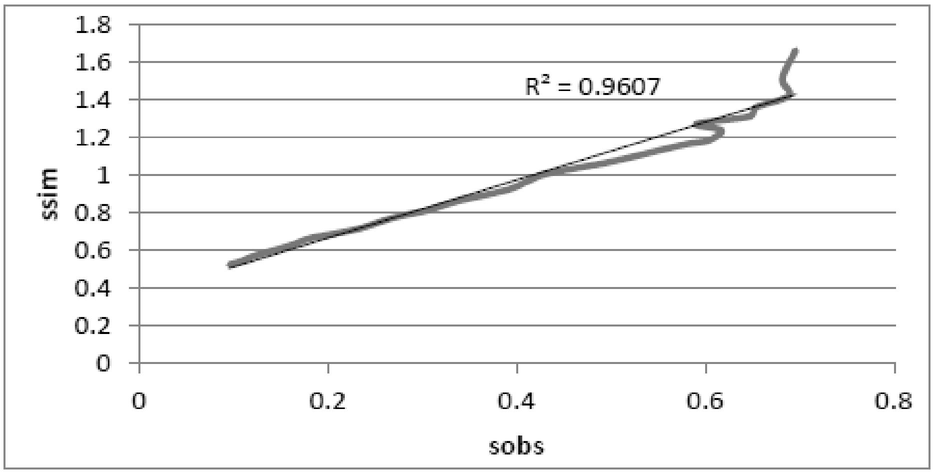

Fig. 2 Comparision of simulated and observed drawdowns (Dataset with large errors)

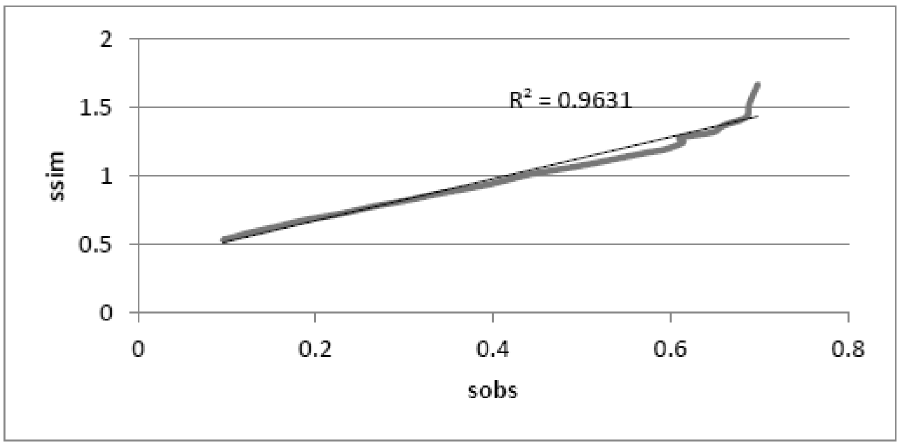

Fig. 3 Comparison of simulated and observed drawdowns (Data set with small errors)

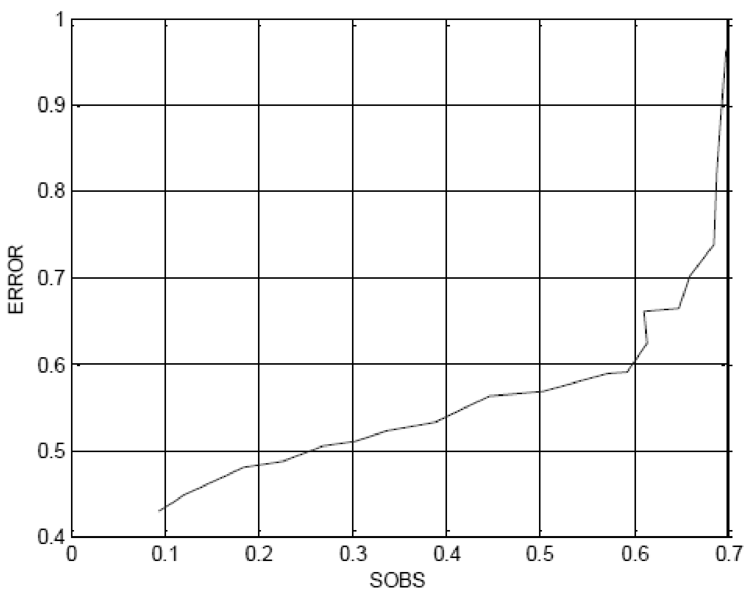

Fig. 4 Error propagation in simulated residual drawdown (Dataset with small errors)

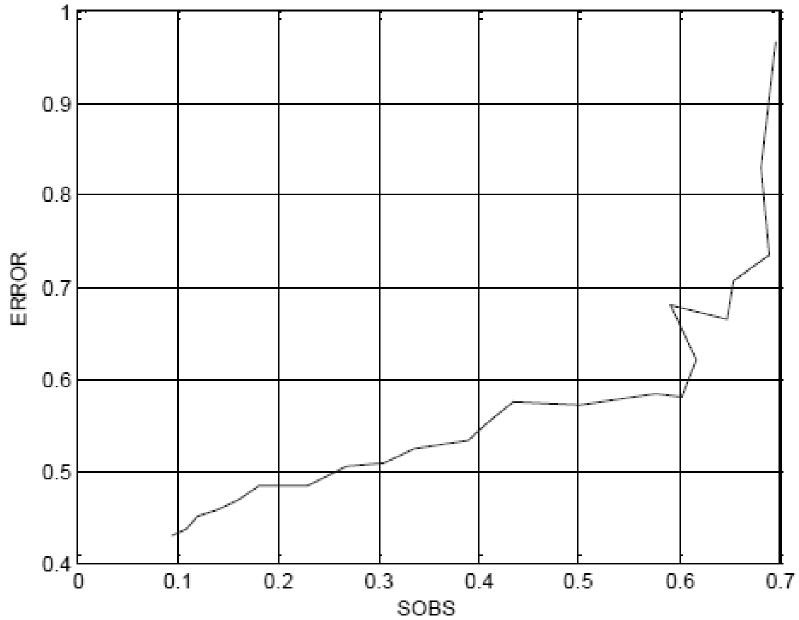

Fig. 5 Error propagation in simulated residual drawdown (Dataset with large errors)

4. CONCLUSION

In this paper the efficacy of the GA optimization technique is examined for estimating the aquifer parameters Similar to the graphical method, the pumping and recovery test field data were utilized within the optimization process and optimal results were compared with calculated ones. The following conclusions are drawn:

For the given data set GA technique gives more accurate results than the graphical methods and is a reliable method for estimating the aquifer parameters of a confined aquifer systems

A unique solution for the aquifer parameters is obtained in less number of iterations making the optimization procedure less time consuming compared to the conventional graphical methods.

A healthy linear Regression Coefficient (R^2) for the considered data is an indication that the simulated values are in close agreement the observed values.

With the advent of high speed and large memory PCs, the use of the GA technique is recommended for estimating aquifer parameters from the pumping test data instead of the traditional tedious graphical and gradient based approaches.

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Surface Water Bodies Monitoring using GIS

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ABSTRACT

Surface water bodies are the water on the surface of the planet such as in streams, river, lake, wet land, or oceans. Non saline surface water is replenished by precipitation and by recruitment from ground water. It is lost through evaporation, seepage and abstracted by mankind for agriculture, living, industry etc. The present study deals with monitoring the surface water bodies located in the Greater Hyderabad Municipal Corporation (GHMC), twelve mandals has been monitoring. Surface water bodies were delineated using toposheets supplied by Survey of India and processed in GIS environment. The twelve mandals are namely Balanagar, Ghatkesar, Hayatnagar, Kandukur, Maheswaram, Malkajgiri, Wargal, Qutbullahpur, Shamirpet, Sherlingampally and Yacharam. The main objective of the work is to identify and calculate the extent of surface water bodies in the GHMC Mandals. The work carried out shows the number of water bodies present in each mandal and the total area covered by the water bodies in that mandal as per the toposheets before urbanization. From the study it has been found that there are 983 surface water bodies in 12 mandals of GHMC, in which Shamirpet mandal have got 144 water bodies which is the highest number in a mandal and Ghatkesar mandal have got only 26 surface water bodies which represents the lowest number in a mandal. The largest water body in area is Osman sagar with 1996.32 hectares of Sherlingampally mandal and smallest water body in area is Bachupalli open scrub kunta with 0.23 hectares of Qutbullahpur mandal.

INTRODUCTION

The surface water bodies plays vital role in today's life. Since the growth of population and urbanization increased in recent decades the surface water bodies are reduced. Water is very important natural resources of a nation. It is very useful resources for the development of a country. India has very unlimited natural water resources. In this study of GHMC 12 mandals the number of surface water bodies has been reduced because of fast growing scenario. Government has initiated number of GO's for the protection of surface water bodies, mainly the government concentrated on developing and protecting the surface water bodies whose areas are more than 10 hectares. Hence most of the surface water bodies whose areas are less than that of 10 hectares areas are disappeared because of growth in population and urbanization. If water is properly harnessed and utilized, it can prove a boon and immense value to the population. The advancement of civilization, the importance of water has increased greatly. Increasing in population requires more food, which requires more land for agriculture and more water for irrigation and other purpose's; industrial development needs more water for different processes in the industry and for power generation. The objectivities of present study area is to delineate the number of surface water bodies present in 12 mandals of GHMC from the toposheets provided by Survey of India using GIS software and also to calculate the areas of largest and smallest surface water bodies in 12 mandals of GHMC.

Study Area

The study area consists of 12 mandals of GHMC, The respective mandals are Balanagar, Ghatkesar, Hayatnagar, Jinnara, Kandukur, Maheswaram, Malkajgiri, Wargal, Qutbullahpur, Shamirpet, Sherlingampally and Yacharam as shown in the Fig.1. There are total of 983 water bodies present in 12 mandals according to the toposheets provided by Survey of India. Since some of the toposheets are not available in survey of India, some water bodies data is unavailable in these 12 mandals.

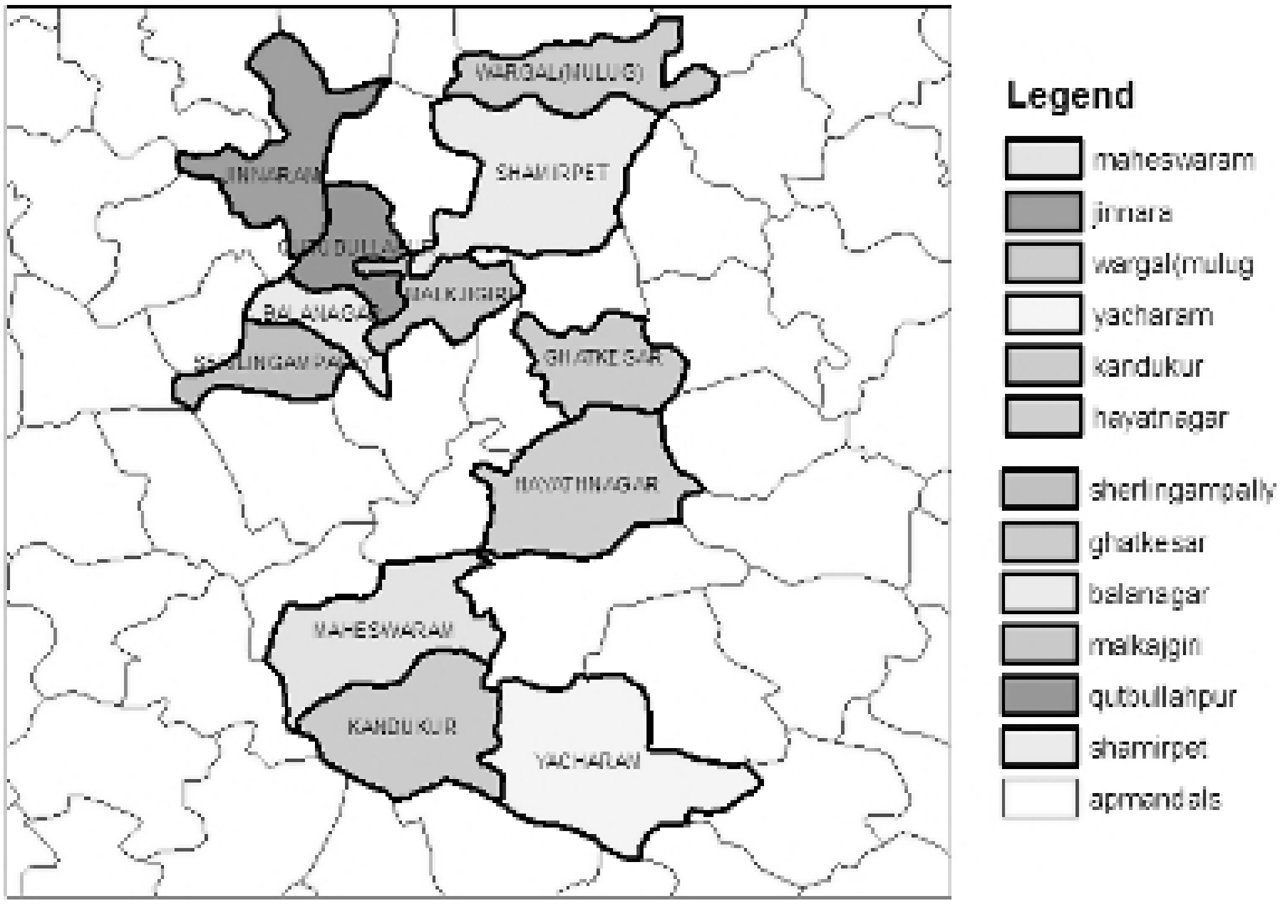

Fig. 1 Study area

Review of Literature

Surface water bodies monitoring using GIS are not new. In fact it was practiced in India and other countries long back. Aim of GIS is to store geographically referenced data as different layers. These different data layers may be manipulated and visually accessed as output data. The usefulness of the output data, however is determined by the quality of the input data. Data was digitized with Arc/info and processed in raster format. Wetlands are areas of land that are covered by water indicating seasonal and perennial variability. Wetlands provides habitat to large varieties of plant and animal species, adapted to seasonal variation of water levels. It meets the essential needs of the human beings such as drinking water, food, energy and stabilizes the climate (Ramachandra and Uttam Kumar, 2008). Wetlands are important source of ecosystem that removes the dissolved nutrients and improves the quality of water. In India, 3.2% of the geographic area constitutes the wetlands and supports the aquatic biodiversity (Prasad et al. 2002). However in recent years, increased populations, industrialization, residential and agricultural development, most of these wetlands have discovered to be disappeared and some are degraded in its quality. As population spikes, the pressure on the wetlands increases (Rahman, and Begum, 2011). The human induced treats and encroachment for infrastructure development have resulted in the destruction of wetlands (Amezaga, et al., 2002).

Methodology

The step by step methodology adopted in the present work is outlined in the following flowchart.

Survey of India Toposheets

⇓

Scanning of Toposheets

⇓

Geo-referencing of Toposheets

⇓

Digitization of water bodies

⇓

Clipping-Merging number of Toposheets

⇓

Creation of water bodies shape file

⇓

Clipping of water bodies

⇓

Extraction of water bodies by mask

⇓

Finding Polygon (water bodies) Area

⇓

Intersection of respective water bodies with GHMC mandal

⇓ Layout View

⇓ Export Map

RESULTS AND DISCUSSIONS

The mandal wise detailed results are explaining in the following subsections.

Balanagar: Balanagar mandal consists of 44 surface water bodies according to the survey of India toposheet number 56k/6/SW surveyed during the year 1996-1997, 56k/6/SE surveyed during the year 1996-1998, 56k/7/NW surveyed during the year 1996-1997 and 56k/7/NE surveyed during the year 1973-1974. Out of which Maisamma Cheruvu is the largest one with 46.89 hectares and Musapet open scrub kunta is the smallest one with 0.38 hectares area. Figure 2 shows the Balanagar mandal boundary and number of surface water bodies present.

Ghatkesar: In this mandal there are 26 surface water bodies according to the survey of India toposheet number 56k/11/NE surveyed during the year 1996-1997. Out of which Edulabad Cheruvu is the largest one with 256.87 hectares and Ankushapur kunta is the smallest one with 0.43 hectares area. Figure 3 shows the mandal boundary along with number of surface water bodies present in ghatkesar.

Hayatnagar: This mandal consists of 68 surface water bodies according to the survey of India toposheet number 56k/11/SE surveyed during the year 1996-1997. Out of which Masab cheruvu is the largest one with 118.87 hectares area and Koneda colony kunta is the smallest one with 0.5 hectares, Figure 4 shows the mandal boundary and number of surface water bodies present in hayatnagar.

Yacharam: In this mandal there are 67 surface water bodies according to survey of India toposheets number 56k/12/SW surveyed during the year 1998-1999 and 56k/12/SE surveyed during the year 1998-1999. Out of which Takkelapalli cheruvu is the largest one in area with 46.92 hectares and Chintapatla is the smallest one with 0.3 hectares area, Figure 5 shows the Yacharam mandal boundary and number of surface water bodies present.

Jinnaram: This Mandal consists of 143 surface water bodies according to the survey of India toposheets number 56k/6/NW surveyed during the year 1996-1997, 56k/6/SW surveyed during the year 1996-1997, and 56k/6/SE surveyed during the year 1996-1998. Out of which Ran cheruvu is the largest one with 79.12 hectares and Jagampet kunta is the smallest one with 0.42 hectares area, Figure 6 shows the mandal boundary and number of water bodies present.

Kandukur: In this mandal there are 120 surface water bodies according to the survey of India toposheets number 56k/8/SE surveyed during the year 1998-1999 and 56k/12/SW surveyed during the year 1998-1999. Out of which Mailamma cheruvu is the largest one in area with 37.84 hectares and Utlapati kunta is the smallest one with 0.42 hectares, Figure 7 shows the mandal boundary and number of surface water bodies present in kandukur.

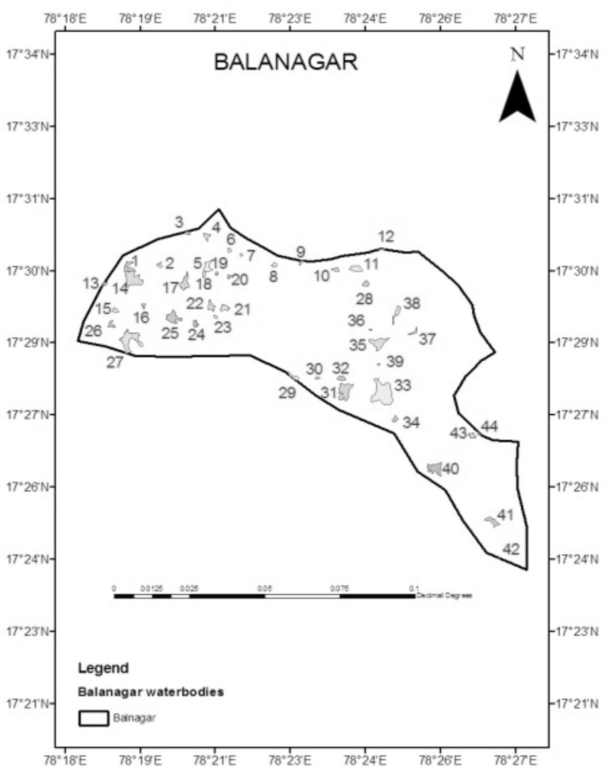

Fig. 2 Surface water bodies in Balanagar mandal

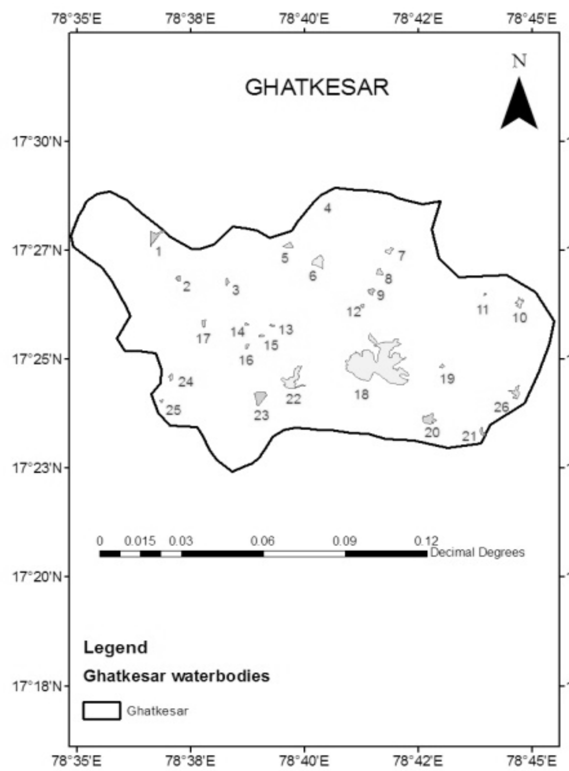

Fig. 3 Surface water bodies in Ghatkesar mandal

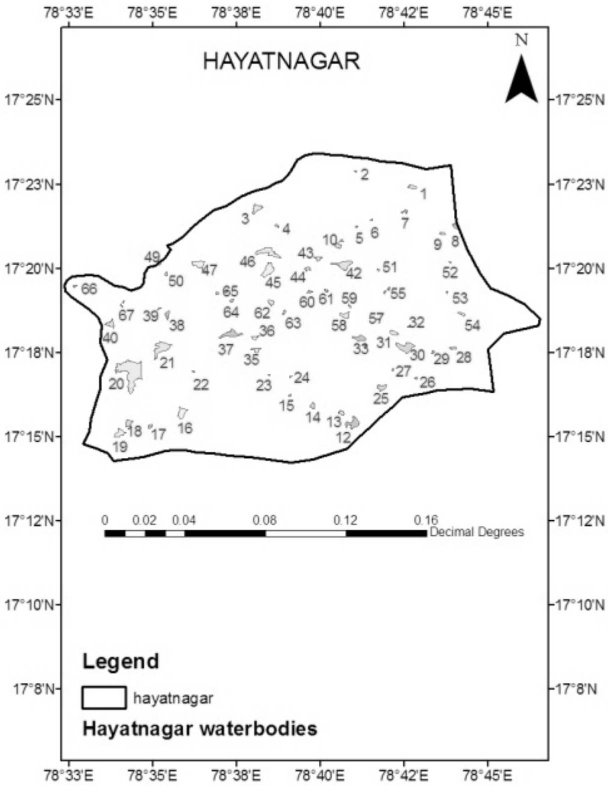

Fig. 4 Surface water bodies in Hayatnagar mandal

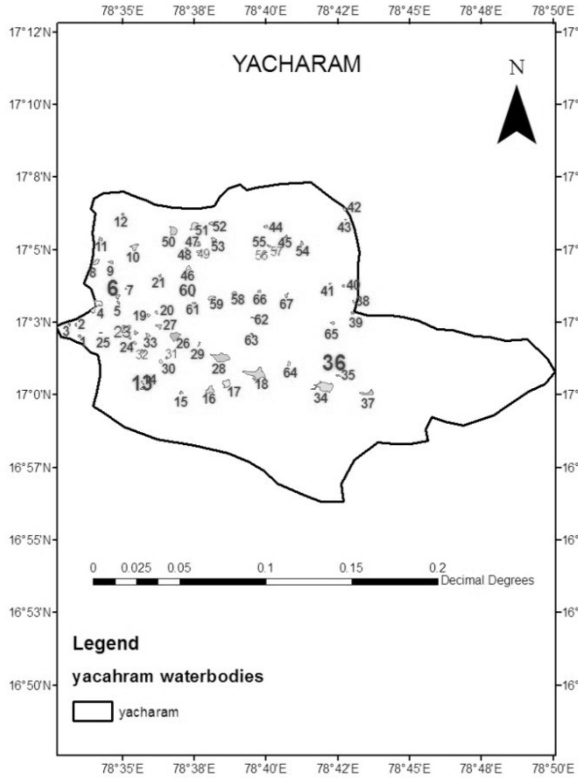

Fig 5 Surface water Bodies of Yacharam Mandal

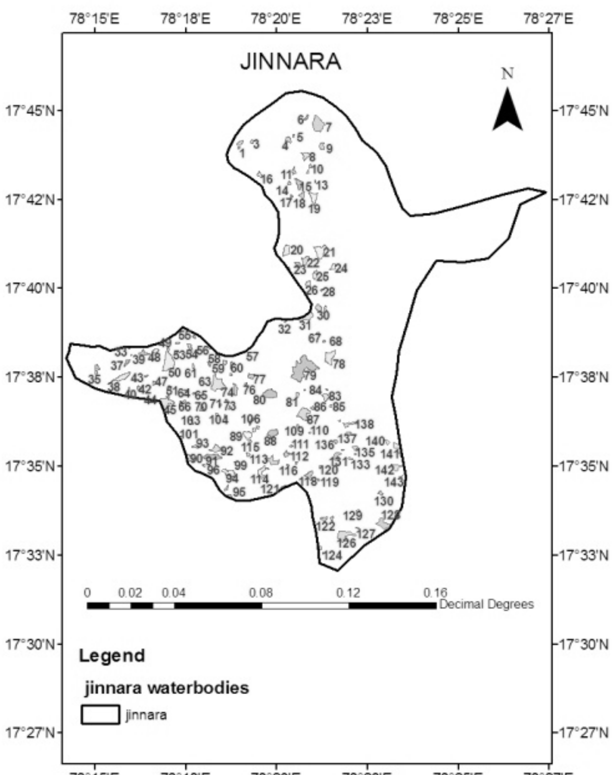

Fig. 6 Surface water bodies of jinnara mandal

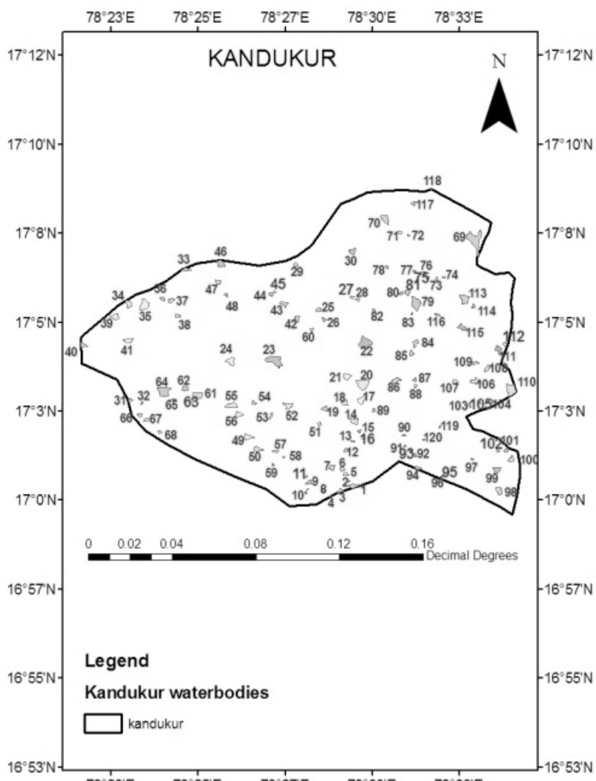

Fig. 7 Surface water bodies of kandukur mandal

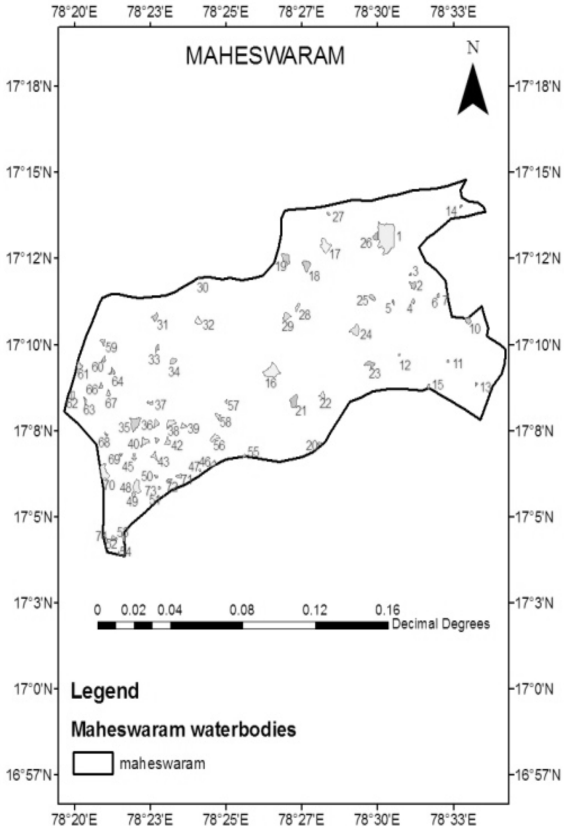

Fig. 8 Surface water bodies of Maheswaram mandal

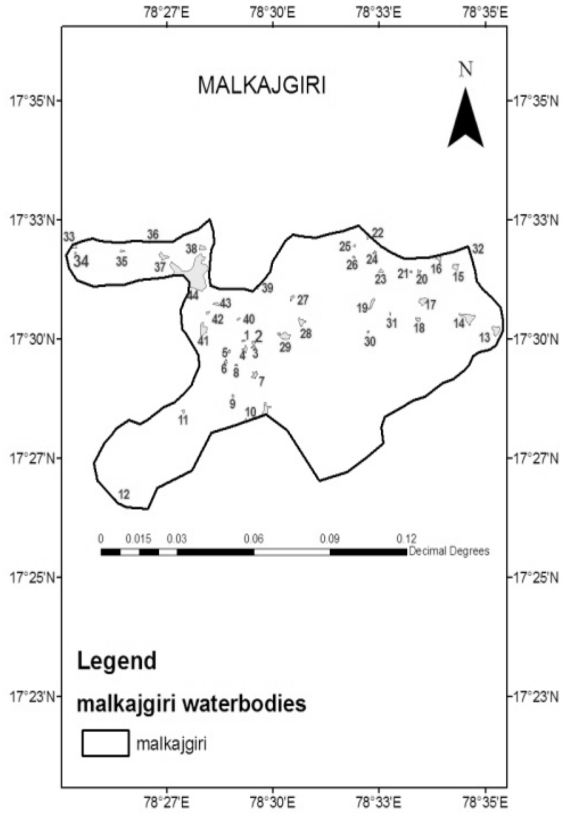

Fig. 9 Surface water bodies of Malkajgiri mandal

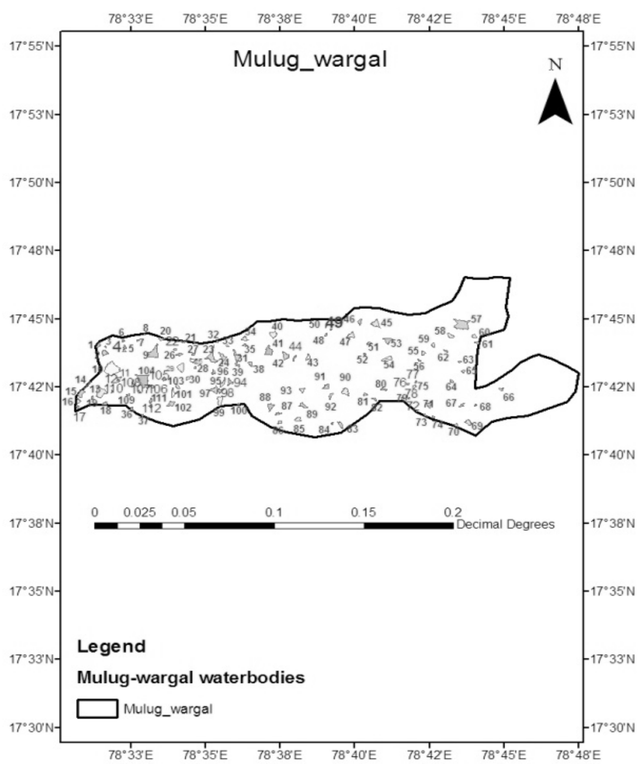

Fig. 10 Surface water bodies of wargal mandal

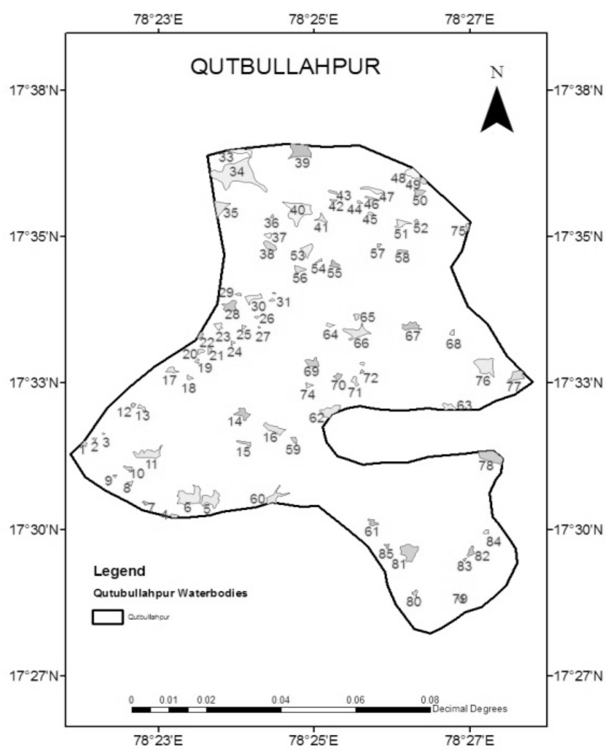

Fig. 11 Surface water bodies of Qutbullahpur mandal

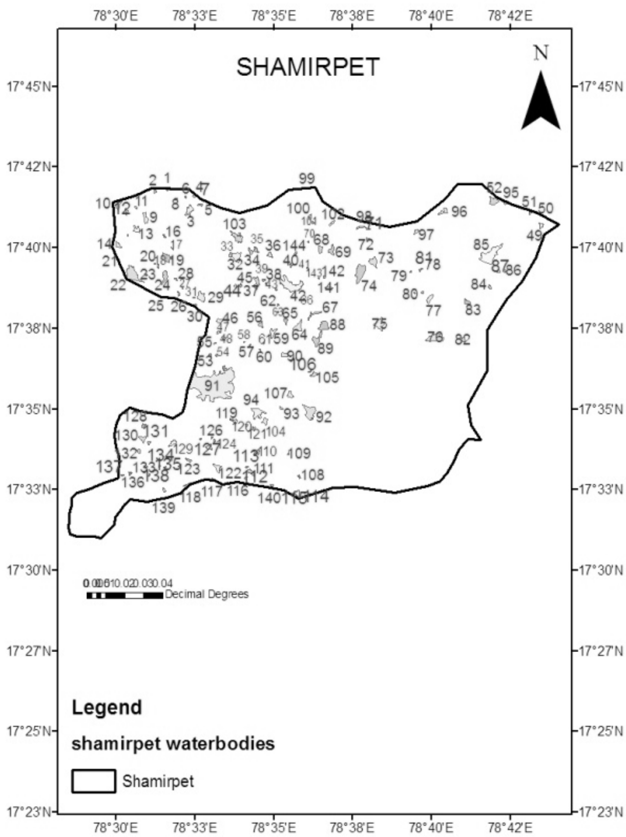

Fig. 12 Surface water bodies of Shamirpet mandal

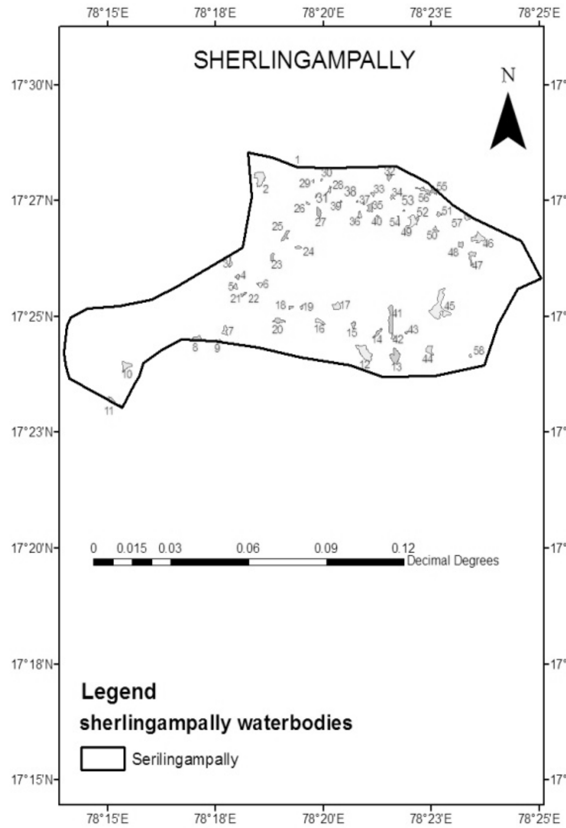

Fig. 13 Surface water bodies of Sherlingampally mandal

Maheshwaram: Maheshwaram mandal consists of 72 surface water bodies according to the survey of India toposheets number 56k/8/NW surveyed during the year 1998-1999, 56k/8/NE surveyed during the year 1998-1999 and 56k/12/SW surveyed during the year 1998-1999, 56k/12/NW surveyed during the year 1998-1999. Out of which Rairal cheruvu is the largest one with 127.91 hectares and Kongara kunta is the smallest one with 0.89 hectares area, Figure 8 shows the Maheshwaram mandal boundary and number of surface water bodies present.

Malkajgiri: In this mandal there are 44 surface water bodies according to the survey of India toposheet numbers 56k/6/SE surveyed during the year 1996-1998, 56k/10/SW surveyed during the year 1973-1974, 56k/7/NE surveyed during the year 1973-1974. Out of which Fox sagar cheruvu is the largest one in with 116.04 hectares and Yapral kunta is the smallest one with 0.31 hectares area, Figure 9 shows the mandal boundary and number of surface water bodies present in malkajgiri.

Mulug WARGAL: This mandal consists of 112 surface water bodies according to the survey of India toposheet numbers 56k/10/NW surveyed during the year 1997-1998 and 56k/10/NE surveyed during the year 1997-1998. Out of which Kokunda cheruvu is the largest one with 53.93 hectares and Alingaram Lake is the smallest one with 0.53 hectares area, Figure 10 shows the wargal mandal boundary and number of surface water bodies present.

Qutbullahpur: Qutbullahpur mandal consist of 85 surface water bodies according to the survey of India toposheets number 56k/6/SE surveyed during the year 1996-1998, 56k/6/SW surveyed during the year 1996-1997 and 56k/7/NE surveyed during the year 1973-1974. Out of which Fox sagar cheruvu is the largest one with 116.04 hectares and Bachupalli open scrub kunta is the smallest one with 0.23 hectares area, Figure 11 shows the mandal boundary and number of water bodies present in qutbullahpur.

Shamirpet: In this mandal there are 144 surface water bodies according to the survey of India toposheets number 56k/10/NW surveyed during the year 1997-1998, 56k/10/NE surveyed during the year 1997-1998, 56k/10/SW surveyed during the year 1973-1974. Out of which Shamirpet cheruvu is the largest one with 371.13 hectares and Lalugadi kunta is the smallest one with 0.3 hectares area, Figure 12 shows the shamirpet mandal boundary and number of water bodies present.

Sherlingampally: This mandal consists of 58 surface water bodies according to the survey of India toposheets number 56k/7/NW surveyed during the year 1996-1997 and 56k/7/NE surveyed during the year 1973-1974. Out of which Osman sagar is the largest one in area with 1996.32 hectares and Khanamet kunta is the smallest one with 0.25 hectares, Figure 13 shows the mandal boundary and number of water bodies present in sherlingampally.

CONCLUSION

Geographic information system is one of the fastest growing technologies being applied in the field of water resources. With the use of Arc GIS and toposheets provided by survey of India, it is studied that there are 983 surface water bodies in 12 mandals of GHMC, in which shamirpet mandal have got 144 water bodies which is the highest number in a mandal and ghatkesar mandal have got only 26 surface water bodies which represents the lowest number in a mandal. The largest water body in area is Osman sagar with 1996.32 hectares of sherlingampally mandal and smallest water body in area is Bachupalli open scrub kunta with 0.23 hectares of qutbullahpur mandal. By digitization of water bodies using arc gis we have find out the number of water bodies present in 12 mandals and its area. Using GIS without going to the field we can know number of surface water bodies spatially and temporally. The present conclusions are compared with the present decade surface water bodies and the encroachment in the surface water bodies, areas are found out in later part of project work, using arc gis software and survey of India toposheets.

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Development of 1-Dimensional Coupled Wavelet-Neural Network Model to Predict Suspended Sediment Discharge

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ABSTRACT

Modeling transport of sediment load in rivers is one of the most complex hydrological and environmental phenomenon due to large number of obscure parameters. These include spatial variability of basin characteristics and river discharge patterns. A number of numerical and empirical models have been provided in literature to simulate this phenomenon to reasonable accuracy. Artificial intelligence techniques and statistical based data driven models are proved to be effective in modeling sediment transport. This research aims at integrating the theories of wavelets and neural networks to accurately predict the sediment discharge. A 3-layer feed forward wavelet-neural network (WNN) model with error back propagation algorithm using MATLAB was developed in the present study. The activation function drawn from wavelet basis (wavelons) was used in lieu of classical sigmoid class functions. Application of the developed code was tested considering the daily data at the USGS site number 08317400 for the period 1970 to 2013. Inputs to the model include time-series data on water temperature, stream flow discharge, turbidity of water, and suspended sediment concentration, and were portioned into training and testing sets based on statistical parameters. Simulated sediment discharge was well matched with the observations during the training phase. A significant improvement in the model performance in predicting sediment discharge was observed when compared to using conventional artificial neural network (ANN) tools. Use of WNN over ANN has resulted in an increase in coefficient of determination (R^2), and an increase in Nash-Sutcliffe efficiency (NSE).

Keywords: ANN, WNN, Sediment Discharge, simulation

1. INTRODUCTION

Hydrology system is influenced by many factors such as weather, land cover, infiltration, evapotranspiration, and different other characteristics. Hydrologic time series are often non-linear and non-stationary. Artificial neural networks (ANNs) have gained significant attention in past two decades and had been widely used for hydrological forecasting [1]. Many studies focused on stream flow predictions have proved that ANN is superior to the traditional regression and time series models [2]. In situations like non stationary and non-linearity, ANN may not be able to cope with the data of seasonal irregularity. Thus, preprocessing techniques like standardization of mean and variance, seasonal removal, transforming input and output variables are applied to remove non stationary in data used to build soft computing models.

Feed Forward Back Propagation algorithm has been widely used in literature for ANN modelling. There are also many disadvantages with this algorithm such as local minima, slow convergence, unable to stand non-linearity and non-stationary time data series. To minimize these Wavelet transformation techniques are used to achieve high forecast accuracy and consistency in multi-time series. The wavelet transformed data is helpful in improving the model performance by capturing helpful information at various resolutions. Also, WNN results in faster convergence over other non-linear models like ANN, FL etc.

2. METHODOLOGY

The data used in the present study was taken from USGS Surface-Water Data for the Nation specific to the site number 08317400 (Rio Grande River below Cochiti Dam) representing the mean daily data of the parameters like water temperature, stream flow discharge, turbidity of water, suspended sediment concentrations.

The total data points taken in this study are 366 in which 242 (2/3rd of the data) were taken for training and the rest 124 for the testing phases by randomly considering the mean and standard deviation of data, threshold values for mean and standard deviation of the data is considered as 1%,to generate a 3 – layer feed forward back propagation network.

1.1. ANN (Artificial Neural Network)

Artificial Neural Networks are mathematical inventions inspired by observations made in the biological systems. ANN has gained popularity among Hydrologist in recent decades due to its large array of application in the field of Engineering and research. The purpose of ANN is to map input space to an output-space.

ANN has excellent flexibility and high efficiency in dealing with nonlinear and noisy data in Hydrological modeling. A typical ANN consists of a number of nodes that are organized according to a particular arrangement. It consists of “Neurons” which are interconnected computational elements that are arranged in a number of layers which can be single or multiple. Each pair of neurons is linked and is associated with weights. ANN are trained by adjusting the values of these connection weights between network elements. The weighted inputs in each layer are processed from neurons in the previous layer and transmit its output to neurons in the next layer. A transfer function/activation function is used to convert a weighted function of input to get the output. Usually non-linear sigmoidal activation functions are used as reported in the literature which was also adopted in this study. The inputs to the ANN model were normalized and kept within the range of 0.1 to 0.9.

The learning rate and momentum coefficient are influential parameters which controls the convergence rate towards optimizing the solution. Here, both the parameters were kept as constant with 0.4 and 0.6 respectively throughout the network structure for various number of hidden neurons.

The data is standardized by using the formula

$$z_i = \frac{x_i}{x_{max}} \qquad \text{..... (1)}$$

Where x_i = Corresponding to observation□i□, x_{max} = Maximum number in the data

The summation method is used for the net value

$$net_j = \Sigma x_i * w_{ij} + b_{ij} \qquad \text{.....(2)}$$

Were the x_i = corresponding to observation □i□, w_{ij} = weight between the neurons □i□ and □j□, b_{ij} = bias

The Activation function used is sigmoid function

$$f(net)_j = \frac{1}{1 - e^{-net\ j}} \qquad \text{.....(3)}$$

1.2. WNN (Wavelet Neural Network)

A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. The wavelet transform of a signal is capable of providing time and frequency information simultaneously, hence providing a time-frequency representation of the signal. Usually one can assign a frequency range to each scale component. Each scale component can then be studied with a resolution that matches its scale. To do this, the data series is broken down by the transformation into its “wavelets” that are “scaled” and “shifted” version of the mother wavelet.

This study deals with an irregular mother wavelet viz., Gaussian Mother Wavelet. The network architecture that yielded the best results in terms of determination coefficient and root mean square error on the training and verifying steps may be determined through trial and error process. The time series data before going through the network are usually normalized between 0 and 1 as sigmoidal activation function was used in the study.

The Gaussian Wavelet function is

$$h(j) = \frac{j}{\sqrt{2\Pi}} * \exp(-\frac{j^2}{2}) \qquad \text{.....(4)}$$

Where j is the net_j used in ANN.

The activation function i.e.., sigmoid function is changed to

$$h(j) = h_j * \left(\Sigma_{i=1}^{n} w_{ij} * x_i - b_j \right) / a_j \qquad \text{.....(5)}$$

Where b_j = shift factor, a_j = stretch factor

2. RESULTS AND DISCUSSION

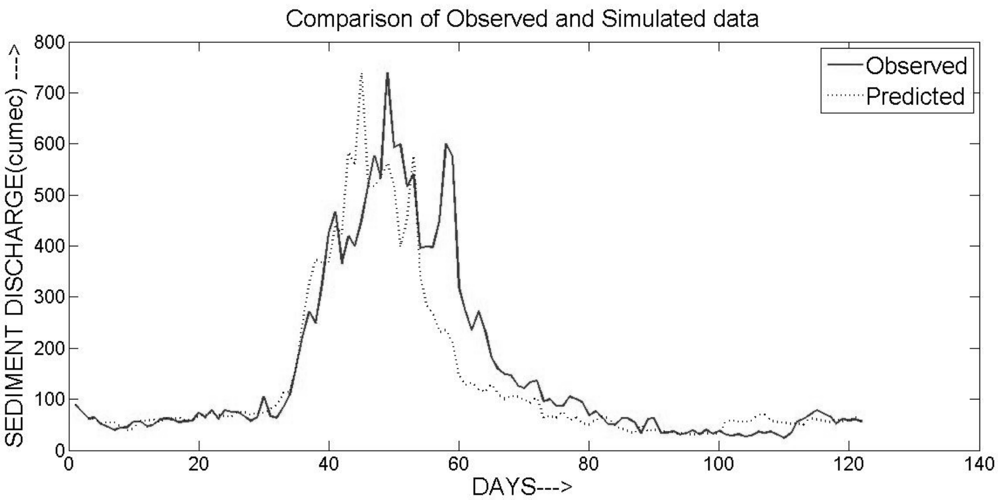

Fig. 1 Comparison of observed and simulated sediment discharge using ANN

The simulation is done for 200 iterations and the shift factor and stretch factor are taken as 0.01 and 0.02 respectively. Figure 1 gives the comparison of the observed and simulated sediment discharge using ANN and the Figure 2 give the comparison of the observed and simulated sediment discharge using WNN. The RMSE obtained using ANN is 0.812 and the RMSE in WNN is 0.942.

The NSE of the model by using ANN is -0.29 and by using WNN is 1.018

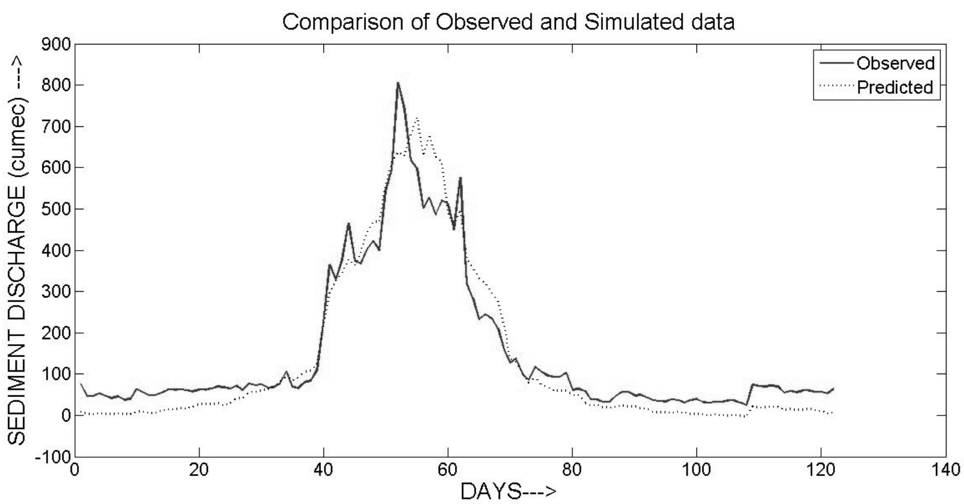

Fig. 2 Comparison of observed and simulated sediment discharge using WNN

3. CONCLUSION

The use of wavelet functions in soft computing technique over ANN and its application in water resource has been consistently increasing. A 3-layer feed forward wavelet-neural network (WNN) model with error back propagation algorithm using MATLAB was developed in the present study. Application of the developed code was tested considering the daily data at the USGS site number results of the analysis conclude that model performance with WNN is increasing over ANN method. This was observed by an increase in coefficient of determination (R^2) about 0.13 and an increase in Nash-Sutcliffe efficiency (NSE) about 1.308

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A Study on the Relationship between Kalpana VHRR Land Surface Temperature and AWS Observed Air Temperature

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ABSTRACT

The main objective of the thesis is to statistically compare and correlate the ground and satellite observations of air temperature and Land surface temperature temperatures (LST), to develop a temperature database for both parameters and to study the relationship between these two parameters (Land surface temperature and air temperature). The Satellite data is used Kalpana VHRR Very High Resolution Scanning Radiometer of ISRO. The data is retrieved on 15th day of every month during January to May of 2012, during November & December of 2011. AWS (Automatic Weather stations) maintained by ISRO selected as the ground air temperature data. The LST data is in ASCII format is converted to raster format by Arc GIS software. The air temperature data is obtained from MOSDAC website for the required time span. From the analysis it is found that Regression Coefficient values are different at different places. Theoretically speaking the air temperature and Land surface temperature must have high correlation. According to the energy balance theory, the relationship between air temperature and Land surface temperature is strongly influenced by land surface characteristics and varies across different land types for different surface conditions. The air temperature data is strongly influenced by many complicated factors, for example land use types, soil moisture, sky conditions and topographical factors in complex terrain regions. However in the present study it has been observed that wherever cloud free data is available it gives high value of correlation, low correlation obtained due to non availability of data during certain timings, the data is not cloud free and also the influence of other atmospheric parameters.

INTRODUCTION

The world is getting warmer. Whether the cause is human activity or natural variability and the preponderance of evidence says its humans thermometer readings all around the world have risen steadily since the beginning of the Industrial Revolution, the average global temperature on Earth has at a rate of roughly 0.8^0 Celsius (1.4^0 Fahrenheit) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20^{0}C per decade. The global temperature record represents an average over the entire surface of the planet. The temperatures we experience locally and in short periods can fluctuate significantly due to predictable cyclical events (night and day, summer and winter) and hard to predict wind and precipitation patterns. But the global temperature mainly on how much energy the planet receives from the Sun and how much it radiates back into space quantities that change very little. The amount of energy radiated by the Earth depends significantly due to predictable cyclical events (night and day, summer and winter) and hard to predict wind and precipitation patterns. The amount of energy radiated by the Earth depends significantly on the chemical composition of the atmosphere, particularly the amount of heat trapping greenhouse gases. Land surface temperature is how hot the “surface” of the Earth would feel to the touch in a particular location. From a satellite’s point of view, the “surface” is whatever it sees when it looks through the atmosphere to the ground. It could be snow and ice, the grass on lawn, the roof of a building, or the leaves in the canopy of a forest. Thus, the land surface temperature is not same as the air temperature that is included in the daily weather report. Land surface temperature is a key parameter in Land surface processes not only acting as a indicator of climate change, but also due to its control of the upward terrestrial radiation, and consequently the control of the surface sensible and latent heat flux exchange with the Atmosphere (Aries,2001; Sun 2003). Traditionally, L.S.T. measured by sheltered thermometer 1.5-3.5 m above a flat grassy, well ventilated surface. The satellite based L.S.T. called skin temperature is becoming available globally (Dickson 1994). Satellite L.S.T. products provide an estimate of kinetic temperature of the earth’s surface skin (Norman & Becker), 1995) i.e., the aggregate surface medium viewed by the sensor to a depth of about 12 micrometers. The generic source of Air temperature data is the Meteorological station, which only provides data at single locations (Hart amp et al; 1999). Air temperature estimation is useful for wide range of applications such as Agriculture, climate related diseases and climate change studies.

Study Area: The study Area includes in the following states of India. The AWS stations are (Automatic Weather Stations): Andhra Pradesh, Tamilnadu, Kerala, Karnataka, Assam, Gujarat, Jharkhand, Maharashtra, Uttar Pradesh, Orissa, Nagaland, Delhi, Rajasthan, and West Bengal. The Air temperature, Land surface temperature data is taken for 2012 and 2011 years.

Objective: The objective of the present study is to statistically compare and correlate the ground and satellite observations of Air temperature and Land surface temperatures. To develop a temperature database (i.e. Air temperature and Land surface temperature) for the stations mentioned under study area. To study the relationship between these two components.

Product Details: In this study the Land surface temperature product is KALPANA-1 VHRR, and Air temperature source is Automatic Weather Stations maintained by ISRO.(Indian Space Research Organization) **(a) KALPANA-1 VHRR:** Kalpana-1 is the first dedicated meteorological satellite launched by Indian Space Research Organization using Polar Satellite Launch Vehicle (PSLV) on 2002-09-12, into the Geostationary orbit .The satellite was originally known as MetSat-1. The satellite features a Very High Resolution Scanning Radiometer (VHRR), for 3-band images and a Data Relay Transponder(DRT) payload. So far meteorological services had been combined with telecommunication and television services in the INSAT series.Met Sat-1 is a precursor to the future. INSAT system that will have separate satellites for Meteorology and Telecommunication and broad casting services. This product is obtained through VHRR Sensor of KALPANA1 Satellite of ISRO and covers Indian region. This product is generated every 30 minutes. The data is available since 2009 onwards. The data is available in standard hdf5 format for registered and authorized users on MOSDAC. Details are available on www.mosdac.gov.in This product is a level-2 retrieved Land Surface Temperature parameter derived Kalpana-1 VHRR data.(www.isro.gov.in) **(b) ISRO Automatic weather Stations (AWS)** The Indian Space Research Organization-Designed Automatic Weather station (AWS) provide point based weather monitoring. AWS can continuously record weather data like temperature, atmospheric pressure, wind speed and direction, rainfall, relative humidity, solar radiation, etc. The data from a large number of Automatic Weather Stations located across the country could be collected through the Data Relay Transponder on board the ISRO’s INSAT satellites. At present, more than 700 AWSs are deployed in clusters working all over specific regions in India. AWS features include easy programming of sensors, front panel display, archival of one-year data and communication options -- via INSAT, telephone, modem, cellular telephone, etc. A GPS integrated with AWS provides accurate time for transmission of data. For validation of present study, AWS data during 2011 and 2012 are used.

METHODOLOGY

DATA ANALYSIS: Kalpana-1 VHRR land surface temperature product is obtained from ISRO’S MOSDAC website. The data is obtained for 15th day of the months spanning from January to May and November, December months of the years 2012 and 2011. The L.S.T. data is obtained in HDF (HIERARCHICAL DATA FPORMAT) format. This format can make possible to manage large and complex data collections. Depending upon the latitude and longitude of weather stations we can retrieve the land surface temperature values from the HDF files. The AWS ISRO weather stations data is obtained from MOSDAC website, for the required time span. Here the L.S.T. product is obtained through VHRR sensor of Kalpana-1 satellite of ISRO and covers Indian region. This product is generated every 30 minutes. The data is available in HDF format on MOSDAC. This product is a level-2 retrieved L.S.T. parameter derived Kalpana -1 VHRR data. For example Satellite derived L.S.T. product is shown in the Fig. 3.3(1) dated on 15th December 2011 at 5.30 A.M., likewise for every half an hour the figures are generated and are available in ISRO’s MOSDAC website. In this figure the land surface temperature indicated in different colours with respective the values in increasing order. Land surface temperature is in Kelvin, later converted in to Celsius ((°C) = [K] − 273.15) for analysis. The Air temperature values are in Celsius. Air temperature available in hourly and Land surface temperature is available in half hourly available. L.S .T. available in G.M.T. (Greenwich Mean Time). In Fig. 1 L.S.T. values are representing the colours in the order of violet, blue, green, yellow etc. and ends at dark red colour.

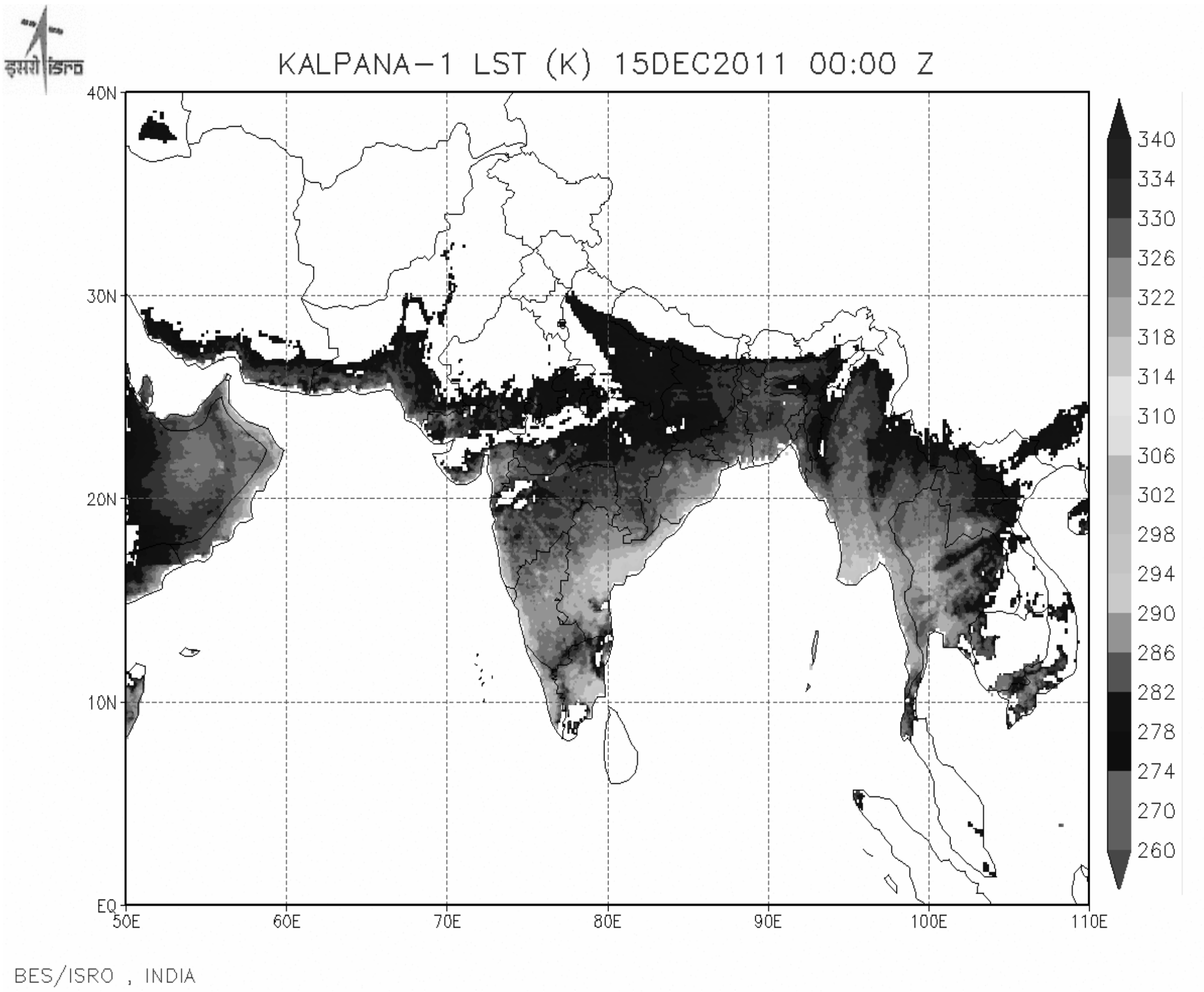

Figure 1: KALPANA-1 VHRR L.S.T. PRODUCT

DATA PROCESSING

SOFTWARE USED: Arc GIS 9.3.

Conversion: The Kalpana VHRR land surface temperature (LST) was converted from the ASCII format to using conversion tools in tool box of software Arc GIS 9.3versions. Specify the input raster as land surface temperature and then click on the button next to get output. Here the input is in ASCII format, is converted to raster format to enable grid-wise study of the Kalpana-1 VHRR L.S.T. One grid represents $0.1^0*0.1^0$sq.km.

Extraction: As the Kalpana-1 VHRR image covers the whole span area of VHRR sensors, the image covers all the A.W.S. stations in India maintained by ISRO. So we took only the AWS stations which are under the study area from different states of India are separated from the image using the extraction tools in Arc. GIS 9.3, and saved as a shape file.

Overlaying: Now the raster image of VHRR is overlaid upon a map comprising all AWS locations and states of India.

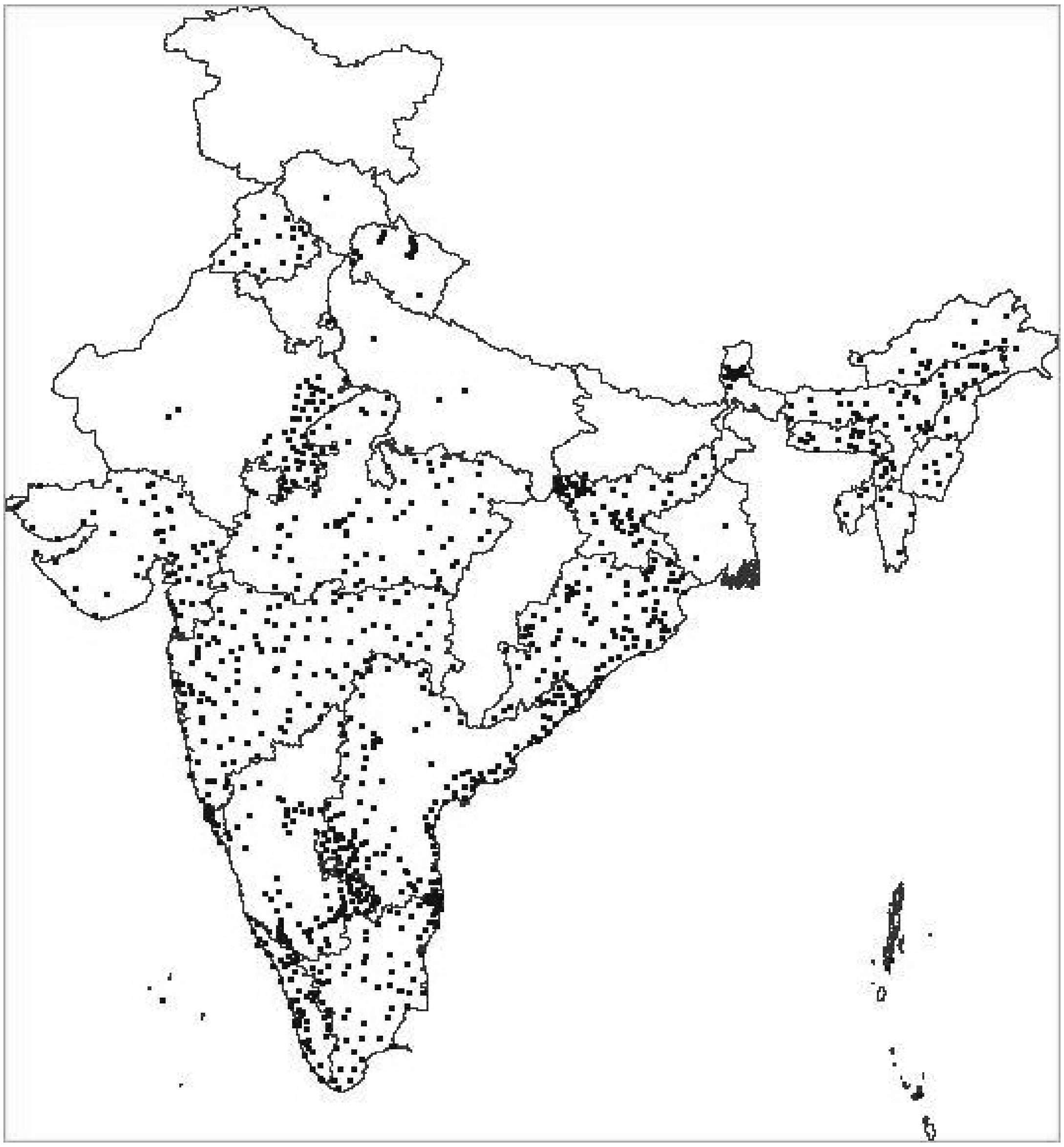

Figure 2: Various AWS locations in INDIA.

Recording the L.S.T and Air temperature: Now one particular pixel of raster image represents 11×11=121sq.km grid of the VHRR. So a pixel value of one grid is represents the satellite estimated L.S.T. for an area of 11*11sq.km. As the AWS points are overlaid on the AVHRR image, now we can visualize and study the grid wise distribution of the AWS locations. So the grids which represent the AWS locations along with the AVHRR L.S.T. are selected for analysis. Now a grid with an AWS location contains information of the Kalpana-1 AVHRR L.S.T of that particular time and also displays the latitude, longitude of that AWS station, and name of the AWS station. If more than one AWS occupies the grid then the mean of their temperature values taken. Even though the grid displays satellite value, it displays only the location of AWS and the L.S.T. satellite value. The ground Air temperature data for the particular AWS for the date is obtained from MOSDAC website. For a given date both AVHRR L.S.T. and AWS Air temperature values are tabulated. As the air temperature is available hourly and land surface temperature is available half hourly in the datasets, the air temperature data and land surface temperature values were taken and tabulated with respective to time in GMT for every station covered in Fig:3 the study area.

Map Showing Various AWS Stations

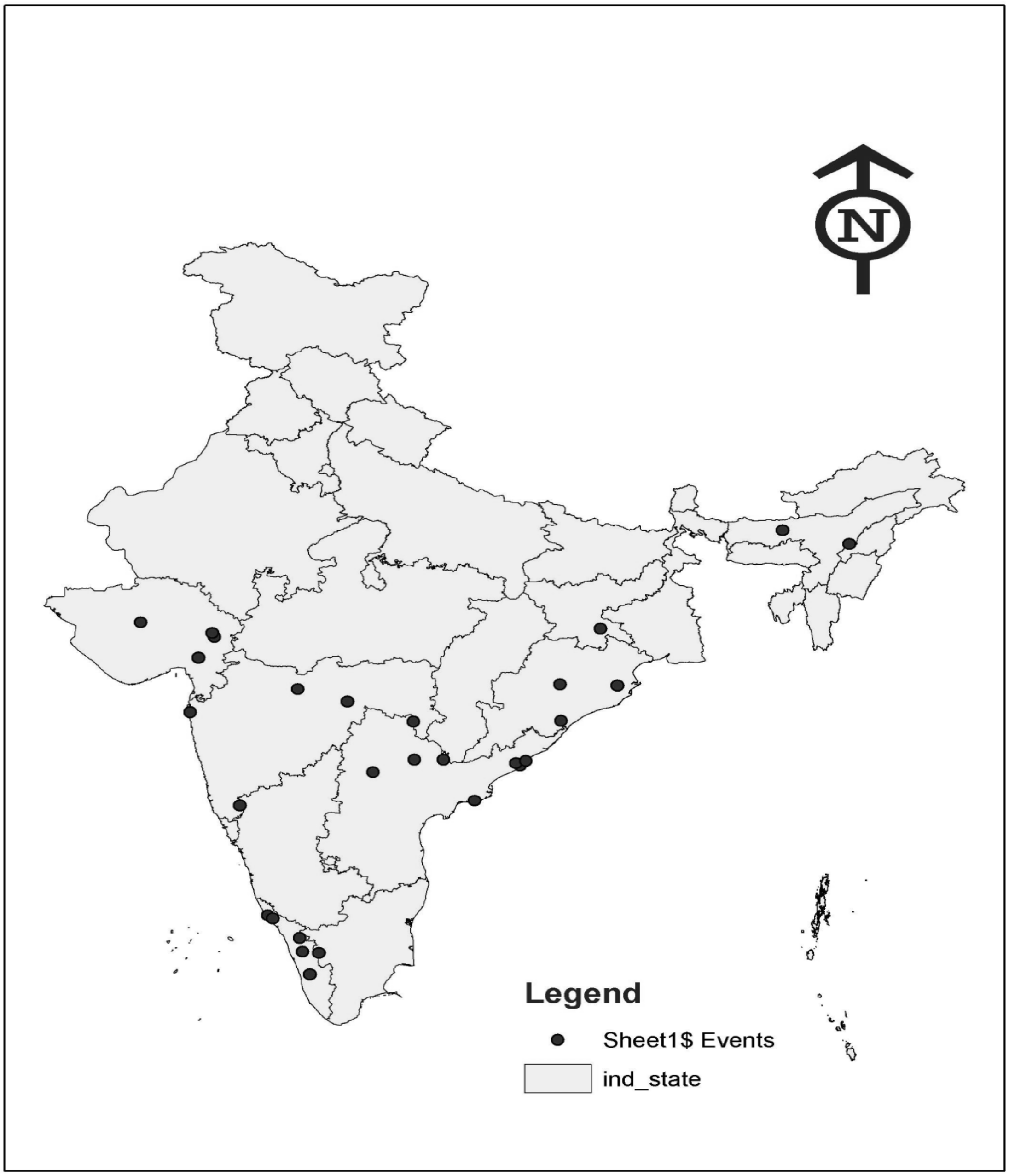

Fig 3 : Automatic Weather Stations covered in the study area.

Statistical Analysis: Statistical Analysis carried out by calculating the Regression Coefficient R^2 and Regression line by plotting graph with respect to time of these parameters (L.S.T. and Air temperature). At each station the maximum air temperature, maximum land surface temperature, minimum air temperature, minimum land surface temperature, values were taken and tabulated. The Regression line is drawn through the points on the scatter plot to summarizes the relationship between the land surface temperature and air temperature is being studied. It gives the regression equation on the scatter plot. For example January month data provided below.

Table 1: Maximum Air temperature vs. LST on 15th Jan'2012 (day time) in different states of India.

S.No:	Name of the station	Name of the state	Max. LST(^{0}c)	Max. Air temp.(^{0}c)	Difference (^{0}c)
1	ISRO1106_15F452 (Rangiya Degree College. Rangiya)	ASSAM	19.58	21.8	-2.22
2	ISRO894_15F37E (The Tahsildar-Narsampet Mandal-)	ANDHRA PRADESH	38.47	28	10.47
3	ISRO006_15F006(TIFR Balloon facility Hyderabad)	ANDHRA PRADESH	43.24	26.5	16.74
4	ISRO161_15F0A1(AF Kankol Kannur)	KERALA	36.79	32.3	4.49
5	ISRO162_15F0A2(DF Thallparamba Kannur)	KERALA	36.17	32.7	3.47
6	ISRO147_15F093(DAF Neriyamangalam Eranakulam)	KERALA	31.83	33	–1.17
7	ISRO789_15F315(TASILDAR OFFICE BEJJUR)	ANDHRA PRADESH	37.25	32.2	5.05
8	ISRO301_15F12D(ASI Pavagadh Hallol Godhra)	GUJARAT	37.3	28.7	8.6
9	ISRO508_15F1FC(ARS Buldhana Buldhana)	MAHA RASHTRA	36.78	23.5	13.28
10	ISRO084_15F054(Dhimapur)	NAGALAND	22.89	22.7	0.19
11	ISRO699_15F2BB(B.D.O.-PanchayatSamithi Office- DIGAPAHANDI)	ORISSA	31.64	27.1	4.54

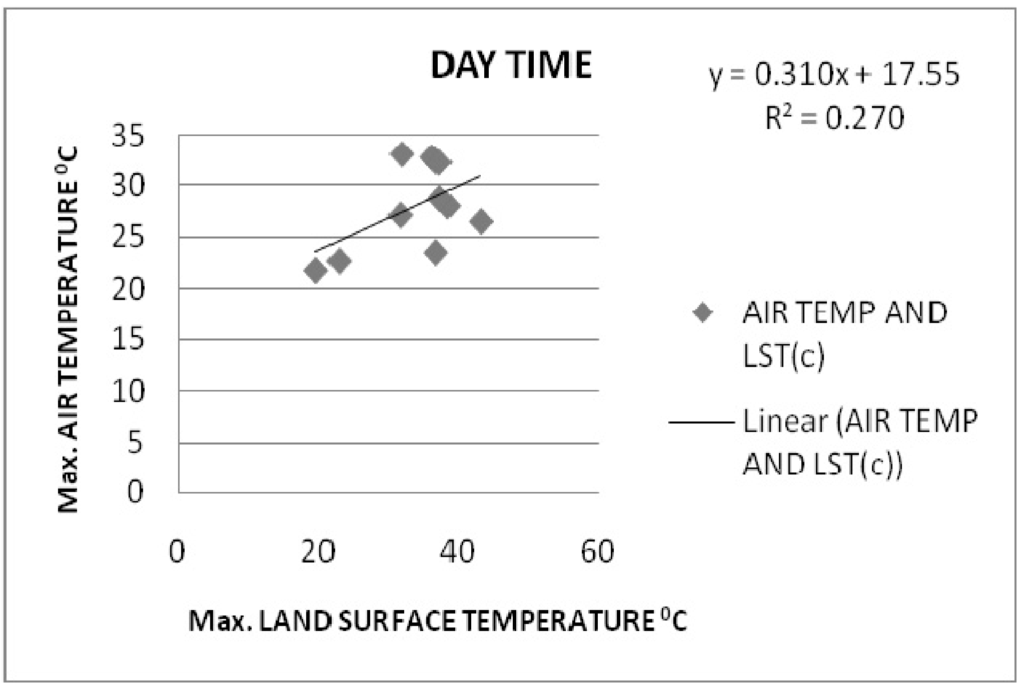

Figure 4: Regression analysis of Maximum Air temperature and Maximum LST on Jan15th, 2012

Table 2: Minimum Air temperature vs. LST on 15th Jan'2012 (night time) in different states of India

S.No:	Name of the station	Name of the state	Min. LST(^{0}c)	Min. Air temp.(^{0}c)	Difference (^{0}c)
1	ISRO1106_15F452 (Rangiya Degree College. Rangiya)	ASSAM	4.1	8.3	–4.2
2	ISRO894_15F37E(The Tahsildar-Narsampet Mandal-)	ANDHRA PRADESH	8.07	10.1	–2.03
3	ISRO006_15F006(TIFR Balloon facility Hyderabad)	ANDHRA PRADESH	7.67	12	–4.33
4	ISRO161_15F0A1(AF Kankol Kannur)	KERALA	19.31	19.4	–0.09
5	ISRO162_15F0A2(DF Thallparamba Kannur)	KERALA	18.56	18.1	0.46
6	ISRO147_15F093(DAF Neriyamangalam Eranakulam)	KERALA	13.03	20	–6.97
7	ISRO789_15F315(TASILDAR OFFICE BEJJUR)	ANDHRA PRADESH	5.6	6.5	–0.9
8	ISRO301_15F12D(ASI Pavagadh Hallol Godhra)	GUJARAT	9.48	9.8	–0.32
9	ISRO508_15F1FC(ARS Buldhana Buldhana)	MAHA RASHTRA	7.34	8.3	–0.96
10	ISRO084_15F054(Dhimapur)	NAGALAND	3.52	7.7	–4.18
11	ISRO699_15F2BB(B.D.O.-PanchayatSamithi Office- DIGAPAHANDI)	ORISSA	10.19	10	0.19

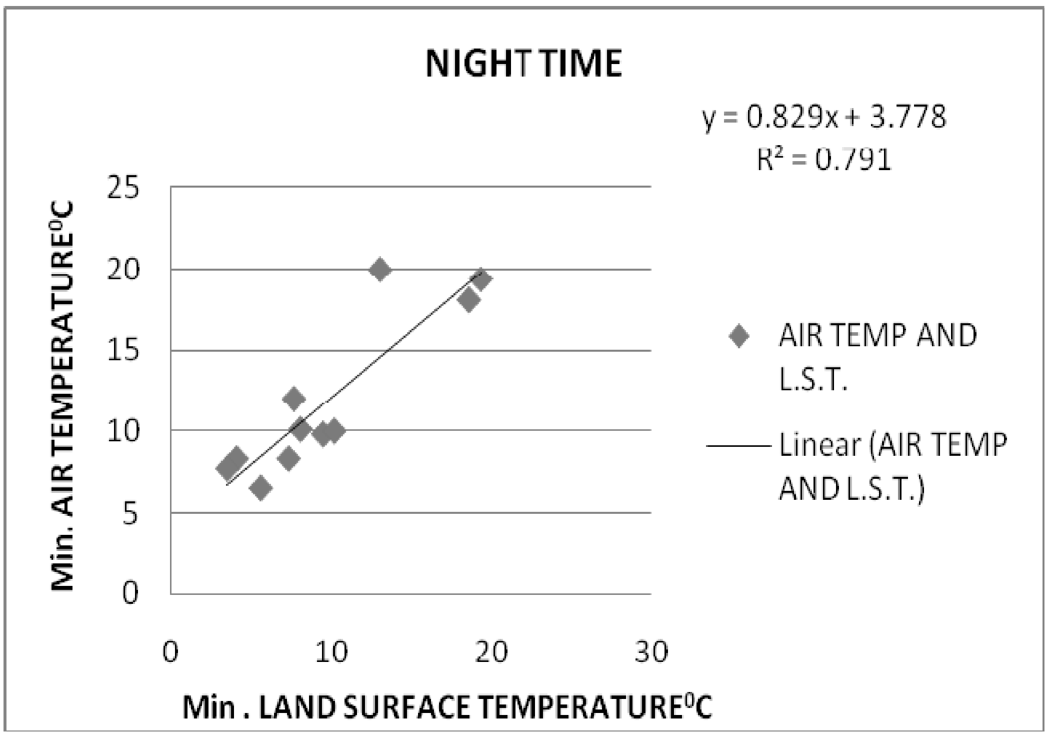

Figure 5: Regression analysis of Min. Air temperature and Min. LST on 15th Jan' 2012

Table 3: R^2 values and Regression line equations

S.No.	Min. L.S.T-Min. Air Temp. ^{0}C		Night Time
	Month Name	**R² Value**	**Regression line Equation**
1	JANUARY	0.79	y = 0.829x + 3.774
2	FEBRUARY	0.25	y = 0.430x + 13.16
3	MARCH	0.18	y = -0.073x + 21.17
4	APRIL	0.17	y = 0.345x + 18.64
5	MAY	0.38	y = 1.619x + 17.37
6	NOVEMBER	0.22	y = 0.465x + 9.386
7	DECEMBER	0.42	y = 0.774x + 6.522
S.No.	**Max. L.S.T-Max. Air Temp. ^{0}C**	**R² Value**	**Day Time**
	Month Name		Regression line Equation
1	JANUARY	0.27	y = 0.310x + 17.55
2	FEBRUARY	0.09	y = 0.122x + 28.09
3	MARCH	0.26	y = 0.128x + 29.54
4	APRIL	0.05	y = 0.198x+35.07
5	MAY	0.37	y = 0.223x + 29.23
6	NOVEMBER	0.35	y = 0.128x + 24.76
7	DECEMBER	0.24	y=0.230x+ 19.77

Table No 4: Latitude and Longitude of Automatic Weather Stations

S.No	Name of the Station	Name of the State	Latitude	Longitude
1	ISRO1106_15F452 (Rangiya Degree College. Rangiya)	ASSAM	26.42	91.61
2	ISRO894_15F37E(The Tahsildar-Narsampet Mandal-)	ANDHRA PRADESH	17.93	79.89
3	ISRO006_15F006(TIFR Balloon facility Hyderabad)	ANDHRA PRADESH	17.46	78.58
4	ISRO161_15F0A1(AF Kankol Kannur)	KERALA	12.15	75.23
5	ISRO162_15F0A2(DF Thallparamba Kannur)	KERALA	12.05	75.38
6	ISRO147_15F093(DAF Neriyamangalam Eranakulam)	KERALA	9.96	76.56
7	ISRO789_15F315(TASILDAR OFFICE BEJJUR)	KERALA	19.34	79.86
8	ISRO301_15F12D(ASI Pavagadh Hallol Godhra)	GUJARAT	22.48	73.53
9	ISRO508_15F1FC(ARS Buldhana Buldhana)	MAHA RASHTRA	20.53	76.19
10	ISRO084_15F054(Dhimapur)	NAGALAND	25.91	93.73
11	ISRO699_15F2BB(B.D.O.-PanchayatSamithi Office-DIGAPAHANDI)	ORISSA	19.38	84.56

RESULTS

Low values of Regression Co-efficient at some of the stations indicate that the Air temperature and land surface temperature data is not cloud free. The results suggests that the relationship between L.S.T. and Air temperature can vary with the location, due to different materials existing on ground, and other atmospheric parameters. Thus it requires a locally developed relationship. More data can give better equations. It also indicates that the other atmospheric parameters such as soil moisture, humidity, wind direction, precipitation factors, and vegetation etc. parameters plays vital role in getting better results. The present work can be extended for all the grids of India by maintaining the Temperature data base it is quite useful for Meteorological, hydrological, ecological and Agricultural studies. Land surface temperature database is also useful to the farmers to evaluate water requirements during which the crops are prone to heat stress in summer. Conversely, in winter, the database can help farmers to determine where and when fruit groves could have been exposed to damaging fog. By including other atmospheric parameters like vegetation index, soil type, altitude, soil moisture, etc. the analysis further yields good results. By analyzing land surface temperature obtained from different satellites will also make the analysis more precise. This data base quite help full to quantify surface's heat and water fluxes, monitor drought conditions and crop health, assess soil moisture content, map geological features, assess water quality etc.

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Rainfall-Runoff Modeling – A Geomatic Approach

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ABSTRACT

The Soil Water Assessment Tool (SWAT) model in GIS as an interface is parameterized and simulated for runoff of study area of the Godavari River sub basin in Adilabab, Andhra Pradesh with delineated area of 258245.79 Ha. The model divided study area into 35 sub basin and 107 Hydrological Response Units. The study area has stimulated by giving the parameters such as Soils, Landuse/Landcover, Precipitation, Temperature, etc., as input files for effects of land use on runoff volumes with daily time step for the periods 2006 to 2010. The model has shown that trend of both yearly simulated runoff and observed runoff indicated increasing trend over the study area. All the hydrological parameters which are spatially and temporally variable were given as input files and found to be more accurately estimated through DEM and GIS with SWAT. The results of SWAT model adequately predicted the runoff volumes of the watershed and compared against observed for 5 years annual surface runoff of sub basin for years 2006 to 2010 are 51.48%, 48.21%, 44.45%, 44.87% and 58.17% respectively of the annual effective rainfall. The simulated runoff registered variation owing to the predominant rocky and land use/land cover being a forest with 73% of the study area. The difference between simulated runoff and observed runoff variance for the above corresponding durations are 9.72%, 9.88%, 10.40%, 9.49% and 8.29% respectively. Present study demonstrated that GIS is found to be flexible to apply on large areas, enables gathering of all data in a common data base for spatial analysis and watershed characterization. This study has demonstrated that this SWAT model is a useful tool for predicting the runoff in watersheds.

Keywords: SWAT, Watershed, Streamflow, Hydrology, Geo-Information Systems

INTRODUCTION

Water is one of the most essential elements for life and indisputably sought after for industrial development. Water is one of natural resources and very complex to manage and maintain due to its dynamic behavior in nature. The global water resources are scarce and are greatly diversified in form, space and time and also depleting day by day due to indiscriminate use for ever increasing population and industrialization of world. Therefore it is essential to address the issues and challenges for sustainable development of water resources by scientifically approached methods with advanced technology. In this context, watershed based development and management approach has proven its effectiveness and efficiency. The watersheds are geo-physical areas considered to be ideal, logical and scientific hydrologic units for effective and efficient planning, development and management of land and water resources. The watershed based resources development and management is therefore necessary to plan, develop and conserve the available natural resources for sustained development and ecological balance of the globe. The calibration and validation approach used in this study is different from the above studies. The specific objectives of this study are to conduct: (1) a spatially distributed calibration of long-term average annual runoff at sub watershed level in a regional scale river basin to capture the spatial variation in runoff in different parts of the river basin, and (2) a temporal validation of stream flow at key locations (gauge) along the river. For integrated soil and water management practices, both vegetative as well as structural control measures are essential and control measures to be planned and undertaken, thorough knowledge of runoff at micro level becomes essential. Keeping these points in view, a GIS based semi distributed SWAT Model has been used in the present study for predicting runoff of Kaddam watershed of Middle Godavari sub Basin of Godavari River, Adilabad district of Andhra Pradesh, India with the following objectives.

SCOPE AND OBJECTIVES OF THE PROJECT WORK

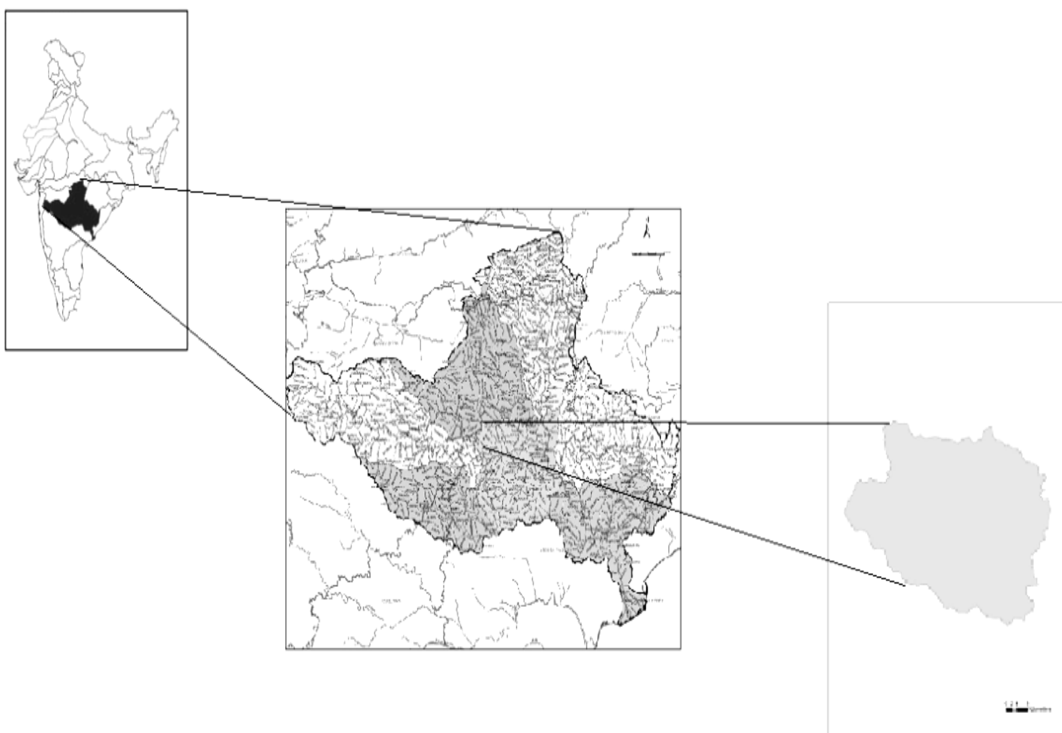
The following are the scope and objectives:

1. To prepare the Geo-Spatial database of Land Use/ Land Cover, and soils in GIS environment.
2. To down load and prepare DEM for study area from SRTM.
3. To delineate Watershed/catchment in GIS environment with SWAT tool.
4. To carry out analysis of observed runoff at basin level for the study area.
5. To determine daily runoff at HRU level using this model.
6. To compare the simulated runoff from this model with observed runoff at basin level.

Study Area

The river Godavari sub basin (G5-middle Godavari) along with its tributaries, physiographic, climatic parameters and basin rainfall were broadly outlined. The study area details of middle Godavari sub-basin such as topography, physiographic, geology, hydrogeology, climate, rainfall, meteorological parameters, Land Use / Land Cover details, cropping pattern etc., studied and analyzed over this sub basin. The sub basin lies between latitudes $18^{0}20^{'}$ and $19^{0}35'$ North and longitudes $77^{0}36^{'}$ and $79^{0}56^{'}$ East. The length of Godavari River in the sub-basin between the points of confluence with the rivers Manjira and Pranhita is 304 km. The major tributaries in this reach are Rallavagu, Gudivagu, Kaddam, Swarna, Siddha, Peddavagu and Phulanvagu.

The sub-basin has a catchment area of 17205 km^2 which is about 5.5 % of the total basin area. The catchment area of the Middle Godavari sub basin lies in the States of Andhra Pradesh and Maharashtra. However, in the present study, Middle Godavari sub basin has been considered up to Kaddam reservoir only as shown in Fig. 1. The geographical area of the study area is 2, 584.46 sq km.



METHODOLOGY

The methodology for the preparation of several maps such as DEM, Slope map has been dealt within the following sections. Further, delineation of watershed boundary, extraction of soil map and drainage map are also discussed.

Digital Elevation Models (DEM)

A DEM is a raster representation of a continuous surface, usually referring to the surface of the earth. The DEM is used to refer specifically to a regular grid of spot heights. It is the simplest and most common form of digital representation of topography. The Digital Elevation model for the study area was generated from the contour map using Surface Analysis tool of Spatial Analyst in Arc Map.

Slope Map

The Slope function in Arc GIS 9.3 calculates the maximum rate of change between each cell and its neighbors. Every cell in the output raster has a slope value. The lower the slope value indicates the terrain is flatter and the higher the slope value, the steeper the terrain. The output slope raster can be calculated either in percent of slope or degree of slope. Slope map was prepared from the DEM.

Delineation of Watershed Boundary Map

A watershed is geo-physical area contributing flow to a given location. Such an area may also be referred to as a basin/catchment/contributing area. A sub basin is simply part of a hierarchy, implying that a given sub basin is part of a larger watershed i.e., a basin. G-5 sub basin was delineated by Arc SWAT watershed delineation tool from DEM by computing the flow direction with interface of Arc Map module in Arc GIS 9.3.1. The watershed function uses a raster of flow direction to determine contributing area. Flow accumulation threshold or the pour points were used to delineate watersheds. When the threshold is used to define a watershed, the pour points for the watershed will be the junctions of a stream network derived from flow accumulation. Therefore, a flow accumulation raster was specified as well as the minimum number of cells that constitute a stream. When a feature dataset is used to define a watershed, the features identify the pour points.

Extraction of digitized soil map

The soil map was collected from National Bureau of Soil Survey and Land Use, Nagpur which was prepared on a scale of 1:5,00,000. The collected soil maps were scanned and registered with tic points and rectified. Further, the rectified maps were projected. All individual projected maps were finally merged as a single layer. Later, the delineated study area map of sub basin was overlaid on projected soil map and finally, soil map pertaining to the study area was thus extracted in GIS environment. Boundaries of different soil textures were digitized in ARC/INFO and the polygons representing soil classes were assigned different colors for reorganization of hydrologic soil groups. Now, the already prepared Thiessen polygon coverage was overlaid on the extracted soil map of the study area to bring out sub areas in the soil map and to classify soil types in each sub area of the middle Godavari sub basin in GIS environment.

Mandal administrative map

The study area falls entirely in Adilabad district of Andhra Pradesh, India. Mandal boundaries in Adilabad district were digitized, registered, rectified, projected and also merged. The study area boundary was overlaid on merged Mandal map to extract Mandal administrative boundaries in the study area.

RESULTS AND ANALYSIS

The results and analysis pertaining to viz., watershed parameters evaluated through GIS environment with SWAT interface, Watershed characterization, Land Use / Land Cover and Rainfall and Runoff for the study area of Godavari sub basin were analyzed and discussed. Analysis between rainfall and runoff estimated with the SWAT Model watershed approach has been discussed in details.

ANALYSIS OF WATERSHED PARAMETERS

Watershed parameters of the study area were evaluated using Arc GIS 9.3.1 with interface of SWAT Model 2009 of Godavari sub basin/watershed was auto delineated by using SWAT Tool by using the DEM as an input and also Slope map, Drainage network map, Soil map, Land Cover/Use map and Watershed map were produced in GIS environment. From the prepared Slope map, the maximum and minimum elevations in the study area were found to be 350 m and 160 m. Slope map indicated very mild slope for the study area with average slope less than 2.55%. Similarly from the soil map, areas of different soil covered in the study area. The soil unit 63 is found to be predominant in the study area. The total watershed study area is predicted by the SWAT 2009 is 2582.46 Sq. km.

LAND USE / LAND COVER & SOIL ANALYSIS

The study area's thematic map of Land Use/Land Cover has been prepared using ERDAS 8.7. The land Use/Land Cover classes were estimated using Normalized Difference Vegetation Index (NDVI) approach. Satellite imageries pertain to the dates 22-12-2006 and 28-05-2006. Two of them pertain to Rabi season and another related to summer season. Land Use/Land cover map was prepared for Rabi season for the year 2006. Similarly, Land Use/ Land cover map was prepared for the year 2006 corresponding to Kharif season. Study area has been classified into five classes' viz., Water bodies, Crop land, Bare soil, Fallow land with bushes and Forest based on NDVI values for Land Use / Land Cover classification. This is used as input file of LU/LC and also Soil input files in the SWAT model 2009. The LU/LC and type soils are two major factors which effect runoff in sub basin.

RAINFALL ANALYSIS

The rainfall data of 8 rain gauge stations at Khanapur, Kaddam, Neredigonda, Boath, Ichoda, Utnoor, Indravelly, and Bazarhatnoor have collected from Revenue department for the duration of 2006 to 2010 of study area of Godavari Sub basin. The daily rainfall in sub basin tabulated of the eight rain gauge stations located study area form an input file RGStations with Latitude and Longitude to locate them in the study area. The SWAT interface use this rainfall data and land use and land cover for simulation of runoff prediction as shown table 2. The annual rainfall in the years 2006 to 2010 in sub basin are 1259.65 mm, 806.96 mm. 525.47mm, 660.23mm and 1268mm.

ANALYSIS OF RAINFALL AND SIMULATED RUNOFF WITH SWAT MODEL

Runoff has been simulated by SWAT Model with daily time step for the study area at sub basin level. This Model divided the study area into 35 sub basin and 104 Hydrological Response Units (HRUs). Basin level simulated runoff has been compared with basin rainfall in table 1 & 2 month wise as well as yearly for the base periods 2006 to 2010. The effective rainfall which caused the annual runoff of sub basin from years 2006 to 2010 are 51.48%, 48.21%, 44.45%, 44.87% and 58.17% respectively of annual rainfall. The simulated runoff did register much variation owing to the predominant land use/land cover class being forest with 73% of the study area.

ANALYSIS OF SIMULATED AND OBSERVED RUNOFF

The monthly runoff data was collected for a period 2006 to 20010 for same period of the rainfall data. The model simulated with daily step, runoff data was processed and converted to monthly and yearly runoff for further analysis. The monthly simulated runoff and observed runoff were shown in tables 3 & 4. For comparison and analysis of observed runoff with simulated runoff of SWAT model presented. And also year wise simulated and observed runoffs represented for differentiation between yearly simulated and observed runoffs. It is found that simulated and observed runoffs in the study area differ among them 9.72%, 9.88%, 10.04%, 9.49% and 8.29% respectively for 2006 to 2010. This variation may have caused due to the other small ditches storages or in observed runoff.

Table 1 Monthly Rainfall & Simulated Runoff

S.No	Month	Year 2006		Year 2007		Year 2008		Year 2009		Year 2010	
		Rain-fall	Simulated Runoff	Rainfall	Simulated Runoff	Rain-fall	Simulated Runoff	Rainfall	Simulated Runoff	Rain-fall	Simulated Runoff
1	Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.53	5.50
2	Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.81	0.64
3	Mar	71.85	18.56	0.00	0.00	40.67	10.31	0.34	0.00	5.91	0.33
4	Apr	25.05	7.80	0.00	0.00	3.57	0.80	0.00	0.00	4.15	0.63
5	May	36.64	10.27	0.00	0.00	0.00	0.00	0.76	0.00	0.81	0.19
6	Jun	219.01	104.74	154.04	64.20	143.20	63.68	127.66	62.52	136.34	55.40
7	Jul	302.17	164.95	189.62	102.61	193.06	90.30	150.34	59.33	433.01	278.70
8	Aug	292.36	175.56	198.12	90.78	131.66	64.33	184.14	81.74	395.55	250.03
9	Sept	273.06	147.21	231.76	116.09	12.94	4.13	140.07	72.18	252.54	155.00
10	Oct	33.75	17.74	24.18	12.81	0.37	0.00	24.74	7.71	13.21	4.45
11	Nov	5.75	1.69	9.24	2.54	0.00	0.00	31.18	12.75	0.00	0.00
12	Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Total		**1259.64**	**648.52**	**806.96**	**389.03**	**525.47**	**233.55**	**660.13**	**296.23**	**1268.86**	**750.87**

Note: Rainfall & Simulated Runoffs are in 'mm'

Table 2 Yearly Rainfall & Simulated Runoff

Yearly Rainfall and Simulated Runoff			
S.No	**Year**	**Rainfall(mm)**	**Simulated Runoff(mm)**
1	2006	1259.65	648.52
2	2007	806.96	389.03
3	2008	525.47	233.55
4	2009	660.13	296.23
5	2010	1268.86	750.87

Table 3 Monthly Simulated & Observed Runoff

S.No	Month	Year 2006		Year 2007		Year 2008		Year 2009		Year 2010	
		Simulated Runoff	Observed Runoff	Simulated Runoff	Observed Runoff	Simulated Runoff	Observed Runoff	Simulated Runoff	Observed Runoff	Simulated Runoff	Observed Runoff
1	Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.50	3.16
2	Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.15
3	Mar	18.56	12.54	0.00	0.00	10.31	7.25	0.00	0.00	0.33	0.02
4	Apr	7.80	4.03	0.00	0.00	0.80	0.00	0.00	0.00	0.63	0.05
5	May	10.27	9.45	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00
6	Jun	104.74	98.53	64.20	58.65	63.68	57.13	62.52	56.02	55.40	46.24
7	Jul	164.95	153.05	102.61	96.61	90.30	85.67	59.33	55.56	278.70	263.80
8	Aug	175.56	168.15	90.78	82.59	64.33	59.08	81.74	78.62	250.03	235.62
9	Sept	147.21	138.57	116.09	108.35	4.13	3.11	72.18	67.18	155.00	142.26
10	Oct	17.74	13.19	12.81	7.48	0.00	0.00	7.71	4.35	4.45	2.05
11	Nov	1.69	0.83	2.54	0.98	0.00	0.00	12.75	8.82	0.00	0.00
12	Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		**648.52**	**598.34**	**389.03**	**354.66**	**233.55**	**212.24**	**296.23**	**270.55**	**750.87**	**693.35**

Note: Simulated & Observed Runoffs are in 'mm'

Table 4 Yearly Simulated & Observed Runoffs

S.No	Year	Simulate Runoff(mm)	Observed Runoff(mm)
1	2006	648.52	598.34
2	2007	389.03	354.06
3	2008	233.55	212.24
4	2009	296.23	270.55
5	2010	750.87	693.35

CONCLUSIONS

The specific conclusions have been listed out regarding watershed parameters, watershed characterization, land use/land cover, rainfall, observed runoff, simulated daily runoff from watershed model. The Arc SWAT model was parameterized and has calibrated study area, a part of Godavari River sub basin in Adilabad in Andhra Pradesh with an aggregate area of 258245.79 ha. The sub basin has been simulated by giving the parameters such as Soils, Landuse/Landcover, Precipitation, Temperature, etc., as input files to determine effects of land use on runoff volumes with daily time step for the periods 2006 to 2010. The specific conclusions drawn from the present study are as follows.

The model has shown that trend of both yearly simulated runoff and observed runoff showed increasing trend over the study area. All the hydrological parameters which are spatially and temporally variable were as input files found to be more accurately estimated through DEM and GIS with SWAT. The simulated runoff was estimated for the sub Basin of Godavari River for 2006 to 2010 are 51.48%, 48.21%, 44.45%, 44.87% and 58.17% respectively of annual rainfall from watershed hydrological model. The simulated and observed runoffs results of the SWAT model has shown a variance of 9.72%, 9.98%, 10.04%, 9.49% and 8.29% respectively for 2006 to 2010. This variation might have been caused due to the other small ditches storages or in observed runoff. Present study demonstrated that GIS is found to be flexible and is relatively easy to apply on large areas enabling gathering of all data and information in a common data base for spatial analysis and watershed characterization. The runoff registered much variation owing to the predominant land use/land cover class being forest with 73% of the study area. The present study demonstrated how GIS and SWAT model and remote sensing data can assist to predict run off volume. Wide scope of applying Geo-Informatics has been presented in the present work.

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THEME - II

CLIMATE CHANGE AND ENVIRONMENT

Water Resources Assessment due to Climate Change Impacts

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ABSTRACT

General Circulation Model (GCM) data obtained at global scale for different climate change scenarios are downscaled to river basin scale using Support Vector Machine (SVM). Geographical Information System (GIS), remote sensing and Digital Elevation Model (DEM) are used along with GCM downscaled data in assessing the impact of climate change on water resources using ArcView Soil and Water Resources Assessment Tool (AV-SWAT).Catchment of Malaprabha reservoir in Karnataka state of India is chosen for demonstration.

INTRODUCTION

There is growth in scientific evidence about global climate change. Since, hydrological processes are sensitive to climate variability and change, understanding linkages between the climate and the hydrological processes and their feedbacks becomes critical for sustainable management of water resources, environmental quality, economic development and social well-being. Understanding the aforementioned linkages will not only increase the awareness of how the hydrological systems may change over the coming century, but also prepare us for adapting to the impacts of climate change on water resources. So any holistic integrated and environmentally sound sustainable management of the available water resources in climate change scenario is intimately linked to the ability to adequately assess them. Water resources assessment (WRA) involves determination of the sources, extent, dependability and quality of water resources for their proper utilization and control. Here water resources are defined as the water available, or capable of being made available, for use in sufficient quantity and quality at a location and over a period of time appropriate for an identifiable demand (UNESCO and WMO, 1992). The past experience suggests that it is easier to assess the water resources of a river basin or aquifer framework rather than for jurisdictional or economic regions (UNESCO and WMO, 1997).

Impact of climate change on hydrology

The impacts of climate change on the hydrology of a region include:

(i) Changes in the concentrations of greenhouse gases in atmosphere that are expected to alter the radiative balance of atmosphere, causing changes in temperature. Associated with these changes are those in precipitation patterns and other climate variables.

(ii) Changes in water balance, owing to changes in the various components of hydrologic cycle (such as runoff, evapotranspiration, soil moisture, infiltration and groundwater recharge) and their feedbacks. Consequently, the natural ecosystems such as forests, pastures, deserts, mountain regions, lakes, streams, wetlands, coastal systems and oceans may face difficulties in adapting to the changes, and may lose some of the flora and fauna. The hydrological cycle may be intensified, with more evaporation and consequent higher precipitation.

(iii) Changes in precipitation, which could be in its amount, spatial distribution, intensity (temporal distribution) and frequency. Every one of these affects the magnitude and timing of runoff, which in turn affects the frequency and intensity of hydrologic extremes such as floods and droughts.

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(iv) Alterations in river discharges that have implications on safety and performance of water resources systems. For example, reduced inflow into a reservoir would cause deficits in meeting demands and economic loss.

(v) Variations in temperature which have affect on soil moisture evaporation, evapotranspiration, desertification processes and environmental degradation. Warming of lakes and rivers in the region will have affect on thermal structure and water quality. Apart from temperature, the other factors that affect the evaporative demand of atmosphere include vapor-pressure deficit, wind speed and net radiation.

(vi) Changes in wind speed. The ill effects of high wind speed include increase in the rate of evaporation of water, increase in aridity, poor crop growth and reduction in yield due to mechanical damage to crops (e.g., stripping of leaves, abrasion in plant canopies through rubbing).

(vii) Variation in relative humidity that can have consequences on crop growth and yield, pests, diseases, evaporation and evapotranspiration.

WRA of a region involves a detailed study of the surface as well as sub-surface water availability through integration of the surface and sub-surface water data. This, however, requires thousands of man-hours due to the vastness of the data to be handled. . In facing this predicament, the Geographic information system (GIS) software proves to be a powerful tool. The software is useful in building hydrologic information systems that synthesize geospatial and temporal water resources data to support hydrologic analysis and modeling for WRA.

Role of GIS in WRA

GIS is not only a computer based spatial database system, capable of gathering, storing, manipulating, analyzing and disseminating geographical data but also, in a wider sense, is a data system which facilitates management of the environment for its sustainable development.

GIS has been able to capture the synergy between the time series data on hydrological, hydrometeorological, and hydrogeological variables covering water properties and the geospatial data on water environment encapsulating the water resources features of the landscape for a better WRA. Hence GIS can play an important role in WRA.

The first stage of WRA involves collection, processing and inventorying the existing hydrological and auxiliary data. GIS could be used to integrate and relate any data with a spatial component, regardless of the source of the data. The tools available in GIS facilitate data creation, relating data from different sources, data representation, handling non-spatial data and digitization, conversion of existing digital information (such as digital satellite images generated through remote sensing), which may not yet be in map form, into forms which can be recognized and used (e.g., map-like layers of digital information about vegetative cover, drainage network).

The second stage of WRA involves application of techniques such as hydrological modeling and regionalization to extract technical information from the water resources data. The most commonly used technique is the estimation of water balance in river basins by modeling various components of the water cycle based on the existing methods/models. GIS with its features such as presentation of data, topological, network and cartographic modeling, map overlay, and geostatistics is a useful tool in the second stage of WRA.

In the final stage of WRA, GIS is used to extract and organize model output data for charting and display. GIS is useful for better visualization of the outputs from the methods/models selected for the study and analysis of results which provide information about the characteristics of the existing water resources, stress on the water resources if any, and problems due to natural and man-induced factors, mismanagement etc. Results of such analysis would be useful to anticipate future conditions of water due to climate change either to decide a suitable course of action, or to evaluate the results of an action or policy.

Role of Digital Elevation Models (DEMs) in WRA

A high resolution DEM can be used as the basic spatial data source for defining the hydrography of a region. Studies have demonstrated the feasibility of delineating drainage basins and extracting topographic information such as slope, drainage divides, drainage networks, and morphometric properties (e.g., area and perimeter) of drainage basins from DEM. The information extracted is easy to access, precise and reproducible than that determined by applying traditional manual techniques on topographic maps. Further, these techniques find more use in extracting information from large watersheds (greater than 10 km^2), where manual determination of drainage network and sub-watershed features is a tedious, time-consuming, error-prone and often highly subjective process.

Role of Remote Sensing in WRA

Remote sensing is the act of collecting data about an object from a distance without physically contacting the object. The methods of remote sensing such as SONAR (SOund NAvigation Ranging which can be used for mapping ocean floor, water quality etc.), RADAR (RAdio Detection And Ranging which can be used for measuring rain, snow etc.), satellite imagery (which can be used for detection of vegetation change, land use etc.) have become sources of observed data, in addition to those that have been collected through direct contact with the source. Thus remote sensing, coupled with numerical models provides unique tools to improve the appraisal of climate change by developing techniques to monitor and model environmental and climate change processes. This highly synthesized information is needed for sustainable WRA.

With increase in population, the demand for freshwater for domestic, industrial and agricultural uses definitely increases. This situation makes it prudent to assess the variability of hydrological processes due to the projected future changes in climate and population, and develop sustainable water management strategies to meet the projected water requirements.

The primary objective of this paper is to demonstrate the use of GIS, DEM and remote sensing in assessing the impact of climate change on water resources through a case study of rainfall-runoff simulation using AVSWAT. Catchment of Malaprabha reservoir in Karnataka state of India is chosen for demonstration.

SWAT and AVSWAT

The Soil and Water Assessment Tool (SWAT) is selected for rainfall-runoff prediction, as this model has been widely used in hydrology. SWAT is a river basin scale hydrological model developed for the United States Department of Agriculture (USDA), Agricultural Research Service. Being a physically based, semi-distributed, continuous time model, it requires numerous inputs and parameters that represent weather, hydrology, soil properties, plant growth, nutrients, pesticides, bacteria and pathogens, and land management. Since its development in the early 1990s, SWAT has undergone continual review and expansion of capabilities. The schematic flow of the SWAT model is provided in Fig. 1. In SWAT, a watershed is divided into multiple subwatersheds, which are then further subdivided into hydrologic response units (HRUs) that consist of homogeneous land use, management, and soil characteristics. The overall hydrologic balance is simulated for each subwatershed.

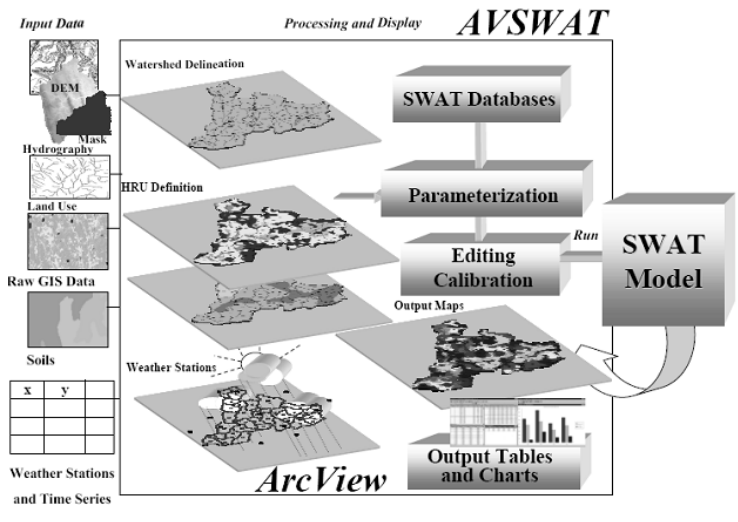

Fig. 1 Schematic of AVSWAT (Di Luzio et al., 2002)

The SWAT model simulates streamflow using the modified SCS runoff curve number method (USDA-NRCS, 2004) or the Green-Ampt method. To apply the SWAT model for streamflow estimation, the observed (historical) and downscaled future climate variables, namely precipitation, maximum and minimum temperature, wind speed and relative humidity, are used as inputs in addition to other processed inputs such as DEM, land use and soil map (obtained using satellite information). The ArcView GIS interface of SWAT (AVSWAT) provides an easy-to-use graphical user interface for organizing all the required inputs. Delineating the sub-watershed boundaries, defining the HRUs, generating SWAT input files, creating agricultural management scenarios, executing SWAT simulations, and reading and charting of results were all carried out by the various tools available in the interface.

Study region and data used

As a case study, the catchment of Malaprabha reservoir in the Karnataka state of India is taken up. It has an area of 2564 km^2 situated between 15°30′ N and 15°56′ N latitudes, and 74°12′ E and 75°15′ E longitudes. The source of water for the catchment of Malaprabha reservoir is precipitation. This reservoir is chosen, as it is one of the major lifelines for the arid regions of north Karnataka (possibly the largest arid region in India outside the Thar desert). The reservoir supplies water for irrigation of 218,191 hectares in the districts of northern Karnataka. The location of the study region is shown in Fig. 2.

The meteorological data used for this study comprises of the recorded data at various stations, the reanalysis data extracted from database prepared by National Centers for Environmental Prediction (NCEP), (Kalnay et al., 1996), and data extracted from simulations by Canadian Center for Climate Modeling and Analysis's (CCCma) third generation Coupled Global Climate Model (CGCM3) for four scenarios prescribed in special report of emission scenarios (SRES) (Nakicenovic et al, 2000). Details of the data used are furnished in Table 1. The GCM data and the information on atmospheric fluxes are re-gridded to a common 2.5° NCEP grid using Grid Analysis and Display System (GrADS) (Doty and Kinter, 1993).

Land use/land cover map and soil map are procured from the Karnataka State Remote Sensing Application Center (KSRSAC), Bangalore, India, prepared based on panchromatic (PAN) and linear imaging self scanner (LISS) III merged, Indian remote sensing (IRS) satellite images. Modified data of Shuttle Radar Topography mission (SRTM) in the form of Digital Elevation Model (DEM) for the study region is procured from the International Water Management Institute (IWMI), Hyderabad, India. Topomaps of the study region are procured from Survey of India (SOI) at the available finest scale 1:50,000.

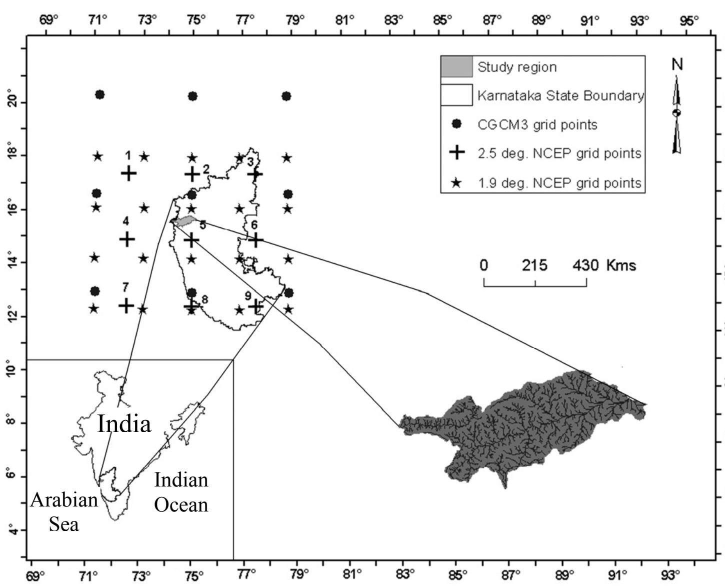

Fig. 2 Location of the catchment of Malaprabha reservoir in Karnataka state, India.

In Figure 2, latitude, longitude and scale of the map refer to the Karnataka state. The data extracted from CGCM3 at 1.9° grid points are re-gridded to the nine 2.5° NCEP grid points. Among the nine grid points 1, 4 and 7 are over Arabian Sea, and the remaining points are on land.

Sensitivity analysis was carried to refine the parameters of SWAT model. The development of the SWAT model involves calibration and validation phases. The data for the period January 1978-December 1993 is used for calibration (training) and the remaining data (January 1994 - December 2000) is considered for validation. The performance of SWAT model in generating streamflows was assessed for each of the parameter sets using the Pearson's correlation coefficient (Pearson, 1896) as a performance measure.

Table 1: Meteorological data used in the study

Data Type	Source of data	Period	Details	Time scale
Observed data of precipitation	Department of Economics and Statistics, Government of Karnataka (GOK), India	1971-2000	Data at 11 gauging stations are used to arrive at representative values of precipitation for the basin	Daily
Observed data of temperature, wind speed, relative humidity, and cloud cover	India Meteorological Department (IMD)	1978-2000	Data at 2 gauging stations namely Santhebasthewadi and Gadag	Daily
Observed data of streamflow	Water Resources Development Organization (WRDO), GOK, India	1978-2000	Data at one streamflow gauging station recording inflow into the Malaprabha reservoir	Daily
CGCM3 T/47 data on atmospheric variables	http://www.cccma.bc.ec.gc.ca/cgi-bin/data/cgcm3	Future: SRES A1B, A2, B1 & COMMIT – 2001 to 2100.	12 grid points for atmospheric variables, with grid box ≈ 3.75°. Latitudes range: 9.28°N to 20.41°N. Longitudes range: 71.25°E to 78.75°E	Monthly
NCEP re-analysis data of atmospheric variables	Kalnay et al. (1996)	1971-2000	9 grid points for atmospheric variables, with grid box 2.5°. Latitudes range: 12.5°N to 17.5°N. Longitudes range: 72.5°E to 77.5°E	Monthly
NCEP re-analysis data of atmospheric fluxes	Kalnay et al. (1996)	1971-2000	16 grid points for atmospheric fluxes with grid box 1.9°. Latitudes range: 12.3°N to 20.0°N longitude range: 71.6°E to 77.5°E	Monthly

Application of AVSWAT model

The runoff from the Malaprabha catchment was modeled using SWAT (Anandhi *et al*., 2010). The DEM data was processed using ArcView interface of SWAT**,** to obtain stream network in the study region. For this purpose, the minimum watershed area (CSA; critical source area) was specified as 210 hectares. Subsequently, the drainage basin outlets are fixed on the stream network through screen interactive option of the SWAT and the model was run forming 14 drainage sub-basins in the study region. The land-use/land-cover and soil maps of the region are overlaid on each other to identify Hydrological Response Units (HRUs). Subsequently, the data of observed climate variables are fed into the SWAT model and it is run to obtain streamflows.

In the calibration phase, the performance of SWAT is assessed by comparing runoff generated by the model at monthly time scale with that observed at the Malaprabha reservoir. The model, in general, over-predicted runoff for several months. This could be attributed to retention storage in natural depressions/tanks of the catchment, which goes unaccounted for in estimating inflows into Malaprabha reservoir every water-year. Sensitivity analysis revealed that curve number (CN), available water capacity (AWC) of soil, plant uptake compensation factor (EPCO) and the soil evaporation compensation factor (ESCO) are the sensitive parameters. The possible options to improve the model performance include decreasing the CN and increasing the AWC, EPCO and ESCO (Neitsch et al., 2002). In addition, the model was calibrated empirically to account for retention storage in the region. For each combination of these parameters, the streamflows obtained from the SWAT model are compared with those observed at the Malaprabha reservoir for the calibration period

(January 1978-December 1993), in terms of the performance measure (Pearson's correlation coefficient) to arrive at optimal set of parameters. Parameters thus obtained are used for the model validation. The correlation between SWAT generated and observed streamflows for the validation period (January 1994 - December 2000) was found to be 0.98. SWAT, being a physically based model, captures the relationships between climate features influencing hydrometeorology of the study region and the underlying mechanism governing streamflow generation in the study region.

The future climate variables for Malaprabha catchment are downscaled using support vector machine (SVM) model from large scale atmospheric variables simulated by the third generation, Canadian Coupled Global Climate Model (CGCM3) for SRES scenarios (which represent plausible future climates) namely A1B, A2, B1 and COMMIT (Anandhi 2007; Anandhi et al., 2008 and 2009). For this analysis, the other inputs to SWAT model, such as DEM, land use/land cover, and soil type are considered to be the same for the past and the future scenarios. The results indicate that on an annual scale, the streamflow is projected to increase during 2021-2100 for A1B, A2, and B1 scenarios, and during 2061-2100 for COMMIT scenario (Fig. 3). The projected increase in streamflow is high for A2 scenario, whereas it is least for B1 scenario. The scenario A2 has the highest concentration of equivalent carbon dioxide (CO_2) equal to 850 ppm, while the same for A1B, B1 and COMMIT scenarios are 720 ppm, 550 ppm and ≈ 370 ppm respectively. Rise in the concentration of equivalent CO_2 in the atmosphere causes the earth's average temperature to increase, which in turn causes increase in evaporation especially at lower latitudes. The evaporated water would eventually precipitate. Increase in precipitation results in increased streamflow. In the COMMIT scenario, where the emissions are held the same as in the year 2000, no significant trend in the projected future streamflow could be discerned.

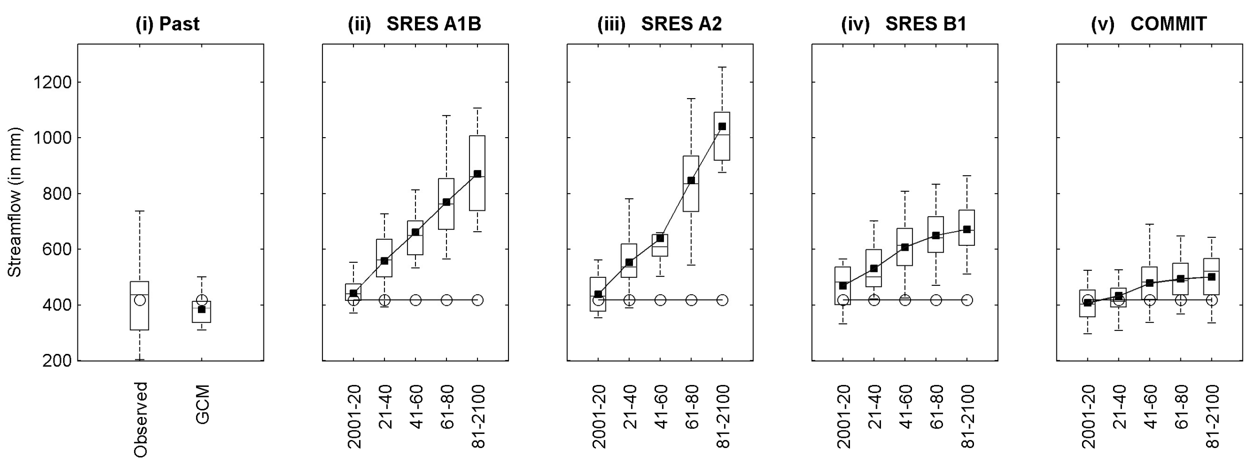

Fig. 3 Hydrological scenarios of annual streamflows obtained for IPCC SRES scenarios using SWAT model.

In Figure 3 (i), the horizontal line in the middle of the box represents median. The circles denote the mean annual value of observed streamflow, and the darkened square represents the mean annual value of simulated or projected streamflow. In (ii), (iii), (iv) and (v) the solid lines that join the circles indicate the historical trends of streamflow under stationary conditions, while the lines connecting the solid squares depict the mean trends of streamflow projected by CGCM3. GCM denotes streamflow obtained using downscaled meteorological variables obtained from GCM as input to SWAT for the past period (1978 to 2000). The future period is from 2001 to 2100.

SUMMARY AND CONCLUSIONS

GIS containing data, topological, network and cartographic modeling, map overlay and geostatistics techniques, is a useful tool for hydrologic modeling. DEMs used for delineating drainage basins and extracting topographic information such as slope, drainage divides, and drainage networks are useful for hydrologic modeling. Satellite remote sensing data provides information on land use/ land cover and soil for hydrologic modeling. These tools viz., GIS, DEM and remote sensing can be used to develop scenarios of future streamflow to study the impacts of climate change on the hydrology of a river basin. Their use is demonstrated through a case study of rainfall-runoff simulation in Malaprabha reservoir catchment of India using AVSWAT model.

The future climate variables are downscaled using SVM model from large scale atmospheric variables obtained from the third generation, Canadian Coupled Global Climate Model (CGCM3) for SRES scenarios (which represent plausible future climates) namely A1B, A2, B1 and COMMIT. For this analysis, the other inputs to SWAT model, such as DEM, land use/ land cover, and soil type are considered to be the same for the past and the future scenarios. The results indicate that on an annual scale, the streamflow is projected to increase during 2021-2100 for A1B, A2, and B1 scenarios, and during 2061-2100 for COMMIT scenario. The projected increase in streamflow is high for A2 scenario, whereas it is least for B1 scenario.

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Saving Women's Time and Energy through Sustainable Energy Practices in the Hill Areas of the Kullu Valley, Himachal Pradesh: A Successful Initiative of Community based Organisation JAGRITI, Kullu

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ABSTRACT

In the mountains, most of the household depends on firewood for cooking and heating which is generally acknowledged due to an important the role of women. This paper aims to document the successful initiative of JAGRITI, a community based organisation towards reducing the drudgery and empowerment of mountain women through the promotion of sustainable energy devices in the Kullu Valley of Himachal Pradesh. Promotion of these sustainable energy devices such as Liquefied Petroleum Gas (LPG) and Hamam (water heating device) for cooking and water heating have reduced women's daily trips to forests to collect fuelwood (1-4 trips per week) and provided smoke free environment in the kitchen which otherwise also adversely affect women. Subsequently, use of 10-12 kg of fuelwood is now reduced to only 2 kg of agricultural waste for heating 25 litres of water. As a result, now they spend very less time in different household chores and use their extra time to develop skills and generate income through establishing small individual and group enterprises. The most preferred fuelwood species in this area is *Quercus floribunda* which is also a slow growing tree and difficult to regenerate. Reduction in fuelwood consumption also has lowered the stress on this particular species and improved its regeneration process in the forest. Across the mountain regions of Himachal Pradesh and other hilly regions of the country, the geo-physical and socio-cultural format is almost similar. Mountain women everywhere are overburdened with the daily chores and, therefore, the possibility of less strenuous work and greater social mobility is instantly appealing. In that sense, the drudgery reduction initiatives of JAGRITI are suitable for replicability in similar other parts of the Indian Himalayan Region.

Keywords**:** Mountain women**,** fuelwood, sustainable energy.

1. INTRODUCTION

Fuelwood has remained one of the principal components of rural domestic India and in most of the developing countries. Historically, India's economy was intimately related to forest resources and these have been part and parcel of our economy, culture and tradition (Bhat, 2010). However, this relation is now reflecting a negative impact on the conservation of India's forest resources as the pressure exerted by the human and livestock population is increasing continuously day by day. The dependency of rural people on forest resources in India ranges from fuelwood for domestic energy requirement to fodder for animals, timber for house constructions and agricultural implements and a large number of NTFPs for variety of uses. Fuelwood collection is one of the most traditional activities which contribute to the forest degradation in the event of ruthless cutting to meet their requirements (Heltberg *et al.*, 2000; Trossero 2002; Jaiswal and Bhattacharya 2013). A major segment of Indian rural populations gather fuelwood from the forest and other sources free of cost and therefore there could not be found any evitable records on account of consumption (Pandey, 2002). As of now the energy use pattern in rural India is changing with the uptake of clean energy, but traditional fuels including fuelwood, crop residue and cow dung still constitute the main source of energy for many households due to its inadequate and unreliable supply (Balakrishnan *et al.,* 2004; Das and Srinivasan, 2012). In the mountain state of Himachal Pradesh biofuels is the primary source of energy with a large number of population (93%) using fuelwood and only 7% of population were using exclusively clean source of energy and the average consumption of fuelwood is 7.4 kg per household per day (Parikh, 2008). The total fuelwood availability in the state is about 15 million m^3; while the total fuelwood requirement for the entire state is 1.26 million m^3 per year (Agarwal and Chandel, 2004). In the cold dry temperate zone of Himachal Pradesh during winters, it requires more amount of fuelwood for space heating than cooking. Due to low connectivity with the urban areas of the region and less alternative options to replace their fuelwood demand for cooking, and water heating people still depends on fuelwood which is also due to its easy availability (Bhat and Sachan*,* 2004). Although the state of Himachal Pradesh has progressed in the areas of education, roads, asset ownership, etc. but the use of new energy technology still remains on the periphery especially in the rural areas, and lack of progress prevails there which is faced primarily by women. The impact of forest degradation is commonly seen as an increased amount of energy being spent by women in collecting fuelwood and water (Pandey and Singh, 1984; Raizada *et al*., 2008). Fuelwood collection, cooking, cleaning and all the other household works are concerned with women's only in the rural areas of the state which increases the women drudgery. In addition women have a greater risk of respiratory symptoms as they are exposed to a smoky atmosphere for long hours despite the physical strains in terms of backache, headache, etc. According to the MoEF 2006 report, the over exploitation of the natural resources leads to the faster degradation of the Himalayan forests. With the destruction of forest cover in the Himalaya, many perennial hill streams are drying up, frequency of floods are increasing during rainy season. Extended period of droughts is affecting the huge amount of soil erosion, and ultimately low farm productivity at the end leads to poverty (Nautiyal and Babor, 1985).

The primary objective of this paper is to document the successful initiative of the community based organisation JAGRITI for saving women's time and energy. Most of the energy of rural women going in the collection of fuelwood through promotion of sustainable energy devices among the hill rural women's in the Kullu district of Himachal Pradesh.

2. MATERIALS AND METHODS

2.1 Study Site

Kullu district has a unique geography with mountainous terrain where about 90% of its population live in villages which are situated in far-flung and inaccessible areas. It is located at 31.9° N latitude and 77.10°E longitude. Its altitude ranges from 1500 to 4800 above mean sea level (amsl).The total geographical area is 5503 km² with the total 4,37,474 individuals according to the 2011 census. It lies on the bank of the Beas river. December and January during winter observe lowest temperature ranging from 4°C to 20°C, sometimes with some snowfall. Annual highest temperature in summer ranges from 25°C to 37°C during May to August. Months of July and August are rainy because of monsoon, having around 15 cm rainfall monthly. Climate is pleasant in October and November. While the average annual rainfall is 1111 mm (Pal, *et al.*, 2013). Here, the main occupation of the people is agriculture. Fig. 1 shows the location of Kullu valley in Kullu district of Himachal Pradesh

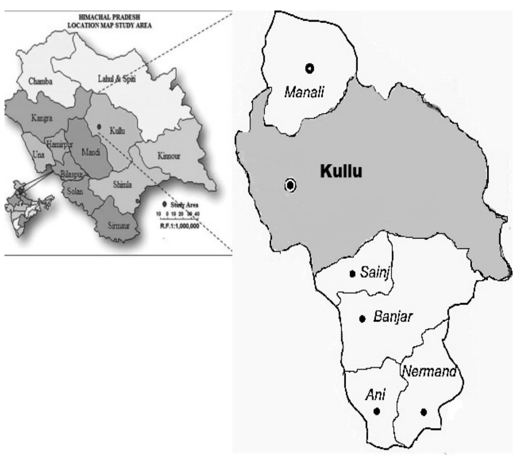

Fig. 1: Location of Kullu valley in Kullu district of Himachal Pradesh

2.1 JAGRITI Initiative

JAGRITI is a community based organisation working for poor and disadvantaged hill women in 22 gram Panchayat of Himachal Pradesh. Through the JAGRITI's energy programme, improvement in the quality of life of poor rural women through introducing energy efficient and drudgery reduceing devices such as LPG stoves and humans have been made possible so the objective of the present attempt was (i) to expand the usage of energy efficient and drudgery reducing devices to reduce dependence on fuelwood and (ii) to use women's 'freed' time to improvement in their livelihood through activities that helping their income. In addition to this encouraging their participation in public forums and devoting time for leisure. Till now JAGRITI operates through more than 130 Women Saving and Credit Groups (WSCGs) of these disadvantaged hill area poor women's in the different locations of the Kullu valley inhabit. These women's saving and credit groups (WSCGs) are playing a vital role in the energy programme of the organisation. Leader of these groups are called as Group Organisers (GO's) who motivates the members of the group to purchase these devices, and collect orders and monetary contribution. In these hill areas, the main barrier to use these energy efficient devices is its initial high cost and the difficult accessibility to the areas. In these rural areas, people spend very small amount of income to the energy sector (UNDP, 2006).

Before starting this energy programme, some of the main challenges in the area were as under:

1. Besides cooking fuelwood is also used for space heating and washing/bathing.
2. The burden of gathering, cutting and carriage of the fuelwood falls squarely on women's part.
3. Sharp decline in regeneration of slow growing tree species like oak and pine resulting in forest degradation.
4. Decrease in natural resource base adds work load and drudgery in women.
5. Inefficient and wasteful use of fuelwood loses energy and promotes energy crises.

Fig. 2: (a) Fuelwood collection (b) Traditional earthen stove (*Chullah*), (c) Improved metal stove (*tandoor*), (d) Hamam (water heating device), (d) Women using LPG stove for cooking, and (e) women using pressure cooker for cooking.

2.3 Women Status

The women's workday in the Kullu valley stretches between 16 to 18 hours. An analysis carried out in the Lag valley of Kullu district shows that the time spend on cooking, utensil washing and fuelwood gathering together reach up to a daily total of 6 to 7 hours (Chander and Tandon, 2004). This is followed by the care and work related to domestic livestock (including grass/fodder cutting and carriage for stall fed animals) that takes another 3 to 4 hours every day. Thus, about 50 to 60 % of the average women's work day goes on a cluster of just two interconnected household chores. Often unavoidable daily drudgeries, the help of the girl child is taken especially during sowing/harvesting seasons or peak work times during festivals, fairs, marriages, etc. An effective drudgery reduction intervention therefore needs to target these two major chores in the women's work day. Less time schedule for a village woman has two serious implications on their economic condition and social mobility. The women are becoming indispensible in day to day household chores and therefore do not have so much time for anything else. Her stepping out of the house is rare and any increase in the frequency of her leaving the house is discouraged by men/in-laws of the households. Preoccupation with the household chores leaves no time for the village women if wants to begin the empowerment journey. If they do not have to gather fuel, these hours could be used towards their self-development or for economically productive activities. This step will also alleviate poverty. The intersection of energy, poverty alleviation and gender are the key issue that need to be addressed.

3. RESULT AND CONCLUSION

The result show that till the date 631 LPG connections and 2486 hamam (water heating device) were distributed among the women of Kullu valley. These distributions are done on cost sharing basis where 60% cost is borne by women and 40% by JAGRITI through different projects. Time saved in cooking and in fuelwood collection is very significant which have critical implications for empowerment of women. This will greatly reduce their drudgery and free them to pursue other income enhancement pursuits. It is also observed that now the women's participation in other economic activities such as daily wages is increasing.

Table 1: Distribution of devices and cost sharing (as on January 2014)

Devices	No. of device distributed	Member's contribution 40% (Rs.)	Programme support 60% (Rs.)	Total expenditure (Rs.)
LPG	631	578,205	385,471	963,676
Hamam (water heating device)	2486	853,738	569,159	1,422,898

Earlier fuelwood collection for most of the women involved in daily backbreaking grind varying between 2-6 hours (depending on the distance from forests) which is now reduced between 1-4 trips per week. Daily cooking time is down by 1-2 hours for most women's. This appears to be correlated between the number of refills used and daily time (in hours) saved by women. Those who have used more refills reported saving 2 hours a day as against 1 hour by those whose refilling is low. The time saved on cooking in all cases is also due to the utensils which are not getting blackened by the smoke and requiring less time to scrub and clean. On an average, women save between 15-30 minutes in cleaning utensils. Average hot water requirement per day per household during winter is around 50-60 litres. Earlier where it takes 10-12 kg of fuelwood to heat 25 litre of water in 35-40 minutes time period, now it takes only 15-20 minutes in case of hamam (water heating device) that is also using 2 kg of agricultural and household waste. In this way, it was estimated that in a 130 days per year a household can save up to 1.5 tonnes of fuelwood. Fuelwood is the primary source of cooking and heating in many rural areas of the state and other energy efficient devices is limited to only some of the well off households of the urban area which is mainly due to the easy and freely available of the fuelwood sources.

As the number of LPG users grow, the impact of reduced fuelwood collection on tree and forest growth would be significant. Another important aspect, in terms of measuring impact of forests, is based on the fact that the preferred species for fuelwood and charcoal making are the slow growing hardwood like oaks. Depletion in the growing stock of oaks for instance is hard to replace and regeneration is very slow and costly affair. The white oak (*Quercus floribunda*) and the green oak (*Quercus dilitata*) also form the major resource of green fodder for livestock particularly in winter and the need to use these sustainably has significant repercussions on livestock related livelihoods.

RECOMMENDATION

Across the mountain regions of Himachal Pradesh and other hilly regions of the country, the geo-physical and socio-cultural format is almost similar. Mountain women everywhere are overburdened with the daily chores and, therefore, the possibility of less strenuous work and greater social mobility is instantly appealing. In that sense, the drudgery reduction initiatives of JAGRITI are suitable for replicability in similar other parts of the Indian Himalayan Region. On account of this, some of the other recommendations are:

1. To promote the cheaper and clean alternative for the fuelwood will reduce the forest dependency of the local community. Thus the pressure on the forest resources and enhancing the success of monitoring and protecting the forest biodiversity would encourage energy promotion indirectly.
2. Technological interventions including the fuel efficient improved chullahs, solar energy and other renewable source of energy should be promoted.
3. There are some of the institutional and financial constraints which need to be understood and removed for proper implementation by the state government.
4. A large number of donor agencies should come forward for the larger implementation of the programmes and more and more income generating programmes should be a integral part of any fuel strategy.
5. Other than this sensitisation about the health centre of these rural areas there should be a priority for the health issues such as indoor air pollution and other physical distress.
6. Finally health impact of this hardships endured by women which needs more studies with the larger sample in near future.

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Present Scenario and Future Challenges of Water Resources in India

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ABSTRACT

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. It is also a scarce resource. As India experiences rapid industrialization and urbanization, the demand for water is going up significantly. While agriculture constitutes >75% of the water consumption in our country, the rest is used up by industries and domestic consumption. Studies show that the total demand for water by 2031 is likely to be 50% higher than that of today. This gap has to be bridged if the projected GDP growth is not to be compromised. Nearly 20% of this gap can be bridged by ensuring additional storage of water and by employing groundwater retention techniques. The rest of the problem can be solved by using water more efficiently. As per present estimate, India receives on average annual precipitation of about 4000 Billion Cubic Meter (BCM), which is its basic water resource. Out of this, after considering the natural evaporation-transpiration, only about 1869 BCM is average annual natural flow through rivers and aquifers. Due to spatial-temporal variations, an estimated 690 BCM of surface water is utilizable. Add to this 432 BCM of replenishable groundwater means, only about 1122 BCM is utilizable through the present strategies, if large inter-basin transfers are not considered. The water crisis can be alleviated but to do this, a more structured way of thinking with increased momentum is required by making best use of the available technologies and resources to conserve the existing water resources, convert them into utilizable form and make efficient use of them for agriculture, industrial production and human consumption.

***Keywords*: ** Water demand, water resources.

INTRODUCTION

Water is essential for sustaining life and at the same time, it is an important component for almost all developmental plans. Considerable progress has been made in respect of water resources development in India after independence through various Plans and such developments have helped in almost five fold increase in creation of irrigation potential. Total created irrigation potential at pre-Plan period was about 22.6 million hectares (Mha) which at present is about 108.2 Mha (GOI.,2011). However, growing population, urbanization and industrialization has led to considerable increase in demand of water for various purposes e.g., irrigation, domestic needs, industrial requirements etc. India has significant spatial mismatches of the population and water resources (Amarasinghe et al. 2005). Less water is available in places where more people live and much of the food is grown. Some river basins are already experiencing physical water scarcities. A few others face problems of unsustainable groundwater use. Thus, how India meets its increasing food and water demand was the major focus of many recent food and water demand projections at the global scale (IWMI 2000; Rijsberman 2000; Rosegrant et al. 2002; Seckler et al. 1998) and the national scale (Bhalla et al. 1999; Dyson and Hanchate 2000; GOI 1999).

The average annual rainfall in the country is about 117 centimeters (cm). The total precipitation including the snowfall, when converted in volumetric terms, works out to be about 4000 billion cubic meters (BCM). The average annual rainfall varies considerably from about 1,000 cm in north eastern region to less than 10 cm in western part of Rajasthan. In India, the rainfall mostly occurs during the monsoon and that too through a few spells of intense rainfall. It has been estimated that the lower rainfall zone (less than 750 mm annual rainfall) accounts for 33% of net sown area. The medium rain fall zone (750-1125 mm) accounts for 35% of net sown area, the high rain fall zone (1125 to 2000 mm) covers 24% of net sown area where as very high rainfall zone (more than 2000 mm) accounts for remaining 8% of net sown area. After accounting for the losses due to evaporation, the total average annual water availability for the country has been estimated to be 1869 BCM. However, due to hydrological characteristics and topographical constraints, the utilizable water works out to be only 1123 BCM, out of which about 690 BCM is from surface water and about 433 BCM is through replenishable ground water. However, there are considerable spatial and temporal variations in availability of water as in case of rainfall. The present level of water utilization has been estimated to be about 690 BCM out of which about 83% is utilized for irrigation, 5% each for domestic uses and industrial uses and rest for other purposes. The "National Commission for Integrated Water Resources Development (NCIWRD)" has assessed the projected demand for water for the years 2010, 2025 and 2050. NCIWRD has made assessment both for low and high demand scenario in the year 2050. The total water requirement for meeting the demand for various uses as assessed by NCIWRD is 973 BCM for the low demand scenario and 1180 BCM for the high demand scenario.

WATER RESOURCES OF INDIA

Rainfall

The average annual rainfall in the country is about 117 centimeters (cm). The total precipitation including the snowfall, when converted in volumetric terms, works out to be about 4000 billion cubic meters (BCM). The average annual rainfall varies considerably from about 1,000 cm in north eastern region to less than 10 cm in western part of Rajasthan. In India, the rainfall mostly occurs during the monsoon and that too through a few spells of intense rainfall. It has been estimated that the lower rainfall zone (less than 750 mm annual rainfall) accounts for 33% of net sown area. The medium rain fall zone (750-1125 mm) accounts for 35% of net sown area, the high rain fall zone (1125 to 2000 mm) covers 24% of net sown area where as very high rainfall zone (more than 2000 mm) accounts for remaining 8% of net sown area. After accounting for the losses due to evaporation, the total average annual water availability for the country has been estimated to be 1869 BCM. However, due to hydrological characteristics and topographical constraints, the utilizable water works out to be only 1123 BCM, out of which about 690 BCM is from surface water and about 433 BCM is through replenishable ground water.

Percapita water avilablity Year	Population (in millions)	Per Capita water availability (in m3)
1951	361	5177
2001	1027	1820
2025 (projected)	1394	1341
2050 (projected)	1640	1140 (GOI.2011).

Irrigation Development

Water is the most critical input for agriculture and it plays a significant role for ensuring increase in production through timely availability of water in required quantity in order to facilitate improved farming practices. The gross ultimate irrigation potential for the country has been estimated to be about 139.9 million hectare (Mha). At pre-Plan stage i.e. in the year 1951, the total irrigation potential created was about 22.6 Mha. There has been considerable development in water resources sector. About 108 Mha i.e., about 77% of the ultimate irrigation potential has since been created.

Storage Capacity Created

As indicated earlier, about 80% of the runoff is generated during the monsoon period of about 4 to 5 months and that too through a few spells of intense rainfall. Therefore, the conservation of water through storage either over the ground or under the ground is very important in view of very high temporal variations.

Unsustainable Development

There are many cases of development of projects and schemes for utilization of water resources without proper investigation and planning. Many of the cases of "slipped back" habitation in respect of drinking water supply may also be attributed to unsustainable development without necessary investigations. Over-exploitation of ground water in some areas poses a big challenge for its sustainability. At present, about 15% of the assessment blocks are over-exploited and about 14% of the assessment blocks fall in the category of critical and semi-critical blocks.

Rainwater Harvesting and Ground Water Recharge

Necessary measures in the form of rain water harvesting and ground water recharge and proper management through appropriate legislative measures have been initiated. facilitate improvement in ground water situation in the affected area, to increase the sustainability of wells during lean period, to improve quality of ground water and community involvement in water resources management in the affected areas.

Gap between Irrigation Potential Created and Utilised

It is observed that the gap between the irrigation potential created and the irrigation potential utilized has continued to increase and at present about 15% of the created irrigation potential remain unutilized. Further, the difference between the irrigation potential created and utilized may also be due to changed cropping pattern and larger use of water by the farmers near the head reach of the canal. One of the important reasons is non-completion or absence of on-farm development works, irrigation system deficiencies including poor operation and maintenance. Lack of proper regulation of canal water also leads to over-use by the farmers on one hand and the shortage of water for the tail-enders on the other hand.

Over-use of Resources – Problems of Water Logging

Although development of irrigation has resulted in increase in agricultural production, it has also caused adverse effect in the form of water logging leading to soil salinity. Problem of water logging has been observed in the canal irrigation system and also in the areas of poor drainage resulting in accumulation of water. Apart from lining of canals, wherever required there is a need for drainage development either through surface/sub surface/bio drainage or a combined approach followed by appropriate agronomic measures. There is also a need for conjunctive use of surface and ground water. In the natural water logged areas if the sub surface sink is developed by appropriate utilization of ground water, the excess water can be stored in the ground water reservoir for its use at the time of requirement.

Efficiency of Water Use

The irrigation infrastructures are not operating at desired efficiency. Efficiency of surface water projects has been assessed to be about 30-40%, which can be increased up to 60% by adopting efficient management practices, proper maintenance and modernization of existing infrastructures, command area development, participatory irrigation management and efficient irrigation and agricultural practices. Similarly, the efficiency of ground water facilities can be increased from the present level of about 65% to about 75%. This measure alone can save considerable water to meet the major portion of demand supply gap. the key principles for improving water productivity at the field, farm and basin levels are: (i) increase in the marketable yield of the crop for each unit of water used, (ii) reduction of all outflows (ex. drainage, seepage and percolation), and (iii) increase in the effective use of rainfall, stored water and water of marginal quality. New irrigation technologies that will improve field level water application efficiencies will be critical components of the demand-side management.

Crop Diversification

Various issue involved in crop diversification are relatively complex and need to be addressed with due consideration of all aspects. Proper management strategies for ensuring availability of irrigation water on demand may help in addressing the issues to a great extent. Food security is the supreme national priority and loss in cultivation of rice due to overexploitation of ground water in the Coastal South and Western India has to be more than compensated in high rainfall regions of Eastern and Coastal India. In the East and North East India ground water resources are under-utilized to the tune of 58-82% and also blessed with sufficient rainfall. Rice is a staple diet in major parts of India and food security at the country level can be ensured by enhancing its productivity and production in the most befitting agro-ecologies in the Eastern and Coastal regions with high rainfall and vast resources of under-utilized ground water. In addition, non-availability of irrigation water when required by farmers is also one of the reasons for over exploitation of ground water.

FUTURE CHALLENGES

Growing Population and Increasing Demand of Water

Increasing population has resulted in growing water demand, particularly for meeting the requirements of drinking water and food production. The present level of water utilization has been estimated to be about 690 BCM out of which about 83% is utilized for irrigation, 5% each for domestic uses and industrial uses and rest for other purposes.

Impact of Climate Change on Water Resources

climate change on water resources are: (a) decline in the glaciers and the snowfields in the Himalayas, (b) increased drought like situations due overall decrease in the number of rainy days over a major part of the country, (c) increased flood events due to overall increase in the rainy day intensity, (d) effect on ground water quality in alluvial aquifers due to increased flood and drought events, (e) influence on ground water recharge due to changes in precipitation and evapo-transpiration, and (f) increased saline intrusion of coastal and island aquifers due to rising sea levels.

STRATEGIES

1. Expeditious implementation of water resources projects particularly the multipurpose projects with carry over storages benefiting drought prone and rain deficient areas.
2. Research in area of increasing water use efficiency and maintaining its quality in agriculture, industry and domestic sector.
3. Promotion of traditional system of water conservation.
4. Physical sustainability of groundwater resources.
5. Intensive programme for ground water recharge in over-exploited, critical and semi-critical areas.
6. Conservation and preservation of wetland
7. Incentivize recycling of water including wastewater
8. Development of Eco-friendly sanitation system
9. Promotion of water purification and desalination
10. Systematic approach for coping with floods.
11. Undertake Pilot projects for improvement in water use efficiency in collaboration with States
12. Incentive through award for water conservation & efficient use of water.
13. Incentivize use of efficient irrigation practices

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Effect of Climate Change on Water, Environment and its Consequences

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ABSTRACT

Model based predictions in temperature and thus predicted impacts on nature/ environment are only hypothetical. The main component of climate change is the natural rhythmic variations wherein extremes form part of it. They are repetitive in nature. Such rhythmic cycles in precipitation are mainly contributing to variations in water resources availability [droughts & floods] and thus agriculture. Similar rhythmic variations are also observed in global temperature, cyclonic activity, polar ice melt/temperature and thus sea level raise. All these are part of general circulation patterns of given region. In such scenarios, it is dangerous to use conclusions arrived at from truncated data sets. Non-climate activities are also affecting water and environment to a large extent. To maintain sustainable water and environment and thus meet future generation needs both weather and non-weather factors must be taken in to account.

INTRODUCTION

Weather is what we experience at a given movement of time. Climate is the average of such events over a period of time. We call such average over a period of 30 years as normal – IMD published such normal and extremes for the period 1931-60 for around 365 met stations spread over the country. With the advent of sophisticated computers, it is made easy to handle large amounts of data series even at daily interval. This has lead mutilation of the science of climate and climate change. Man has no control over climate and needs to adapt to it. The nature of climate is sometimes complicated because of the wide range of ecological and topographical diversities and hence require in depth studies to develop such adoptive measures (Gupta & Reddy, 1999). Now, this became a complicated issue with half-baked computer model predictions of the so called global warming and associated impacts. As a result the research priorities changed drastically and thus climate has become the victim. In the present article in brief discussed the climate change in its totality and myths & realities of such changes and their effect on environment, water and thus their consequences.

Myths and realities in climate change

The word climate change is widely misused. Some use it as an adjective to get hype to their reports; and majority of the scientific community use it as de-facto global warming. In this area with billions of dollars are available for research and carbon credit policy, reputed national and international journals and media publishing articles and reports with highly misleading headings and that too based on hypothetical computer model simulations. All these are happening even after IPCC changed its tone and tenor from AR4 to AR5 on global warming and its impact issues after 2009 December Copenhagen fiasco. Reddy (2013b) discussed the myths & realities of IPCC's report on climate change.

Earth's climate is dynamic and always changing through the natural cycle. What we are experiencing now is part of this system. Also, general circulation patterns over different parts of the globe are part of this system. However, with the unabated population growth to meet their needs under new lifestyles based technological innovations local and regional environments are modified and thus they influence the natural cycle in climate at local and regional scales is represented by trend. WMO (1966) presented a manual on "Climate Change" wherein it discussed methods to separate natural inbuilt variations from man induced trend. That means climate change has inbuilt natural variations consisting of rhythmic variation in which irregular variations associated with intra-seasonal and intra-annual variations are part. The other part, namely human-induced variations represented by trend (increasing or decreasing) consisting of land use and land cover changes, known as ecological changes wherein urban-heat-island and rural-cold-island effects are part; and temperature increase due to increased levels of anthropogenic greenhouse gases, known as global warming.

Myths & Realities of global warming

IPCC, states that "Global Warming" is the increase in the average temperature of global surface air and oceans since about 1950, and to continuing increases in those temperatures. IPCC in its 2007 report [AR4] observed that "confirms that global warming is now unequivocal and states with more than 90% certainty that increasing concentrations of greenhouse gases produced by human activity very likely has been the primary cause of rising temperatures worldwide since 1950". IPCC in its 2013 report [AR5] changed the 90% and very likely to 95-100% and extremely likely. It also states that "Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together".

All this means that around 50% of the trend in global average temperature starting from 1951 is contributed by global warming and the rest by other human actions. In global average temperature, urban-heat-island and rural-cold-island effects play vital role. However, in the global averaging process the former is over emphasized with dense met network and the later is under emphasized with sparse met network. The disparity is growing with growth of population-urbanization and wet-land agriculture. This is reflected the Southern Hemisphere temperature which is lower than that of Northern Hemisphere. Because of this the NASA satellite data showed no increasing trend in global average temperature – this was later removed from the internet & I included this in my book (Reddy, 2008).

Very recently British Royal Society and US National Academy of Sciences brought out an overview "Climate change: Evidence & causes". The report included a figure of annual march of global temperature anomaly along with 10-year, 30-year & 60- year moving average patterns using 1850 to 2010 data series. Moving average technique is one of the techniques to separate trend from rhythmic/systematic variations (WMO, 1966). The 60-year moving average pattern showed the trend after eliminating 60-year rhythmic variation – my study showed sine curve varying between -0.3 to +0.3 ^{o}C. The trend showed less than 0.5 ^{o}C raise during 1950 to 2010. After correcting this figure for overestimation and underestimation factors discussed above, is expected to be far less than 0.5 ^{o}C. As per AR5 summary, around 50% of this [far less than 0.25 ^{o}C] is contributed by anthropogenic greenhouse gases, which is termed as global warming. This is insignificant to impact nature/environment and water. Thus, by 2100, global warming component is expected to rise by less than 0.5 ^{o}C and not 3 to 5 ^{o}C of IPCC model based predictions. A figure presenting Satellite and balloon data in NAC-Rebuttal (2014) also support this estimation. Here, we must remember the fact that the unit of measurement changed from degrees Fahrenheit to degrees of Celsius. This may also contribute to higher temperature after 1957.

Global warming is in fact a brain-child to counter the environmental Movement against pollution, more particularly agriculture pollution, initiated in late 60s and early 70s. Now, all ills of the society are attributed to this word as there are billions of US$ to share under the disguise of research and carbon credit schemes. Nobody looks at why there is large difference in the Southern and the Northern Hemispheres temperature trend.

Myths & realities of natural variations

Global warming is a trend in temperature and climate change is a trend and rhythmic variation**s,** in which extremes form part**,** in temperature and rainfall. During drought years the temperature and evaporation goes up and during flood years the temperature and evaporation goes down. My studies in early 80s showed that cube root of precipitation follows the global solar radiation and evaporation (Reddy 1993 & 2002). Because of this interrelationship between rainfall and temperature, the rhythmic variation present opposite patterns. Rhythmic variation was observed in precipitation, temperature, cyclonic activity (hurricanes, typhoons & cyclones), polar ice melt/temperature and thus sea level rise. In such scenario, if we use a truncated data of such series leads to misleading conclusions. Hurricanes follow opposite pattern to typhoons; Antarctic ice melt follows the opposite pattern to Arctic ice melt pattern; sea level rise follows them.

My studies in late 80s showed that Indian southwest monsoon precipitation and thus the global temperature followed a 60-year cycle (Reddy, 2000 & 2007). WMO released a press note on extreme weather events of 2013 on the occasion of World Meteorological Day (23rd March 2014) in which it observed droughts and warming conditions in Southern Hemisphere Nations. My studies of early 1980s on the rhythmic variations in precipitation data series of stations in Southern Hemisphere Nations and their projections showed below the average precipitation during 2013. Though in the Southern Hemisphere nations presented cycles of different periods in the precipitation data series [52 to 66 years], coincidentally majority of them showed below the average pattern during 2013 (Reddy, 1993 & 2007). The higher temperature regime in Southern Hemisphere Nations could be attributed to the dry weather prevailing in 2013. This is not part of global warming but it is a part of climate change – natural variation. These influence the water resources availability and thus agriculture. Truncated data of a data series with rhythmic variations lead to misleading conclusions. This is dangerous when we apply such conclusions to water and environment.

Myths & Realities of effects of climate change

IPCC's WG-II AR5scenarios

IPCC's WG-II AR5 is the second of three assessment reports that assesses the impacts of climate change, adaptation and vulnerability of human and natural systems, runs around as highlighted by UN climate change secretariat in Bonn "The IPCC report makes clear that people around the world are already suffering from climate change, as it directly affects their livelihoods, reducing crops, destroying homes and raising food prices, and that this will ***accelerate if climate change is left unchecked*** – it implies global warming and not climate change --. It provides a detailed assessment of regional aspects, which give a much clearer understanding of climate impacts in different regions." Let me present important paras from three chapters of IPCC's WG-II AR5:

Chapter-3: Fresh water resources -- under the executive summary of key risks at the global scale, IPCC observed "So far there are no widespread observations of changes in flood magnitude and frequency due to anthropogenic climate changes but projects imply variations in the frequency of floods (medium agreement, limited evidence). Flood hazards are projected to increase in parts of south, southeast and northeast Asia, tropical Africa, and South America (medium agreement, limited evidence). Since the mid-20th Century, socio-economic losses from flooding have increased mainly due to greater exposure and vulnerability (high confidence). Global flood risks will increase in the future partly due to climate change (medium agreement, limited evidence). There is little or no observational evidence yet that soil erosion and sediment loads have been altered significantly due to changing climate (medium agreement, limited evidence). However, increases in heavy rainfall and temperatures are projected to change soil erosion and sediment yields, although the extent of these changes is highly uncertain and depends on rainfall seasonality, and land cover, and soil management practices.

Scientist countered National Climate Assessment – 2014 report (NAC Rebuttal, 2014) using the observed -- ground realities -- satellite and balloon data sets. They also observed that "With the Earth's vast oceans and atmosphere never in complete equilibrium, our climate will always be changing on time scales from weeks to months to decades to centuries and beyond". They quoted that "According to IPCC there is high agreement among leading experts that long-term trends in weather disasters are not attributable to our use of fossil fuels". Hurricanes have not increased in the US in frequency, intensity, or normalized damage since at least 1900. Currently US are enjoying a period of over eight years without category 3 or stronger Hurricanes making land fall. Government data also indicate no association between use of fossil fuels and tornado activity. They also quote that "IPCC also states there is low confidence in any climate-related trends for floods magnitude or frequency on a global scale".

Chapter-7: Food security and production systems -- Though crop production relates to the fresh water resources, under executive summary of this chapter, IPCC observed "The effects of climate change on crop production are evident in several regions of the world (high confidence). All aspects of food security are potentially affected by climate change, including food access, utilization, and price stability (high confidence).

Deccan Chronicle, a daily News paper from Hyderabad dated 20th June 2013 presented a report "World Bank releases report, paints grim picture of future – Global warming to dry up rivers, inundate cities". It observed that India's monsoon will become highly unpredictable if the world's average temperature rises by 2^oC in the next two-three decades. Below this article presented my observations also. Indian agriculture scientists in the same tone and tenor forecasted using El Nino saying that it is destroying agriculture, production is coming down by around 20%, severe losses to dry-land agriculture, affecting northeast monsoon, etc. By looking at yield levels versus El Nino intensity [1–weak, 2–medium and 3–strong], there is no correlation; and yet they deduced such strange conclusions. In fact the yield is a function of chemical inputs, which I published more than a decade back. Also, reports after reports were published saying that production is less than the demand and thus price rise and affecting food security. At the same time FAO report presents that globally 30% of what is produced is going as waste. Before this in my All-India Radio on National Network presented this as 40-50% in India – the same was presented by Union Finance Minister in his budget speech later. That means to that extent the natural resources & finances used are going as waste. In India, the main reasons for such losses are lack of storage facilities, and timely transport facilities. All these are nothing to do with global warming but it relates to poor governance and business manipulations.

Chapter-24: Asia – under executive summary, IPCC observed "Warming trends and increasing temperature extremes have been observed across most of the Asian regions over the past century (high confidence). Increasing numbers of warm days and decreasing numbers of cold days have been observed, with the warming trend continuing into the new millennium. Precipitation trends including extremes are characterized by strong variability, with both increasing and decreasing trends observed in different parts and seasons of Asia.

This is exactly what I was advocating (high confidence) since long wherein the observed changes in nature are mainly associated with physical impacts due to human action and natural variations; and not with the anthropogenic global warming. Also, so far the increase of anthropogenic global warming is insignificant to influence nature and weather systems. We are working in a climate system that showed high seasonal and annual variations. We can see this from Climate Normal books. We need to make better and efficient use of the available resources. We must choose technologies that will not destroy our natural resources. We must look at pollution and not at anthropogenic greenhouse gases.

Ice melt & Sea level scenario

It is a fact that in the last 17 years there has been no significant change in temperature, including ocean temperatures; ice melt in Arctic and Antarctic zones are within the standard deviation around the mean; no change in precipitation – monsoons, etc. In association with local conditions and natural disasters the sea levels show rises in some places, falls in some places, and no change in the majority of places. Ice is confined to outside the South Polar Ring and inside the North Polar Ring. That means South Polar ice melt is the true reflection of global warming impact on ice melt. At present it is not showing any melt in the Southern Polar zones. The Southern Polar zones are on the contrary building ice. North Polar zones are losing the ice but this is within the long-term standard deviation around the mean. In the North Polar zone, impacts other than climate are also contributing to ice melt. Ice melt patterns of Arctic and Antarctic zones are following opposite pattern (around 60 year cycle) and the respective sea levels in the respective zones are also following this pattern.

Islands constitute less than five percent of world's land area. The islands are influenced by several weather and non-weather factors. One such factor is sea level rise. There are several factors both climate-related and human-induced factors that contribute to sea level changes.

Cyclonic activities including Hurricanes and Typhoons – and precipitation, all present cyclic variations. With the growing population of the planet and building more structures in the path of cyclonic storms – that includes Hurricanes & Typhoons – and Tornadoes, and thus this makes ordinary storms more damaging. In all these general circulation patterns of the region plays vital role. Without understanding these issues we go nowhere!!!

AGRICULTURE SCENARIO

How climate in terms of different meteorological parameters influence water resources and farming systems and thus agriculture production in developing countries were discussed by Reddy (1993, 2007 & 2011). Natural variations in precipitation data series were also taken in to account. Food production, food security & nutrition security are not affected by global warming. Floods and droughts are part of rhythms in precipitation. However, their impacts are modified by agriculture technology and ecological changes. Food includes not only agricultural products but also include several others such as Dairy products, Poultry products, Sea & Water products [fish & prawns], Animal products [meat], etc. These are affected by agriculture technology and pollution components and not by global warming as crops adapt to temperature regimes which is evident from extremes in temperature given under climate normal data. These, along with ecological changes are the major contributors of destruction of biodiversity – on land, in water including oceans. Pollution, more particularly from new agriculture technology, is the major source of health hazards globally and not associated with Global Warming. Global Warming is in fact a brain-child to counter the Environmental Movement against pollution, more particularly agriculture pollution, initiated in late 60s and early 70s.

In the agricultural perspective, these matter: stop wastage of food; plan better utilization of water resources; shift from chemical inputs to organic inputs technology that help reducing pollution and public health aspects; do not forget that the losses due to intense weather systems increase with the population growth. Globally, cold waves are affecting many more vulnerable people than heat waves. Wild fires have nothing to do with global warming. Dry weather helps spread of fire over wet weather, which is nothing to do with global warming.

Myths & realities of consequences

To create panic IPCC, World Bank, Oxfam, CGIAR, etc is pouring sensational consequences associated with the impacts of climate change. In fact all those are the consequences of human action and greed. The worst affected natural resource with the green revolution agriculture technology is the water – river water, groundwater & ocean water. Runoff from agriculture fields polluted with high toxic chemicals carried in to rivers and then on its way enters into groundwater and finally oceans creating dead zones. Gulf of Mexico is the classical example – with the Mississippi river water from US. Agriculture pollution created air, water, soil and food pollution and thus health hazards. Reddy (2011 & 2013a) discussed these issues in detail.

In India, though planned to interlink rivers to improve the quality of life in rainfed areas, vote bank politics are creating more problems under the disguise of interstate disputes on water sharing on one side and World Bank with its anti-dam propaganda on the other side. World Bank and its PR groups are working against building dams in India. Now they say climate change as a culprit. Unfortunately, climate change is a part of dam development. Rainfall variations were taken in to account while building dams. In the case of Krishna River water sharing UPA government appointed a tribunal consisting of three judges of their choice to favor Karnataka & Maharashtra at the cost of Andhra Pradesh. At present Andhra Pradesh is getting allocated water [by the first tribunal] in 75% of the years. The new tribunal as vote bank package through technical fraud, proposed new allocations. Andhra Pradesh will be getting the allocated water in only 25% of the years. These are nothing to do with global warming but it relates to governance – political effect. This will affect the water availability and thus agriculture. This effect water resources as well environment.

Destruction of ecologically sensitive zones affects the coastal zones, mountain zones, etc and thus environment. Inundation of low lying areas under high tides became a common feature with the destruction of mangroves. This causes coastal erosion. This is clearly evident along the east coast. All these are linked to climate change. Industrialists are looking at coastal zones for cheap source to divert their pollution. This in turn is destroying the life in the shallow coastal zones, a livelihood to millions.

Concluding remarks

Climate change is a vast subject and wherein global warming is only one component. The global warming since 1951 is insignificant to influence water and environment. Natural variability is seen in precipitation and cyclonic activity, global temperature, arctic & Antarctic ice melt and thus sea level rise. Droughts and floods are part of natural variability in precipitation and at local & regional level based on the degree of human induced variations they change. Non-climate and human impacts causing changes in local & regional level along the coasts and thus sea levels and ice melts

Unfortunately, IPCC and other agencies are attributing all ills of the society to global warming, a phenomenon that is insignificant to influence nature. Developing countries follow these and waste their public money on them. In India Planning Commission prepared a report on Low Carbon Strategies forgetting pollution a major problem in India. The issues that are raised under water resources and agriculture by IPCC are nothing to do with global warming but they are primarily related to poor governance and human physical impacts on nature. We must adapt to natural variations in climate. This is what our forefathers did. We need to control pollution [air, water, land & food] and reduce the wastage in food and water resources through better management. We must use local technologies that help in this direction.

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Environmental Impacts of Metal Driven Vectors of Acid Mine Drainage from Mining-Metallurgical Complexes- An Insight

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ABSTRACT

The core metal mining and metallurgical sites affect relatively small areas of land but cast profound influence on local environment. Both terrestrial and aquatic environments are greatly devastated through release of metals from mine sites, acid mine drainage, erosion of waste dumps and tailing deposits. The extraction of ores and smelters produce large quantities of wastes, which are deposited on land or into aquatic systems. While localized impacts are easily visible, dispersion can occur over hundreds of kilometers in the downstream reaches of the floodplains. Metal mining contributes significantly to mercury, lead, arsenic, lead, cadmium and other heavy metals from ore stockpiles, ore transportation, smelting and refining, disposal of tailings and wastewater. Toxic elements are also released to water bodies as a result of weathering of heaped dumps. This article gives a brief overview of the basic processes involved in the release of metals from mining activities and their fate of transformation after release.

Keywords**:** Acid mine drainage, heavy metals, mine wastes, mine tailings.

1. INTRODUCTION

Mining and metallurgical industries form the basic platform for economic upheaval and growth of human society. But mining activities impose severe damage to environment that is mostly irreversible and harmful on terrestrial and aquatic environments. Mining industries are known as one of the popular source of heavy metals in the environment. Mining and milling, tailings, waste rock deposits all these pose significant threat to environment. Tailing is the finely ground remains of milled ores and these are deposited in the close vicinity of mining. When these deposits contain sulphides (pyrites) and there is enough oxygen in air the ultimate outcome is Acid mine Drainage (AMD). Mineralogy of the rock materials, availability of water and oxygen play a significant role in the origin of the Acid Mine Drainage from mine waste rocks, tailing, mine structure such as pits and other factors affecting the AMD generation are highly site specific so the prediction so the prediction of the potential for AMD is currently very difficult and costly. Mining process relatively effects small area but the Acid Mine drainage generated from waste deposits and elevated concentration of metals such as mercury, copper, lead, chromium, nickel, cadmium, arsenic leach from mine wastes. When these contaminants leach into the nearby surface and subsurface water, a large range dispersion of metals both in solution and particulate form is possible. Discharge of effluent generated from waste rock deposits in the nearing riverine system introduces particulate of metals into the aquatic ecosystems. Smelting is another source of release of metals to the atmosphere sometimes may be the rate of metals release is higher than mining activities.

The considerable impact of a mining project is its adverse effects on the water quality and availability of water in and around the study area. This article will provide information about the basic processes involved in Acid Mine Drainage generation and in the release of metals from metal mining and their ultimate fate after release.

2. PROCESSES AT MINE SITES

2.1 Oxidation of Metal Bearing Sulphides:

Presence of metal sulphides is the main key factor for the generation of Acid Mine Drainage. Generally metal sulphides minerals are common association in the host rock that is related with metal mining activity. Oxidation of these sulphide containing minerals and generation of sulphuric acid is a common phenomenon in weathering process. Extraction operation involved with metal mining activities increase the rate of sulphide oxidation by exposing large volume of these sulphide rock materials with increased surface area to water and air. Oxidation rate differ with each sulphide minerals. For an example, muscovite and framboidal pyrite both are oxidized quite first than crystalline pyrite. The most common mineral responsible for Acid Mine Drainage is pyrite (Kleimman *et al.*, 1981).

2.2 Sources and Contributing Elements of Acid Mine Drainage

Oxidation of pyrite occurs in following way:

$$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 4H^+ + 4SO_4^{2-} + 2Fe^{2+} \quad (1)$$

$$4Fe^{2+} + 10H_2O + O_2 = 4\,Fe\,(OH)_3 + 8H^+ \quad (2)$$

$$2Fe^{2+} + O_2 + 2H^+ = 2\,Fe^{3+} + H_2O \quad (3)$$

$$FeS_2 + 14\,Fe^{3+} + 8H_2O = 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \quad (4)$$

The entire process can be divided into three stages:

In case of first stage, the considerable conditions are a) pH above 4.5 b) High sulphate and low iron concentration c) Little or no acidity. Reaction (1) continues both abiotically and by direct microbial oxidation. Reaction (2) is pH dependent and slow down with decreasing pH.

Considerable conditions for stage two are a) pH is in between 2.5 and 4.5. b) sulphate level high, acidity and iron level increasing c) Fe^{3+}/ Fe^{2+} ration is still low. At the pH range 3.5 to 4.5, iron oxidation is catalyzed by a variety of *Mettallogenium* a filamentous bacterium. But pH of 3.5 same reaction is catalyzed by the iron bacterium *Thiobacillus ferroxidans* (Manahan, 1991). This situation established below the pH value 2.5, high sulphate and iron level. In this stage the reaction (3) totally controlled by bacterial oxidation and the reaction (4) is dependent on the rate of reaction (3).

$$2FeS_2(s) + 14\,Fe^{3+} + 8H_2O = 15\,Fe^{3+} + 2SO_4^{2-} + 16H^+$$

This reaction is responsible for more acid production. The dissolution of pyrite by ferric ions (Fe^{3+}) and oxidation of ferrous ions constitutes a cycle of dissolution of pyrites. Ferric ions precipitated as hydrated iron oxides that are deposited as amorphous yellow, red or orange deposit on stream bottoms (yellow boy).

2.3 Few important Factors and their significance in Acid Mine Drainage generation

Acid Mine drainage production and release of pollutants are highly dependent on some factors and they are highly site specific. According to Ferguson and Ericson there are mainly three factors- primary, secondary, tertiary that control acid drainage.

Primary factors of acid generation include sulphide minerals, water, oxygen, ferric ion and bacteria to catalyze the oxidation reaction. Water and oxygen both are very important for acid drainage production. Water acts as reactant and also source of bacteria that catalyze the oxidation process. Water also considered as the transporting medium of oxidation products. Atmospheric oxygen trigger up the bacterial oxidation at pH value below 3.5 and oxidation process significantly reduce if the oxygen concentration in the pore spaces of mining waste units is less than 1 or 2%. Catalytic activity of different bacteria is pH dependent. Physical and chemical characteristics of soil and water of surrounding environment influence the growth condition and population size of bacterial colony.

Table 1 provides synoptic information on bacteria that thrive on Acid Drainage formation (Ferguson and Erickson, 1988).

Table 1: Bacteria present in sulphide ores and their growth condition

Microorganism	pH	Temp°C	Aerobic	Nutrition
Thiobacillus thioparus	4.5-10	10-37	+	autotrophic
T. ferrooxidans	0.5-6.0	15-25	+	autotrophic
T. thiooxidans	0.5-6.0	10-37	+	autotrophic
T. neapolitanus	3.0-8.5	8-37	+	autotrophic
T. denitrificans	4.0-9.5	10-37	+	autotrophic
T. novellus	5.0-9.2	25-35	+	autotrophic
T. intermedius	1.9-7.0	25-35	+	autotrophic
T. perometabolis	2.8-6.8	25-35	+	autotrophic
Sulfolobus acidocalderius	2.0-5.0	55-85	+	autotrophic
Desulfovibrio desulfuricans	5.0-9.0	10-45	-	heterorophic

Role of secondary factors mainly act to balance the consumption or alteration of the components from the acid generation reaction. These factors try to neutralize the acid and change the effluent characteristics by adding of metal ions mobilized by residual acid. The neutralization process occurs in presence of carbonate minerals such calcite, dolomites etc. Others possible reactions that are usually non- neutralizing but act to consume the acid are ion exchange on clay particles, gypsum precipitation and dissolution of other minerals. Generally reaction of acid generation by pyrite oxidation and neutralization of the acid by calcium carbonate is considered as a combined process (Williams, 1982).

Tertiary factors affecting acid drainage are the physical characteristics of the waste material and the hydrological characteristics in the vicinity of mining area. The physical nature of the waste materials include the particle size, permeability, and physical weathering characteristics that are important factor for determining the intensity acid generation. Particle size is a fundamental concern since it is related with the surface area exposed to weathering and oxidation. Surface area is inversely proportional to particle size. Very coarse grain material, as it is found in waste dumps, exposes less surface area but may allow air and water to penetrate deeper into the unit, exposing more material to oxidation and ultimately producing more acid. On the other hand fine-grain material may restrict air movement and very fine material may limit water flow but finer grains expose more surface area to oxidation. The relationships between particle size, surface area, and oxidation play a prominent role in acid prediction methods. Weathering process gradually reduce the particle size, so more surface area will be available and these changing physical characteristics ultimately influence the potential for acid generation and are therefore important considerations for the long-term (Ferguson and Erickson, 1988).

Fate and Behaviour of Metals in Aquatic Systems

Discharge of effluent from mining area and leachate generated from the waste heaps, tailing ultimate drained into the nearby aquatic system. When these elements reach the water bodies they can travel a long distance downstream. Various physical and chemical alterations of these metals occur during this downstream transport, ultimate outcome of these reactions is the accumulation of contaminants in the riverine system. Adsorption of metals on sediments or on suspended particles is one of the most common phenomenon occurs when pH of water increases. Metals can be adsorbed on the various constituents of natural waters such as clay minerals, carbonates, quartz, feldspar and organic matters. A coating of hydrous manganese and iron oxides, organic substances generally regulate the whole adsorption process (Elberling *et al.*, 2000). Other major constituent of water is organic matter. Most of the organic matter in water is dissolved organic carbon and metals have a higher tendency to form complexes that tends to increase the dissolve fraction of metals in water. The ionic form metals are most toxic but if they form complexes with suspended matter or with organic matter the risk associated with metal toxicity will be decrease.

Particulate form of metals is released into the environment either due to erosion from active and inactive mining areas or direct discharge of waste tailing into the water. Stability of these particulates is dependent on the present geochemical conditions of the mine site. These eroded materials also enriched with sulphides. Due to low solubility of sulphides these particulates form of metals are mainly trapped into the silicate matrix hence less exposed to environmental changes. Chemical speciation of metals also a determining factor of the fate of the metals and their behavior in water bodies. In river water most metals are present in various chemical forms and the speciation of metals provides us the information about the chemical reactivity of these metals. Discharge flow of effluent is another point that to be considered to understanding the metals distribution within the downstream. Generally metal concentrations are low during the period of high discharge and just opposite scenario occur during high discharge. If the river bed is already vulnerable due to erosion and contamination, high discharge will enhance the dispersion of the contaminants into the water environment.

CONCLUDING REMARKS

Acid Mine Drainage and leaching of toxic metals into environment is the crux of the problem in mining and metallurgical industries. The objective of this study is to control and remediate this toxic drainage water during and after the mining operations and prevent leaching of heavy metal contaminants into the surroundings. The primary processes that cause formation of acid mine drainage and release and dispersion of toxic metals into the floodplain environment are discussed. A continuous assessment of present and future impacts of mining activities on the surrounding environment thus need to be carried out so that the pollution load cannot exceed the carrying capacity of the local environment. A holistic hydrogeochemical study of the mining province can shed requisite information on the nature of the contaminants, their source and cause of enrichment, fate of alteration and transport in natural environment. Based on systemic examination of all factors and forces, suitable risk analyses and strategic management options can be worked out to ensure long term sustainability and extraction of ore deposits based on techno-economical and socio-environmentally acceptable practices.

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Income Enhancement and Resource Conservation through Chickpea (Kabuli Type) Cultivation in Watershed Programme of Central India

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ABSTRACT

Among various pulse crops Bengal gram or chick pea or gram plays a prominent role not only for soil fertility restoration, but its role for enhancing farm income is most significant one. However, its cultivation in dry regions using poor quality ground water (high RSC values) is not feasible. Low water requirement, rough seed bed preparation and high market price for kabuli type can very well be taken in dry areas if rain water can be harvested. An attempt was made to make it a success in Jalalpur watershed. Jalalpur watershed of Jagner block in Agra district receives an annual average rainfall less than 500mm spreading across 35 rainy days. Highly erratic rainfall coupled with sub soil hard rock and ravinous topography result in maximum runoff and hence poor water infiltration. An attempt was made to harvest rain water through watershed management programme and the conservation of fresh water for rabi crops. One Participatory Technology Demonstration (PTD) trial was undertaken in split plot design with four replications. Three treatments(control, Farmers' practice and scientific practice) were assigned to main plots and two varieties (Kabuli type- Subhra and desi type Pusa Dharwad) were assigned sub plots. In farmers practices 100 kg DAP + FYM @ 2 tonnes/hectare were applied. Scientific practice included 20-40-20-20 Kg/hectare nitrogen(N), phosphorous(P_2O_5), potassium(K_2O) and sulphur, respectively + FYM @ 2 tonne/ha. Recommended agro techniques were followed. Scientific practices produced significantly higher grain yield compared to farmers practice and control. Subhra with scientific practices produced significantly higher grain yield(20.86 q/ha) compared to Pusa Dharwad(19.44q/ha) with scientific practices. By cultivating Subhra(Kabuli type) in scientific practices, farmers can receive a minimum of Rs 18578.00 additional profit per hectare compared to Pusa Dharwad with same management practices due to premium market price of bold seeded variety without any additional expenditure except marginal increase of seed cost.

Keywords: Income enhancement, resource conservation, chickpea, watershed, Central India.

INTRODUCTION

The Jalalpur watershed comprises of three villages namely Jalalpur, Dhanina and Deori, in Jagner block of Agra district of Uttar Pradesh. This watershed has been identified by the state department under NWDPRA scheme by proper prioritization of different parameters for watershed selection criteria (Annexure VI). The watershed is located in the south-west of Agra district. It lies between $26^0$49' to 26^o 51'N latitude and 77^o 32' 30" to 77 ^{o}35' 30" E longitude **(Code No. 2C5A5g1b & 2C5A5l2e)**. Its altitude ranges from 184 to 217m above the mean sea level (MSL). The total area of watershed is 697.5 ha. It is surrounded by the Aravalli and Vindhyas hills.The climate of the region is characterized as arid to semi-arid with average annual rainfall less 500 mm spreading over of 35 rainy days. Out of which about 85 percent is received during the monsoon season from July to September. The area receives very less rainfall in the winter season. Temperature ranges from as high as 48^oC in the May-June to as low as 1^0C during December-January. The trend of rainfall is highly erratic and maximum water goes as runoff.

Geomorphology and agriculture

The Jalalpur watershed is located south west corner of the Agra district. The entire watershed is topographically divided into three major landforms. Accordingly, the soils of watershed can be grouped into three major categories. Such as hill terrain, plain land and ravinous land. Agriculture is the main occupation of the dwellers of the watershed. Various crops such as wheat, bajra, mustard, gram, tur, sesame etc are grown depending upon irrigation availability. Most of the lands are kept fallow during the *kharif* season for in situ moisture conservation and for efficient utilization of last kharif rain. Mustard and wheat are the most preferred crops grown during the *rabi* season depending upon ground water availability. About 37% area under agriculture is cropped during *kharif* season in the watershed.

The problem of erosion of the watershed is to be tackled by harvesting additional water in existing water harvesting structures, which have lost most of their capacity due to siltation and creating new water bodies. Water stored in the water harvesting structures shall be properly recycled to provide supplemental irrigation at critical growth stages of crops and for the establishment of fruit orchards and forest trees. Agricultural lands are treated with bunding along with minor leveling. Waste lands are treated with the engineering measures like staggered trenches and a-fforestation etc. When the rainfall is well distributed and good amount of rainfall is received in the last shower, farmers cultivate gram in the winter season. In the entire areas, ground water availability is very low and the quality of water is also remains poor due to presence of sodium. In the watershed we created water harvesting structures and fresh rain water was harvested and the desiltation of the exiting water bodies were done to increase the volume of rain water storage from runoff. This water was used for pre-sowing irrigation which ensured proper germination and good growth. Water requirement of gram is very less and it takes much water from dew during winter season. Wherever need aroused, one light irrigation was given

MATERIAL AND METHODS

Jalalpur watershed was selected following common guidelines 2008(NRAA,2008). The land was selected on participatory technology development mode. The experimental site belonged to sandy clay loam texture with pH 8.40 and organic carbon(0.37%).The available soil nitrogen, phosphorus and potassium status were 284, 26 and 176 Kg/ha N, P_2O_5 and K_2O, respectively. The experiment was undertaken in split plot design with four replications. Three treatments(control, Farmers' practice and scientific management) were assigned to main plots and two varieties (Kabuli type- Subhra and desi type Pusa Dharwad) were assigned to sub plots. In control no nutrient was applied but the other crop management practices remained same. In farmers practices 100 kg DAP + FYM @ 2 tonnes/hectare were applied as per the practice followed by local farmers. Scientific management included 20-40-20-20 Kg/hectare nitrogen(N), phosphorous(P_2O_5), potassium(K_2O) and sulphur, respectively + FYM @ 2 tonne/ha. Recommended agro techniques were followed. Various biometric and reproductive observations were recorded and data analysed following stand procedure (Gomez and Gomez,) for interpretation.

Experimental finding

Perusal of the data presented in table1 revealed that scientific management recorded significantly higher grain yield(20.15q/ha), 100 seed weight and harvest index over farmers practice and control in both the years. However, scientific management practice and farmers practice were found to be at par with respect to 100 seed weight in 1^{st} year. Among two chickpea types, Subhra(Kabuli type) registered significantly higher seed yield, test weight and harvest index(only in 2^{nd} year) over Pusa Dharwad. Subhra with scientific management practices produced highest seed yield of 20.86 q/ha over all other treatment combinations. Scientific management proved to be significantly superior to both M_1 and M_2 with respect to protein yield. M2 & M3 are found to be at par with regards to fat yield. Both the varieties were found to be at par with each other in respect to above two characters. Highest output/input ratio was observed by scientific management practices in both the years(refer table 3). Chickpea variety Subhra registered significantly higher output/input ratio compared to Pusa Dharwad. In scientific management practices all the major nutrients such as nitrogen, phosphorus , potassium, sulphur and the required micronutrients from FYM in combination resulted in proper nutrition and hence better vegetative growth and optimum partitioning of photosynthates towards reproductive sink was achieved there by giving higher yield. This finding is in agreement with the findings of of Ramakrishna *et al.*2005 and Ramakrishna *et al.*2005.In farmers practice, sulphur deficiency which is an essential component of many amino acids resulted in incomplete physiological activity and hence yield was reduced.

Table 1: Effects of treatments on seed yield of chickpea

Sl. No.	Treatments	Seed yield(q/ha)		100 seed weight(g)		Harvest Index (%)	
1	Main plots	1st year	2nd year	1st year	2nd year	1st year	2nd year
2	M_1-Control	10.97	9.82	25.12	24.96	31.15	30.28
3	M_2- Farmers' practice	17.06	16.54	26.70	26.54	33.33	33.19
4	M_3- Scientific management	20.15	19.45	27.20	27.06	34.02	34.78
5	CD(0.5)	1.52	1.30	0.62	0.42	0.52	0.48
6	Sub plots						
7	S_1-Subhra(Kabuli type)	16.62	15.76	34.02	33.84	32.74	32.43
8	S_2-Pusa Dharwad(desi type)	15.50	14.74	18.62	18.20	33.04	33.11
9	CD(P=0.05)	0.85	0.72	1.50	1.48	0.46	0.42
10	Interaction(MXS)	Sig.	Sig.	NS	NS	NS	NS

Table 2: Interaction effects of management practices and varieties on seed yield(q/ha)

Sl. No.	**Seed yield(q/ha)**						
1	**1st year**	**2nd year**					
2	Name of the varieties	Control	Farmers practice	Scientificmanagement	Control	Farmers practice	Scientific management
3	Subhra	11.74	17.26	20.86	10.24	16.84	20.00
4	Pusa Dharwar	10.20	16.88	19.44	9.40	16.24	18.70
5	*Two subplot means CD(P=0.05). *Two main plot mean CD(P=0.05)	0.82 1.26	0.86 1.20				

Table 3: Effects of treatments on output/ input ratio and protein and fat yield

Sl. No.	Treatments	Protein yield(q/ha)		Fat yield(q/ha)		Output/Input ratio	
1	Main plots	1st year	2nd year	1st year	2nd year	1st year	2nd year
2	M_1-Control	2.30	2.06	0.49	0.44	2.05	1.83
3	M_2- Farmers' practice	3.58	3.47	0.77	0.74	2.65	2.57
4	M_3- Scientific management	4.23	4.08	0.90	0.87	2.82	2.72
5	CD(0.5)	0.42	0.36	0.18	0.16	0.12	0.14
6	Sub plots						
7	S_1-Subhra(Kabuli type)	3.49	3.30	0.74	0.70	2.77	2.63
8	S_2-Pusa Dharwad(desi type)	3.25	3.09	0.69	0.66	2.17	2.06
9	CD(0.5)	0.24	0.22	0.16	0.15	0.10	0.12
10	Interaction(MXS)	NS	NS	NS	NS	NS	NS

Fig. 1 Rain water harvesting at Jalalpur watershed

Fig. 2 Kissan Gosthi at Jalalpur watershed

CONCLUSION

The kubuli type Subhra variety of chickpea can be cultivated in watershed of central India and seed yield of 20.86 q/ha can be obtained by applying 20-40-20-20 Kg/ha nitrogen(N), phosphorous(P_2O_5), potassium(K_2O) and sulphur, respectively along with FYM @ 2 tonne/ha. . By cultivating Subhra(Kabuli type) in scientific practices, farmers can receive a minimu of Rs 18578.00 additional profit per hectare compared to Pusa Dharwad with same management practices due to premium market price of bold seeded variety without any additional expenditure except marginal increase of seed cost.

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Environmental Risk Assessment and Mitigation

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INTRODUCTION

The basic elements of life are land, water, air, and light/heat. Life on this planet exists as plants, animals on land, aquatic species, birds and most important human. By Environment we mean the different basic necessities of life surrounding us. Man by virtue of his intelligence, has evolved as one efficient form of life, using all the other forms of basic elements, to his advantage, in the past many centuries. Most important of all is water which man needs especially for drinking, bathing, washing and cooking. Let us see the resources of water.

It is estimated that India has 16% of world population and 4% of its fresh water resources. Estimates also indicate that surface and ground water availability is around 1869 Billion Cubic Meters (BCM). But 40% of this not available due to geological and topographical reasons. Around 4000 BCM of fresh water is available due to precipitation in the form of rain and snow, most of which returns to the seas via rivers. 92% ground water extracted is used in the agricultural sector, 5% and 3% are used by the industrial and domestic sectors respectively. The average availability of water remains more or less fixed according to the natural hydrological cycle, but the per capita availability reduces steadily due to an increasing population. In 1955, the per capita availability was 5300 Cubic meters (Cum) per person per year which came down to 2200 Cu.m per person per year in 1996. It is expected that by 2020, India will be a "water stressed" country with per capita availability declining to 1600 Cum/person/year.

QUALITY OF DRINKING WATER

While accessing drinking water continues to be a problem with increasing population, assuring that is safe is a challenge by itself. Water quality problems are caused by pollution and over exploitation. The rural population of India comprise more than 700 million people residing in about 1.4 million habitations spread over 15 diverse ecological regions. Due to this there is non – uniformity in level of awareness, socio economic development, education, poverty, practices, and rituals which add to the complexity of providing safe drinking water? It is estimated that around37.7 million Indians are affected by water borne diseases annually and 1.5 million children are estimated to die of Diarrhea alone. What is the reason for this dismal picture? How is this risk in the lives of people occurring? It is due to pollution of drinking water, which gets contaminated with several deadly chemicals.

SOURCES OF POLLUTION

It is very essential to identify the sources of pollution which are risk to health and even life in some cases. There are two major sources of Pollution: (i) Point source and (ii) Non – point source.

(a) The point source consists of source at a well defined place where pollutant is discharged, such as outfall pipes of sewage treatment plants and factories.

(b) Non point source, in contrast, cannot be located with such precision. A run off from street drain, construction site, farm or a mine etc. Therefore, prevention of water pollution requires a mixture of controls on discharges from both point and non-point sources. Domestic waste water and industrial discharge are major point sources.

Domestic waste water: It is the liquid effluent of a community. The spent water is a combination of the liquid and water- carried wastes from residences, commercial buildings. Industrial waste water: It is the liquid waste effluent discharged from factory.

Waste water may be grouped in four classes

Class 1: Effluents those are non – toxic and not directly polluting but liable to disturb the physical nature of the receiving water. They can be improved by physical means. They include such effluents as cooling water from power plants.

Class 2: Effluents those are non – toxic, but polluting because they have an organic content with oxygen demand. They can be treated for the removal of objectionable wastes by biological methods. The main constituent of this class of effluent is usually domestic sewage. But the class includes storm water and wastes from diary product plants and other food factories.

Class 3: Effluents those contain poisonous materials and therefore are often toxic. Theycan be treated by chemical methods. When they occur such effluents are included in industrial wastes, for example, those form metal finishing.

Class 4: Effluents those are polluting because of organic content with high oxygen demand and in addition toxic. Their treatment requires a combination of chemical and physical and biological processes. When such effluents occur, they are in industrial wastes, for example those from tanning.

Bacterial Contamination

Bacterial contamination continues to be widespread Problem across the country and is a major cause of illness and deaths. The major pathogenic organisms responsible for water borne diseases in India are bacteria E Coli, Shigella, V Cholera; Viruses (Hepatitis A Polio Virus, Rota Virus) and parasites (E Histolytica, Glaridia, Hookworm)

Contamination Due To Over Exploitation

In the 1980s and 1990s, ground water tables bucked under increased extraction as water tables started to decline and bore wells ran dry. More disturbingly by then 80% of drinking water resources were ground water dependent. As a result habitations and villages in rural India that were covered with a safe water supply hither to by the government started 'slipping back'. Besides in rural areas of West Bengal endowed with 1,650 mm of rainfall and several rivers, using surplus water and water ponds, as drinking water sources. When ground Water sources were used, reports of arsenic contamination came to light. Similarly, over Extraction of ground water has resulted in increase of fluoride concentration in Andhra Pradesh, Assam, Gujarat, Karnataka, Madhya Pradesh and Rajasthan. Other contaminants include excess iron, nitrates, and brackishness, in coastal areas, as a result of ground water extraction through deep tube well, for drinking and irrigation purposes. Another major cause for concern is pollution of ground and surface water from increased fertilizers, and pesticide use in agriculture. The consumption of fertilizers shot up from 7.7 million tonnes in 1984 to 14.0 million tonnes in 1994 and that of pesticides from 24,500tonnes in 1984 to 85,000 tonnes in 1994. The rise in the usage of such compounds has degraded the quality of surface water resources by causing nitrate contamination.

Industrial Effluents

In 1995, a survey under taken by the Central Pollution Control Board identified 22 sites in 16 states as critical for ground water pollution due to industrial effluents. There have been instances of heavy metals like lead, cadmium and mercury being reported 9in ground water in Gujarat, Andhra Pradesh, Kerala, Delhi and Haryana.

Persistent Organic Pollutants

These are chemicals that degrade very slowly and remain in the environment for years. "POPS" bio accumulates in the fat tissue of organisms and once exposed which means that they are not excreted from the body. the "POPS" used widely in India is DDT, with an annual consumption of 10,000 Metric tonnes; Poly chlorinated Biphenyls used widely in capacitors and transformers and dioxins and furans used in the cement and pipe industry. Ground water in some locations in Jharkhand, West Bengal, Himachal Pradesh and Delhi has reported levels of DDT, Aldrin, Dieldrin and Heptachlor that are in excess of prescribed standards.

Behavioural Practices

It is essential to have clean surroundings around the source to prevent contamination. Open drains and disposal of solid waste near source of water may lead to presence of ammonia and Coli form bacteria, in the drinking water source. Provision of facilities for a sanitary disposal of excreta and introducing sound hygienic behavior are of utmost importance.

Cultural Practices

There are various religious practices that are observed in India take place around sources of water. Immersion of painted idols into surface water bodies are a prime cause of deteriorating water quality. Water bodies (rivers or ponds) are used as dumping grounds for various religious offerings like "Sraaddha" karmas that also degrade the potability of surface water. Defecation on boundaries of water bodies, bathing of cattle and men result in bacterial contamination of the water body.

Pollution Load

90% of the sewage generated by municipalities and over 50% of sewage discharged by municipal corporations goes untreated. The industrial sector contribute 30700 million – cubic meters of effluent being discharged in to our water bodies. In India, an estimated 2,00,000 tonnes of faecal load is generated every day due to open defecation, may be besides humans, cattle, dogs, pigs and such animals too but nevertheless it is appalling.

Mitigation of Risks of Pollution

Having analyzed the various ways water gets polluted, the task of making water potable is clearly devising means of removing the injurious pollutants if not totally, but at least bring them within permissible limits. Indian Standards are there with specific methods of purification of water in a supply and distribution system, by sedimentation, coagulation, filtration for removal of suspended Impurities, the mineral impurities, occur in a dissolved state. The content of these impurities can be ascertained only through testing the water sample. Planning, designing, construction and operation with maintenance are done by state governments.

Purification Methods: The following are the purification processes available in India.

(a) Water with turbidity ----- Pressure filtration with addition of a coagulant.

(b) Water with hardness ----- Sodium Base Exchange water softening or nano filtration.

(c) Water with TDS ----- Reverse Osmosis desalination or Electro dialysis.

(d) Water with Iron ----- Aeration (oxidation of Fe) and subsequent precipitation.

(e) Water with fluorides ----- Deflouridation unit.

(f) Water with bacteriological contamination ----- Boiling for 20 minutes, exposure to UV radiation, Iodination, Ultra filtration.

There are companies with substantial and proven expertise in water purification using all the above processes who can assess the user's requirement accurately and select appropriate treatment systems, which they can supply, install and service.

CONCLUSION

The World Bank estimates the total cost of environmental damage in India amounts to US $ 9.7 billion annually or about 4.5% of India's GDP, of this 60%results from the health impacts of water pollution. Considering the colossal damage of the health of millions of people affected by water pollution, all efforts shall have to be directed to correctly monitor continuously the pollution sources, promptly get the samples of water or effluents tested and then see the water is treated properly removing or scaling down the pollutant level below the maximum permissible limit, before serving to the people. Erring industries letting their effluents without testing, should be brought to book, as per law. Ignorant people must be educated. As the task is challenging, perhaps, involving community in continuous monitoring, locating the pollution points, testing, passing the results to concerned authorities will go a long way to lessen or mitigate the risks of health.

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Community Participation in Conservation of Marine Eco System Biodiversity in Tallarevu Mandal, East Godavari District in Andhra Pradesh

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ABSTRACT

Wetlands spread all over the country provide another distinct class of habitat. Broadly, wetlands are considered complex hydrological and biogeochemical systems. Wetlands are situated in our country different climatic conditions. The study was focused on mangrove eco system and how the bio diversity was depleting in Andhra Pradesh and the role of the local community for protection and conservation of the marine eco system. The study was focused on role of the community in protection and conservation of mangrove biodiversity in Thallarevu mandal, East Godavari district in Andhra Pradesh. The sample was covered 100 community members in 10 villages. The primary data was collected from the community members and secondary data was collected from the MRO, MPDO and forest Department and UNDP office Kakinada. The situation of present and past climate and environmental changes has been collected through the schedules. Majority of the community opined that marine bio diversity was gradually decreased due to industrialization and pouching of animals etc., and revealed that the they are getting many health problems related to skin, eyes, hair fall due to the drastic increase of air and water pollution.

***Keywords*:** Biogeochemical systems, mangrove eco system, floral and faunal species.

1.1 The study profile

The study was conducted at Tallarevu mandal in East Godavari District is located in the North Coastal part of the state of Andhra Pradesh. The district has hilly terrain and climate of this area is characterized by very high humidity, it continues throughout the year. Rains get during the southwest monsoon and retreating monsoon. October is the rainiest month in the year. The average rainfall of the area is 1,378 mm. 100 respondents were participated in the research in which 67 were men and 33 were women. The study was conducted in 10 villages of Tallarevu mandal viz., Aratikayala lanka, Gidlavaripet, P. Mallavaram, Babanagar, Gadimoga, Chollangi, Korangi, Ramannapalem, Pakshulapuntha and Patavala.

Majority of the respondents belongs to illiterate's i.e., 52 respondents.(52 per cent).13 respondents completed primary education (13 per cent), 4 respondents completed upper primary education (4 per cent) 16 respondents completed secondary level (16 per cent) 9 respondents completed degree (9 per cent) and only 3 respondents completed intermediate (3 per cent). The study covered 10 villages which consists SC, BC and OC communities and majority of the respondent's primary occupations are agriculture, fishing and residing in these villages since their birth.

1.2 Biodiversity of the eco system

The study area is situated in the lower Godavari valley, more specifically in the estuaries of the branches of the Godavari, which drain into the Bay of Bengal. The Godavari, the border land vegetation of the estuarine is characterized by dense and expansive growth of woody plants, shrubs and succulent herbs in varying proportion dispersed on a relief, lying under the constant influence of tidal and fresh water resources. The tidal mangrove is characterized by the presence of abundantly growing shrubs and mangrove tree species.

Table 1: Table Showing Situation Past in the Context of Availability Of Biodiversity

			Name of the Village										Total
			Aratikayala lanka	Gidlavaripet	P.Mallavaram	Babanagar	Gadimoga	Chollangi	Korangi	Ramannapalem	Pakshulapuntha	Patavala	
Situation in the past	Hot Temperature and water scarcity	Count	0	0	0	0	0	10	0	0	0	0	10
		Row %	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	10.0%
	Climate condition not bad	Count	0	0	0	0	0	0	10	0	0	0	10
		Row %	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	10.0%
	More health problems, no development	Count	0	0	0	0	0	0	0	0	10	0	10
		Row %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	10.0%
	Good climate condition	Count	0	0	0	10	0	0	0	0	0	10	20
		Row %	.0%	.0%	.0%	50.0%	.0%	.0%	.0%	.0%	.0%	50.0%	100.0%
		Col %	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	100.0%	20.0%
	Earlier people used to stay comfortable life, good environment	Count	10	0	0	0	0	0	0	0	0	0	10
		Row %	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	financially not bad	Count	0	10	0	0	0	0	0	0	0	0	10
		Row %	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	There are so many problems like eye, hair fall etc., due to f	Count	0	0	10	0	0	0	0	0	0	0	10
		Row %	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	Ill health due to hot temperature	Count	0	0	0	0	0	0	0	10	0	0	10
		Row %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	10.0%
	Economically poor	Count	0	0	0	0	10	0	0	0	0	0	10
		Row %	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	10.0%
Total	Count		10	10	10	10	10	10	10	10	10	10	100
	Row %		10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	100.0%
	Col %		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 2: Situation Present in the Context of Availability of Biodiversity

			Name of the Village										Total
			Aratikayala lanka	Gidlavaripet	P.Mallavaram	Babanagar	Gadimoga	Chollangi	Korangi	Ramannapalem	Pakshulapuntha	Patavala	
Situation in the present	Eye problem, Water scaricity due to reliance company	Count	0	0	0	0	0	10	10	0	0	10	30
		Row %	.0%	.0%	.0%	.0%	.0%	33.3%	33.3%	.0%	.0%	33.3%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	100.0%	100.0%	.0%	.0%	100.0%	30.0%
	Villagers are suffering with diseases due to change in envir	Count	10	0	0	0	0	0	0	10	0	0	20
		Row %	50.0%	.0%	.0%	.0%	.0%	.0%	.0%	50.0%	.0%	.0%	100.0%
		Col %	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	20.0%
	Now it is very comfortable in this village than earlier as i	Count	0	0	0	0	0	0	0	0	10	0	10
		Row %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	10.0%
	So many problems due to pollution	Count	0	0	0	10	0	0	0	0	0	0	10
		Row %	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	Financially good and had all facilities	Count	0	10	0	0	0	0	0	0	0	0	10
		Row %	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	Loosing residential place due to factories	Count	0	0	10	0	0	0	0	0	0	0	10
		Row %	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
	Economically good	Count	0	0	0	0	10	0	0	0	0	0	10
		Row %	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	100.0%
		Col %	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	10.0%
Total	Count		10	10	10	10	10	10	10	10	10	10	100
	Row %		10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	100.0%
	Col %		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

1.2.1 Mangrove Forest

Tallarevu area has huge mangrove forest. Mangroves are salt tolerant forest ecosystems of tropical and sub tropical intertidal regions of the world. They constitute a dynamic ecosystem with a complex association of species both of flora and fauna of terrestrial and aquatic system and the vegetation in this forest is of evergreen type. They normally occur between high water levels and near about mean sea level along the sheltered shores, estuaries, tidal creeks, back-waters, lagoons, marshes and mud-flats. Mangroves are extensive and productive forests in the sheltered coastal lines and contain a highly specialized community of plants associated with animal species which are not capable of surviving in any other situations. Mangrove occurs in Andhra Pradesh in estuaries of Krishna and Godavari rivers.

1.3 Situation analysis

The situation analysis was made with the interview schedule and Focus Group Discussion with the respondents who are the community members of respective villages. Majority of the respondents, i.e. 90 respondents (90 per cent) have been stated that the earlier environment and climatic condition was good and had abundant resources like water creatures, birds, animals , insects, planets , trees and shrubs etc were available in their villages. While the study represents 90 respondents (90 per cent) opined that marine bio diversity was gradually decreased due to set up of industries in and around the Thallarevu manda which lead to pollution and pouching of animals also one of the reason for declining bio diversity. Majority of the respondents stated that they are getting so many health problems related to skin, eyes, hair fall due to the drastic increase of air and water pollution in their area. 90 per cent of the respondents stated that water scarcity has been increased since 10 years due to dried wells in the villages.10 per cent of the respondents lost their residential area because of establishment of industries. Below give table no.1 explains the situation in the past and also Table no.2 explains about present situation in the context of availability of biodiversity.

1.4 Reasons for decreasing bio diversity at marine eco system

There are different reasons for decreasing the marine bio diversity in Tallarevu mandal. 100 per cent of the respondents were affirmed that marine bio diversity was lost due to the increased hot climate, increased industries in their area since 10-15 years and lead to air and water pollution. This is the main reason for loosing bio diversity.

1.5 Impact of degradation of marine biodiversity:

The loose of biodiversity affect the different aspects in the environment especially human health, animals, agriculture and water bodies.100 per cent of the respondents were agreed that environmental impact was very high for increased hot climate in their area for last one decade. 20 per cent of the respondents stated that increased health problems. 40 per cent of the respondents stated that health problems rose due to reliance industry and sugar factories at their localities.

1.6 Initiatives for conservation of biodiversity

The reliance industry has taken up initiation for the development of the villages by providing employment opportunity at industries, drinking water facilities in their villages stated by the 60 per cent of the respondents, but not focused on conservation and protection of the environment. 10 per cent of the respondents stated that the forest department has taken initiation for plantation programmes like social and avenue plantation in the villages.

1.7 Community participation

100 respondents in 10 villages (100 per cent) were aware about the conservation and protection of the biodiversity and importance of the biodiversity. 100 per cent of the respondents were taken initiatives for conservation of biodiversity. 90 respondents (90 per cent) of the respondent's evidences that the they actively participate for the protection of biodiversity in their villages, besides that, 100 respondents (100 per cent) respondents participated biodiversity activities in consultation with the forest department and other NGOs.

Majority of the respondents were participating in incentive mode and functional mode like participating in awareness camps, trainings, meetings and workshops. Except the Gurupalli village community rest of the 9 villages are self mobilized for conservation and protection of the biodiversity.

CONCLUSION

The research study found that the community aware about importance of the biodiversity and actively participating for conservation of biodiversity in their villages. It is also observed that there is loss of marine bio diversity due to increased industries and lead to pollution which adversely affecting human health drastically in Talarevu mandal. The Government and Non Government Organization should implement precautionary steps to reduce the pollution and protect the conservation of marine eco system.

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Studies on Impact of Mining on Surface and Groundwater in Chimakurthi Mandal of Prakasam District, Andhra Pradesh, India

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ABSTRACT

There is an appreciable and adagio impact of mining on surface and groundwater. Rapid development of mining throughout the world with the galloping advances in science and technology is changing the shape of our planet and also hydrological region at micro level. World top quality galaxy granite (Gabbro) occurs in Chimakurthi mandal of Prakasam district of Andhra Pradesh. From the analysis of data pertaining to mining, rainfall and groundwater levels (1999-2010), it is observed that, the rainfall in the mandal shows declining trend over the successive years and more prominent since 2002 onwards. There is no noticeable effect of rainfall on groundwater recharge, because of poor aquifer system.

INTRODUCTION

Mining refers to obtaining valuable minerals and rocks from the ground. Mining boosts both the local economy of the area where the actual mining is taking place and countries economy as well; it creates primary and secondary employment and also earns foreign exchange.

The environmental impact of mining includes erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, ground water and surface water by chemicals from mining process. Besides creating environmental damage, modify the existing drainage pattern and also causes the environmental hazards.

STUDY AREA

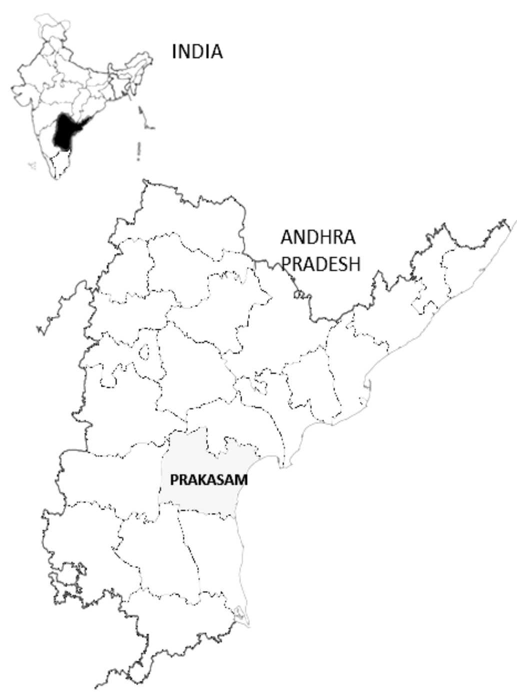

Fig. 1 Study area of the proposed research work

Table 1 Comparision of Groundwater level with Rainfall for the Year 2000-2004

Sl. No	Month	2000-01		2001-02		2002-03		2003-04		2004-05	
		Ground Water Level (mts)	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**
1	June	12.17	128.0	12.43	29.0	11.79	51.3	15.05	88.1	14.91	24.2
2	July	10.27	142.4	13.49	36.7	12.49	45.4	13.79	112.7	15.02	91.00
3	August	6.28	332.6	11.89	85.1	10.77	90.5	13.38	75.2	15.63	22.5
4	September	6.75	68.7	10.99	157.8	11.56	52.3	13.57	132.8	13.97	171.2
5	October	6.77	83.6	6.79	259.5	10.44	217.4	10.03	160.5	13.20	136.1
6	November	6.64	45.7	5.89	90.0	9.87	56.2	10.19	14.7	12.76	47.6
7	December	7.22	17.0	6.78	11.5	10.72	0.0	11.44	26.6	14.00	0.0
8	January	8.49	5.3	7.77	38.5	11.98	3.6	12.44	5.4	14.72	0.2
9	February	9.46	0.0	8.47	0.0	12.94	0.0	13.12	0.0	15.84	4.4
10	March	10.11	1.4	9.62	1.9	13.62	21.1	14.70	6.2	16.52	3.4
11	April	10.33	49.0	10.45	2.8	13.75	3.4	15.21	11.8	17.30	3.6
12	May	10.13	6.9	9.85	21.8	15.15	1.0	13.91	118.7	17.57	41.2

Table 2 Comparision of Groundwater level with Rainfall for the Year 2005-2009

Sl. No	Month	2005-06		2006-07		2007-08		2008-09		2009-10	
		Ground Water Level (mts)	**Rainfall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**	**Ground Water Level (mts)**	**Rain fall (mm)**
1	June	17.7	13.8	8.7	79.4	11.1	263.6	9.8	28.1	12.0	40.5
2	July	16.5	103.9	9.2	27.7	8.3	72.5	9.9	87.8	12.4	19.6
3	August	16.6	58.2	9.7	39.2	7.8	135.8	9.8	103.3	13.1	113.3
4	September	14.2	162.6	9.6	128.1	7.2	127.2	10.1	69.5	12.7	108.0
5	October	9.0	431.6	9.9	201.3	7.3	167.6	10.1	119.0	10.8	45.0
6	November	6.4	47.8	7.5	154.2	6.2	43.7	9.7	292.8	8.3	210.7
7	December	6.6	6.1	8.0	9.7	7.0	0.4	6.2	5.5	8.1	16.5
8	January	7.2	0	9.0	0	7.9	0.0	6.8	1.0	9	4.1
9	February	7.9	0	10	7	8.1	87.7	8.3	0.0	10.2	1.8
10	March	8.2	66.6	11	0	7.7	99.7	9.3	2.4	10.7	1.6
11	April	8.0	74.2	11.5	17.6	8.2	4.0	10.4	5.2	11.8	9.5
12	May	8.5	43.5	12	45.6	8.7	19.2	11.4	47.6	11.8	196.7

Correlation between mining and rainfall =	+ 0.1554
Correlation between mining and Avg Ground Water Table =	– 0.3457
Correlation between Rainfall and Avg Ground Water Table =	– 0.6788

Chimakurthi mandal is one of the important mandal in Prakasam district which is located in East side of the district, where world top quality galaxy granite (gabbro) is available. Gabbro is an igneous rock belonging to younger intrusive (proterozoic age). Chimakurthi igneous body is in crescent shaped hill range with Southern convexity at its centre and two protruding arms on either side. The mining belt of Chimakurthi black Galaxy Granite (Gabbro) is confined to the Southern plains, which reach a low altitude of around 60 meters near the Ongole – Podili State highway. The area in general witnesses to a topographic relief of around 570 meters. The water course in the area is ephemeral in nature. The streams originating on the Eastern flanks of Chimakurthi hill range drain into big tank called Peddacheruvu. The proposed study has shown in Fig. 1.

The streams originating on the South Western flanks join into Musi River. The streams originating on the Northern Concave portion joins the Dornapu vagu. The Nagarjuna Sagar Jawahar Canal passes through the valley between the Ervakonda and the Sarivi Konda hill range and crosses the Chimankurthi black Granite belt. From ground water point of view all the wells, borewells, dugcum borewells approximate yields are 15m^3/hr, permeability of the rock is around 0.5 – 25, specific yield 0.005 - 0.40. Hence, well yields are moderate. Comparision of Groundwater level with rainfall for the years 2000 to 2004 and 2005 to 2009 has listed in Tables 1 and 2.

METHODOLOGY

Galaxy granite (Gabbro) mining data collected from the district mines and geology department from 1999 – 2010 and were analyzed, rainfall data collected from District Chief Planning Officer and ground water table data collected from the State Ground Water Board and were analyzed by using statistical methods. Drainage system are also studied by using Survey of India topo sheet no.57M/14 , on 1:50,000 scale, which is surveyed in 1970-73, and compared with recent google map with same scale and also find out the correlation coefficient. Correlation is to estimate the values of one factor by reference to the values of an associated factor, it also discover and measuring the relationship. Rainfall data is shown in Table 3.

Table 3 Rainfall mining area for the years 2000 to 2009

Year	Rainfall in mm	Mining in Cum	Avg.GWT in metres
2000-01	880.6	52993	8.718
2001-02	734.6	719125	9.535
2002-03	542.2	86223	12.090
2003-04	752.7	203638	13.069
2004-05	545.4	194193	15.120
2005-06	1008.3	223634	10.567
2006-07	709.8	258716	9.675
2007-08	1021.4	407511	7.958
2008-09	762.2	344009	9.317
2009-10	767.3	342415	10.908

ANALYSIS OF DATA

From Tables 1 and 2 maximum rainfall receives in October month (i.e., 431mm) minimum rainfall is zero in the month of February. Average rainfall is 64.37mm. Study area receives more than average in 5 months and in 7 months less than average which indicates no good rainfall.

Average depth of water table is 10mtrs. The maximum depth is more than 15mtrs in the months of March, April and May months.

RESULT AND CONCLUSION

- From the analysis of rainfall data it is observed that the study area receives good rainfall during the southwest monsoons, it is an erratic rainfall.
- The average rainfall is 64.371 mm, most of the years rainfall is less than average. Standard deviation of the rainfall is 48.578; there is a lot of deviation in rainfall (approximately 50%).
- By the analysis of monthly rainfall and ground water levels from year 1999 to 2010, the levels of ground water are not affected in the area.
- From drainage map it is observed that drainage system is Dendroitic, first order streams are 54 in number with length of 137.143 Kms it is in the year 1970-73, in the year 2014, and first order streams are 46 numbers with a length of less than 100 Kms which is clearly indicated that mining impact on stream flows in study area.
- Ground water table decreased rapidly during 1999 to 2000, which is around 2m.
- Mining activity in the area increased hugely from year 2006 especially in granite quarrying (537138 m^3 to 3626372 m^3) by 3089234 m^3 because of mining ground water table from year 2005 decreased by 8m even though good amount of rainfall because aquifer system is galaxy granite which is not a good aquifer because fine grain, crystalline, compacted rock with less than 1 % of water absorption poor porosity.
- Correlation between mining and rainfall is a positive, mining vs groundwater table and rainfall vs average groundwater table is a negative which is clearly indicate there is no relation which means the aquifer system (gabbro) is not respond according to rainfalls.
- It is also observed that drainage pattern also change which is affected till irrigation, drinking water sources and soil fertility.

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Fungal Diversity Studies from the Soil Samples of Desiccate Surface of Ponds with Different Land-Use

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ABSTRACT

To explore the spatial variation of the fungal community of soils of temporary ponds of different land-use, including birds sanctuary, domestic utilization and irrigation purpose, the present work was done. Three ponds viz., Periya Kollukudipatty (CKPTY), Chinna Kollukudipatty (CKPTY) and Vettangudipatty (VGDPTY) were selected and soil samples were collected from the dry surface of the experimental ponds and were tested for the fungal community. PKPTY pond soil showed comparatively more number of fungal species whereas; CKPTY pond soil had the least number of fungal species. Common occurrence of few fungal communities were also observed in the experimental sediment samples, collected from the ponds. The varying nature on the occurrence of the fungal species in ponds' dry surface is found influenced by the biological interactions occurred due to varying land-use nature of the ponds.

***Keywords*: Fungal communities – Temporary ponds – Birds sanctuary.**

INTRODUCTION

Soil is flourished with rich biological diversity. Studies related to determining environmental factors controlling the distribution and abundance of soil microorganisms are inadequate (Rousk *et al.,* 2010). Land-use change plays a significant role in altering the soil conditions and thereby affects the biotic composition in the soil system (Lauber *et al.,* 2008). Such alterations have long-lasting effects on soil parameters such as soil carbon, nutrient contents, soil texture and pH (Murty *et al.,* 2002), eventually will have the influence on the soil microbial community and their physiological functions. The land-use pattern severely alters the fragile ecosystem. Hence the management of pond systems are foremost important. This precious ecosystem conservation and management include the monitoring of ponds on their ecological nature, biodiversity and their interrelationship. This critical approach would fetch the sustainability of ponds for their benefits to be available to human beings.

Ponds have a wide variety of microbial life with different types of microbes, which may be attributed due to the existence of different levels of dissolved oxygen and light at different depths in the pond. These factors lead distinctly different niches from green algae and cyano bacteria on the surface to sulfate reducers and methanogens on the bottom. In addition to that, biotic interaction including the vegetation, microflora and microfauna, avian population, insects and other organisms further causing a dynamic interaction with the ecological factors.

Fungi is known to play a vital in any ecosystem, as decomposers, symbiotic association with plants and animals and as parasites to living organisms. Fungi interact with their hosts, and also with abiotic variables in the associating environment. They are omnipresent and occur in soil and fresh water, in extreme habitats experiencing high and low temperature on dry substrates and in concentrated nutrients.

Temporary ponds are important inland wetland ecosystem having rich productivity and diversity of wildlife such as birds, fishes, crabs, worms, insects, reptiles and amphibians (Madhyastha *et al.,* 2000). However, studies pertaining to influence of land-use change on the biotic composition of temporary ponds are yet to be studied completely. The microbial populations and their activity are greatly influencing over the property of ponds' sediment and the surface soil system. Elemental exchange occurs between sediment and overlying water is responsible for the hydro geochemical cycle in pond (Beena,2010).

In the present study, an attempt was made to explore the spatial variation of the fungal community of soil samples, collected from the dry surfaces of three experimental ponds of Vettangudi Birds Sanctuary, Sivaganga District, Tamil Nadu, which have various land-use nature.

MATERIALS AND METHODS

Study area

The Vettangudi bird sanctuary is located in the villages of Periya Kollukudi Patty, and Vettangudi Patty Villages of Singampunari Block, Tiruppathur Taluk, Sivagangai district, Tamilnadu State. Vettangudi ponds were declared as a Bird Sanctuary in June, 1977. The Vettangudi bird sanctuary has comprised three drainage ponds viz., Vettangudi Patty pond (VGDPTY), Chinna Kollukudi Patty pond (CKPTY) and Periya Kollukudi Patty pond (PKPTY), where the present work was done.

Vettangudi Patty pond is the biggest pond among the ponds in the proposed study The total area of VGDPTY (latitude 10º 06.10'N and longitude 78º 01.23"E) is 18.42 ha; CKPTY pond (latitude 10 º 06.57'N and longitude 78 º 30.41E) is the smallest pond of the study area. CKPTY pond (latitude 10 º 06.57'N and longitude 78 º 30.81E) spreads to an area of 6.315 ha. All the three experimental ponds are temporary or ephemeral ponds and generally those ponds are filled with water for 4-5 months between the months of November and February.

PKPTY pond accommodates a large number of avian population of the size of about 20,000 individuals comprising about 30 species, mostly migratory from within the county and overseas countries. The preference of the migratory birds to PKPTY pond is muti-fold as shelter, forage and breeding. PKPTY and other two ponds are utilized the ponds by the communities for their domestic needs, irrigation and cattle ranching in the ponds during drying. Hence the multifold utility has been observed on the experimental ponds.

Sampling

Sediment samples were collected from different ponds of Vettangudi Birds sanctuary, comprising of three different ponds viz., VGDPTY, PKPTY and CKPTY in November 2013, just before the onset of north-east monsoon,. Sediment layer at a depth of 0-10 cm was collected, using soil auger. .Sediment samples were collected in the labelled sterile polythene bags and stored in cold condition at the environment analysis laboratory, Thiagarajar College, Madurai.

Sterilization of Samples

All glasswares were washed with detergent, rinsed thoroughly with distilled water before sterilization.The glasswares, media and solutions prepared were sterilized by autoclaving at 121°c for 15-30 minutes. Inoculations were done with flame sterilized loops and all experiments were performed at clean and aseptic conditions.

Isolation of Fungi

The soil was Fungal populations were isolated on potato dextrose agar using the method of Gilman (1957). Fungal species were identified based on its morphological features viz., hyphae and conediophore structures (Watanabe, 2002).

Fungal Culture

Isolation of fungi was performed by making serial dilution from the pond sediment samples and the dilution factors used for the present study were between 10^{-2} and 10^{-7}. The dilution was spread in potato dextrose agar medium plates and media was weighed out and prepared according to the manufacture's specification, with respect to the given instructions and directions. The plates were incubated at 37°C for 48 hrs. The Pure cultures were obtained and fungi species were identified by morphological structures observed by lactophenol cotton blue staining under 100X, 40x and 10X magnification using light microscope.

The presence of fungi present in the samples were calculated by using the following formula:

No. of microorganism/gm sample = number of colonies × dilution factor

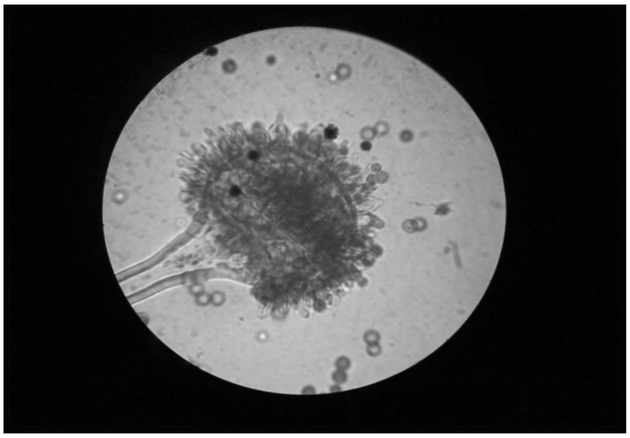
RESULTS AND DISCUSSION

In relation to the two experimental ponds viz., VGDPTY and CKPTY, fairly a rich diversity of fungal organisms were observed in the sediment samples, collected from PKPTY pond (Table 1). The common occurrence of *Penicillum chrysogenum* was found irrespective of the sediment samples, collected from the three experimental ponds. Fungi like *Mucor, Trichoderma, Curvularia, Chrysonilia, Aspergillus niger, A.flavus* were found from the sediment samples (Plate 1). Both in PKPTY and CKPTY samples, there was no difference observed in the fungal colonies. Considerably low number of fungal colonies formation was observed from VGDPTY pond sediment sample, when compared with the other two experimental samples (Figure 1)..

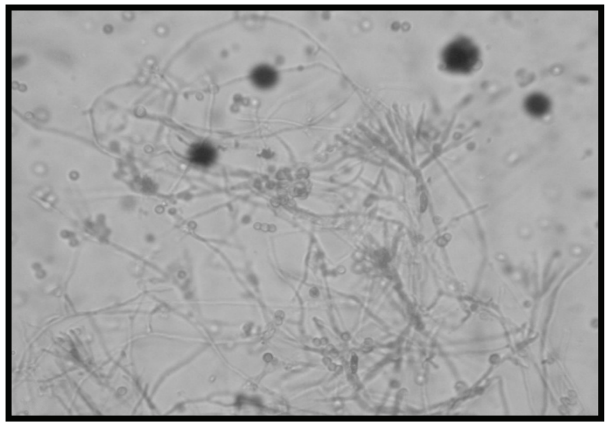
Table 1: Occurrence of fungal species, observed from the sediment samples of experimental ponds' surface. (✓ shows the presence and x represents the absence of organisms)

Fungal species	PKPTY	CKPTY	VGDPTY
Alternaria alternate	✓	×	×
Aspergillus flavus	✓	×	×
Aspergillus fumigates	✓	×	×
Aspergillus niger	✓	×	×
Aspergillus quercinus	✓	×	×
Chrysonilla sp	✓	×	×
Curvularia clavata	✓	×	×
Helminthosporium oryzae	×	✓	×
Isaria fumosoroseus	✓	×	✓
Metarhizium anisopliae	✓	×	✓
Mucor sps.	X	✓	×
Penicillium chrysogenum	✓	✓	✓
Penicillium lanoso-coeruleum	✓	×	×
Rhizophus sps.	✓	x	x
Saprolegnia glomerata	✓	×	×
Thamnidium elegans	✓	×	×

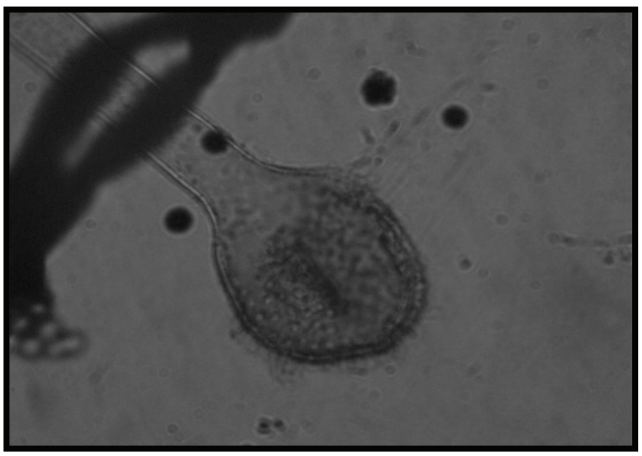
Aspergillus



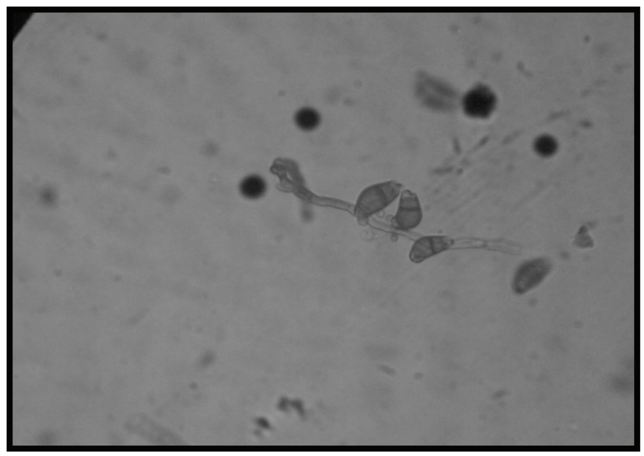
Penicillium



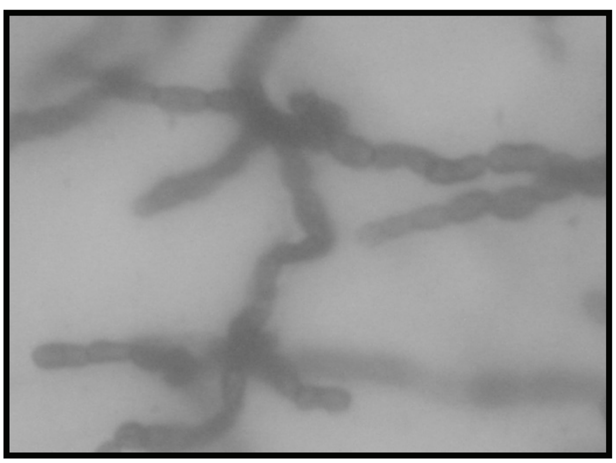
Mucor



Curvularia



Chrysonilia



Rhizopus

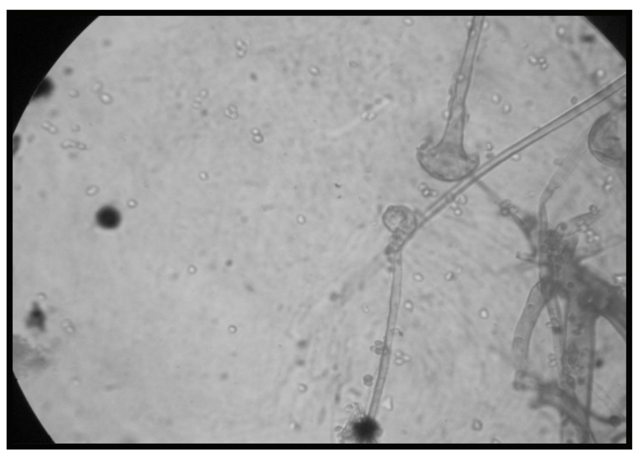


Plate 1: Microscopic (10x) view of fungal species, observed from the three different experimental sediment samples

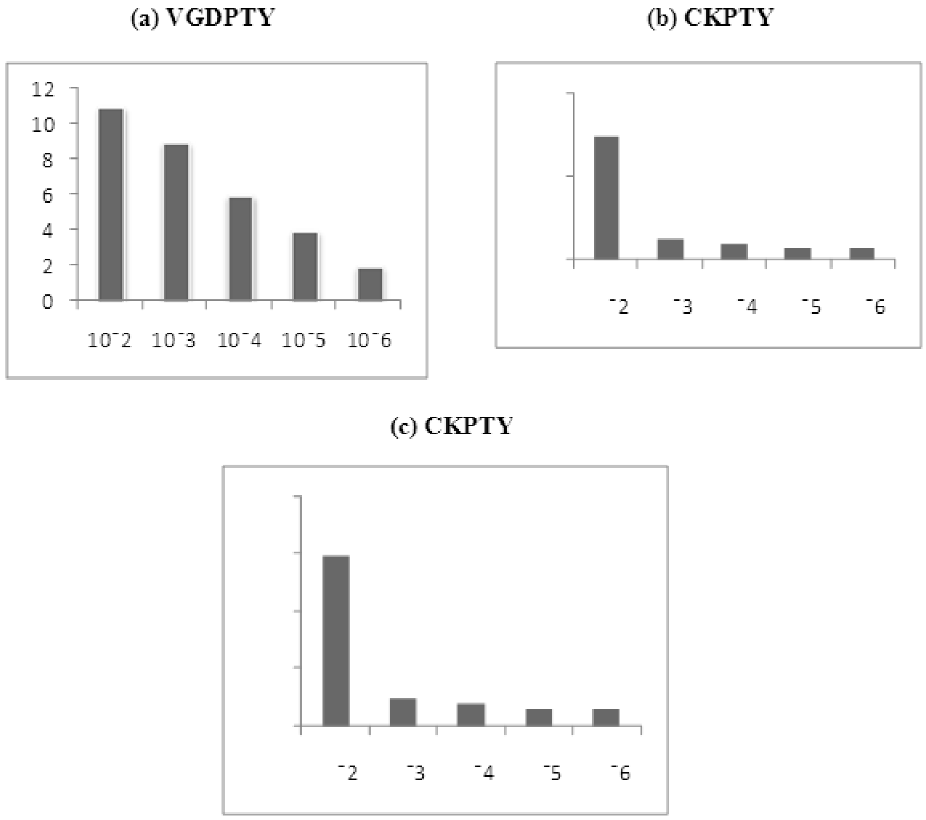


Fig.1: Fungal colonies of the experimental ponds' sediments samples

In the present study, soils found in the three temporary ponds were varied among them in their fungal species composition. The variation might be due to biological influence exerted on these soils. Presence of a greater fungal diversity in PKPTY pond could be attributed to the pond was largely used by the avian population, sheltering in the pond for foraging and breeding. This feature causes a significant role in causing eutrophication of pond water through the ornithogenic products such as feathers, fecal wastes, etc. This would lead to the enhancement of microbial diversity including the microfungal diversity A positive relationship between vertebrate presence and microfungal diversity was reported in earlier studies (Wicklow, 1968; Seppelt *et al.,* 1999; Kerry, 1990a, b), which substantiates the results of the present study.

Fungal community in PKPTY pond was found to be dominated by species belonging to Ascomycota. Similar result was also observed by Alias *et al* (2013) in ornithogenic soils of Antarctic regions. Soil fungal diversity was found to be increased with increase in soil acidity and decrease in pH (Alexander, 1980), which would have been done through the ornithogenic products, where from the possibility of uric acid secretion is in greater amount. . *Penicillium* are ubiquitous soil fungi preferring cool and moderate climates, commonly present wherever organic material is available. Saprophytic species of *Penicillium* live mainly on organic biodegradable substances. *Mucor* is capable of degrading polycyclic aromatic hydrocarbons (PAHs) and hence the presence of this species clearly indicates the scavanging activity of such organism to the environment; thereby reducing the land pollution effect.

Community study is an important aspect in ecology (Saju and Tiwari, 2011). In this study, we explored the fungal biodiversity in the sediments of spatially separated three temporary ponds. Biotic interaction due to bird populations was the reason for such variations due to its influence on soil edaphic properties. The results of the present study is useful to understand the ecological nature of pond functioning, thereby it provides a better understanding to develop proper management guidelines. The study is required to be extended further to understand the ecological interrelationships among the hydrological nature of pond water and the water quality by means of physical, chemical and biological.

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Comparative Analysis on the Riparian Vegetation of the Pambar and Thalaiyar Freshwater Streams, Tamilnadu, India

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ABSTRACT

Floristic composition was analysed through field studies along the riparian zones of Pambar and Thalaiyar streams, originating and flowing through the reserve forests of Palani Hills, South – East Western Ghats, Tamilnadu. Both the streams are third to fourth order natural freshwater and seasonal streams. They have different land-use patterns with different rate of human interventions on the streams. The objective of the present study was to undertake the riparian vegetation community analysis to find out the similarity and variations among those vegetation community existed between the experimental streams. Results of the present study would be useful to relate the environment conditions, biotic interactions and human disturbance on the streams, which are the environment monitoring system, eventually can be applicable in the sustainable management of natural fresh water streams.

***Keywords*:** Freshwater streams – Pambar – Thalaiyar - Riparian vegetation.

INTRODUCTION

Freshwater ecosystems sustain several organisms' life and establishing civilizations throughout history. Freshwater ecosystems are among the most threatened environments in the world (Richter et al., 1997; Malmqvist and Rundle, 2002). Riparian forests (RF) growing along streams, rivers and lakes have special functions in the landscape as the interface between the terrestrial and the aquatic ecosystem. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian zones are usually a diverse mosaic of landforms, communities and environments within landscapes and they serve as a framework for understanding the dynamics of communities associated with fluvial ecosystems (Gregory *et al*., 1991; Naiman *et al*., 1993). Riparian vegetation supports ecosystem function in streams and rivers by providing shade, habitat and food for terrestrial and aquatic animals, stabilizing banks, intercepting and sequestering contaminants and contributing coarse woody debris that creates diversity in aquatic habitats. Plant communities in large river flood plains are amongst the most productive and diverse in the world and frequently support higher number of plant species arranged in vegetation associations of greater complexity than surrounding landscaping units (Menges and Waller, 1983; Tockner and Stanford, 2002).

The world's wetland and river have felt the brunt of human impacts. In Asia alone, about 5000km^2 of wetland are lost annually to agriculture, dam construction, and other activities. About 50% of the global wetlands area has been lost as a result of human activities (Annonymous, 1996). Much of this has been occurred in northern countries during the first half of the twentieth century, but increasing trends towards the alternative land uses have accelerated wetland loss in tropical and subtropical area since the 1950's (Moser *et al.,* 1996). In addition, wetlands are important feeding and breeding areas for wildlife and provide a stopping place and refuge for waterfowl. As with any natural habitat, wetlands are important in life supporting species diversity and have a complex of wetlands values (Prasad *et al.,* 2002). The removal of such Wetlands system has been leading to worsening of water quality, because of urbanization or varying land-use change (Vincy *et al.,* 2012). Fresh water ecosystems are some of the most threatened in the world, the loss of biodiversity appears to be more intense than that of any other habitat (Dudgeon *et al.,* 2006; Clavero *et al.,* 2010; Olden *et al.,* 2010; Moyle *et al.,* 2011). The objective of the present study is to undertake the riparian vegetation community analysis to find out the similarity and variations among those vegetation community existed between Pambar and Thalaiyar streams.

MATERIALS AND METHODS

Study Area

The present study was carried out in two different fresh water streams viz., Pambar stream ($10^0$11 '17N and 77^0 31`74 E) and Thalaiyar stream (10^0 13' 25 N and77^0 35' 54 E), both originating and flowing through the southern Palani Hills of Southern Western Ghats, situated respectively in Theni and Dindigul districts of southern Tamilnadu, India.

Pambar Stream *(Kumbakkarai falls):*

Pambar stream is a natural perennial stream, located in the downstream of Kodaikanal area of southern Palani hills range. The perennial stream develops into Pambar River with the total length of approximately 20 km, including the main waterfalls. The total flowing distance of the stream is about 23-25kms, with varying degree of slopes leading into short and lengthy waterfalls. Kumbakkarai waterfalls a popular ecotourism spot is located in Theni district, 9 kms from Periakulam town. The stream originates at Kodaikanal hills and flow along with rocks and finally reaches the foothills. The perennial stream is one of the important water sources of Vaigai reservoir. The Riparian zone of the stream constitutes an diversified vegetation with various kinds of flora and fauna communities.

Thalaiyar Stream*: (Rat-tail falls)*

Thalaiyar stream is a semiperennial second order stream, located in lower Palani Hills of Western Ghats of Dindigul district. It has a waterfalls at its downstream which is 975 feet tall, which is the highest watefalls of Tamilnadu. The total length of the stream is about 15km from its main source at Perumalmalai, near Kodaikanal. Perennial rivers such as Moolayar and Arunganal and semiperennial rivers like Irutar and also Thalaiyar are important water source of Manjalar reservoir and it is used for irrigation in lower Palni areas. The climate is sub-tropical with major vegetation types broadly classified into scrub forest, moist and deciduous forest of low and mid elevations and montane evergreen forest of high elevation. The Manjalar reservoir forms an important water body for water birds. Some parts of the river delta in lower Palnis constitueted an endemic eco-region with very rare and endangered plants and animals of India but now it has been modified with cultivation of silk cotton, teak, mango orchard, coconut, sugarcane and other cash crops.

Floristic Study

The study of Plant diversity community structure and specimens collection were conducted along the Riparian zones of both experimental streams. Extensive and intensive floristic study was carried out in the study area at monthly intervals during the study periods of June 2012 to May 2013. Specimens of flowering and non-flowering vascular plants found in the study area were collected and processed in the laboratory. The Plants were identified with their botanical names, using standard keys and flora: Flora of central Tamilnadu by K. M. Mathew (1995), Flora of Tamilnadu vol-2 by Henry *et al.,* (1987), Flora of Eastern Ghats vol 3 and 4 by Pullaiah *et al* (2007; 2011) and Plants of Western Ghats vol 1 and 2 by Ganeshaiah *et al*., (2012). The valid names of the Plants were checked by Catalogue of life, IPNI (International Plant Name Index), GBIF (Global Biodiversity Information Facility), and Biodiversity portal. The voucher specimens are kept in the Department of Botany in Thiagarajar College, Madurai. Tamil Nadu. India.

Vegetation Community analysis

Vegetation community analysis was carried out July and December, when usually the majority of the plants occurrence on the riparian zone is expected during that period. Seven quadrats of 2m×2m (4 m^2) size were randomly laid to study the vegetation structure. Shannon's diversity index was calculated using the following formula. Similarity index values were also for the analysed vegetation.

$$H = \sum_{i=l}^{s} -(P_i * \ln\ P_i)$$

where ,

H = Shannon diversity index,

Pi = Fraction of the entire population made up of species I,

S = Numbers of species encountered,

∑ = Sum from species l to species S

Similarity index for the vegetation analysis are calculated by using the following formula.

Eveness index (H') = $\frac{S}{hl'}$ Where, S= total number of species. H'=diversity index value.

RESULTS AND DISCUSSION

Totally 31 plant species representing 30 genus and 22 families were recorded in Pambar stream and 36 species belongs 39 genera and 24 families were occurred in Thalaiyar stream (Tables 1 and 2). The higher Shannon's diversity index is 1.43 and lower index value 0.53 in Pambar and a range between 0.429 and 1.567 as the index values, noted for different species observed through the quadrat study done in Thalaiyar stream (Table 2). In comparision with Pambar stream, Thalaiyar stream have dense vegetation. This phenomenon could be attributed due to structural differences exists in the experimental streams. *Chromolaena odarata, Dysphania ambrosioides, Oplismenus compositus, Anamirta cocculus* are the dominant species found in the Pambar stream. In the Thalaiyar stream *Homonoia riparia* is dominantly found. *Persicaria hydropiper, Oplismenus compositus, Hemionities cordata, Drymaria cordata, Asclepias currassavica* are richly found in the surface, of the forest floor, influenced by the stream environment at Thalaiyar.

Table 1: Floristic composition and vegetation diversity indices of Pambar stream

S.N	Binomial name of Plants	Shannon's index	Similarity index
1.	*Achyranthes bidentata* Blume.	1.03	0.937
2.	*Adiantum incisum* Forssk	0.689	0.994
3.	*Amaranthus viridis* L.	0.53	0.764
4.	*Anamirta cocculus* (L.) Wight & Arn.	1.055	0.96
5.	*Bidens pilosa L.*	0.824	0.75
6.	*Blepharis maderaspatensis (*L.) Heyne ex RothNov.	0.831	0.757
7.	*Caryota urens* L.	0.637	0.918
8.	*Chloris barbata* Sw.	0.606	0.874
9.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	1.358	0.98
10.	*Cissus quadrangularis* L.	0.562	0.811
11.	*Cyanotis cristata* (L.) D.Don.	0.76	0.691
12.	*Desmodium laxiflorum* Dc.	0.673	0.971
13.	*Dichrostachys cinerea* (L.)Wight & Arn.	0.693	1
14.	*Drymaria cordata* subsp. *cordata* (L.) Willd. ex Roem. & Schult.	0.673	0.971
15.	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	1.43	0.889
16.	*Elytraria acaulis (*L. f.*)Lindau*	0.637	0.918
17.	*Eupatorium album* L.	0.637	0.918
18.	*Evolvulus alsinoides (*L.) L.	0.655	0.946
19.	*Hybanthus enneaspermus* subsp. *enneaspermus* (L.) F. Müll.	0.637	0.918
20.	*Ipomoea hederifolia* L.	1.099	1

Table *Contd*…

S.N	Binomial name of Plants	Shannon's index	Similarity index
21.	*Ipomoea turpethum* (L.) R. Br.	0.637	0.918
22.	*Ixora pavetta* Andr.	0.637	0.918
23.	*Kalanchoe laciniata* (L.) DC.	0.937	0.853
24.	*Kyllinga pumila Michx.*	0.693	1
25.	*Murdannia esculenta* (Wall. ex C.B.Clarke) R.S.Rao & Kammathy	0.562	0.811
26.	*Nephrolepis biserrata* (Sw.) Schott	0.937	0.853
27.	*Oplismenus compositus (*L.) P.Beauv.	1.022	0.93
28.	*Pouzolzia pentandra* (Roxb.) Benn.	0.562	0.811
29.	*Sansevieria roxburghiana* Schult. & Schult.f.	0.637	0.918
30.	*Stenosiphonium parviflorum* T. Anders.	0.974	0.887
31.	*Streblus asper* Lour.	0.693	1

Table 2: Floristic composition and vegetation diversity indices of Thalaiyar Stream

S.N	Binomial name of Plants	Shannon's index	Similarity index
1.	*Acalypha indica* L.	0.943	0.859
2.	*Achyranthes aspera* L.	0.662	0.954
3.	*Adenanthera pavonina* L.	0.451	0.65
4.	*Adiantum incisum* Forssk	1.466	0.911
5.	*Amaranthus viridis* L.	0.5	0.722
6.	*Anamirta cocculus* (L.) Wight & Arn.	0.637	0.918
7.	*Anisochilus carnosus* (L. f.) Benth.	0.429	0.619
8.	*Artemisia nilagirica* (C.B.Clarke) Pamp.	0.652	0.94
9.	*Asclepias curassavica* L.	1.221	0.88
10.	*Begonia malabarica* Lam.	0.637	0.918
11.	*Bidens pilosa* L.	1.315	0.948
12.	*Blepharis maderaspatensis (*L.) Heyne ex Roth Nov.	0.52	0.75
13.	*Blumea obliqua* (L.) Druce	0.673	0.971
14.	*Boerhavia diffusa* L.	0.562	0.811
15.	*Boerhavia erecta* L.	0.562	0.811
16.	*Bonnaya oppositifolia* (Retz.) Spreng. *Bonnaya oppositifolia* (Retz.) Spreng.	0.606	0.874
17.	*Cestrum nocturnum* L.	0.5	0.722
18.	*Chloris barbata* Sw.	0.647	0.934
19.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	1.249	0.776
20.	*Cleome viscosa* L.	0.5	0.722
21.	*Clerodendrum viscosum* Vent	0.673	0.971
22.	*Commelina benghalensis* L.	0.691	0.997
23.	*Cyanotis cristata* (L.) D.Don.	0.474	0.684
24.	*Cyperus rotuntus* L.	1.061	0.966
25.	*Dicliptera cuneata* Nees	0.637	0.918
26.	*Drymaria cordata* subsp. *cordata* (L.) Willd. ex Roem. & Schult.	1.061	0.966
27.	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	0.929	0.846

Table *Contd*…

S.N	Binomial name of Plants	Shannon's index	Similarity index
28.	*Hemionitis cordata* Roxb. ex Hook.&Grev.	1.334	0.963
29.	*Homonoia riparia* Lour.	1.567	0.875
30.	*Justicia betonica* L.	0.662	0.954
31.	*Justicia procumbens* L.	0.637	0.918
32.	*Kyllinga pumila Michx.*	0.665	0.959
33.	*Oplismenus compositus (*L.) P.Beauv.	1.092	0.994
34.	*Persicaria glabra* (Willd.) Gomez de la Maza	0.637	0.918
35.	*Persicaria hydropiper* subsp. *hydropiper* (L.) Spach	1.523	0.946
36.	*Phyllanthus amarus* Schumach. & Thonn.	0.562	0.811
37.	*Rhinacanthus nasutus* (L.) Kuntze	0.637	0.918
38.	*Sansevieria roxburghiana* Schult. & Schult.f.	0.662	0.954
39.	*Solena amplexicaulis* (Lam.) Gandhi in Saldanha & Nicolson	0.562	0.811

The higher density of Plant species occur in the Thalaiyar stream was due to the fact of less human interventions than Pambar stream. Tropical forests often are referred to as one of the most species diverse terrestrial ecosystems. Dugan (1993) reported that wetlands occupy only about 4 to 6% of the Earth's surface but provide habitat for about 20% of the world's species. Around the world, freshwater habitats are being subjected to increased levels of human disturbance (Saunders *et al.*, 2002). *Homonoia riparia* is a riparian indicator species, dominanty found the all part of Thalaiyar stream. Some of the plant occurred in both streams such as *Hemionitis cordata, Bonnaya oppositifolia, Drymaria cordata, Sansevieria roxburghiana.*The vegetative composition of riparian forests can vary widely because of natural and human disturbances (Pabst and Spies 1999, Nierenberg and Hibbs 2000). When riparian habitat is lost, many animals can no longer survive due to loss of habitat. Riparian vegetation is also important to protect waterway from erosion and pollutants entering the stream. the lack of plants along the banks may cause the poor water quality by increasing turbidity, which will affect aquatic life. Differences in riparian forest composition can, in turn, influence the function of stream ecosystems by altering wood delivery and nutritional subsidies, particularly in small headwater streams with closed canopies (Richardson and Danehy 2007).

However, our understanding of the interplay and relative importance of factors that control species diversity at different spatial scales is limited by the logistical and conceptual difficulties of scaling up local-scale processes to explain large-scale patterns of biodiversity (Harrison & Cornell 2008; Ricklefs 2008; Brooker et al. 2009). The inherent complexity of local-scale processes, such as biotic interactions among coexisting species, makes it difficult to extrapolate from small-scale studies to landscape, regional and global scales. Continuous human development and urbanization has changed most natural habitats, including wetlands. Hence, the current trend of landscaping, and particularly for new townships, incorporates artificial habitat as one of its primary components to treat the effluent and maintain the water quality and environmental health. A global assessment of the status of inland water ecosystems shows that most threatened river catchments are to be found in the Indian subcontinent. Dudgeon (1994; 2000) stressed the importance of biomonitoring and identifying areas of riverine biodiversity for long-term conservation.

CONCLUSION

Abundant freshwater system attract human settlement and also the other biotic communities. Plant community richness on the riparian zone is determined by water quality. Riparian ecosystem form very unique ecosystem in the forest region of both experimental streams of western ghats. Riparian areas acts as a migratory corridor and routes for many wildlife as it has been used for regular daily movements and seasonal migration. Riparian zones offers an three critical resources for wildlife: cover, food and water in one space. The existence of such a vast number of both the floral and faunal diversity is really an encouraging sign for conservation. If proper conservation and sustainable utilization is ensured, then the lake resources can have a good economic contribution to the lives of local people.

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Effect of Pharmaceuticals to the Environment and Wildlife: Occurrence and Options for Action

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ABSTRACT

Pharmaceuticals, Chemicals widely used globally by humans and for food production for an intended purpose, may enter and persist in the environment during their life cycle creating a new and emerging problem, and may pose a threat of important magnitude, with significant adverse effects on environment and human health and special impact in vulnerable populations. Properties that make pharmaceuticals useful are the same properties that make them hazardous. Pharmaceutical companies invest billions of dollars every year to develop substances able to affect human metabolism at very low concentrations. This potency does not change when a material enters the waste stream. Field studies and laboratory experiments show adverse effects on organisms; even at population level Analgesics like diclofenac have shown to effect wild animals E.g. Vulture populations in the Indian Subcontinent declined down to 1% because they had eaten the carcasses of livestock treated with the veterinary pharmaceutical diclofenac. Anti depressants like fluoxetin may cause developmental delays E.g. in tadpoles of the Northern Leopard Frog effect concentrations (0.1µg/L) are comparable to measured environmental concentrations. Hormones like estrogens reduce reproduction of fish in very low concentrations (<1 ng/L) E.g.in the fathead minnow Measured concentrations that have shown to effect reproduction in laboratory studies have already been detected in the environment.

Keywords: Pharmaceuticals, Hazard, Waste stream, Metabolism, Livestock, Hormones.

INTRODUCTION

Pharmaceutical chemicals are designed to be non-degradable to resist the acid environment in the stomach, and to be long-lasting; to be administrated according to a specific defined time schedule. Pharmaceuticals, Chemicals are widely used globally by humans and for food production for an intended purpose, may enter and persist in the environment during their life cycle creating a new and emerging problem, and may pose a threat of important magnitude, with significant adverse effects on environment and human health and special impact in vulnerable populations.

As the world's population is growing and ageing, more people can afford medical treatment and new treatments are developed, the amounts of pharmaceuticals can be expected to increase rapidly. Pharmaceuticals chemicals entering the environment persist there and residues are presently found in drinking water. They are found in fish where they may accumulate. The presence of different pharmaceutical chemicals contributes to the increasing multiple chemical cocktail that today's population is exposed to. Vulnerable populations are exposed, for example foetuses during the windows of development, with possible important consequences for life. The properties that make pharmaceuticals useful are the same properties that make them hazardous. Pharmaceutical companies invest billions of dollars every year to develop substances able to affect human metabolism at very low concentrations. This potency does not change when a material enters the waste stream. Some pharmaceuticals must be extremely toxic in order to function. Antineoplastic agents (the type of drug most often used in chemotherapy), for example, are designed to kill dividing cells. Some radioactive compounds are used for the same purpose.

A few drugs have other properties, unrelated to their intended action that makes them hazardous. Nitro-glycerine, for example, which causes blood vessels to dilate and can be used to treat chest pain, is also well known for its explosive properties. A relevant property of pharmaceuticals unrelated to their function is their water solubility. In order to administer drugs in liquid form, those that are not sufficiently soluble in water must be dissolved in some kind of solvent, generally an alcohol-water mixture. This can pose a flammability hazard, as discussed below. Pharmaceuticals in the waste stream can pose several different types of risk. The most straightforward is that the active ingredients in a discarded drug could act on an unintended target. But other ingredients in pharmaceutical formulations can present hazards:

- Preservatives and other ingredients can pose a toxicity hazard over and above the effect of the main active ingredient
- Some common solvents can pose a fire hazard (ignitability)
- A few compounding agents are corrosive, including strong acids with pH less than 2 (such as glacial acetic and carbolic acids) and strong bases with pH greater than 12.5 (such as sodium hydroxide)
- Some compounds are radioactive, including certain chemotherapy drugs, and certain agents that are used as tracers or markers.

Risks from pharmaceuticals in healthcare facilities generally cannot be eliminated by finding substitute materials, since the risk is often inherent in the function. But the risks can be minimized and managed. Pharmaceuticals reach the environment mainly in three ways:

- They are excreted from humans and animals, intact or metabolized, mainly into the urine, passing on to the environment directly or via sewage plants.
- Unused reach the environment either via household water or via urban solid garbage handling.
- Manufacturing plants producing the active substances might unintentionally release pharmaceuticals into the environment.
- Pharmaceuticals from various sources enter the environment via different pathways
- 156 different pharmaceuticals have been detected in Germany:
- Sampling campaigns of government agencies, water utilities, universities, etc.
- Highest concentrations measured near WWTP outflow
- 131 pharmaceuticals found in surface waters, mostly 0.1-1.0 μg/L range
- Detection also in groundwater and sporadically in drinking water
- Veterinary pharmaceuticals are detected in soil due to manure application to soil and dung excretion from pasture animals.

Some pharmaceuticals are degraded to various extents in sewage treatment plants, but others leave the plant in active forms. Active residues of pharmaceuticals have been detected in surface water, and they may persist in the environment for long periods of time. Large amounts of antibiotics and other pharmaceuticals have been found downstream from sewage plants for pharmaceutical industries. EPPPs from sewage sludge used as fertilizer are absorbed by soya, and antibiotics have been found in the leaves.

Presence of pharmaceuticals in aquatic systems

Around the world, thousands of tons of pharmacologically active substances are used annually but surprisingly little is known about the ultimate fate of most drugs after their intended use. A large proportion of an administered dose (up to 90%) may be excreted, unchanged, while metabolites can be converted back to the active compound via bacterial action. In addition, the general public often disposes of unused medicines through the sewage system. From published occurrence data it seems likely that a large proportion of urban sewage is contaminated with drug compounds, differing only in the type and abundance of the substances present.

Drinking water

Which EPPPs are found in drinking water depends on what resources and detection methods are available. Atenolol (beta blocker), Citalopram (antidepressant drug), Diclofenac (analgesic), Ibuprofen (analgesic), Metoprolol (beta blocker), Naproxen (anti-inflammatory) and Trimetoprim (antibiotic) have been found in drinking water of Stockholm, Sweden. Fish caught downstream from the sewage plants of Stockholm contain Citalopram (antidepressant drug) and Propoxyphene (narcotic/anesthetic). Several broad-spectrum antibiotics in very high concentrations, as well as bacteria resistant to all known antibiotics, were found downstream from a sewage plant in India. Also in Indian drinking water Cetirizine (antihistaminic), Ciprofloxacin (antibiotic), Enoxacin (antibiotic), Terbinafin (antimycotic), and Citalopram (antidepressant drug) were found. Up to 14 different pharmaceuticals have been found in the drinking water of big cities around the world. There also exist publications reporting the presence of cancer drugs in surface water in some countries.

Some of these environmental pharmaceuticals chemicals are well known to have serious genotoxic effects in humans. Many are not very well studied for their toxic effects on human periods of development. Half-life in nature varies depending on the environment (air, water, soil, sludge), but is more than one year for several compounds. Clofibric acid, a metabolite of the lipid-lowering agent Clofibrate, can still be found in surface as well as well water, although Clofibrate long ago has been withdrawn. Concentrations of EPPPs can vary from 1 ng to 1 mg per litre (2). Serious effects of EPPPs on water-living organisms, especially on reproductive systems, have been already shown, as well as on microbial communities.

Concentrations in surface waters, groundwater and partially treated water are typically less than 0.1 μg/l (or 100 ng/l), and concentrations in treated water are generally below 0.05 μg/l (or 50 ng/l). (ny 8 WHO) However, all water on the earth is part of the same stable pool, and as larger amounts of pharmaceuticals are consumed, there is a risk that the concentration of pharmaceuticals in drinking water will increase. The tendency of bio-accumulation in fish is alarming, as fish is important nourishment. The impact of pharmaceutical chemicals, due to diffuse exposure by their presence in the water environment, might contribute to the wide chemical exposure of all species and to their possible extinction, as well as to the imbalance in sensitive eco-systems. Consequences for human health and the equilibrium of the biological environmental system may be irreversible.

Multiple human exposures to EPPP may start at conception and may be combined with a cocktail of other chemicals present in the environment. The effects of exposure to these mixtures are difficult to understand due the complexity of the situation during a period of special vulnerability and sensitivity, but cannot be denied. Another very serious threat is development and spread of bacteria, viruses and other microbes resistant to the antibiotics present in the environment, with possible unpredictable important consequences. Pharmaceuticals are special kinds of chemicals. They are manufactured to be biologically active in living organisms, to be persistent to biodegradation and to have long half-lives. This makes them more risky in nature. Release is ongoing always and everywhere, diffuse and impossible to control. They cannot be forbidden.

The levels of pharmaceuticals in surface or drinking water are generally below 1 mg per litre, often measured in ng per litre (2, 8). This low concentration might appear to guarantee that they hardly pose any problem to public health. Assuming a concentration of 100 ng/l of a pharmaceutical that in humans has DDD (defined daily dose) of 10 mg implies that a volume of 100,000 litres would be required to make up one single DDD. Such calculation, however, is an over-simplification that does not take into account several important dynamic aspects of the low chronic exposure to concentrations of pharmaceuticals in the water or the vulnerable population exposure for example during the period of development. Aquatic organisms may bio-concentrate and bio-accumulate lipid soluble chemicals, including pharmaceuticals. It is well known that certain fish species, like Herring, may contain very high concentrations of the persistent and lipophilic chemicals DDT (dichlorodiphenyl-trichloroethane, an insecticide) and PCBs (Polychlorinated biphenyls, a group of industry chemicals earlier used in e.g. building materials). The same mechanism may also be applied for chemicals synthesized for pharmaceutical uses. Bioaccumulation of citalopram (SSRI, antidepressant) and Propoxyphene (painkiller) has been found in Perche in the Baltic Sea. A therapeutic level of Levonorgestrel (a sex hormone) has been found in Rainbow trout downstream a sewage plant.

Pharmaceutical chemicals are not thought or designed to enter in the environment and persist there but for a clear pharmaceutical purpose. Pharmaceutical are synthetic chemicals, they belong to a wide group of different chemical families and may also react differently in the environment. When a new medicine is developed, its pharmacological and toxicological effects are tested in acute trials, before being accepted for marketing. However, clinical test procedures are not entirely sufficient to completely guarantee that a new pharmaceutical is devoid of unacceptable side effects when used in large cohorts of patients for a long time. Furthermore, there are currently no test methods to assess whether such effects may occur after long-term use in human, during periods of development, on aquatic microorganisms or how they may affect other animals. Based on this, the persistent and diffuse exposure to low doses of pharmaceutical synthetic chemicals, for long periods of time, is not currently well known or studied.

The diffuse dissemination of the EPPP in the environment may indiscriminately expose vulnerable populations: embryos/foetuses, children and adolescents, men and women of reproductive age, and elderly or weak persons. Some of the pharmaceuticals found in surface water are prescribed to patients under special controlled conditions for short periods of time due the risk of side effects. Others are prohibited from prescription to pregnant women or children. These chemicals were not synthesized to expose the general population in a diffuse manner. This presents a new and emerging issue under the chemical safety global pollution. It can be assumed that a large portion of excreted or disposed medicines reach the public sewage treatment plants (STP's). Today, the sewage plants do not have the capacity to clean the water from pharmaceutical chemicals. This is sometimes also the case for the industries' own sewage plants. In many parts of the world, the sewage plant water is reused as drinking water, not always after cleaning treatment. To add a step for cleaning sewage water from pharmaceuticals means more energy, more chemicals and higher costs. - Alternatively, the sewage is directly let out into various surface waters like rivers, lakes, streams or the open sea. - Detection and monitoring at global scale of EPPPs in drinking and surface water as in animals and plants is necessary to understand the magnitude of the problem. The first step is to recognize EPPP as an emerging issue to be able to invest the necessary human and financial resources and develop effective environmental detection methods.

Known effects of pharmaceuticals in the environment

Estradiol (estrogen, synthetic hormone) Concentrations in surface water alone are not sufficient to assess the risk of negative environmental effects in the aquatic environment. Synthetic hormones are endocrine disruptors. Thus, estrogenic compounds like ethinyl-estradiol (estrogen hormone) at concentrations < 1 ng per litre may cause both vitellogenin production (a frequently used index for feminization of male fish), and structural change in their sex organs. It has also been demonstrated that fish exposed to sewage treatment plant (STP) effluent can take up and concentrate estrogenic compounds, including ethinyl-estradiol, to very high internal levels. These observations on feminization of fish by estrogenic compounds in STP effluents have been observed in many countries, and have also been observed in other species, like frogs, alligators and molluscs.

Cardiovascular medicines

Other examples of environmental impact in the aquatic environment of human medication concern both cardiovascular and neuro-psychiatric medicines. The non-selective beta-blocking agent Propanolol was found to cause a significant decrease in egg production in Medaka fish, at a concentration close to that demonstrated in the sewage treatment plants (STP) effluents. Gemfibrozil (cholesterol and triglycerides lowering drug) often appears in the effluent from STPs. At concentrations close to those reported in STP effluent, Gemfibrozil lowers the blood levels of testosterone in fish. Some SSRI's have been shown to accumulate in exposed fish. Citalopram has been detected in liver from wild perch in low µg per kg levels, and fluoxetine affects the serotonin system in the same way that it does in humans. Fluoxetine has also been shown to affect swimming activity in shellfish; whether this is linked to a disturbance of serotonin function in the brain is still unknown.

Antibiotics

High levels of antibiotics in the water are a cause for alarm as there is an increased risk of selecting resistant bacteria, an issue of global concern. This can lead to some highly effective antibiotics becoming ineffective. There are several examples: In India, bacteria resistant to ciprofloxacin have been found downstream pharmaceutical plants, genes for multi resistance were found in drinking water, and multi resistant Salmonella in water sprayed on vegetables. From Europe we know about the epidemic with multi resistant EHEC in summer 2011, originating from water sprayed vegetables.

The term "eco-shadow" has been introduced to describe the ecological impact of antibiotics. Antibiotics with a wide spectrum that are also stable will have a greater impact on the bacterial flora (a long eco-shadow) than those with a narrow antibacterial spectrum which disintegrates more rapidly (a short eco-shadow). The ecological effects of tetracyclines and quinolones have been observed. They are not metabolized in the human body and are therefore excreted unmodified. When entered into the environment they are poorly degraded. They can be toxic to other animals, affecting particularly microorganism and fish. In the effluent from a sewage plant in India, several broad spectrum antibiotics were found in concentrations toxic to bacteria and plants. In the sewage plant itself, there were entero-coccae resistant to all known antibiotics.

The development of resistant bacteria in sewage plants is stimulated by high concentration of antibiotics (e.g. in plant sewage), large amounts of bacteria (e.g. from human sewage water that is added in plant sewage), and selection of Information that can be used to assess the nominated issue have been observed.

Environmental classification of pharmaceuticals

In Sweden, the industry together with universities and health care sector has developed a method for environmental risk assessment and environmental classification of drugs. Environmental risk refers to the risk of toxicity to the aquatic environment. It is based on the ratio between predicted environmental concentration of the substance (PEC) and the highest concentration of the substance that does not have a harmful effect in the environment (PNEC). Environmental hazard expresses the inherent environmentally damaging characteristics of the substance in terms of persistence, bioaccumulation and toxicity. The toxicity tests used are acute toxicity of fish, acute toxicity of Daphnia sp. and growth inhibition test of algae. Most medications on the Swedish market are now classified. This gives the health care possibilities to make better choices when prescribing medicines.

Pharmaceuticals are biologically active substances Field studies and laboratory experiments show adverse effects on organisms, even at population level Analgesics like diclofenac have shown to effect wild animals. E.g. Vulture populations in the Indian Subcontinent declined down to 1% because they had eaten the carcasses of livestock treated with the veterinary pharmaceutical diclofenac

Antidepressants like fluoxetin may cause developmental delays E.g. in tadpoles of the Northern Leopard Frog effect concentrations (0.1µg/L) are comparable to measured environmental concentrations. Hormones like estrogens reduce reproduction of fish in very low concentrations (<1 ng/L) E.g.in the fathead minnow Measured concentrations that have shown to effect reproduction in laboratory studies have already been detected in the environment. In order to reduce environmental impact of Pharmaceuticals action is needed on different levels. To characterize the potential risk of pharmaceuticals comprehensive data before marketing is needed. The Environmental Risk Assessment (ERA) prior to marketing approval provide information on fate, effects and behaviour of pharmaceuticals

Risk management options of pharmaceuticals include technical and non-technical measures

- Options for action in the fields of production, use and disposal that are discussed within Europe:
- Improve communication to different target groups e.g. - consumers - doctors - veterinarians - pharmacists
- Offer advice on appropriate disposal
- Establish new and/or improve existing waste water treatments
- Sustainable pharmacy, e. g. good manufacturing practice, development of easily degradable drugs
- Develop a harmonized monitoring approach

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Effect of Climate Change on Environment and its Consequences

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ABSTRACT

Global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. Climate change and its impact is a matter of great concern among all countries of the world because it has the potential to make vulnerable life on the earth. Therefore an attempt has been made here to examine the impact of climate change on the food security of India with special reference to the agro-climatic regions. The study revealed that climate change can adversely affect the all four dimensions of food security i.e. food availability, accessibility, utilization and stabilization. There is a great deal of uncertainty regarding climate change, but there are some certainties. The prospects of Indian food security under the upcoming climate change will depend a numbers of immediate measure i.e.to reduce the vulnerability of food system to climate change and other global environmental changes, which has started looming large the very existence of human kind.

INTRODUCTION

Change is a law of nature, every phenomenon in this universe is dynamic and climate is not an exception. There are always two kinds of processes behind the climate change one is natural and other is human being induced. Anthropogenic activities are more responsible for climate change. Climate change has become one of the most important global environmental challenges of 21st century facing humanity with implications for food production and food sustainability. It has been at the centre of scientific and political debate in recent years, today, more than at any time in the past there is an almost unanimous consensus among scientists, politician, policy-makers, administrators and the common people alike that climate has changed and that it is still changing (IPPCC,2007). However, scientist have become more confident that greenhouse gases will lead to a rise in global temperature (Haughton et al 1996).In the developing countries have grown increasingly concerned about the economic impact of climate change on agriculture (Watson et al, 1996). Food security exists when all people at all times have physical or economic access to sufficient safe and nutrition's food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). It has four basic components availability, accessibility, utilization and stabilization. The four components of food security are availability a function of production, accessibility is related to purchasing power, utilization is determined by the availability of minimum basic needs i.e. safe drinking water, primary health care, primary education, proper housing facilities, environmental hygiene fourth one stabilization is influenced by the extent of attention given to the sustainability of the system. Therefore, concept of food security is very complex and multidimensional and it cannot be limited to its specific divisions. So it must include the issue of food production, distribution, quality of food, capability of purchasing and sustainability of this entire process.

Climate Change and Food Security in India

India has many reasons to be concerned about climate change, because a majority of population depends on climate sensitive sector i.e. agriculture, forestry and fishing for livelihood. The existing problem of food security in our country, if not addressed in time, will become more acute due to change in the climate. It will become more difficult to ensure food security under the changing climate for country like India where more than one third of the population is estimated to be absolutely poor and one half of all children are malnourished in one way or another (Dev and Sharma, 2010).To examine the impact of climate change on Indian agriculture sector is quite complex as several factors are concerned in this phenomena. For the detail discussion about impact of climate change on food security we have taken the four components of food security and discuss the impact of climate change on these components in the Indian context.

Climate Change and Food Production

The evaluation of climate change impacts on agricultural production, food supply and agriculture based livelihoods must take into account the characteristics of the agro- ecosystem where particular climate-induced changes in biochemical processes are occurring, in order to determine the extent to which such changes will be positive, negative or neutral in their effects (FAO-2008 P. 21) greenhouse fertilization effect will produce local beneficial effects where higher level of atmospheric CO_2 stimulate plant growth. This is expected to occur primarily in temperate zones with yield expected to increase by 10 to 25%. (IPCC, 2007c) These effects are not likely to influence projections of world food supply, (Tubiello et al., 2007). But in India tropical type of climatic condition prevails so here most probably the greenhouse fertilization will have negative impacts.

Climate change and Storage, processing and distribution of food grain

Food production varies spatially, so food needs to be distributed between regions. The major agricultural production regions are characterized by relatively stable climatic conditions but many food-insecure regions have highly variable climates. The main grain production regions have a largely continental climate, with dry or at least cold weather conditions during harvest time, which allows the bulk handling of harvested grain without special infrastructure for protection or immediate treatment. Depending on the prevailing temperature regime, however, a change in climatic conditions through increased temperatures or unstable, moist weather conditions could result in grain being harvested with more than the 12 to 14% moisture required for stable storage. Because of the amounts of grain and general lack of drying facilities in these regions, this would create hazards for food safety, or even cause complete crop loses, resulting from contamination with microorganisms and their metabolic products. It would leads to a rise in food prices if stockiest have to invest in new storage technologies to avoid the problem (FAO, 2008). Distribution depends on the reliability of import capacity, the presence of food stocks and when necessary-access to food aid (Maxwell and Slater, 2003). These factors in turn often depend on the ability to store food. Storage is affected by strategies at the national level and physical infrastructure at the local level. Transport infrastructure limits food distribution in developing country like India. Where infrastructure is affected by climate, through either heat stress on roads or increased frequency of flood events that destroy infrastructure, there are impacts on food distribution, influencing people access to markets to sell or purchase food (Abdulai and Crole Rees, 2001).

Climate change on food access

Food is allocated through market and non-market distribution mechanisms. Factors that determine whether people will have access to sufficient food through markets are considered in the affordability. These factors include income-generating capacity, amount of remuneration received for products and goods sold or labor and services rendered and the ratio of the cost of a minimum daily food basket to the average daily income (FAO, 2008). Non market mechanisms include production for own consumption, food preparation and allocation practices within the household, and public food distribution schemes. The approximately 70% population of India live in rural areas. For rural India where people who produce a substantial part of their own food, climate change impacts on food products may reduce availability to the point that allocation choices have to be made within the household. A family might reduce the daily amount of food consumed equally among all household members, or allocate food preferably to certain members often the able-bodied male-adults who are assumed to need it the most to stay fit or continue working to maintain the family. Non-farming low income rural and urban households whose incomes fall below the poverty line because of climate change impacts will face similar choices.

Climate change on food utilization

Food insecurity is usually associated with malnutrition, because the dieting patterns of people who are unable to satisfy all of their nutritional requirements don’t consist of nutritious food grains. Declines in the availability of mild foods and limits on small-scale horticultural production due to scarcity of water or labor resulting from climate change could affect nutritional status adversely. In general, however, the main impact of climate change on nutrition is likely to be felt indirectly, through its effects on income and capacity to purchase in order to diversify their food basket. In India climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risk for food security, food safety and human health. Increased incidence of water-borne diseases in food-prone areas like U.P., Bengal, Orissa, Bihar, Andhra Pradesh and Maharashtra etc; changes in vectors for climate responsive pests and diseases, and emergence of new diseases could affect both the food chain and peoples physiological capacity to obtain necessary nutrients from the foods consumed. These will expose crops, livestock, fish and humans to new risks to which they have not yet adopted. They will also place new pressures on care giver within the home. Malaria in particular is expected to change its distribution in a result of climate change (IPCC, 2007a). In coastal area of India more people may be exposed to vector-and water-borne diseases through flooding linked to sea-level rise. Food safety may be compromised in various ways. Increasing temperature may cause food quality to deteriorate, unless there is increased investment in cooling and refrigeration processing of perishable foods to extend their shelf-life.

Climate change on food sustainability

Many crops have annual cycles and yields which fluctuate with climate variability, particularly rainfall and temperature. Maintaining the continuity of food supply when the production process is seasonal in nature is a therefore challenging task. Droughts and floods are a particular threat to food stability and could bring about both chronic and transitory food insecurity. As we know India is a country which is more prone to drought and floods. Both are expected to become-more frequent, more intense in India and less predictable as a consequence of climate change. In rural areas which depend mostly on rain fed agriculture has the 70% of the total population of India which depends on the local food supply. Changes in the amount and timing of rainfall within the season and an increase in weather variability are likely to aggravate the precariousness of local food system. Increasing instability of supply, attributable to the consequences of climate change, will most likely lead to increases in the frequency and magnitude of food emergencies with which the global food system is ill-equipped to cope. Climate change might exacerbate conflict in numerous ways, although links between climate change and conflict should be presented with care. Increasing incidence of drought may force people to migrate from one area to another, giving rise to conflict over the access to resources in the receiving area. Resource scarcity can also trigger conflict and which could be driven by the global environmental change.

CONCLUSION & SUGGESTIONS

There is a great deal of uncertainty regarding climate change, but there are some certainties. The prospects of Indian food security under the upcoming climate change will depend a numbers of immediate measure i.e.to reduce the vulnerability of food system to climate change and other global environmental changes, which has started looming large the very existence of human kind. A multifaceted approach of adoption in terms of increasing food production, improving food distribution and increasing economic access to food as well as different mitigation options for reduction of green house gases needs to be adopted. Adaptation to climate change impacts should not be approached as separate activity, isolated from other environmental and socio-economic concerns that also impact on the development opportunity of poor people (OECD, 2003).

The climate change calamity can then become a blessing in terms of reorientation of our agricultural research and development strategies based on the principles of ecology economics, equity, employment and energy security. The path ways to an evergreen revolution are organic farming and green agriculture (Swaminathan, 2008). Diversification of agriculture away from staple crops to horticulture, floriculture and commercial crops can also increase the income of small farm holders (Thakur and Chand, 2013). Approaches and the implications of each for protecting food security in the face of climate change are explored it may be reaching vulnerable rural people with useful information related to climate change. There are need to maintain up-to date agro-metrological data and to develop some methods and tools for assessing extreme weather impacts and guiding adaptation. We have to protect our existing livelihood system and diversify the sources of food and income. Most important things are to manage agriculture; land and water with more efficiently. There are need to understand the linkages among climate change, energy security, food security and Improve household energy security and food security simultaneously.

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THEME - III

HYDROPOWER, BIODIVERSITY, CATCHMENT TREATMENT AND EIA

Chaotic Analysis of Daily Wind Speed Data

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ABSTRACT

Many hydrological and meteorological processes such as rainfall, runoff, inflow, stream flow, temperature, pressure etc. are proved to be chaotic in nature. However, very less work has been reported on chaotic analysis of wind speed data. The study of chaos helps to understand the behavior of time series as well as to model the nonlinear dynamics of the hydrological systems. Out of many methods employed to study the chaotic behavior, correlation dimension which uses Heaviside step function is employed in the present study. In this method, a relationship between correlation integral (Cr) and radius (r) is determined using the log plot. The scaling regions in those plots are identified to estimate the slope from the correlation integral plots. The slope of the scaling region of each correlation integral plot is called as correlation exponent (υ). The slope of this scaling region (correlation exponent) is plotted against various embedding dimension (m). Based upon this relationship the behavior of time series is categorized as deterministic (if υ constant for all m), stochastic (increasing υ with increase in m) or chaotic (initially increasing υ and then saturating υ with further increase in m). Based on the range of correlation exponent, the chaotic behavior of time series is finalized as low, medium or high. The present study presents the details of the statistical analysis and the application of correlation dimension method to find the chaotic behavior of the daily wind speed data collected from a meteorological station located at Tirunelveli, Tamilnadu, India. It has been observed that the wind speed is showing a chaotic behavior. It is also found that the correlation dimension for daily wind speed data saturate at six, indicating a high chaotic behavior of the wind speed time series.

Keywords: Chaotic analysis, correlation dimension method, Heaviside step function, wind speed data, high chaotic behaviour.

INTRODUCTION

In hydrological time series modelling, two modeling approaches have been prevalent: deterministic and stochastic, recently soft computing techniques (data driven techniques). The permanent nature of the Earth and the cyclical nature of the associated mechanisms support the deterministic approach. The highly irregular and complex nature of hydrologic processes and our limited ability to observe the details, favours the stochastic approach. Chaos theory (Williams, 1997) can couple deterministic stochastic approach, since its underlying concepts of nonlinear interdependence, hidden determinism and order, sensitivity to initial conditions are highly relevant in hydrology (Sivakumar et al, 2007). The number of dimensions that governs a particular process can be identified through nonlinear chaotic analysis (Sivakumar, 2011). The study of chaos (nonlinear chaotic analysis) helps us to study the behavior of the system and also indicates the minimum number of dimensions required to model the nonlinear dynamics of the systems. Fairly a large amount of works has been reported on nonlinear dynamic analysis of many hydrological processes like rainfall, runoff and stream flow (Jothiprakash and Fathima, 2013a,b). Very limited works has been reported on chaotic behavioral study of meteorological parameters like wind speed, temperature etc. Wind speed is the one which moves from one phase to another, it moves from land to ocean and vice versa affecting oceanographic and land parameters (like wave height) also. The change in the circulation patterns of oceanic currents is likely to have been the key mechanism for the abrupt climate change that took place during the last glacial period of Earth. If this is indeed true, then air temperature and wind speed could have also had a significant contribution to the process. In the present study, it is aimed to study the behavior of the land wind speed time series. The average daily wind speed observed over a period of 10 years at Tirunelveli, Tamilnadu, India is used in the present study. The correlation dimension method is used to analyze the non linear dynamics.

Correlation Dimension Method

Many of the hydrological time series behavioural studies applied correlation dimension method (Grassberger and Procaccia, 1983). The procedure usually begins by embedding the data in a two-dimensional pseudo phase space. The dynamics of time series {x1, x2 ...xn} are fully captured or embedded in the m-dimensional phase space (assuming delay time as $\tau=1$) defined by

$$Y_\tau = \{x_\tau, x_{\tau-1}, x_{\tau-2} \ldots x_{\tau-(m-1)}\} \qquad \ldots..(1)$$

For a given radius ‘r’, count the number of points within distance r from the reference point. After doing that for each point on the trajectory, find the sum of the counts and normalize the sum. That yields a so-called correlation integral (Cr). The correlation integral values for different values of r by increasing steps in constant intervals by using the following equation (Sivakumar 2001).

$$C(r) = \lim_{n\to\infty} \frac{2}{N(N-1)} \sum_{i,j(1<i<j<N)} H(r - |Yi - Yj\,|) \qquad \ldots..(2)$$

If the time series is characterized by an attractor, then for positive values of r, the correlation function C(r) and radius r are related (when N tends to infinity and r tends to zero) and is given in equation (Sivakumar 2001).

$$\underset{\substack{r\to 0\\ N\to\infty}}{C(r)} \sim \alpha\, r^{\upsilon} \qquad \ldots..(3)$$

Where H is the Heaviside step function, with H(u) =1 for u >0, and H(u)= 0 for u≤0 ,

N = Number of data points

u = r-|Yi-Yj |,

‘r’ is the radius of the sphere centered on Yi or Yj.

Yi is the basic series of inflow data

Yj is the subseries of inflow data

‘α’ is a constant and ‘υ’ is the correlation exponent

Then repeat that procedure to get correlation integral for larger and larger values of ‘r’ (Sivakumar, 2000).

A log plot of correlation integral (Cr) versus r (for that particular embedding dimension) typically shows a straight or nearly straight central region. The slope of that straight segment is the correlation exponent (υ). The next step is to repeat the entire procedure for larger and larger embedding dimensions. For deterministic series, the correlation exponent (slope of log r Vs log Cr graph) will be constant for all the value of embedding dimensions and for stochastic series, the correlation dimension increases with increase in embedding dimension.

However for chaotic data, the correlation exponent initially increases with embedding dimension, but eventually (at least in the ideal case) it asymptotically approaches a final constant value. From this, it implies that for smaller embedding dimension, it behaves like a stochastic series and for higher embedding dimension, the time series behaves like a deterministic series. Thus, chaotic series is somewhere between deterministic and stochastic series (Grassberger and Procaccia, 1983).

Study Area

The daily average wind speed data collected for10 years (1993-2003) from a meteorological station located at Tirunelveli, Tamilnadu, India with global coordinates of longitude 77°44‘ E and latitude 8°44‘ N is used in the present study. The meteorological station is maintained by Tamilnadu Agricultural University, Valanad campus, Killikulam, Tirunalveli, Tamilnadu. The time series of the observed wind speed is showing decreasing trend with irregular pattern (Figure 1). Wind speed has a decrement of 1.46km/hr (17.56%) over these 10 years. It can be observed that wind speed pattern appears to be responding maximum during the months June to August.

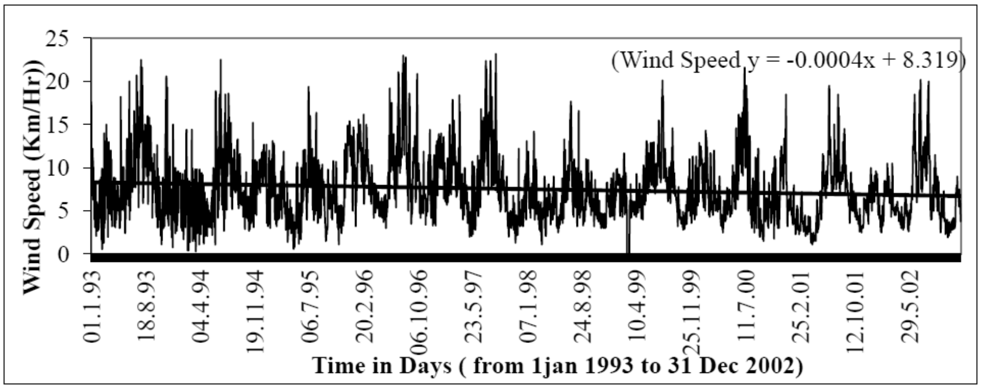


Fig. 1 Wind Speed Time Series

The variation of daily statistical parameters such as Mean, Standard deviation, Skewness, Kurtosis, Minimum observed value, Maximum observed value, Coefficient of variation in the observed daily wind speed time series are shown in Table 1.

Table 1 Statistical Parameters

Statistical Properties	Daily Wind Speed
Average (m/s)	7.52
Standard deviation (m/s)	3.81
Skewness	1.03
Kurtosis	1.26
Minimum Wind Speed (m/s)	0.82
Maximum Wind Speed (m/s)	23.26
Coefficient of Variation	0.51
No. of data points	3652

The observed data showed positive skewness indicating that the data is not following normality. Kurtosis coming out to be positive and its value indicates that the data is having a peak top near the mean. The variation in data is higher and this can be observed by coefficient of variation, which has relatively higher values for all the months and has a maximum in October. Hence, it can be concluded that the wind speed data has high variation and requires sophisticated models for prediction.

In order to find the number of inputs required for proper modeling especially using linear stochastic models, two statistical methods, autocorrelation function (ACF) and partial autocorrelation function (PACF) are employed (Francesco and Villi, 2001).

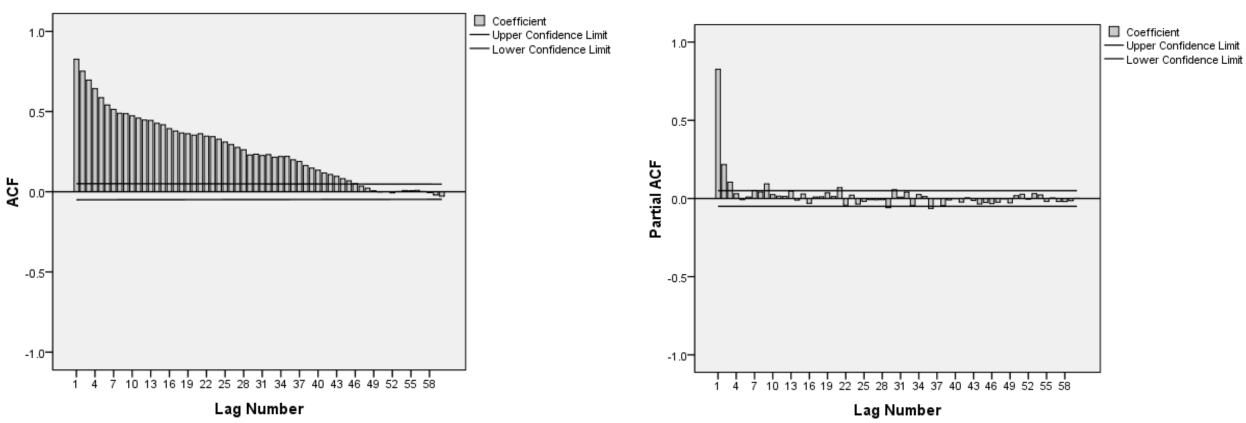
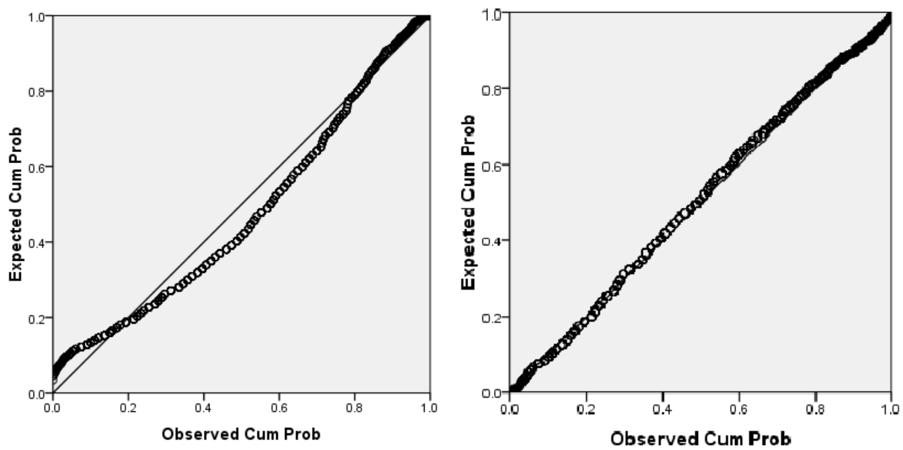


Fig. 2 ACF and PACF Plot

The ACF and PACF of the observed wind speed data (Figure 2) show strong persistence up to 7 lags (higher than 0.5) with 95% confidence level. The ACF crosses zero correlation relatively at larger lag (51) showing that there is good dependence of two month wing speed data. In PACF plot it shows significant correlation of 1 lag and after that its shows a correlation for 7 lags then negative and crossed zero. Latter it falls within the correlation band.

Since, the observed data shows high skewness and coefficient of variations, to model the process raw data is brought to follow normal distribution through a logarithmic transformation. The Probability Plot for checking the distribution is shown in Figure 3(a) and 3(b). In this case logarithmic transformation has been employed to bring the observed time series to follow normal distribution.



(a) Raw data (b) With logarithmic transformation

Fig. 3 PP Plots

PP plots are generally checked if data points collapse in alignment on sloping line both by raw and logarithmic transformed plots of wind speed. From PP plot examination, it is found that the raw series is not following the diagonal line, after logarithmic transformation it is following normal distribution. Thus, it can be concluded that the raw data follows near logarithmic distribution.

RESULTS AND DISCUSSIONS

The phase space diagram of lag one for daily observed wind speed is depicted in the Figure 4 and it is worth mentioning that phase space diagram also gives an idea about the attractor. The attractor indicates the possibility of chaos (chaotic behavior) in the data set (Hense, 1987). Low wind speed is more chaotic since the presence of attracter is found at low wind speed.

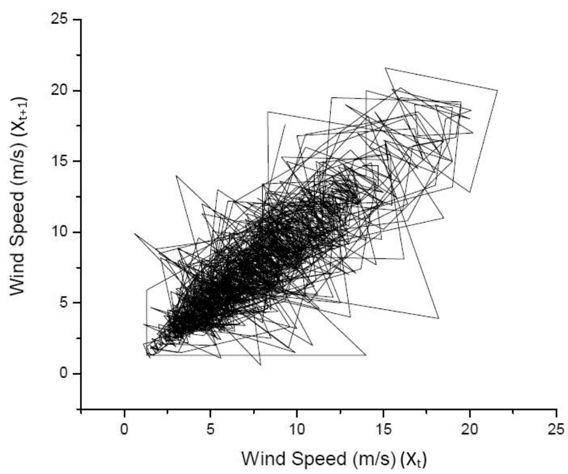


Fig. 4 Phase Space Diagram

The correlation integral of daily wind speed data is determined. A plot was prepared after finding the logarithm of r as well as Cr (Figure 5). Any appropriate value in between the maximum and minimum value among data can be used. However it is better to have a log r Vs log Cr plots without initial disturbances (Sivakumar et al., 2002). It is also seen that there is a prominent break in lines around log r =0.5. This may be an indication of the noise in the data and this zone has to be avoided while estimating the correlation exponent (Sivakumar et al., 1999).

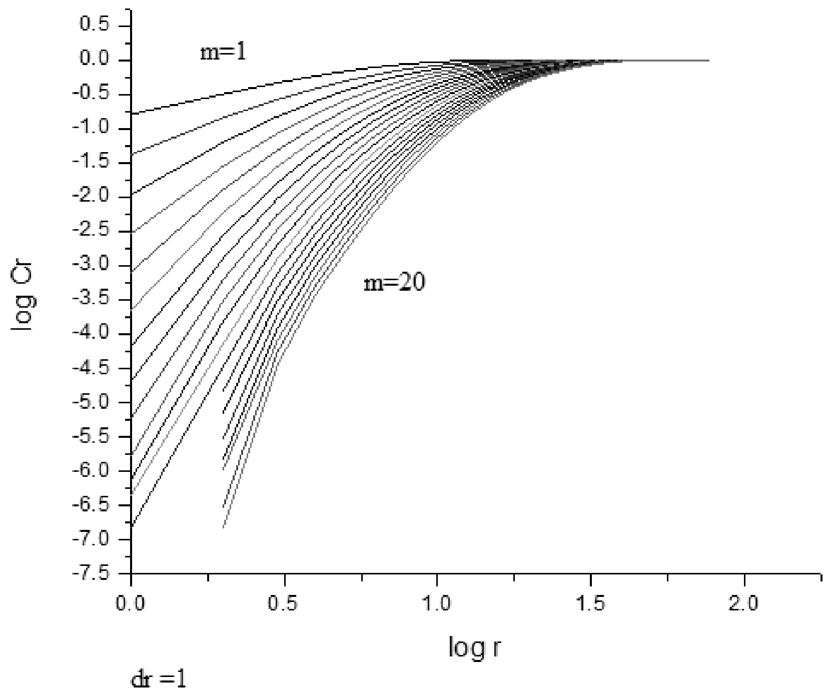


Fig. 5 Plot showing a relation between Log r and Log Cr

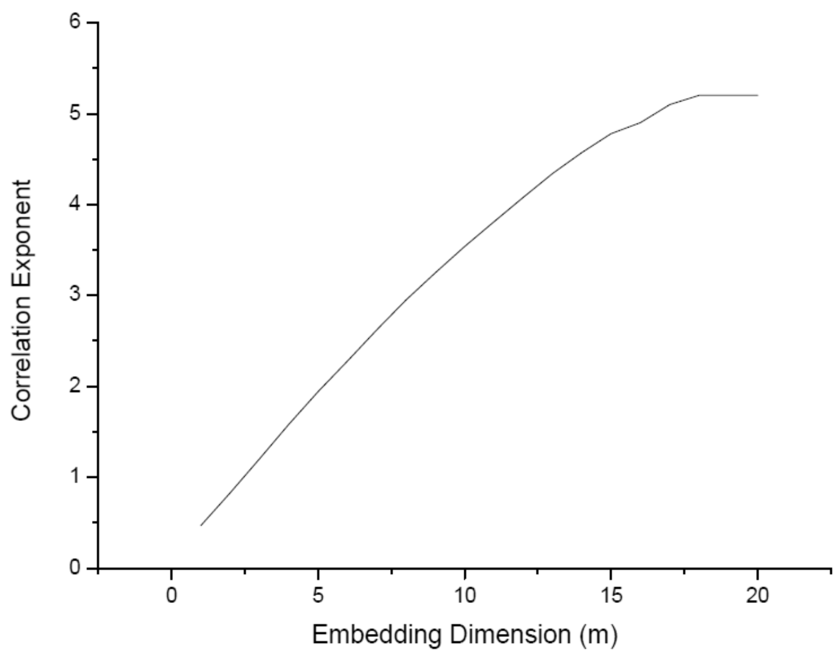


Fig. 6 Embedding dimension and correlation exponent

Since the lines are not parallel to each other and there are breaks in slopes which creates difficulty in selecting the scaling region. The most linear portion of log r versus log Cr graph (dr=1) is considered to estimate the correlation integral. The values of slope (correlation exponent) are plotted against the embedded dimension as shown in Figure 6. It is found that the value of correlation exponent is saturating around six indicating a chaotic behavior with a correlation dimension six. It indicates that six different dimensions may be required to model the wind speed process.

CONCLUSION

In the present study, the chaotic behavior of the average wind speed measured at the meteorological station located at Tirunelveli, Tamilnadu, India is analysed. The correlation dimension method based on Heaviside step function is employed to study the chaotic behavior of wind speed data. From statistical analysis, it is found that the wind speed data has high variation and requires sophisticated models for prediction. From PP Plot, it is seen that the raw data follows near normal distribution. The phase space reconstruction shows the possibility of deterministic chaos as the attractor in the phase space occupies a small area and thus is distinct and unique. From the chaotic analysis, it is concluded that the wind speed data follows chaotic behavior. The correlation dimension for daily wind speed data is six indicating high chaos in the wind speed time series.

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A Study on the Aquatic Flora Diversity in Vettangudi Birds Sanctuary Pond, Sivagangai, Tamil Nadu

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ABSTRACT

Periya Kollukudipatty pond, situated in Kollukudipatty village of Sivagangai District, Tamil Nadu (10º 06.57'N; 78º 30.81'E) serves as the Vettangudi birds sanctuary. The ecoclimatic nature of the pond is semi-arid and pond is a temporary wetland. This unique feature of the vernal pool fills with water in rainy season and dry down in the spring and remains desiccated throughout the summer. The aquatic flora of Periya Kollukudipatty pond was studied through systematic sample collection and identification using flora and the specimens were preserved in the Thiagarajar College Herbarium. In the present study, 72 species of angiosperms were enumerated which are found to belong to 59 genera and 34 families The varying nature of the growth forms of wetland plants viz., floating, submerged and emergent hydrophytes were recorded in this study. The relationship between the pond habitat and the biological interaction is discussed to the context of aquatic vegetation diversity.

***Keywords**:* Vettangudi Birds Sanctuary – Vernal Pool- Periya Kollukudipatty - Aquatic vegetation.

INTRODUCTION

Wetlands are the land areas which are damp either seasonally or permanently occupying the land area at different sizes. Wetlands are mainly categorized into natural or constructed. Water is being the major component upon which other ecological factors are depending upon and thus, a dynamic association among the environmental factors is established. Ponds are one among the wetlands and they are generally small shallow water bodies, either form naturally or man-made which permanently or temporary hold water (De Meester, *et al*, 2005). Ponds are found in many ports of world which contain water for a few months following recharged with water from run-off, and are dry for the reminder of each year, (Alan, 1944). Temporary or ephemeral ponds are very unique in their ecological functioning and hence the biotic aggregation in such pond ecosystems is highly varying in the consequent drying and water-logging conditions. Human population utilizes the pond and their resources for most of their needs from a time immemorial and hence pond becomes the life line of several organisms, including human beings.

Among the biotic organisms, several forms of vegetation viz., emergent, submerged and/ free-floating aquatic species generally occur both in natural and constructed wetlands (Brix 1994, 1997). Aquatic plant species play an important role as producers and in oxygen production, nutrient cycling, water quality improvement and sediment stabilization (Mohan and Hosetti, 1999; Cronk and Fennessy 2001).

The ephemeral vegetation of temporary ponds is dominated mainly by annual and herbaceous perennials that appear during the availability of water and when pond is at varying degrees of desiccation. This phenomenon makes a remarkable shift in the vegetation and their different nature of abundance.. Annual hygrophytes, hemi cryptophytes and geophytes vegetation is diverse and rich (Brullo and Minissale, 1998; Barbour *et al*., 2003; Deil, 2005) Aquatic angiospermic flora was reported in various studies (Subramanyam, 1962; Cook, 1996, Saini *et al*., 2010, Sugumaran and Jeeva 2011 and Kannan and Miller Paul, 2013). Ponds with varying utility values especially the bird sanctuary ponds are of paramount important to analyze, since the biotic aggregation in such ponds is largely depend on the water quality and hence the environmental monitoring of ponds becomes inevitable. The objective of the present study was to carry out the vegetation analysis of Periya Kollukudipatty pond, which is the Vettangudi Birds Sanctuary, Tamil Nadu, developed as the *Ex-situ* conservation of migratory birds.

MATERIALS AND METHODS

Brief description of the experimental area

The present study was conducted in Periya Kollukudipatty pond (PKPTY) of Vettangudi birds sanctuary (10º 06.57'N; 78º 30.81'E; alt. 424ft.), located in Periya Kollukudipatty Village of Singampunari Block, Tiruppathur Taluk, Sivagangai District, Tamilnadu. PKPTY pond spreads to a total area of 13.66 ha and it was declared as the bird sanctuary in June 1977. The experimental pond is a temporary or ephemeral pond; during onset of north-east monsoon, the pond receives from run-off water and remains filled for about 3-4 months between November and February months in a year. During this period, about 30 bird species, a majority of local and overseas migratory avian fauna visits to this pond for forage and breeding and hence the *Acacia nilotica* (gum Arabic) plantation is established for landing and nest-making by the birds.

Vegetation analysis

Aquatic and semi aquatic vegetation analysis was carried out during February 2013- January 2014, by employing collection, identification and verification. Aquatic vegetation of all the growth forms during water availability in the experimental ponds and while drying, the shift of the vegetation occurred on the pond sediment or the drying surface were observed, using all out search method. Specimens were collected using standard method and were identified using regional floras (Gamble and Fischer, 1915 – 1935; Saini *et al.* 2010; Cook 1996). Further, the specimens were authenticated for their proper identification by referring thought relevant literature and expert judgment. A list quadrat was prepared with their botanical names and their growth habit, represented in Table (1).

RESULTS AND DISCUSSION

During the study period, a total of 72 species of 59 genera belong to 34 families were recorded from the PKPTY pond (Table 1**)**. Families with maximum number of species include Asteraceae (8 species) followed by Poaceae (7 species). Convolvulaceae and Malvaceae families represented with 5 species each. Amaranthaceae, Euphorbiaceae and Fabaceae had 4 species each and 3 species representing to Commelinaceae family. Whereas, Araceae, Boraginaceae, Cappridaceae, Lythraceae, Molluginaceae and Solanaceae were represented by two species each. Twenty families viz., Acanthaceae, Apiaceae, Apocynaceae, Aponogetonaceae, Aristolochiaceae, Cucurbitaceae, Cyperaceae, Hydrochaitaceae, Hydroleaceae, Lillaceae, Menispermaceae, Nyctaginaceae, Nymphaeaceae, Onagraceae, Passifloraceae, Rubiaceae, Sapindaceae, Typhaceae, Ulmaceae and Vitaceae were monospecific.

The dominant genus of *Ipomoea* and *Sida* represented each with 3 species. *Alternanthera*, *Cleome*, *Commelina*, *Euphorbia*, *Alysicarpus*, *Ammannia*, *Brachiaria* and *Echinochloa* genus had two representative species to each genus. Eleven genera comprised single species. Based on the observation free floating, submerged, Submerged with free floating shoot system, Submerged ; Varying habit invasive edge, Swamp , Submerged emergent, emergent, Emergent and swamp, Emergent edge, Edge and partial emergent. When compared to the aquatic vegetation, semi-aquatic vegetation was relatively found more number of species than the other forms (Figure 1).

Table 1: List of aquatic and semi aquatic plants of Periya Kollukudipatty pond of Vettangudi Birds Sanctuary

S. No	Botanical Name	Family	Growth Form (Habit)
1.	*Hygrophila schulli* (Hamilt.) M. R. Almeida & S. M. Almeida	Acanthaceae	Edge, herb
2.	*Achyranthes aspera* L.	Amaranthaceae	Semi aquatic herb
3.	*Alternanthera pungens* Kunth.	Amaranthaceae	Semi aquatic herb
4.	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	Edge and Partial emergent
5.	*Gomphrena globosa* L.	Amaranthaceae	Semi aquatic herb
6.	*Centella asiatica* (L.) Urb.	Apiaceae	Emergent Creeping herb
7.	*Oxystelma esculentum* (L. f.) R. Br.	Apocynaceae	Emergent and swampy climber
8.	*Aponogeton natans* (L.) Engl. & K.Krause.	Aponogetonaceae	Submerged with free floating shoot system; herbaceous
9.	*Lemna minor* L.	Araceae	Free floating herb
10.	*Wolffia globosa* (Roxb.) Hartog & Plas.	Araceae	Free floating herb
11.	*Aristolochia indica* L.	Aristolochiaceae	Semi aquatic; climbing herb
12.	*Acanthospermum hispidum* DC.	Asteraceae	Semi aquatic herb
13.	*Ageratum conyzoides* L.	Asteraceae	Semi aquatic herb
14.	*Eclipta prostrata* (L.) L.	Asteraceae	Emergent Edge herb
15.	*Emilia sonchifolia* (L.) DC. ex Wight.	Asteraceae	Semi aquatic herb
16.	*Pentanema indicum* (L.) DC.	Asteraceae	Semi aquatic herb
17.	*Sphaeranthus indicus* L.	Asteraceae	Swampy herb
18.	*Tridax procumbens* L.	Asteraceae	Semi aquatic herb
19.	*Xanthium strumarium* L.	Asteraceae	Semi aquatic herb
20.	*Euploca ovalifolia* (Forssk.) Diane & Hilger.	Boraginaceae	Semi aquatic herb
21.	*Heliotropium indicum* L.	Boraginaceae	Edge, herb
22.	*Cleome chelidonii* L. f.	Cappridaceae	Semi aquatic herb
23.	*Cleome viscosa* L.	Cappridaceae	Semi aquatic herb
24.	*Commelina benghalensis* L.	Commelinaceae	Swampy herb
25.	*Commelina erecta* L.	Commelinaceae	Swampy herb
26.	*Cyanotis axillaris* (L.) D.Don ex Sweet.	Commelinaceae	Swampy herb
27.	*Evolvulus alsinoides* (L.) L.	Convolvulaceae	Semi aquatic herb
28.	*Ipomoea aquatica* Forsskal.	Convolvulaceae	Submerged; Edge herb
29.	*Ipomoea carnea* subsp. *fistulosa* (Martius ex Choisy) D.F.Austin.	Convolvulaceae	Submerged; Edge shrub
30.	*Ipomoea obscura* (L.)Ker Gawler.	Convolvulaceae	Submerged, climbing herb
31.	*Merremia emarginata* (N.L.Burman)Hallier F	Convolvulaceae	Semi aquatic; creeping herb
32.	*Cucumis maderaspatanus* L.	Cucurbitaceae	Semi aquatic; climbing herb
33.	*Eleocharis acicularis* (L.) Roem. & Schult.	Cyperaceae	Emergent, herb
34.	*Croton bonplandianus* Baill.	Euphorbiaceae	Semi aquatic herb
35.	*Euphorbia hirta* L.	Euphorbiaceae	Semi aquatic herb
36.	*Euphorbia prostrata* Aiton.	Euphorbiaceae	Semi aquatic; Shrub

Contd…

S. No	Botanical Name	Family	Growth Form (Habit)
37.	*Phyllanthus reticulatus* Poir.	Euphorbiaceae	Semi aquatic herb
38.	*Abrus precatorius* L.	Fabaceae	Semi aquatic; climber
39.	*Alysicarpus longifolius*(Spreng) Wight & Arn.	Fabaceae	Semi aquatic herb
40.	*Alysicarpus monilifer* (L.) DC.	Fabaceae	Semi aquatic herb
41.	*Senna occidentalis* (L.) Link.	Fabaceae	Semi aquatic herb
42.	*Vallisneria spiralis* L.	Hydrochaitaceae	Submerged; emergent
43.	*Hydrolea zeylanica* (L.) Vahl.	Hydroleaceae	Submerged; emergent
44.	*Gloriosa superba* L.	Lillaceae	Semi aquatic; Climbing herb
45.	*Ammannia auriculata* Willd.	Lythraceae	Semi aquatic herb
46.	*Ammannia baccifera* L.	Lythraceae	Swampy herb
47.	*Abutilon indicum* G. Don.	Malvaceae	Semi aquatic; under shrub
48.	*Sida acuta* Burm. F	Malvaceae	Semi aquatic herb
49.	*Sida cordata* (Burm. f.) Borss. Waalk.	Malvaceae	Semi aquatic herb
50.	*Sida cordifolia* L.	Malvaceae	Semi aquatic herb
51.	*Urena lobata* L.	Malvaceae	Semi aquatic herb
52.	*Tinospora cordifolia* (Willd.) Miers.	Menispermaceae	Semi aquatic; climber
53.	*Glinus oppositifolius* (L.) Aug.DC.	Molluginaceae	Semi aquatic herb
54.	*Mollugo pentaphylla* L.	Molluginaceae	Semi aquatic herb
55.	*Boerhavia diffusa* L.	Nyctaginaceae	Semi aquatic herb
56.	*Nymphaea nouchali* var. *pubescens* (Willd.) Hook. f. & Thomson.	Nymphaeaceae	Submerged; free floating shoot system
57.	*Ludwigia perennis* L.	Onagraceae	Swampy herb
58.	*Passiflora foetida* L	Passifloraceae	Semi aquatic; climber
59.	*Apluda mutica* L.	Poaceae	Semi aquatic herb
60.	*Brachiaria distachya* (L.) Stapf.	Poaceae	Semi aquatic herb
61.	*Brachiaria mutica* (Forssk.) Stapf.	Poaceae	Semi aquatic herb
62.	*Cynodon dactylon* (L.) Pers.	Poaceae	Semi aquatic herb
63.	*Echinochloa colona* (L.) Link.	Poaceae	Semi aquatic surface; herb
64.	*Echinochloa crus-galli* (L.) P.Beauv.	Poaceae	Semi aquatic surface; herb
65.	*Urochloa glumaris* (Trin.) Veldkamp.	Poaceae	Semi aquatic herb
66.	*Oldenlandia umbellata* L.	Rubiaceae	Semi aquatic herb
67.	*Cardiospermum halicacabum* L.	Sapindaceae	Semi aquatic; Climbing herb
68.	*Physalis minima* L.	Solanaceae	Semi aquatic herb
69.	*Solanum torvum* Sw.	Solanaceae	Semi aquatic herb
70.	*Typha domingensis* Pers.	Typhaceae	Submerged; floating shoots; shrub
71.	*Hybanthus enneaspermus.* (Linn.) F. Muell	Violaceae	Semi aquatic herb
72.	*Cayratia trifolia* (L.) Domin.	Vitaceae	Semi aquatic; Climbing herb

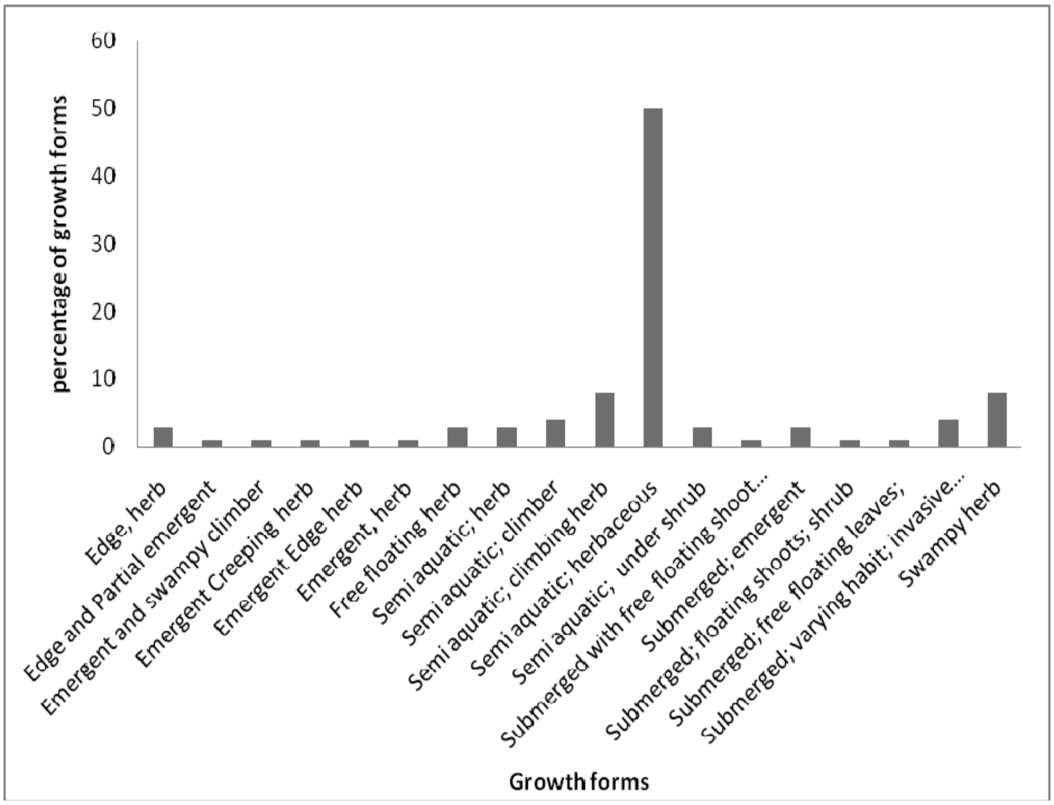

Fig. 1: Per cent value of different aquatic and semi-aquatic vegetation occurred in PKPTY pond area

In the present study it is reported that maximum number of species belongs to Asteraceae with 8 species followed by Poaceae family and similar trend was reported by Saini *etal*., (2010). Grasses are widespread than any other family of flowering plants in most habitats including wetlands (Karthikeyan 2005). The interaction among the ecological components viz., plants with environment; plants with animals and interrelationships among plants were also observed in the present study. In the study area 10 species of climbing plants were occurred. These plants were highly used by avian population for making their nests. *Ipomoea obscura* species was found that it was used for the birds nest construction. The edge plant *Phyllanthus reticulatus* is used for the nesting of water birds. The edge reefs form shelter for the aquatic insects, which in turn forms the prey to the water birds. Similarly, *Phyllanthus reticulates* – a gregariously foliated shrub facilitates the migratory birds like Common Coot (*Fulica atra*) and Little Grebe (*Tachybaptus ruficolis)*. Invariably to the forms, many of the aquatic vegetation serves as the feed to the water fowls and the present study results are corroborated with (Jha, 2013).. The experimental pond area also contains the aquatic plants *Lemna minor*, *Wolffia globosa*, *Aponogeton natans, Cyanotis axillaris*, *Ipomoea aquatic*, *Hydrolea zeylanica, Nymphaea nouchali* and *Typha domingensis.* Such a diverse plant community is beneficial to migrating and wintering water birds and similar emphasis was made in a previous study (Benedict and Hepp, 2000).

CONCLUSION

The ecological components of the wetland and their interactions are necessarily to be monitored for the effective management of the fragile wetland ecosystem. Aquatic vegetation and its implications on water quality, the beneficial nature to the associating organisms in the ecosystem, the utility values and ecosystem services are the major areas of research and analysis, which are required to be addressed. Such a comprehensive study would be useful to manage the sustainable wetland ecosystem for the benefit of the environment and the associating communities.

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Treatment of Industrial Effluent at Jeedimetla Effluent Treatment Plant

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ABSTRACT

Industrial Estates have become common feature of global landscape. The number of estates has increased dramatically in the more developed countries and especially in the rapidly industrializing countries of Asia. Industrialization and pollution are like two side of the same coin. The goods and services are the result of Industrialization, which leads to the pollution of water, air and other natural resources. So, the need for treatment of waste water is utmost important in the environment perspective. Industries consume large amount of water for their process but only a fraction of water is used in the process. The rest finds its way into the drain as waste water. If this untreated water is allowed to accumulate it causes the decomposition of organic material thus leading to the production of large quantities of harmful gases. Industrial waste contains toxic compounds have their own adverse effects which in turn effects ground water, which stimulates the growth of aquatic flora and fauna. So, the effluent released from the industries cannot be directly disposed onto the land, they need some treatment before disposal to avoid contamination of soil, ground water etc., that contain unacceptable amounts of suspended solids, dissolved solids, minerals etc., which are dangerous when disposed without treatment. The report emphasizes on the biological treatment process of combined waste water, design their operation and maintenance and also the safety measures that are to be taken.

1. INTRODUCTION

Water which is a resource that is regenerative could absorb loads up to certain levels without affecting its quality. Industries release variety of chemicals, dyes, acids and alkais beside other toxic compounds like heavy metals. Industries consume high amount of fresh water and release wastewater. The wastewater released is not directly disposed on to soil, which contaminate groundwater. So several anthropogenic treatment methods are introduced such as primary treatment, secondary treatment or biological treatment, tertiary treatment which include reverse osmosis, activated sludge process, trickling filters etc. The main reason Jeedimetla Industrial Estate is situated at a distance of 20 km from Hyderabad city. It is spread over 450 hectares was the first to be developed by Andhra Pradesh Industrial Infrastructure Corporation (APIIC) in 1975.

Marching ahead in its commitment for clean environment, JETL has the distinction of being the first ever co-operative effluent treatment plant in India. As a result of growing realization for common effluent treatment plant by various industries in the locality, the Jeedimetla Industrial Estate had began its Common Effluent Treatment Plant (CETP) was initiated in the year 1987. About 65 chemical industries from the IDA Jeedimetla and surrounding IDA’s have joined the JETL.

The project started its operation on April 1989, and with some improvement it established an reverse osmosis plant in the year March 2013. A water pollution treatment consists of collection, conveyance, treatment and disposal of waste waters.

It is very difficult to estimate the future waste water flow and their point of generation at this stage. The collection and conveyance costs of water pollution control system generally tend to be as high as 60% and are rarely less than 50% of the total system cost.

2. Scope of the Project

Industrial effluent treatment work in developing countries concentrates on research on very rudimentary facilities to treat the effluent. Little is known about the viability of Sewage Treatment Plant (STP). Installation and maintenance of industrial effluent treatment unit systems carry enormous costs.

Industrial Wastewater treatment usually means plants as large as football fields with equalization tanks, buffer storage tanks, distribution chamber aeration tanks, clarifiers. Local's sewage treatment plants, to where the households of a municipality are attached via the sewerage system are standard. It is not so well know that wastewater can also be treated directly "on site" in technically sophisticated sewage treatment plants.

3. Industrial Overview

3.1 Introduction to JETL

Jeedimetla industrial estate is situated at a distance of 20 km from Hyderabad city centre. It is accessible by road maintained by Hyderabad municipality and is within the residential. commercial area of Hyderabad City. It is spread over 450 hectares was the first to be developed by A.P industrial infrastructure corporation (APIIC) in 1975. The industrial estate (JIE) was promoted primarily as a chemical zone with the result, between 1976 and 1982 a large number of heterogeneous industries viz., bulk drug, pharmaceuticals and chemicals manufacturing units of small and medium scale got established and the issue of water pollution reached alarming state by the year 1986. The following developments aggravated the problem of environmental degradation.

1. Presence of large residential areas, townships inside and close to industrial areas.
2. Existence of small and medium scale industrial units which cannot afford to install their own effluent treatment plants. Marching ahead in its commitment for clean environment. JETL has the distinction of being the first ever co-operative effluent treatment plant in India. The uniqueness is further highlighted by the fact that is entirely self financed by its member units numbering about 70, majority of which are in the small and medium-scale sector.

Construction of Common Effluent Treatment Plant (CETP)

The CETP was built in four phases. The construction of the units was undertaken after identifying the problems and conducting laboratory and pilot plant studies. Initially JETL was handling 350 m^3 waste water per day and reached ultimate capacity of 1500 m^3 waste water per day.

The CETP has been modifies to operate as the first Combined Waste Water Treatment Plant (CWWTP) in India treating industrial waste along with domestic sewage to meet standards for disposal into on land surface water. JETL gets effluents by tankers from various industries. Each tanker has a capacity of 10 m^3. Nearly 90-100 no's of tankers are received per day.

Laboratory

The laboratory provides technical and analytical support to the industry units located in and around Hyderabad, on environmental management. Sampling and analysis of samples is done in strict adherence to safety norms.

JETL laboratory is successful in converting secondary sludge into compost by using Effective Microorganism (EM) technology with active participation of Auroannam, Pondicherry.

JETL also conducted the R&D activity on studies on the Impact of EM sludge/compost prepared from the secondary biological sludge for crop quality which is assigned to Acharya N.G. Ranga agricultural university, Hyderabad. It proved its usefulness as manure to crop growth without adverse effects. JETL consists of 3 laboratories:

1. Control lab
2. Wet lab and
3. Instrumentation lab.

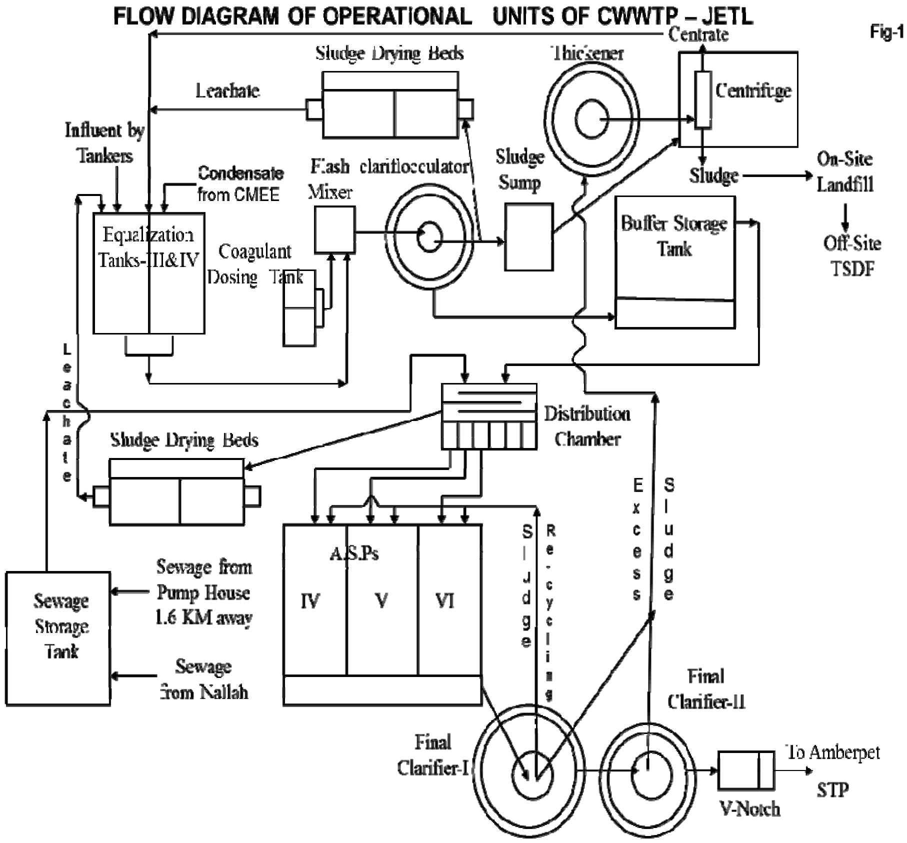

Fig. 1 Schematic representation of Effluent Treatment Plant

5. INDUSTRIAL WASTE WATER TREATMENT

Industrial waste water treatment covers the mechanisms and processes used to treat wastewater that have been contaminated in some way by industrial or commercial activities prior to its release into the environment or its re-use.

5.1 Biological Treatment for low TDS waste water

The objectives of the biological treatment of wastewater

1. Transform (i.e., oxidize) dissolved and particulate biodegradable constituents into acceptable end products

The clarified effluent is given biological treatment. The system comprises of aeration tanks, surface aerators, secondary clarifiers, sludge recirculation pump. The biologically treated effluent is monitored for quality and is finally discharged to STP. The concentrated biological sludge is converted into EM (Effective Microorganism) compost.

In JETL the treatment is done in the following stages:

5.2 Equalization tank

- Ensure the proper dispersion of air in the Equalization tank.
- Pump the wastewater from Equalization tank into Flash mixer.

5.3 CMEE Condensate Pumping

Collect condensate sample at 2 hr interval grab sample and make it composite for 24 hrs and handover to lab for analysis.

5.4 Equalization tank No IV

- Take the condensate in to the Equalization tank – IV
- Pump the condensate from Equalization tank no –IV to BST (2-3 hr) depending up on the BST wastewater concentration.

5.5 Flash mixer

- Ensure the Flash Mixer is in operation during pumping wastewater from Equalization tank.
- Pump the prepared non-Ferric Alum coagulant with a dosage of 8.00-10.00 ppm.

5.6 Clarifloculator

- Ensure continuous operation of Scrapper and Flocculator mechanism.
- Sludge from the clariflocculator bottom is to be removed once in every two hours intervals into sludge sump till observe very less solids and record the interval time of sludge decanting.

For remaining suspended solids and colloidal particles poly electrolyte is added, flash mixed and clarified in the clariflocculator. This process reduces the SS, COD and BOD.

5.7 Sludge Slump

- Collect the primary sludge from Clariflocculator bottom of the tank at 2 hr intervals.
- Ensure running of mixer in the sludge sump while pumping of the sludge in to Decanter Centrifuge.

5.8 Sludge Thickener

- The thickened sludge is to be pumped to Decanter Centrifuge.
- Ensure clear treated wastewater flow into the V –Notch chamber.

5.9 Decanter centrifuge

5.9.2 Secondary Sludge

- Wash with water before and after feeding the sludge to DCF.
- Record quantity of sludge disposed into sludge RCC storage tank.

5.9.3 Decanter Centrifuge

Centrifuge is used to de-water the thickened sludge, so that volume of sludge for the treatment/storage is further reduced. For de-watering of the sludge from thickener a solid bowl centrifuge has been provided.

5.10 Buffer Storage Tank

- Ensure homogeneous mixing of wastewater in the Buffer Storage Tank.

5.11 Activated Sludge Units

- Maintain Dissolved Oxygen (DO) level in the aeration tanks.
- Influent feed and sludge recirculation flow into aeration tanks to be stopped whenever aerators are not in operation.

5.12 Final Clarifier-I

- Ensure Clarifier - I launder and weir should not have any Suspended Solids.

5.13 Final Clarifier-II

- If Suspended Solids observed in the treated wastewater add alum dosage at required concentration.

6. Final Clarifier

The mixed liquor from aeration tanks flow into clarifier and the settled sludge is recycled to maintain required level of MLSS in ASP.

6.1. V-NOTCH

- Measure discharge flow every one hour with the help of measuring scale and record.

6.2. Sample Collection

For evaluating the performance of the treatment plant CWWTP, the supervising staff collects from specified sampling points at fixed intervals.

7. MULTI EFFECT EVAPORATION PLANT (MEE)

7.1 Evaporation

- Evaporation is an operation used to remove a liquid from a solution boiling off some of the liquid. It is thus a thermal concentration process.
- The main functions of evaporation are it is used to pre concentrate, increase solids content.

7.2. Types of Evaporators

7.2.1 Falling Film Evaporators

- Falling film evaporators can be operated with very low temperature differences between the heating media and the boiling liquid.

7.2.2 Forced Circulation evaporators

- Forced circulation evaporator has a tubular exchanger to heat up the solution without boiling. The superheated solution flashes in a vapor separator where it gets concentrated.

7.2.3 Multiple effect evaporation

- The multiple-effect evaporators allow decreasing consumption of energy for a concentration almost proportionally to number of effects.

7.3 Thermal vapor recompression [TVR]

- Thermo-compressors operate at very high steam flow velocities and have no moving parts. The construction is simple, the dimensions small, and the costs low.

8. SPRAY DRAYER

- Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with a gas.
- Hot air is the drying medium. Spray dryers use some type of atomizer or spray nozzle to disperse the liquid or slurry into a controlled drop size spray.

8.1 Hazardous Air Pollutants (HAPs)

Solvents in huge quantities are used in pharmaceutical, chemical, dye and dyer intermediate units. The recovery and re-use of solvents in such units is poor of indigenous technology, equipment machinery. This adds to pollution load in ETP / CETP. Also it adds to problem of hazardous air pollutants (HAPs). Nearby residents always raise problem of odour, but they are not aware of the problem of HAPs. The effluent received in ETP / CETP is subjected to treatment. During the process, HAPs are emitted. The primary HAPs emitted include xylems, methylenes chloride, toluene, ethyl benzene, chloroform, tetra chloroethylene, benzene and naphthalene

8.2 Problem caused by HAPs

CETP are expected to be one of the major sources of HAP emissions. HAPs have potential adverse health impacts. Health impacts of methylene chloride and benzene are well known in animals and human beings respectively.

8.3 Behaviour of HAPs

The primary HAPs would be emitted from effluent from effluent treatment plants when the compounds are present in the influent in sufficient concentrations and treatment units are uncontrolled for air emissions.

8.4 HAPs Control Options

Two different control options:

1. Add on controls (i.e., covers or covers vented to a control device); and
2. Pre-treatment (i.e., source control) are available.

9. CONCLUSION

The CETP (Common Effluent Treatment Plant) has been modified to operate as the first combined waste water treatment plant (CWWTP) in India treating industrial waste along with domestic sewage. It is successful in its treatment and meeting the **surface discharge standards.**

A part of treated wastewater is being **Re-used** in the plant for greenery development and supplying to the industrial municipality for green belt development in the Jeedimetla Industrial Estate. A part of treated wastewater is also **Re-cycled** by using RO technology. The filter water generated from RO is used for in house Boiler as feed water. The process achieves **99% of BOD** removal and **88 % of COD** removal. Each and every treatment unit as per the design requirements and also can accommodate future inflow.

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Impact Study of Regulator Cum Bridges

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ABSTRACT

Water scarcity is an alarming problem that we face now-a-days. Even though we have abundant sources of water, good quality water is not available when it is needed. Here comes the relevance of water conservation structures. Allocation of water in case of multi-purpose projects among various competing needs such as drinking water, irrigation, industrial demands, downstream release etc. is a matter of great concern. Hence reservoirs must be subjected to thorough analysis to see that each drop of water impounded is utilized in the best possible manner. A study was undertaken for analyzing the impact of Regulator cum Bridges at Chamravattom and Kootayi in Malappuram District of Kerala. The study was conducted with the specific objectives of determining the impact of RCB on water quality, soil characteristics, ground water recharge, agriculture sector, tourism possibilities, transportation and ecosystem. Even though Regulator Cum Bridges have number of positive impacts, it has got number of negative impacts also on the upstream side of it. From the present study it could be revealed that Koottayi Regulator Cum Bridge has got many positive impacts including prevention of salt water intrusion and increased fresh water availability. At the same time it adversely affects the river water quality due to the restriction of natural flushing action of the river. It creates stagnant layers of water and also accumulates pollutants in the upstream side of Regulator cum Bridges. Due to this reason amount of dissolved oxygen in river water gets reduced, which adversely affects the aquatic ecosystem. Chamravattom Regulator Cum Bridge has also got number of positive impacts like prevention of saline water intrusion, increase in ground water table, increase in area of agricultural production and improved transportation and communication facilities. Chamravattom Regulator Cum Bridge is a new RCB which was commissioned only one year back and hence the negative impacts were not prominent in this case. In the subsequent years this RCB may also face the same problems as in the case of Koottayi Regulator Cum Bridge. The results of the present study reveals that a thorough EIA of the RCB' s are to be conducted to assess the negative impacts on the upstream side and appropriate corrective / remedial measures are to be taken to overcome these negative impacts.

1. INTRODUCTION

Water is an essential and unique resource that provides life support for human, plants and animals. The phenomenal growth in population during last two decades has resulted in excessive use of water resources in the country. The world population has tripled, but the uses of water for human purpose are multiplied six fold. Today about 80 countries comprising of 40% of the population suffer from serious water crisis. Leading experts on water resources have been warning that the world is heading towards a water shock which may dwarf the oil crisis. It is, therefore, advisable to have total water planning in a region for allocating water to different sectors for future use. There is no fixed universal mathematical principle by which priorities can be set up in a particular location. The priority to which water should be given would depend upon the local conditions like climate, soil, habits of the people, status of development of agriculture and industries, recreational and tourist requirements etc.

One of the main water quality problems in coastal areas is due to salt water intrusion. Saltwater intrusion is the movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences. Saltwater intrusion occurs naturally to some degree in most coastal aquifers, owing to the hydraulic connection between groundwater and seawater. Because saltwater has a higher mineral content than freshwater, it is denser and has a higher water pressure. As a result, saltwater can push inland beneath the freshwater. Water extraction drops the level of fresh groundwater, reducing its water pressure and allowing saltwater to flow further inland.. Groundwater extraction is the primary cause of saltwater intrusion.

Groundwater extraction can lower the level of the freshwater table, reducing the pressure exerted by the freshwater column and allowing the denser saltwater to move inland laterally. Groundwater extraction can also lead to well contamination by causing upcoming of saltwater from the depths of the aquifer. The National water policy (1987) suggested that the water resources development projects should be planned and developed as far as possible as multi- objective projects with drinking water supply as top priority followed by irrigation, hydro power etc. In a multipurpose project, the water management would require optimum use of water for various needs at different times. Irrigation consumes a huge quantity of water and quite naturally the major allocation from a reservoir system goes for irrigation. Hence, our aim should be to increase the effectiveness of every drop of water used for irrigation in terms of economy. Construction of regulator cum bridge is a multipurpose project. The main and primary aim this project is to evolve storage, sufficient for irrigating gross ayacut area and drinking water supply. Another important aim of this project is effective control of the intrusion of saline water into the upstream side of regulator. Besides, the river when bridged connecting the two adjacent areas, it will improve the communication facilities and also solve the unemployment problems in that area. Regulator Cum Bridges use radial or sluice gates to control and raise water levels in their upstream reaches of streams and irrigation canals with mild slopes.

Environmental Impact Assessment (EIA) is a key aspect of many large scale planning applications. It is a technique which is meant to help us understand the potential environmental impacts of major development proposals. Unfortunately both the process and the outcome of EIA can be complex and confusing leaving local communities unsure as to how a development might affect them. In case of a need for a new project arise, the planner has to assess the ecological impacts in and around the stream carefully to improve the project in a manner that it will have the least hazardous impacts. Wherever the location of a dam is, its ecological results are the same. The present investigation was undertaken to study the impact of regulator cum bridges.

The specific objectives were:

1. To study the impact of regulator cum bridges on water quality.
2. To study the impact of regulator cum bridges on soil characteristics.
3. To study the impact of regulator cum bridges on ground water recharge.
4. To study the impact of regulator cum bridges on agriculture sector.
5. To study the impact of regulator cum bridges on transportation.
6. To study the impact of regulator cum bridges on tourism possibilities.
7. To study the impact of regulator cum bridges on ecosystem.

2. MATERIALS AND METHODS

2.1 Chamravattom Regulator Cum Bridge

The project is about 6 km upstream of the confluence point of the river and sea. The latitude and longitude of the site are 10º 51' North and 75º 57’ East. The project site is in the Ponnani and Tirurtaluks of Malappuram district. The entire area is thickly populated.The intensity of population in Ponnani and Tirur taluks is 1070 per sq.km. Agriculture is the main occupation of the people,51% of the inhabitants depending on it. Paddy is the main crop cultivated in the area, with coconut,arecanut,banana,tapioca and pepper occupying the second position. People are well concious about the irrigation, fertilizers, pesticides and high yielding varieties of seeds and modern technologies in agriculture. The Chamravattom RCB is built across the second longest river, ‘Bharathappuzha’ in Malappuram district of the state Kerala with a length of 209 km. Length of bridge is 978 m with a span of 12m having 70 nos. of shutters of 12 x 4.50 m size. Height of the shutter is 4 m and the carriage way of the bridge is 7.50 m wide excluding foot path of 1.50 m on either side. All vents are controlled by lift shutters. So no navigation is anticipated no lock arrangements are proposed. The RCB is proposed to stabilize the ayacut maintained by lift irrigation schemes in the area that have been commissioned by the State Irrigation Department. The project is also aimed for the formation of additional sluices, extending canals, replacement of motors and pumps, improvements to the existing canals, shifting of pump house etc. The drinking water supply schemes face acute shortage of water during the summer, solution to which is also answered better from this scheme. Another important aim of this project is the effective control of the intrusion of saline water into the upstream side of the regulator. Besides, the river when bridged will be an important link connecting the coastal towns of Ponnani and Tirur and thereby reducing the distance 20km by road. This also reduces the distances between Ernakulam and Calicut and thereby contributes much to the development of the coastal towns.

Plate 1 Chamravattom Regulator Cum Bridge

2.2 Kootayi Regulator Cum Bridge

The Kootayi RCB is built across the river 'Thirurpuzha' in Malappuram district of the state Kerala with a length of 48 km. Tirur River begins in the Tirur taluk village of Athvanad in the Malappuram district of the state of Kerala in south India and flows south-west to Thiruvnavaya and then north-west to Elamkulam where it turns south-west, joining the Bharathapuzha River which flows into the Arabian Sea near the coastal town of Ponnani. It is known for its beautiful mangroves and its many varieties of fishes and birds. This river is navigable and forms part of west coast water transport system. Its length is 48 km . Construction of a lock-cum-regulator-cum-bridge at Koottayi across Tirur Ponnanipuzha in Malappuram District were awarded in 1979 and 1981 respectively, the department was forced to terminate the contract in December 1981 and June 1984 after completing 14 out of the 25 spans, The original proposal was for construction of 24 spans and a lock chamber. Out of the above 24 spans, 14 spans were completed. The work was held up due to various technical reasons. The fixing of shutters for the completed spans could not be arranged due to various factors. The above work was proposed twenty years back and at that time no other projects were executed and water was not stored in the upstream portions of Bharathapuzha. Later a number of projects such as Chulliyar, Meenkara, Pothundy, Kanjirappuzha, Mangalam etc were executed in addition to the major project, Malampuzha. Hence the discharge of water in the river basin has been considerably reduced. Moreover the Koottayi regulator was designed considering the flood of 1924, which was the peak flood. Since 1924 no such flood had occurred and even if such a flood could occur the above mentioned projects could absorb a major portion of the flood. Hence after considering all the above facts the Chief Engineer, Irrigation and Administration and Chief Engineer IDRB jointly decided to reduce 4 spans from the original proposal of 24 spans.

2.3 Methodology

Soil and water analysis were conducted for understanding the effect of RCB on soil characteristic and water quality.Water depth measurements are taken from a number of open wells located at the upstream and downstream side of the RCB in periodic intervals to understand the RCB effect on ground water table. Details of increase in area of cultivation and increase in irrigated area are collected from krishibhavans of respective Gramapanchayath. Details of maintanance and replacement of pump sets are collected from pump houses.

Plate 2 Kootayi Regulator Cum Bridge

2.3.1 Water Quality

Four sampling sites were chosen in the upstrem side of Kootayi RCB, they are Thazhepalam, Mangatteri,Pachutteri,Vettumcheri. Five sampling sites were chosen in Bharathapuzha in the upstream side of Chamravattom RCB, they are chamravattam, Nariparamb, Athalur, Tavanur and Kuttippuram. At each site, water samples were collected in bottles. The different quality parameters like Electrical Conductivity, quality parameter such as chloride, sulphate, calcium, magnesium, iron, nitrate, nitrite, phosphate, total coliform and E.coli were determined in the laboratory.

2.3.2 Soil Characteristics

Soil samples were collected from different locations on the upstream sides of both Chamravattom RCB and Kootayi RCB. The soil samples were analysed for various physical properties like particle size distribution, pH and Electrical Conductivity.

2.3.3 Ground Water Recharge

Ground water related environmental issues such as declining of water levels and consequent quality deterioration due to salinity intrusion from the cost and the river course during the summer periods are serious environmental problems. The structure across Bharathapuzha at Camravattom is supposed to have a positive impact on ground water regime which can solve the ground water related environmental issues in the surrounding blocks to a large extent. In case of unconfined aquifer, water table depth will be in line with the water level of the open wells. Inorder to measure the increase in recharge of ground water, water level readings are taken from selected 8 open wells located on the upstream and downstream side of the Chamravattom RCB. Measurements are taken repeatedly throughout 2 months when RCB was in closed state.

2.3.4 Survey

To understand the effect of RCB on area of cultivation, productivity, and maintenance of pump houses, a survey was conducted using a questionnaire among the people living around the RCB locations and collected information about water quality, crop yield, ground water table, salt water intrusion and socio-economic issues.

3. RESULTS AND DISCUSSION

The major findings of the study conducted on ‘Impact of Regulator Cum Bridges’ regarding water quality, ground water recharge, salt water intrusion, soil characteristics, transportation, agriculture, ecosystem and socio economic issues are described in this section.

3.1 Water Quality

The result shows that EC of water samples at various sites, both from upstream of Koottayi RCB and Chamravattom RCB are in desired range. From the survey report of downstream reach of RCB, the main problem faced by the people was insufficient drinking water due to salt water intrusion. This indicates that salt water intrusion is successfully prevented by the RCB in the upstream so that more fresh water is available for irrigation and drinking in the upstream. Desired limit of pH of river water is between 6.50 to 8.50. Result of the analysis show that pH of water samples at various sites, both on the upstream sides of Koottayi RCB and Chamravattom RCB are in desired range. Water quality analysis of the samples taken from the upstream of Kootayi RCB revealed that most of the sample have amount of total alkalinity, sulphate, calcium, iron concentration much lower than the desired limit. But the total coliforms, E coli count, chloride, sulphate, magnesium, total dissolved solids and turbidity are much larger than desired value, indicating that water is highly polluted. Among the 4 samples, water sample from Mangatteri is highly polluted, which contains large amount of sulphate, calcium, magnesium in the water sample. Total Hardness of this sample is 7790 while the desired limit is 500. Samples from Thazhepalam and Vettumchery are biologically polluted by the presence of high amount of total coliforms and E coli in the water sample. Since these places are very nearer to the Tirur town, this biological pollution may due to discharge of Municipal drainage pipelines to the river. The Total Coliform counts were high for all samples taken and the main threat to the health of the local population drawing water for drinking is this bacterial contamination. The high concentration of E coli and total coliforms may due to stagnant layers of impounding water in the upstream of regulator cum bridge. A stagnant layer of water is due to the closing of shutters. It will prevent the natural flushing action of river.

3.2 Soil Characteristics

The results of particle size analysis reveals that all the samples are well graded gravel. Soil gradation is very important in geotechnical engineering, which is an indicator of other engineering properties such as compressibility, shear strength, and hydraulic conductivity. A poorly graded soil has better drainage than a well graded soil because there are more void spaces in a poorly graded soil. A well graded soil is able to be compacted more than a poorly graded soil. Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient. pH of the soil samples varied from 6.42 to 8.41. EC test result of samples revealed that the EC of soils range from 0 - 2 ds/m. According to USDA classification the soils falls under class A group of salinity range between 0 and 0.13 g/100g of soil.

3.3 Ground Water Recharge

Results of surveys conducted in the upstream and downstream sides of RCB reveals that ground water table is raised during closing of shutters on the upstream side and quality of well water is improved a lot and salinity intrusion is prevented effectively. So the drinking water shortage during the summer is solved effectively on the upstream side. But on the downstream side water taste become salty and become yellow in colour and there is no change in the water level.

3.4 Agriculture

Results of surveys conducted at the upstream of RCB reveals that 10 to 15 % of people depend on river water for irrigation. Details were collected from Panchayat Krishibhavans and by interacting with farmers.

3.5 Transportation

The main advantage of Chamravattom Bridge is the reduction in the distance between Calicut and Cochin by 40 kilometers, Tirur and Ponnani by 20 kilometres and the distance between Ponnani and Malappuram by 10 kilometers. The bridge has also helped to reduce the traffic congestion at Edappal, Valanchery and Kottakal towns. This bridge serves as a bypass avoiding traffic conjunction in the coastal towns, thus contribute indirectly towards their social and economic development.

3.6 Tourism

Tourism department has initiated for number of projects in the upstream side of Chamravattom RCB and decided to make Chamravattom as the tourism window of Malappuram. Tourism department plans to start boating by utilizing the water availability in the river and to build Nila heritage village. Heritage will consist of museum, art gallery, sports complex and convention centre. This project can bring employment opportunities to the unemployed youth.

3.7 Ecosystem

The decomposing organisms cause an increase in the nutrient substances in water in a short period of time, hence BOD (Biological Oxygen Demand) value of water rises. An anaerobic decomposition is performed with the help of the stationary layers along the reservoir depth. This results in a dark coloured river smelling badly. Besides the plants covering the water surface as large green-dark coloured bodies, macro flora grows up on water surface. These events can be harmful both for the life of the river and for the people. The regulator cum bridge is a real obstacle for the animals swimming from one end of the river to the other end. The existence of the regulator leads to death for the fish species. Eutrophication has resulted in the abundance of filamentous algae and weeds in the lower reaches of the river. Such large scale pollution not only degrades the habitat but also causes endocrine disruptions and several other physiological imbalances in fish including breeding failure which could ultimately lead to their extinction.

SUMMARY AND CONCLUSIONS

The availability of water is decreasing with increase in its demand. With such decrease in the availability, the increasing demand can be met only through scientific management of water resources. Water resource projects involving reservoirs are very expensive and interlinked with many social issues. Regulator cum bridge is gated structures which restricts the natural flow of river water and impound the water behind it. Primary objectives of construction of RCB are increasing the fresh water availability, ground water recharge and increasing area of crop production. Even though regulator cum bridges has many positive impacts, it has got some negative impacts also. Koottayi regulator cum bridge also got many positive impact including prevent ion of salt water intrusion (from EC measurements). At the same time it adversely affects the quality of water due to the restriction of natural flushing action of the river. It creates stagnant layers of water and also accumulates pollutants in the upstream side of RCB. Due to this amount of dissolved oxygen in river water gets reduced. This intrusion adversely affects the aquatic ecosystem. The following conclusions are obtained from the present study:

(i) River Water analysis in the upstream side of RCB, shows that EC values range from 50 to 1500 μmhos/cm. EC is the measure salinity of the water; which is within the desired limit. This shows that salinity intrusion in the upstream side of the RCB could be prevented successfully. But in downstream side of RCB, the adverse effect of salt water intrusion is more prominent.

(ii) Water quality analysis of the samples revealed that most of the sample have amount of total alkalinity, sulphate, calcium and iron concentrations much lower than the desired limit. But the Total coliforms, Ecoli count, chloride, sulphate, magnesium,total dissolved solids and turbidity are much larger than desired value, indicating that water is highly polluted. From this it is evident that the water is more polluted due to the restriction of natural flushing out of the river and due to dumping of sewages to the river. The problem of smelling and colour change of water in the upstream sides of the Chamravattom and Kootayi RCBs is regularly reported.

(iii) Results of pH analysis of Kootayi and Chamravattom water samples revealed that, pH values range from 6.77 to 7.46, when shutters are closed, which lies between the desirable limits. While shutters are opened, pH values are more than that of desirable limits.

(iv) Results of EC analysis of soils show that EC value range is 0.154 to 0.18μmho/cm of soil, which indicates that soil salinity is very low.

(v) Results of surveys conducted in the upstream and downstream sides of Chamravattom RCB reveals that ground water table could be raised upto 80 cm during closing of shutters on the upstream side and quality of well water was improved and salinity intrusion was prevented effectively. So the drinking water shortage during the summer could be solved effectively on the upstream side.

(vi) In Chamravattom region especially in the Purathoor and Thruprangodu Panchayaths area of production is increased about 20% by implementing the RCB in Chamravattom. And these Panchayaths implementing new agro-projects like "Seed Village", converting pasture lands to cultivating lands and paddy cultivation throughout 3 seasons by forming clusters of farmers. It will improve the socio-economic status of farmers. Now-a-days there are 8 irrigation schemes working properly under Chamravattom project.

(vii) The main advantage of Chamravattom Bridge is the reduction in the distance between Calicut and Cochin by 40 kilometers, Tirur and Ponnani by 20 kilometres and the distance between Ponnani and Malappuram by 10 kilometers. The bridge has also helped to reduce the traffic congestion at Edappal, Valanchery and Kottakal towns.

(viii) Tourism department has initiated for number of projects in the upstream side of Chamravattom RCB and decided to make Chamravattom as the tourism window of Malappuram. Tourism department plans to start boating by utilizing the water availability in the river and to build Nila heritage village.

(ix) A thorough EIA of the Regulator cum Bridges are to be conducted to assess the negative impacts on the upstream side and appropriate corrective / remedial measures are to be taken to over cum these negative impacts.

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Hydro Power Development in India and Environmental Issues

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ABSTRACT

Energy sufficiency is the latest catchword for the wellbeing of a country. The large domestic population also puts significant pressure on power generation and sometimes it is pretty dismal. It often leads to public outcries and demonstrations. Hydro is the most well-established form of renewable electricity production. These projects are the best form for the production of electricity. The development of the hydropower may affect the environment in many ways. In this paper we are dealing with those issues that environment faces. Generally, a project which produces power up to 25 MW is considered as a Small Hydro Project (SHP) and there will be less environmental issues with these types when compared to the Large Projects. Environmentally the issues may be due to river diversion over a long stretch which causes a decrease in fish population and other aquatic animals. Often downstream flows are reduced considerably or even completely stopped during certain periods of time with sudden intervals of high flows. Due to sedimentation, the storage capacity of water becomes less, thereby the generation of power becomes less. hydropower dams can produce power with low GHG emissions and can in some cases also deliver flood and irrigation control, the adverse social and environmental costs can be substantial as we have described above. Such negative impacts are not compatible with the promotion of sustainable development. There are only two things that are undisputed about hydropower projects: One, they emit no air pollutants; and two, they certainly destroy local ecology and culture. As per our view constructing SHP's are better when compared to large projects and also proper maintenance of the projects may lessen the environmental issues.

ENERGY SCENARIO IN INDIA

Emerging economies are particularly facing severe energy crisis. Therefore, energy sufficiency is the latest catchword for the wellbeing of a country, particularly for India where economy is growing at 8-9% annually. The large domestic population also puts significant pressure on power generation. Over the last 10 years, energy and peak demand shortage averaged around 8% and 12% respectively. Renewable energy accounts for about 11% of the total installed power generation of 170GW. Wind energy, with an installed capacity of 14 GW, accounts for the bulk of installed renewable energy in India. From 1984 to 2011, the demand for electric power increased at the rate of 6.35% per annum and the availability increased at the rate of 6.28%. For the Indian economy to grow at 9% annually, additional capacity of 60GW must be added ever five years. Figure 1 shows the consumption of resources for power consumption

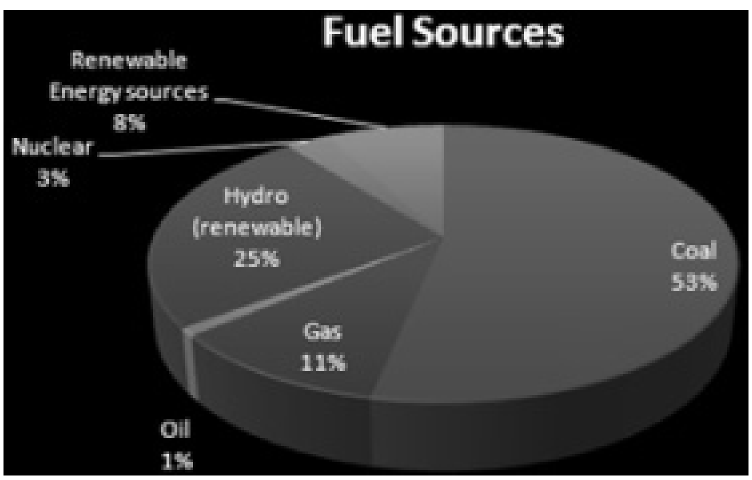

Fig. 1 : Consumption of resources for power consumption

Why hydropower?

Hydro is the most well established form of renewable electricity production. In 2010, hydro comprised 82% of all the renewable electricity capacity in the world, and accounted for about 20% of global electricity production capacity. Hydropower is also the most efficient means we know of to convert energy into electricity. Typically 85%-95% of the energy in water is converted to electricity, compared to 15%-20% for PV solar, 35%-45% for wind and 30%-45% for coal. Hydropower has immense benefits and has been brought forward as a preferred option for power generation over the last decade. The reasons for these can be summarized as follows:

- It is totally renewable, non polluting and can also provide a more stable price regime over a long period of time.
- It has remarkably higher efficiency compared to thermal and gas and it's durable.
- It has inherent capability for quick starting, stopping, load variations, etc… and is thus ideally suited for meeting the peak demand.
- Generation cost is not only inflation free but it also reduces with time.
- Development of hydropower projects is also in many cases associated with irrigation, drinking water, flood control, pisciculture, navigation, recreation and tourism benefits.
- Small hydro plants have least environmental impacts and would be ideally suited for rural electrification particularly in remote areas.

What is Hydro Power?

Hydropower captures the energy produced by moving water. The method for harnessing this power is remarkably simple: Falling water possesses energy. When the water falls downwards, its gravitational potential energy is converted into kinetic energy. The kinetic energy is transferred to the water wheel and it rotates. If the water wheel is connected to a generator, electricity can be generated. This is the basic principle of hydroelectricity, using falling water to generate electricity as shown in fig 2, 3.

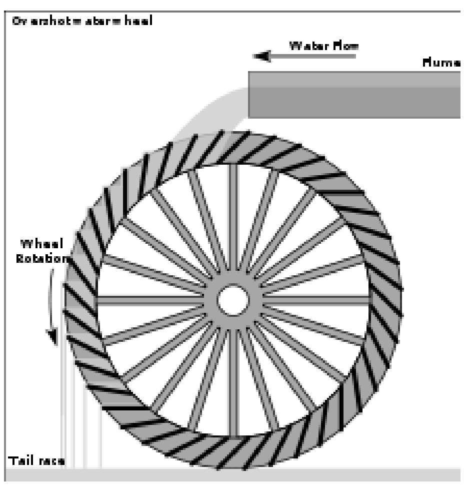

Fig. 2: Basic principle of hydro power

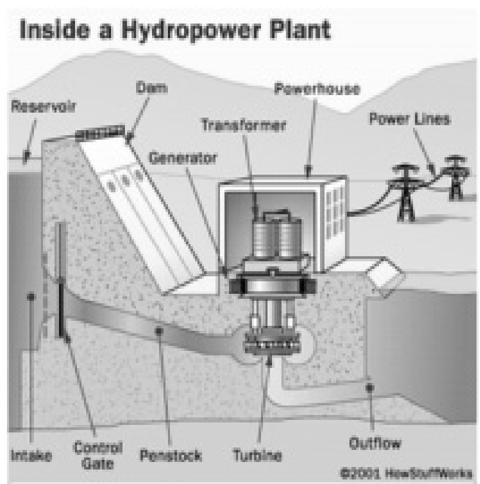

Fig. 3 Inside a water plant

TYPES OF HYDROPOWER

1. ***Reservoir Hydro Systems:*** Most people visualize a Reservoir system when they hear the term "hydroelectric project". Reservoir systems consist of a large dam that creates a sizeable lake behind it. The large manmade lakes behind the dams submerge a vast area with countless plants, animals and people. Yet an entire new ecosystem develops over time.
2. ***Streaming or Run of the River (ROR) Systems:*** In this type there are no dams and lakes, only diversion systems that direct a portion of a stream or river through the hydroelectric turbine. ROR systems are typically installed on smaller streams and rivers, and generate less power than large reservoir systems.

They are rapidly gaining popularity due to their ease of installation and small ecological footprint. Without reservoir, streaming hydro power systems solely depends on the water pressure created by the pipeline, steep terrain are ideal location for such small hydro systems as it allows high pressure to be created in short distances, which dramatically reduce the cost of the systems. Streaming hydro sites also tend to be located closer to the point of electricity usage, substantially reducing the line losses inherent to large power plant designs.

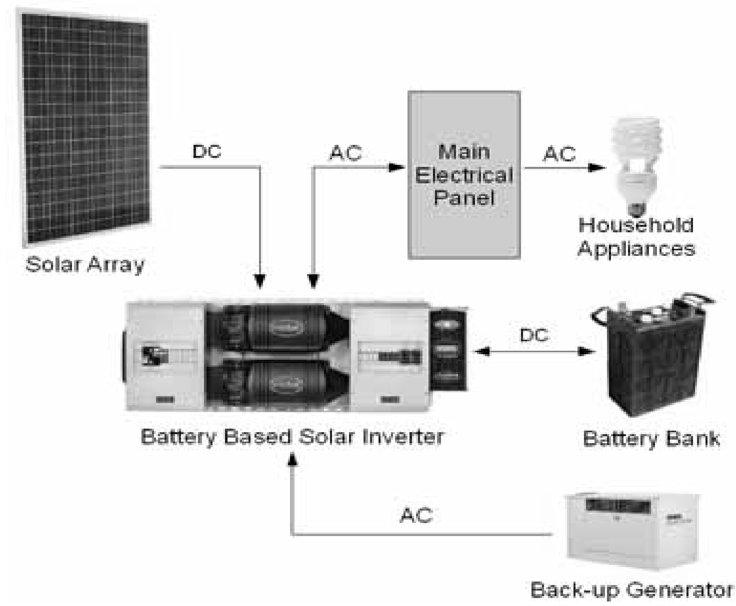

Fig. 4 Small Hydro power systems

ENVIRONMENTAL AND SOCIAL IMPACTS OF HYDROPOWER

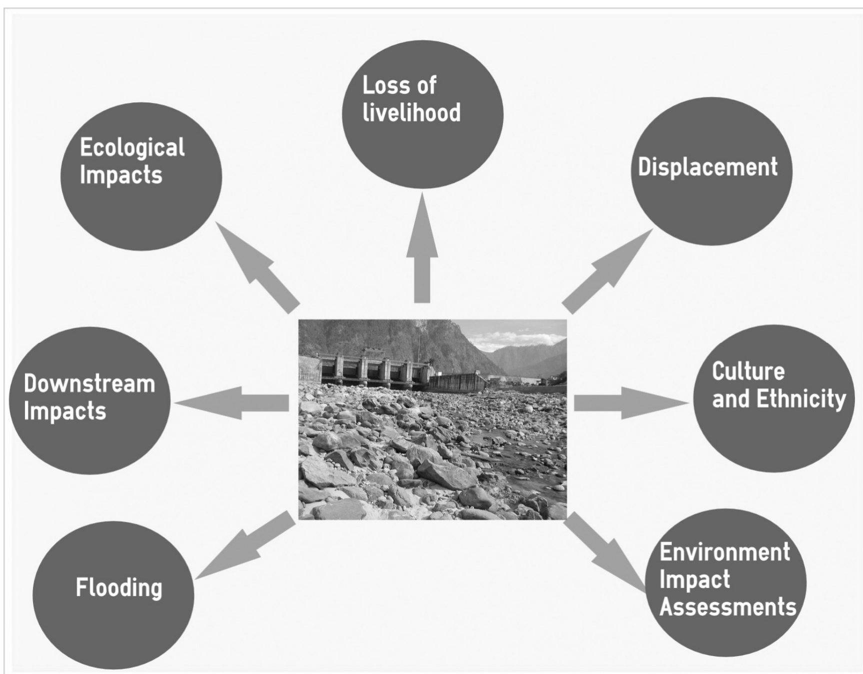

Fig. 5: Environmental Impacts of Hydropower

1. ***Impact of Size and Type of Hydropower Plant:*** It is difficult to correlate the damage caused by dams to their size or type, as the impacts depend on local conditions. Generally plants with smaller dams are considered less environmentally damaging than those with larger dams. Also, run-of-river (ROR) hydropower plants are generally less damaging than reservoir power plants, because it is not necessary to flood large areas upstream of the project for storage. Yet in some cases run of river impacts can also be severe due to river diversion over long stretches of the river.
2. ***Impact of River diversion:*** While both ROR and reservoir types of hydropower dams may divert water, this is always the case with ROR plants, since they seek to increase kinetic energy with an increased head. The length of diversion can range from a few meters or less to kilometers (km). For example, the Teesta-V ROR dam in northeastern India diverts water for a 23 km long stretch of the river. Eventually the diverted water is returned to the river. Often downstream flows are reduced considerably or even completely stopped during certain periods of time with sudden intervals of high flows. Such drastic variability in water flow impacts the structure of aquatic ecosystems often leading to a loss of biodiversity. Also, under normal conditions, increased sediment transport from low to intermediate flows provides a warning to aquatic organisms that high flows may follow. Abrupt changes from low to high flows obliterate this cue, making it difficult for organisms to respond to impending environmental changes. A decrease in fish populations has been observed in dewatered reaches below diversions. After long periods of little to no flow some species may not be able to recover and go extinct.
3. ***Impact of the reservoir:*** Dams have major impacts on the physical, chemical and geo-morphological properties of a river. Environmental impacts of dams have largely been negative. Worldwide, at least 400,000 square kilometers have been flooded by reservoirs. Once the barrier is put in place, the free flow of water stops and water will begin to accumulate behind the dam in the new reservoir. This land may have been used for other things such as agriculture, forestry, and even residences, but it is now unusable. The loss of habitat may not seem severe but if this area was home to a threatened or endangered species, the dam construction could further threaten that species risk of extinction.

3.1 Sedimentation

Large dams with reservoirs significantly alter the timing, amount and pattern of river flow. This changes erosion patterns and the quantity and type of sediments transported by the river. Sedimentation rate is primarily related to the ratio of the size of the river to the flux of sediments. The reservoir that has been rapidly filling up with water immediately begins filling up with sediment as well. The trapping of sediments behind the dam is a major problem. Every year it is estimated that 0.5 to 1% of reservoir storage capacity is lost due to sedimentation. The engineering problem with sedimentation is that less power is generated as the reservoir's capacity shrinks.

3.2 Downstream Erosion

Trapping of sediments at the dam also has downstream impacts by reducing the flux of sediments downstream which can lead to the gradual loss of soil fertility in flood plain soils. Clean water stripped of its sediment load is now flowing downstream of the dam. This clean water has more force and velocity then water carrying a high sediment load and thus erosion of the riverbed and banks becomes problematic. Since this is unnatural and a form of "forced erosion" it occurs at a much faster rate than natural river process erosion to which the local ecosystem would be able to adapt.

3.3 Impact on Local Climate

Another often-ignored environmental effect of the reservoir is the impact on the microclimate level. Studies indicate that man-made lakes in tropical climates tend to reduce convection and thus limit cloud cover. Temperate regions are also impacted with "steamfog" in the time period before freezing. Since water cools and warms slower then land, coastal regions tend to be much more moderate then land-locked regions in terms of temperature. Therefore, large dams have a slight moderating effect on the local climate.

3.4 Greenhouse Gas Emission from Dams

Freshwater reservoirs can emit substantial amounts of the greenhouse gases methane and carbon dioxide as organic matter submerged in a reservoir decays under anaerobic and aerobic conditions, respectively. Studies indicate that GHG emissions from hydropower reservoirs in boreal and temperate region are low relative to the emissions from fossil fuel power plants, but higher relative to lifecycle emissions from wind and solar power.

Tropical reservoirs with high levels of organic matter and shallow reservoirs have higher emission levels. A recent compilation of greenhouse gas emissions from reservoirs found a correlation between the age of the reservoir and latitude. Younger reservoirs and those in low latitudes are the highest emitters. For example, of four Brazilian dams in the Amazon, showed that the GHG emissions factor of the electricity produced by those hydropower dams exceed those from a coal-fired power plant.

3.5 Dams Inducing Earthquakes

Finally, a least studied and most disputed physical impact of reservoirs is the possibility of inducing earthquakes. Many scientists believe that seismic activity can be attributed to the creation of dams and their adjacent storage reservoirs. They postulate that the added forces of the dam along inactive faults seem to free much stronger orogenic tensions. Early research indicates that the depth of the water column may be more important to inducing earthquakes rather than total volume of water in the reservoir. While more research is needed on this subject several disasters such as the Koyna Dam in India seem to provide some truth to this theory. While these impacts can be quite severe often they do not receive the attention of the biological impacts that people tend to associate more with animals like fish.

3.6 Impact on Fisheries

Dams and river diversion can impact freshwater, as well as marine fisheries. Estuarine and marine fisheries are dependent on estuaries and rivers as spawning grounds and the transport of nutrients from the river to the sea. Migratory fish are especially vulnerable to the impacts of dam construction. Dams can prevent migrating fish such as salmon and eel to reach their spawn grounds. A survey of 125 dams by the World Commission on Dams (WCD) reported that blocking the passage of migratory fish species has been identified as a major reason for freshwater species extinction in North America. Lower catch is a common side effect of dams and has been reported worldwide. There have been cases where fishery production below a dam has increased due to controlled discharge of the sediments.

4. Biological Impact: Flora & Fauna

Animal and plant life are impacted significantly by the dam construction. As mentioned earlier the large scale flooding destroys a large area of habitat for animals and destroys an equally large number of plants. If the region was forested prior to the construction of the dam the timber is harvested before the flooding begins. Reservoirs that in the future will be used for recreation such as boating or fishing tend to be completely cleared of trees.

Another negative biological impact of dams is the growth of aquatic weeds. Tropical and semi-tropical regions seem to have the largest problem with weed growth. The impacts of weeds can be significant to water loss. More weeds growing in the reservoir result in a higher rate of evapo-transpiration. The weeds compete with fish for space and nutrients that are already under stress living in an unnatural setting.

Some insects such as malaria and schistosomasis tend to increase as weeds provide a very favorable habitat for mosquitoes and other diseases spreaders. How do we contain these problems? The weeds can be controlled, although the task is often very difficult and expensive. In shallow water mechanical or manual clearing is by far the most effective.

However, in deeper waters this is not an option and either chemical or biological means must be used to remove the weeds. Chemical herbicides work very well but bring about a whole new set of environmental hazards to organisms, humans and the ecosystem in general. The scariest part about using chemical herbicides is that their overall effect is generally not known until they have caused a problem.

For some kinds of fish the building of a dam makes completing their life cycle nearly impossible. Anadromous fish, such as salmon, are hatched upstream in a freshwater environment but spend their adult lives at sea in the salt water. The eel, a kind of fish classified as catadromous, is hatched at sea but spends much of its adult life in freshwater streams. Since these fish rely on streams and rivers to get to and from different environments, creating a dam makes a large roadblock for these animals to overcome.

Without features such as fish ladders these fish would die off. However, even the fish ladders do not work perfectly and many fish die due to the dams. There are a number of measures that can be taken to help minimize fish mortality at hydroelectric power plants. The most obvious step is to lower the number of fish that pass through the turbine. This can be accomplished by using better screens to capture the fish or establishing diversion passageways. A more complicated and emerging technology involve making “fish-friendly” turbines. Pelton turbines, which are small turbines designed for high head installations cause nearly complete mortality of fish passing through. Kaplan, Francis, and Bulb turbines tend to be safer for small fish with mortality rates of only about thirty percent. These types of turbines have much larger areas of water passage. Kaplan turbines are thought to be the most fish friendly of the conventional turbines they have low mortality rate of just 10 – 15 percent.

CONCLUSION

While hydropower dams can produce power with low GHG emissions and can in some cases also deliver flood and irrigation control, the adverse social and environmental costs can be substantial as we have described above. Such negative impacts are not compatible with the promotion of sustainable development.

There are only two things that are undisputed about hydropower projects: One, they emit no air pollutants; and two, they certainly destroy local ecology and culture. In the end, economics more often than not is the reason for the success or failure of a proposed project.

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Application of Cluster Validation Indices to Performance Evaluation: A Case Study

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ABSTRACT

In the present paper, applicability of K-Means clustering algorithm and five cluster validation indices, namely, Silhouette, Calinski-Harabasz, Separation, Davies-Bouldin and Dunn's are explored to determine the optimal number of clusters of irrigation subsystems for possible improvements in performanceof Khadakwasla irrigation system, Maharashtra, India. Twenty irrigation subsystems of Khadakwasla irrigation system are analyzed for five evaluation criteria, namely, participation and cooperation, effective water availability, conjunctive use, economic status and agricultural education. Group decision making methodology which is based on additive ranking of each cluster is applied. It is observed that optimum number of clusters of irrigation subsystems is found to be 3 based on group decision making environment. It is concluded that Dunn's index can be recommended as suitable cluster validation index due to its compatible ranking on par with group outcome.

Keywords: Cluster Validation, K-Means, Evaluation, Khadakwasla, India.

INTRODUCTION

Existing fresh water resources are under stress due to significant increase in demands from sectors such as irrigation, industrial and municipal that includes drinking water. In addition, many irrigation systems in developing and developed countries are performing below their potential, warranting significant improvements. In this regard, monitoring and evaluation of irrigation systems have received good attention in recent years. These evaluation processes provide valuable information to water resources planners about the long-term and short-term effectiveness of these irrigation systems. Accordingly, innovative and sustainable improvement strategies for the existing irrigation systems can be formulated and implemented in a prioritized manner in view of the large expenditure involved (Raju and Nagesh Kumar, 2011). In addition, these irrigation subsystems may be formed into homogeneous clusters for similar improvements to facilitate effective implementation. Clustering techniques are found to be suitable for this purpose (Jain and Dubes, 1988; Raju and Nagesh Kumar, 2011). Similarly, cluster validation indices are gaining importance due to their ability to handle compactness/separation between clusters in an efficient way to determine the optimal number of clusters in a structured way (Wang et al., 2009).

Numerous authors stressed the performance evaluation, integrated water resources management, clustering and cluster validation indices (Billib et al., 2009; Raju and Nagesh Kumar (2007, 2011), Rao and Srinivas (2008), Raju et al. (2012). As far as authors knowledge is concerned, this is the first study where evaluation criteria, clustering and cluster validation indices are integrated for a real world case study related to performance evaluation in irrigation planning environment. In the present paper, K-Means clustering algorithm is applied to a case study of Khadakwasla irrigation system, Maharashtra, India for forming irrigation subsystems into homogeneousclusters based on five performance evaluation criteria, namely, Participation and Cooperation (PC), Effective Water Availability (EWA), Conjunctive Use (CU), Economic Status (ES) and Agricultural Education (AE). Five cluster validation indices, namely, Silhouette, Calinski-Harabasz, Separation, Davies-Bouldin and Dunn's are explored to determine the optimal number of clusters of irrigation subsystems in group decision making environment.The subsequent sections describe techniques employed, case study, results and discussion followed by conclusions.

Clustering algorithms, Validation Indices and Group Decision Making

K-means clustering algorithm is used for clustering irrigation subsystems (Raju and Nagesh Kumar, 2014). More details about K-Means algorithm are available in Jain and Dubes (1988). For the clustering algorithm, the number of clusters is an important input. However, it is difficult to ascertain the suitable number of clusters for the chosen irrigation system manually. In this regard, cluster validation indices are playing major role for determining the optimal number of clusters for the irrigation subsystems. For each cluster, the validation indices are evaluated and the best index value is used as the basis for determining optimal/ adequate number of clusters (Wang et al., 2009). Indicative properties of each cluster validation index are presented in Table 1 which is based on the perceptions of authors. More information about Silhouette index is available from Chen et al. (2002);Calinski-Harabasz(CH) index from Shu et al. (2003);Separation index from Xie and Beni(1991); Davies-Bouldin(DB) index from Davies and Bouldin (1979), Dimitriadou et al. (2002), Bolshakova and Azuaje (2003); Dunn's index from Dunn (1974) and Bolshakova and Azuaje (2003).

Additive ranking approach is applied to integrate the output of cluster validation indices for each cluster in the ranking perspective.

Case study and formulation of payoff matrix

The Khadakwasla Project is situated in Upper Bhimasubbasin of Krishna basin, located in Pune district of Maharashtra State, India.Khadakwasla project supplies irrigation water through New Mutha Right Bank Canal (NMRBC), taking off from Khadakwasla dam through a distributary network. There are 60 distributaries/ irrigation subsystems to irrigate 62,146 ha area. The main canal is 202 km long (Khadakwasla Complex Project Note, 2008). In the present study, 20 irrigation subsystems are considered and are named as A1 to A20 for academic purpose.

Table 1 Indicative Properties of the Five Cluster Validation Indices

Features	Silhouette Index	Calinski-Harabasz Index	Separation Index	Davies-Bouldin Index	Dunn's Index
Indicative of Overall Goodness of Clusterization *	Yes	Yes	Yes	Yes	Yes
Indicative of Goodness of Clusterization within a cluster *	Yes	No	Yes	Yes	Yes
Ascertaining whether an individual dataset belongs to the cluster it has been assigned *	Yes	No	No	No	No
Complexity of Logic *	Low	High	Medium	High	High
Number of Calculations *	Large	Medium	Medium	Low	Low
Applicability to large number of Datasets *	Unsatisfactory	Good	Good	Good	Good
Value Indicative of Optimum Number	Highest	Highest	Lowest	Lowest	Highest

*Perception of authors

The questionnaire used for the study was designed after a considerable literature review, consultation with irrigation department officials, local researchers and experts, who are well versed with the project. The field survey was conducted distributarywise. On an average 20 to 30 farmers in each distributary were contacted personally. In the present study, evaluation criteria chosen are: Participation and Cooperation (PC), Effective Water Availability (EWA), Conjunctive Use (CU), Economic Status (ES) and Agricultural Education (AE). Each evaluation criteria for the respective irrigation subsystem was assessed subjectively (based on the perceptions of authors) i.e., Very Good (VG), Good (G), Moderately Good (MG), Fair (F), Unsatisfactory (UNS). Table 2 presents payoff matrix consisting of irrigation subsystemsconsidered.

RESULTS AND DISCUSSION

Cluster Validity Analysis Platform (CVAP) developed by Wang (2007) is used for K-Means clustering and cluster validation indices. K-means algorithm is run for 2 to 10 clusters in CVAP (Table 3). Table 3 presents irrigation subsystems falling in each subcluster and their number, sum of squared error. It is observed from Table 3 that asthe number of clusters is increased, the sum of squared error decreased from 2420.99to 633.33 (to almost 25%). It is also observed that there is no trend in error reduction

Table 2 Irrigation Subsystems and Evaluation Criteria and Indicators

Representative Irrigation Subsystems	Criteria					Sub cluster*
	PC	EWA	ES	CU	AE	
A1	MG	F	MG	G	MG	1
A 2	G	F	MG	G	MG	3
A 3	MG	F	F	MG	MG	1
A 4	G	MG	MG	G	MG	3
A 5	G	MG	F	G	MG	3
A 6	MG	F	F	G	F	1
A 7	VG	MG	F	MG	MG	3
A 8	MG	G	MG	VG	MG	2
A 9	MG	MG	MG	MG	MG	1
A 10	MG	F	F	G	MG	1
A 11	F	F	F	G	F	1
A 12	G	F	MG	MG	MG	3
A 13	MG	F	MG	MG	MG	1
A 14	F	F	MG	MG	F	1
A 15	G	MG	MG	MG	MG	3
A 16	G	F	F	MG	MG	3
A 17	MG	MG	MG	G	F	2
A 18	MG	F	F	MG	F	1
A 19	F	F	F	MG	MG	1
A 20	VG	F	MG	G	MG	3

* Subclusterformation based on K-Means algorithm, field conditions, and administrative aspects.

Table 3 Clustering of Irrigation Subsystems using K-Means Algorithm

Cluster	Sub cluster	Irrigation subsystem number	No. of irrigation subsystems	% Number of irrigation subsystems	Sum of Squared error
2	1	1,3, 6, 9,10,11,13,14,17,18,19	11	55	2420.99
	2	2,4,5,7,8,12,15,16, 20	9	45	
3	1	1, 3, 6, 9, 10, 11, 13,14,18,19	10	50	1907.50
		8, 17,	2	10	
	2	2, 4, 5, 7, 12, 15, 16 ,20	8	40	
	3				
4	1	1,3,9,10,13	5	25	1607.50
	2	8,17	2	10	
	3	6,11,14,18,19	5	25	
	4	2,4,5,7,12,15,16,20	8	40	

Contd…

Cluster	Sub cluster	Irrigation subsystem number	No. of irrigation subsystems	% Number of irrigation subsystems	Sum of Squared error
5	1	2,4,12,15,20	5	25	1390.00
	2	1,3,9,10,13	5	25	
	3	6,11,14,18,19	5	25	
	4	5,7,16	3	15	
	5	8,17	2	10	
6	1	5,7,16	3	15	1195.00
	2	3,6,10,18	4	20	
	3	2,4,12,15,20	5	25	
	4	8	1	5	
	5	1,9,13,17	4	20	
	6	11,14,19	3	15	
7	1	9,12,13,15	4	20	1033.33
	2	3,6,10,18	4	20	
	3	11,14,19	3	15	
	4	5,7,16	3	15	
	5	1,17	2	10	
	6	8	1	5	
	7	2,4,20	3	15	
8	1	8	1	5	900
	2	5,7,16	3	15	
	3	6,11,18	3	15	
	4	9,12,13,15	4	20	
	5	2,4,20	3	15	
	6	14	1	5	
	7	3,10,19	3	15	
	8	1,17	2	10	
9	1	2,12,20	3	15	766.67
	2	7	1	5	
	3	17	1	5	
	4	6,10,11	3	15	
	5	3,16,18	3	15	
	6	1,9,13	3	15	
	7	4,5,15	3	15	
	8	8	1	5	
	9	14,19	2	10	
10	1	14,19	2	10	633.33
	2	8	1	5	
	3	9,15	2	10	
	4	7	1	5	
	5	6,11,18	3	15	
	6	17	1	5	
	7	1,3,10,13	4	20	
	8	12,16	2	10	
	9	2,20	2	10	
	10	4,5	2	10	

Abbreviation “A” before irrigation subsystems is omitted to conserve space fromclusters 2 to 10. It is also interesting to note that as the number of clustersis increased to 6 and more, only one irrigation subsystem is observed in some subclusters. In clusters 6 and 7, A8 alone is in subcluster 4 and subcluster 6; In cluster 8, similar situations occurs for A8 and A14; In cluster 9 and 10, these are A7, A17, A8. Outcome is on the expected lines as irrigation subsystems are only 20 and number of clusters are too many.

Table 4 Rank and Corresponding Index Value of Each Cluster in Cluster Validation Perspective

Cluster	Silhouette	CH	Separation	DB	Dunn	Additive	Rank
2	4 (0.2476)	1 (8.7589*)	9 (0.6208)	9 (1.3707)	2 (1.4099)	25	5
3	3 (0.2553)	2 (7.9875)	8 (0.6204)	5 (1.0414)	1 (1.6704*)	19	1
4	8 (0.1568)	3 (6.9425)	7 (0.5920)	6 (1.1044)	6 (1.1517)	30	8
5	9 (0.1407)	4 (6.2320)	6 (0.5780)	8 (1.1481)	5 (1.2119)	32	9
6	6 (0.1790)	5 (5.8695)	5 (0.5727)	7 (1.1089)	4 (1.3131)	27	7
7	7 (0.1788)	6 (5.5914)	4 (0.5672)	4 (0.9691)	3 (1.3229)	24	4
8	5 (0.2268)	8 (5.3333)	3 (0.5644)	3 (0.8142)	7 (0.0000)	26	6
9	2 (0.2765)	9 (5.2609)	2 (0.5617)	1 (0.6646*)	8 (0.0000)	22	3
10	1 (0.2967*)	7 (5.3801)	1 (0.5599*)	2 (0.6973)	9 (0.0000)	20	2

*Preferred index values

Table 4 presents the values of 5 indices (presented in parenthesis) and corresponding rank of each cluster. It was observed from Table 4 that:

- Silhouette Index increased from 0.2476 (cluster 2) to 0.2553 (cluster 3) and thereafter decreased upto cluster 7 and increased from cluster 8.
- Maximum Silhouette Index value of 0.2967 is achieved for cluster 10 and is more than double the minimum value of 0.1407 for cluster 5. Optimum cluster in this index is therefore 10.
- Calinski-Harabasz Index values decreased from cluster 2 (8.7589) to cluster 9 (5.2609) and thereafter increased to 5.3801 at cluster 10.
- The highest value of Calinski-Harabasz Index of 8.7589 is observed for cluster 2 which is desirable and is more than 1.5 times the minimum value of 5.2609 for cluster 9.
- Lowest value of Separation Index of 0.5599 is observed for cluster 10 whereas the highest value of 0.6208 is observed for cluster 2 with no significant difference between them.
- Separation index values progressively decrease from cluster 2 (0.6208) to cluster 10 (0.5599).
- In case of Davies-Bouldin Index, the lowest value of 0.6646 is observed for cluster 9 and highest value of 1.3707 is observed for cluster 2 and accordingly cluster 9 is preferred.
- Davies-Bouldin Index values decreased from cluster 2 (1.3707) to cluster 9 (0.6646) but not in chronological order. However, it increased to 0.6973 at cluster 10.

- Dunn's index value increased from cluster 2 (1.4099) to cluster 3 (1.6704). Thereafter it decreased to 1.1517 (cluster 4). From cluster 4, index values increased to 1.3229 (cluster 7) and steeply fall to zero for cluster 8. It is interesting to note that clusters 8,9 and 10 are having zero index values indicating that they are not good clusters.
- Highest Dunn's value desirable is 1.6704 for cluster 3.

It is observed from Table 4 that Silhouette and Separation indices indicated optimal cluster as 10, whereas CH index, Davies-Bouldin and Dunn's index preferred 2, 9 and 3 respectively thus giving conflicting outcomes. It may be mainly due to the different methodologies with which each validation index is developed. It is felt appropriate to evaluate this outcome in group decision making environment for more meaningful optimal clusters. It is observed from additive ranking approach (Table 4) that group rankings are 25, 19, 30, 32, 27, 24, 26, 22, 20 for clusters 2 to 10 and relevant consolidated ranking is 5, 1, 8, 9, 7, 4, 6,3,2. Table 4 indicates that three clusters are found to be suitable based on consolidated ranking i.e., rank 1). It is concluded that Dunn's index can be recommended as suitable cluster validation index due to its compatible ranking on par with group outcome. Three formulated subclusters of irrigation subsystems (A1, A3, A6,A9, A10, A11, A13,A14,A18,A19), (A8, A17), (A2, A4, A5, A7, A12, A15, A16, A20) can be explored further for possible performance improvements subclusterwise.

CONCLUSION

K-means clustering algorithm along with 5 cluster validation indices, namely, Silhouette, Calinski and Harabasz, Separation, Davies-Bouldin, Dunn's are applied to the case study of Khadakwasla Irrigation System, India. Inferences that can be drawn from the study are:

- Sum of squared error decreased from 2420.99 to 633.33 (to almost 25%)
- It is observed that three clusters is found to be suitable. Three formulated subclusters of irrigation subsystems (A1, A3, A6,A9, A10, A11, A13,A14,A18,A19), (A8, A17), (A2, A4, A5, A7, A12, A15, A16, A20) can be explored further for possible performance improvements subclusterwise.
- Maximum Silhouette Index S value of 0.2967 is achieved for cluster 10 and is more than double the minimum value of 0.1407 for cluster 5.

It is relevant to note that the inferences emanated from the present paper depends on data availability of the command area, the views of the surveyed stakeholders and mainly on the chosen clustering and validation algorithm. However, the thrust of the present paper is on methodology that can be applied and replicated with ease.

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Flood Management Planning in the Mahanadi River Basin, Odisha

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ABSTRACT

Historic floods in Mahanadi (Orissa) Delta i.e the floods of 1982, 2008 and 2011 reveal that the floods creating havoc were primarily due to contribution from uncontrolled catchments beyond Hirakud reservoir up to the delta head at Munduli. This necessitates the need to construct a flood control reservoir in the downstream of Hirakud to accommodate the flood peak contributed from the uncontrolled catchment beyond Hirakud, particularly from River Tel. Towards meeting the above objective, a flood moderation reservoir on the Mahanadi with the Manibhadra hill on the right and the Subalaya hill on the left can be proposed. This reservoir can be specially designed with minimum submersion problems, to moderate a flood peak of 51817 cumecs at Subalaya to 24632 cumecs at the head of Mahanadi Delta which is the no-distress flood for Mahanadi Delta, inhabited by more than ten million people.

INTRODUCTION

In the land ocean interaction zone, river deltas are formed due to dynamic interaction of fluvial and marine agencies on the coastal margin. Delta building varies depending upon geologic, tectonic, geographic, climatic and environmental settings. Geometry of sediment bodies, sedimentary facies and dynamic processes vary in deltas found in different parts of the world. Major deltas in India occur on the Bay of Bengal coast on the eastern part (Mohanty, 1993). The Mahanadi river Delta in Orissa has experienced several severe floods causing huge damages to life and property. An analysis of earlier historic flood events clearly revels that even after construction of Hirakud Dam; the peak floods in the deltaic region are not reduced to a safe flood limit (24660 cumecs).

Location

The Mahanadi River delta plain covers 0.9 x 104 km^2 and lies between 85^0 40' to 86^0 45' E and 19^0 40' to 20^0 35' N. The catchment area of the river covers 1.42 x 10^5 km^2. The climatic setting is tropical with hot and humid monsoonal climate. The sediment yield of the catchment is likely to be in order of 200-400 tons/km^2 (Meijerink, 1982-83). With an average annual rainfall of catchment 1572 mm, over 70% is precipitated during the southwest monsoon between Mid June to Mid October. After traversing a long distance of over 800 km the Mahanadi River starts building up its delta plain from Naraj where the undivided Mahanadi branches forming its distributary system (Figure 1) ramifying in the delta plain area. Devi River is its principal distributary.

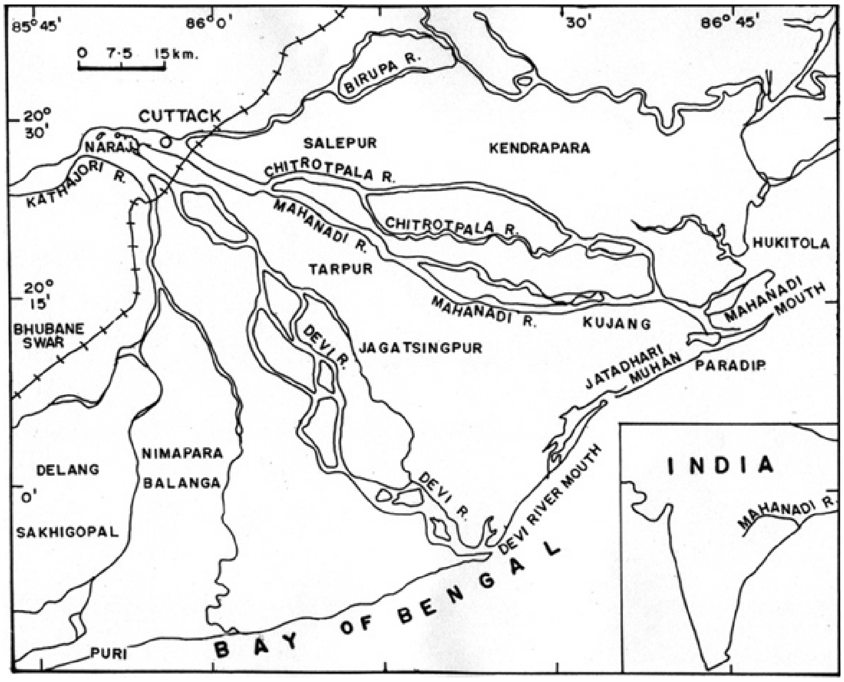

Fig. 1: Mahanadi River and its distributary system in the delta plain.

Floods in Mahanadi System

The Mahanadi basin has experienced many historic floods. Among others, the floods of 1855, 1933, 1937, 1955, 1980, 1982, 2008 and 2011 were highly severe and devastating and had caused huge damages to life and property. The most recent severe flood recorded after independence was in 1982 which was extended over 114 blocks, 7 municipalities and 16 NACs, inundating an area of 90,000 sq km; endangering 5 million people and 12 lakh ha cultivated land (Das et.al, 1998). During this flood the peak observed at Munduli was 44492 Cumecs against the capacity of existing embankment system to carry 25510 cumecs (75% excess) (Flood Management Manual, 2009). It was also observed that this flood was primarily contributed from the downstream catchment of Mahanadi system beyond Hirakud dam. Another look on historic floods in Mahanadi system also reveals that 12% major floods were caused due to contribution from Hirakud releases only, 45% major floods were due to contribution from downstream of reservoir beyond Hirakud reservoir up to Munduli only and another 43% were jointly due to contribution from Hirakud reservoir and its downstream catchment up to Munduli.

In the above context, a flood control reservoir in the downstream of Barmul to accommodate flood peak contributed from the uncontrolled catchment beyond Hirakud can be suggested. The objective of present paper is to suggest an optimally selected moderation reservoir on the Mahanadi with the Manibhadra hill on the right and the Subalaya hill on the left to minimize the flood havoc in the deltaic region of Mahanadi under the constraints of minimum inundation and maximum flood volume storage so that the flood peak at Munduli remains within the no distress flood of 25510 cumecs in Mahanadi Delta.

Inadequacy of Hirakud Dam Towards Flood Control in Delta

An analysis of earlier historic flood events clearly revels that even after construction of Hirakud Dam, the peak flood in the Deltaic region was not reduced to a safe flood limit 25510 cumecs. The important reasons behind its inability to control flood at delta head are: (i) Hirakud intercepts only 58.9% of the catchment leaving aside an area of 43820 sq km uncontrolled which contributes significantly to flood at delta, (ii) Hirakud is a multipurpose project, which provides benefits like irrigation and hydropower in addition to flood control and flood storage space is very limited and (iii) contributions from uncontrolled catchments beyond Hirakud up to Delta is significant and sufficient to create flood havoc at delta alone even if there is no significant release from Hirakud.

Earlier Proposals for Second Dam

An earlier proposal to construct a second dam on Mahanadi at Tikarpada (known as Tikarpada project) was conceived by late Dr. A.N. Khosla in 1964 as the second unit of the comprehensive plan for the unified basin wise development of Mahanadi. However, on the ground of large scale submergence of important towns i.e Boudh, Athamallik and Sonepur, the project was shelved on human consideration.

Necessity of Storage Scheme at Subalaya for Flood Moderation

During the floods of 1982 and 2008 about 44840 and 44785 cumecs of water had passed at Naraj though very negligible release (1700 cumecs) was made from Hirakud Dam and the above floods had caused unprecedented damage in the coastal belt of Orissa (Gouda, 2009). In view of the above the construction of a storage dam with an objective of moderating the peak flood in between Hiraud and Munduli was examined. Accordingly the provision of a storage dam on Mahanadi just downstream of the confluence of Brutang can be suggested.

It shall be pertinent to mention here that even if all the possible balance tributary projects of the Mahanadi basin master plan are completed, the flood peak moderation at the delta head would be very meager in the event of a 100 year flood of 51817 cumecs, determined using Gumbels distribution, (Subramanya, 2008) and that too at the cost of irrigation and other benefits as many of these reservoirs may remain partly full at the end of monsoon.

Moreover, there is possibility of synchronization of releases from these reservoirs unless they are properly operated to avoid such eventualities. Also, these aforesaid tributary projects would take more than 10 years for completion and would involve rehabilitation of many villages. These tributary projects will not be cost effective due to flood operational need to keep all these reservoirs empty right up to end of August. If the irrigation benefits are not sacrificed, much larger reservoirs with carryover storage would enormously increase the cost of these tributary projects.

The Subalaya Project

In the above context, the possibility of a barrage project at Subalaya can be re-thought, which with a conservation level of 54.90 meter and a maximum water level of 77.00 meter will be able to reduce the 100 years maximum flood peak of 51817 cumecs to 24632 cumecs. The above objectives will be satisfied within the constraints of minimum inundation and maximum flood volume storage. Figure 2 shows respectively the proposed Barrage and Rockfill Dam site near Subalaya and Schematic diagram of Mahanadi River depicting the location of Subalaya Project.

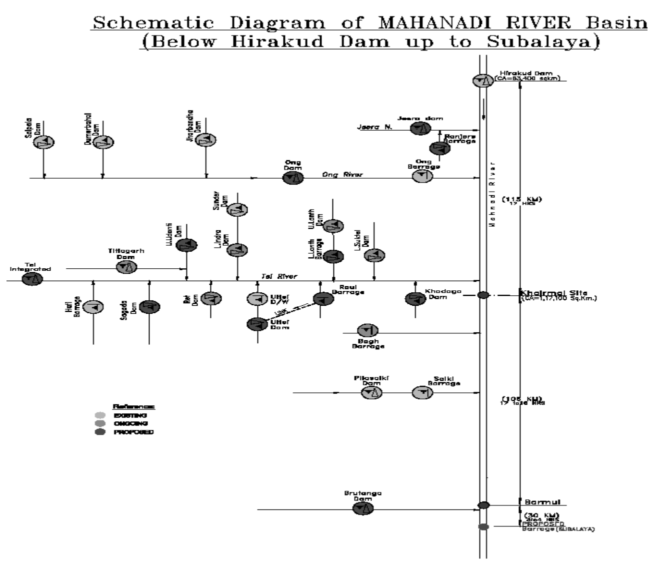

Fig. 2: Schematic diagram of mahanadi river system showing the subalaya project

The project may include (i) A Barrage from Puta hill to Ranitala hill (ii) River training works like leaves from Manibhadra hill to Subalaya hill (iii) Dykes from Ranitala hill to Miticalfpur hill (iv) Right head regulator (v) Protective embankment ring around clusters of villages with road connection to higher levels

This can be a totally people friendly project in which all the three towns i.e. Boudh, Athamallik and Sonepur would be totally free from flooding as water level would rise to maximum RL of 77.00 meter.

CONCLUSION

Floods creating havoc in Mahanadi river Delta are primarily due to contribution from uncontrolled catchments beyond Hirakud reservoir up to the delta head at Munduli. To minimize this flood havoc at delta head, a flood control reservoir may be constructed in the down stream of Hirakud dam to accommodate the flood peak contributed from the uncontrolled catchment beyond Hirakud. Towards meeting the above objective, a moderation reservoir on the Mahanadi with the Manibhadra hill on the right and the Subalaya hill on the left can be proposed. This reservoir can be specially designed with minimum submersion problems to moderate a flood peak of 51817 cumecs to 24632 cumecs which is the no-distress flood for Mahanadi Delta, inhabited by ten million people.

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The Standard Precipitation Index Analysis for Drought Assessment in Indian Agro-Climate Regions, using of GIS and Remote Sensing Data

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ABSTRACT

This study describes the drought development in the near-real-time with help of Standard Precipitation Index (SPI) for Agro climatic-region of India and gave the drought development in last six year (2002-2007) over the Agro climatic-region of India using decadal time data set from NOAA satellite for 2002-2007 time periods.

The each Agro-climatic region of study, 1° x 1° degree in area, is part of India agro-climate regions is taken for analysis. Using remote sensing and Geographical Information System (RS and GIS) methods, 2190 Daily rainfall images were generated based on the NOAA (rainfall data) data by NOAA Web site thought inter net. Furthermore, cloud-free NOAA data for the period of study were obtained and geo-referenced for further analysis. Images of daily rainfall were transformed into ten-day images due to short data set only six year (2002-2007) and from these images cut out 1°x1° degree of area by preparing a layer representing ten Agro-region of India as base mapping units (BMU).

***Keywords*:** Droughts, SPI, drought indices, drought severity, remote sensing.

1. INTRODUCTION

1.1. General Introduction

Droughts are recurring climatic events, which often hit South Asia, bringing significant water shortages, economic losses and adverse social consequences. Preparedness to drought should form the important part of national environmental policies. The levels of drought preparedness in countries of the region differ significantly.

1.2. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is a tool which was developed primarily for defining and monitoring drought. It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interest for any rainfall station with historic data. It can also be used to determine periods of anomalously wet events. The purpose is to assign a single numeric value to the precipitation that can be compared across regions with markedly different climates. Technically, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution. The SPI was designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale while groundwater, stream flow, and reservoir storage reflect the longer-term precipitation anomalies.

The SPI calculation for any location is based on the long-term precipitation record that is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. A drought event occurs any time; the SPI is continuously negative and reaches intensity of -1.0 or less (Table 3). The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed as the drought's "magnitude".

Table 1 Study area (agro-climatic region) with location and zones.

Region	Min LAT	Max LAT	Min LONG	Max LONG
Region1	20°59'N	21°59'N	74°00'E	75°00'E
Region2	16°59'N	17°59'N	81°00'E	82°00'E
Region3	17°00'N	18°00'N	77°00'E	78°00'E
Region4	18°00'N	19°00'N	75°00'E	76°00'E
Region5	19°00'N	20°00'N	73°00'E	74°00'E
Region6	16°59'N	17°59'N	71°59'E	72°59'E
Region7	15°00'N	16°00'N	71°00'E	72°00'E
Region8	15°59'N	16°59'N	75°00'E	76°00'E
Region9	13°59'N	14°59'N	73°00'E	74°00'E
Region11	11°00'N	12°00'N	74°00'E	75°00'E

Table 2 Output Bias and Correlation of Various Input Data Combinations

Data	Bias (mm/day)	Correlation
GPI only	2.26	0.345
SSM/I only	-0.24	0.321
AMSU-A only	-0.15	0.095
GTS+GPI+SSM /I+AMSU-A	-0.15	0.501
GTS+GPI	-0.04	0.467

Table 3 The Standardized Precipitation Index (SPI) value.

SPI Value	Brief Description	Estimated Likelihood
2.00 and Greater	Extremely Wet	about 2.3% of events (roughly 1 out of 40) are expected to exceed 2.00
1.50 to 1.99	Very Wet	about 6.7% of events (roughly 1 out of 15) are expected to exceed 1.50
1.00 to 1.49	Moderately Wet	about 16% of events (roughly 1 out of 6) are expected to exceed 1.00
0.99 to -0.99	Near Normal	about 68% of values (roughly 2 out of 3) fall in this range
-1.00 to -1.49	Moderately Dry	about 16% of events (roughly 1 out of 6) are expected to exceed -1.00
-1.50 to -1.99	Severely Dry	about 6.7% of events (roughly 1 out of 15) are expected to exceed -1.50
-2.0 and Less	Extremely Dry	about 2.3% (roughly 1 out of 40) of events are expected to exceed -2.00

2. AGRO-CLIMATIC REGIONS OF INDIA (STUDY AREA)

The climate of India is essentially a temperate one (Joshi and Rajeevanm, 2006; Sarkar and Kafatos, 2004). India lies to the north of Equator, so the southern part of India is usually much warmer than the rest of India. Also, water bodies flank India on three sides thus giving the peninsular region maritime climate. The duration of summer in India is from March to June. The temperature in the plains of northern India can go up to 45° Celsius. The southern region is equally hot. The Monsoon season in India usually lasts from the month of June to that of September. During this time, most of the areas in the country get their share of rainfall. The South West Monsoon enters India through the coast of Kerala and Andaman & Nicobar Islands and passing through Mumbai, central India and eastern India, reaches other parts of North and North West India. During the months of October to November, some parts of South India experience rains in the form of the northeast-monsoon. The northern part of India experiences harsh weather conditions with cold wave sweeping almost entire northern regions and central parts of India. The hilly areas experience sub-zero temperature conditions

Based on the climatic condition and the agricultural practices, the Indian Subcontinent has been broadly divided into 15 divisions known as the agro-climatic regions (Fig.1). These are as follows:

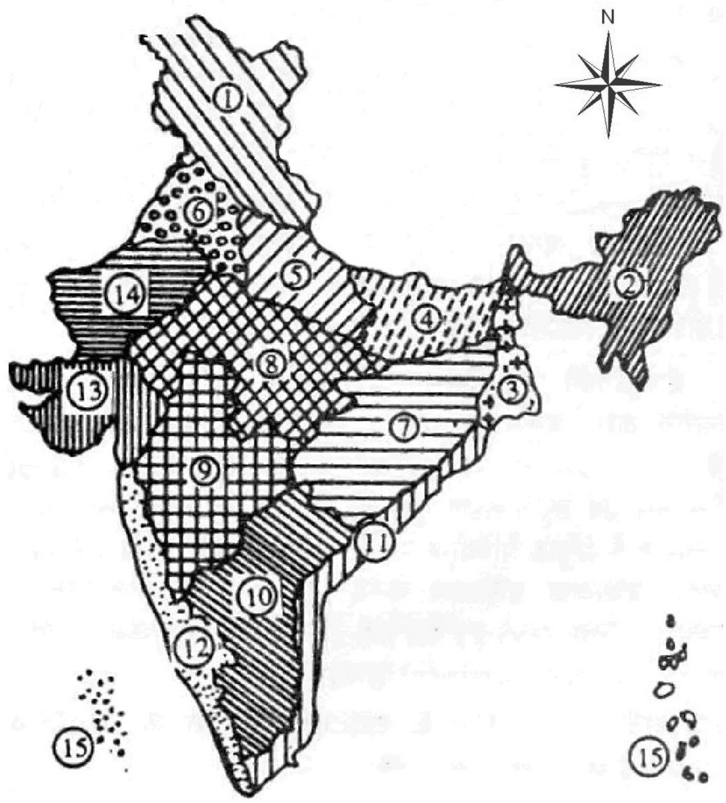

Fig. 1 Agro-climatic regions of India (Study area)

1. Western Himalayan Region: Jammu and Kashmir, Himachal Pradesh, Utter Pradesh and Uttrakhand.
2. Eastern Himalayan Region: Assam Sikkim, West Bengal and all North-Eastern states.
3. Lower Gangetic Plains Region: West Bengal.
4. Middle Gangetic Plains Region: Utter Pradesh, Bihar.
5. Upper Gangetic Plains Region: Utter Pradesh.
6. Trans-Gangetic Plains Region: Panjab, Haryana, Delhi and Rajasthan.
7. Eastern Plateau and Hills Region: Maharastra, Utter Pradesh, Urissa and West Bengal.
8. Central Plateau and Hills Region: Madhya Pradesh, Rajasthan, Utter Pradesh.

9. Western Plateau and Hills Region: Maharastra, Madhya Pradesh and Rajasthan.
10. Southern Plateau and Hills Region: Andhra Pradesh, Karnataka, Tamil Nadu.
11. East Coast Plains and Hills Region: Urissa, Andhra Pradesh, Tamil Nadu and Pondicheri.
12. West Coast Plains and Ghat Region: Tamil Nadu, Kerala, Goa, Karnatak, Maharastra.
13. Gujarat Plains and Hills Region: Gujarat.
14. Western Dry Region: Rajasthan.
15. The Islands Region: Andman and Nicaobar, Lakshya Dweep.

Note: Agro-climatic regions 10,12,13,14 and 15 are not taken for study.

3. DATA AND METHOD

3.1 Rainfall data

Daily satellite derived precipitation data for the entire study duration and Southern Asia domain was provided by the NOAA climate prediction center, downloaded from the site ftp://ftpprd.ncep.noaa.gov/pub/cpc/fews/S.Asia/. The need for satellite-estimated precipitation arises because of the non-dependable and poorly spatially distributed ground rainfall data.

The daily rainfall estimation files are provided for the southern Asia (70°-110° E; 5°-35° N) beginning from May 01, 2001. The product is updated three times daily at around 9 am, 1 pm, and 9 pm eastern local time and covers a 24-hour period of accumulated precipitation. Resolution (Herrmanna et al., 2005) of rainfall estimates are 0.1 by 0.1 degree and inputs include Global Telecommunication System (GTS) station data, as well as GOES Precipitation Index (GPI) infrared cloud top temperature fields derived from Meteosat and polar orbiting satellite precipitation estimate data from Special Sensor Microwave/Imager (SSM/I) on board Defense Meteorological Satellite Program and Advanced Microwave Sounding Unit (AMSU-B) on board NOAA 15, NOAA 16 and NOAA 17.

Four kinds of observation-based data sets are used as inputs to construct the merged analysis of daily precipitation. Fig.2 shows an example of the input daily precipitation fields for July 20, 2001.

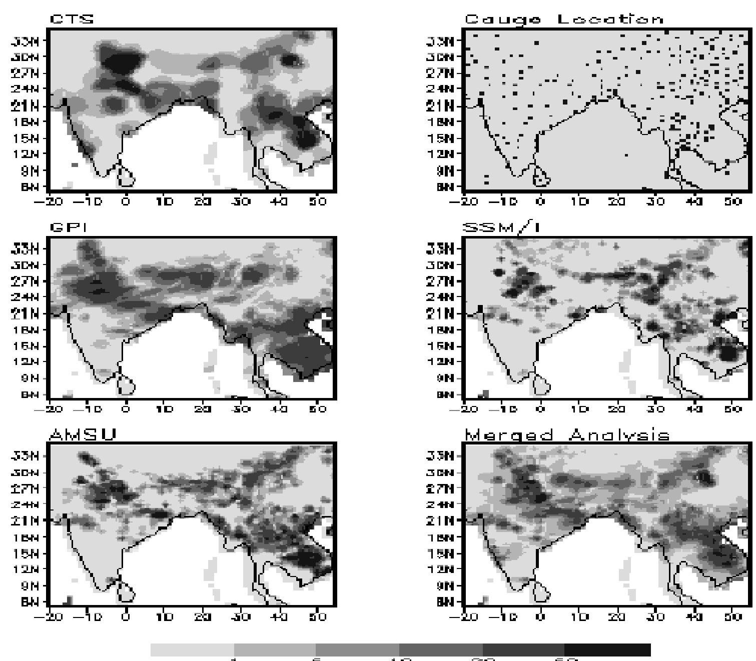

Fig. 2 Daily Precipitation (mm/day) for July 20, 2001, obtained from GTS gauge-based analysis, satellite estimates of GPI, SSM/I and AMSU-B, and the merged analysis. Also display is the distribution of GTS gauge stations over the target domain.

The gauge-based analysis of daily precipitation is derived by interpolating reports from ~280 GTS stations over the target domain. The GPI estimates are based on up to 48 times of half-hourly IR observations but they are indirect in nature and exhibit significant bias over land. The SSM/I and the AMSU-B estimates are more physically based but they have incomplete spatial coverage and large random error due to the limited sampling. In general, all of the individual data sources show similar large-scale distribution patterns but present differences in smaller scale features and in magnitude. Three major deficiencies exist in these individual data sources, i.e., incomplete spatial coverage; significant random error; and non-negligible bias.

The analysis of daily precipitation is defined by merging the four kinds of individual input data sources (Fig. 2).

Fig.2 shows an example of the merged analysis of daily precipitation for July 20, 2001. The merged analysis presents similar spatial distribution patterns with those of satellite estimates while its magnitude is close to the gauge-based analysis over areas with gauge data. Fig.3 shows a final product after merging the inputs for January, 2003.

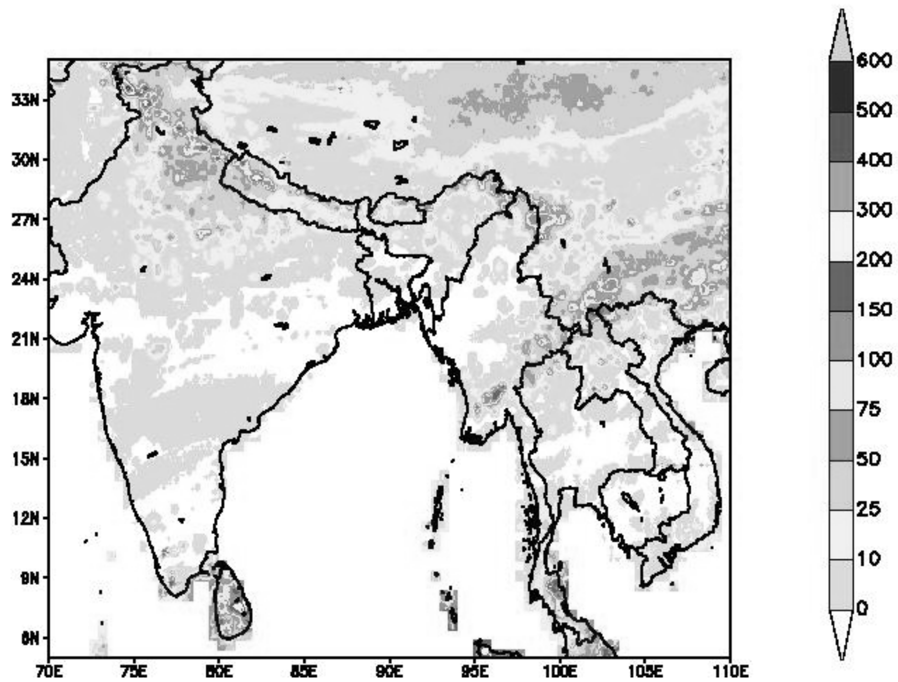

Fig. 3 January 2003 Precipitation Estimate (mm); based on GPI, SSM/I, AMSU and GTS

The rainfall estimates were compared with the station recorded precipitation values. Statistics were generated upon completion of all processes and the results are shown in table 2 (NOAA CPC website).

GTS, GPI, SSM/I, and AMSU-A data are considered the operational inputs of the RFE 2.0 algorithm. It can be seen that this set of inputs produces the highest correlation between estimated precipitation and actual station rainfall amounts, with a relatively small bias.

3.2 Model set-up

The software used for compiling and analyzing the data, is ILWIS 3.2 (Integrated Land and Water Information System). ILWIS 3.2 has an image processing and GIS operation capability and is specially built for Land-Water analysis. With the added advantage of easy script (program) writing facility, it is well suited for the present study. Rainfall data was analyzed for ten agro-climatic regions of India. A one degree by one degree grid was developed for each of the ten agro-climatic regions. The values of rainfall for each of the grid were extracted and analyses performed to study the relationship.

4. ANALYSIS

4.1. Grid generation

One degree by one degree grid map was created for the ten agro climatic regions by digitizing, using map shown in figure 1 of the agro-climatic regions of India. By cross operation (in ILWIS) between grid map and decadal rainfall map, a table was generated contain values of rainfall of each pixel under each grid of agro-climatic region. Each grid of agro-climatic region consisted of 10,000 pixel values of Rainfall for the decadal period (Hess et al., 1996). The weighted average of the Rainfall values for the 10,000 pixels was determined to yield single value for a decadal period.

4.2. Drought Analysis using Standard Precipitation Index

Drought risk using Standard Precipitation Index (SPI) for the 10 agro-climatic regions over 6 years has been estimated and is plotted in figures 4−13. Drought events are characterized by continuous negative value of the index over a consecutive temporal period and the intensity builds up as the index value crosses -1 limit.

The analysis to the data for the different regions shows the presence to drought conditions developing in several regions during the study period. Region 1 (fig 4), the SPI value remained above the -1 limit throughout the study period indicating a normal condition. The lower limit varied between 0 and -1 in a consistent manner with negative values occurring only during dormant season. In Region 2 (fig 5) the SPI values were seen to be highly fluctuated, with no particular pattern. Development of any dry condition cannot not be figured as the index value always remained above the critical level. Although there was no particular trend in the variation of SPI index value in Region 3 (fig 6), yet there were three instances when the value was below zero for a long period. Since the index values were always higher than the lower limit of -1, a dry condition never occurred. Moderate to severe dry conditions were observed in Region 4 (fig 7) with SPI values dipping below critical level of -1. Severe dry conditions were seen to build up during January-June 2003 and 2007 with SPI index going below -1.5 level. Moderate dry conditions were also seen during three instances. SPI index varied in a regular pattern for Region 4 with periods of dry and wet conditions occurring frequently. Region 5 (fig 8) and Region 6 (fig 9) shows normal value of SPI index with no signs of dry condition in any of the study year. Region 7 (fig 10) experienced moderate dry condition during October 2002-January 2003, and September 2005-November 2005. Region 8 (fig 11) shows SPI value -1 for January 2002-February 2002, October 2007-December 2007 which is indicated to Moderately Dry period and December 2002-March 2003 is Near Normal Dry time. Region 9 (fig 12) shows a Near Normal Dry pattern of SPI for all the study period. Region 11 (fig 13) the SPI value was seen -1 value during the period November 2002- January 2003 and November 2007-December 2007 indicating the Moderate Dry conditions.

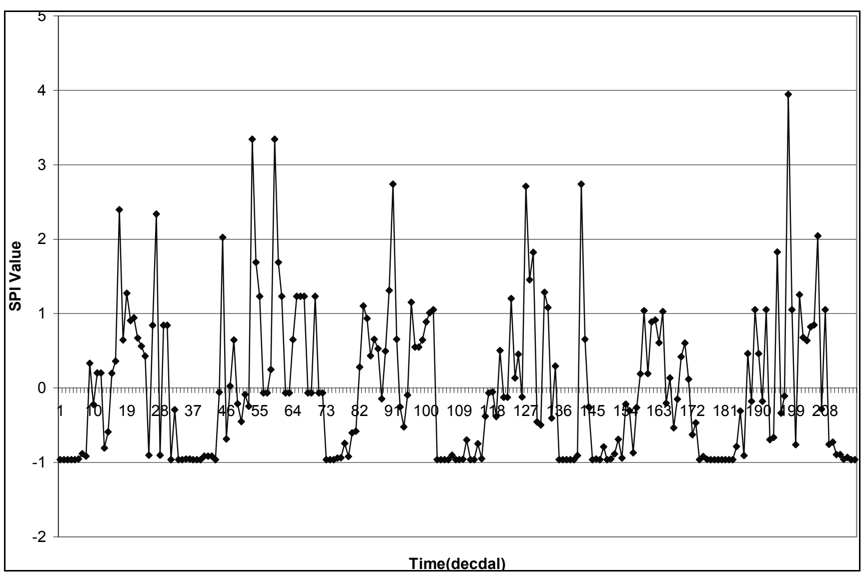

Fig. 4 SPI for agro-climatic region 1 for duration 2002-2007

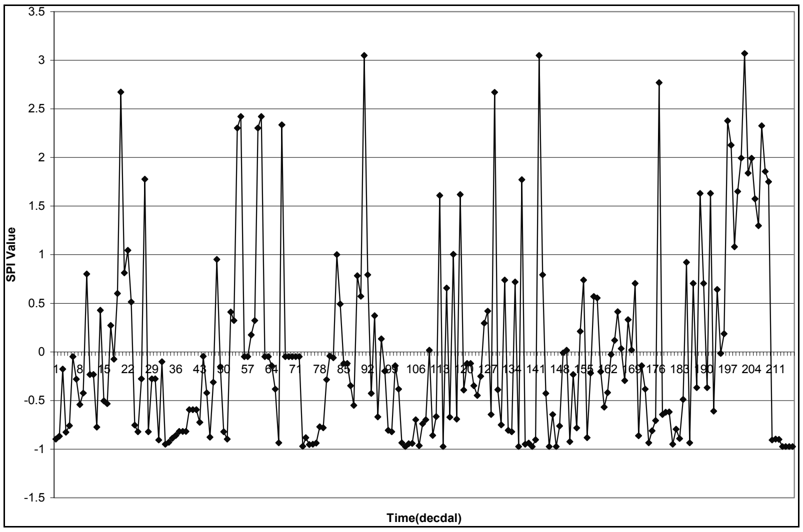

Fig. 5 SPI for agro-climatic region 2 for duration 2002-2007

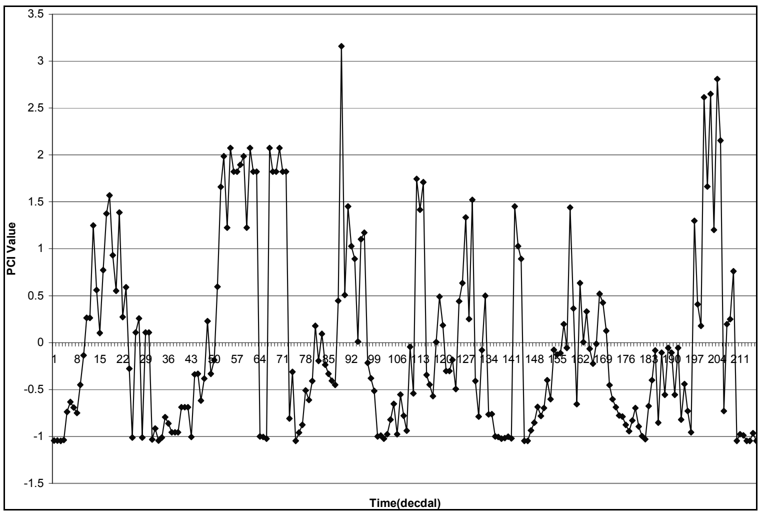

Fig. 6 SPI for agro-climatic region 3 for duration 2002-2007

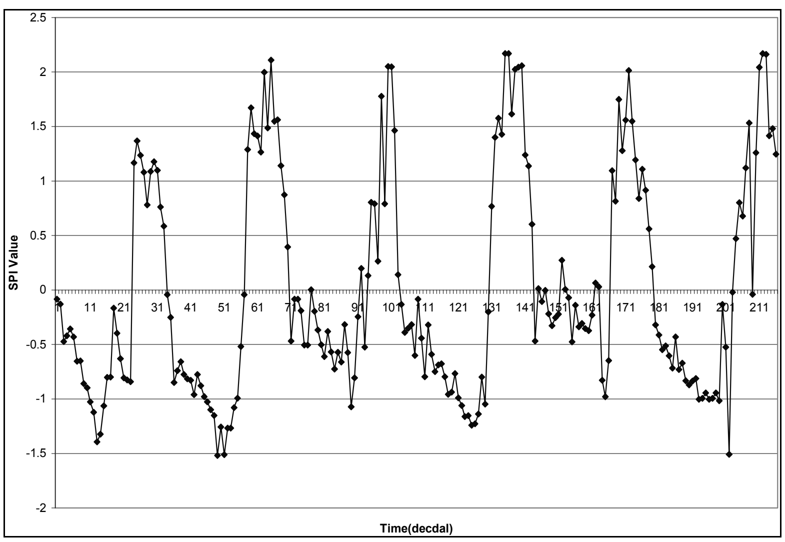

Fig. 7 SPI for agro-climatic region 4 for duration 2002-2007

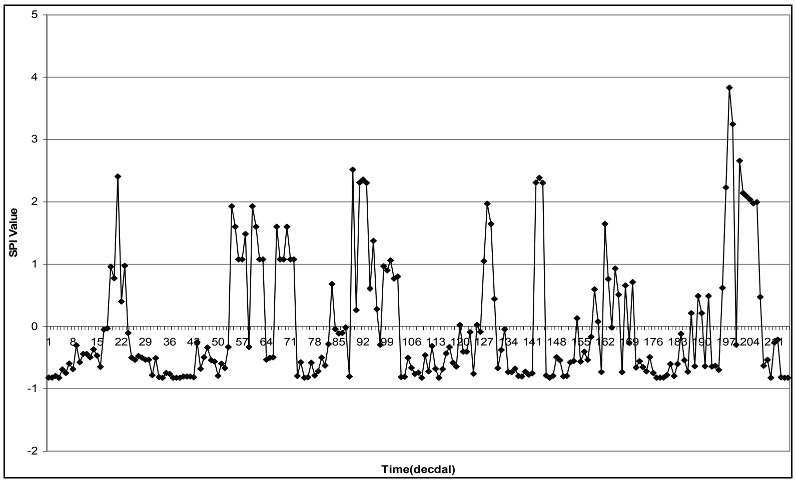

Fig. 8 SPI for agro-climatic region 5 for duration 2002-2007

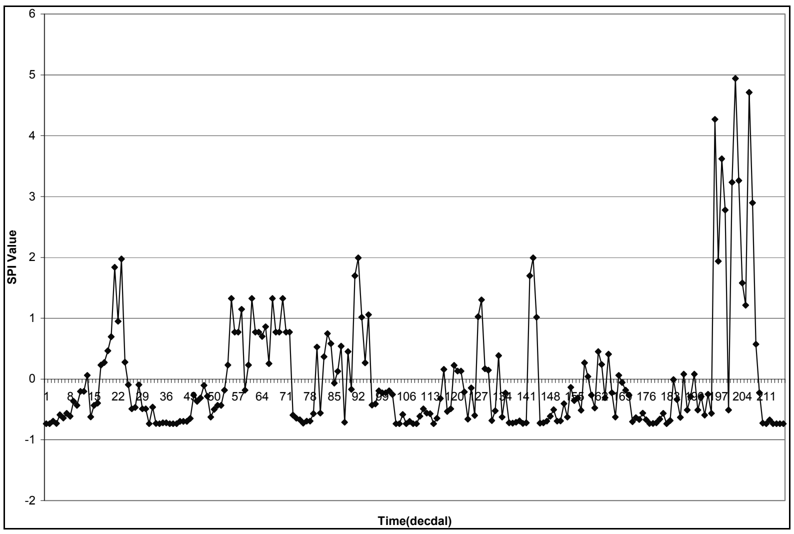

Fig. 9 SPI for agro-climatic region 6 for duration 2002-2007

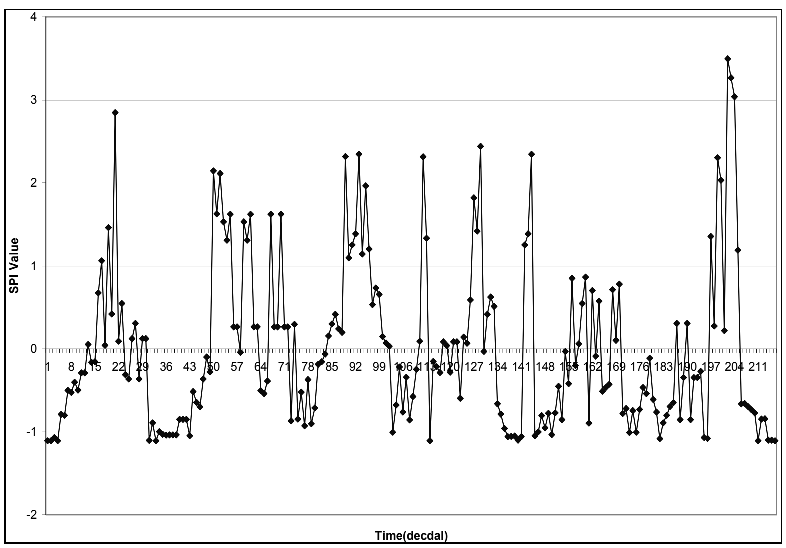

Fig. 10 SPI for agro-climatic region 7 for duration 2002-2007

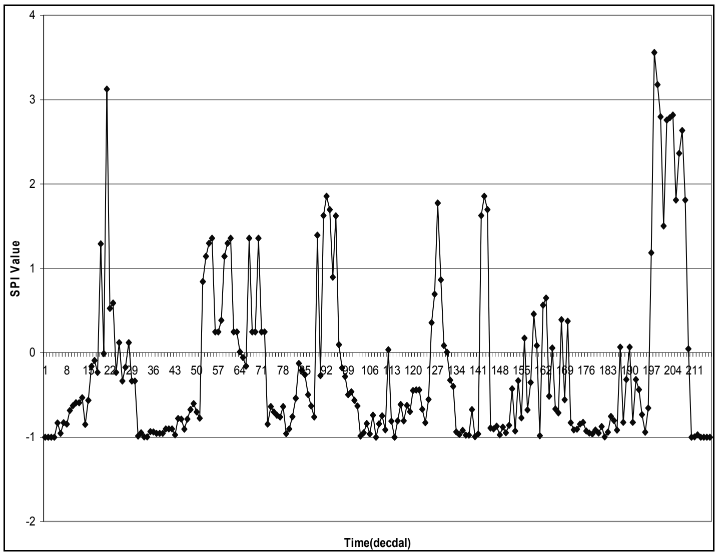

Fig. 11 SPI for agro-climatic region 8 for duration 2002-2007

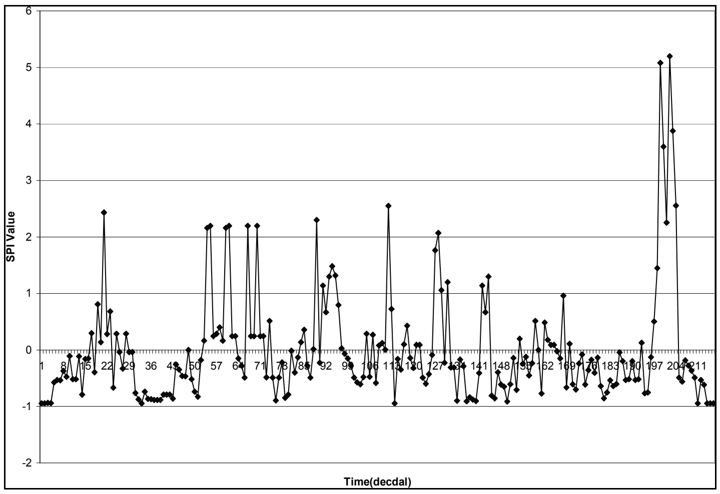

Fig. 12 SPI for agro-climatic region 9 for duration 2002-2007

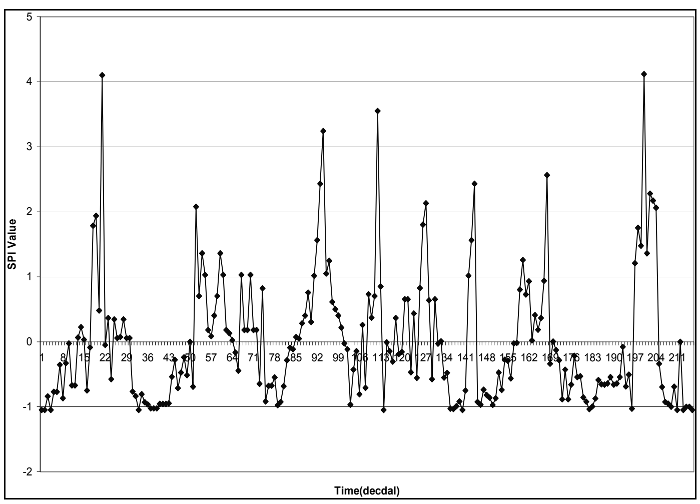

Fig. 13 SPI for agro-climatic region 11 for duration 2002-2007

CONCLUSION

The study validated SPI method for drought assessment through remote sensing rainfall data. It established relationships between Rainfall and drought condition over Agro climatic-region of India.

This study suggested methods and techniques for continuous drought monitoring by linking historical Remote sensing Rainfall data of NOAA satellite. This methodology is one good option for the development of a region drought monitoring system. Considering the spread and frequency of droughts in the region on one hand, and the lack of ground climate observations and technical capacity in the countries of the region to deal with droughts on the other, such a system could play an invaluable role for drought preparedness.

The goal is to make the system available on the Internet for all stakeholders in the region, including government agencies, research institutions, NGOs, and global research community. It may be used as a drought-monitoring tool and as a tool for decision support in regional drought assessment and management.

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Abbreviation use in paper

AVHRR	Advanced very high resolution radiometer
AMSU-B	Advanced Microwave Sounding Unit
BMU	Base mapping units
ftp	File Transfer Protocol
GIS	Geographical Information System
GTS	Global Telecommunication System
GPI	GOES Precipitation Index
ILWIS	Integrated Land and Water Information System
NOAA	National oceanic and atmospheric administration
RS	Remote sensing
SSM/I	Special Sensor Microwave/Image
SPI	Standardized Precipitation Index

A Mathematical Model for Hydropower Scheme

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1.0 GENERAL

The power development has become a responsibility due to rapid industrialization, modernization and also all-round development aspects taken up in the agriculture sectors in India and hence the construction of numerous Hydro Electric schemes to harness the enormous hydro power potential. Present power generating capacity is much below the current demand and chronic power shortage exits in many parts of the state and country. Power sector in Andhra Pradesh state is augmenting its power generating capacity by contemplating and constructing new power projects to meet the rapidly growing power demand in the state. Since, energy is one of the critical inputs in the process of development, the development of hydro electric scheme is most reliable of the all renewable source with wide spread availability in the natural stream. Hydel power projects which have been built are contributing bulk of power requirements in the state. The whole concept of hydroelectricity is based on kinetic energy of water to be converted into electricity. Electricity generated from water is entirely renewable, since that water can be used for other purposes like irrigation water supply etc, and no water is expended during the electricity generation process. Run-off-river hydroelectricity is a type of hydroelectric generation whereby the natural flow and elevation drop of a river are used to generate electricity.

The present study is proposed to develop a mathematical model for a river hydro electric power project across a river. It is proposed to evaluate the potentiality for installation of hydro electric project and to develop simulation model to assess the better combination of hydro power units for a case study. The developed model is to simulate run of river plant for various conditions of stream flows and to evaluate the power potential. It is also proposed to compute the hydel station parameters like load factor, plant capacity etc. for the case study.

***Keywords*:** Water Resources, Hydroelectric, Simulation model, Power potential, Plant load factor, Installed capacity.

2. 0 LITERATURE REVIEW

Number of studies have been carried out on hydropower operation, guidelines and design principles and were reported in the literature. Dandekar & Sharma (1979) have reported the concept of basic design principles [2] apart from of plant parameters i.e load curve, load factor, capacity factor, utilization factor, diversity factor etc. Guide lines for electric designs of Small hydro plants have been formulated by Alternate Hydro Energy centre, Indian institute of Technology, Roorkee. [4]. They also cited the guidelines for selection of turbine and governing system for small hydropower which illustrates various types of turbines helps in selection of turbine to be adopted based on chart developed on specific speed versus head [4]. Bureau of Indian Standard Codes of practices [1] has proposed for the detailed design of hydraulic turbines and their selection standards. Douglas G. Hall, Richard T. Hunt, Kelly S. Reeves and Greg R. Carroll, (2003) have formulated tools [3] for estimating the cost of developing and operating and maintaining hydropower resources in the form of regression curves, developed based on historical plant data.

3.0 STUDY AREA

The present paper is on a proposed project by constructing a gravity dam on river Godavari at Dummugudem village in Khammam district has been considered for the case study. The proposed scheme is a run of river scheme. The pond level is fixed at EL +60.00M. The tail water level of the proposed project would be EL +45.72M which is the RL of d/s project i.e. Polavaram project where reservoir FRL extends up to this project. Hence the theoretical head of (60.00 m – 45.72 m) of 14.28 m. can be utilized for power generation at this location. The location map of the project is given in figure 1. The project has a catchment area of 2, 81,000 Sq. Km. with average annual rainfall of 990 mm. A hydrograph at the project site with yearly average discharges in (m^3/Sec) is shown in figure 2.

4.0 MATHEMATICAL MODEL

A mathematical analysis has been carried out to compute, visualize and evaluation of power potential with storage by consideration of allowable seasonal filling schedule during the year duly meeting all required demands and considerable losses. Based on the schedule every month the water available in storage is also being utilized to the extent of barrage level depending on inflows. The water storage available for power generation can be computed duly considering storage capacity. The mass balance equation for storage computation is given in equation 1

$$S_{t+1} = (S_t + I_t - E_t - R_t - O_t) \qquad \text{....(1)}$$

Where St =Initial storage i.e., considering storage capacity with dead storage (i.e., minimum water ever available in the reservoir)

It = Inflows occurred during the day

Et = Evaporation losses,

Rt = Releases are considered based on the required demands like agriculture, drinking water and other seasonal demands time o time.

Ot = Spill over flows in particular period of time i.e quantum of surplus water beyond storage capacity.

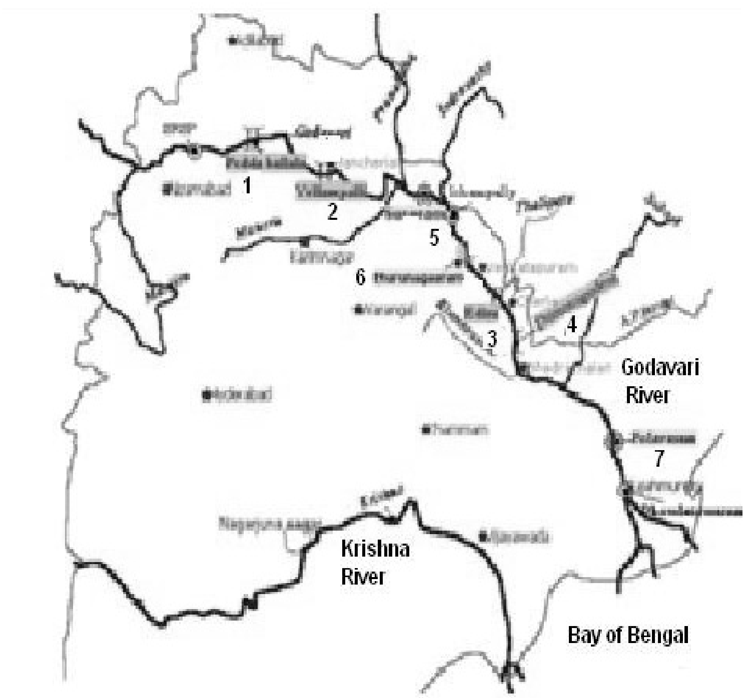

Fig. 1: Location of storage works on river Godavari

4.1 POWER DURATION CURVE

The Power duration curve prepared is shown in figure 3. It has been established for identifying unrestricted energy output evaluated in Million Units for 50%, 75% and 90% dependable flows and in cases of both reservoir storages with and without spills.

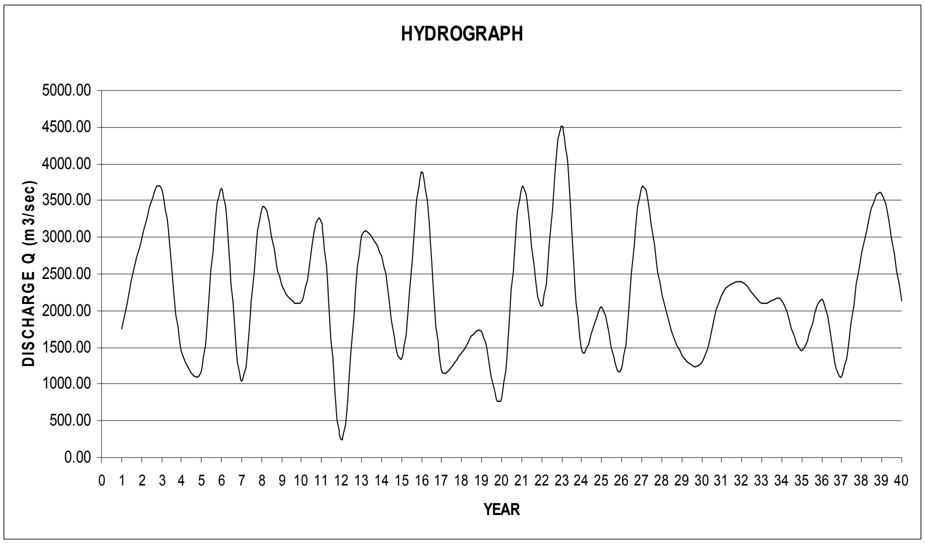

Fig. 2: Hydrograph of River Near Project Site

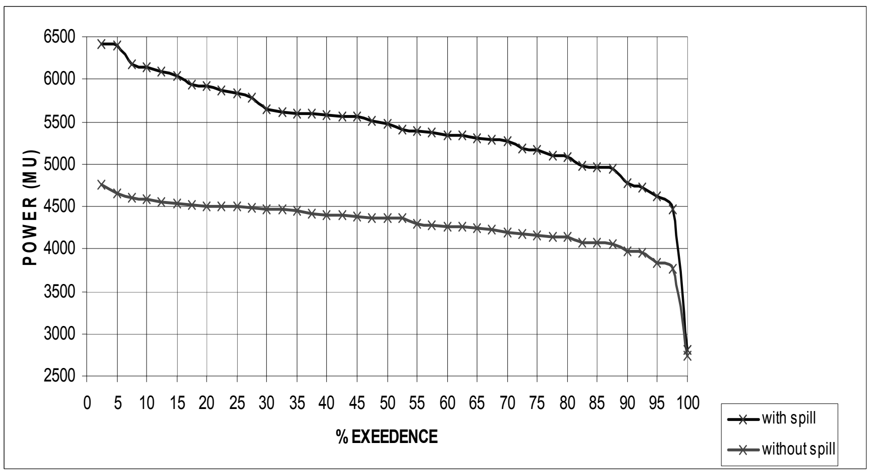

Fig. 3: Power Duration Curve for Storage With & Without Spill

Based on the power duration curve developed, the availability of unrestricted power potential of 50%, 75% and 90% dependability is evaluated by operation of reservoir with storage water available including spill and without spill from the daily water inflow data of flow. The unrestricted power potential of 50%, 75% and 90% dependable years for storage with and without spill are given in table 1

Table 1: Un-restricted Energy for Dependable Flows

Sl. No	Reservoir operation	Energy Generation →	90% Dependability	75% Dependability	50% Dependability
1	Storage with spill		4768.29 MU	5170.06 MU	5477.07 MU
2	Storage without spill		3977.02 MU	4154.66 MU	4357.14 MU

From the table – 1, it can be assessed that, there is possibility of improvement of power potential with improved installed capacity by utilizing storage with spills also. To determine the better installed capacity, a study is carried out with restricted installation capacity from 250 MW to 350 MW in steps of 10 MW for energy evaluated with respect to 50%, 75% and 90% dependability for storage with spill.

5.0 MODEL WITH SIMAHPP PROFESSIONAL SOFTWARE

The analysis was carried out using software SIMAHPP (Simulation Analysis for Hydro Power Project). The outcome results of analysis made with above SIMAHPP Software for 40 years data with pond storage discharges including spill as well as only pond storage discharges without spill are enumerated along with investment cost per KW. The results of energy output for extent maximized design time of operation are also furnished

From the analysis of SIMAHPP model, the maximum design time of operation is the 72% i.e about 263 days in a period of 365 days for all the years. Hence, the power output at 72% design time of operation is considered as enumerated above. Hence, it can be analyzed from the both the cases that, the power output is 361 MW at 75% dependability for storage discharge without spill, and 369 MW at 75% dependability for storage discharge with spill. The energy evaluated from the model was compared with studies with 10 day average of river flow for every month of all the 40 years. The energy evaluations made now with mathematical model under periodical water demands through day to day scheduled reservoir storages according to inflows as well as with SIMAHPP model as given in table 2.

The variation in energy generation as per the table 2 shows large variation between previous studies when compared to present models. This is due to the fact that the previous studies are based on 10 day average flows and without any storage at plant. However in the model the data is based on daily basis and storage considered as maximum of 24.41 TMC i.e., 8001 m^3/sec and minimum of 0.76 TMC i.e. 248 m^3/sec. .

Table 2: Restricted Energy Variations for Varied Dependable Flows

S.No.	% Dependability	Restricted Energy Generation (MU)	Restricted Energy Generation (MU)	Restricted Energy Generation (MU) by SIMAHPP Model
1	50%	1036.48	2285.65	2173.53
2	65%	936.53	2263.35	2296.12
3	75%	798.44	2249.28	2331.22
4	90%	672.27	2160.11	2147.04
5	100%	671.09	1842.88	1656.26

The design time of operation based on excel model and SIMAHPP model is 263 days out of 365 days. The evaluated results are represented by bar graph shown in figure 4 for comparing the percentage dependability and maximum restricted energy potential from the figure 4. It can be assessed that, there is an improvement in potential even with considerable demands and scheduled reservoir storages.

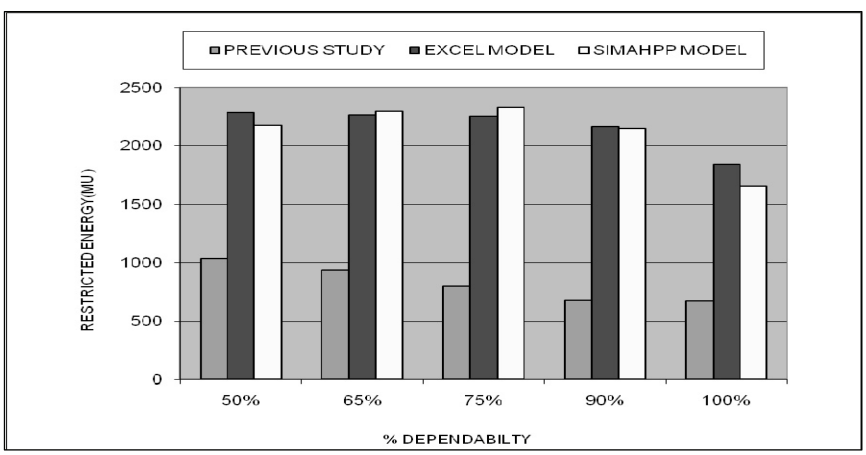

Fig. 4: Variable Energy for Dependable Flows

By analyzing the combinations of installed capacity of units to arrive at optimum installed capacity of the scheme based on techno economic studies. A study is carried out accordingly to estimate the annual energy generated with average plant load factor based on the operating days of restricted installed capacity of units for the 75% dependable years evaluated from the both mathematical and SIMAHPP models as given in table 3. Here, the plant load factor is a measure of average capacity utilization. It is load factor measure of the output of a power plant compared to the maximum output it could produce. A higher plant load factor is better which means greater total output where fixed costs are spread over more kilo watt hour of output.

Table 3: Installation capacity of different alternatives with plant load factor at 75% dependability for both SIMAHPP model and Excel model.

Alternative Number	**Alternatives with various combinations of Installed Capacity (MW)**	**Total Installation capacity (MW)**	**PLF% of 75% dependable flows with SIMAHPP model (MW)**	**PLF% of 75%. dependable flows with Mathematical model(Excel) (MW)**
1	8 x41	328	73.95	73.95
2	8x39 +1x17	329	83.8	78.98
3	6x 42.9 +2 x36.1	329.6	76.66	76.66
4	5x 51 +3 x 25	330	76.71	78.08
5	5x 46.2 +3x 33	330	76.06	76.06
6	4x 57 +2x 51	330	76.73	76.73
7	5x 47 +3x 32	331	76.32	75.64
8	5x 57 +2x 23	331	77.93	77.25
9	5x 51 +3x 21+1x15	333	83.06	79.87

6.0 CONCLUSIONS

The analysis of results evaluates alternatives of 2 and 9 i.e. Combination of Nine units (Eight units of 39 MW and one unit of 17 MW) or Nine units (five units of 51 MW, three units of 21 MW and one unit of 15 MW) are standard in both cases. Among the obtained values, it is feasible to have the installation capacity with maximum plant load factor point of view as well as economical point of view. Taking to account of financial criteria for above, evaluation of optimal installation of unit size for the maximum available potential is 333 MW with nine numbers of units.

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Economical Hybrid Power Systems

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ABSTRACT

Hybrid power generating systems mainly focuses on the renewable energy resources. In our hybrid model Solar and Wind has been planned to use to generate electricity. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of energy resources. As we know this type of model are involved with high installation costs, so these are least preferred. The main objective of the present study is to convert the solar and wind into electricity and to optimize the energy requirement in economical mode. It reduces the environmental pollution using environmental friendly technology and also creates awareness among people regarding renewable energy resources consumption at low cost as possible.. The study area considered for the present study is Kamala Nehru Girls Hostel in Jawaharlal Nehru Technological University campus which was located in Kukatpally of Hyderabad city, Ranga Reddy District. It is situated in between 17º30´ to 17º29´ North Latitudes and 78º23´ to 78º24´ East Longitudes.

***Keywords*:** Solar Photo Voltaic, Wind Power and Hybrid Model.

INTRODUCTION

Energy is the critical factor where the economic development of any nation depends. In India, present electricity generation cannot meet the requirements as the population steadily increasing. Traditional sources are depleting very fastly. Most of the research is now about how to conserve the energy and how to utilize the energy in a better way. Research has also been into the development of reliable and robust systems to harness energy from non-conventional energy resources. So in this connection there is a strong necessity to go for non conventional sources like solar, wind, tidal, geothermal, bio energy etc. Among them, the wind and solar power sources have experienced a remarkably rapid growth in the past 10 years as they are mostly uniformly distributed on the earth surface, so need to encourage the generation of electricity through freely and abundantly available Solar and Wind energy resources. Both are pollution free sources of abundant power. Even though they are the most popular non-conventional energy resources, several variations are existed making the uneven distribution from the sources in a day or a season. Such a stand-alone systems are not sufficient to supply load continuously, keeping economical factors into consideration the correlation of the other source is needed to overcome the above obstacles. Here solar energy converts solar energy or solar radiation to electricity. Solar power generation system has some drawback, that is, it cannot generate power in cloudy or rainy days. Therefore, people using this solar system have to remain without electricity (power) after battery gets discharged during the rainy season or in the sun's shortcomings, as it is completely dependent on appearance of the sun in the sky. So the correlation or a combination with wind energy system or any other systems like Diesel (backup system) etc can be done, but for environmental, fuel cost and maintenance convenience it (diesel system) is not encouraged.

The design of the Hybrid Power System comprising Solar and Wind is to be done very efficiently as well as economically and then only its applications can be extended rapidly in a huge populated country like India. Designing of hybrid power systems holds major contribution in making system economic and efficient. Strong analysis, configuration optimization and planning are required. In this system it can be generated by both sources at a time or based on its availability. To tap the energy, good controlling unit and converter components are required. Load compatibility with sources like frequency, voltage, current and type of system (AC or DC) and other load characteristics are important. Distance from the power generation to load is also cost factor.

WORKING

To make an Economical and Efficient Hybrid Power Systems the following factors have to be fulfilled:

1. *Data analysis:*

   Proper data analysis is to be carried out at the location before installing the power system because in renewable energies there is always a major drawback i.e. variance in the source availability as it may change hourly, daily, monthly or seasonally.

2. *Selection of Material:*

   The material used in the system should be efficient and economic to invest by any community (rural or urban) based upon the availability of the source.

   I. The material of solar cell are classified as follows

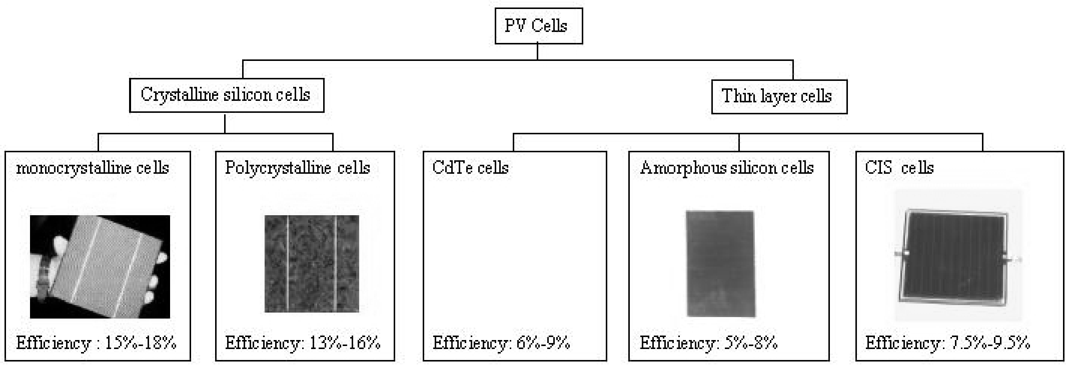

Figure 1: Classification of solar PV cells

   Among the above types poly crystalline cells are having almost same efficiency and durability compared to mono crystalline, but the cost of mono crystalline is expensive than poly crystalline cells.

   II. Wind turbines are of two types and they are classified as follows

Table 1: Classification and performance of wind turbine

Sl.No	Performance	Horizontal axis wind turbine	Vertical axis wind turbine
1	Power generation efficiency	50-60%	>70%
2	Steering Mechanism of the Wind	Needed	Not Needed
3	Blade rotation space	Quite large	Quite small
4	Wind resistance capability	Weak	Strong
5	Noise	5-60dB	10dB
6	Starting wind speed	2.5-5m/s	1.5-3m/s
7	Ground projection effects on human beings	Dizziness	No effect
8	Failure rate	High	Low
9	Maintenance	Needed	Not needed
10	Effect on Birds	High	Low
11	Rotating speed	High	Low
12	Area of installation	Rural or sea shore large open area, large installations	Urban or rural open area, lower installations

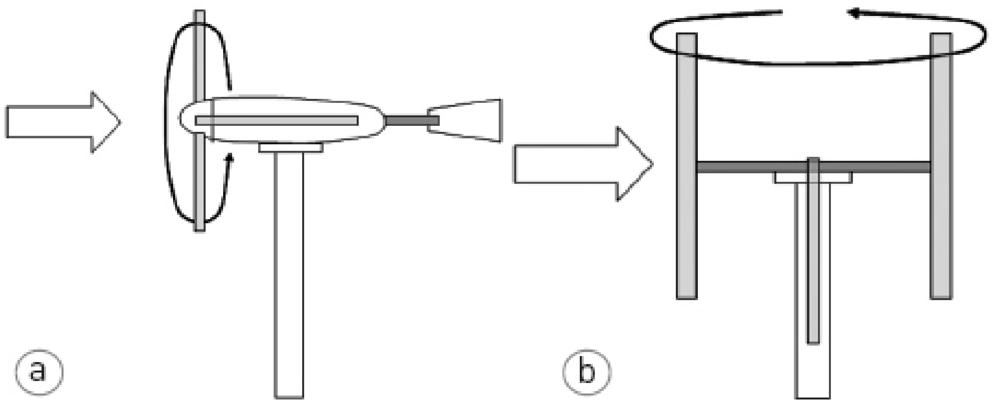

Figure 2: (a) Horizontal Axis Wind Turbine (HAWT) (b) Vertical Axis Wind Turbine (VAWT)

Vertical Axis Wind Turbine will yield good results when the set up is small and having low capital sources. The configuration can be made by material which gives durability, effective tapping of wind energy, efficiency etc. Aluminum alloys are preferred over other materials for its strength, less weight and above factors.

III. Power converter units and controlling units should have automated as we can reduce the maintenance

3. *Optimized Configuration:* Generated power through the system is to be handled very efficiently to get maximum output. A well designed system aids the purpose.

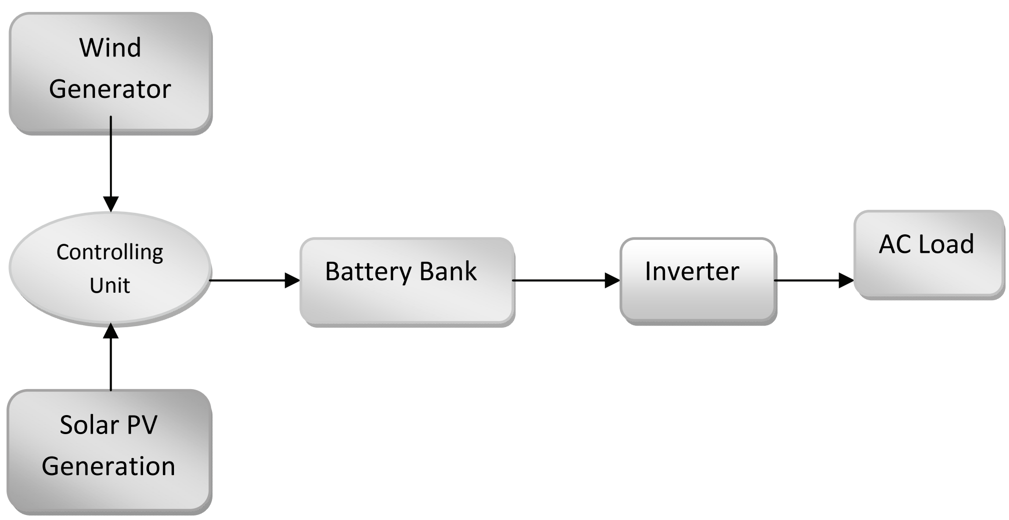

Figure 3: Block diagram showing design when connected to AC loads.

As shown in the diagram, if the generated power supplies to AC loads at other than generating times it needs Battery bank and always an inverter for conversion. In this configuration battery is costly, nearly one quarter part of capital is needed but continuity exists. Losses will be there at conversions and AC loads. This design can be optimized more as per load requirement (institutions, offices, residential, public places, street lightings, agriculture or industrial etc) and type of load (AC or DC). The above diagram is a basic model for AC loads at residential, public places, street lightings, industrial etc. This is quiet expensive one.

The block diagram for DC loads at institutions, offices etc is follows

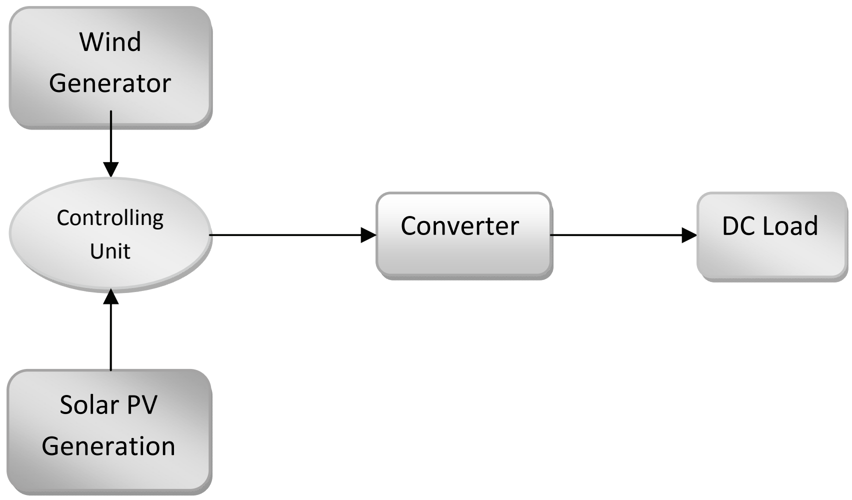

Figure 4: Block diagram showing design when connected to DC loads.

As mentioned above DC loads at institutions, offices etc it does not needs battery as the load are runs in sun shine hours mostly and DC loads will have less losses compared to AC loads. It can supply the energy to treatment plants of water or any particular purposes. This configuration gives purely natural and freely energy at day timings. It also can have battery bank as per its requirement of load.

4. *Transmission:* The generating location should be as near as possible to loads because transmission costs are increased and disturbances in conveyances may occur. Generating location depends on the space available like in urban area space is less so system is fixed on roof top where as in rural type large space may available then system can be on ground surface but very near to the load itself.
5. *Load Compatibility:* In India, the generating power is of alternate current type so the loads are also same but direct current type equipments have less losses when compared both and effective consumption occurs in it. In hybrid generation, solar power is of DC type so to avoid conversion losses DC loads can be powered to reduce cost. Conversion of frequency, voltage, current and power levels to match the load is done by using converter circuit.

CONCLUSION

During early days of solar panel and wind turbine introduction it is very costly and low efficiency but now costs are falling down every year and very efficient technologies were introduced. Hybrid power system operation and maintenance costs are very less, almost zero if they are automated. However installation costs are returned in long term can be reduced to short term by introducing the compatible designs according to site, appliances and requirement. In future, cost will fall drastically as it is being competitive. Renewable energy subsidies from MNRE, NGO's, NREDCAP and other agencies are to be awared by each and every individual. It will be great contribution to environment by avoiding the green house gas emissions which is absolutely not seen in renewable energy technologies. On the other side fossil fuel costs are nominal but rapid grazing of resources and their transportation, maintenance costs are increasing. Fossil fuel grazing rate is reduced for future uses. In rural electrification transmission of lines is the problem so by introducing hybrid power systems there education promotion, health care, socio-economic development, employment, transportation, prevents urban migration, improves living standards, communication can be fulfilled.

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Effect of Salt Stress on Germination and Early Seedling Growth Stage of Roselle (*Hibiscus sabdariffa* L.) Landraces

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ABSTRACT

The response of three Roselle landraces (RKS-1, RKS-2 and RKS-3) against eight salts (Distilled water as control, NaCl, Na_2SO_4, Na_2CO_3, NaCl+Na_2SO_4, NaCl+Na_2CO_3, Na_2SO_4+Na_2CO_3, NaCl+Na_2SO_4+Na_2CO_3) with three salinity levels (0. 15, 0.30, and 0.45%) were studied at germination and early seedling stages. An experiment with factorial arrangement was conducted by using a completely randomized design with 2 replications. Germination percentage, the length of shoot and root, length of seedling, rate of germination, and vigor index measured 12 days after germination. Results of data analysis showed that, there were significant differences between landraces and salinity stress levels for all investigated traits except mixed factor. Result of means comparison showed that in all of landraces there was a decrease in germination percentage due to salinity stress increment and maximum germination percentage was delayed. Results of this experiment showed that, under conditions of the highest saline stress that is 0.45% all landraces had not any germination after 12 days. The maximum fall in germination percentage was detected in RKS-2. According to the results of this research, Landraces RKS-3 is the most resistant and RKS-2 is the most sensitive varieties at germination stage and early seedling growth.

***Keywords*:** Germination, Salinity Stress, Seedling, Roselle.

INTRODUCTION

Roselle plant (*Hibiscus sabdariffa* L.) is one of the most important and popular medicinal and industrial plants. (Abdel Latef *et al.* 2009). Nowadays, a great interest exists in this crop due to the high antioxidant properties of the flowers calyxes, which have been extensively evaluated (Tee *et al*. 2002; Tsai *et al*. 2002; Tsai and Huang, 2004; Tseng *et al*. 1997; Prenesti *et al*. 2007). During their growth crop plants usually exposed to different environmental stresses which limits their growth and productivity. Among these, salinity is the most severe ones (Kaymakanova, 2009).

Salinity becomes a concern when an excessive amount or concentration of soluble salts occurs in the soil, either naturally or as a result of mismanaged irrigation water. The major inhibitory effect of salinity on plant growth and development has been attributed to osmotic inhibition of water availability as well as the toxic effect of salt ions responsible for salinization. Nutritional imbalance caused by such ions leads to reduction in photosynthetic efficiency and other physiological disorders (Hakim *et al*. 2010). Soil salinity and alkalinity seriously affect about 932 million hectares of land globally, reducing productivity in about 100 million hectares in Asia (Rao *et al.* 2008). Salt stress affects many physiological aspects of plant growth. Shoot growth was reduced by salinity due to inhibitory effect of salt on cell division and enlargement in growing point. (Maghsoudi Moud and Maghsoudi, 2008).

Seed germination is usually the most critical stage in seedling establishment, determining successful crop production (Bhattacharjee, 2008). Crop establishment depend on an interaction between seedbed environment and seed quality (Khajeh-Hosseini *et al*. 2003). It is necessary to identify the sensitivity and tolerance level of a variety at early seedling stages for successful crop production in a saline environment (Hakim *et al*. 2010). Therefore the present study was conducted with the objectives to determine the response of Roselle landraces to salinity stress at germination and seedling stages under controlled conditions. Moreover, NaCl, Na_2SO_4,

Na_2CO_3, $NaCl+Na_2SO_4$, $NaCl+Na_2CO_3$, $Na_2SO_4+Na_2CO_3$, $NaCl+Na_2SO_4+Na_2CO_3$ were used for salinity stress induction in Roselle.

MATERIALS AND METHODS

In order to study the effects of salinity stress on germination and early seedling growth in Roselle landraces, an experiment was conducted in factorial form; using a 3x8x3 factorial completely randomized design with two replications. In this experiment, three Roselle landraces inclusive RKS-1, RKS-2 and RKS-3 were evaluated in three levels of salinity treatment (0.15, 0.3 and 0.45%) by using different sodium salts (Distilled water as control, NaCl, Na_2SO_4, Na_2CO_3, $NaCl+Na_2SO_4$, $NaCl+Na_2CO_3$, $Na_2SO_4+Na_2CO_3$, $NaCl+Na_2SO_4+Na_2CO_3$). This experiment was carried out at NBPGR, Rjendranagar, Hyderabad, India.

The seeds were sterilized by soaking in a 5% solution of sodium hypochlorite for 5 min. After the treatment, the seeds were washed several times with distilled water. The seeds were soaked overnight with respective salt solutions for 12 hours. 10 seeds were placed in each petridish (with 3 cm diameter) on filter paper moistened with respective treatment in 2 replications. The petridishes were covered to prevent the loss of moisture by evaporation. The petridishes were put into seed incubator room for 12 days at 25^{o}C temperature and 65% relative humidity. Every 24 hours after soaking, germination percentage and other traits were recorded daily. After 12 days of incubation, shoot length, root length and vigor of germinated seeds was measured. Seeds were considered germinated when the emergent radical reached 2 mm length. Rate of germination, germination percentage and vigor index were calculated using the following formulas (Mostafavi, 2011).

Formula 1: GP = SNG/SNO × 100%

Where: GC is germination percentage, SNG is the number of germinated seeds, and SNO is the number of experimental seeds with viability (Close and Wilson 2002; Danthu *et al*. 2003).

Formula 2: $GR=\Sigma N/\Sigma(n\times g)$

Where: GR: Germination race; n: number of germinated seed on gth day and g: Number of total germinated seeds.

Formula 3: Seed Vigor = [seedling length (cm) × germination percentage]

Analysis of variance was performed using standard techniques and differences between the means were compared through Critical Difference ($P < 0.05$) using SAS release 9.1 (SAS, 2002) software package.

RESULTS AND DISCUSSION

Analysis of variance showed that, there were significantly differences between landraces and salinity stress levels for all investigated traits except mean interaction between three factors. The results of this study reveal that various concentrations of Na_2CO_3 had a significant effect on the all measured traits (Table 1). Roselle landraces showed different responses to each salinity level, the highest values in control level were usually obtained from RKS-3 landrace. In addition, it was clearly determined that there were statistical differences between measured landraces at high salinity levels for all traits except interaction between three landraces (Table 1). The differences between the means (Landraces and salts stress levels) were compared by C.D. and are shown in Table 2. It observed that, in all of landraces there was a decrease in germination percentage due to salinity stress increment and maximum germination percentage was delayed. While in this experiment different landraces had different response to the salinity stress.

At salinity levels of 0 and NaCl 0.15%, the highest germination rate was attained from landrace RKS-3 and RKS-2. Under conditions of the highest saline stress that is 0.45% all landraces had decreased germination% after 12 days. The maximum fall in germination percentage was detected in RKS-2. The rate of reduction in germination percentage in comparison with the control was detected from RKS-1 as 87.917 %, RKS-2 as 48.333 and RKS-3 as 97.292 % which means RKS-3 was more tolerant to salinity stress in terms of germination percentage. According to Ayaz *et al*. (2000), decrease of seed germination under salinity stress conditions is due to occur of some metabolically disorders. It seems that, decrease of germination percentage and rate of germination is related to reduction in water absorption into the seeds at imbibitions and seed turgescence stages (Mostafavi, 2011).

Root length is one of the most important characters for salinity stress because roots are in contact with soil and absorb water from soil. For this reason, root length provides an important clue to the response of plants to salinity stress. Among the cultivars, the longest root length was determined in RKS-3 genotype while RKS-2 gave the shortest root length at this level. Generally, increasing salinity levels decreased root length, and RKS-3 landrace exhibited the greater performance in respect of root length. Mean shoot length varied between 7.835 and 8.343 cm in the landraces and 9.037 and 5.541 cm for salinity levels (Table 2). Mean shoot length was 11.426 cm at control level while it decreased linearly to 5.541 cm at 0.45 % salinity stress. In general, shoot length diminished with increasing salinity levels in all landraces (Table 2). The highest and the lowest vigor index were observed in RKS-3 and RKS-2 landraces, respectively (Table 2).

Table 1: Analysis of variance of Roselle landraces by different Salts concentrations

Source of variation	D.f.	Germination (%)	Rate of germination	Shoot length	Root length	Vigour index
Landraces (F_1)	2	313.374**	87.007**	6.316**	183.622**	230.929**
Salt Treatments (F_2)	7	11.209**	31.137**	109.361**	210.683**	85.178**
Concentration (F_3)	2	35.960**	88.250**	142.163**	131.537**	130.162**
F_1 x F_2	14	5.598**	4.716**	6.088**	3.921**	4.407**
F_1x F_3	4	8.245**	6.052**	7.824**	0.776^{ns}	4.197**
F_2x F_3	14	1.700^{ns}	2.362**	4.216**	7.002**	2.719**
F_1x F_2x F_3	28	0.733^{ns}	1.169^{ns}	1.546^{ns}	1.316^{ns}	0.983^{ns}

**, ns, significant at 1% and non significant respectively

Table 2: Mean comparison of Roselle Landraces and Salt treatments

	Germination Percentage	Rate of germination	Shoot length	Root length	Vigor index
Landraces					
RKS-1	87.917	6.170	7.963	1.580	880.365
RKS-2	48.333	3.289	7.835	1.192	474.129
RKS-3	97.292	7.047	8.343	1.670	956.956
C.D. 5%	4.140	0.594	0.296	0.053	48.153
1%	5.495	0.789	0.394	0.070	63.922
salt types					
control	96.111	9.944	11.426	2.314	1322.62
NaCl	76.111	4.476	9.037	1.783	846.256
Na_2SO_4	75.000	5.013	8.472	1.647	793.322
Na_2CO_3	71.667	3.509	5.541	0.916	483.433
NaCl+Na_2SO_4	81.667	5.928	8.473	1.551	822.222
NaCl+Na_2CO_3	72.222	4.904	6.793	1.113	584.494
Na_2SO_4+Na_2CO_3	76.667	5.115	6.653	1.169	598.733
NaCl+Na_2SO_4+Na_2CO_3	73.333	5.126	7.981	1.353	712.778
C.D. 5%	6.760	0.971	0.484	0.086	78.634
1%	8.974	1.289	0.643	0.115	104.385

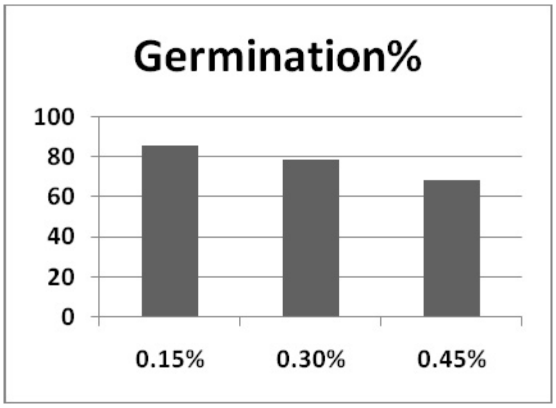

Fig.1 A Effect of Salts conc. on germination%

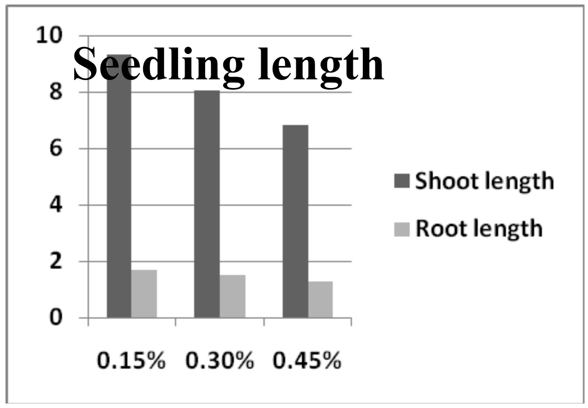

Fig.1 B Effect of Salts conc. on seedling length

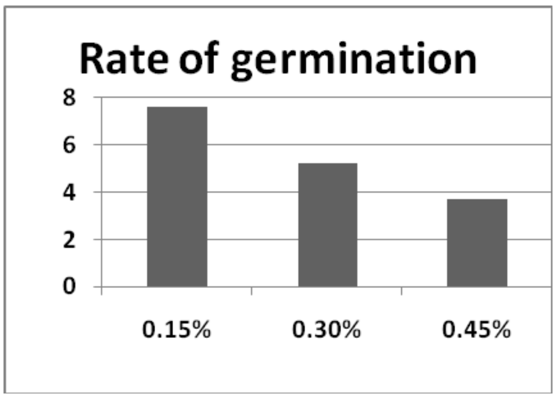

Fig.1 C Effect of Salts conc. on germination rate

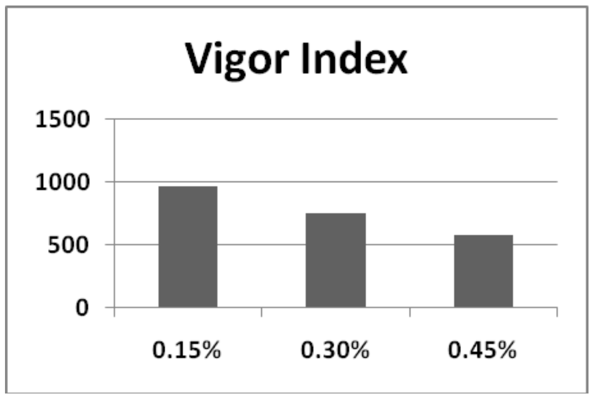

Fig.1 D Effect Salts conc. on Vigor Index

Fig.1 A,B,C and D reveals that the concentrations of salts adversely effects on germination percentage, seedling growth (shoot length and root length), rate of germination, vigor index respectively.

The decline in germination rate between the control and final salinity levels was the lowest in RKS-3 while the highest reduction was determined on RKS-2. Generally, all measured traits declined with increasing salinity levels, which showed that a greater reduction in root length occurred than that in shoot length. On the other hand, it means that the roots were more adversely affected than shoots by Na_2CO_3 concentration. Ajmal Khan and Weber (2006) found that, resistance to stress at germination stage and primary growth of seedling is independent from next growth stages and evaluation of stress tolerance need more experiment at next growth stages.

High salt-stress generally leads to growth arrest and even plant death (Munns and Tester 2008). However, in the present study, the injurious effect of alkali stress was greater than that of salt stress. Some reports have clearly demonstrated alkaline salts ($NaHCO_3$ and Na_2CO_3) are more destructive to plants than neutral salts ($NaCl$ and Na_2SO_4) (Shi and Sheng 2005, Shi and Wang 2005, Yang *et al*. 2008a, b, c). The variation among landraces showed that germination percentage decreased with the increase in Na_2CO_3 concentration in all the genotypes. However RKS-3 performed better than others. Many reports indicated that germination percentage and Vigor Index can be utilized as screening criteria for stress tolerance.

In present study the findings are very similar to the earlier studies (Shi and Sheng 2005, Shi and Wang 2005), in which germination decreased due to the increase in Na_2CO_3 concentration. Present study strongly supports that germination percentage and root to shoot ratio can be utilized to screen Roselle landraces for salinity tolerance. There are many reports which are in agreement with the present findings indicating that salinity stress severely reducing the seed germination and early seedling growth. But the landraces having genetic potential to maintain the higher growth under stress conditions are saline tolerant.

CONCLUSION

Results of this experiment showed that, different levels of salinity stress have significant effect on Roselle seed germination and early seedling growth. Many researchers have been reported similar results (Shi and Sheng 2005, Shi and Wang 2005, Yang *et al.* 2008a, b, c). Obviously, acceptable growth of plants in arid and semiarid lands which are under exposure of salinity stress is related to ability of seeds for best germination under unfavorable conditions, so necessity of evaluation of salinity resistance landraces is important at primary growth stage. To find the best tolerant landrace to such conditions, taking all traits into account in this study, we found that RKS-3 is the most resistant and RKS-2 is the most sensitive landraces.

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Analysis of Hydrological Responses of Watershed by using SWAT Model

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ABSTRACT

Hydrological unit watershed is socio-political –ecological entity which plays crucial role in determining food, social and economical security and provides life support services to rural people. Sustainable development of watershed can be defined as development that needs of the present without compromising the ability of future generations to meet their needs. For development and management of watersheds various hydrological models have been developed. Among these models SWAT (Soil and water assessment tool) is a river basin, or watershed, scale model developed by Dr. Jeff Arnold for the USDA Agriculture Research Services (ARS). Objective of present study is to analyse hydrological responses such as land use distribution and soil classification, slope in watershed by using Arc SWAT. Watershed No. GV-45 which is located in Khultabad village of Aurangabad district of Maharashtra selected as case study. Required meteorological data is collected from IMD Pune and Soil maps are collected from NBSS Nagpur. SWAT divides the watershed into multiple sub-basins using topography. Each is then further subdivided into hydrological response unit (HRUS) that consist of homogeneous land use, management, and soil characteristics. The HRUs represent percentages of the sub watershed area and are not identified spatially within a SWAT simulation. Arc GIS has been used for preparation of basic geodatabase for SWAT. The overall hydrological balance is simulated for each HRU, including interception of precipitation, partitioning of precipitation, snowmelt water, and irrigation water between surface runoff and infiltration, redistribution of water within the soil profile. In current study SWAT has developed to predict area of land use pattern and type of soil in particular sub basin of watershed. Results shows that 33 sub basins are present in watershed GV-45 having area 239.45 ha. Sub-basin parameter gives percentage area under elevation and detailed land use, soil, slope distribution of sub- basin of watershed.

Keywords: Sustainable development, Hydrological responses units, ARC – SWAT, LULC.

INTRODUCTION

Watershed is a land or an area that drains water to the outlets during rainstorm. Boundary of the watershed consisting of line drawn across the contours joining the highest elevation surrounding surface of basin and area is encircled by a ridgeline following ridge and valley topography. .Sustainable development of watershed can be defined as development that needs of the present without compromising the ability of future generations to meet their own needs. For development and management of watersheds various hydrological models have been developed. Among these models SWAT is a river basin, or watershed, scale model developed by Dr. Jeff Arnold for the USDA Agriculture Research Services (ARS). SWAT divides the watershed into multiple sub-basin using topography which is further sub-divided into the hydrologic response unit (HRU), which consists of homogeneous land use and soil characteristics. On each HRU hydrologic cycle is simulated on the basis of the water balance equation. The model is physically 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 watershed, which receiving monsoon rains, common agriculture activities and all this contribute to agrochemicals to water resources along with sediment transport during the monsoon period. So that it is required to quantify the water quality effects of monsoon rains either on individual watershed. Because of the assessment of this processes using measurement is costly and time consuming, modelling could use as a tool for this purpose. The objective of this paper is to prepare thematic map of the watershed such as Digital Elevation Model, Soil Map, Landuse & Land Cover, Stream flow map for the study area by using remotely sensed data and GIS. Further study is carried out for analysis of hydrological responses such as land use distribution and soil classification, slope in watershed, sub- basin parameter of watershed.

LITERATURE REVIEW

Mishra A.et.al, (2012) discussed about SWAT model is used to simulate the stream flow, sediment yield and NPS pollutants (nitrate-N, ammonical and soluble –p) from a small watershed (muti-vegetated) situated in the subhumid, subtropical climate in India. Sang X., et.al.(2010) have given improvement on irrigation model and consumptive water use module and the new SWAT model is developed based on human water use and application in the area of high human activities in order to apply to the water system in Tanjinicity china where the water cycle is strongly affected by the human activities. Gong Y, et.al, (2010) [3] have discussed to select an appropriate subdivision scheme area of watershed from SWAT modelling while considering parameter uncertainty hydrology and soil erosion modelling. Gabrial G., et.al (2008) have used SWAT to generate long data series to fit autoregressive and autoregressive moving average models, in order to perform short-term forecasting of monthly streamflow and groundwater table depth in areas that lack long historical records. Kirby, et.al. (2007) have given the coupling and validation of a hydrologic-forest productivity model PnET-II3SL with a hydrologic-agricultural productivity model to represent the hydrologic response characteristics of large spatial areas. Kim, et.al (2012) The soil and water assessment tool (SWAT) was used to evaluate the effects of flow regulation by upstream Soyanggang and Chungju multipurpose dams on downstream flow regimes at the inlet of Paldang Dam, a major water source of the Seoul Metropolitan area in the Han River basin of Korea.

CASE STUDY

The study area watershed No.GV-45 is located in Taluka Khultabad and Kannad of Aurangabad district, Maharashtra India. It falls in between North Latitudes of 19 45' 0" and 19 30' 0" and East longitudes of 75 0' 0''and 75 15'0''. The area of watershed covers 239 ha under Geological survey of India toposheet no. (46 P/4, 46 P/8, and 47 M/1, 47 M /5). The scale of toposheet 1: 50,000 means that (one inch measured on the map represents the 50, 000 inch on the ground surface).The area experiences moderately tropical climate. The average annual rainfall is about 796.13 mm. The maximum and minimum temperature recorded in the area is 40°c and 13° c. The Digital Elevation model (DEM) of study area taken from SRTM. Soil properties, soil map, soil types (black soil, red soil, clay,) structure, Texture, structure, received from NBSS Nagpur. Daily Weather Precipitation, Temperature, Humidity, Collected from IMD Pune. Land use and land cover derived from Remote sensing satellites IRS, linear imaging self – scanner (LISS) III remote sensing images from Bhuvan.

Toposheet and Masked watershed of study area

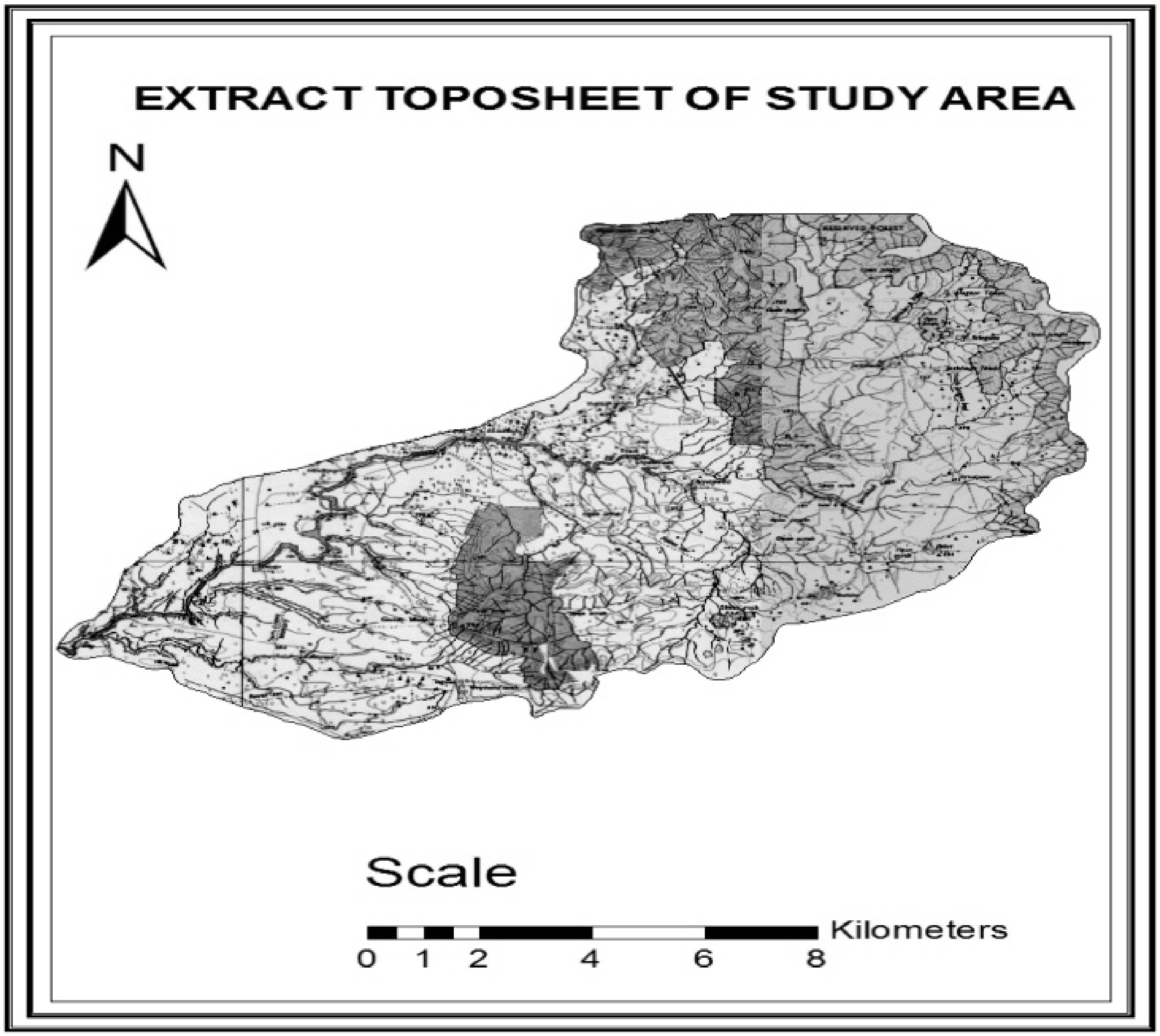

Figure 1 Toposheet and Masked watershed of study area

METHODOLOGY

Database Development – The public domain model (Soil and water Assessment tool) ArcSWAT (2009) working with ArcGIS9.3 interface is selected for this study. SWAT requires three basic files for delineating the basin into the sub basin and Hydrological response unit (HRUs). DEM (digital elevation model) DEM consist of sampled array or grid of elevations for a number of ground position at regularly spaced interval, soil map and land use / land cover (LULC) map. Therefore for preparing basic geodatabase, A Geographic information system (GIS, ArcGIS) is used to develop and store the features of the watershed like topography, soil type, texture, existing land use, land cover, water resources, and drainage pattern as obtained from field measurements, topographic maps, and remotely sensed imagery. The watershed delineated from the Survey of India topographic sheets and then registered in The Arc Info GIS tool. A digitized contour coverage was established and a 90 m × 90 m digital elevation model (DEM) has been generated from SRTM for estimating the slope, drainage pattern, and aspect of the watershed. The watershed was subdivided into five nested sub watersheds on the basis of the drainage channels and land use/land cover. The drainage pattern of study area has drawned by digitization of watershed from toposheet. Soil map and database procured from NBSSLU&P, Nagpur. land use / land cover (LULC) map prepared from satellite image IRS – 6 / LISS III which is processed in ERDAS software to supervised in various classification.

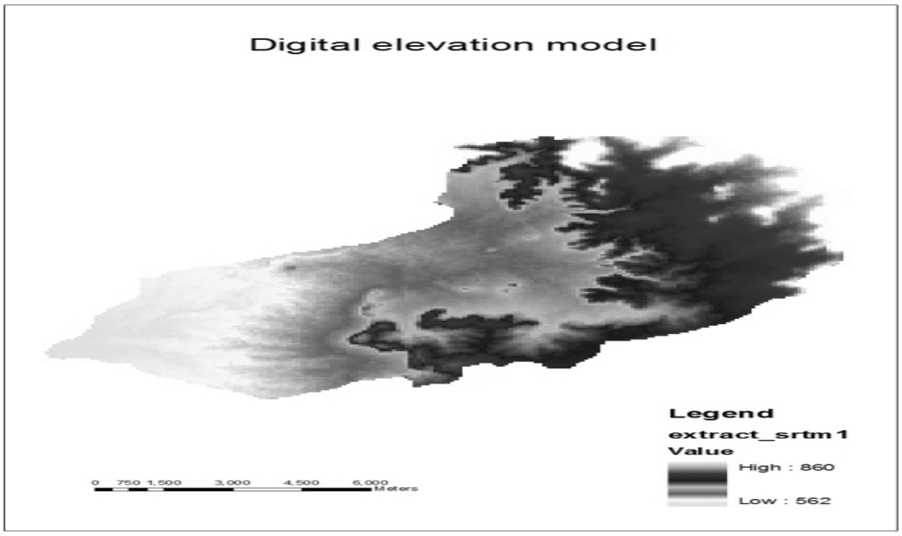

Figure 2 DEM map of watershed

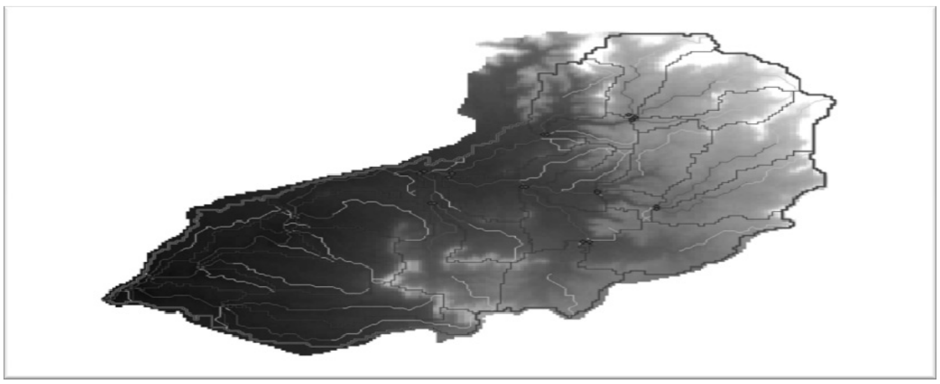

Figure 3 Swat sub- basin calculation of watershed

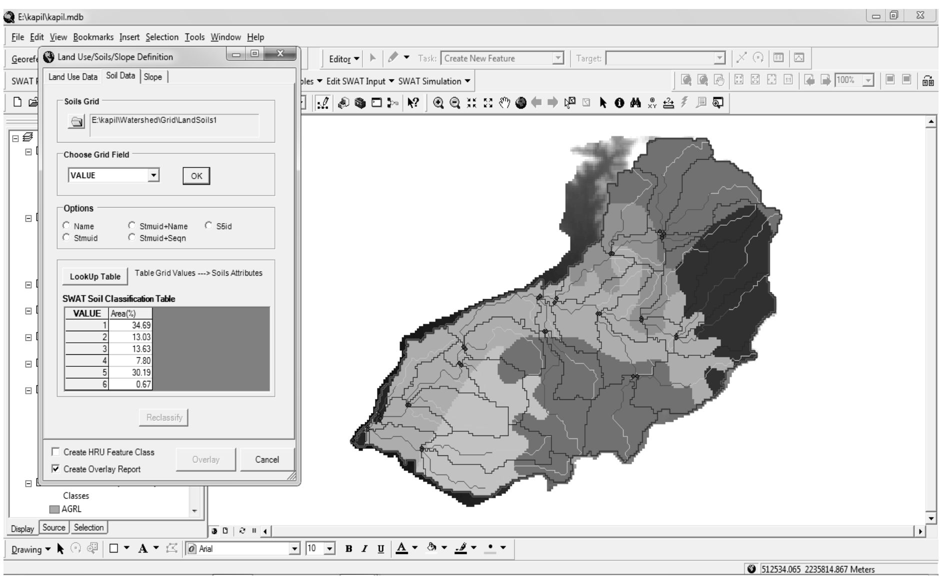

Figure 4 Soil map of watershed

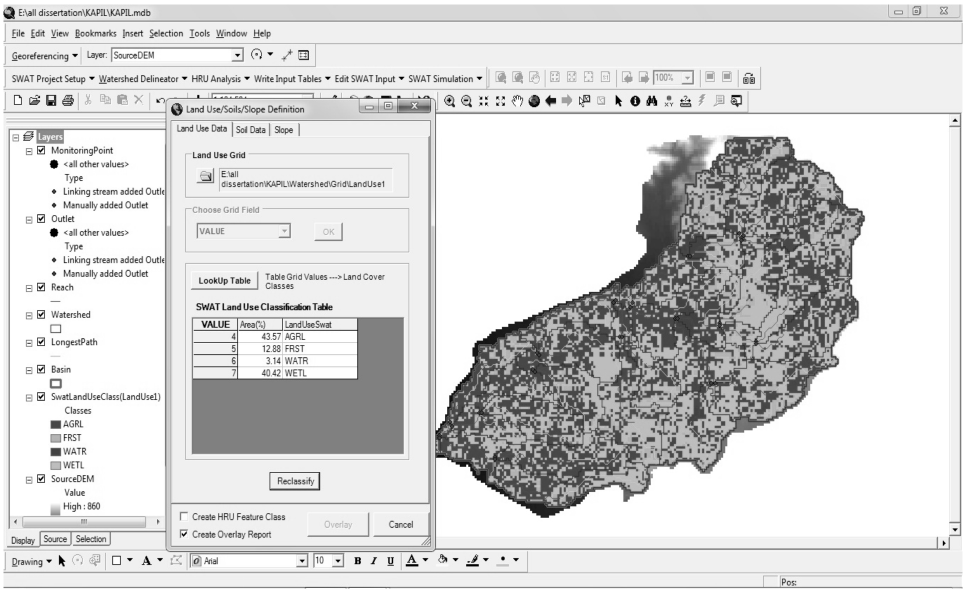

Figure 5 LULC map of watershed

RESULT AND DISCUSSION

Watershed delineation: Estimated Sub basin parameters are as following, Elevation report for the watershed Statistics: All elevations reported in meter Min. Elevation: 562 Max. Elevation: 858, Mean Elevation: 657.47, Std. Deviation: 54.86

Detailed LANDUSE/SOIL/SLOPE distribution of watershed

	Area [ha]	Area[acres]	
Watershed	11969.1618	29576.3972	
Number of Subbasins: 33			
LANDUSE:			%Wat.Area
Agricultural Land-Generic – AGRL	1540.9735	3807.8227	43.56
Forest-Mixed—FRST	1540.9735	3807.8227	12.87
Water --> WATR	376.1376	929.4549	3.14
Wetlands-Forested →WETF	4837.9565	11954.8324	40.42
SOILS:			
CSGPLS	4151.5228	10258.6204	34.69
CSMSSS	79.8504	197.3144	0.67
CSRLSS	933.6899	2307.1944	7.80
FCSGSS	3612.8825	8927.6133	30.18
FSGSSS	1559.8855	3854.5550	13.03
LSMSSS	1631.3306	4031.0995	13.63
SLOPE			
0-10	10266.3860	25368.7531	85.77
10-30	1612.4187	3984.3672	13.47
30-60	90.3571	223.2769	0.75

CSGPLS: Clay soil, on gently sloping plains, moderately well drained CSMSSS: - Clay soil, on moderately sloping Plains, CSRLSS: - Clay soil, excessively drained, sloping rolling land.

Detailed LANDUSE/SOIL/SLOPE distribution of sub-basins

Sub basins		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Area [ha]		525.27	631.02	4.20	308.15	438.42	216.41	47.62	357.8
Landuse	AGRL	266.86	298.38	0.70	143.59	148.49	48.33	22.41	189.1
	FRST	96.66	64.44	0.70	39.22	125.37	44.82	23.11	69.34
	WATR	3.50	17.51	-----	12.60	23.81	42.72		17.51
	WlF	158.30	250.75	2.80	112.77	140.78	80.55	2.10	81.95
Soil	CSGPLS	512.02	631.09	4.20	129.58	212.23	28.01		
	CSMSSS	-------	-------						
	CSRLSS	10.50	-------			226.24	149.89		179.31
	FCSGSS	-------	-------				38.52	47.63	178.61
	FSGSSS	-------	-------						
	LSMSSS	2.80	-------		178.61				
Slope	0-10	297.68	451.08	4.20	237.45	203.12	143.59	47.63	343.21
	10-30	205.93	169.50		66.54	225.54	72.84		14.70
	30-60	21.71	10.50		4.20	9.80			
% water – area	AGRL	2.23	2.49	0.01	1.20	1.24	0.40	0.19	1.58
Landuse	FRST	0.81	0.54	0.01	0.33	1.05	0.37	0.19	0.58
	WATR	0.03	0.15		0.11	0.20	0.36		0.15
	WlF	1.32	2.10	0.02	0.94	1.18	0.67	0.02	0.68
Soils	CSGPLS	4.28	5.27	0.04	1.08	1.77	0.23		
	CSMSSS								
	CSRLSS	0.09				1.89	1.25		1.50
	FCSGSS						0.32	0.40	1.49
	FSGSSS								
	LSMSSS	0.02			1.49				
Slope	0-10	2.49	3.77	0.04	1.98	1.70	1.20	0.40	2.87
	10-30	1.72	1.42		0.56	1.88	0.61		0.12
	30-60	0.18	0.09		0.04	0.08			
% sub. area									
LULC	AGRL	50.81	47.29	16.6	46.60	33.87	22.33	47.06	52.84
	FRST	18.40	10.21	16.6	12.73	28.60	20.71	48.54	19.38
	WATR	0.67	2.78		4.09	5.43	19.74		4.89
	WETF	30.14	39.74	66.6	36.60	32.11	37.22	4.41	22.90
SOIL	CSGPLS	97.48	100.01	100	42.05	48.41	12.95		
	CSMSSS								
	CSRLSS	2.00				51.60	69.26		50.10
	FCSGSS						17.80	100.01	49.91
	FSGSSS								
	LSMSSS	0.53			57.96				
SLOPE	0-10	56.67	71.48	100	77.05	46.33	66.35	100.01	95.90
	10-30	39.20	26.86		21.59	51.44	33.66		4.11
	30-60	4.13	1.67		1.36	2.24			

CONCLUSION

Result of the present study indicates that the SWAT model is used to estimate sub basin parameter of watershed situated in Aurangabad district. The result is obtained from ArcSWAT model which gives different percentage area below elevation and area of watershed under minimum to maximum elevation of sub basin from digital elevation model of watershed. It also gives detailed landuse, soil, and slope distribution of watershed as well as sub-watershed. From this result we can analyse hydrological response of watershed given by SWAT. Also SWAT model can be utilize in characterizing the stream flow, sediment yield, and associated NPS pollution of water in subhumid, subtropical regions, receiving monsoon rains; thus, it can serve as a decision management tool in solving water quantity and quality problems. Swat model can be utilize where river basin water cycle is strongly affected by the human activities, where new developed SWAT model is based on nature and human duality water cycle theory which specify agriculture, industrial and living consumptive water use in space time. SWAT can run to determine which HRU has highest modelling efficiencies. SWAT model has capability to generate long data series which can utilize to perform monthly stream flow and ground water table depth in the area that lack historical data.

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Storm Water Management Problems and Initiatives in India

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ABSTRACT

Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localised incidents to major incidents, resulting in cities being inundated from a few hours to several days. In most of the cities, damage to vital infrastructure has a bearing not only locally but could even have global implications. There has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected. The most notable amongst them are Hyderabad in 2000, Ahmedabad in 2001, Delhi in 2002 and 2003, Chennai in 2004, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009 and Guwahati and Delhi in 2010. Among the important cities of India, the average annual rainfall varies from 2932 mm in Goa and 2401 mm in Mumbai on the higher side, to 669 mm in Jaipur on the lower side. The rainfall pattern and temporal duration is almost similar in all these cities, which receive the maximum rainfall from the south-west monsoons. The average rainfall for the month of July in Mumbai is 868 mm and this far exceeds the annual average rainfall of 611 mm in London. Even though urban flooding has been experienced over decades in India but sufficient attention was not given to plan specific efforts to deal with it. The present paper emphasizing on stormwater management indices brought out by Government of India and management practices that can be adopted in India.

INTRODUCTION

Storm water management encompasses the policies, strategies and activities to manage fresh water as a sustainable resource to protect the water environment and to meet current and future human demand. Stormwater is water that originates during precipitation events. Stormwater that does not soak into the ground becomes surface runoff, which either flows directly into surface water ways or is channeled into storm sewers which eventually discharge to surface waters. Stormwater is of concern for two main issues: one related to the volume and timing of runoff water (flooding) and the other related to potential contaminants that the water is carrying, i.e. water pollution. Stormwater is also a resource for ever growing world's human population as readily available water. Techniques of stormwater harvesting with point source water management and purification can potentially make urban environments self-sustaining in terms of water. But the storm water also causes problems if not properly designed and managed especially in urban areas in the form of flooding. Urban flooding is the inundation of land or property in a built-up environment caused by stormwater overwhelming the capacity of drainage systems. It is characterized by its repetitive, costly and systemic impacts on communities. Although the number of casualties from urban flooding is usually limited, the economic, social and environmental consequences are considerable. Urban flooding has significant economic implications. In the U.S., industry experts estimate that wet basements can lower property values by 10-25 percent and are cited among the top reasons for not purchasing a home.[1] According to the Federal Emergency Management Agency almost 40 percent of small businesses never reopen their doors following a flooding disaster.[2] In the UK, urban flooding is estimated to cost £270 million a year in England and Wales; 80,000 homes are at risk.[3] A study of Cook County, Illinois, identified 177,000 property damage insurance claims made across 96 percent of the county's ZIP codes over a five-year period from 2007-2011. This is the equivalent of one in six properties in the County making a claim.[4]

Urbanization in India

In 2001, there were about 286 million people residing in urban areas in the country accounting for about 27.8 % of the total population. Urban population is projected to be around 433 million by 2021. There is a marked impact of globalization on urban growth, which is increasingly concentrated in and around urban areas, large and small. The trend of urbanization in India is shown in Table 1.

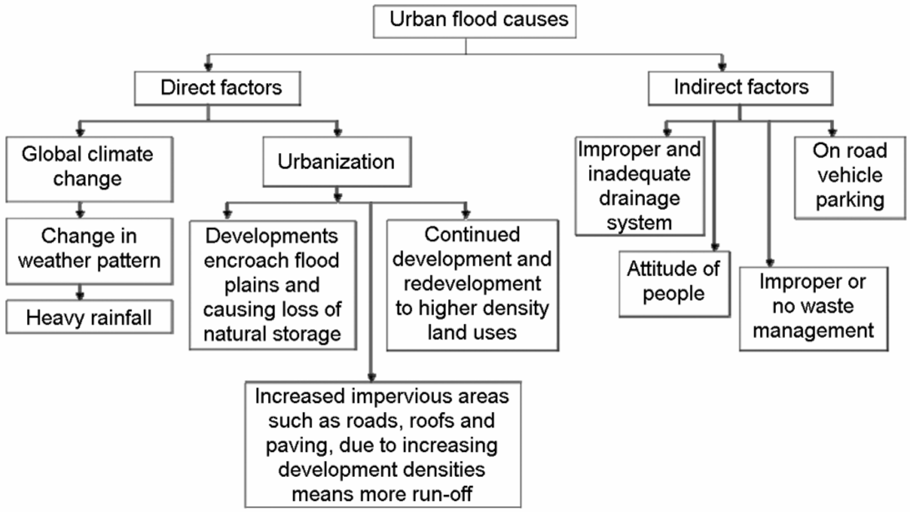
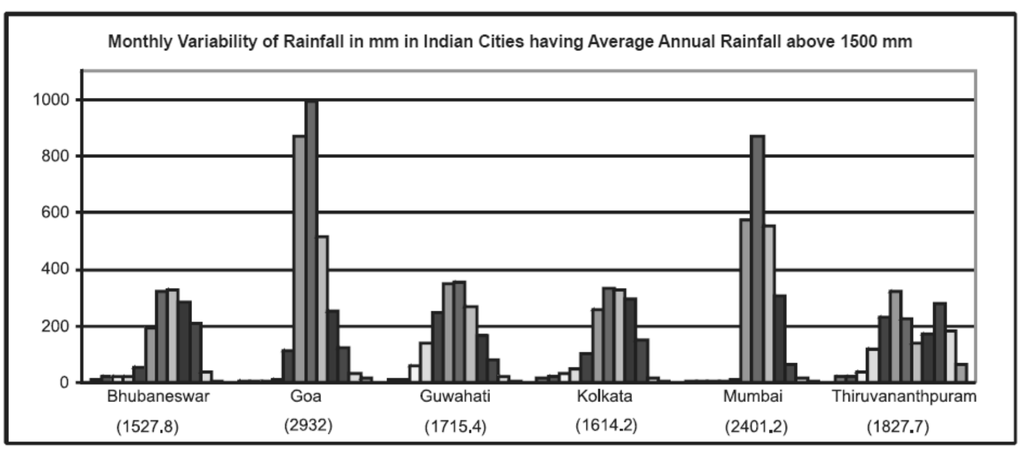


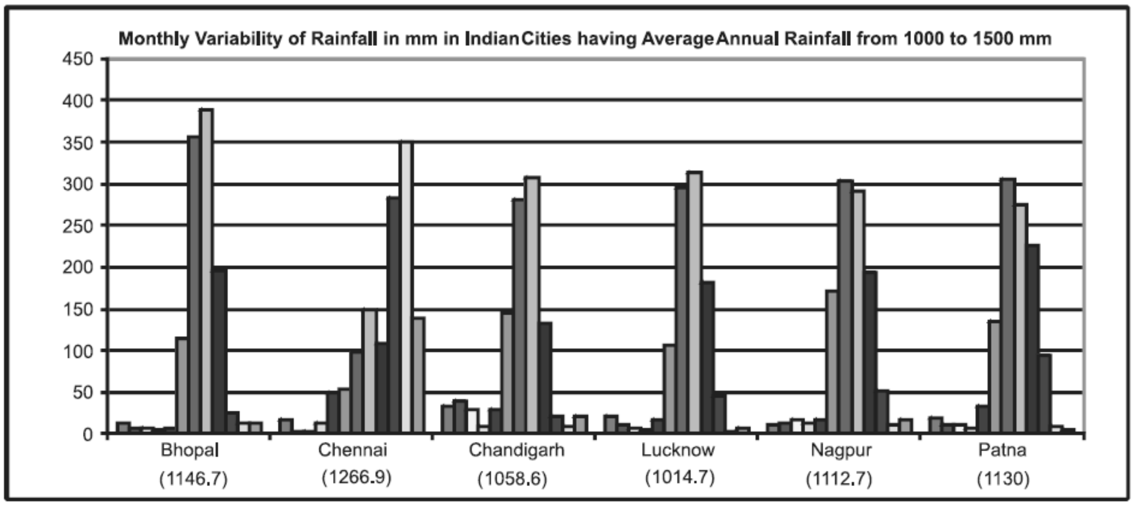
Table 1: Trend of Urbanization in India

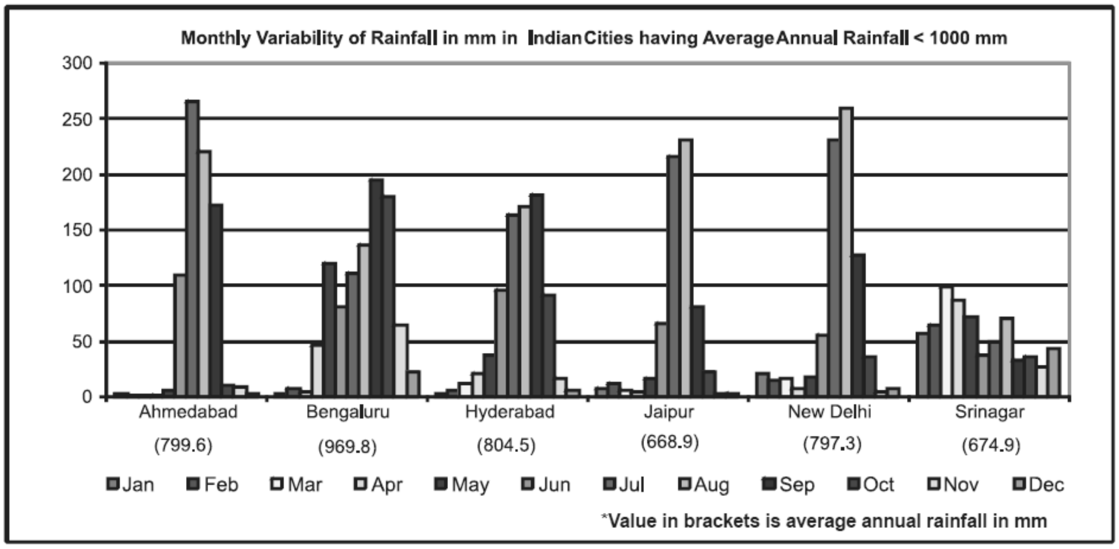
S.No	Details	Year			
		1991	**2001**	**2011**	**2021#**
1	No. of Urban Agglomerations, Cities & Towns	3768	5161	7935	10000
2	Urban Population (in million)	216.61	285.35	377.1	433
3	Percentage of total population	25.71	27.8	31.16	32.3

Causes for Urban Floods: Even though urban flooding has been experienced over decades in India but sufficient attention was not given to plan specific efforts to deal with it. In the past, any strategy on flood disaster management largely focused on riverine floods affecting large extents of rural areas. Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times.

Monthly Variability of Rainfall in some important Indian Cities







Source: National Disaster Management Guidelines: Management of Urban Flooding

Stormwater Management

That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface water body, or a constructed infiltration facility is known as stormwater. The process of controlling the quality and quantity of stormwater to protect the downstream environment is stormwater water management

Impact of Stormwater in Urban Areas

Urban conditions exacerbate drainage problems; runoff is increased by impermeable urban surfaces due to inadequate development control mechanisms settlements are constructed with little consideration for storm water drainage. Impact due to storm water flooding can be classified in relation to their physical and environmental health impacts, which are:

(i) *Physical impacts:* Flooding can cause widespread disruption to transportation, power and communication systems, as well as structural damage to buildings and infrastructure. The disruption, damage to properties, loss of possessions, as well as financial worries and other stresses from living in damp houses mean that flood events can place a considerable strain on households. Due to the high intensities of rainfall during rainy seasons, the lack of drainage infrastructure and the failure to maintain existing systems, the impacts of flooding are widespread and it is the poor who are most susceptible and consequently suffer the most.

(ii) *Environmental health impacts:* Experience indicate that flooding and poor drainage have a significant impact on the prevalence of illness, and that large-scale flooding may disrupt water supply and sanitation systems and result in disease epidemics. In poorly drained areas with inadequate sanitation, urban runoff mixes with excreta – spreading pathogens around communities and increasing risks to health from various waterborne diseases. Infiltration of polluted water into low-pressure water supply systems can contaminate drinking water and is frequently a source of gastrointestinal disorders. Flooded septic tanks and leach pits, and blocked drains provide breeding sites for *Culex* mosquitoes, which transmit filariasis,

The benefits of stormwater management

There are many benefits to stormwater management. It supports environmental sustainability by:

- minimizing or avoiding the creation of polluted stormwater
- reducing environmental impacts on the lakes, rivers and watersheds
- achieving greater harmony with the water cycle in the watershed
- potentially reducing municipal water supply requirements by using stormwater as an alternative water source
- minimizing health risks
- Stormwater management also contributes to community safety and financial risk management by reducing the risk of urban flooding and erosion. The associated basement flooding and damage to public and private properties can also be avoided (in conjunction with major drainage systems built by municipalities).

Stormwater Management Actions initiated in India: Prime Minister of India released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation on June 30, 2008, The NAPCC has set out eight "National Missions" as the way forward in implementing the Government's strategy and achieving the National Action Plan's objective. The focus of these missions is on "promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation." The National Mission on Sustainable Habitat is one of them. With a view to initiating action in respect of the first deliverable i.e development of National Sustainable Habitat Standards, the Ministry of Urban Development has constituted six sub-committees. The Sub-Committee for Development of "National Sustainable Habitat Parameters on Urban Stormwater Management" was constituted by the Ministry of Urban Development in August 2010 and subsequently, re-constituted on 11.10.2010. The approach that emerged was that "What gets measured gets managed". Based on detailed deliberations, the following main parameters have been identified, which will enable developing legal frame work/regulations to improve the urban planning in respect of storm water drainage and minimize the incidence of flooding in urban areas.

Development of Indices

To assess and monitor the progress of implementing sustainable stormwater management, there is a need to develop key parameters and indicators in the form of indices, for systematic and scientific assessment of situation, progress and deficit. Each of the indicators designed for stormwater management should serve the purpose and promote understanding of where we are, where we are going and how far we are from the goal, which can be further aggregated to form complex indices. Based on this approach, a set of parameters/indicators in the form of indices have been developed which need to be considered at all stages of development namely, planning, implementation and operation and maintenance subject to its appropriateness and significance to the specific stage.

1. **Master Plan Index**: Existing storm water drains are provided based on comprehensive planning and designing or in piece-meal manner. The basic assumption is that each city has a basic master drainage

plan and where none exists, the master plan would be formulated and the indices would also complement the formulation of the drainage master plan. This will enable the integration of the city's **drainage master plan** with the CDP.

2. **Natural Drainage System Index**: This index can be defined as the ratio of natural drainage systems up and running to the total natural drainage systems (as existing on a predetermined date) and can be used as an indicator for the sustainability of the natural drainage system.
3. **Drainage Coverage(Constructed) Index**: Level of coverage of an urban area with man-made storm drainage systems. This index can be defined as the ratio of the length of existing constructed drains to the length of total constructed drains required for an area.
4. **Permeability Index-** This index can be defined as the percentage of the catchment which is impervious. (Note – Attempts should be made through sustainable drainage practices to restore the permeability index of the catchment to pre-development levels).
5. **Water bodies Rejuvenation Index**: This index is to define the sustainability of the water bodies (past and present). For the rejuvenation of water bodies, the ratio of total area under water bodies planned for rejuvenation to the total area of water bodies including those encroached upon may be used as an indicator.
6. **Water body Vulnerability Index**: In regard to the habitations in the existing water bodies/flood prone areas, it was proposed that the ratio of total area under water bodies encroached (present date) to the total area under water bodies (on a datum date) may be used as an indicator.
7. **Water logging Index**: This index is to reflect the sustainability of an area to incidences of water logging. Presently, the area inundated for four hours or more and having water depth more than 6" are considered as affected by water logging. However, to make our cities more sustainable and disaster resistant, the duration of 4 hours should be reduced to 1 hour based on experiences in cities like Delhi and Mumbai. (Flood prone area is categorized as one having 15 houses or more which are affected by flood).
8. **Area Vulnerability Index**: In regard to the habitations in low lying areas / flood prone areas, it is proposed that the ratio of total flood prone as area (present date) to the total city area (on a datum date) may be used an indicator.
9. **People Vulnerability Index:** Identify vulnerable points in the slums -Number of people affected in vulnerable area with or without drainage divided by total number of people staying in the vulnerable area (with or without drainage) may be an indicator.
10. **Flood Moderation Index**: Lakes/ponds are the best moderators. The index may be defined as the ratio of area not flooded due to moderation to the area that would have been flooded without moderation.
11. **Drainage Cleaning Index**: This is a very important parameter as regards, routine operation & maintenance / cleaning of drains. It is opined that cleaning should be done at least three times a year. (i) First, the process must start by 31st March each year and be completed one month before the normal arrival of monsoon each year. (ii) The drains should also be thoroughly cleaned after first heavy shower, (iii) subsequently, after retreating of rain i.e. in the post monsoon, the cleaning of drains is essential. In addition, the ULBs may clean drains regularly, as per requirement. The availability of trained manpower and O & M Manual for operating and maintaining drainage system also need to be ensured.
12. **Complaint Redressal index:** A certain eligible category of complaints registered and those addressed may be considered as an indicator of the efficiency of stormwater O & M. The index may be defined as the ratio of drainage-related complaints addressed satisfactorily to the total number of drainage-related complaints.
13. **Climate Change Stress Index**: The matter regarding the overstressing of existing drainage infrastructure due to climate change was also considered. As per the recommendations of International Conference on Urban Drainage in 2008, 20% increase in calculated discharge suggested for designing for future storm

water drains was agreed. The index may be defined as the ratio of the projected rainfall intensity for a city to the present rainfall intensity being used for design for that city.

14. **Stormwater discharge quality Index**: This may be defined as the ratio of the measured value of Total Suspended Solids (TSS)/Biochemical Oxygen Demand (BOD) of the storm drain water to the prescribed limits of TSS/BOD.
15. **Sewage Mixing Index**: Incidences of mixing of sewage with storm water to be avoided / prohibited. The index may be defined as the ratio of the volume of sewage flows entering the storm water drainage system to the total volume of flows in the storm water system.
16. **Preparedness Index/ Early Warning Index:** This index would enable the quantification of the preparedness of the city/community and can be defined for each point on the drainage system as the **ratio of lead time to the flow time at the point.** Radar based advance warning system of rainfall as well as one based on real time rainfall intensity viz. critical rainfall intensity causing flooding /real time rainfall intensity likely to cause flooding in flood prone areas.
17. **Rainfall Intensity Index:** can be defined as the ratio of the observed rainfall intensity to the rainfall intensity which causes flooding in that particular area. It will enable the determination of the sustainability of an area to flooding.
18. **System Robustness Index -** for areas dependent on pumping, the index can be defined as the ratio of rate of incoming storm flow to rate of pumping.
19. **Tidal Index**: Parameter based on cycle of high and low tide for coastal areas. The index may be defined as the ratio of tidal level for which the present protection is adequate to the maximum tidal level observed for that area/city.
20. **Rain water Harvesting/Artificial Ground water Recharge Index:** With reference to the encroachment of natural streams passing through urban, it was observed that on one hand, the pathway / water line of natural streams are being blocked / constructed and on the other hand, more and more developments are coming on by paving the way in enhancing the run-off causing increased peak flow and frequent inundation in urban area. To overcome this, rain water harvesting to be made mandatory, while following building bye-laws and at suitable places, considering the overall suitability, artificial ground water recharge also to be encouraged. The recharge index may be defined as the ratio of the rainwater volume stored/harvested to the ratio of the measured rainfall volume. In the planning level itself, 2 to 5% of urban area should be reserved for water bodies to work as recharge zone.

Management of Stormwater

Stormwater management can be achieved by managing it at its source (Source Control) or through conventional infrastructure – or "conveyance" and "end-of-pipe treatment."

Source control: "Source control" means managing stormwater and preventing pollution where rain falls on individual lots or nearby in the neighborhood, such as along public roads. Some of the technologies are: i) rain gardens (plants and soils are built to absorb and use water), ii) green roofs, iii) permeable pavement, iv) rain barrels, v) rainwater harvesting, vi) treatment system for the reuse of stormwater as an alternate source of water

SUMMARY

Land development activities convert highly permeable surfaces into impermeable ones. This conversion often causes an increase in stormwater runoff and a decrease in both surface water quality and infiltration to groundwater. The combined effects of development are increased stormwater runoff into surface waters and decreased infiltration for groundwater recharge. The responsibility for stormwater management is often handled on a large scale and can be fragmented between state, local, and municipal government. While the focus is typically on large developments and the storm sewers systems, small areas can also contribute significant volumes of stormwater during rain events. By making changes at the residential lot level, much greater infiltration over the watershed area can be attained. Each home owner can significantly reduce the stormwater load that leaves his or her property, thereby improving surface water quality and helping to recharge groundwater reserves. On residential lots, these negative effects can often be minimized by incorporating some of the techniques described in this publication. By making small changes at the local level, water quality in the watershed can be greatly improved.

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THEME - IV

GROUNDWATER EXPLORATION, DEVELOPMENT, RECHARGE AND MODELING

Aquifer Systems and their Characteristics in India

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ABSTRACT

Ground water has emerged as important source of water in various sectors in the country. The increasing dependence on ground water has resulted in large scale exploitation warranting the need to focus more on management practices. A need has been felt to revisit aquifers with clearcut link to groundwater management. The entire country has been classified into 14 Principal Aquifer Systems, of which alluvium is the major aquifer which covers maximum area of around 31% of the entire country. Over exploited units cover 14.8 % of total area, which is observed to be more in alluvium (48%), followed by BGC (16.5 %). Area covered by critical units is around 2.29 % of total area, which is also more in alluvial aquifers, followed by BGC. Overexploited area is highest in Rajasthan followed by Karnataka, Tamil Nadu. In consolidated aquifers, Over exploited units are more in Peninsular states Karnataka, Tamil Nadu. The analysis of data from 15,000 ground water monitoring wells being monitored by Central Ground Water Board indicates that the depth to water (DTW) ranges upto 40 m. The areas with deeper water level coincide with areas under OE & critical categories in the country. The most widespread ground water quality problem**s** due to geogenic contamination are fluoride, arsenic, salinity. Fluoride affected areas also suffer from over-exploitation suggesting relation between fluoride incidence and high development. Arsenic contamination is observed mainly in alluvial aquifer in West Bengal, Uttar Pradesh, Bihar and Assam. The comprehensive aquifer information being generated through aquifer mapping together with concerted ground water management interventions with active involvement of public, NGOs, VOs and government departments will go long way in sustainable management of ground water resource.

Keywords**:** Aquifer System, Characteristics, management strategies, India

INTRODUCTION

Ground water has emerged as the backbone of India's agriculture and drinking water security. It is the source for more than 85 percent of India's rural domestic water requirements, 50 percent of its urban water requirements and more than 50 percent of its irrigation requirements and is depleting fast in many areas of the country due to its large-scale withdrawal for various sectors (CGWB, 2013). The rapid development of ground water resources for varied usages has contributed in expansion of irrigated agriculture, overall economic development and in improving the quality of life in India. The ground water development with time has changed the hydrogeological regime and as a result recharge and draft components have altered to a great extent. Out of a total of 5723 assessment units in the country, 802 units have been categorised as over exploited, 169 as critical and 523 units as semi-critical as on 31st March 2004, apart from 71 units as saline infested (CGWB, 2013). Ground water is a common pool resource and the first design principle in management of resource is the clear delineation and demarcation of the aquifer boundaries and an understanding of its essential features. Thus a need has been felt to demarcate aquifer systems in the country so as to provide critical information to plan sustainability of aquifer systems. Central Ground Water Board (CGWB) over the years has generated lot of aquifer related data through its exploration in the entire country.

As a first step towards depiciphering the aquifers, CGWB has analysed the available data and brought out atlas of aquifer systems of India on regional scale (1:2 million scale), in which country has been divided into 14 principle aquifers, which are further divided into 42 major aquifers (CGWB, 2012). Realising the importance of the aquifer mapping, of late Ministry of Water Resources, Government of India proposed aquifer mapping on 1:50,000 scale with an objective of delineation of aquifer geometry, linked to groundwater management with participatory mode at village level. The objective of this paper is to bringout various aquifer systems, their characteristics, issues and management strategies for sustainability of resource in the country.

Aquifer Systems

India is a vast country with diverse geological, climatological and topographic conditions which gave rise to widely varying ground water situations. Physiography varies widely from rugged mountainous terrains of Himalayas, Eastern Ghats, Western Ghats and Deccan Plateau to the flat alluvial plains of the river valleys and coastal tracts, and the aeolian deserts in western part. The rock formations, ranging in age from Archaean to Recent, control the occurrence and movement of ground water and by their unique characteristics, formations can be classified as different aquifers.

Based on the hydrogeological characteristics, the entire country has been classified into 14 Principal Aquifer Systems namely; Alluvium (unconsolidated formation), Sandstone, Shale (semi-consolidated formations) Laterite, Basalt, Limestone, Granite, Schist, Quartzite, Charnockite, Khondalite, Banded Gneissic Complex (BGC) , Gneiss and Intrusives (consolidated formation) (Fig.1). Alluvium is the major aquifer which covers maximum area of around 31% of the entire country and form prolific aquifers in Uttar Pradesh, Bihar, West Bengal, Assam, Odisha, and Rajasthan. The Sandstone aquifer covers around 8% area in the country and is available in Chhattisgarh, Andhra Pradesh, Madhya Pradesh, Gujarat, Karnataka and Rajasthan. The rest of the country is covered with the other formations that cover around 60% of the area. Among these, Basalt aquifer covers maximum of around 17% area of the country and mainly spread over Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Karnataka. Shale aquifer accounts for around 7% of the area in the country and occurs mostly in Chhattisgarh, Andhra Pradesh, Madhya Pradesh, Rajasthan, and in the north-eastern states as well as in Himalayan terrain. Limestone aquifer covers a very small area of around 2% in the country and mainly available in the states of Chhattisgarh, Andhra Pradesh, Karnataka and Gujarat and in the Himalayan states. Around 20% of the area of the country is covered by Banded Gneissic Complex (BGC) and gneiss aquifers which are existing almost in all the peninsular as well as Himalayan states. The rest 15% of the area is covered by aquifers namely; Schist, Granite, Quartzite, Charnockite, Khondalite, Laterites and intrusive, occur sporadically in Peninsular India, western India and Himalayan region.

Fig. 1

Aquifer Characteristics

The various aquifer systems and their general characteristics in the country are given in Table 1. Of all aquifers, alluvium is the most potential aquifer with multiple zones with thickness of over 700 m (explored depth). The yield ranges upto 4000 m^3/day with transmissivity ranging upto 16000 m^2/day. Ground water quality varies widely from fresh to saline. Semi-consolidated Sandstone and shale aquifers constitute multi layered aquifer systems with thickness of over 600 m. The yield ranges upto 4800 m^3/day with high transmissivity values ranging upto 6000 m^2/day. Ground water in Basalt, Granite, Schist, Quartzite, Charnockite, Khondalite, BGC , Gneiss and Intrusive aquifers is mostly limited to weathered and fractured zones and as such ground water occurrence is highly heterogeneous and site specific. The thickness of weathering varies vary widely from few meters to as high as 40 m, while the fractures are encountered down to depth of 200 m or even beyond. The fracture intensity is more at shallow depths and along the lineament zones. The yield varies widely from meagre to 5 litres per second, often recording very high discharges upto 10 lps. The transmissivities are usually low while the specific yield values range upto 3 %. In limestone aquifers solution cavities form promising zones. Typical hydrogeological environments of major aquifers are shown in Fig.2 while typical hydrogeological sections in grantic and sandstone/alluvial aquifers are depicted in Fig.3. Fig.4 depicts yield pattern of different aquifers in the country.

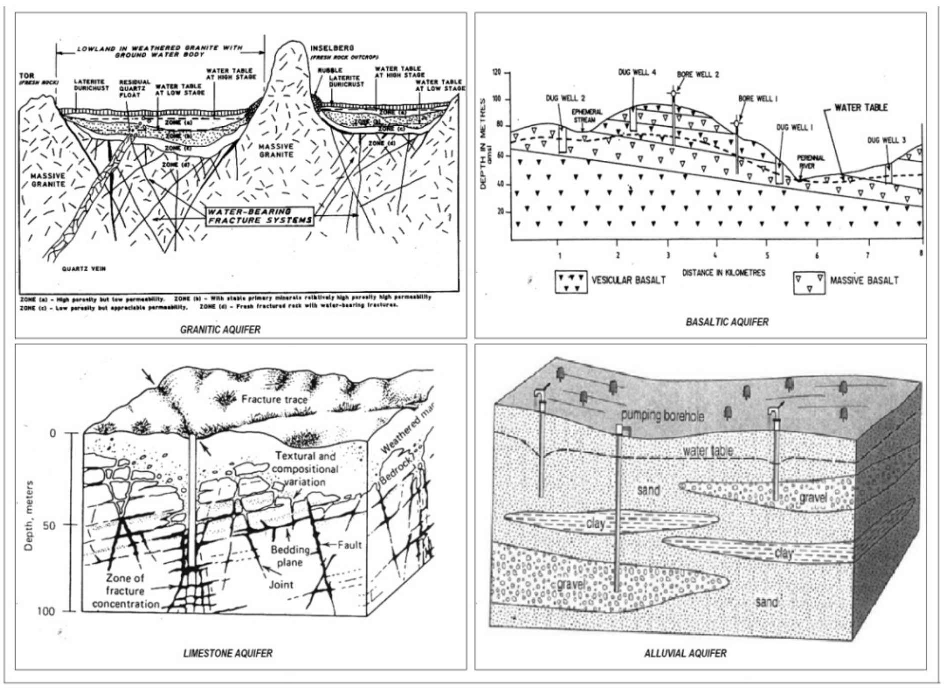

Fig. 2 Typical hydrogeological environments

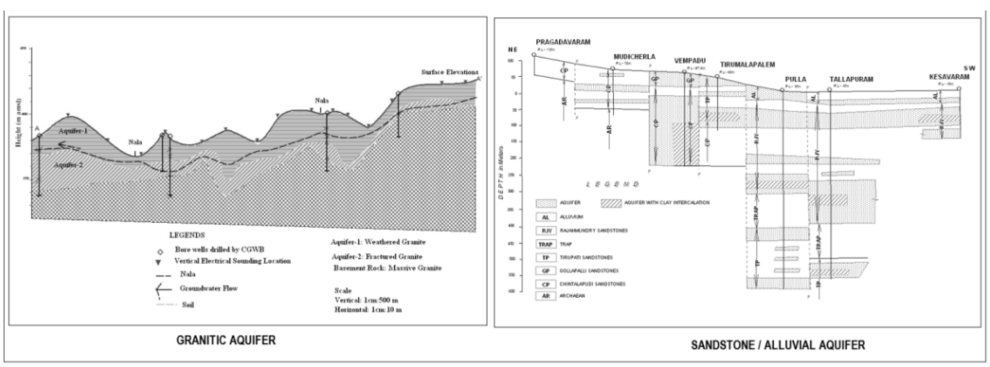

Fig. 3 Typical Hydrogeological Sections

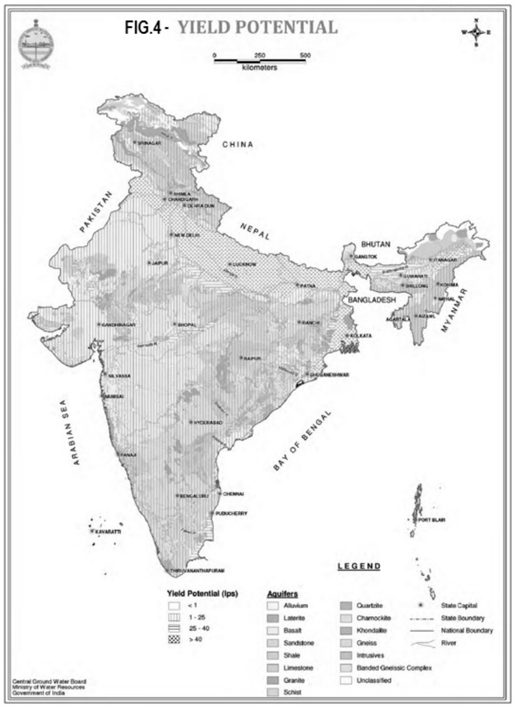

Fig. 4 Yield potential

Table 1 Aquifer systems in India and their characteristics

Sl. No.	Name of the Aquifer	Area (%)	Thickness range (m)	Transmissivity (T) (m^2/day)	Yield range (m^3/day)	Specific Yield (%)	Quality (EC in micromohos/ cm)
1	Alluvium	9,45,753.52 (29.82%)	0 to 700	2 to 16000	10 to 4000	6 to 20	500 to 3000
2	Basalt	5,12,302.02 (16.15%)	5 to 60	6 to 740	1 to 480	1 to 3	500 to 8000
3	BGC	4,78,383 .00 (15.09%)	3 to 100	2 to 186	2 to 691	Upto 3	500 to 4000
4	Gneiss	1,58,753.26 (5.01%)	3 to 25	5 to 80	20 to 2500	Upto 5	500 to 4000
5	Sandstone	2,60,415.61 (8.21%)	20 to 600	3 to 6000	5 to 4800	Upto 15	500 to 5500
6	Shale	2,25,937.03 (7.12%)	Upto 250	Upto 740	8 to 2880	Upto 3	500 to 6000
7	Limestone	62,898.91 (1.98%)	8 to 451	1.2 to 450	4 to 2100	Upto 3	500 to 3000
8	Granite	1,00,991.81 (3.18%)	5 to 40	2.3 to 500	1 to 1440	Upto 3	500 to 2500
9	Schist	1,40,934.90 (4.44%)	4 to 80	2 to 90	3 to 562	Upto 3	500 to 5000
10	Quartzite	46,904.09 (1.48%)	5 to 30	2.7 to 211	2 to 400	1 to 2.5	500 to 4500
11	Charnockite	76,359.75 (2.4%)	5 to 45	5 to 476	0.5 to 2500	Upto 5	500 to 3000
12	Khondalite	32,913.94 (1.04%)	5 to 30	10 to 476	20 to 1500	Upto 3	500 to 4000
13	Laterite	40925.68 (1.29%)	2 to 30	4 to 1500	5 to 6048	Upto 9	500 to 3000
14	Intrusives	19895.95 (0.63%)	13 m	0.71 to 81	0.02 to 258	Upto 2	500 to 4500

BGC – Banded Gneissic Complex

Major Ground Water Issues

Ground water resource availability

Rainfall is the major source of ground water recharge in India, which is supplemented by other sources such as recharge from canals, irrigated fields and surface water bodies. The dynamic ground water resource assessment was carried out with Block/Mandal/Taluka/Watershed as the unit as per norms recommended by the Ground Water Estimation Committee (GEC)-1997. The annual replenishable ground water resource has been estimated as 431 billion cubic meter (bcm) while net ground water availability is 396 BCM. (Central Ground Water Board, 2013).

There is huge resource in alluvial aquifer in Indo-Gangetic alluvium particularly in U.P, Bihar, due to huge thickness of multi-granular zones, high specific yield and good rainfall. However, in Rajasthan, the resource is less due to less rainfall. In coastal tracts though considerable resource lies in deltaic alluvial aquifers, it suffers from inherent salinity, as such there is constraint in further ground water development. In hard rock aquifers the resource availability is less, and even the limited available ground water resource cannot be fully tapped due its uneven distribution and as such these aquifers are highly vulnerable to droughts.

Out of 5842 assessment units, 802 units have been categorised as over exploited, 169 as critical and 523 units as semi-critical. Area covered by over exploited units cover around 48,6564 sq km which forms around-14.8 % to total area. This area is observed to be more in alluvium (48%), followed by BGC (16.5 %). Area covered by critical units cover around 75,604 sq km which forms around 2.29 % to total area (Table-2). Like OE units, area under critical category is also more in alluvial aquifers, followed by BGC (Table-3). A glance at the data shows that OE area is highest in Rajasthan (2,19,149 sq km), followed by Karnataka (67,474 sq km), Tamil Nadu (44,174 sq km). In consolidated aquifers, OE units are more in Peninsular states Karnataka, Tamil Nadu, Maharashtra, Andhra Pradesh etc.,

Water level depletion

Rapid and indiscriminate ground water development has resulted in depletion of ground water level in several parts of the country. Pre-monsoon decadal mean (2002-2011) of 15,000 ground water monitoring wells being monitored by Central Ground Water Board (Fig.5,6) indicates that depth to water (DTW) ranges upto 40 m. It suggests that in alluvial aquifer, decadal mean is shallower (<5 & 5-10 m range) in UP, Bihar, Assam while it is deeper (ranges of 10 to 20, 20-40 & >40 m) in parts of Punjab, Haryana, Rajasthan. This can be attributed to low ground water development in the UP, Bihar, Assam and high groundwater development in Punjab, Haryana, Rajasthan In alluvial aquifers along the coastal tracts, decadal mean is shallow (<5 m). In other aquifers decadal mean is highly variable, mostly in the range of 5-10 & 10 to 20 m in parts of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala In non-command areas, wherever ground water development is high and rainfall is less, ground water depletion is observed to be more. Broadly, the areas with deeper water levels coincide with areas under OE & critical categories in the country.

Ground Water Contamination

Geogenic contamination

The most widespread ground water quality problem due to geogenic contamination faced in the country is fluoride. As per the available data, 20 states have been affected, of which most affected states are Tamil Nadu, Karnataka, Andhra Pradesh, Rajasthan, Gujarat (covering hard rock aquifers), Punjab, Haryana, Rajasthan, Gujarat covering alluvial aquifer. Perusal of data suggests that these areas also suffer from over-exploitation suggesting relation between fluoride incidence and high development.

Arsenic contamination is observed mainly in alluvial aquifer in West Bengal, Uttar Pradesh, Bihar and Assam. Arsenic contamination has not been reported in consolidated aquifer except in Chattisgarh.

Inland salinity (>3000 micromhos/cm) is observed in parts of Delhi, Rajasthan, Punjab, Haryana, Gujarat which is attributed mostly to depositional environment. In East coast inherent ground water salinity of varied degree and dimensions (up to 60,000 microsiemens/cm) exist particularly in alluvial aquifers under major deltas. The salinity is mostly due to entrapped saline water (insitu) and leaching of salts could not get flushed during geologic time.

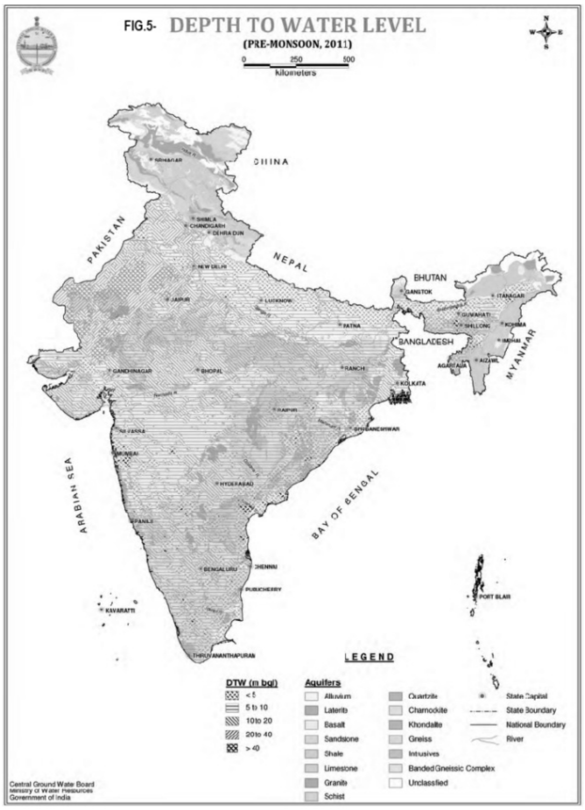

Fig. 5 Depth to water level

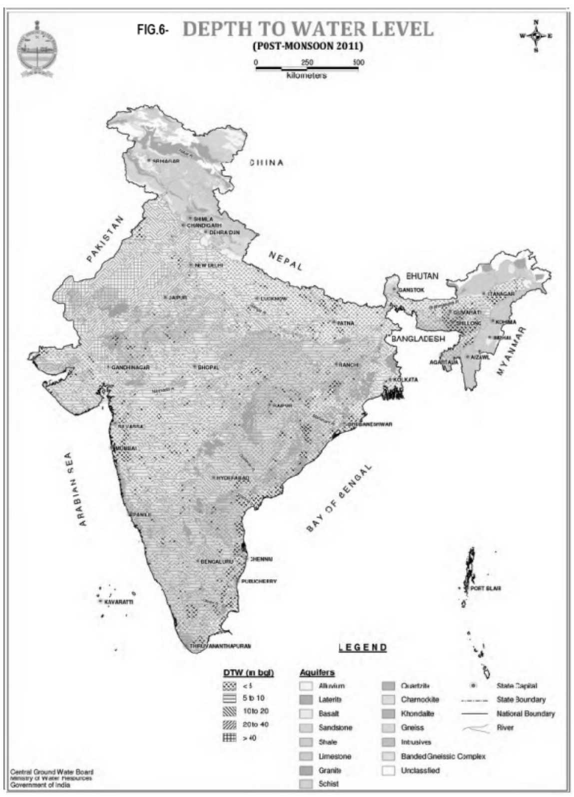

Fig. 6 Depth to water level

Table 2 Aquifer-Wise Area Under Over Exploited (OE) Blocks

State Name	Alluvium	Laterite	Basalt	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	Charnockite	Khondalite	BGC	Gneiss	Intrusives	Total
Andhra Pradesh	218	150	198	480	4365	577	1505	77	1675		258	11943	1	7	**21454**
Delhi	866								136						**1002**
Gujarat	15828		1059	1469	860	376	57						16		**19665**
Haryana	25262								201						**25463**
Jharkhand	229			124			2	344	17			500	56	1	**1273**
Karnataka	64	215	12575	118		2464		5323				46717			**67476**
Kerala													266		**266**
Madhya Pradesh	480	33	18176	320	357										**19366**
Maharashtra	2828		5001	2											**7831**
Punjab	37770			46											**37816**
Rajasthan	123621	74	7433	20502	11748	904	12157	3257	5367	173	74	17658	15712	470	**219150**
Tamil Nadu	5959	136		2247	123		503	7		13138	617	2207	18939	298	**44174**
Uttar Pradesh	20115			157								1356			**21628**
Grand Total	**233240**	**608**	**44442**	**25465**	**17453**	**4321**	**14224**	**9008**	**7396**	**13311**	**949**	**80381**	**34990**	**776**	**486564**

Table 3 Aquifer-Wise Area under Critical Blocks

State Name	Alluvium	Laterite	Basalt	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	Charnockite	Khondalite	BGC	Gneiss	Intrusives	Total
Andhra Pradesh	7	444	497	281			237	76				4414	28		**5984**
Delhi	392														**392**
Gujarat	4765	6	790	1861	1635	44	119	88	41				17		**9366**
Haryana	7297			1					37				4		**7339**
Jharkhand				18				2		42		438			**500**
Karnataka	74	28	2721			42		922				9366			**13153**
Kerala	45	7								6			468		**526**
Madhya Pradesh	454	6	1127	349	1180	636		9					15		**3776**
Punjab	995														**995**
Rajasthan	11389			1210	714		139	2	85			13	986	41	**14579**
Tamil Nadu	1041			349			94	112		3724	132	627	4330	13	**10422**
Uttar Pradesh	7801				10				141			620			**8572**
Grand Total	**34260**	**491**	**5135**	**4069**	**3539**	**722**	**589**	**1211**	**304**	**3772**	**132**	**15478**	**5848**	**54**	**75604**

Categorization Based on Dynamic Ground Water Resource of India, 2009.   Area in Sq.km

Anthropogenic contamination

Nitrate contamination in shallow aquifers is widespread in all aquifers in the country. Ground water when not polluted contains less than 5 mg/l. High concentration in ground waters suggest contamination, due to untreated sewerage.

Sea water intrusion has been reported from alluvial aquifers in Minjur area of Tiruvallur district north of Chennai city, ii)Puducherry and iii. Kuttam area of Tuticorn district in Tamil Nadu due to large scale exploitation of ground water. In Gujarat sea water intrusion has been reported around Jam Nagar, Porbandar, Mandvi and Gandhidham along Saurashtra and Kuchch coasts in Gujarat state. Various investigators have reported sea water intrusion in small patches locally in East Coast.

Management strategies

Revisiting aquifers by understanding them better through the aquifer mapping with clear cut forward link to participatory ground water management is desired. Govt. of India has launched National Project on Aquifer Mapping & Management (NAQUIM) during XII & XIII plans. An area of about 23 lakh sq km is being covered in prioritised areas at an estimated total cost of Rs.10,000 crores. The proposed programme is designed to make a significant step forward in ground water resource management by identifying and mapping aquifers, quantifying the available ground water resource potential and proposing plans appropriate to the scale of demand, aquifer characteristics and institutional arrangements. The comprehensive aquifer information being generated through aquifer mapping together with concerted ground water management interventions with active involvement of public, NGOs, VOs and government departments will go long way in sustainable management of ground water resource.

In hard rock aquifers, where ground water yields are low and erratic, one of the management practices could be change in the cropping pattern from high water consuming crops to less water consuming crops in ground water irrigated areas. There is need to increase the area under micro irrigation so as to conserve water which not only helps in reducing stress on ground water but also in increasing irrigated area and food production. Community well and cooperative farming methods need to be encouraged and practiced.

Concerted efforts need to be made to take measures to improve sewerage systems in urban areas, adopting artificial recharge and ensuring alternate drinking water sources in quality affected areas. Emphasis should be laid on R& D studies on reclaimation of contaminated aquifers.

Artificial recharge has now been accepted world-wide as a cost-effective method to augment ground water resources in areas where continued overexploitation without due regard to their recharging options has resulted in various undesirable environmental consequences. This can be adopted in all aquifers particularly in ground water stress areas (OE/critical/semicritical) and water quality affected areas. However, suitability of structure is to be decided based on hydrogeological considerations, availability of surplus run-off and landuse pattern. Based on the experience gained, check dams and percolation tanks are the suitable structures in hard rock aquifers. A total area of about 941541 sq km has been identified for artificial recharge in the country by CGWB. It is estimated that annually about 85565 MCM of surplus run off is to be harnesses to augment the ground water.

Scientific studies have proved that ample reserve of ground water is available in the areas underlain by Indo-Gangetic and Brahmaputra alluvial plains in the northern and north-eastern parts of country. In storage ground water resources down to 400 m works out to be 10812 bcm. Ground water in this area is sub-optimal and offers considerable scope for further ground water development in future.

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Assessment of Depth to Groundwater Levels (DTW) in Kalyandurg Area of Anantapur District, Andhra Pradesh, India using Remote Sensing and GIS Techniques

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ABSTRACT

The present paper examines the Depth to Groundwater levels and stage of the groundwater development in the study area of Kalyandurg, Anantapur District of Andhra Pradesh. The Depth to Water levels (DTW) for pre and post monsoon period of 2000 and 2012 year assessed. For this study Groundwater Samples collected for 6 locations in the study area from Groundwater department, Anantapur, A.P, the study has found that the depth to water level of pre (May) and Post Monsoon (Nov) period of 2000 observed deep water levels 10.36 and 12.55 m (bgl) in Setturu and Shallow groundwater zones is observed at Vepulaparthi 3.75 m (bgl) Golla 4.54 m (bgl) in Kalyandurg mandal, at the same time for 2012 water level depth has been increased compare to 2000. Deep water levels 12.86 m (bgl) and 16.79 m (bgl) in Setturu and shallow groundwater levels observed in Golla 2012m (bgl) and 4.96 m (bgl) for pre and post monsoon period of 2012. Present's Stage of ground water development in the study area as estimated by the A.P. Groundwater Department collected this data and analyzed, ground water development has reached the critical or overexploited Stage in two thirds of the villages in the study area.

Keywords: Ground Water, Water levels, Andhra Pradesh, Samples.

INTRODUCTION

Groundwater is a replenishable and dynamic natural resource widely distributed on the earth. In fact the largest source of fresh water lies underground and it accounts for 97 per cent of the fresh water if glaciers are excluded. The arid and semi-arid regions depend upon more ground water for major part of the water requirements. The available ground water has to be investigated and developed on scientific lines.

The challenges to facilitate the livelihoods of any region to adopt a judicial and scientific utilization of land and water resources for a sustainable well-being are huge, diversified, quite complex and dynamics. The major problems like over-exploitation, under-utilization and miss-utilization of water resources are presented in one way or other as the significant regional claims and conflicts and ultimately leading to jeopardizing the local environment from micro to macro spatial levels. In view of these problems, spatial understanding and analysis of water resource use for human welfare with environmental safeguards seems to be a paramount need now.

Groundwater study is multi-disciplinary in approach and knowledge of different disciplines such as Hydrometeology, Hydrology, Geology, Geophysics, Hydrologeology, Engineering, well hydraulics and chemistry is necessary for its evaluation and development.

As different factors like morphology, slope, drainage pattern, rock type, attitude of the rock, joint patterns and texture and structure control, the occurrence and distribution of ground water, a detailed study of these aspects is made here with the help of geological and topographical maps and high resolution satellite images. Material from the reports of the State and Central Ground water Department is also used. In this contest about wells distribution, use, other well statistics and domestic water.

The Kalyandurg area has been selected for this study because (a) it falls in the backward region of Rayalaseema, which has been experiencing droughts and famines for several decades, at the same time India's second lowest Rainfall was recorded at Hagiri Valley is located in this region. (b) it has diversified landforms. (c) The easy availability of remotely sensed data and other socio-economic data.

STUDY AREA

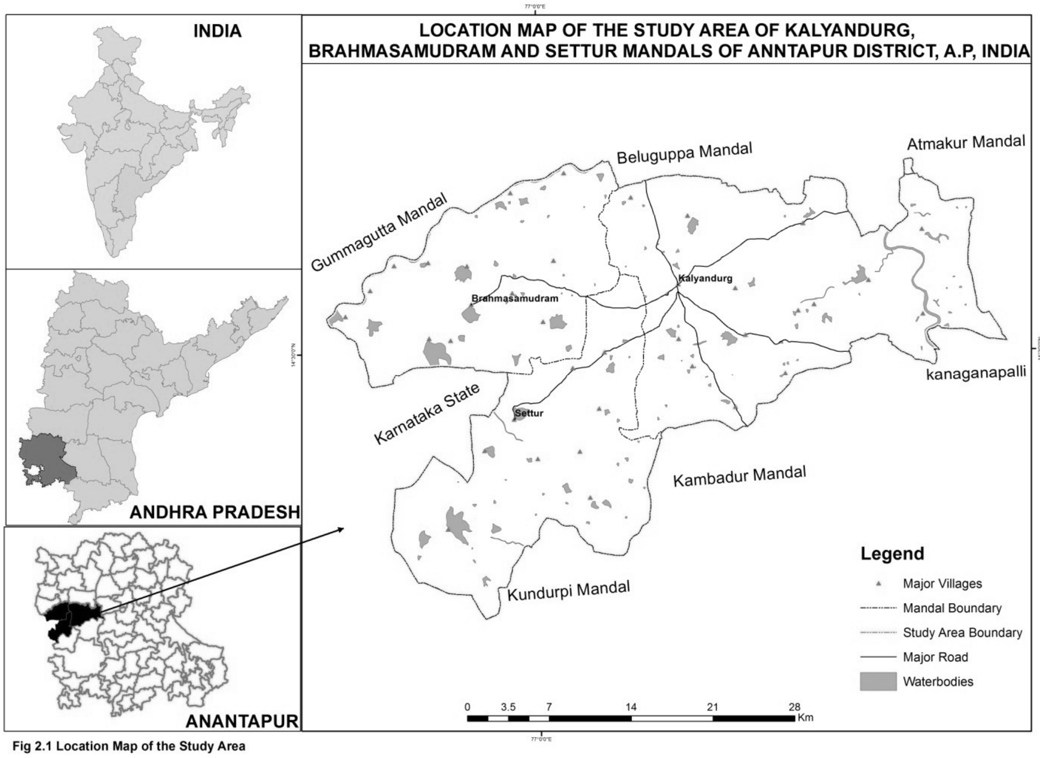

Fig. 1 Location Map of the Study Area of Kalyandurg

The present Study area of Kalyandurg, consisting of Kalyandurg, Brahmasamudram and Settur Mandals of Ananthapur district of Andhra Pradesh. Lies between 14^0 17' and 14^0 40' north latitude and 76^0 50' and 77^0 24' east longitude. It is located in the middle of the peninsular region and is confined to southwestern part of Andhra Pradesh. It is bounded by Gummagatta, Beluguppa, Atmakur, Kanaganapalli and Kambadur Kundurphi mandals of the same district and western side bounded by Karnataka state. The total geographical area of the study area is 1101.25 Sq Km., According to 2011 census the total population is 1, 76,297 of which urban population is 32,335 (18 %), with literacy rate of 60.92 % and the sex ratio of total population is 964.

Kalyandurg area is the most chronicle drought prone part and also the most backward area located on western side of Anantapr district. Annual temperatures vary between 21 and 42^OC. In summer, temperatures will reach up to 42^OC for three months from March to May. Annual average rain fall varies between 370 m.m. and 760 m.m. Soil cover in the study area is predominantly red loamy soils followed by black soils and alluvial soils.

Natural vegetation is very thin and scanty and mostly thorn scrub jungle type. The terrain is largely undulating and closely disclosing the characteristic feature of plateau topography.

DATA BASE AND METHODOLOGY

In the present study an application of geospatial technologies like Remote sensing and GIS techniques is vigorous for assessment of water resources in the present study area.

REMOTE SENSING

Remote sensing is the process of sensing and measuring objects from a distance without directly coming physically into contact with them. This technique employs a sensor, positioned on a platform, which detects and records data from one or more bands within the electromagnetic spectrum. In this chapter, the basic parameters of remote sensing: electromagnetic spectrum, and the past and present satellites available and its capabilities for earth resources observation were discussed.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

Geographic information system tools are used for the processing of spatial data into information, generally information explicitly used to make decisions. GIS can be defined as "a computer system for collecting, checking, integrating and analyzing information related to the surface of the earth" (Fundamentals of Geographic Information Systems" by Michael N Demers from John Wiley & sons Inc). Some of the major components of GIS are: a). Hardware b). Software c). Data

Material requirement for mapping of DTW (Depth to Water Levels) are Basic Requirements

(a) Hardware requirement for interpretation for robust handling and timely accomplishment of the steps involved in image analysis, the following minimum standard hardware configuration is required. i. Processor: Minimum of 2.0 GHz P –IV make or equivalent processor ii. Disk space: Minimum of 80 Gigabyte iii. RAM: Minimum of 512 Mb iv. Display size: At least 17 inch monitor iii. Topographical maps iv. District profiles

(b) *Field work*: Optimal ground data collection in terms of precision and content needs to be carried out by involving following instruments i.GPS ii. Good quality photographic camera (Digital camera is preferred) iii. Hardcopies of images for ground data collection.

Survey of India Topographic maps on 1: 50000 scale has been used for preparation of base features such as Settlements, Transportation, Forest boundaries Drainage features and other Resource maps. The study area falls under Survey of India topo sheet No D43 K14, K15, L2, L3, L6 and L7 of 1: 50,000 scale (latest series).and Secondary data Collected from Groundwater department for preparing the Depth to Groundwater levels (DTW) maps.

Base Map and other maps prepared using Survey of India Topographic maps on 1: 50,000 scale and Depth to Groundwater level (DTW) maps prepared based on Ground water samples collected from Groundwater department, initially this excel table joined into spatial data and using Spline with Barriers tool prepared DTW mps (Interpolates a raster surface, using barriers, from points using a minimum curvature spline technique. The barriers are entered as either polygon or polyline features) –using Arc GIS 10.1tool and for Geo-rectification of Toposheets used ERDAS 8.6.

RESULTS AND DISCUSSION

DYNAMICS OF GROUND WATER RESOURCES

The dynamics of ground water reserves for the study area are collected from Ground water department, Anantapur, A.P. prepared shown in tables and figures, pre and post monsoon period of 2000 and 2011.

DEPTH TO WATER LEVELS (DTW)

Table 1 Depth to Ground water (DTW) levels for 2000

S. No.	Location of the well		Pre-Post(May-Nov) Monsoon depth to groundwater level in m.(bgl) in 2000	
	Mandal	Village	May	November
1	Brahmasamudram	Brahmasamudram	9.55	8.64
2	Brahmasamudram	Kannepalli	6.19	3.59
4	Kalyandurg	Golla	4.54	2.05
5	Settur	Settur	10.36	12.55
6	Settur	Anumapalli	5.75	5.2

Source: District ground water department, Anantapur

Depth to Water levels for pre and Post monsoon period of 2000: The study of depth to water level of pre (May) and post monsoon (Nov) period of 2000 as shown in the Figure 6.2 and Table 6.2, indicates deep water levels 10.36 m (bgl) Is observed in Setturu and 9.55 m (bgl) Brahmasamudram at the same time post monsoon period (November) also observed 12.55 m (bgl) in Setturu and 8.64 in Brahmasamudram. Moderate ground water levels are observed for pre monsoon period in Kannepalli 6.19 m (bgl) in Brahmasamudram mandal and Anumpalli 5.75 m (bgl) in Setturu mandal at the same time for post monsoon period Vepulaparthi 5.65 m (bgl) Brahmasamudram mandal, Anumpalli 5.2 m (bgl). Shallow groundwater zones with water levels <5m. is observed in Golla 4.54 m (bgl) in Kalyndurg mandal and Vepulaparthi 3.75 m (bgl) for pre monsoon period, for post monsoon period Kannepalli 3.59 m (bgl) and Golla 2.05 m (bgl) was observed as shown in Table 6.2 and Figure 6.2 and 6.3.

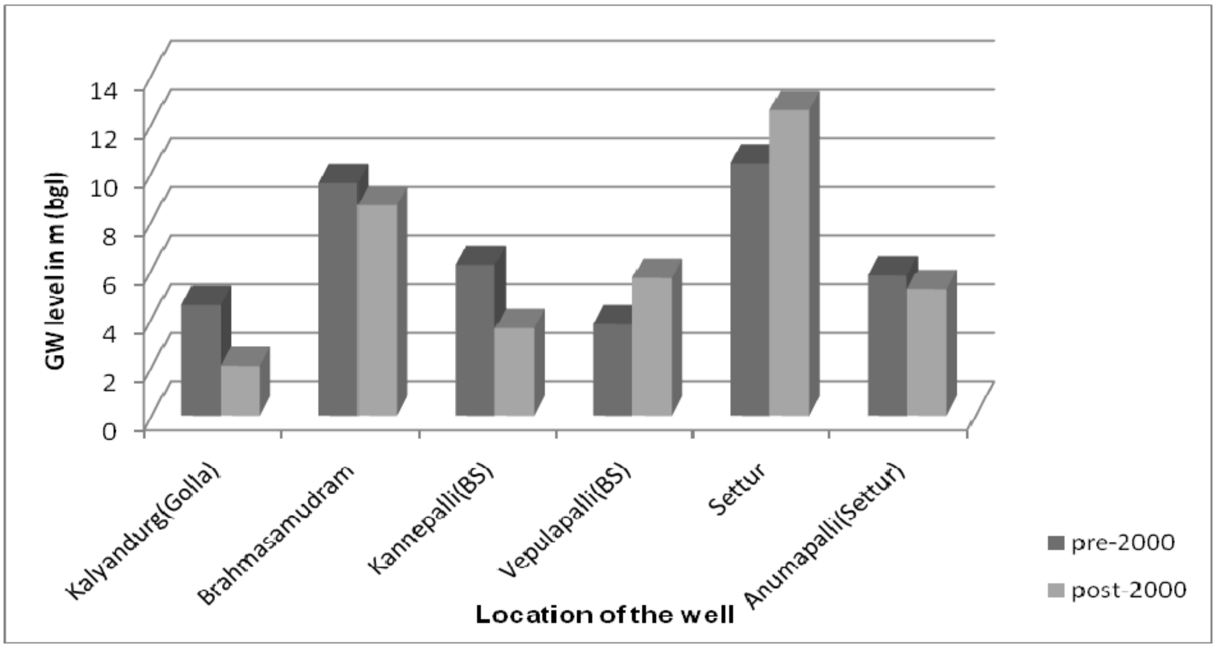

Fig. 2 Depth to Water Levels (DTW) for 2000

Table 2: Depth to Ground water levels for 2012

S. No.	Location of the well		Pre-Post(May-Nov) Monsoon depth to groundwater level in m. (bgl) in 2012	
	Mandal	Village	May	November
1	Brahmasamudram	Brahmasamudram	10.76	12.62
2	Brahmasamudram	Kannepalli	6.35	6.87
3	Brahmasamudram	Vepulapalli	3.25	11.49
4	Kalyandurg	Golla	2.12	4.96
5	Settur	Settur	12.86	16.79
6	Settur	Anumapalli	7.62	11.99

Source: *District ground water department, Anantapur*

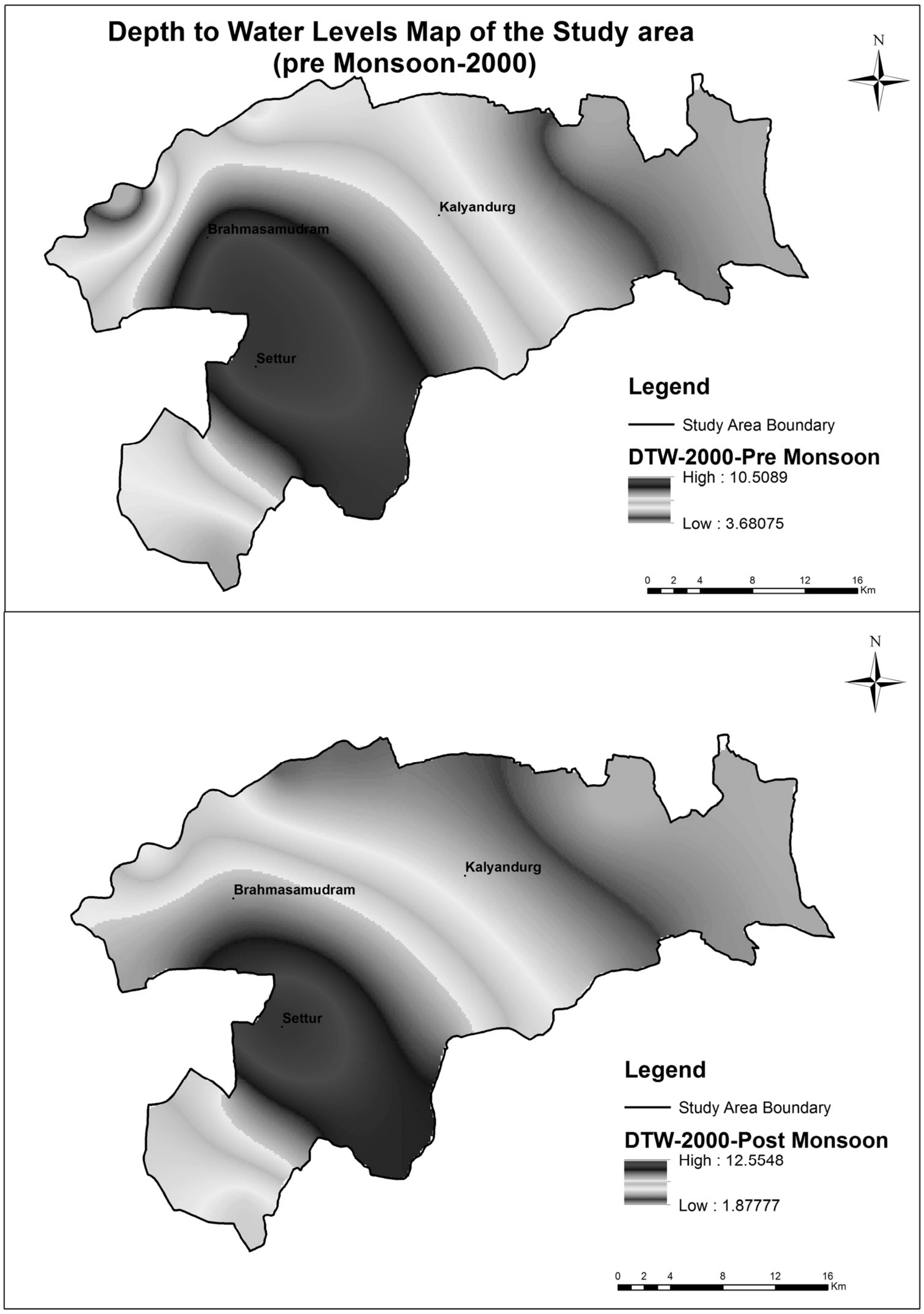

Fig. 3 Depth to Groundwater Level (DTW) Map for 2000

Depth to Water levels for pre and Post monsoon period of 2012: DTW Figures and Table indicate water level depth has been increased compare to the 2000. Deep water levels 12.86 m (bgl) is observed in Setturu and 10.76 m (bgl) Brahmasamudram at the same time post monsoon period (November) depth has been increased more and observed 16.79 m (bgl) in Setturu, 12.62 m (bgl) in Brahmasamudram, Vepulaprthi 11.49 m (bgl) and Anumpalli 11.99 m (bgl). Moderate ground water levels are observed for pre monsoon period in Anumpalli 7.62 m (bgl). Kannepalli 6.35 m (bgl) in Brahmasamudram mandal, at the same time for post monsoon period Kannepalli 6.87 m (bgl) observed. Shallow groundwater zones with water levels <5m is observed in Golla 2.12

m (bgl) in Kalyndurg mandal and Vepulaparthi 3.25 m (bgl) for pre monsoon period, for post monsoon period Golla 4.96 m (bgl) was observed shown in Table 6.3 and Figure 6.4 and 6.5.

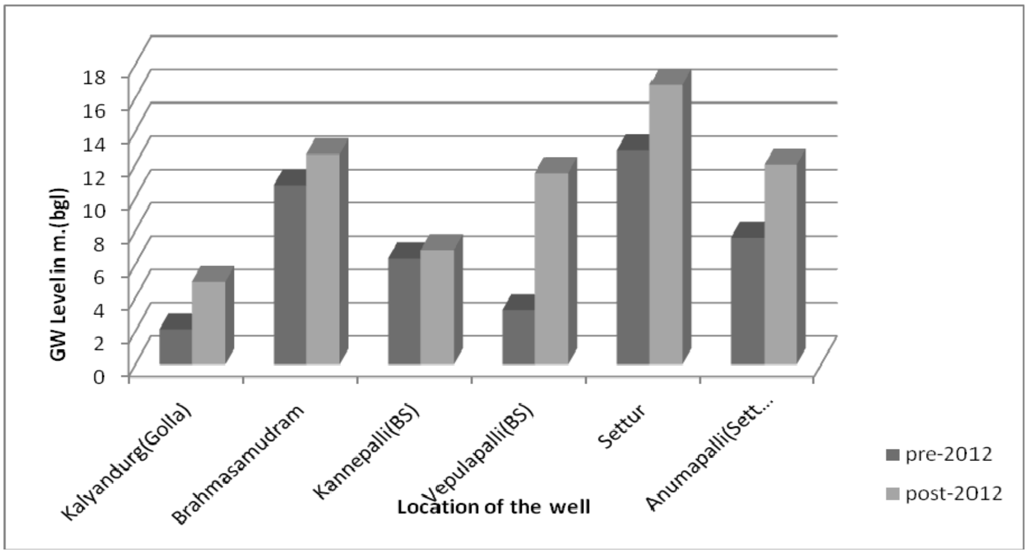

Fig. 4 Depth to Ground water levels for 2012

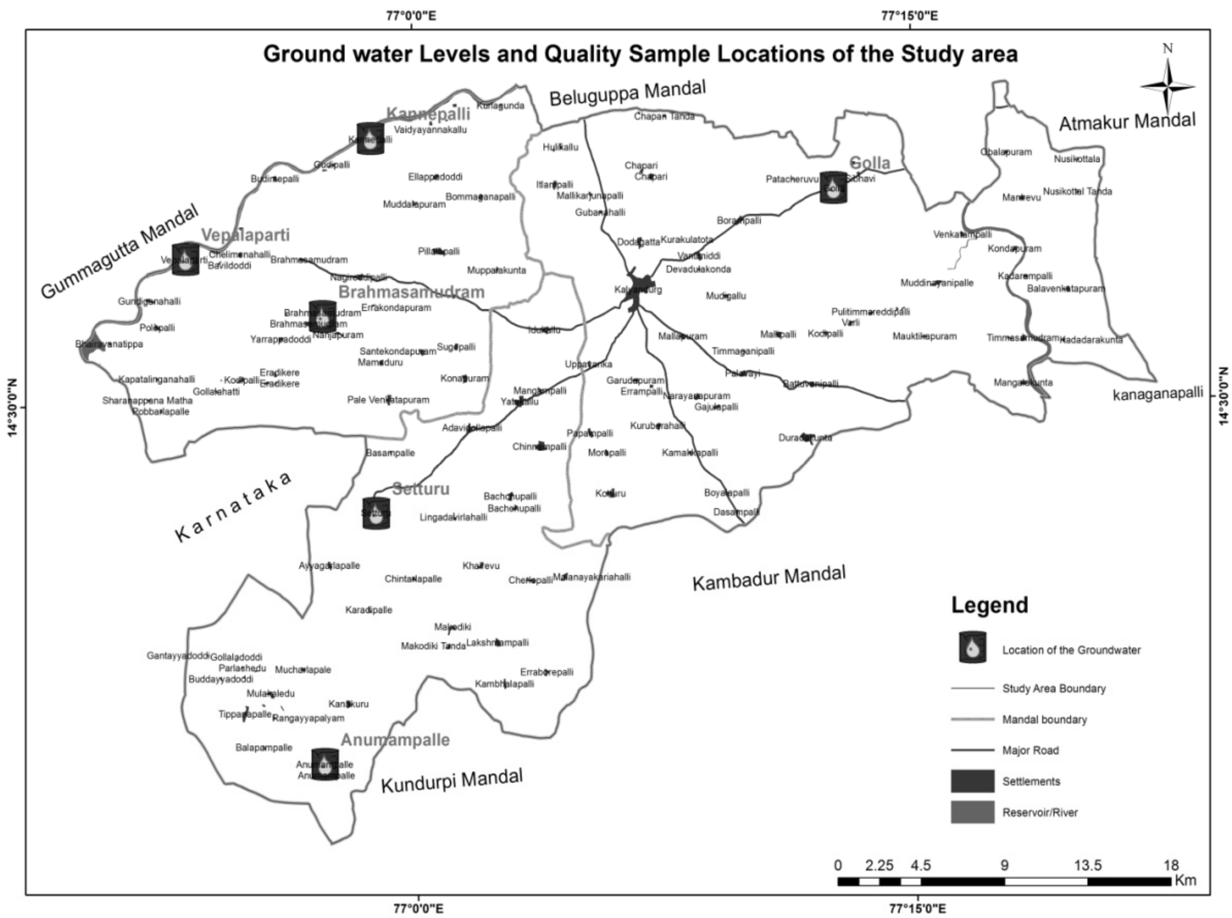

Fig. 5 Groundwater sample locations of the study area

Stage of Groundwater Development in the Study Area

Figure 6.6 present's stage of groundwater development in the study area as estimated by the A.P. Groundwater Department collected this data and analyzed. Safe zone of the Ground water stage villages are observed in Kalyandurg mandal are East Kodipalli, Mudigal, Chapari, Hulikal and Kalyandurg, in Brahmasamudram mandal Safe stage villages are Teetakal, Pillalapalli, Bhairasamudram and West kodipalli and in Setturu mandal Mulakaledu, Khairevu, Bachepalli and Yatakal.

Semi-critical Villages are observed in Manirevu, Golla, Palavoy and Garudapuram in kalyandurg mandal and Adiviganipalli, Kamthanahalli and Ayyagarlapalli in Setturu mandal. Critical villages in Kalyandurg Mandal are Muddinayanapalle and Thimmasamudram, in Brahmasamudram mandal Kannepalli, Bhyravanithippa and Brahmasamudram and in Setturu mandal Chintarlapalle Villages are observed.

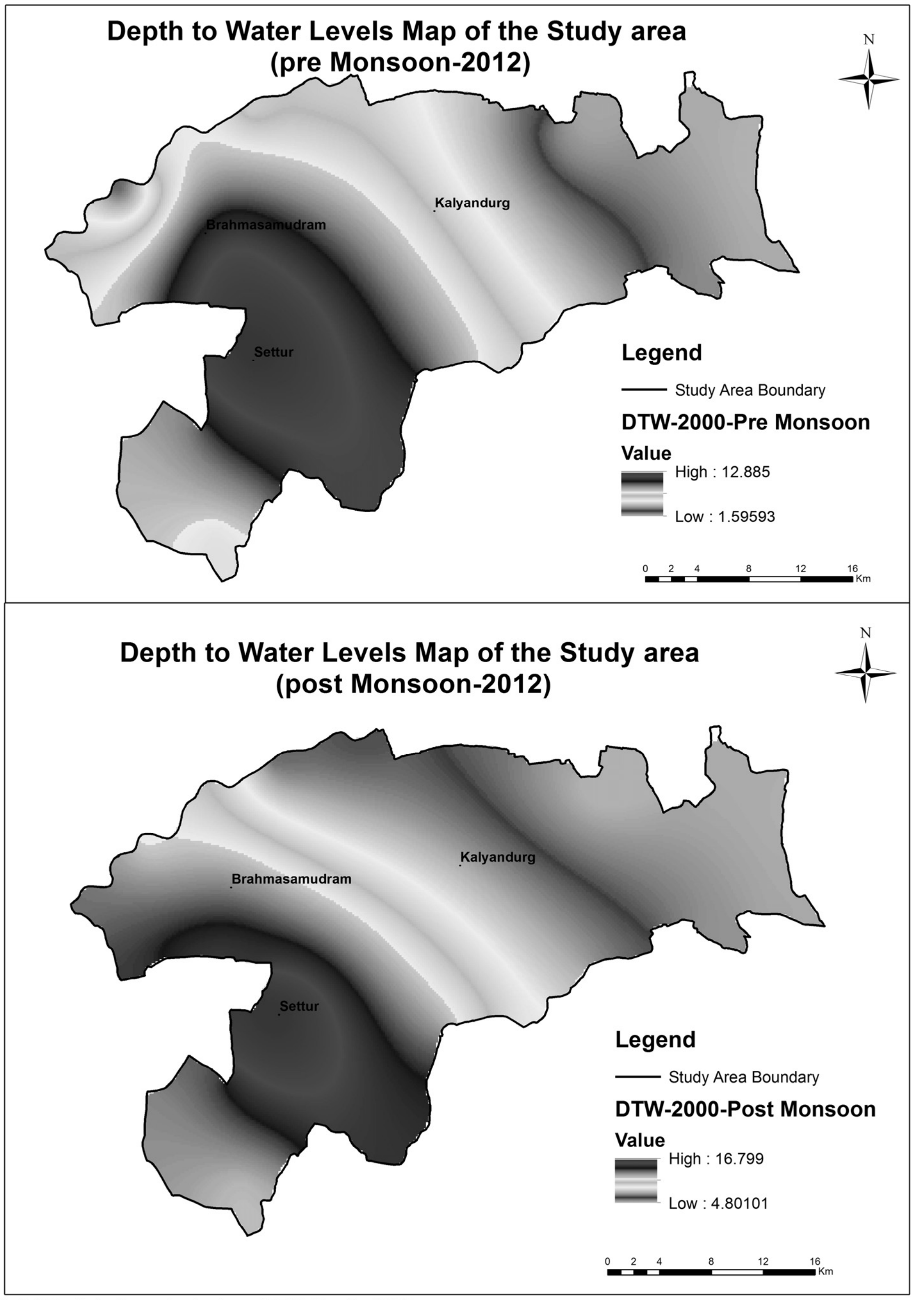

Fig. 6 Depth to Groundwater Leve (DTW) Map for 2012

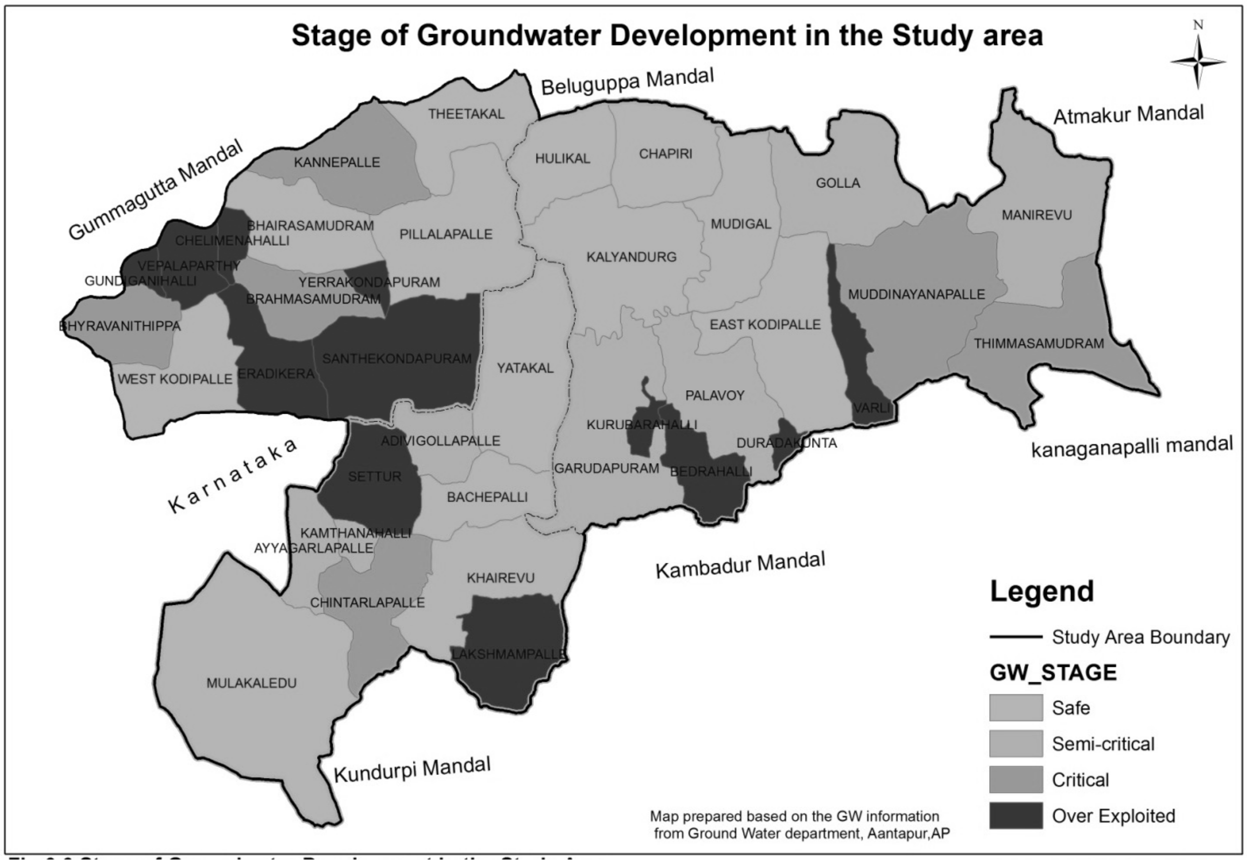

Fig. 7 Stage of Groundwater Development in the Study Area

This Figure shows that ground water development has reached the critical or over-exploited Stage in two thirds of the villages in the study area. All The mandals in the study area belongs to very high groundwater usage (over all stage of ground water development > 70 %).

Critical Groundwater stage villages are observed, Varli, Duradakunta, Bedrahalli and Kurubarahalli villages in Kalyandurg mandal, Chelimenahalli, Vepulaparthy, Eradikera, Santhekondapuram and Yerrakondapuram in Brahmasmudram mandal and Settur and Lakshmampalle villages in Setturu mandal in the study area.

CONCLUSION

The present study has brought out the following conclusions.

- ❖ Based on Depth to water level maps (DTW) Groundwater distribution is very low in Setturu and highest in Brahmasamudram Mandal.
- ❖ The state ground water department estimated, that Annual ground water availability in the study area has 7594 ha.m , Existing gross Ground water draft for all uses 6821 ha.m, Ground water balance is 945 ha.m and Stage of ground water development in the study area estimated as 91 %.

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Subsurface Dam- An Efficient Groundwater Recharge Measure

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ABSTRACT

Artificial recharge of groundwater is a process by which the groundwater reservoir is augmented at a rate exceeding the rate of natural replenishment. Due to over exploitation of groundwater, decline in groundwater levels resulting in various avoidable problems such as shortage of supply of water, intrusion of saline water in coastal areas, deterioration in quality and land subsidence are observed frequently. In such areas, there is need for artificial recharge of groundwater by augmenting the natural infiltration of precipitation or surface water into underground formations. Groundwater is recharged through surface, subsurface and indirect methods. Surface methods, such as basin methods, channel methods, ditch and furrow methods, flooding method, irrigation methods and percolation methods are still in use, the evaporation losses and poor efficiency cause these methods less preferred. In the case of sub surface methods, such as recharge pits, shafts, ditches and recharge wells..though they are better in performance.. their construction cost and maintenance are the problems worth mentioning. Recently the method of recharging of ground water by using sub surface dams is gaining momentum. In this method using various geophysical exploration techniques such as resistivity survey or seismic survey the depth and quality nature of aquifer are noted. Using groundwater level data from the existing nearby bore wells...the direction of groundwater flow is noted. Then depending upon the properties of subsoil formations, direction of ground water flow and availability of hard rock ... a dam below the ground level inside the soil formation, that is, "SUBSURFACE DAM" is constructed. It is similar to surface dam in functioning; it impounds water on its upstream side and thus creates subsurface reservoir. The water thus stored enables recharge of the surrounding aquifer. This paper presents the details of study on performance of subsurface dam located across Kalangi river drainage basin. The results of the study are expected to enhance the level of knowledge regarding artificial recharge of groundwater.

INTRODUCTION

Fresh water availability for sustainable development isa major challenge facing the global community. In man yarid and semi-arid regions in South Asia and the Middle East, large amounts of water annually flood the sea or desert during extreme rainfall events. Dillon(2005) defined managed aquifer recharge (MAR) as the 'intentional banking and treatment of waters in aquifers'. The term MAR was introduced as an alternative to 'artificial recharge', which has the connotation that the use of the water was in some way unnatural. Managed aquifer recharge of reclaimed water can be an important water management tool in arid lands in three main ways, (1) by providing storage,(2) improving the quality of stored water through natural contaminant attenuation processes, and 3) protecting freshwater resources (e.g salinity barrier systems). In coastal margins of the fresh groundwater basin, the lowering of ground water level beyond certain limit can result in sea water intrusion. On one side is prudence and thrift regarding water; on the other lies extensive use of technology to harness the maximum amount of safe drinking water for consumption. In order to sustain agriculture and general water supply, efforts to harvest rainwater are currently being employed in many arid and semi-arid regions throughout the world. Increase of population and subsidized electricity for agricultural pumps in India has encouraged the rural affluent class to lift more and more water for irrigation from deeper aquifers. Areas of low to moderate rainfall occurring mostly in single monsoon period do require all efforts to conserve rainwater to recharge the depleted shallow aquifers in arid and semi-arid regions. Rainwater harvesting structures in semi-arid areas to tap stream water was practiced by ancient Jordanians about 5,000 years ago to provide drinking water to the old city of Jawa (Abdelkhaleq and Ahmed 2007), in the Mediterranean region around 4,000 years ago (Joshi 2002) and archaeological evidence reveals that RWH activities have been central to indigenous civilizations in India for the past2,000 years (Gunnell et al. 2007). In the light of the decreasing recharge space and over-exploitation of groundwater resources by modern extraction techniques, there has been a resurgence of traditional rainwater harvesting activities in many parts of India in recent decades(Sharma 2002). Several rainwater harvesting structures such as check dam, across the drainage system at Mandvi in Gujarat has been taken up to arrest the declining trend of water levels, deterioration of groundwater quantity and prevent seawater intrusion into coastal aquifers (CGWB1994). The Komesu underground dam is the first full scale underground dam constructed to prevent saltwater intrusion in Japan (Nawa and Miyazaki 2009). Seawater intrusion is often associated with over pumping in coastal regions, resulting in overdraft conditions and creating an inland gradient of seawater (El Moujabber et al. 2006). The intrusion of saltwater into coastal aquifers is a wide phenomenon, especially in Mediterranean regions where semi-arid conditions lead to excessive pumping, high extraction rate and low recharge. Check dams were constructed across seasonal streams in many states in India to make water available for agriculture and domestic use (Balooni et al. 2008). Small alluvial aquifers will have lower potential storage than larger ones which are seen as good source of irrigation water in the summer seas onto save the agricultural crops. Groundwater flow rate varies depending on the geologic characteristics of the stratum holding the groundwater, the depth of stratum, and the permeability and shape of the basement. Generally, shallower groundwater runs at a relatively higher flow rate, the water can be stored by damming the upstream flow with an impermeable wall as is done with rivers (OGB 1986). Sub-surface dam is a facility that stores groundwater flow in the pores of permeable strata to enable sustainable use in agricultural well as domestic purposes. The advantages of the underground dams, unlike a normal surface dam, is cheaper to construct and the thickness of the wall is very thin compared to normal dam, evaporation is very low, the reservoir area can be used for cultivation (no land is wasted) and the riparian rights of the downstream formers are not affected as the dam does not project out (lies 1 m below the land surface). The sub-surface dam allows the development of water resources in the alluvial aquifer regions and prevention of seawater intrusion into the fresh water alluvial aquifers. The classification of storage dams and salt-water intrusion prevention dams, is important (Hanson and Nilsson1986). Storage dams are used to raise the groundwater level where the groundwater table is originally low and salt water intrusion prevention dams are used to prevent saline water infiltrating the aquifer from the sea coast as shown in Fig. 1.

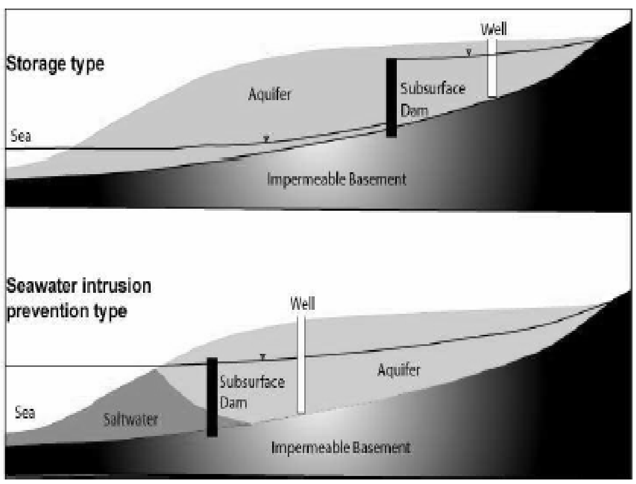

Fig. 1 Schematic Diagram of different types of Subsurface Dams

STUDY AREA

The alluvial tract of Andhra Pradesh is 700 km long and5-25 km in extent from the coast line. The Kalangi river rises near Narayanavanam in Chittoor district, Andhra Pradesh and drains 355.75 km2 in Chittoor district and119.25 km^2 in Nellore district before joining Bay of Bengal as shown in Fig. 2.

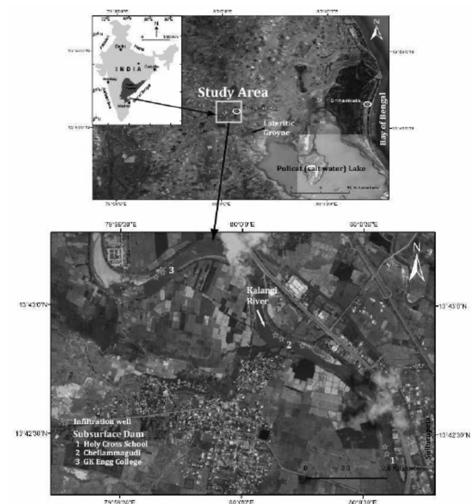

Fig. 2 Location Map of the Kalangi River Basin and Pulicat Lake

The Kalangi river is an ephemeral river and the river course near Sullurpet is highly meandered. After draining a length of 86 km it enters Pulicat (saltwater) lake at Gradhagunta which is 11.6 km from Sullurpet town. In Kalangi river, continuous flow of surface water exists only for three months (90 days) during rainy season. The average thickness of sandy alluvium in the river is around 5 m. The Kalangi river is the main source of water supply for irrigation and drinking in and around Sullurpet area. The bed level of Kalangi river from Sullurpet to confluence with Pulicat lake runs below high tide level. Due to the presence of backwaters of Pulicat lake, surface water in Kalangi river becomes saline and not useful for any purpose. Almost 500acres of land is available on either side of Kalangi river in the stretch of around 10 km length from Sullurpet to confluence of the Pulicat lake. The irrigation was being perceived through dug wells and filter (tube wells) point wells. The average annual rainfall recorded at Sullurpet rain guage station is 1090 mm. The hydrograph of Sullurpet observation well is showing generally a declining trend in water level as presented in Fig. 3

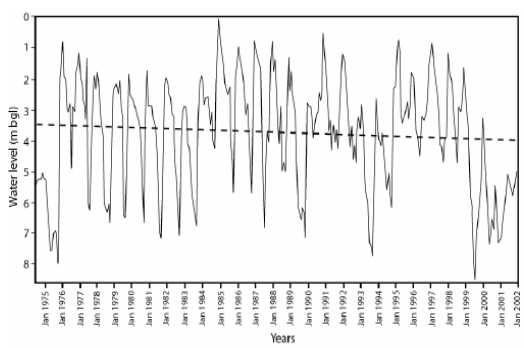

Fig. 3 Water Level Fluctuation of the observation Well of Sullurpet Area

GEOLOGYAND HYDROGEOLOGY

Geologically, the area is covered by unclassified crystalline rocks of Archean age which are overlain by recent alluvial deposits consisting of sand, clay, pebbles and boulders of different sizes. At few places late rite out crops are observed along the course of Kalangi river. Most of the soils are derived by the disintegration of late rite and hence are classified as lateritic soils. Though the basement is of crystalline rocks in the area, no trace of exposure are found along the river course. From the geological investigations, the sub-surface dam must rest either on crystalline rock or hard clay stratum to collect maximum storage of sub-surface water in the river.

Detailed well inventory has been done for a length of 5 km and a width of 250 m on both the riverbanks around Sullurpet area and the cross sections of vertical thickness of wells are shown in fence diagrams (Fig. 4).Groundwater extraction is mainly from the dug and shallow tube (filter points) wells with some exceptions of deep bore wells in the area. Both dug wells and tube wells are pierced through the sand bed of the present and ancient river course (buried channels). From the well inventory data, it is found that there are two sandy types of aquifers (unconfined and confined) in which the movement of water is occurring (Fig. 4).

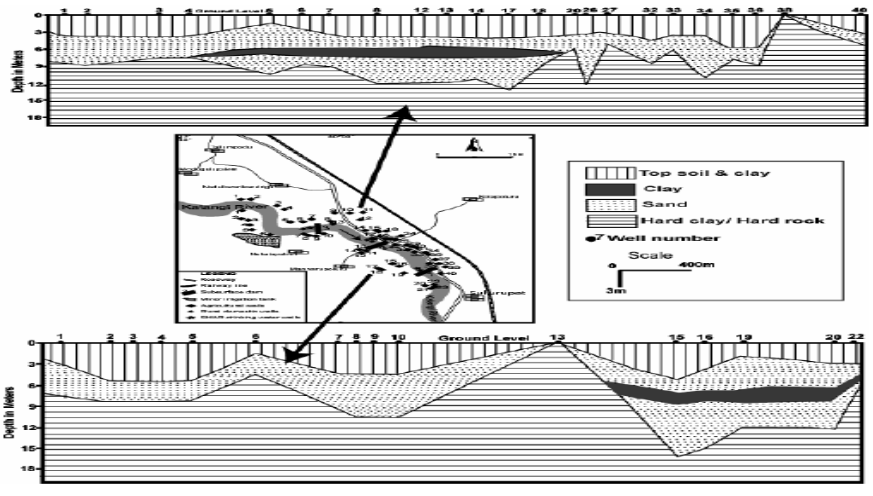

Fig. 4 Fence Diagram of Well Inventory along the Kalangi River Course near Sullurpet Environs

The quality of water in confined aquifer is highly saline and is not potable. Hence, it is intended to store groundwater in unconfined freshwater aquifer by constructing sub-surface dams. Groundwater from bore wells and open dug wells is extensively used for drinking and agriculture. The depth of groundwater level is too shallow and varies from 1-10 mbgl. After thorough examination of geology and well inventory data, a few locations along the Kalangi river have been chosen to probe geophysically in order to know the sub-surface lithology, depth to basement and also these sand bed occurs up to a maximum depth of 7 m in the unconfined aquifer position of end connections. Hand augur drilling was done across the river bed in order to corroborate results of the geophysical studies. The longitudinal cross sections of three sub-surface dams (i.e. GK Engineering College, Challammagudi and Holy Cross School) are shown in the Fig.5.

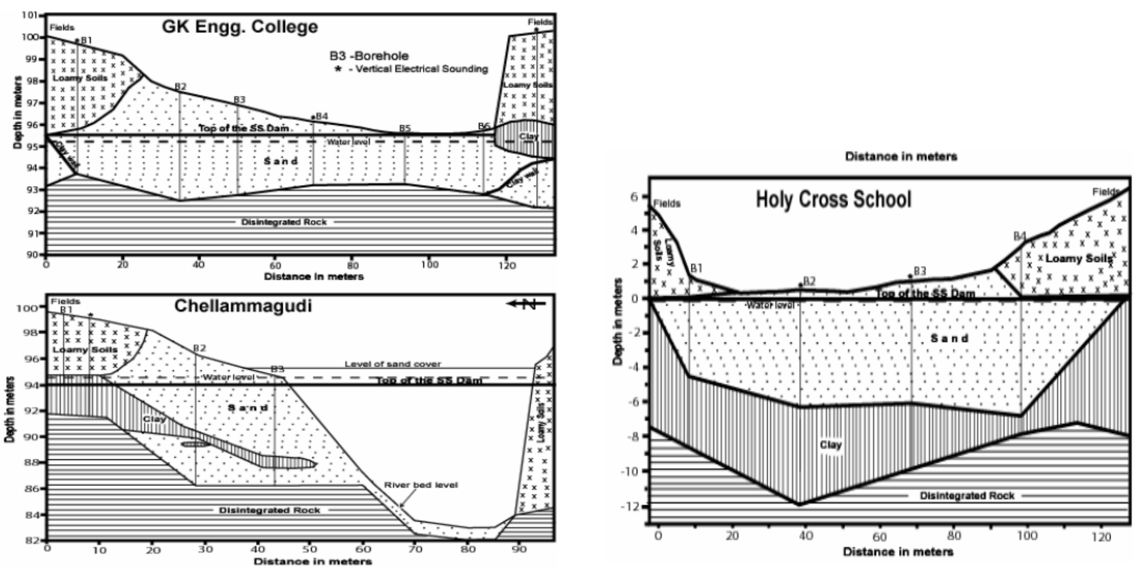

Fig. 5 Lithological Cross Section of the Subsurface Dams Constructed across the Kalangi River

WATER RESOURCE SCENARIO IN THE STUDY AREA

To understand the overall salinity problems along the coastal area of Nellore district, approximately 60 groundwater samples were collected (2 km away from the coast line) and a rapid determination of total dissolved solids (TDS) made by measuring electrical conductivity of groundwater samples were made. Based on the TDS values of groundwater samples, a tentative saline zone is marked which is approximately 13 km away from Bay of Bengal sea coast near the Sullurpet area (Fig. 6).

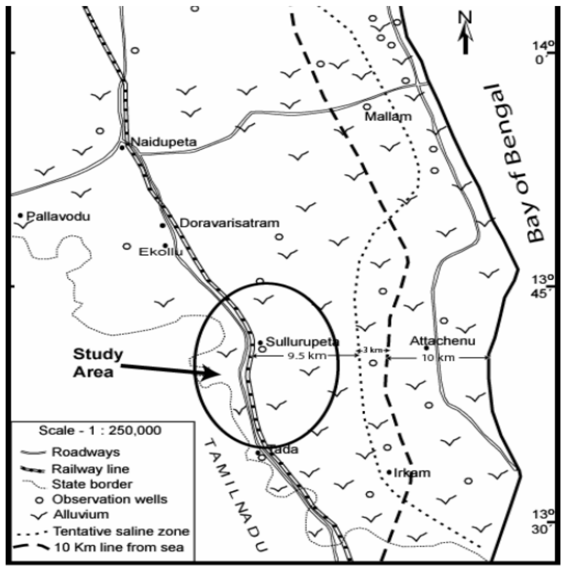

Fig. 6 Demarcation of the Tentative Saline Zone from Coast of the Bay of Bengal

But town is still 9.5 km away from this tentative saline zone. Then, the source of salinity in the Kalangi river up to Sullurpet town may be due to the contamination of Pulicat lake back waters. The majority of the wells reported in and around the Sullurpet area are contaminated with saline water intrusion. In order to understand the sources of salinity in the area, the river course for a length of ~20 km has been examined to locate suitable sites for the construction of sub-surface dams. The Panchyat of Sullurpet has constructed infiltration wells in the Kalangi river bed for providing drinking water supply, but the quantity of water is grossly inadequate to supply for 30% of its present population at 40 l/capita/day in normal monsoon and 14% of population at 40 l/capita/day in summer months. Remaining population is depending on open wells for domestic consumption. Sriharikota Space Center (SHAR) in Sullupet town has made its own arrangements for the supply of domestic water at the rate of150 l/capita/day to their housing colonies. But in summer these colonies are also facing shortage of domestic water supply (<150 l/capita/day) from the infiltration wells constructed in the Kalangi river. In order to bridge the short supply for domestic consumption it is contemplated to tap base flows in the Kalangi river bed by arresting the flow by constructing sub-surface dams across the river to impound groundwater on the upstream of dams. Five kilometer stretch of Kalangi river upstream of Sullupet town has been investigated for location of suitable sites for construction of sub-surface dams. Based on the detailed hydrogeological, geophysical, hydrological engineering surveys, three suitable sites have been located for construction of sub-surface dams across Kalangi river (Fig.2). The average specific yield ofsandy alluvium in the river course is taken as 10%. The length of three sub-surface dams varies from 90 m to 130 m depending on the availability of end connections and average thickness of sandy alluvium at the sub-surface dam site varies from 2.8 m to 6.6 m. The calculated storage capacity of theHoly Cross School dam, Chellammagudi dam and GK Engineering College are 3.143 mcft, 6.23 mcft and 1.28mcft, respectively (total storage capacity in three dams is10.656 mcft) during non-flowing season of Kalangi river(Fig. 7). This will facilitate to recharge the existing infiltration wells in the river bed apart from stabilizing the bores drilled on the left bank of river for drinking water supply to the Sullurpet town.

Necessity for Rainwater Harvesting Structures across the Kalangi River

1. The water table (~3 m bgl) in the infiltration wells along Kalangi river (near Holy Cross School) in Sullurpet town has short supply of drinking water.

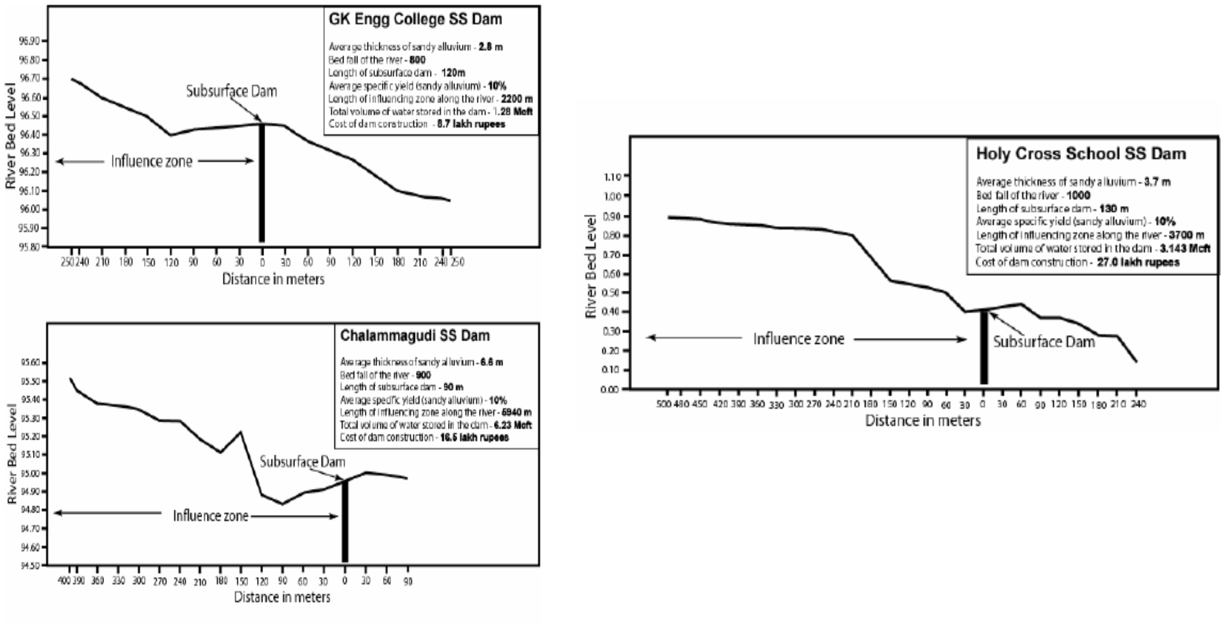

Fig. 7 Influencing Zones of River Water Storage upstream of the Subsurface Dams

2. On the Kalangi river bed, seawater contamination has been noticed up to a length of 10.2 km along the river course and it made the farmers stop pumping of surface water to their fields of 500 acres on both sides of the river.
3. Over-exploitation of groundwater in excess of the annual replenishment has caused continuous decline of water levels from shallow wells along the Kalangi river course.
4. Salinity has also been noticed in the groundwater from tube wells (filter points) and dug wells located in the agricultural fields.
5. Badly damaged rough stone late rite groyne near Vattembadu village allow surface seawater to enter into river Kalangi which contaminates the groundwater.
6. River bed level from Sullurpet town (10.2 km) to damaged late rite groyne is below high tide (depth of0.8 m) at confluence, causing inundation of entire length of 10.2 km by seawater
7. When there is no surface river flow sand mining has taken place and a reverse gradient developed enhancing the velocity and depth of water to flow upstream towards Sullurpet town.

RESULTS AND DISCUSSION

A late rite rough groyne 1.2 m high above river bed level(RBL) was constructed in 1984 (at 1.4 km upstream of the Gradagunta confluence of Pulicat lake with river Kalangi near Vatambedu village), to overcome the problem of surface seawater entry into ephemeral Kalangi river from Pulicat lake which contains saline water. The top of the groyne was kept 0.1 m above high tide level (HTL) of Pulicat lake. In due course of time the groyne was damaged due to water force as well as human activities at many places resulting in the entry of surface saltwater of Pulicat lake into the Kalangi river when it was dry which percolated into the sand bed of the river. Another indication of saltwater ingress in the groundwater is due to the contamination of SHAR infiltrationwell in the year 2003, situated in the Kalangi river bed near Holy Cross School of Sullurpet town. The distance between groyne and the Sullurpet town is around 10.2 km and the analysis of surface water samples along the river course indicated salinity of surface water up to the Sullurpet town. The reason for the saltwater in the Kalangi river bed is due to breaching and badly damaged late rite groyne which allowed high tide Pulicat lake saltwater into the river course. The ingress of seawater into coastal aquifer along Kalangi **Fig.7.** Influencing zones of river water storage upstream of the river through estuary at Pulicat lake has affected the agricultural economy of Sullurpet area and also drinking water availability (Muniratnam, 2004). Revelle (1941) pointed out that the increase in total dissolved solids (electrical conductivity) is not sufficient proof of occurrence of seawater intrusion. Seawater intrusion involves mixing of saline and freshwater. Owing to its considerable salt content, a small fraction of seawater would dominate the chemical composition of groundwater mixture. The most obvious indication of seawater intrusion is an increase in Cl- concentration. Another important indicator related to the predominance of Cl- in seawater is the ratio of chloride to bicarbonate and carbonate ions which is knownas Simpson ratio (El Moujabber et al. 2006) and carbonateions are present only in very small amount in seawater. TheSimpson classification ratio of Cl-/(HCO3-+CO32-) included five classes: 0.5 for good water quality, 1.3 for slightly contaminated water, 2.8 moderately contaminated, 6.6injuriously contaminated and 15.5 highly contaminated water (Todd, 1980). In order to diagnose the seawater intrusion as evidenced by temporary increase of total dissolved solids, Simpson criteria is used to understand the seawater intrusion. Groundwater samples from the infiltration well of SHAR near Holy Cross School of Sullurpet town which supplies the drinking water to the housing colonies was analyzed before construction of rainwater harvesting systems and found the ratio of chlorides and sum of carbonate plus bicarbonate is of the order of 10.47 and after construction the ratio is around 1.16 (Table 1).

Table 1 Water analysis in the Sriharikota Space Center (SHAR) Infiltration Drinking Water Well in the Kalangi River near Sullurpet Town

Water sample analyzed	Chloride (me/l)	Bicarbonate (me/l)	Simpson ratio $Cl^-/(HCO_3^- + CO_3^{2-})$	Remark
Before construction (April 2005)	33.08	3.16	10.47	Injuriously contaminated
During construction (21st June 2005)	30.45	3.77	8.07	Injuriously contaminated
After construction (27th July 2005)	11.5	6.03	1.90	Slightly contaminated
After construction (4th August 2005)	8.46	7.29	1.16	Good quality

Reconstruction of Groyne to Prevent Back Waters of Pulicat Lake

The reconstruction of groyne and construction of subsurface dams were completed in the month of July 2005.The problem of seawater intrusion at estuary was not contemplated during original groyne construction even though there is 3.5 m depth of sand bed over a clay bed. This has resulted in the fresh groundwater becoming saline in the infiltration wells constructed for drinking water. The river bottom level (RBL) is high and width of the river is140 m which is a feasible site for the reconstruction of the groyne to arrest the surface saline water from the Pulicat lake and longitudinal section is shown in Fig.8.

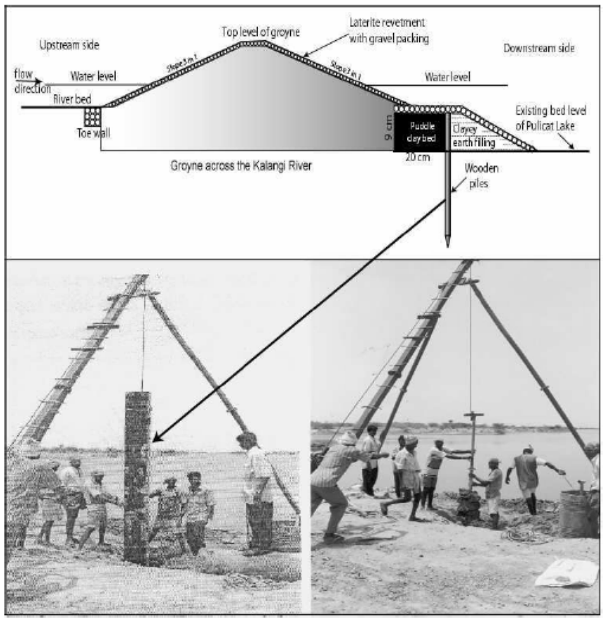

Fig. 8 Strengthening of the Old Groyne by Placing Wooden Piles in the Down Stream Side of the Kalangi River to Protect Saltwater Intrusion

The riverbed level (RBL) on upstream side of groyne is 1.3 m above Pulicate bed level. So drilling has been to the bores drilled on downstream of groyne (i.e. at the bed level of Pulicat Lake). Therefore 3.8 m long wooden pile Is selected to drive to the alluvium. The late rite rough stone groyne is reconstructed whose height is kept 1.2 m above water level of Pulicat lake and timber piles of size 0.3 m x0.15 m x 3.8 m with shoe at bottom and tongue and groove arrangement on both side of pile is made (Fig. 8). Bentonite clay slurry is poured into hole during augur drilling to maket he sides of hole to retain. When the clay bed is encountered the pile is placed in position duly inserting the same in the tongue & groove arrangement made on side of previous pile and hammered with an over head mechanism till it intrudes into clay bed and the pile is kept 1.2 m above Pulicat lakebed level. To avoid cattle/vehicle movements (which will damage the structure) on the reconstructed groyne, small guard stones were placed at the top of this groyne. This procedure of drilling holes with augur and using bentonite clay slurry to retain the sides and also to seal the gap between piles has resulted in stopping the entry of seawater into ground water. A change is seen on upstream of groyne to a stretch of 10.2 km by gradual decrease of standing saltwater in the river bed. Due to this measure the quality of drinking water has improved and also 50 mc ft of irrigation water impounded from the Sullurpet town to Vatambedu groyne along the Kalangi River. There is a possibility of 1.85 m column of impounding river water on the upstream side of groyne in the subsequent monsoon. But due to cyclonic storms there was high runoff in the river in July 2005 which considerably reduced the salinity in the wells (Table 1). The contamination of fresh surface water by the tidal saltwater inflow and the seawater intrusion into groundwater is stopped by the reconstruction of late rite rough stone groyne by providing a wall of timber wooden piles.

Design and Construction of Sub-surface Dams

The location requirements for the construction of underground dams are (i) the distribution of geological layers(reservoir layers) must allow for effective porosity and hydraulic conductivity so groundwater can be stored and collected, (ii) there must be sufficient groundwater recharge to correspond to the amount of water to be stored. Subsurface dams are often built in riverbeds that generally constitute highly permeable aquifers with good storage potential (Raju et al. 2006). A subsurface dam, intended for arresting the groundwater flow in a natural aquifer, is constructed across a valley by digging a trench to bedrock. The trench has at its base an impervious wall which is covered with excavated material until the trench is completely concealed (Raju et al. 2010).

Table 2 Engineering Properties of the Soil Sample used for Construction of Clay Wall

S. No	Property of soil	Value
1	Gravel (%)	0
2	Sand (%)	20
3	Silt + Clay (%)	80
4	Liquid limit (%)	41
5	Plastic limit (%)	20
6	Plasticity Index (%)	21
7	I.S. Classification	CI*
8	Maximum Dry Density MDD (gm/cc) (from Standard Proctor´s Test)	1.632
9	Optimum Moisture Content, OMC % (from Standard Proctor´s Test)	16
10	Coefficient of Permeability, K (cm/sec) (at Proctor´s Density)	1.75×10^{-8}
11	Cohesion, C (Kg/cm^2) (at Proctor´s Density)	0.58
12	Angle of Internal Friction, ö (deg.) (at Proctor´s Density)	8

*CI – Inorganic clay of medium plasticity

The main water shortage period in the Kalangi river basin is from March to August when there is no surface water flow in the river. The well inventory studies reveals that there is a base flow at 0.5 m below river bed level (RBL)during April and gradually decreasing to 6.0 m below bed level by the month of June (Muniratnam 2004). All the infiltration wells for drinking water supply to Sullurpet and SHAR housing colonies are tapping water from 1 to 3.5 m below river bed level (RBL). In order to circumvent this situation and to improve the quantity and also quality ofdrinking water in the Kalangi river basin, three sub-surface dams (GK Engg College, Challammagudi and Holy Cross School) constructed to harvest the rainwater runoff going as a waste to sea in order to recharge the infiltration well sand tube wells in the river alluvium (Fig. 2).The first suitable site for the subsurface dam at Holy Cross School in Sullurpet town with a length of 130 m is selected across Kalangi river. The distance of the first subsurface dam site is around 11.6 km from the confluence of Kalangi river with Pulicat lake. Geophysical surveys were carried out to know the depth of impervious strata and structural weak planes underlying the sandy alluvium whose depth is 7 m. To substantiate the geophysical survey results few augur hand boreholes were drilled along the proposed site (Fig. 5). The sub-surface dam is constructed with clay quarried from an irrigation tank located at 5 km away and engineering properties of soil samples are presented in Table 2. The width of clay wall of subsurface dam is 0.9 m (Fig.9). The dam has been keyed into weathered bedrock0.5 m below the bedrock/hard clay surface. The clay wall was compacted with wooden rammers in order to obtain proctors' density. The clay balls were so prepared as to imbibe optimum moisture content. In order to retain this moisture content for a longer period, 200 μ low-density polyethylene films (LDPE) was emplaced on the upstream, downstream and top of the dam in order to protect the clay wall from yielding cracks (Fig. 9).

The longevity of LDPE film underground is tested as 50 years. Bed pitching on top of sub-surface dam is made to avoid scouring as the dam is0.66 m above river bed level (RBL). Revetment is also provided on both sides of river banks to safe guard the bank from scouring. The storing of fresh water will dilute the seawater intruded before reconstruction of groyne. The river Kalangi has received water from its upper catchment and water has reached up to the Holy Cross School sub-surface dam site in July 2005 and water has been impounded, since0.66 m raise of wall (act as check dam) is made with bed pitching and revetment duly grouting the joints with cement mortar (Fig. 10). One jack well to a depth of 6 m and 1.5 mdia meter with two collector wells on right side of river was erected during the construction of the Holy Cross School sub-surface dam (Figs. 9 &10) for pumping drinking water from the already available infiltration well which is located at 46 m upstream of the jack well. The groundwater sample analysis of SHAR infiltration well in the month of July 2005revealed that the intensity of salinity has been considerably reduced and is within the limits of drinking water standards(Table 1). The available drinking water supply for Sullurpet town plus SHAR housing colonies before construction of sub-surface dam is around 14.40 lakh/litres/day (monsoon)and 8 lakh/litres/day (summer) for the population of around40,000. After the construction of SS dam near Holy Cross School, it is 24.96 lakh/litres/day during monsoon and 16.60lakh/litres/day during summer season. The storage is calculated within the width of river. The groundwater basin also extends on both sides of the river.

Fig. 9 Construction of Subsurface Dam with Clay across the Kalangi River near Holy Cross School, Sullurpet Town.

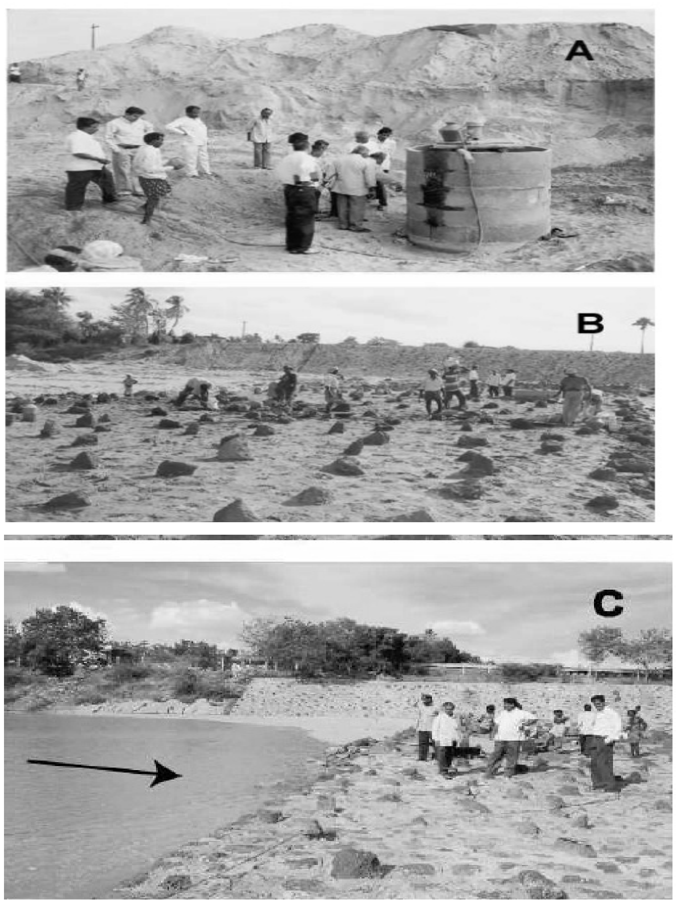

Fig. 10 Construction of Jack Well upstream side of SS Dam (A);
Check Dam above the SS Dam (B); Impounding of River Water (C).

CONCLUSION

Rainwater harvesting and artificial recharge will help to improve the quality and quantity of groundwater of the over exploited/contaminated area. Developing countries are under pressure due to rapid increase in population, fast urbanization and deficient water services reflecting on improper management of water resources. The ingress of seawater into the coastal aquifer has affected the drinking water availability and agricultural economy in the Kalangi river basin. The SHAR infiltration drinking well depth is extended up to 4.3 m in the river bed from the surface near the Holy Cross School in Sullurpet town due to rapid decline of water table in the river. Mean time sand mining has taken place in between damaged groyne and Sullurpet town when water was not available in the entire stretch (i.e up stream of groyne). This has resulted in the intrusion of surface seawater which has contaminated the infiltration well of SHAR situated near Holy Cross School in the Kalangi river bed of Sullurpet town.

A sub-surface dam is a facility that stores groundwater in the pores of strata and uses groundwater in a sustainable manner. The length of the influencing zone after the construction of three sub-surface dams along the river course is 2200 at GK Engineering College, 5940 m at Challammagudi and 3700 m at Holy Cross School. The quantity of groundwater availability has been substantially increased in the Sullurpet area by the construction of sub-surface dams. Due to the reconstruction of groyne seawater intrusion into the river course has been stopped and improved the quality of drinking water. Hence, a general increase not only in agricultural land productivity but also improvement of groundwater quality by these types of constructions in the Kalangi river basin, Sullurpet area. The construction cost of sub-surface dams are around8.7 lakh rupees, 16.5 lakh rupees and 27 lakh rupees at GK Engineering College, Challammagudi and Holy Cross School, respectively. This study indicates that consideration for the construction of groyne and subsurface dams in the Kalangi river basin is feasible and economical by using cheap materials like clay and low density polyethylene film. Watershed management of this type has enhanced base flow and the storage capacity at sub-surface dams and ultimately facilitated the improvement of domestic water supply and agricultural activities in the ephemeral river basin. Involvement of the community is necessary in water management by laying greater emphasison extending and improving local water harvesting systems for the sustainable development of any region.

ACKNOWLEDGEMENTS

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Texture based Classification of Microwave Imagery

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ABSTRACT

Measuring texture in images using the grey level co-occurrence matrix (GLCM) has been carried out in recent studies. It was also proposed, several measures that can be used to extract useful textural information from a GLCM. As the GLCM is calculated for a given pixel separation, it is sensitive to the scale and directionality of image texture. It also requires that the horizontal and vertical offsets of the two pixels be specified along with the size of image segment over which the GLCM should be constructed. Several studies have shown that the texture coarseness increased from very little in clear-cut areas, to intermediate in regenerating stages, to greatest coarseness in mature forests. Homogeneity is considered as the most useful one among several types of texture measures. It is proposed to classify the microwave imagery using texture based analysis.

***Keywords*:** Classification, Synthetic Aperture Radar, RISAT-1, Threshold.

I. INTRODUCTION

In many areas of the world, the frequent cloud conditions often restrain the acquisition of high-quality remotely sensed data by optical sensors. Thus, radar data become the only feasible way of acquiring remotely sensed data within a given time framework because the radar systems can collect Earth feature data irrespective of weather or light conditions. Microwave remote sensing has gained a lot in importance over the last decade with the availability of active radar imaging systems for a wide range of scientific applications. Especially synthetic aperture radars mounted on airborne or spaceborne platforms proved to be of great benefit due to their day and night capabilities and weather independence. Mapping landuse/land-cover of the rural-urban fringe in a timely and accurate manner is thus of great importance for urban planning, landuse planning, conservation of biodiversity and sustainable management of land resources. With its all-weathered capability, SAR instruments have been receiving considerable attention in the remote sensing community. To evaluate the effectiveness of different image processing techniques for extraction of landuse/land-cover information, it is necessary to classify the raw SAR images, filtered images and texture images.

In the present study, the Grey level co-occurrence matrices (GLCM) were used in the interpretation of remotely sensed imagery. It has been found to increase the ability to discriminate different land cover classes using single date and single polarized data.

II. PROCEDURE

1. Intensity Image generation of RISAT-1.
2. Sigma$_o$ image generation of step 1.
3. Textures like entropy, mean, contrast, correlation & etc calculation of step 2.
4. RGB colour image generation from textures.
5. Classification of image in step4.
6. Accuracy measurement.

III. STUDY AREA

Table 1 Characteristics of Data

Radar Carrier Frequency	5.35 GHz (C-band)
Incidence angle	41.337 Deg
Polarizations	HH
Datum	WGS 84
Sensor height at the equator	541 km
Revisit time (Orbit repeat cycle)	12 days
Resolution	36 meters
Mode	ASCENDING
Sensor Look	Right
Mean Local Time	6 AM

The area that we considered for classification is MAYKOP, RUSSIA. The central latitude and longitude values are 44.609 and 40.094 respectively. The characteristics of the scene have been given below.

IV. RESULTS AND DISCUSSION

The back scattering coefficients were calculated to have the sigma$_o$ image. By using textures it has been classified. For that classification we took original image in red, Entropy in green and mean in blue color. Rearrangement of threshold is necessary to have the image in 4 classes.

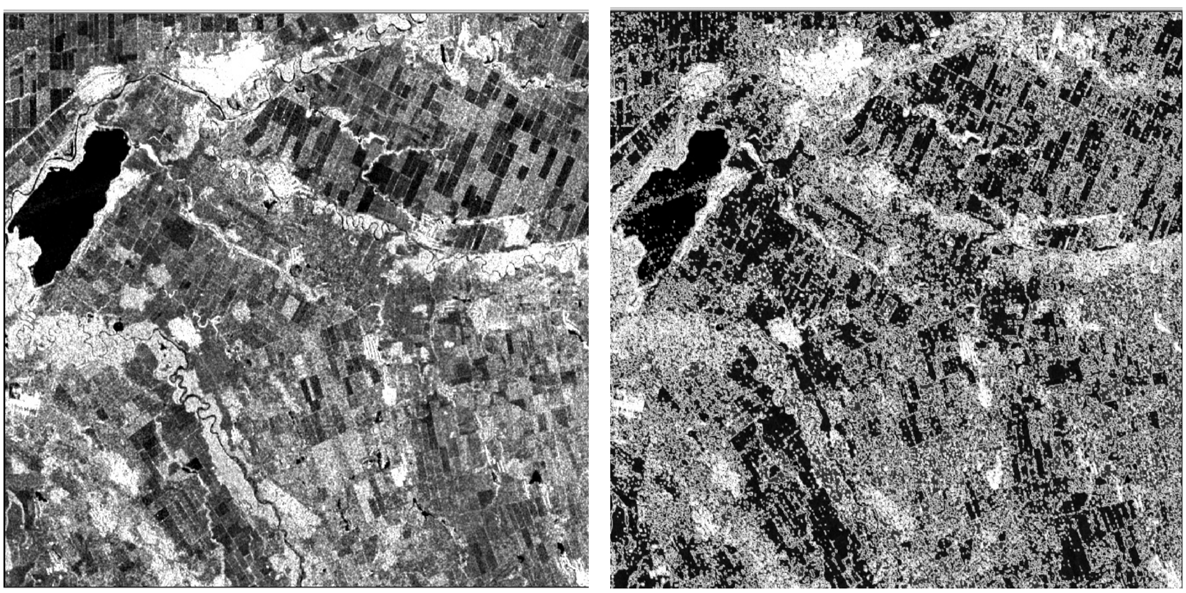

Fig. 1 RISAT-1 Image(Left) and Texture based Color Image with HH Image(Red), Entropy(Green) and Mean Intensity(Blue)

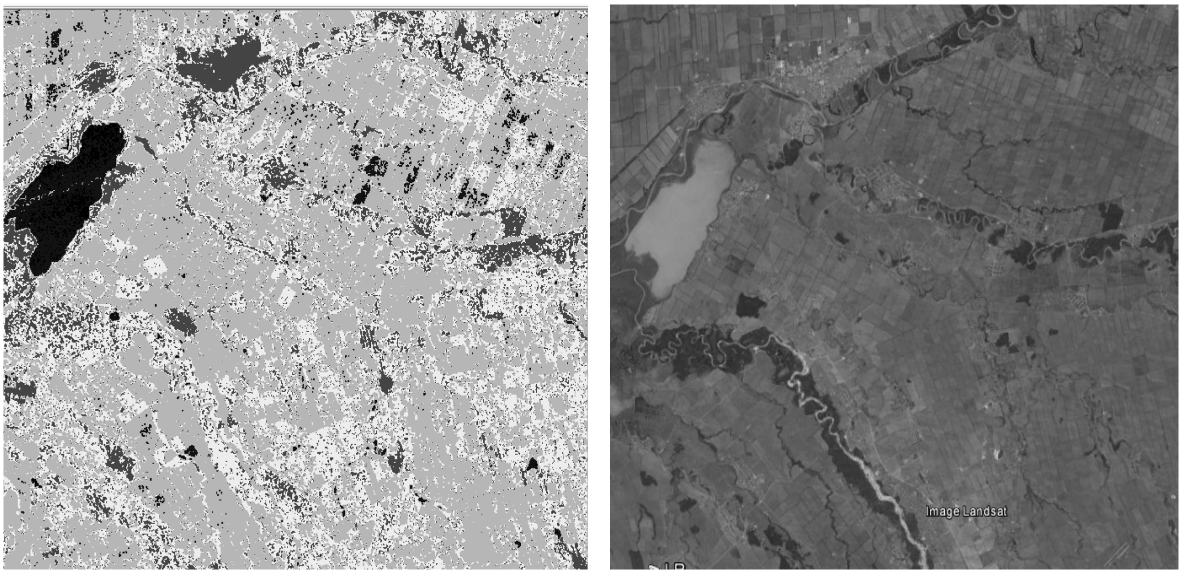

Fig. 2 Supervised Classified Image (Left) and Google Earth Image (Right)

The classification has been done by considering single polarized and single date data. Overall accuracy is the total number of correctly classified samples (diagonal cells in a confusion matrix) divided by the total number of reference pixels. Utilizing all elements from the confusion matrix, Kappa coefficient is a measure of the difference between the actual agreement between reference data and a classification and the change agreement between the reference data and a classification (Lilles and & Kiefer 2000). Kappa takes into account both errors of commission and omission, and thus provides a more complete picture of the information comprising the confusion matrix than overall accuracy (Jensen, 2004).

After classification the kappa statistics have been performed to know the accuracy of the classification. We got accuracy of 76% and kappa value as 0.6016. The table1 gives accuracy calculations of all classes and table 2 gives kappa calculations.

Table 2 Accuracy Calculations

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
WATER	4	4	4	100.00%	100.00%
SETTLEMENTS	8	8	6	75.00%	75.00%
AGRICULTURE	50	46	38	76.00%	82.61%
BARREN	38	42	28	73.68%	66.67%
Totals	100	100	76		
Overall Classification Accuracy = 76.00%					

Table 3 Kappa Calculations

Class Name	Kappa
WATER	1
AGRICULTURE	0.6522
BARRON	0.4624
SETTLEMENTS	0.7283

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Estimation of Evapotranspiration by Artificial Neural Network

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ABSTRACT

This study describes the conceptual framework and implementation to estimate the evapotranspiration by using computation technique artificial neural network.The objective of this study is to test an artificial neural network (ANN) to estimate reference evapotranspiration (ETo). Evapotranspiration is one of the main components of the hydrologic cycle. This complex process is dependent on climatic factors. There are many conventional methods to estimate evapotranspiration. The well-known Modified Penman Method equation always performs the highest accuracy results of estimating reference evapotranspiration (ETo) among the existing methods. However, the equation requires climatic data that are not always easily available. Artificial neural networks are one of the recent technique and studies for modeling complex systems and nonlinear features have shown very high ability. The major objective of this study is to estimate evapotranspiration using an artificial neural network (ANN) technique and to examine if a trained neural network with limited input variables can estimate evapotranspiration (ETO) efficiently.

***Keywords**:* Artificial Neural Network, Evapotranspiration, Modified Penman Method, Climatic Data.

INTRODUCTION

Evapotranspiration (ETo) is a term used to describe the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle. An element (such as a tree) that contributes to evapotranspiration can be called an evapotranspirator.

Evapotranspiration (ETo) is a major component of the hydrological cycle and is involved to some degree in nearly all hydrological studies. It is an especially important factor in planning and developing river basins, water recourses and irrigation management. Evapotranspiration forms the foundation for planning and designing of most irrigation projects. It is usually starting point in determining the surface and subsurface water storage requirements, the capacity of the water delivery system, and general operation practices.

Evapotranspiration can be directly measured using of Lysimeter estimated with meteorological data. However, it is not always possible to use Lysimeter to measure evapotranspiration, because this method is time consuming and requires accurate planning. Hence, indirect methods based on weather data for estimating reference crop evapotranspiration are used. These methods include empirical equations or methods based on physical processes of complex. One of the methods that are widely used to estimate evapotranspiration is the Modified Penman Method. According to research done, the Modified Penman Method is accurate method of estimating evapotranspiration. Though there are conventional methods to estimate evapotranspiration, it is only possible to estimate evapotranspiration when all climatic data is available

Thus there is scope for alternative techniques to estimate evapotranspiration. Artificial neural network is one of the alternate techniques which can be used to estimate evapotranspiration. Artificial neural networks are a useful tool for modeling nonlinear systems. Artificial neural networks offer Simplified mathematical models of biological neuron networks.

A. Location and Extent

The study area consider for the calculation for evapotranspiration (ETo) is the area under the Godavari river basin. For this purpose Jayakwadi reservoir is taken as a case study. The Jayakwadi dam is constructed across Godavari river in Paithan taluka in Aurangabad district of Maharashtra state, India. The main site area is Pategaon station at downstream side of the dam. The study area is bounded by North latitudes 19º27'055" and East longitudes 75º24'27". Altitude of the study area is 439.415meter. The Average annual rainfall of the area is about 734 mm

B. Scope of the Present Study

An application of the Modified Penman Method requires data of solar radiation, wind speed, temperature, saturation vapour pressure, sunshine hours and humidity. However, all these input variables may not be easily available at a given location. If all these climatic data is available then only it is possible to estimate evapotranspiration by Modified Penman Method. Among the inputs needed, temperature data are routinely measured and solar radiation can be estimated with sufficient accuracy. But the other variables are generally measured at only a few locations.

Automatic weather stations (AWS), which are commonly used these days in developed countries to measure climatic variables, are rare in many other countries. Often there may not be even a single AWS over an area of thousands of square kilometers. In such circumstances, one may be forced to use data from the 'nearest' station, which may in fact be far away, often in completely different hydro meteorological settings. In view of the above, it is necessary to develop techniques that can be employed to estimate accurately (ETo) for situations where values of some of the variables are not available. Artificial neural networks (ANN), which is a modern data-driven technique, may be well suited for this purpose.

C. Objectives

The main objective of the present study is to estimate evapotranspiration by conventional method i.e. Modified Penman Method and also with the help of alternative technique i.e. Artificial Neural Network (ANN).

In Modified Penman Method, evapotranspiration (ETo) is been calculated by using all the variables of climatic data whereas in case of Artificial Neural Network (ANN) technique evapotranspiration is to be calculated with the help of available climatic data.

Estimation of Evapotranspiration by Modified Penman Method

The Modified Penman Method is a close, simple representation of the physical and physiological factors governing the evapotranspiration process. The mathematical expression for calculation is simplified as follow:

$$ETo = (A^* Hn) + (Ea^*\gamma) / (A+\gamma)$$

Where,

ETo – Evapotranspiration in mm/day

A – Slope of saturation vapour pressure vs. temperature curve at the mean air temperature, in mm of mercury / °C

Hn – Net radiation in mm of evaporable water/ day

γ- Psychometric constant = 0.49 mm of mercury/ °C

The equation uses standard meteorological records of solar radiation (sunshine), air temperature, humidity and wind speed. To ensure the integrity of computations, the measurements of weather parameters should be made at 2m (or converted to that height) above an extensive surface of green grass, shading the ground and not short of water. It should be kept in mind that all the parameters are recorded at the same place, standard hours and under the same environment.

Artificial Neural Network and Training Algorithms

ANNs employ mathematical simulation of biological nervous systems in order to process acquired information and derive predictive outputs after the network has been properly trained for pattern recognition. The network topography consists of a set of nodes (neurons) connected by links and are usually organized in a number of layers. The basic structure of an ANN usually consists of three layers an input layer, an output layer, and hidden layer(s) between the input and output layers.

In networks, the input (first) layer receivesthe input variables for the problem at hand.The input layer is a means of providinginformation to the network. The hiddenlayers enhance the network's ability tomodel complex functions. The number ofhidden layers and the number of nodes ineach hidden layer are usually determined bytrial and error procedure. The last or outputlayer consists of values predicted by thenetwork and thus represents model output.The nodes within neighboring layers of thenetwork are fully connected by links but they do not interconnect among themselves.A synaptic weight is assigned to each link.Each node in a layer receives and processesweighted input from previous layer andtransmits its output to nodes in the followinglayer through links. The weightedsummation of inputs to a node is convertedto an output according to a transfer function.The type of network, where data flow is inone direction, is known as feed-forwardnetwork. The objective of training is toreduce the global error (E)defined as

$$E = \frac{1}{P}\sum_{p=1}^{P} E_p$$

Where,

P = total number of training patterns

E*p* = error for training pattern p

E*p*is calculated by following formula,

$$E = \frac{1}{2}\sum_{i=1}^{I} (o_i - t_i)^2$$

Where,

I = total number of output nodes

Oi = network output at the ith output node

ti = target output at the ith output node.

In every training algorithm described in thenext section an attempt is made to reduce this global error by adjusting the weights.

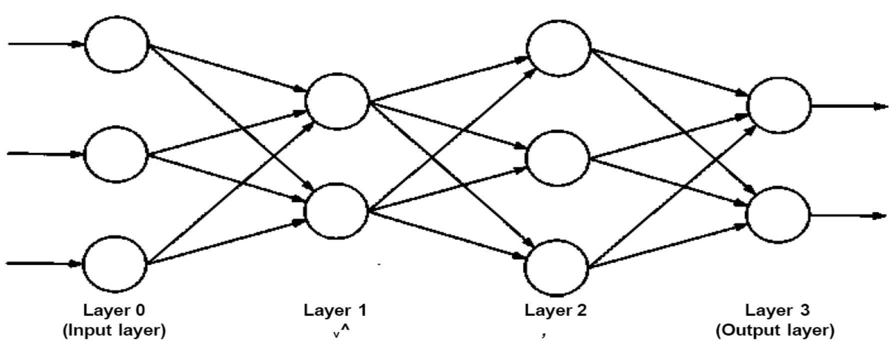

Fig. 1 Artificial Neural Network

RESULTS AND DISCUSSION

The data collected from year 2003 to 2012 of Paithan region for the purpose of calculating Evapotranspiration using Modified Pen Man Method and also with the help of Artificial Neural Network. Following table indicates the results which were calculated using the available data which was collected from Institute of Meteorological Department, Pune (IMD, Pune).

Year	Month	Mean Temp(°C)	Mean Humidity (%)	Wind Velocity (km/day)	Sunshine (hrs/day)	A	Ea	Hn	ETo (mm/day)
2003	1	20.89	75.96	67.68	6.29	1.13	2.22	4.59	3.88
	2	23.06	67.65	91.56	8.78	1.28	3.76	6.17	5.51
	3	26.18	57.6	107.94	8.55	1.5	6.33	6.7	6.61
	4	27.16	68.53	219.55	9.22	1.6	7.05	7.44	7.35
	5	28.47	64.3	364.9	10.01	1.73	11.95	7.88	8.78
	6	32.66	75.97	306.05	8.38	2.08	9.07	7.1	7.47
	7	24.27	86.48	121.5	3.15	1.37	1.89	4.66	3.93
	8	24.25	85.85	107.71	4.21	1.35	1.88	5.08	4.22
	9	20.19	66.45	119.52	6.23	1.07	3.64	5.78	5.1
	10	25.41	77.29	97.38	8.4	1.44	3.11	6.24	5.44
	11	23.03	75.62	112.8	8.32	1.27	3.07	5.53	4.85
	12	20.75	75.92	86.4	8.45	1.09	2.38	5.21	4.33

As per above results of Evapotranspiration for the year 2003, remaining results of average Evapotranspiration for year 2004-2012 are as below:

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Average ETo	5.25	5.12	4.37	4.98	4.77	4.73	4.45	4.28	4.61

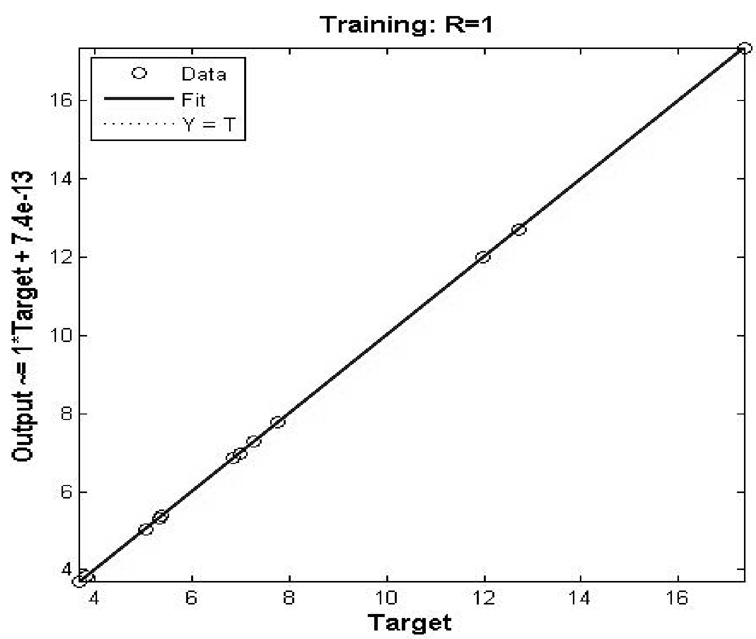

Fig. 2 Scattered Plot

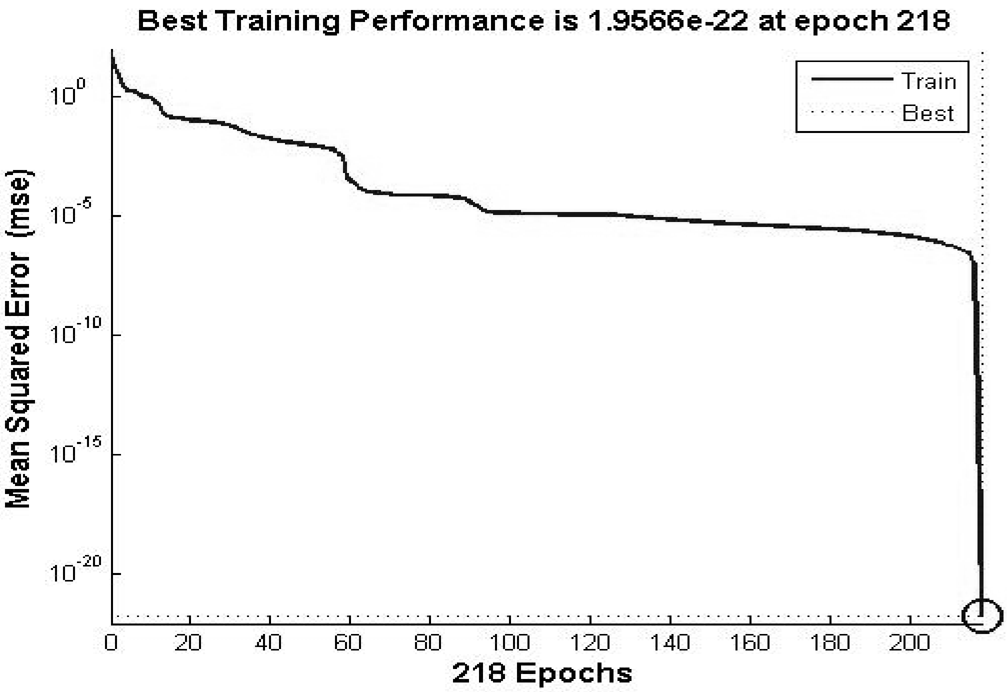

Fig. 3 Mean Square Error Plot

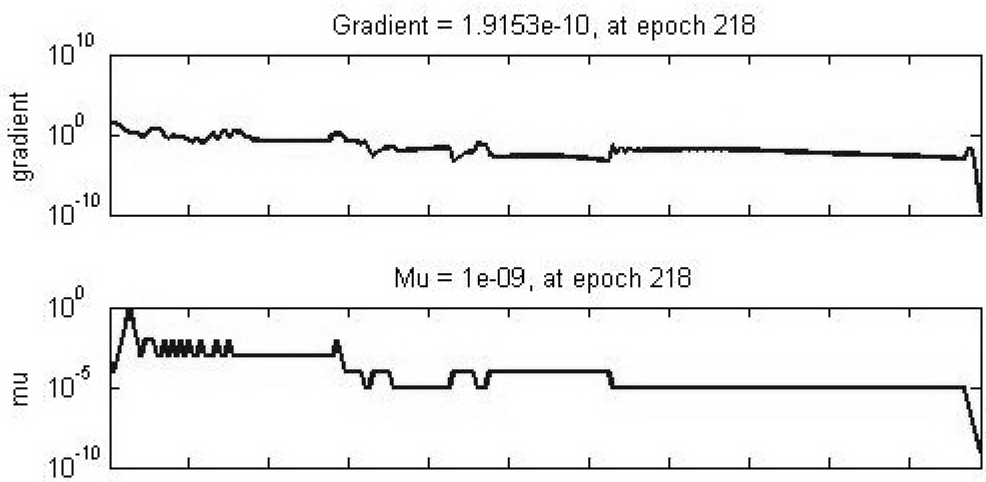

Fig. 4 Gradient and Mean Input Matrix Plot

CONCLUSION

The accuracy of an Artificial Neural Network technique in estimation of evapotranspiration using climatic variables was presented in this study. From all the conventional methods it has been observed that Modified Pen Man Method has great accuracy for calculating Evapotranspiration.

Where as Artificial Neural Network can be successfully used to estimate the evapotranspiration from the available climatic data.

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A Numerical Model on Flood Management for Godavari Sub-Basin

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ABSTRACT

Hydrological modeling of large river catchments has become a challenging task for water resources engineers due to its complexity in collecting and handling of both spatial and non-spatial data such as rainfall, gauge-discharge data, and topographic and hydraulic parameters. In this article, a flood forecast model is developed for the Godavari Basin, India through a mathematical modeling approach using MIKE 11. The approach includes rainfall runoff modeling, hydrodynamic flow routing, calibration, and validation of the model with field discharge data. The study basin is divided into 128 sub basins to improve the model accuracy. This paper describes a forecasting system recently developed in cooperation with the Central water commission (CWC) for the river Godavari. The system exits of two model concepts: i) a numerical, calibrated model consisting of a hydrological part (MIKE11-NAM) and hydraulic part (MIKE11-HD) and ii) a flood forecasting system. For some basins both meteorological and discharge measurements are available. The flood forecasting system (using MIKE-11) uses the combined calibrated hydrological and hydraulic models and produces forecasted water levels and alerts at predefined control points. Hydrological methods use the principle of continuity and a relationship between discharge and the temporary storage of excess volumes of water during the flood period. Hydraulic methods of routing involve the numerical solutions of the convective diffusion equations, the one dimensional Saint Venant equations of gradually varied unsteady flow in open channels.In present research, the examination of the several hydraulic, hydrologic methods, have been preceded for Godavari river data i.e., from Badrachalam to Polavaram stretch, compared with MIKE 11 software analysis. MIKE 11 is a professional engineering software tool for the simulation of hydrology, hydraulics, water quality and sediment transport in estuaries, rivers, irrigation systems and other inland waters. The model is calibrated and verified with the field records of several typhoon flood events. There is a reasonable good agreement between measured and computed river stages. The results reveal that the present model can provide accurate river stage for flood forecasting for the particular stretch in the Godavari River.

Keywords: Hydrological Modeling; MIKE 11; MIKE 11-NAM; MIKE 11-HD.

INTRODUCTION

Flood is the worst weather-related hazard, causing loss of life and excessive damage to property. If flood can be forecast in advance then suitable warning and preparation can be taken to mitigate the damages and loss of life. For this purpose, many river basins have worked to build up the flood forecasting system for flood mitigations. A flood forecasting system may include all or some parts of the following three basic elements: (i) a rainfall forecasting model, (ii) a rainfall-runoff forecasting model, (iii) a flood routing model. The ability to provide reliable forecast of river stages for a short period following the storm is of great importance in planning proper actions during flood event. This article focuses on the development of the flood forecasting model.

In general, the flood routing can be classified into two categories including hydrologic method and hydraulic method. Among the hydraulic method can be widely applied to some special problems that hydrologic techniques cannot overcome and achieve the desired degree of accuracy. But, many researchers used various adaptive techniques and the real-time observation data to develop the real-time hydro-logical forecasting model in most practical applications. The various adaptive techniques include the time series analysis, linear Kalman filter, multiple regression analysis, and statistical method. The real-time observation data including the rainfall, temperature, water stage, and soil moisture were employed in their models for subsequent forecasting.

Hydrologic models were frequently applied to the real-time flow discharge forecasting with adaptive techniques, but they lack the water stages and detailed flow information in a river basin. Hydraulic models can provide the detailed flow information based on basic physical processes, but are unable to use the real-time data to adjust the flow. Hence, building a real-time flood-forecasting model by hydraulic routing is one of the most challenging and important tasks for the hydrologists. The purpose of this study is to develop a dynamic routing model with real-time stage correction method and apply it to the Godavari River in Andhra Pradesh.

Geographic Setting of Godavari Basin

Godavari basin extends over an area of 3, 12,812 sq kms, covering nearly 9.5% of total area of India. The Godavari River is perennial and is the second largest river in India. The river joins Bay of Bengal after flowing a distance of 1470 km (CWC 2005).It flows through the Eastern Ghats and emerges into the plains after passing Koida. Pranahita, Sabari and Indravathi are the main tributaries of Godavari River. (Fig 1).The basin receives major part of its rainfall during South West Monsoon period. More than 85 percent of the rain falls from July to September. Annual rainfall of the basin varies from 880 to 1395 mm and the average annual rainfall is 1110 mm.Floods are a regular phenomenon in the basin.Badrachalam,Kunavaram, and the deltaic portion of the river are prone to floods frequently.Perur and Koida gauge stations are the main base stations of the Central Water Commission for flood forecasting in the basin. Geographic setting and locations of these basin stations are shown in Figure 1.

Fig. 1 Geographic Setting of Godavari Basin

Flood Routing

In hydrology, routing is a technique used to predict the changes in shape of water as it moves through a river channel or a reservoir. In flood forecasting, hydrologists may want to know how a short burst of intense rain in an area upstream of a city will change as it reaches the city. Routing can be used to determine whether the pulse of rain reaches the city as a deluge or a trickle. . Flood routing is important in the design of flood protection measures, to estimate how the proposed measures will affect the behaviour of flood waves in rivers, so that adequate protection and economic solutions may be found.

Central Water Commission started flood-forecasting services in 1958 with the setting up of its first forecasting station on Yamuna at Delhi Railway Bridge. The Flood Forecasting Services of CWC consists of collection of Hydrological/ Hydro-meteorological data from 878 sites, transmission of the data using wireless/ fax/ email/ telephones /satellites /mobiles, processing of data, formulation of forecast and dissemination of the same. Presently, a network of 175 Flood Forecasting Stations including 28 inflow forecast, in 9 major river basins and 71 sub basins of the country exists. It covers 15 States besides NCT Delhi and UT of Dadra & Nagar Haveli. Central Water Commission on an average issues 6000 flood forecasts with an accuracy of more than 95% every year.

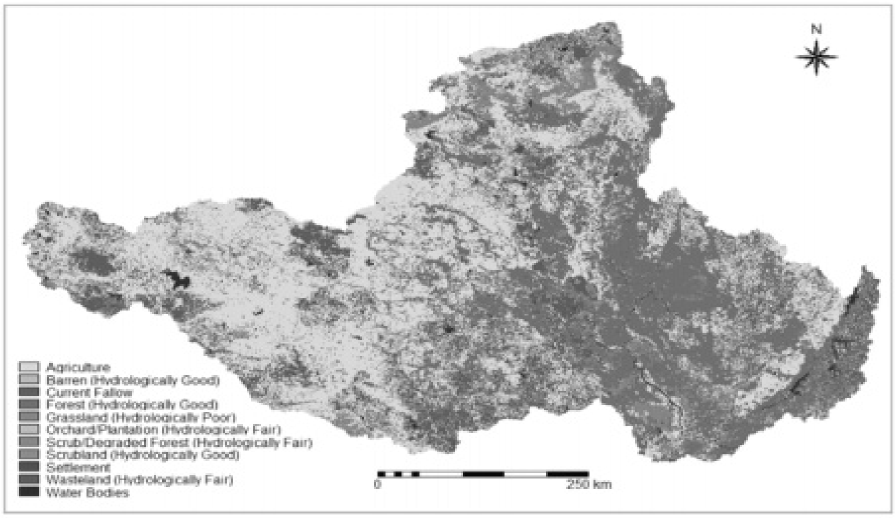

Fig. 2 Hydrological Land Covers of Godavari Basin

Modeling Approach and Methodology

MIKE 11 is a professional engineering software tool for the simulation of hydrology, hydraulics, water quality and sediment transport in estuaries, rivers, irrigation systems and other inland waters. MIKE 11 is a modeling package for the simulation of surface runoff, flow, sediment transport, and water quality in rivers, channels, estuaries, and floodplains.

A. Hydrodynamic (HD) Module

The most commonly applied hydrodynamic (HD) model is a flood management tool simulating the unsteady flows in branched and looped river networks and quasi two-dimensional flows in floodplains. MIKE 11 HD, when using the fully dynamic wave description, solves the equations of conservation of continuity and momentum (known as the 'Saint Venant' equations). The solutions to the equations are based on the following assumptions:

- The water is incompressible and homogeneous (i.e. negligible variation in density)
- The bottom slope is small, thus the cosine of the angle it makes with the horizontal may be taken as 1
- The wave lengths are large compared to the water depth, assuming that the flow everywhere can be assumed to flow parallel to the bottom (i.e. vertical accelerations can be neglected and a hydrostatic pressure variation in the vertical direction can be assumed)
- The flow is sub-critical (super-critical flow is modeled in MIKE 11, however more restrictive conditions are applied)

The equations used are:

CONTINUITY:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = q$$

MOMENTUM:

$$\frac{\partial Q}{\partial t} + \frac{\partial(\alpha \frac{Q^2}{A})}{\partial x} + gA\frac{\partial h}{\partial x} + \frac{gQ|Q|}{C^2AR} = 0$$

Where

- Q:discharge,(m^3/s)
- A:flowarea,(m^2)
- q:lateral inflow,(m^2/s)
- h:stage above datum,(m)
- C:Chezy resistance coefficient,($m^{1/2}/s$)
- R:hydraulic or resistance radius,(m)
- I: momentum distribution coefficient

Model Calibration and Validation

Model calibration is the process of adjusting model parameter values until model results match historical data. The process can be completed using engineering judgment by repeatedly adjusting parameters and computing and inspecting the goodness-of-fit between the computed and observed hydrographs. Significant efficiency can be realized with an automated procedure (U.S. Army Corps of Engineers 2001). The quantitative measure of the goodness-of-fit is the objective function. An objective function measures the degree of variation between computed and observed hydrographs. The key to automated calibration is a search method for adjusting parameters to minimize the objective function value and to find optimal parameter values. A hydrograph is computed at the target element (outlet) by computing all of the upstream elements and by minimizing the error (minimum deviation with the observed hydrograph) using the optimization module. Parameter values are adjusted by the search method; the hydrograph and objective function for the target element are recomputed. The process is repeated until the value of the objective function reaches the minimum to the best possible extent. During the simulation run, the model computes direct runoff of each watershed and the inflow and outflow hydrograph of each channel segment. The model computes the flood hydrograph at the outlet after routing flows from all sub basins to the basin outlet .The computed hydrograph at the outlet is compared with the observed hydrograph at all the sites.

Hydrodynamic (HD) Editor

The bed resistance is defined by a type and a corresponding global value. Local values are entered in tabular form at the bottom of the editor. There are three resistance type options:

1. Manning's *M* (unit: $m^{1/3}/s$, typical range: 10-100)
2. Manning's *n* (reciprocal of Manning's *M*, typical range: 0.010-0.100)
3. Chezy number.

The resistance number is specified in the parameter `Resistance Number'. This number is multiplied by the water level depending `Resistance factor' which is specified for the cross sections in the cross section editor (.xns11 files) to give a resulting bed resistance.

Initial Conditions

Initial conditions for the hydrodynamic model are specified in fig 4. The initial values may be specified as discharge and as either water level or water depth. The radio button determines whether the specifications are interpreted as water level or depth. The global values are applied over the entire network at the start of the computation. Specific local values can be specified by entering river name, chainage and initial values. Local values will override the global specification.

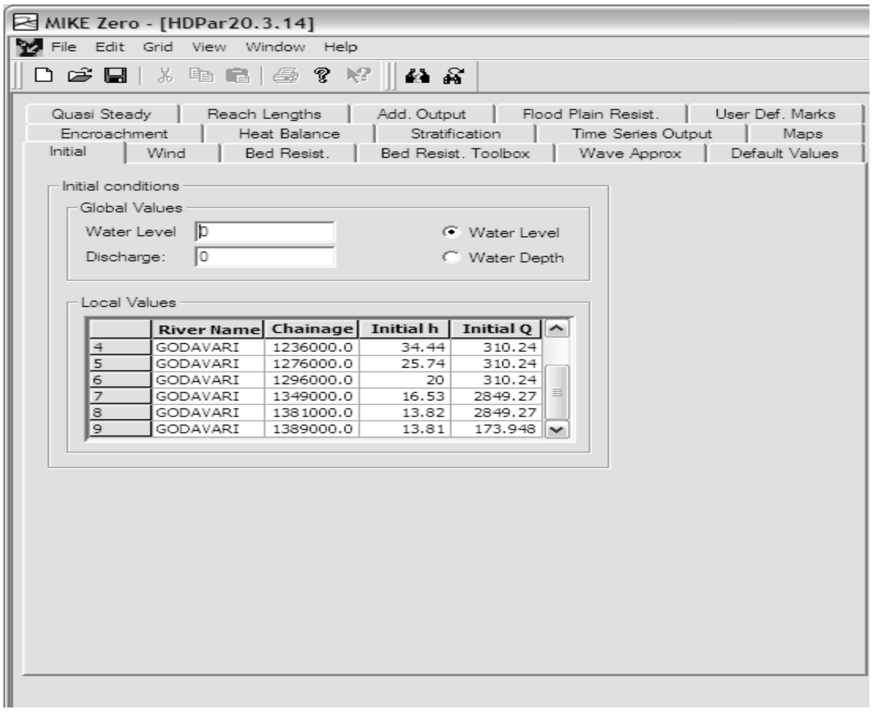

Fig. 3 Initial Conditions of Hydrodynamic Editor

Bed Resistance Toolbox

The bed resistance toolbox offers a possibility to make the program calculate the bed resistance as a function of the hydraulic parameters during the computation by applying a Bed Resistance Equation which is shown in figure 4.

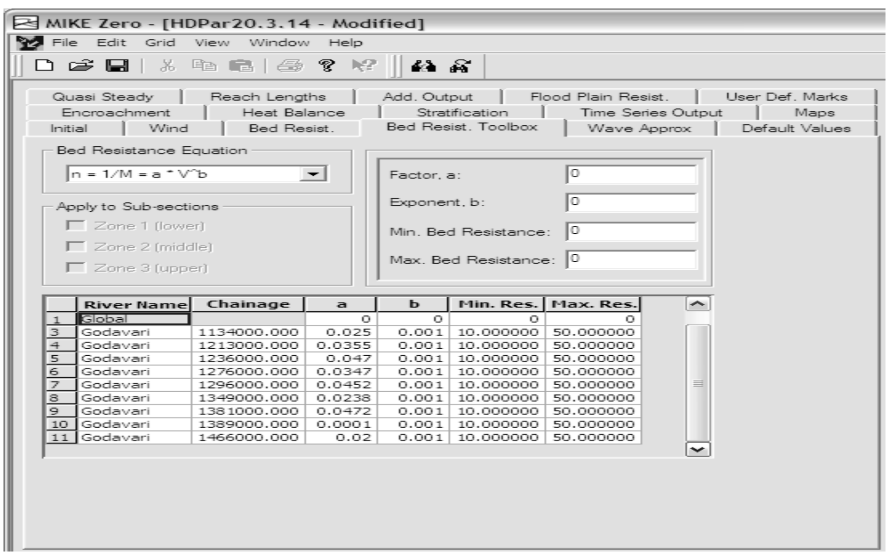

Fig. 4 Bed Resistance Toolbox of Hydrodynamic Editor

Surface and Root zone Parameters

The initial relative water contents of surface and root zone storage must be specified as well as the initial values of overland flow and interflow. Parameters used in surface and root zone are given in figure 6.

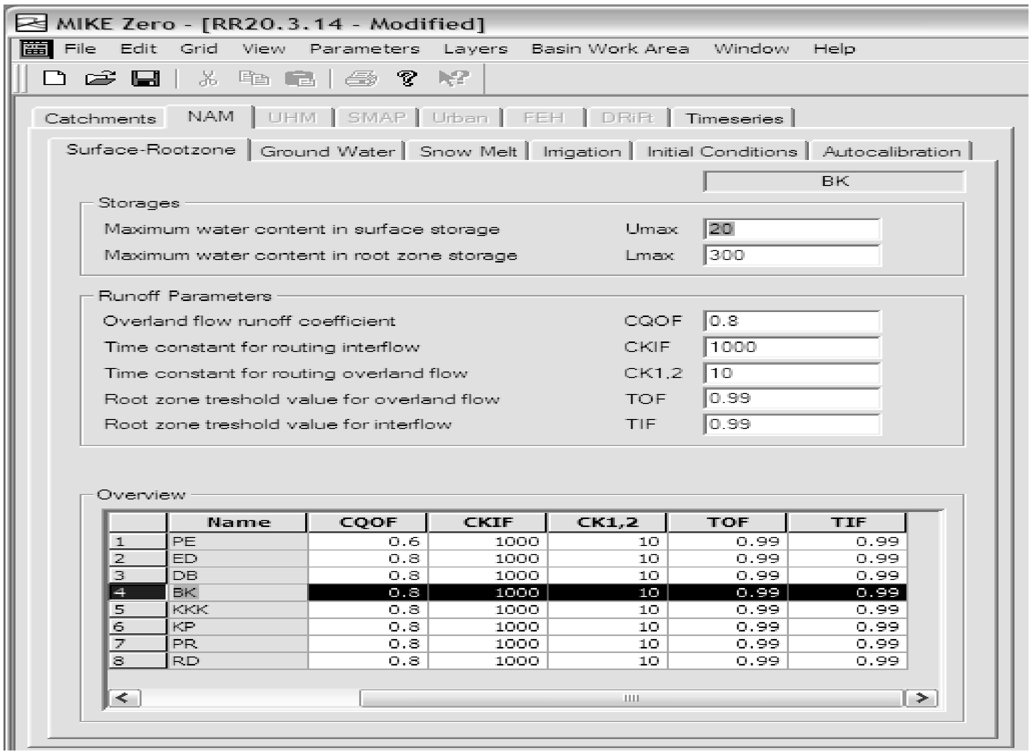

Fig. 5 Surface Root zone parameters of Rainfall-Runoff Editor

The model is calibrated for the years 2009, 2010, 2011.After computing the exact value of the unknown variable during the calibration process; the calibrated model parameters are tested for another set of field observations to estimate the model accuracy. In this process, if the calibrated parameters do not fit the data of validation, the required parameters have to be calibrated again. Thorough investigation is needed to identify the parameters to be calibrated again. In this study, hydro meteorological data of 2012 were used for model validation.

Real Time Validation of the Model

The developed model has been validated thoroughly at the Central Water Commission Office in Hyderabad with the real-time hydro meteorological data during the floods of 2013(the simulation period is 15 June to 15 October 2013). Considering the availability of real-time data, discharge data of the Badrachalam, Rainfall Data of Kunavaram, Koida, Polavaram, and Rajahmundry (Figure 1) were fed into the model as inputs. Rainfall runoff modeling was done in all the sub basins located in the study area down to the above mentioned stations. Hydrodynamic flow routing was also done in all the river channels. The selected river reach Badrachalam to Polavaram is an ideal stretch as we have catchment area, flood routing, and a tributary joining in middle and the stretch is not very long, the intermittent catchment contribution is less. For study purpose this is the best stretch.

RESULTS AND DISCUSSIONS

Agricultural land is the predominant land-use type in the study area that is severely exposed to floods every year. Slopes in the deltaic portion of the river are very flat (less than 3 percent), causing frequent inundation in this area. Soils in the study area are very fine in texture, resulting in more runoff.

The computed hydrograph during the validation process and observed hydrograph at Badrachalam and Polavaram stations are shown in Figures 6, 7, 8, 9.

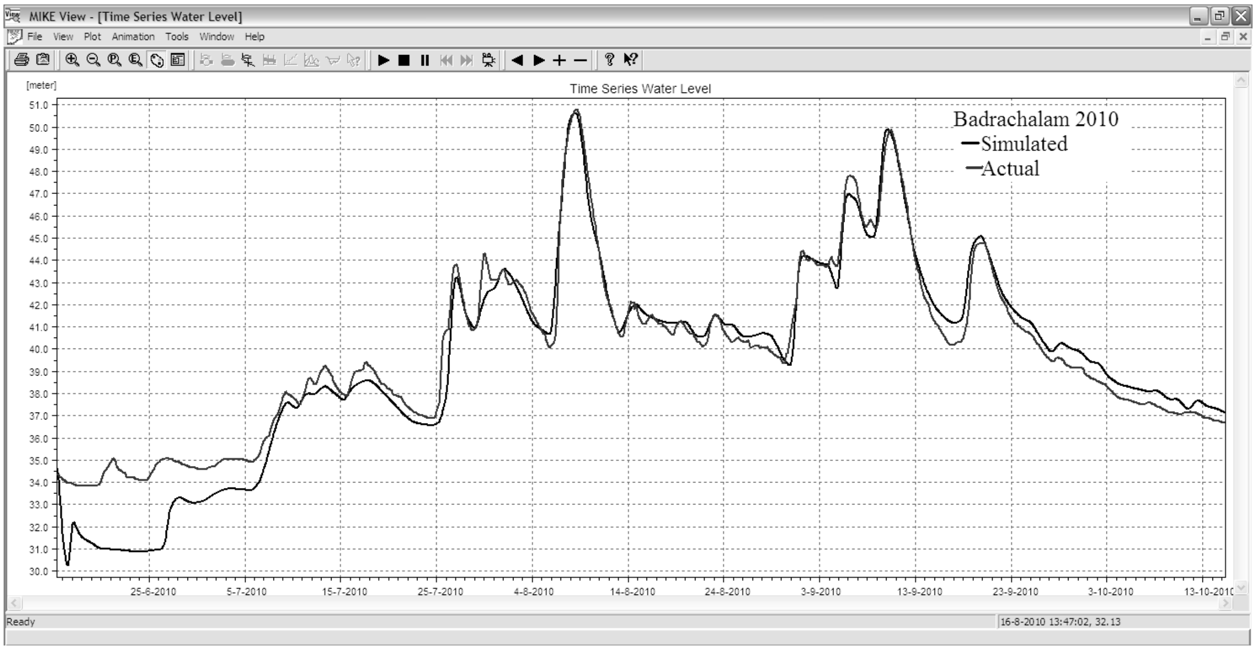

Fig. 6 Comparison of Actual Badrachalam Water Level graph with the Simulated Badrachalam Water Level graph for the year 2010

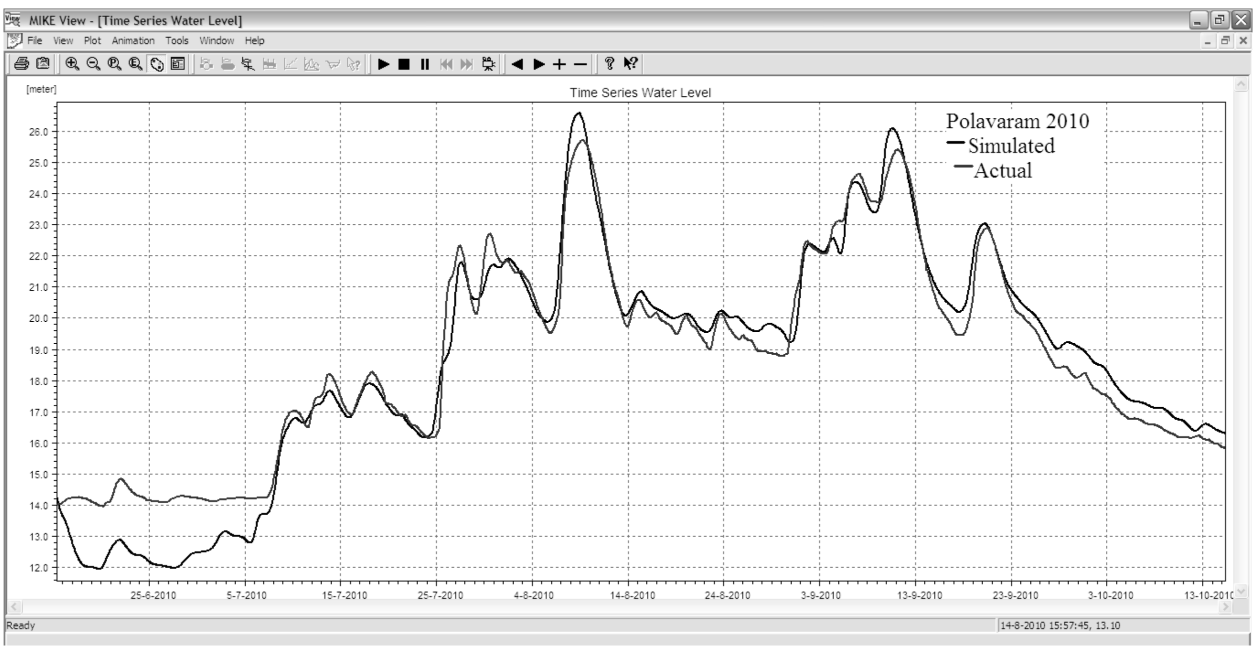

Fig. 7 Comparison of Actual Polavaram Water Level graph with the Simulated Polavaram Water Level graph for the year 2010

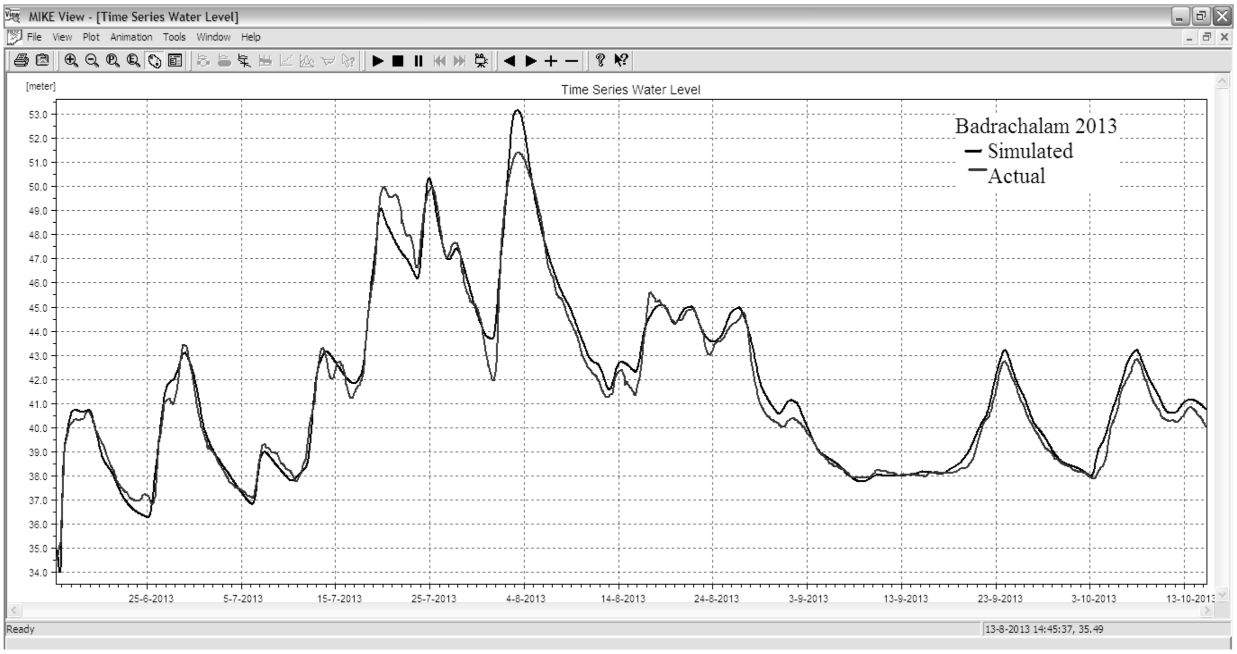

Fig. 8 Comparison of Actual Badrachalam Water Level graph with the Simulated Badrachalam Water Level graph for the year 2013

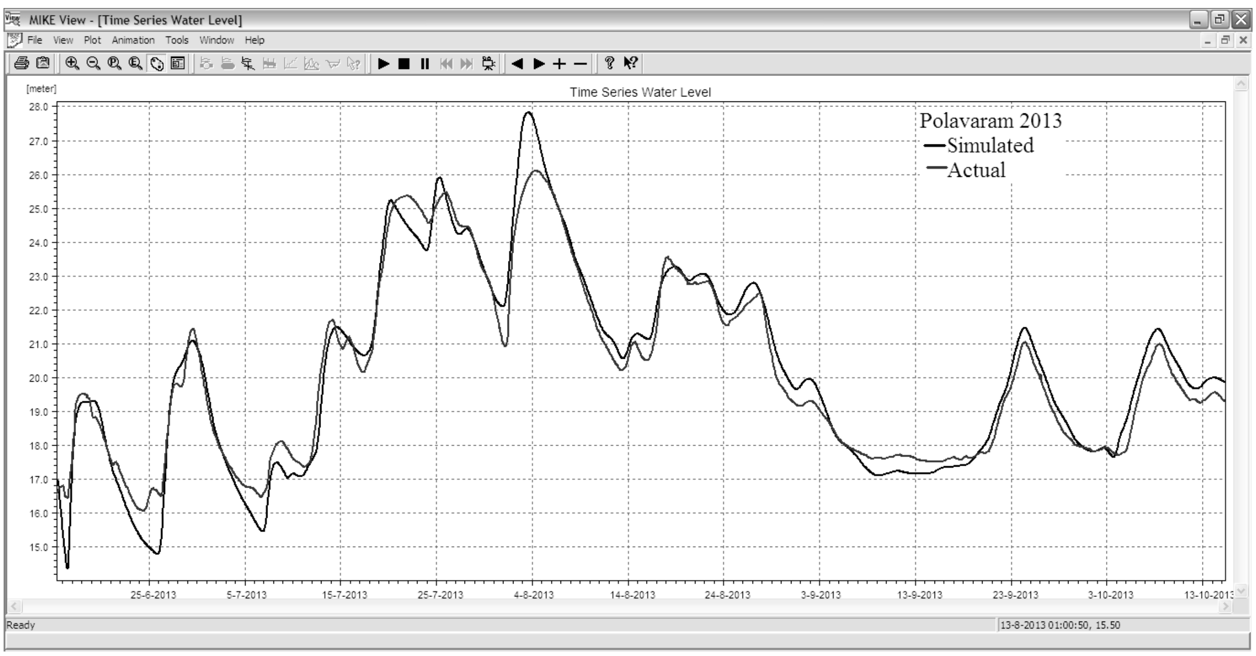

Fig. 9 Comparison of Actual Polavaram Water Level graph with the Simulated Polavaram Water Level graph for the year 2013

CONCLUSION

The computed hydrograph during the validation process and observed hydrograph at Badrachalam and Polavaram stations are shown in Figures. These figures indicate that the computed hydrographs match well with the observed hydrographs.

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Identification of Impacts of Groundwater Mining and Recharge Structures at Tummalapalli Uranium Mining Area

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ABSTRACT

Tummalapalli Uranium mining area near Pulivendula in Kadapa district of Andhra Pradesh has became bright spot in the world map of Uranium deposits. Uranium Corporation of India Ltd. is mining the uranium ore and processes it on site. In this process lot of ground water is being pumped from the mining site affecting the yields of wells in the sourrounding villages as complained by the farmers. On the request of the district collector of Kadapa, Investigations were carried out on the falling ground water levels in the area to ascertain whether the pumping at the mining site is affecting the yields of wells in the surrounding villages or not. Water levels in the area for the years 2006-2009 were collected from the State Groundwater Department. Groundwater levels for the year 2011 were collected by the authors. From the contour map analysis it has been ascertained that the pumping at the mining site is affecting only in the villages of Tummalapalli and Mabbuchintalapalli and not the far off villages like K.K.Kottalu, Bhumayyagaripalli, Velpula and Rachakuntapalli. Further investigations were carried out to identify the groundwater recharge structures at Tummalapalli and surrounding areas. For this purpose satellite data is used to prepare, elevation map, slope map, drainage map and land use/ land cover map. These maps are integrated by using GIS to produce the maps containing the location of recharge structures and identified areas for afforestation so as to recharge the runoff from the study area.

***Keywords**:* Tummalapalli, Uranium Mining, Groundwater.

INTRODUCTION

Ground water levels are droping continuously due to over exploitation of aquifers. The regions with scanty rainfall are widely exposed to this kind of phenomenon. The ground water levels are fluctuating from time to time depending on the recharge and discharge conditions. During mining, encountered ground water is pumped out for smooth conduction of the mining activity. Some times to arrest ground water flow subsurface dykes will be constructed across the ground water flow. These dykes disturb the natural flow of ground water and lead to the failure of the downstream wells due to lack of water supply from upper reaches. The present study at tummalapalli mining area has been taken to address the problems of the surrounding village farmers about bore well failures due to mining activity. In the present study detailed ground water survey was conducted in and around Tummalapalli mining area to understand the present ground water conditions. The present ground water levels with the previous ground water levels are compared. Possible measures to improve ground water levels have been recommended. In the entire work, remote sensing and GIS are used which are playing very good role in delineation and demarcation of the ground water potential zones. Remote sensing and GIS coupled with extensive field work has helped in the detailed analysis of the watershed.

Literature Review

Depletion in Groundwater is the inevitable and natural consequence out of withdrawing water from an aquifer. Bosch and Hewlett (1982) concluded that increasing pasture areas and forest cover could reduce the total annual flows by up to 40%. The practice of artificial recharging is increasingly emerging as a powerful tool in water resources management (Ma and Spalding 1997). Meijerink (2000) recognizes the value of remote sensing in groundwater recharge-based studies and suggests that it can significantly aid to the conventional assessment and modeling techniques. Many assessments on groundwater conditions made with remote sensing techniques (Bastiaansen et al. 1998; Chowdary et al. 2009; Venkata et al. 2008; Jasrotia et al. 2009; Krishnamurthy and Srinivas 1995; Venkateswara Rao 1998; Bekkam 2007). Cowen (1988) defined GIS as a decision support system involving the integration of spatially referenced data in a problem solving environment. In addition, unlike conventional methods, GIS methods for demarcation of suitable areas for ground water replenishment are able to take into account the diversity of factors that control groundwater recharge. In recent years, a shift in groundwater resources management approaches from the traditional concept to the new model using the geographical information system (Rowshon et al. 2009; Koch and Grünewald 2009; Al-Qudah and Abu-Jaber 2009). The GIS applications in hydrogeological mapping can be divided into two parts: hydrological analysis (Naik et al. 2009, Patil et al. 2008;) and water resources development (Chowdary et al. 2009; Wu et al. 2008;).

Study Area and Data Description

Tummalapalle of YSR District, Andhra Pradesh covered under Survey of India Toposheet Nos. 57 J/3 and 57 J/7 between latitudes 14°18'36” N & 14°20'20” N and longitudes 78°15'16” E & 78°18' 03.3” E. The deposit in the study area is dolostone hosted strata bound type formed by the leaching of uranium from underlying basement granites. The rock type belongs to the Vempalli formation of Cuddapah Super group. Tummalapalle project area has an areal extent of 973 ha. For the analysis of land and water resources, watershed has been taken as the unit as shown in Figure 1. To delineate the drainage and water bodies, survey of India topo sheets have been used. The maximum and minimum elevations in the study area are 231 and 759 m respectively. The ground water levels have been observed for the month of August 2011 using water level indicator at thirteen well locations covering the entire watershed area. The available monthly well data from 2006 to 2009 has also been collected from state ground water department. This data has been used to understand the trend in the water levels. The land use / land cover information of the study area is collected during field visit. Most of the area covered with plantation and crops. There is no irrigation from canal. The crops are sustained with ground water only. The digital elevation data from SRTM satellite has been used to produce slope and aspect maps. The satellite images of Landsat TM for the year 2006 and High resolution data from Google earth 2013 have been used for mapping of Land use / Land cover, settlements, surface water bodies and mining activity. The geology of the study area has been delineated from District geological map collected from Geological survey of India. The available rainfall data from the nearest rain guage station has collected from 2000 to 2011. This rainfall data has been used to calculate normal rainfall and trend of the rainfall in the study area. After delineating the all resources maps using remote sensing and GIS, a detailed field work has been carried to cross check the doubtful areas.

METHODOLOGY AND ANALYSIS

The entire work has been carried into two parts. The first part deals with the observation of the change in the ground water levels and the second part deals with recommendations to improve the ground water levels in the study area.

The ground water levels have been collected in the year 2011. These ground water levels are reduced to mean sea level and a contour map has been prepared using inverse distance weighted method in ArcGIS as shown in Fig. 2.

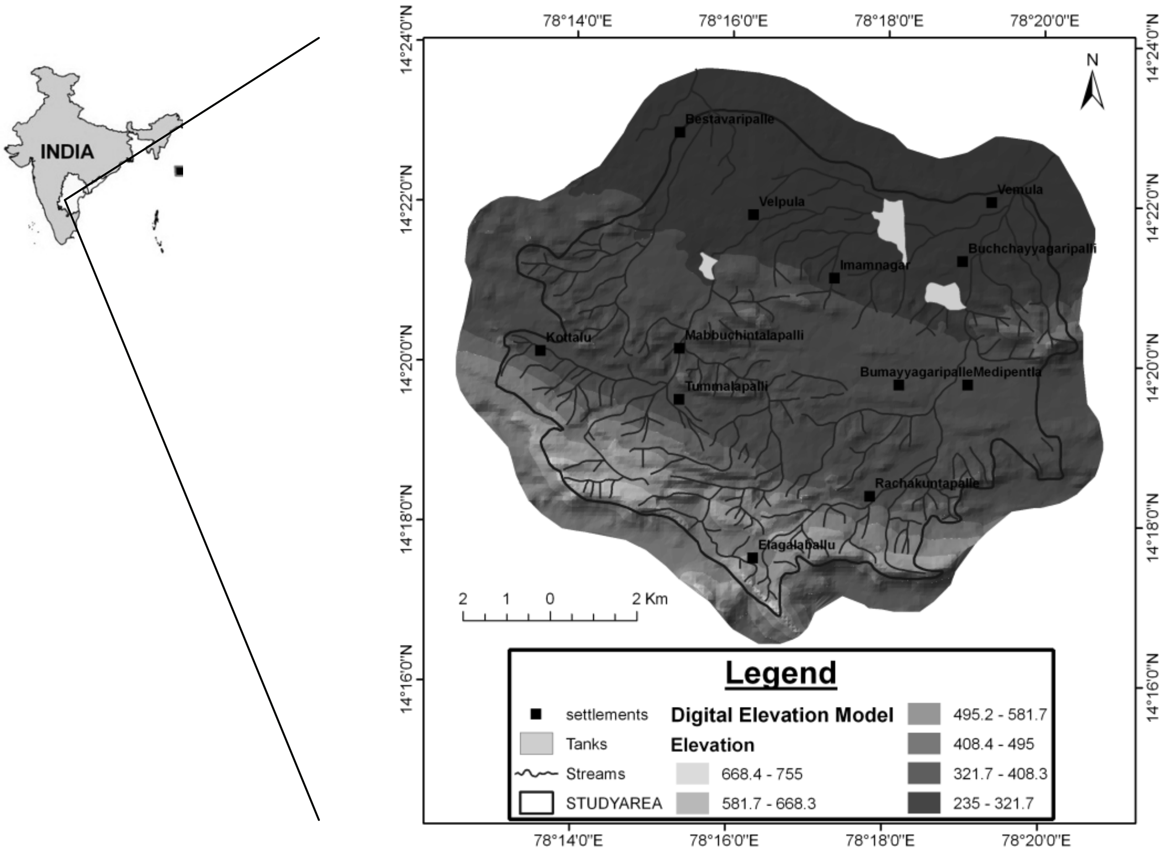


Fig.1 Location Map

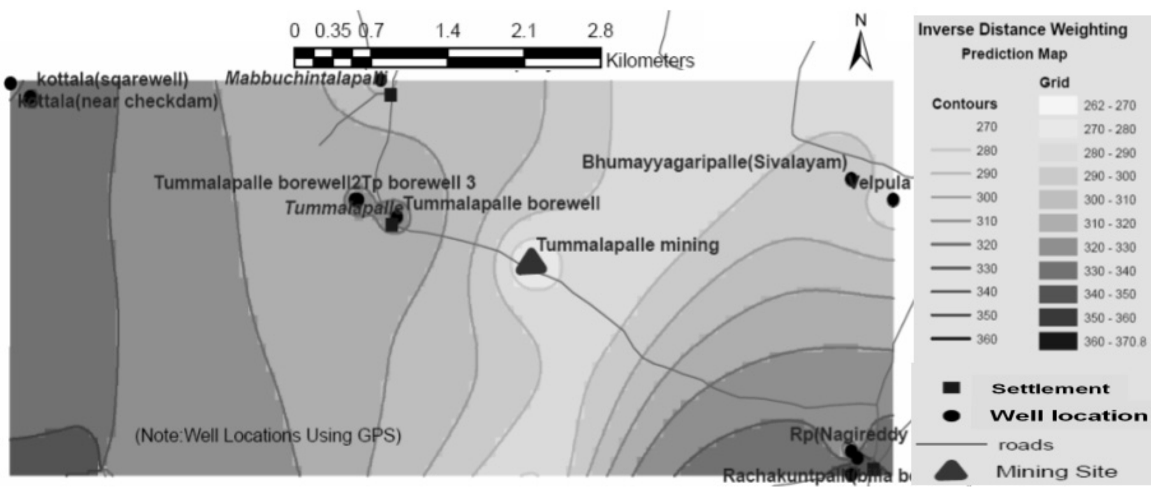


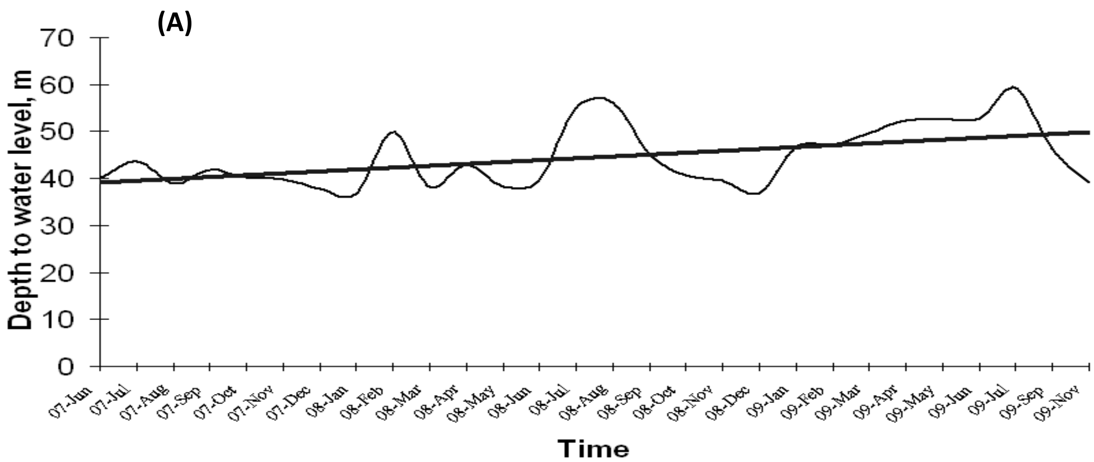
Fig. 2 Contour Map of Groundwater Levels at Tummalapalli Mining Area

From the Figure 2, it can be observed that the groundwater flow is towards the mining site there by influencing surrounding wells mostly in Tummalapalli and parts of Mabbuchintalapalli village. There is a least effect in the villages like K K Kottalu, Bhumayyagaripalli, Velpula, Rachakuntapalli. The heavy groundwater pumping is also observed at mining site as has been shown in Fig 3.

Fig. 3 Groundwater Pumping at the Tummalapalli Mining Site

The argument that, the pumped groundwater has been utilized or recharged therein and there itself so that local groundwater levels do not change is not correct because most of the pumped groundwater, approximately 70 % is lost through evaporation and transpiration.

Further, the groundwater observation data of the study area is collected from the State Groundwater Department at Kadapa. Each well data is plotted to see the change in trend of the groundwater levels from 2006-2009. The study indicates that the decline of groundwater levels are mostly observed in the wells situated near Medipentla (east of tummalapalli mining area) and Mabbuchintalapalli (north of tummalapalli mining area) as shown in Fig. 4. from 2006 to2009.



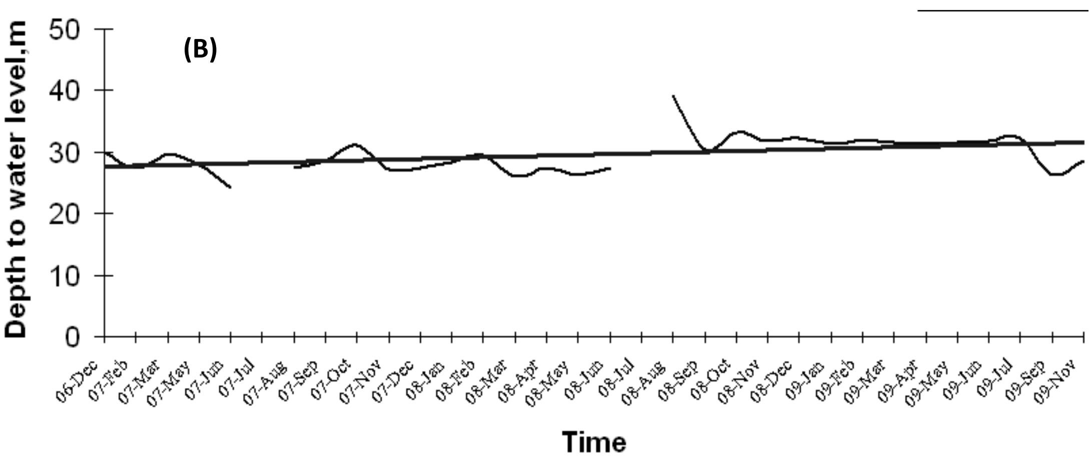


Fig. 4 Well Hydrographs of A) Medipentla and B) Mabbuchintalapalli

But there is not much change in water level in K K Kottalu and it may not be related to pumping at Tummalapalli mining since the K K Kottalu is far away from the mining site. From the contour map analysis also mining effect is not observed at this location. Some wells of Mabbuchintalapalli and Medipentla may be affected by the pumping at the mining site which has been observed in contour map of 2011 also.

Hence, it is deducted that Groundwater levels at Tummalapalli, Medipentla and some wells in Mabbuchintalapalli (Nearer to the mining site) might have got effected due to the pumping of groundwater from the mining site at Tummalapalli.

After getting the present status of the ground water levels and the change in trend of water levels at various locations in the study area, the authors have carried out detailed analysis regarding land use / land cover, rainfall, geology, geomorphology to identify the locations of the recharge areas.

Rainfall

Daily rainfall data from 2000 to 2011 has been collected from Bureau of economics and statistics department, Andrha Pradesh, India. The data has been analyzed for knowing the normal annual rainfall of the study area. The normal annual rainfall of the study area is 501.6mm; it is very low compared to the normal annual rainfall of the India. The trend map (Fig.5) of rain fall is showing the increment in rainfall from 2000 to 2011. In view of the hilly topography, it is always beneficial to have some water conservation structures in spite of low rainfall. Therefore an attempt is made in this paper to identify locations for water conservation structures with the help of thematic mapping of study area and analyzing it with GIS.

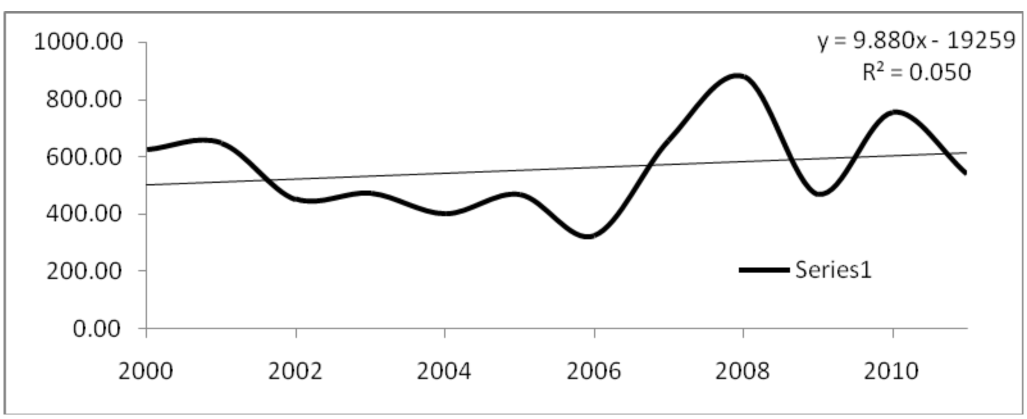


Fig.5 Yearly Trend in Rainfall at Vemula Mandal

Land Use / Land Cover Map

Land Use/ Land cover map has been prepared using the data from Landsat ETM+ sensor. Visual and digital image classification techniques have been employed for the delineation of various land use / land cover units. Various land units have been mapped and finally prepared a combined map showing (1) Dense vegetation, (2) Sparse vegetation, (3) Fallow land or Barren Rocky stony waste, (4) Water and (5) Settlements. The Land use / Land cover map has been shown in Fig.6. These units area used to identify areas of afforestation.

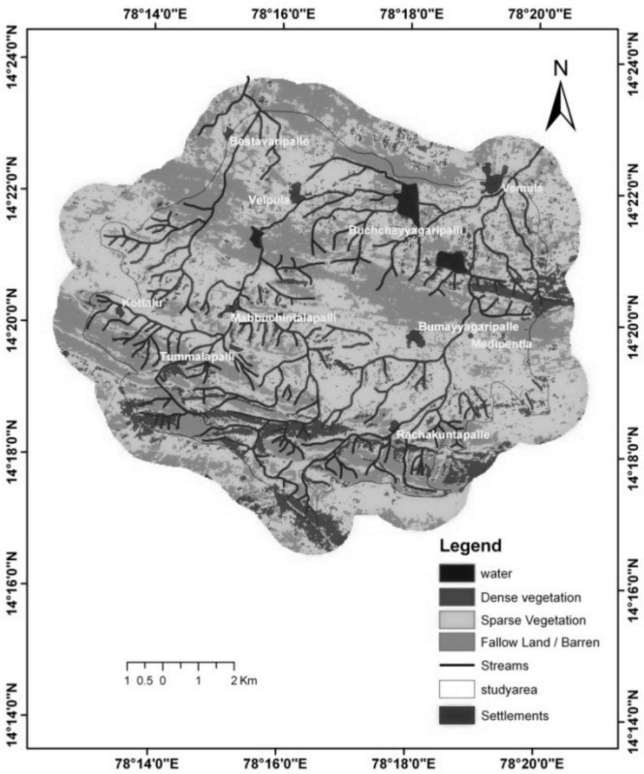


Fig.6 Land Use / Land Cover Map of the Study Area

Slope Map

Slope map has been prepared using SRTM elevation data. There are total seven classes in the slope map. The slope classification has been done by using National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) guidelines. The slope map is useful to identify locations for construction of recharge structures. The areas with slope percentage less than 5 % are suitable for construction of check dams, nalla bunds, and percolation tanks and recharge ponds.

Integrated Studies

By integrating the thematic maps such as drainage, slope, geomorphology and land use / land cover, the final map has been prepared showing the possible locations for the construction of recharge structures and afforastation areas. During field visit, it has been found that most of the recharge structures along the streams have already been constructed. Hence, in the present study only few structures were recommended. Fig.7. shows the existing and proposed areas for the construction of check dams. Check dams are identified in such a way that (1) the drainage map is overlaid on the slope map. (2)The drainage pattern and the slope of the watershed area are carefully studied. (3)Check dams are located where the terrain is fairly level below steeper slopes, where the drainage is nearly straight, and the soil mantle is fairly thick (Venkateswara Rao et al. 2011)

Afforastation has also been suggested at places where sparse or no vegetation exists which have been shown in Fig.8.

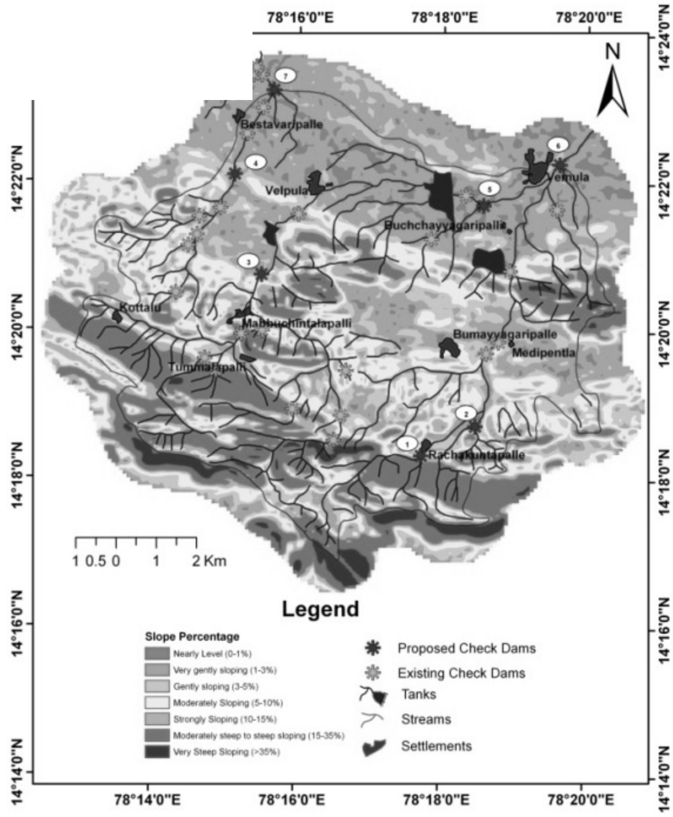


Fig. 7 Suggested Recharge Structures on Slope Map of the Study Area

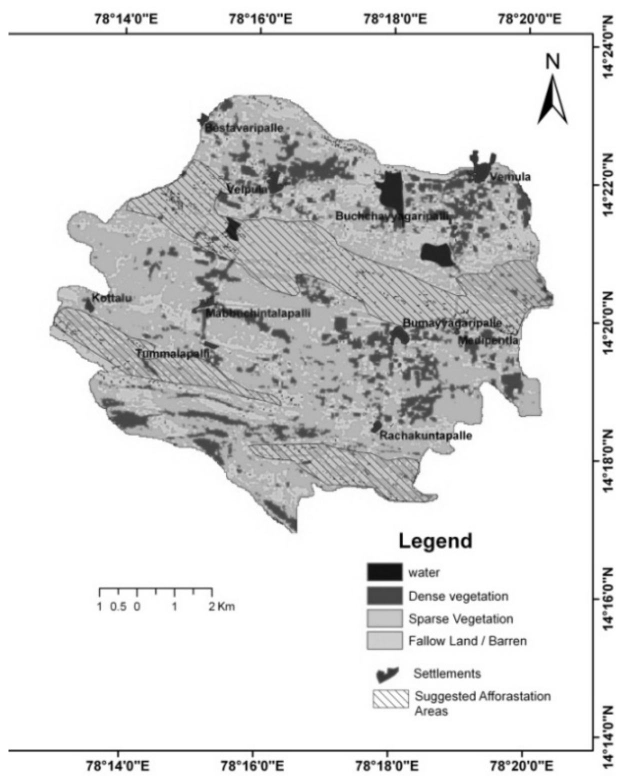


Fig. 8 Afforastation Map of the Study Area

CONCLUSION

It is concluded that Groundwater levels at Tummalapalli, Medipentla and some wells in Mabbuchintalapalli (Nearer to the mining site) might have got affected due to the pumping of groundwater from the mining site at Tummalapalli. From the thematic maps generated namely Land Use / Land cover, Geology, Geomorphology, Drainage and Slope maps, areas are identified for afforastation and construction of recharge structures such as checkdams.

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Simulation of Groundwater Recharge Estimation for Soil Water Balance Method

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ABSTRACT

With the help of MATLAB which is a high-level technical computing language, groundwater recharge estimation model is been developed. It analyses the various input parameters for quantification of ground water recharge. The model is developed for Soil Water Balance Method (SWBM). The study area considered for developing the model is JNTUH, Kukatpally, Hyderabad. For simulation of this model 27 years of climatic data has been collected from 1986 to 2012. From the model results its observed that annual recharge of ground water varies from 151 x 10^3 m^3 to 519 x 10^3 m^3 Minimum recharge is about 151 x 10^3 m^3 during the year 2011 obtained from soil water balance method (SWBM). The maximum recharge is 519 x 10^3 m^3 in the year 1996. The average recharge during the simulation period is found to be 288 x 10^3 m^3.

Keywords: Groundwater Recharge, Soil Water Balance Method, MATAB.

INTRODUCTION

A typical hydrological process which involves precipitation, surface runoff, evapotranspiration, infiltration and recharge with ground water movement. It is a cyclic process starting with precipitation and ending with evapotranspiration. Groundwater is recharged naturally by rain and snow melt and to a smaller extent by surface water (rivers and lakes). Recharge may be impeded somewhat by human activities including paving, development, or logging. Artificial groundwater recharge is becoming increasingly important in India, where over-pumping of groundwater by agricultural industry has led to underground resources becoming depleted. The groundwater recharge is difficult to quantify, unless other processes includes runoff, evapotranspiration and infiltration processes must be computed or measured accurately.

Physical methods use the principles of soil physics to estimate recharge. The direct physical methods are those that attempt to actually measure the volume of water passing below the root zone. Indirect physical methods rely on the measurement or estimation of soil physical parameters, which along with soil physical properties can be used to estimate the potential or actual recharge. Chemical methods utilize the presence of relatively inert water-soluble substances, such as an isotopic tracer or chloride, moving through the soil, as deep drainage occurs. The chemical methods for estimating recharge can be used in arid and semiarid arewwas. Recharge can be estimated using numerical methods, using such codes as HELP, UNSAT-H, SHAW, WEAP and MIKE SHE. The 1D-program HYDRUS1D is available online. These codes generally use climate and soil data to arrive at a recharge estimate, and use Richard's equation in some form to model groundwater flow in the vadose zone.

STUDY AREA

JNTUH is situated in the heart of the city at Kukatpally a major land mark. The study area describes JNTUH campus, Kukatpally, Rangareddy part of Andhra Pradesh. This University has been deemed an autonomous one after Act No.30 of the approval of the Andhra Pradesh legislature known as the Jawaharlal Nehru Technological Universities Act, 2008 which came in to force on 18th August, 2008. The territorial jurisdiction of the University covers the areas of Hyderabad. The study area is located in the Ranga Reddy district and lies between North latitudes 17°30' and 17°29' and East longitude 78°23' and 78°24' and is covered in the survey of India Topographical map number 56 K7. This area is an elevation of about 591 meters above the mean sea level. The layout of the study area is shown in the fig-1.

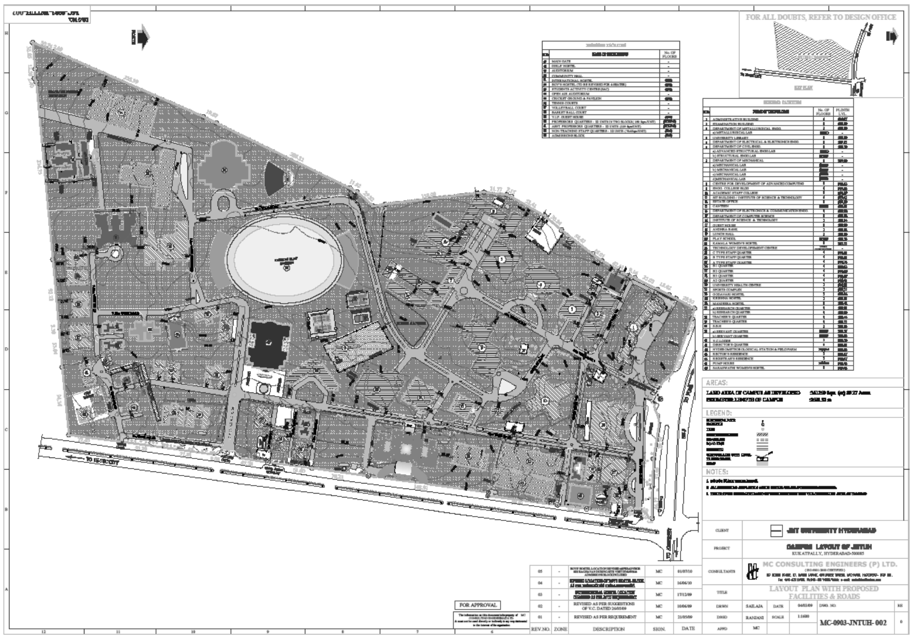

Fig. 1 Layout of Study Area, JNTUH

Climate within the study area is hot summer; moderate monsoon and cold season characterize the climate of the study area. The temperature recorded at JNTUH is taken as the representative of the conditions in the study area. December to January is the coldest period with mean daily maximum temperature of about 29°c and the mean daily minimum 17°c. There after the temperature rises rather rapidly in the initial period and steadily at later period till May, which is the hottest month with mean daily maximum temperature touches 39°c. The monthly mean maximum temperature is 32°c and minimum temperature is 21°c.

There is one meteorological observatory at JNTUH. The normal annual and seasonal rainfall recorded is 754 mm. The southeast monsoon contributes 81% of the annual rainfall, while the north east monsoon contributes 81% of the annual rainfall. Variation in annual rainfall observes decrease in the trend. However, the pattern appears to be more inconsistent over the years. Ground water experts have highlighted that groundwater in the study area is declining at such a rapid pace that in three years the Andhra Pradesh capital will be almost dry. As summer advances, the groundwater table is falling rapidly in different parts of the city. An indication of this is available from the 11 piezometers set up in different locations by the Groundwater Department. An analysis of groundwater levels shows a fall of -0.53 meters from January 2012 to February 2013 while a rise of 0.98 meters is observed when compared to February 2012. Rainfall is the principal source for groundwater recharge in the area. The behavior of groundwater table is governed by the quantity, intensity and frequency of rainfall. In the 2012-13 water year, Hyderabad district received 808.20 mm rainfall against the normal of 719.70 mm. It is been observed, the groundwater depth ranges from 3.0 to 24.0 meters.

METHODOLOGY

Soil Water Balance Method: Estimating the rate of aquifer replenishment is probably the most difficult of all measures in the evaluation of ground water resources. The methods available for the estimation of ground water recharge directly from precipitation can be broadly divided into three-inflow, aquifer response and outflow methods according to how the studies are conducted. Water balance models were developed in the 1940's by Thornthwaite and was later revised. The method is essentially a bookkeeping procedure, which estimates the balance between the inflow and outflow of water. Here, the volume of water required to saturate the soil is expressed as an equivalent depth of water and is called soil water deficit. The soil water balance can be represented as per equation (1).

$$R_i = P - E_a + \Delta W - R \qquad \text{…. (1)}$$

R_i = Recharge

P = Precipitation

E_a = Actual Evapotranspiration

ΔW = Change in soil water storage

R = Runoff

The data requirement of the soil water balance method is large. When applying this method to estimate the recharge for a catchment area, the calculation should be repeated for areas with different precipitation, evapotranspiration, crop and soil type. Storage of moisture in the saturated zone and the rate of infiltration along the various possible routes to the aquifer form important and uncertain factors. Results from this model are of very limited significance without calibration and validation because of the substantial uncertainty in input data. The model parameters do not have a direct physical representation, which can be measured, in the field.

Actual Evapotranspiration: Actual evapotranspiration (E_a) is the quantity of water that is actually removed from a surface due to the processes of evaporation and transpiration. Actual evapotranspiration (E_a) in a soil water budget is the actual amount of water delivered to the atmosphere by evaporation and transpiration. It is computed using equation (2).

$$E_a = \frac{\Delta R_n + (e_s - e_a) * \frac{\rho * C_p}{r_a}}{\lambda(\Delta + \gamma * (1 + \frac{r_s}{r_a}))} \qquad \text{...... (2)}$$

E_a – Actual Evapotranspiration (mm/day).

Δ – Slope of saturation vapour pressure curve at air temperature (kPa/°C).

R_n – Net radiation (MJ/m^2/day).

e_s – Saturated vapour pressure (kPa).

e_a – Actual vapour pressure (kPa).

ρ – Density of air (kg/m^3) = 1.225.

c_p – Specific heat at constant pressure (MJ/kg/^{o}C) = 1.013 x 10^{-3}.

r_a – Net resistance to diffusion through the air from surfaces to height of measuring instruments (day/m).

r_s – Net resistance to diffusion through surfaces of the leaves and soil (day/m) = 0.803 x 10^{-3}.

λ – Latent heat of vaporization (MJ/kg) = 2.45.

γ – Psychometric constant (kPa/°C) = 67.4 x 10^{-3}.

$$\Delta = \left[\frac{4098 x 0.6108 x \exp(\frac{17.27 x T_{Mean}}{T_{Mean} + 237.3})}{(T_{Mean} + 237.3)^2} \right] \qquad \text{.....(3)}$$

T_{mean} = Mean absolute temperature during the 24 hour period in ^{o}C.

Net radiation (R_n) is defined as difference in intensity between all incoming energy and all outgoing energy carried by both shortwave (R_{ns}) and longwave (R_{nl}) radiation as given in equation (4).

$$R_n = R_{ns} - R_{nl} \quad \text{....... (4)}$$

$$R_{ns} = (1-\alpha) R_s \quad \text{....... (5)}$$

Solar radiation $= R_s = K_{Rs} \text{ x } (T_{max} - T_{min})^{1/2} \text{ x } R_a$ .... (6)

T_{max} = Maximum absolute temperature during the 24 hour period in ^oC.

T_{min} = Minimum absolute temperature during the 24 hour period in ^oC.

Extraterrestrial radiation (R_a) is the intensity (power) of the sun at the top of the Earth's atmosphere and is given by equation (7). This effect can be inMJ/m^2/day and is represented empirically with the following equations:

$$R_a = \frac{24 \text{ x } 60 \text{ x } G_{sc} \text{ x } d_r \text{ x } [(\omega_s \text{ x } \sin\varphi \text{ x } \sin \square) + (\sin\omega_s \text{ x } \cos\varphi \text{ x } \cos\square)]}{\Pi} \quad \text{.....(7)}$$

G_{sc} - Solar constant = 0.082 MJ/m^2/min

d_r - Inverse relative distance Earth-Sun = 1 + 0.03 x cos (2 x π x J / 365)

J - Number of the day in the year = int [(275 x (M/9)) - 30 +D] – 2

Where, Month = M and Day = D

ω_s - Sunset hour angle = arccos [-tan(φ) x tan(□)]

φ - Latitude (in radians) of the study area = π x lat (in degrees)/180

□ - Solar declination (in radians) = 0.409 x sin ((2xπxJ/365) - 1.39)

Net long wave radiation [MJ/m^2/day],

$$R_{nl} = \sigma \frac{(T_{\max} + 273.16)^4 + (T_{\min} + 273.16)^4}{2} (0.34 - 0.14\sqrt{e_a}) \left[1.35x \frac{R_s}{R_{so}} - 0.35 \right] \quad \text{.....(8)}$$

R_{so} – Clear sky radiation [MJ/m^2/day] = [0.75 + 2 x 10-5 x Z] x R_a

Z – Elevation above mean sea level.

σ - Stefan-Boltzmann constant [4.903 x 10^{-9} MJ/K^4/m^2/day].

e_a - actual vapour pressure [kPa] = $\dfrac{\{RH_{mean} \text{ x } [e_{(Tmax)} + e_{(Tmin)}]\}}{200}$ .....(9)

RH_{mean} - Mean relative humidity.

$e_{(Tmax)}$ - Vapour pressure at maximum temperature.

$e_{(Tmin)}$ - Vapour pressure at minimum temperature.

e_s - Saturated vapour pressure [kPa] = $\dfrac{[e_{(Tmax)} + e_{(Tmin)}]}{2}$ .... (10)

Net resistance to diffusion through the air from surfaces to height of measuring instruments (r_a) can be calculated using below equation.

$$r_a = \frac{208}{u} \quad \text{....... (11)}$$

Where "u" is wind speed at 2 m above ground surface [m/s].

Change in soil water storage: Soil water storage (SWS) capacity is defined as the total amount of water that is stored in the soil within the plant's root zone. The soil texture and the crop rooting depth determine this. A deeper rooting depth means there is a larger volume of water stored in the soil and therefore a larger reservoir of water for the crop to draw upon between irrigations.

Infiltration (I) = Precipitation (P) – Runoff (R) ……. (12)

To calculate soil water storage (SWS) we use equation SWS = I - E_p

Where Potential evapotranspiration (E_p) can be calculated using below equation (13).

$$E_p = \frac{\Delta x R_n + \gamma \text{ x } 6.43 \text{ (} 1+ 0.536 \text{ x } u_2) \text{ x } (e_s - e_a)}{\{\lambda \text{ x } (\Delta + \gamma)\}} \quad \text{……. (13)}$$

If (I -Ep) < 0 then soil water storage is zero.

If (I -Ep) >= 0 then

soil water storage = (I -Ep) + Previous month storage

The value should be less than or equal to soil field capacity

Field capacity is the amount of soil moisture or water content held in the soil after excess water has drained away and the rate of downward movement has decreased.

$$\text{Change in Soil water} = \left(\begin{array}{l}\text{water storage current}\\ \text{month}\end{array}\right) - \left(\begin{array}{l}\text{water storage previous}\\ \text{month}\end{array}\right) \quad \text{……. (14)}$$

Water content increases (positive change in storage) when inputs including precipitation or irrigation exceed outputs. Water content decreases (negative change in storage) when outputs such as deep percolation, surface runoff, subsurface lateral flow, and evapotranspiration (ET) exceed.

Water storage and redistribution are a function of soil pore space and pore-size distribution, which are governed by texture and structure. Generally speaking, clay-rich soils have the largest pore space, hence the greatest total water holding capacity. However, total water holding capacity does not describe how much water is available to plants, or how freely water drains in soil. These processes are governed by potential energy. Water is stored and redistributed within soil in response to differences in potential energy. A potential energy gradient dictates soil moisture redistribution and losses, where water moves from areas of high- to low-potential energy. When at or near saturation, soils typically display water potentials near 0 MPa. Negative water potentials arise as soil dries resulting in suction or tension on water allowing the soil to retain water like a sponge.

Runoff: Runoff may be referred as flow of water that occurs when the soil is infiltrated to full capacity and excess water from rainfall, snow melt or other sources flow over the land surface.

Rational Formula

The Rational equation is the simplest method to determine peak discharge from drainage basin runoff. It is not as sophisticated as the SCS TR-55 method, but is the most common method used for sizing sewer systems. It is an important formula for determining the peak runoff rate is the rational formula.

Rational Equation: R = 0.28*C*I*A ……. (15)

R	= Peak runoff rate	[m^3 / sec]
C	= Runoff coefficient	[-]
I	= Rainfall intensity	[mm/hr]
A	= Drainage area	[km²]

Inglis DeSouza formula (for Deccan Plateau)

As a result of careful stream gauging in 53 sites in Western India, Inglis and DeSouza evolved two regional formulae between annual runoff R in cm and annual rainfall P in cm as follows:

- ✓ For Ghat regions of western India R = 0.85*P - 30.5
- ✓ For Deccan plateau R = (P*(P-17.8))/254

Where P & R are precipitation and runoff (in cm) for the given study area.

Khosla's Formula

Khosla analysed the rainfall, runoff and temperature data for various catchments in India and USA to arrive at an empirical relationship between runoff and rainfall. The time period is taken as a month. His relationship for Monthly runoff is given by equation (16).

$$R_m = P_m - L_m \text{ and } L_m = 0.48\, T_m \text{ for } T_m > 4.5°C \qquad \ldots\ldots (16)$$

R_m = Monthly runoff in cm; P_m = monthly rainfall in cm.

L_m = monthly losses in cm; T_m = mean monthly temperature of the catchment in °C.

Recharge estimation model has been developed to simulate the soil water balance method as per figure 2. The major steps under this model are runoff, climatological parameters, and actual & potential evapotranspiration using pennman's equation. Finally evaluate recharge quantity using the equation of soil water balance method.

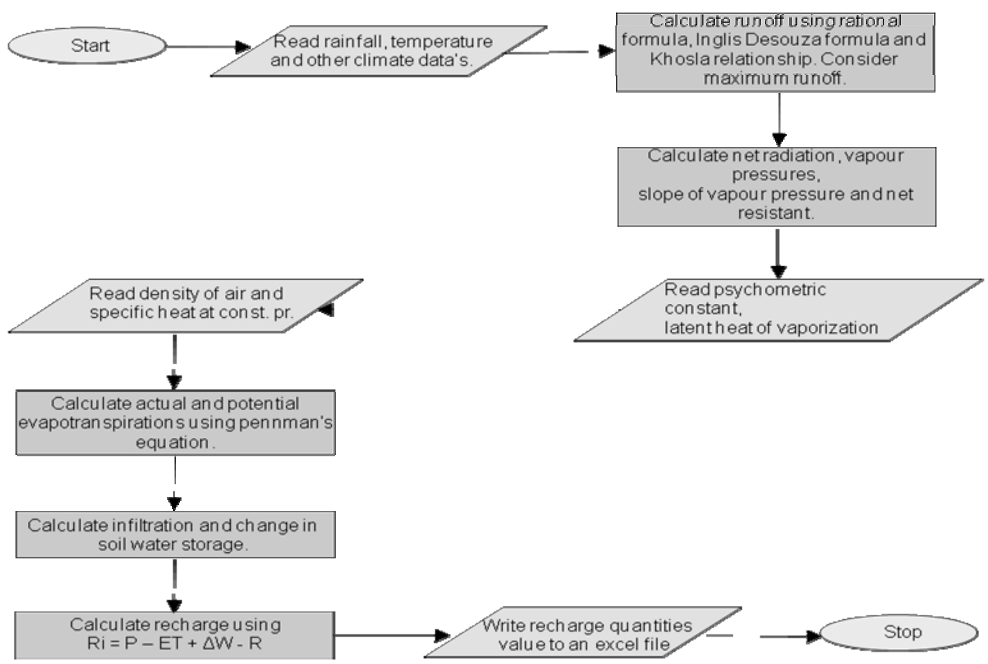

Fig. 2 Flow Chart of Soil Water Balance Method Recharge Estimation Model developed in MATLAB

RESULTS AND DISCUSSIONS

A model has been simulated for estimating ground water recharge quantity using Soil water balance method. These method are explained in detail under methodology. Flow charts for the above mentioned method are formulated and are shown at the end of methodology. To conclude on results, 27 years of climatic data since 1986, 10 years of land use pattern since 2001. The data was collected upto 2012and shown in fig 3.

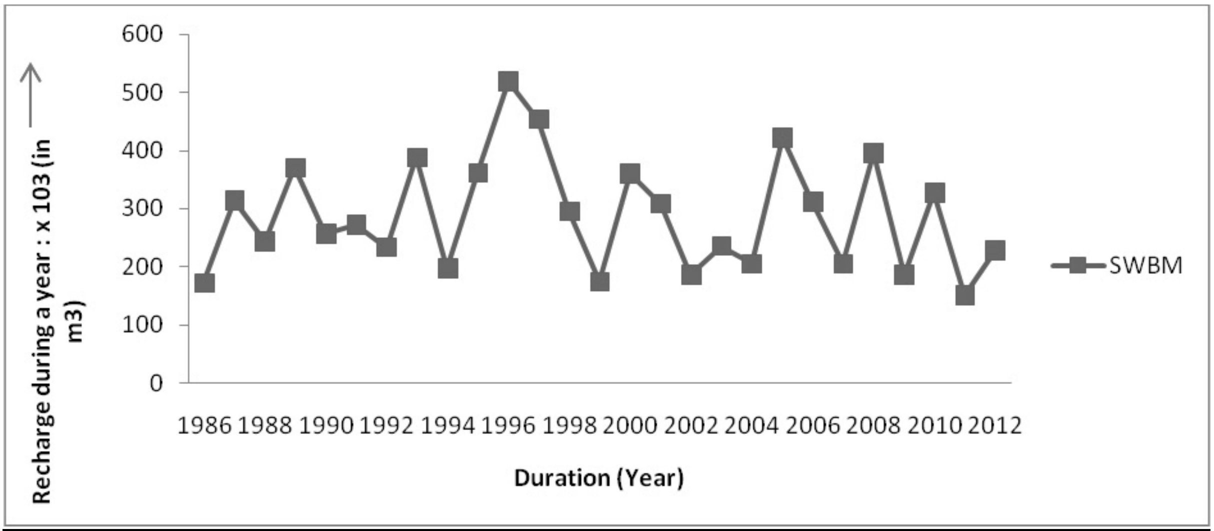

Fig. 3 Results of Recharge Quantity from Simulated Model for Soil Water Balance Method

SUMMARY AND CONCLUSION

1. The maximum recharge is about 519 x 10^3 m^3 during the year 1996 and minimum recharge is about 151 x 10^3 m^3 during the 2011 obtained from soil water balance method (SWBM) considering no extraction of ground water.
2. The average annual ground water to be recharged varies from 271 x 10^3 m^3 to 361 x 10^3 m^3 for every 5 years interval.
3. The annual average recharge during the simulation period is found to be 288 x 10^3 m^3.

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Assessment of Water Quality Index of Groundwater Samples in Kattedan Industrial Area, Ranga Reddy District, Andhra Pradesh, India

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ABSTRACT

The present study aimed to calculate Water Quality Index (WQI) by the analysis of twenty-one physico-chemical parameters on the basis of Weighted Arithmetic Index in order to assess the suitability of ground water for drinking in Kattedan Industrial Area, Ranga Reddy District, Andhra Pradesh, India. Water Quality Index, a technique of rating water quality, is an effective tool to assess spatial and temporal changes in ground water quality. It serves the understanding of water quality issues by integrating complex data and generating a score that describes water quality status. The WQI is used to classify water quality as excellent, good, poor, very poor and unfit for drinking. The parameters were measured for the calculation of WQI at nine groundwater sampling locations in September 2012.The found values were compared with the ICMR/BIS water quality standards. The results observed on WQI for the different sampling locations were found to fall under the class of poor (100-200) class at sample locations S1,S2,S5,S6,S7 to very poor (200-300) class at sample locations of S3,S8 and S9.The analysis reveals that the ground water of the area was not conforming to drinking standards and hence needs some treatment before consumption, and it also needs to be protected from the perils of contamination. It is concluded that WQI can be used as a tool in comparing the water quality of different sources.

***Keywords*:** Water Quality, Water Quality Index, Physico-chemical Parameters, Drinking Water, Industrial Area, Kattedan.

INTRODUCTION

Water is an essential component for survival of life of Earth, which contains minerals, important for human beings as well as plant and aquatic life. The availability of water both in terms of quality and quantity is essential for the very existence of mankind. Drinking water is one of the most important constituents for healthy living of human society. In India most of the people living in rural areas, depend on ground water for drinking purpose. Ground water is ultimate and most suitable fresh water resource. The quality of water may be described according to its physic-chemical and micro- biological characteristics (Bhandari N.S et al., 2008; Narasimha Rao C.et al., 2011).

Urbanisation and the unregulated growth of the population have altered the surface and sub-surface terrains of many areas. Changes in local topography and drainage system directly affect both quality and quantity of the ground water. Pollutants are being added to the groundwater system through human activities and natural processes. Solid waste from industrial units is being dumped near the factories, and is subjected to reaction with percolating rainwater and reaches the groundwater level. The percolating water picks up a large amount of dissolved constituents and reaches the aquifer system and contaminates the groundwater. The problem of groundwater pollution in several parts of the country has become so acute that unless urgent steps for abatement are taken, groundwater resources may be damaged.

Water pollution not only affects water quality but also threats human health, economic development and social prosperity. Hence, evaluation of groundwater quantity and quality and establishing data base are important for the development of further civilization and for future water resources development strategies. In order to avoid ill effects of water pollution on the human and animal health and agriculture, standards/rules/guidelines have been devised for discharge of effluents from industries and municipalities, quality of drinking water, irrigation water, criteria for aquatic life in fresh water by various authorities including Central Pollution Control Board (India), World Health Organization (WHO), World Bank, Indian Standard Institution, Indian Council of Medical Research, etc.

Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water and sub-surface geochemical processes. Temporal changes in the origin and constitution of the recharged water, hydrologic and human factors may cause periodic changes in groundwater quality. Generally higher proportions of dissolved constituents are found in groundwater than in surface water because of greater interaction of ground water with various materials in geologic strata. The water used for drinking purpose should be free from any toxic elements, living and nonliving organism and excessive amount of minerals that may be hazardous to health. Some of the heavy metals are extremely essential to humans, for example, Cobalt, Copper, etc., but large quantities of them may cause physiological disorders. The contamination of groundwater by heavy metals has assumed great significance during recent years due to their toxicity and accumulative behavior. During the last 50 years, the number of industries in India has grown rapidly. But water pollution is concentrated within a few sub-sectors, mainly in the form of toxic wastes and organic pollutants. Out of this a substantial portion can be traced to the Oil, plastics, metal, pharmaceuticals, textiles etc. Major industries have treatment facilities for industrial effluents. But this is not the case with small- scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender.

Therefore, it becomes mandatory to assess the surface and ground water quality especially in the industrial areas. It is desired that the entire industrial community in the area participates by becoming environmentally aware. This monitoring of the Water Quality using the Water Quality Index helps in overall assessment of the water management issues for any industrial area for taking necessary administrative decisions. It can provide useful insights in the development of the water management plan for other industrial clusters as well.

Water Quality Index: “Accurate and timely information on status and trends in the environment is necessary to shape sound public policy and to implement environmental quality programs efficiently. One of the most effective ways to communicate information on environmental trends to policymakers and the general public is with indices.” Ever since the Council on Environmental Quality in its 1972 Annual Report clearly indicated the need for environmental indexes, interest in such indexes has greatly increased throughout the world. (J.Maciunas Landwehr and R.A.Deininger,2009).

In some situations, the treated water does not satisfy the standards in the respect to some water quality properties. The decision to supply such water to the public should depend on the exceeded concentrations as well as the importance of the property, as far as its contributions to the health of the consumers. Making decisions regarding acceptability of water would be easy if the overall effect in the water quality deviation could be expressed in an integrated manner, giving due regard to both the importance of each constituent as well as the magnitude of its exceeded concentration. Therefore it is considered appropriate to set upper and lower levels of standards for drinking water through a single number. This number would show the overall integrated effect of all the water quality variables and their respective concentrations, as well as the related implications of drinking such water. The integrated number, or index, should be so evaluated that the effect of variables with different importance to drinking water quality are appropriately taken care of. (Devendra Swaroop Bhargave,1985). Presentation of drinking water standards through Integrated Water Quality Index(WQI) has been attempted herein.

Water Quality Index is a numerical expression of the degree of pollution, and which takes into account the various pollutants present at the same time (though measured separately).This index, increasing with the degree of pollution, could be used for the numerical evaluation of a purely qualitative characteristic expressed by the term “pollution”(L.Prati et al)

It is simple and easily understandable for decision makers about quality and possible uses of any water body. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption. The standards for drinking purposes as recommended by WHO and IS 10500 have been considered for the calculation of WQI.

The present study on Ground Water Quality in The Kattedan Industrial Estate area was under taken to define the quality of water samples with special reference to physicochemical properties to decide its WQI. The analyzed data were compared with standard values recommended by BIS & ICMR. The WQI is a systematic method that gives comparative evaluation of the water quality of sampling stations. This enables better geographical identification of problem areas contributing to groundwater pollution and to ascertain whether the ground water in the study area is fit for drinking water supplies. Thus, remedial measures may be undertaken for improving the water quality and developing appropriate water quality standards

STUDY AREA

The present study area falls in the RJNR Municipality of Ranga Reddy District. The RJNR Municipality is divided into 9 revenue wards. The kattedan study area falls in ward No.6 of the Municipality, in the south-western part of Hyderabad city of Andhra Pradesh State in India. Geographically, this area is situated 78^{o} 26'East longitude and 17^{o} 18'45" North latitude on the southern suburbs of Hyderabad City. The Location map is shown in figure 1.

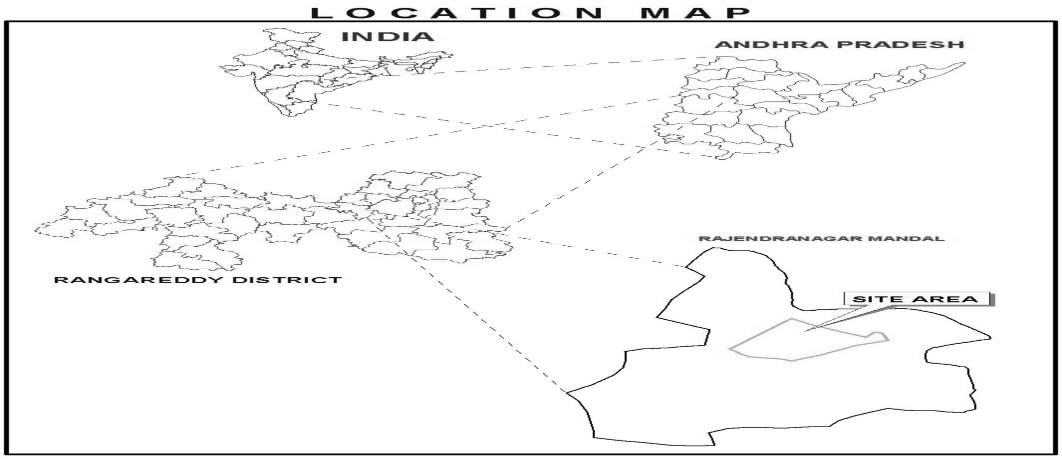

Fig. 1 Location Map of Kattedan Industrial Area

The Self Employed Industrial Park (SEIP), Kattedan is an old industrial estate catering to the needs of the self-employed, micro, small and medium entrepreneurs. This industrial park was established in the year 1976 and extends over an area of 245 acres. Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC) developed the Katedan SEIP. The entrepreneurs were allotted sites/plots depending upon their requirements. The extent of plots allotted varied from 100 yards to a few acres. SEIP, Kattedan is located at about 15 km from Hyderabad city along the Hyderabad- Bangalore Highway. This industrial park houses nearly 535 units which are micro, small and medium enterprises. The industrial park comprises various types of industries, viz. engineering workshops, plastic units, food industry (biscuits, chocolates, potato chips etc.), oil expellers, chemicals, formulation units, non-ferrous metal melting, paint mixing, rubber moulding etc.

The area is gently sloping towards North with the Katedan industrial area located in the highest elevated areas to the South. The highest elevation recorded in the study area is 570m above and the lowest being 520m above MSL. The area under investigation is semi arid. The area receives an average rainfall of 750mm from the southwest and northeast monsoons. The highest precipitation generally occurs during the southwest monsoon in the months of June-September. Mean monthly temperatures range from 18^{o} to 35^{o}C.

METHODOLOGY

The water samples from the study area were collected from nine different wells during September 2012 in the post monsoon season. The groundwater quality survey locations were chosen so that they depict the influence of the prevailing industrial activity of the problem area. Samples were collected from the groundwater structures already in existence from Andhra Pradesh Pollution Control Board (APPCB). Details of sampling locations along with their Latitudes and Longitudes are presented in Table 1.

Table 1 Locations of GW wells along with IDs

S. No	GW Sampling Location Id No	Location (plot no. with reference to KIE layout	Latitude	Longitude
1	S1	(DW 28) Plot No: 35	17.31388	78.4362
2	S2	(DW 11) Plot No: 44B	17.31143	78.4362
3	S3	(DW 23) Plot No: 79	17.30928	78.4308
4	S4	(DW 12) Plot No: 31C	17.3173	78.43373
5	S5	(DW 27) Plot No: E-1	17.31611	78.43674
6	S6	(DW 5) Plot No:156B	17.3193	78.43216
7	S7	(DW 6) Plot No: 156H	17.31943	78.43272
8	S8	(DW 20) Plot No: 81	17.30895	78.43084
9	S9	(DW15) Plot No: 72	17.31269	78.4323

The ground water samples were collected in acid washeplastic container to avoid unpredictable changes in characteristic as per standard procedures. Twenty one parameters were analyzed for WQI such as Dissolved Oxygen, pH, Electrical Conductivity, TSS, TDS, Total Hardness, Cl^-, SO_4^{-2}, NO_3^-, F^-, Fe^{+2}, Mg^{+2} and Ca^{+2}, Total Alkalinity, As, PO_4^3, Cu, Pb, Ni, Cd, Zn, to calculate the Water Quality Index(WQI) for the various locations where Groundwater samples were collected. Samples were transported to the laboratories and analyzed for the relevant parameters as per the standard procedures. The physico-chemical analysis was performed following standard procedures in Andhra Pradesh Pollution Control Board (APPCB).The data is obtained from APPCB for this study. All the physico-chemical parameters of groundwater samples collected from drinking sources have been compared with present standards recommended by BIS – 10500 and WHO Guidelines.

Water Quality Index: Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. Water quality and its suitability for drinking purpose can be examined by determining its quality index. The standards for drinking purpose have been considered for calculation of WQI.

Weights of Parameters: In deciding the weights of parameters incorporated in the index system it was believed that the importance of each parameter depends upon the degree of which the parameter can manifest changes in the water quality. The highest weight of five was assigned to parameters, which have the major effects on water quality. Pb, NO_3^- and F^- were assigned the highest weight because of their importance in the water quality assessment. The Table 2 displaying the standard values, Importance weight and Relative weights of all the selected 21 physio-chemical parameters is given below:

Table 2 Drinking Water standards recommending Agencies, Importance Weights and Relative Weights (All values except pH and EC are in mg/l)

S. No.	Parameters	Standard Value(S_i)	Importance weight(w_i)	Relative weight (W_i)	Recomm-ended
1	DO	300	4	0.0564	ICMR
2	pH	7.5	4	0.0564	ICMR/BIS
3	EC(millimols)	250	4	0.0564	ICMR/BIS
4	TSS	75	4	0.0564	ICMR/BIS
5	TDS	500	4	0.0564	ICMR/BIS
6	Cl	250	3	0.0424	ICMR/BIS
7	SO_4^{-2}	200	3	0.0424	ICMR/BIS
8	Fl	1	5	0.0701	ICMR/BIS
9	$NO_3{}^2$	45	5	0.0701	ICMR/BIS
10	Total Hardness	300	4	0.0564	ICMR/BIS

Table 2 *Contd...*

S. No.	Parameters	Standard Value(S_i)	Importance weight(w_i)	Relative weight (W_i)	Recomm-ended
11	Total Alkalinity	200	3	0.0424	ICMR/BIS
12	Ca^{+2}	75	2	0.0281	ICMR/BIS
13	Mg^{+2}	30	2	0.0281	ICMR/BIS
14	As	0.05	4	0.0564	ICMR/BIS
15	Fe	0.3	3	0.0424	ICMR/BIS
16	PO_4^{3-}	0.4	3	0.0424	ICMR/BIS
17	Cu	0.05	2	0.0281	ICMR/BIS
18	Pb	0.05	5	0.0701	ICMR/BIS
19	Ni	0.02	2	0.0281	ICMR/BIS
20	Cd	0.01	3	0.0424	ICMR/BIS
21	Zn	5	2	0.0281	ICMR/BIS
		SUM	71	1	

*Relative Importance Values based on a scale of "5"(highest relative value) to "0"(lowest relative value)

**Relative Weight is the Relative Importance Value or weight where $\Sigma W_i = 1$

Having established the relative importance values and relative weight, various methods of computing a water quality index are possible. In this study an additive index was used:

$$WQI = \Sigma^{n}_{i=1} (Wi\ qi)$$

Where,

W_i = Relative weight

q_i = Quality rating

N = Number of parameters

There are three steps to computing the WQI of a water sample

In the first step, each of the chemical parameters was assigned a weight (w_i) based on their effects on primary health. The second step involved computing the relative weight (W_i) of each parameter using Eq.1

$$W_i = (w_i / \Sigma w_i) \qquad \text{…..(1)}$$

Where Σw_i is the sum of the weights of all the parameters. In this study, Σw_i was 71

Table 2 Presents the w_i, W_i and the BIS-10500 standard for each chemical parameter used in the study.

In the third step, a quality rating scale, q_i , was computed for each parameter using Eq. 2

$$q_i = (Ci/S_i) \qquad \text{….. (2)}$$

Where Ci and S_i respectively refer to the concentration and the ICMR/BIS standard for each parameter, in mg/l.

The water quality subindex, SI_i was then calculated for each parameter using Eq. 3

$$SI_i = (W_i * q_i) \qquad \text{….. (3)}$$

The Water Quality Index, WQI is then calculated for the parameters using Eq.4

$$WQI = \Sigma\ SI_i \qquad \text{…..(4)}$$

RESULTS AND ANALYSIS

Table 3 provides a statistical summary of the chemical parameters analyzed for this study:

Table 3 Physico-chemical parameters of Ground Water samples
(All values except pH and Electrical Conductivity are in mg/l)

S. No	Parameters	Observed value(C_i)								
		S1	S2	S3	S4	S5	S6	S7	S8	S9
1	DO	40	22	34	24	40	152	160	150	90
2	pH	7.52	6.57	6.84	6.49	7.23	6.44	6.67	7.04	6.99
3	EC(millimols)	2616	2489	4210	3640	4010	3530	3710	5250	4640
4	TSS	15	7	77	12	27	125	140	34	15
5	TDS	1776	1654	3239	2673	2606	2213	1916	4202	3417
6	Cl	475	430	322	525	400	435	473	667	734
7	SO_4^{-2}	275	275	75	400	325	507	354	350	1050
8	Fl	1.938	1.25	1.47	1.1339	1.23	1.938	2.05	1.67	1.6797
9	$NO_3^{\ 2}$	23	46	40	234	24	153	18	19	101
10	Total Hardness	920	1180	1860	1160	1448	1030	580	1620	1320
11	Total Alkalinity	15	539	890	336	121	390	700	568	308
12	Ca^{+2}	224	225.6	460	354	313.6	288	104	356	456
13	Mg^{+2}	87.6	149.8	172.5	67	161.5	75	78	177.4	44
14	As	<0.05	<0.05	0.04	0	0	0	0	0	0
15	Fe	<0.3	0.4	0.1	0.1	0.1	0	0	0.2	0
16	PO_4^{3-}	0.1	0.3	0.3	<0.1	0	<0.1	<0.1	0.2	<0.1
17	Cu	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.05	<0.01	<0.01
18	Pb	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.02
19	Ni	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
20	Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Zn	0.02	0.04	0.02	0.03	0.19	0.04	0.06	0.02	<0.01

Source: APPCB

WQI is established through the measurement of various important physiochemical parameters of the Ground Water. The values of various physiochemical parameters for the sample calculation of WQI for the Ground Water surveying location S3 is presented in Table 4.

Table 4 WQI Calculation at S3 (DW 23) Plot No: 79 of the KIE Layout

S. No	Parameters	Observed value(C_i)	Standard Value(S_i)	Importance weight (w_i)	Relative weight (W_i)	Quality Rating (q_i)	$W_i q_i$
1	DO	34	300	4	0.0564	11.3333333	0.6392
2	pH	6.84	7.5	4	0.0564	91.2	5.14368
3	EC(millimols)	4210	250	4	0.0564	1684	94.9776
4	TSS	77	75	4	0.0564	102.666667	5.7904
5	TDS	3239	500	4	0.0564	647.8	36.53592
6	Cl	322	250	3	0.0424	128.8	5.46112
7	SO_4^{-2}	75	200	3	0.0424	37.5	1.59
8	Fl	1.47	1	5	0.0701	147	10.3047
9	$NO_3^{\ 2}$	40	45	5	0.0701	88.8888889	6.23111111
10	Total Hardness	1860	300	4	0.0564	620	34.968

Table 4 *Contd...*

S. No	Parameters	Observed value(C_i)	Standard Value(S_i)	Importance weight (w_i)	Relative weight (W_i)	Quality Rating (q_i)	$W_i q_i$
11	Total Alkalinity	890	200	3	0.0424	445	18.868
12	Ca^{+2}	460	75	2	0.0281	613.333333	17.2346667
13	Mg^{+2}	172.5	30	2	0.0281	575	16.1575
14	As	0.04	0.05	4	0.0564	80	4.512
15	Fe	0.1	0.3	3	0.0424	33.3333333	1.41333333
16	PO_4^{3-}	0.3	0.4	3	0.0424	75	3.18
17	Cu	<0.01	0.05	2	0.0281	20	0.562
18	Pb	<0.01	0.05	5	0.0701	20	1.402
19	Ni	<0.01	0.02	2	0.0281	50	1.405
20	Cd	<0.01	0.01	3	0.0424	100	4.24
21	Zn	0.02	5	2	0.0281	0.4	0.01124
			SUM	71	1		270.627471

Computed WQI values are usually classified into five categories(Sahu and Sikdar 2008) as shown in Table 5:

Table 5 Water Quality Index (W.Q.I.) and Status of Water Quality

S. No	Water Quality Index	Water Quality Status
1	<50	Excellent Water Quality
2	50-100	Good Water Quality
3	100-200	Poor Water Quality
4	200-300	Very Poor Water Quality
5	> 300	Unfit for drinking

The values of WQI for each of the Ground Water sampling location and the classification based on the status of water quality is shown in Table 6 below:

Table 6 WQI Values at Nine Groundwater Sampling Locations

S. No	Sampling Location	Water Quality Index Value	Classification based on water quality status
1	S1	170.40	Poor Water Quality
2	S2	187.86	Poor Water Quality
3	S3	270.63	Very Poor Water Quality
4	S4	239.00	Very Poor Water Quality
5	S5	219.90	Very Poor Water Quality
6	S6	235.59	Very Poor Water Quality
7	S7	204.46	Very Poor Water Quality
8	S8	294.93	Very Poor Water Quality
9	S9	276.15	Very Poor Water Quality

The values of WQI in Kattedan Industrial Estate showed that Ground Water Quality was between poor and very poor. Accordingly the Ground Water Quality of Kattedan Industrial Estate is not fit for drinking use. Over exploitation of resources and improper waste disposal practices affected the drinking water quality. This clearly indicates that Ground Water samples for this region are highly polluted. The Water Quality Index (WQI) indicates that sampling location S8 is highly polluted. The order of WQI for different sampling locations is as follows:

S8>S9>S3>S4>S6>S5>S7>S2>S1.

The Ground Water collected from three sampling locations, S3, S8 and S9 are more polluted than other 6 sites.

The figure 2 below depicts the WQI values at the Groundwater surveying Locations S1 to S9.

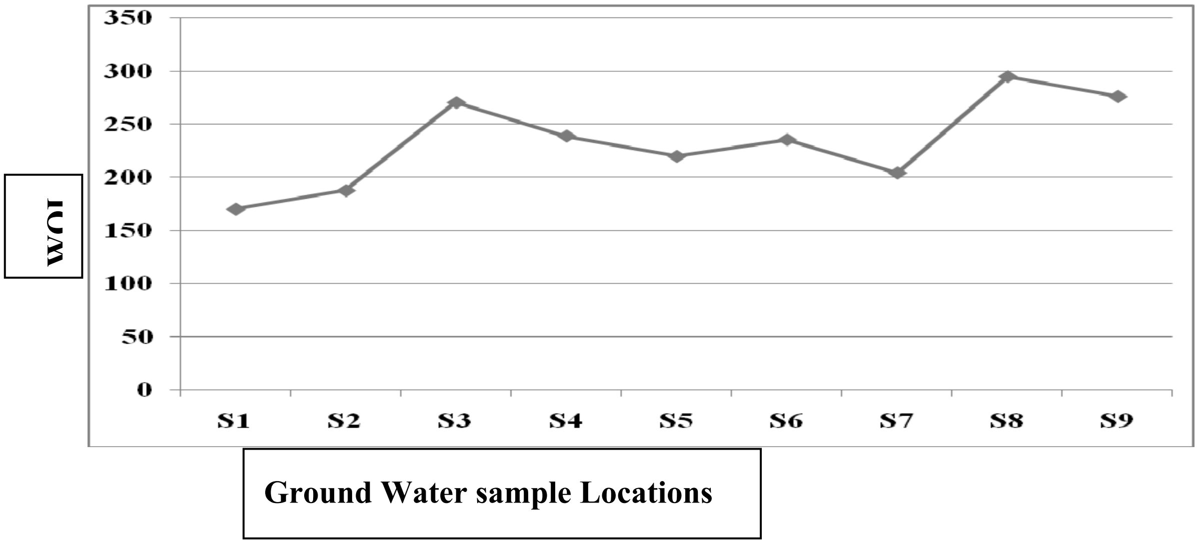

Fig. 2 Variation of WQI Values for Nine Groundwater Surveying Locations

CONCLUSION

Water Quality Index of the present study for Ground Water in Kattedan Industrial Estate was calculated from important various physiochemical parameters in order to evaluate the suitability of water for drinking purposes. The Water Quality rating at all the sampling points in Kattedan Industrial Estate showed that Ground Water Quality is between poor and very poor. Accordingly the Ground Water Quality of KIE is not fit for drinking use during the period of the study because it is not within the BIS standards and guidelines for drinking. Over exploitation of resources and improper waste disposal practices affected the drinking water quality.

The discharging of domestic and Industrial wastewater and also other anthropogenic activities were the main factors for contamination of Ground Water in the Kattedan Industrial Estate area. Also the discharges of untreated sewage and industrial waste water are getting collected at low lying plots of the KIE resulting in a stagnant pool of water near the Sewage Treatment Plants's Pumping Station. The levels of pollution in the stagnant pool appear to be high. There are chances that Ground Water may contaminate due to lechate from Municipal Solid Waste sites and percolation of water through disturbed Hazardous Waste sites mainly in rainy reasons. This may have lead to contamination of Ground Water with heavy metals. Industrial effluents are likely to have variations depending on pre-treatment at industry levels, which is difficult to monitor. They will need extra safeguards for treatment and disposal, or else will pose risks to the Ground Water Quality in the area. Also, drinking water in the studied area requires precautionary measures before drinking so as to protect human beings from adverse health effects.

Application of Water Quality Index (WQI) in this study has been found useful in assessing the overall quality of water and to get ride of judgement on quality of water. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations.

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Rain Water Harvesting and Recharge Augmentation through Percolation Tank in Semi-arid areas- A Case Study

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ABSTRACT

The paper discusses the use of rain water harvesting as an effective tool for water management by using of different techniques. In arid and semi-arid regions the problem of water shortage is one due to low rainfall and uneven distribution throughout the season, which makes rain fed agriculture a risky. Rain water harvesting for dry-land agriculture is a traditional water management technology to ease future water scarcity in many arid and semi-arid regions. As rainfall is the main source of surface water and its conservation is essential. Hence, rainwater harvesting is one of the most promising techniques for collection of excess runoff. Augmentation of recharge to ground water through percolation tank is closely related to the survival of about 30 open and bore well water levels increased, 4.5 ha cropping area increase under the tank, 60 farmers and 120 numbers of cattle, living animal getting benefit in KVK adopted village. Here the Monsoon rains are restricted to 30 to 40 and frequency of very event is less. The efficiency of the percolation tank is hampered by the silt, which accumulates in the tank bed, year after year. It is therefore, necessary for the beneficiary farmers to remove silt from the tank bed when the tank dries in the summer season.

The present study deals with the intervention to enhance the land water productivity and cropping intensity through multiple use management of the harvested rainwater. The study was focused on the conservation of rain water at farmers' fields. This technique attributed to significant improvement in ground water levels in open and bore well depth 4.2 meters.

Keywords: Rainfall, Groundwater Recharge, Percolation Tank, Watershed and Rain Water Harvesting.

INTRODUCTION

Percolation tank is Necessity for rainwater harvesting to improve ground water through artificial recharge to reserve the trend or to reduce the effect of over exploitation, the ground water recharge is essential at large scale at agricultural and residential. But the effort made towards the replenishment of augmentation of ground water resources, are very meager.

Objectives

To address these objectives, an attempt was made by the CRIDA-KVK to design and develop a technology for enhancing intake rate of runoff with inverted filter system / unit by harvesting rainwater available in the form of surplus runoff and its reuse for ground recharge through bore wells / open wells. Further studies were conducted to determine the impact of these by observing the ground water levels of bore wells / open wells existing in the kandlapalli village in pudur mandal and also an attempt was made to recharge ground water using surface runoff. The objectives of these activities are

- To improve ground water resources by artificial recharge.
- To know the technical feasibility and impact of recharge system/unit
- Rearing fish is an additional income to village committee as a source of livelihood
- To know the economic aspects of recharge techniques.

STUDY AREA

The study was carried out during 2011–14 in the Kandlapalli Village Community Percolation Tank situated in Pudur Mandal of Rangareddy district, Andhra Pradesh (Figure 1). The selected tank covers 13 ha, an average slope ranging from 2% to 9%, and consists mainly of red soils. The mean annual rainfall of the area is750 mm. The programme was implemented by the CRIDA under NICRA Project.

Renovation of Village Tank as Recharge Structure

A percolation tank can be defined as an artificially created surface water body submerging a highly permeable land area so that the surface runoff is made to percolate and recharge the ground water storage. Percolation tanks are to be normally constructed on second or third order streams, as the catchment area of such streams would be of optimum size. The existing village tank, which are normally silted and damaged, can be modified to serve as recharge structures. Unlike in the case of properly designed percolation tank, waste weirs damaged and water leakages were there and renovation provided for village tanks. De-silting of village tanks together with proper provision of waste weir can facilitate their use as recharge structures.

Advantages of Rainwater Harvesting by Community Percolation Tank

- An ideal way to solve the water problem
- The ground water levels will rise
- It reduces the runoff which chokes the storm water drains
- It reduces flooding of fields, also reducing soil erosion
- The quality of water improves
- To enhance the sustainable yield in areas where over-development has depleted the aquifer
- Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period.
- To improve the quality of existing ground water through dilution.
- The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development. Desaturated aquifer offers good scope in locations where source water, if available, can be stored using artificial recharge techniques.

Community percolation tank is situated at N 17^0 17.895^1 and E 78^0 1.056^1 towards kandlapally village road Pudur mandal of Rangareddy district. The present tank does not have enough capacity to accommodate all the runoff from the catchment. The tank bed was silted up. After discussion with the farmers it was proposed to enhance the storage capacity by de-silting the tank bed area of 0.354 ha and bud strengthening. 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 tank silt of thickness of approx one meter need to be excavated over tank bed. The proposal has been discussed with farmers and they have agreed to transport the tank silt to their fields for application of same. The tank is surrounded by 15 to 20 open wells and bore wells of which some of them are defunct. If the tank is renovated, all the wells would get recharged and cropping intensity. Could be enhanced 50 to 60 farmers may get benefited from this interventions.

Total Catchment Area to tank:	13 hectares
Water spread area of tank:	0.354 hectares
Annual average rainfall:	750mm
Max. Expected water yield:	10400 m^3
Existing storage capacity:	5575 m^3
Designed storage capacity:	9115 m^3

(To achieve the designed capacity the following work need to be carried out)

Total earth work involved to achieve design storage capacity: 3540m^3

The additional volume is attaining by one meter deep throughout the tank bed area of 0.354 ha

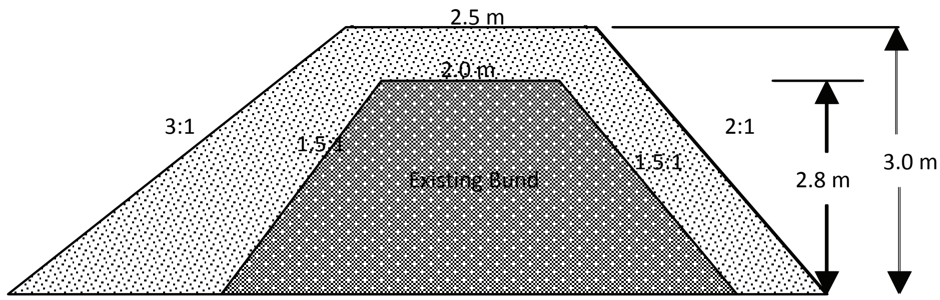


Fig. 1 Cross Section of the Existing Bund and Dimensions for the Proposed Bund (Fig. not to scale)

Table 1 Technical details of Proposed Bund Cross Section

S. No	Particulars	Existing Bund	Proposed Bund
1	Bund width	2.0 m	2.5 m
2	Bund height	2.2-2.8 m	3.0 m
3	U/S slope	1.5 :1	3:1
4	D/S slope	1.5 :1	2:1
5	Average cross section	14.37 m^2	30 m^2

A total length of 75 m bund needs to be strengthened to attain proposed cross section, the earth work involved is around 1062 m^3

Hydrological analysis

Annual rainfall data from 2004 to 2013 (10 years) of this area was analyzed for distribution and probability. It was observed that the average annual rainfall of the past 18 years was 675 mm and run-off-producing rainfall was 418 mm (62% of total rainfall) spread over nine runoff producing rainy days out of a total of 32 rainy days. Average run-off depth was estimated to be 8.60 cm (12.57% of total rainfall) based on SCS method for red soils. Since 2004, the watershed has been treated with soil and water conservation measures. Storm-wise rainfall, antecedent precipitation index (API), run-off, evaporation and percolation for all the structures and detailed water budgeting for predicting run-offs and other related required data collecting form tank.

RESULTS AND DISCUSSIONS

Fish Production for Livelihood

Fish production in Tank was studied with different breeds of fishes released in percolation tank in year 2013. Total 6000 finger lings viz.., Rohu (2000 finger lings), Catla (2000), Shelavathi (2000) were released in the community percolation tank through resolution pass by the village committee, quality of water was observed frequently and nutrient food was provided as per required interval. Through this activity, an additional income was generated to the village committee.

Groundwater use in Pre-project Period

In the pre-project period (2010–11), total water requirement for irrigation during kharif and winter was increase in 15%. This requirement was met by rainfall (0.5 ha m) and by the net availability of groundwater quantity (53.4 ha m) due to existing percolation tanks in the vicinity. This resulted in a desirable situation of groundwater surplus to tide over drought years, which is a common occurrence (once in three years) in this arid to semi-arid tract.

Groundwater use in Post-project Period

In the post-project period (2011–2014), the average irrigated area in the pre-project period. Correspondingly, the average groundwater draft increased pre project period to average post-project period. Irrigation water was met by direct rainfall and natural recharge plus recharge due to existing Tank in the vicinity

Among the existing eighteen open wells (average depth 15 m) some of the well shave dried up since 2006 due to the indiscriminate drilling of bore wells. Further, failure rate of the bore wells commissioned since 2003 was three for every successful bore well and resulted in increasing the financial liability of the farmer. The above situation suggests that authorities should take up measures for groundwater recharge and exploitation simultaneously and should issue guidelines for groundwater exploitation. Percolation Tank actually leads to increased water use for irrigation as shown in table 2, Table 3 because extending the area under irrigation is often an explicit objective or an unintended outcome.

Table 2 Increase in Groundwater use for Irrigation with Time

Project type	Period (Years)	Rainfall (mm)	Irrigation quantity required (ha m)	Water availability* (ha m)	Over-exploitation (ha m)
Pre-Project	2010	1108	14	15.51	0
Post-Project	2011	612	28	17.13	10.864
	2012	780	36	28.08	7.92
	2013	655	30	19.65	10.35
Average		**682.33**	**31.33**	**21.62**	**9.71**

*Source of water availability include rainfall, natural recharge form Tank and outside the tank

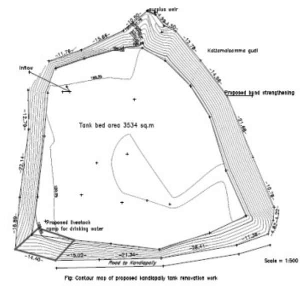
Table 3 Irrigated Crops during Pre and Post Project Area enhanced through Percolation Tank

S.No	Main crops	Pre-2010	Post-Project Irrigation area(ha)			Average (ha)	Area Increased (ha)
		Irrigation area(ha)	2011	2012	2013		
1	Paddy	12.3	14.5	15.6	16.3	15.47	25.75
2	Maize	4.7	5.1	5.3	6.5	5.63	19.86
3	Red gram	12.2	14.1	16.4	20.2	16.90	38.52
4	Jowar	7.5	8.3	9.1	9.8	9.07	20.89
5	Turmeric	3.2	3.5	4.3	5.8	4.53	41.67
6	Vegetables	6.5	7.2	7.7	8.3	7.73	18.97
7	Fodder	2.1	2.4	3.2	3.5	3.03	44.44

Percolation tanks have immense potential to store rainwater. The harvested rainwater can not only be used to meet water requirements but also to recharge groundwater aquifers. The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water. Any man made scheme or facility that adds water to an aquifer may be considered to be an artificial recharge system.


Existing tank (before renovation)


Aerial photograph of tank


Contour map for renovation


Renovation done by CRIDA


Water filled in curst level of tank


Water filled in percolation tank


Layout for water diversion channel


Water diversion channel to tank


Fish realizing into tank

Fig. 2 A View of Rainwater harvesting structure

CONCLUSION

In this study various hydrological parameters related to groundwater recharge have been estimated. Relationship between API-based rainfall and run-off has been developed. The results show that the threshold value of rainfall for ensuring 1 mm potential recharge is 28– 82 mm in this dry region. Potential recharge has been estimated to be 3% of rainfall. The study clearly indicates that water harvesting committee, in semi-arid red soil region helped in improving groundwater recharge, but also led to its subsequent over-exploitation. The results of the study can be applied for similar agro-climatic regions for approximate quantification of surface storage and groundwater recharge.

SUMMARY AND RECOMMENDATIONS

The ground water use may be further enhanced to support agricultural development and to improve rural livelihoods apart from meeting water supply demand. There is a need of adequate knowledge of rainwater harvesting and formulation of proper strategy. An appropriate strategy may take into consideration the following:

- ♦ Identification of Aquifers under the stress and the potential recharge zones in respect of overexploited aquifers. Detailed aquifer mapping is required for scientific planning of the ground water augmentation.

- ♦ Design and implement suitable, site-specific surface water harvesting structure to raise the ground water table.
- ♦ Introduction of water-harvesting structures on unpolluted stream water bodies and open areas
- ♦ Protect aquifer sanctuaries and make them sustainable for future demand.
- ♦ Capacity building of the Community / Gram Panchayat /Water User Association/ and its involvement in implementation and maintenance. Participatory approach for monitoring and management of ground water resources is to be promoted in coming years.

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An Insight into the Hydrogeochemistry of Near Surface Coastal Aquifers of Digha-Shankarpur Tract, East Midnapore District, West Bengal: Identifying Salinity Hazard and Scope for Sustainable Management

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ABSTRACT

The coastal tracts are the major productive centres of ecosystems, tourist and commercial activities and need sound management of groundwater quality for sustainable growth and development. The present study is an attempt to characterize the near surface aquifer system of Digha-Shankarpur coastal tract, and some inland pockets of Contai region, in East Midnapore district of West Bengal. The study seeks to identify the locales of pollution hotspots in groundwater systems on a systems perspective. The selected stretches surveyed are Digha, Shankarpur, Tazpur, Mandarmani, Junput and Contai regions. These areas are presently reeling under severe fresh water crisis resulting out of tourist over-population and fishing merchandise. The present research undertakes detailed hydrogeological investigation and groundwater quality assessment of the affected sub-surface reservoirs. A total three sets of longitudinal sand dunes extend in this region from coastline inwards. These sand dunes provide the scope for storage and development of fresh groundwater. The groundwater available in the first set of sand dunes is brackish in nature and extracted at random by realtors by shallow tube wells for purposes other than drinking. The threat of saline water intrusion looms large and there is distinct evidence of sea water ingression in these frontal dunes. The saline water-fresh water interface is evidenced in the neighbourhood of these four dunes that trends almost parallel to the coast. The second and third set of sand dunes, occurring at 3-10 km landward from the water line, is relatively older and situated at higher grounds. The saline water-fresh water interface in these posterior dunes lies at relatively deeper levels compared to the first set. The groundwater stored in these sand reservoirs is yet undisturbed and can be the potential source of water supply in near future. The quality of water is found suitable for drinking (after chlorination) and agricultural purposes. Estimation of aquifer parameters reveals that the quantity of water available is sufficient for potable use and agriculture which will boost the marginal farmers in raising second crops each year and elevate their socio-economic conditions. The recharge potentiality of the aquifers can be substantially enhanced through sustainable groundwater management.

INTRODUCTION

The hydrogeochemistry of near surface coastal aquifers is a burning geo-environmental issue in today's world. The coastal tracts are the major productive centres of ecosystems that need sound management of groundwater quality for sustainable growth and development. The coastal ecotone represents a vulnerable and hydro-dynamically active milieu marked by 'edge effect'. The coastal groundwater, usually a mixture of salt and fresh water, is an ideal hydro-geochemical buffer system and maintains equilibrium between the sea water on one hand and terrestrial groundwater on the other (De Wiest, 1965; Jacob and Schmorak, 1960; Revelle, 1941; Todd and Mays, 2005).

Hence, the proper study of the hydrodynamic set up of Digha-Shankarpur coastal framework is the need of the hour. The present study is an attempt to characterize the near-surface aquifer of Digha-Shankarpur coastal tract, and some inland pockets of Contai region, in the East Midnapore district of West Bengal.

Study Area:

The present study is focussed on the coastal tracts of Digha-Shankarpur area of East Medinipur district, West Bengal. The area extends between 21°36'28.43"N to 21°41'59.52"N Latitude and 87° 29'21.05" E to 87° 37'30" E Longitude.

The region forms the easternmost extension of the Orissa coastal plain and is a famous tourist hub of West Bengal. Besides a sizeable resident population, the area is flocked by floating population. The need for drinking water for the local population is satisfied from groundwater lying at deeper levels. Limited fresh water is also available in the near-surface aquifer of the sand dunes within the depth zone of 30 m depth that gets recharged only by rain water. Considering the tremendous importance of Digha-Shankarpur as a tourist and commercial hub, this uppermost unconfined horizon can provide respite to water users. But this near surface water resource is very precious and needs judicious and conjunctive use. An attempt has been made in this study to characterize and understand the groundwater resource of near-surface aquifers of Digha-Shankarpur beach.

Review of Literature

Limited literatures are available on the hydrogeology of coastal aquifers in Digha-Shankarpur area and whatever available pertains to deeper freshwater aquifers and their sustainability (Goswami, 2010; Jana et al., 2013; Maity, and Bhattacharya, 2010; Maity, 2011; Mandal et al., 2013; Mandal et al., 2013; samanta and Paul, 2008).

Relevance of Sand Dunes in Relation to Study Problem

A distinct three sets of sand dunes representing shoreline shift at different geological times could be delineated through study of landsat imagery and aerial photographs (Fig. 1). It is observed that three sets of sand dunes extend from Digha to Khejuri area, of which Digha-Shankarpur tract forms a part. The first set of sand dunes is subjected to interaction with sea water. The area adjacent to these four dunes is characterized by saline-fresh water interface which trends almost parallel to shoreline. The second and third set of sand dunes is relatively older and stretch away from the water line at higher altitudes. The saline-fresh water interface in this aquifer lies at deeper levels compared to the first one.

In Digha-Shankarpur tract, the three sets of sand dunes have significant relevance in the exploitation of groundwater from shallow aquifer zones. Water is being extracted from these sand dunes with the help of shallow wells for purposes other than drinking. The sand dunes occurring at distances of 3-10 km from the sea coast can be the source of water supply in future if properly planned. The recharge potentiality of this aquifer can also be enhanced, as these sand dunes are under considerable stress. The dune set in close proximity to the sea is under severe threat of saline water intrusion.

Synoptic Hydrogeological Set-up

The Digha-Shankarpur tract is underlain by a thick pile of unconsolidated sediments of Quaternary Alluvium. The subsurface lithology, as evidenced from drilling down to depth of 400 m below ground level (bgl), indicates alternate layers of sand and clay with predominance of clayey fractions. The entire tract is blanketed by sand dunes from the ground level to varying depths of 20 to 30 m which are underlain by clay layers. This sand is very fine-to-medium grained having higher uniformity coefficient. At further depths, between 100-200 m bgl, there occur sand layers (of 20-30 m in thickness) which again get repeated at greater depths by very-fine-to-fine grained sandy fractions within the depth range of 250-350 m.

Water quality analyses have revealed that the sand beds within 20 to 30 m bear fresh water owing to direct recharge from the rain water. The water that exists within the sandy layers of 100-200 m bgl is dominantly brackish in nature and not fit for human consumption. However, the sandy aquifer that occurs between 250-350 m bgl is relatively fresh. This deeper aquifer is mainly tapped by tube wells for purpose of drinking by the local people. It is, however, possible to utilize the freshwater stored in the upper layer sand dunes after proper assessment and scoping for planned development.

Fresh Groundwater Resources in Near Surface Aquifer

Considering the total length, width and thickness of the near surface-aquifer in the study tract as 8000 m, 3000 m, 5 m respectively, the total volume of the aquifer is estimated to be 120×10^6 m^3. Taking into account a seasonal fluctuation of 1 m, the total volume of groundwater available for the near surface aquifer will be of the order of 24×10^6 m^3. If the specific yield of the aquifer is taken as 10%, the total volume of water available in this aquifer will be 24×10^5 m^3. If the population size is 30000, the total annual requirement of water will be 77×10^4 m^3. Thus the drinking water need of the local population can be easily met from the uppermost sand dune aquifer of Digha-Shankarpur area.

Aquifer Characteristics of Near Surface Sand Dunes

To assess the aquifer characteristics of the near surface sand dunes, a series of pump tests were conducted in the study area. The finings are presented in Table 1. Water samples collected from test wells have been analyzed to examine the concentration of major chemical constituents that are present in groundwater of that particular area (Table 2). The concentration of Total Dissolved Solids (TDS) and Chloride (Cl^-) of the samples are found to lie within the permissible limits of Drinking Water Standard IS 10500:2005, except in sample no. 4 which shows higher value. The relation between the concentrations of TDS and Chloride is graphically represented in Fig. 2. The overall water quality was found to be fresh and suitable for drinking purpose.

Table: 1

Site No.	Transmissivity (m^2/day)	Storage Coefficient	Thickness of aquifer (m)	Permeability (m/day)	Yield of well (m^3/day)	Static water level (m)	Duration of pumping (min)	Pumping water level after pumping (m)	Drawdown (m)
	Jacob's Method								
1	878.98	996.79×10^{-10}	5	175.79	144	8.34	120	8.62	0.28
3	1198.61	49.93×10^{-3}	5	239.72	144	6.97	120	7.002	0.032
4	117.19	1.01×10^{-3}	5	23.43	16	1.696	45	1.745	0.049
6	329.62	364×10^{-15}	5	65.92	36	5.232	120	5.34	0.108

Table 2

Sample No.	Name of Block (Sampling Area)	BIS 10500:2005				Depth of Monitoring Wells (in m)	TDS (mg/l)	Chloride (mg/l)
		Desirable Limit of TDS (mg/lt)	Maximum Permissible Limit of TDS (mg/l)	Desirable Limit (mg/l)	Maximum Permissible Limit (mg/l)			
1	Kanthi - I	500	2000	250	1000	18	176	35.45
2	Ramnagar - I					6	432	85.08
3	Kanthi-I					21	866	354.5
4	Ramnagar - I					6	1633	567.2
4.(a)	Ramnagar - I					122	276	14.18
5	Ramnagar - II					6	966	340.3
6	Ramnagar - I					8	159	35.45
7	Ramnagar - II					6	130	21.27

CONCLUDING REMARKS

The present study attempts to review the hydrogeochemistry of near-surface coastal aquifers of the Digha-Shankarpur beach of southern West Bengal. The problem has hardly been attempted by any researcher hitherto before. Preliminary hydrological investigations of this strategic coastal province, as detailed above, have furnished encouraging results. This needs to be followed by preparation of comprehensive master plan to understand the mobility and dynamics of the fresh water-saline water interface through round-the-year monitoring of aquifer parameters. The data for pre- and post- monsoon seasons would indicate the likely nature and depths of infringements of salt and fresh water zones and would help in outlining optimum groundwater development schemes for the stressed areas. Regular monitoring and surveillance programmes are to be arranged with stakeholders for checking over-withdrawal of this precious resource and preventing migration of saline water towards inland.

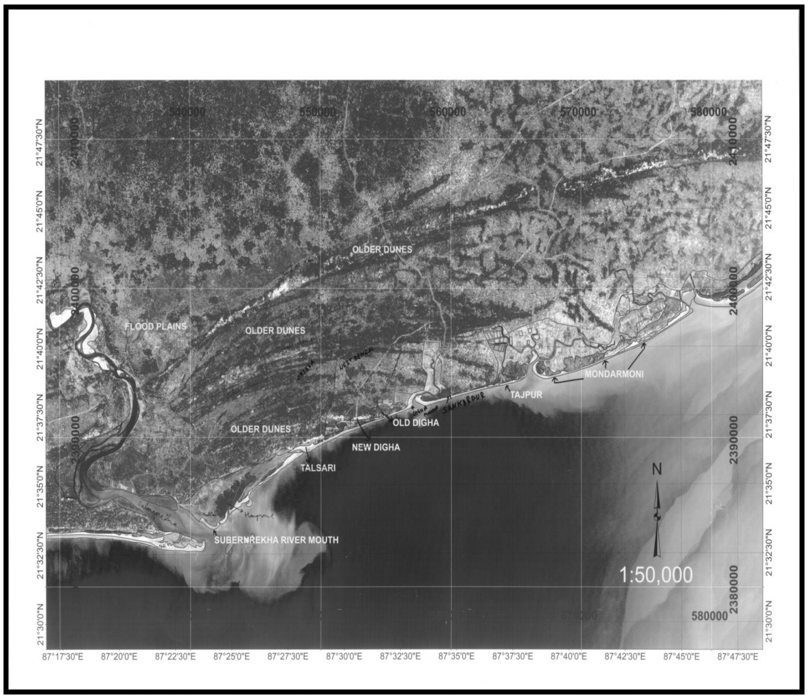

Fig 1: Study Area Showing Location of Sand Dunes for Prospective Groundwater Management

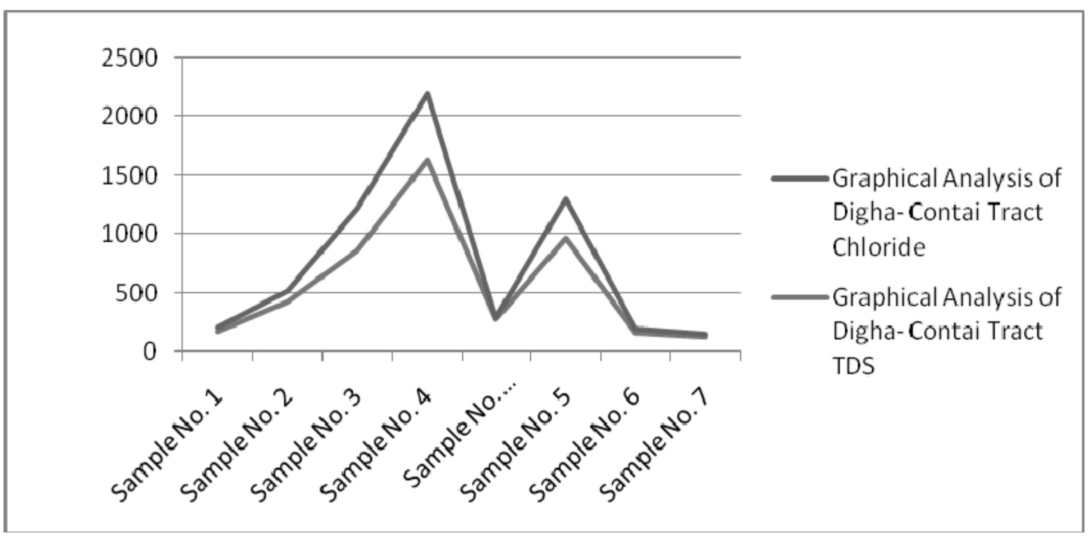

Fig. 2 Graphical Representation of TDS and Chloride in the Analyzed Samples

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2D Resistivity Imaging Survey for Charecterization of Hard Rocks in Annaram Village, Karimnagar District, Andhra Pradesh

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ABSTRACT

In the hard rock regions ground water plays a major role in human life. The day to day increasing human activities leads to the water scarcity and quality problems. For understanding the aquifer system and management of ground water for optimal utilization, characterization of hard rock's is needed. The present study is to carry out the Geo-physical investigations in the Annaram village, Karimnagar District, AP to understand the sub-surface lithology of the watershed. It serves as a base line data for future water resources planning and development. Yield potential of the aquifers in the consolidated rocks vary widely as the resistivity values at 4-43 feet indicate the resistivity of 28-59 Ω-m representing laminated zone, at 43-84 feet indicating the resistivity of 59-646 Ω-m representing weathered zone, and above 84 feet resistivity values are very high (>646 Ω-m) representing fresh granite/basement zone. In the present watershed, the groundwater occurs in phreatic condition in weathered and fractured rocks. The Talchir boulder bed is favorable for sinking open wells and the yields range from 15 to 25 m3/day. The rise in water level between pre and post monsoon period is more than 4 m. Based on the results of the study, the groundwater conservation and management techniques have been suggested.

Keywords: Resistivity, Hard rock, Watershed.

INTRODUCTION

Groundwater is simply the subsurface water that fully saturates pores or cracks in soils and rocks. Aquifers are replenished by the seepage of precipitation that falls on land, although people can artificially replenish them, also. There are many geologic, meteorological, topographic, and human factors that determine the extent and rate to which aquifers are refilled with water. Resistivity techniques are a powerful borehole siting tools although there are many other geophysical techniques, which are in uses. However the rapid increase in the popularity of electrical imaging has brought the focus back onto electrical methods. Electrical images provide a more detailed view of subsurface structure than can be obtained using other geophysical techniques and may therefore lead to a better understanding of local hydrogeology.

Objectives of the Study

In The Present Study, 2D Resistivity Imaging Was Carried Out At Granitic Terrain Of Annaram Village, Karimnagar District, Andhra Pradesh. The study include Delineation& Characterization of sub-surface formations in the Annaram watershed. To study the aquifer geometry and aquifer properties in the study area. Preparation of Resistivity and Thickness maps of sub-surface layers.

Location and Description of the Study Area

The study area is Annaram village is situated at the entry of the Karimnagar town while coming from Hyderabad/Warangal. The Karimnagar district located at North Latitude 18^0 00' and 19^0 00' East Longitude 78^0 40' and 80^0 00'. The area under investigation falls under semi-arid zone with a hot and humid climate. "The maximum and minimum elevations of topographic contours are 455 m and 605 m above mean sea level respectively." The climate is hot and humid and receives an average normal rainfall of the district 968.6mm, "90% of the groundwater is drafted through bore well structures and main crops grown in the watershed are paddy, cotton and vegetables.

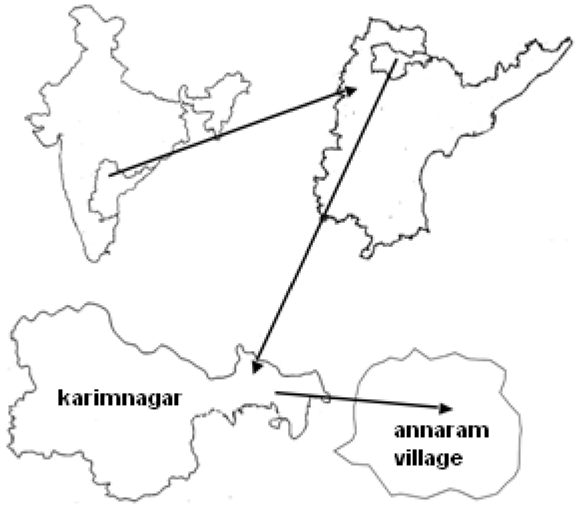

Fig.1 Location Map of the Study Area

Literature Review

Singh et al., (2006) studied the groundwater condition at Central Mining Research Institute campus in detail and recommended a new deep tube well by using 2D resistivity imaging surveys. Exploration surveys were conducted by Sushobhan Dutta et al., (2006) from Indo-French Center for Ground Water Research, NGRI, Hyderabad at one of the important sites in Maheshwaram watershed, Andhra Pradesh, India with a multi electrode resistivity imaging system and recommended a few artificial recharge sites.

METHODOLOGY

Conventional resistivity sounding and lateral profiling, 2D resistivity imaging is a fully automated technique that uses a linear array of about 48 electrodes connected by multi core cable. The current and potential electrode pairs are switched automatically using a control module connected to a earth resistivity meter(that provides output current).In this way a profile of resistivity against depth(Pseudosection) is built up along the survey line data is collected by automatic profiling along the line until the last electrode is reached. The spacing is than increased by minimum electrode separation and the process is repeated in order to provide an increased depth of investigations. The maximum depth of investigation is determined by the spacing between the electrodes and the number of electrodes in the array. For 48 electrodes array

With an electrode spacing of 5 m this depth is approximately 50 m. The raw data is initially converted to apparent resistivity values using a geometric factor that is determined by the type of electrode configuration used. Once converted the data is modeled using finite eliminate and least squares inversion methods in order to calculate a true resistivity versus depth pseudosection.

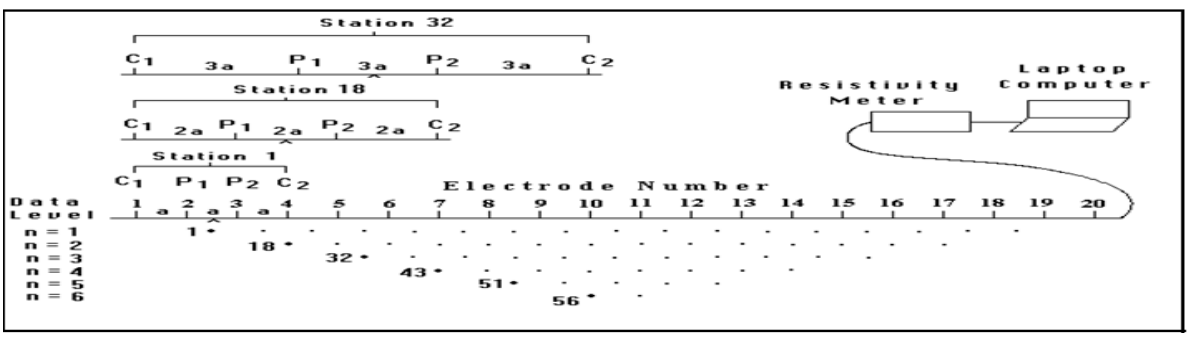

Fig. 2 Sequence of Measurements to Build up a Pseudosection

Investigations in Study Area

Profile: 1

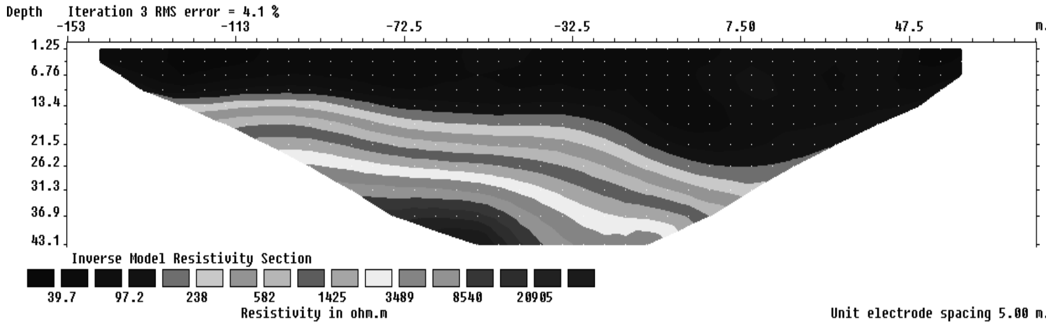

Fig.3 Resistivity Imaging of Sub-surface Layers at Annaram Village by using Terrameter SAS 1000/4000

The 2-D image obtained from Terrameter by using Wenner-Schlumberger configuration. The total depth of investigation is 43.1 m. The top level up to 13.4 m depth the sub-surface layers having resistivity in the range of 39.7 - 97.2 ohm-m, indicating weathered zone which contain groundwater. The middle layer from 13.4-15 m depth with resistivity of 238 ohm-m representing a fracture zone. The bottom layers possessing high resistivity values from 582 -20905 ohm-m it indicates highly massive granite rock (basement) from the depth of 21.5 m onwards. Thickness of weathered zone extended up to 21.5m.

Profile: 2

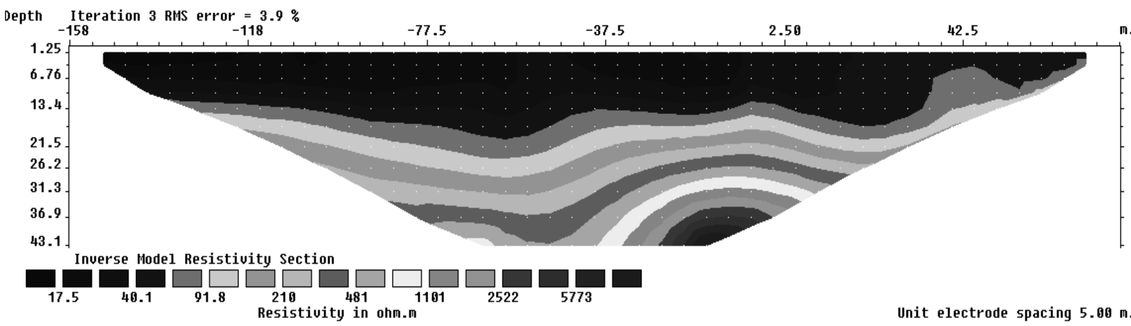

Fig.4 Resistivity Imaging of Sub-surface Layers at Annaram (Down stream side) Village by using Terrameter SAS 1000/4000.

The 2-D image obtained from Terrameter by using Wenner-Schlumberger configuration. Up to a depth of 21.5 m image showing low resistivity values from 17.5 – 91.8 this indicates groundwater zones. The middle layers from 21.5 m to 26.2 m depth having resistivity in the range of 210-410 ohm-m, indicates fracture zone. The bottom layers showing resistivity values up to 5700 ohm-m.

Profile: 3

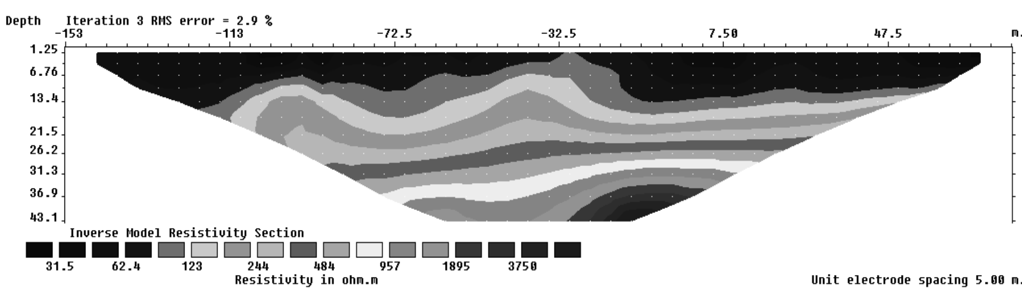

Fig.5 Resistivity Imaging of Sub-surface Layers at Annaram (Beside stream) Village by using Terrameter SAS 1000/4000

Fig 6 shows the distribution of electrical resistivity along the profile. The figure shows low resistivity zone of 31.5 to 62.5 ohm-m. From 13.4 to 21.5 m depth on vertical scale showing resistivity values upto 123 ohm-m. Indicating fracture zone along the profile. From 21.5 to 31.3 m image showing medium resistivity values upto 957 ohm-m. The bottom layers indicating high resistivity values up to 3750 ohm-m . The above image showing low resistivity (62.4 ohm-m) values on lateral scale up to a depth of 13.4 m.

Profile: 4

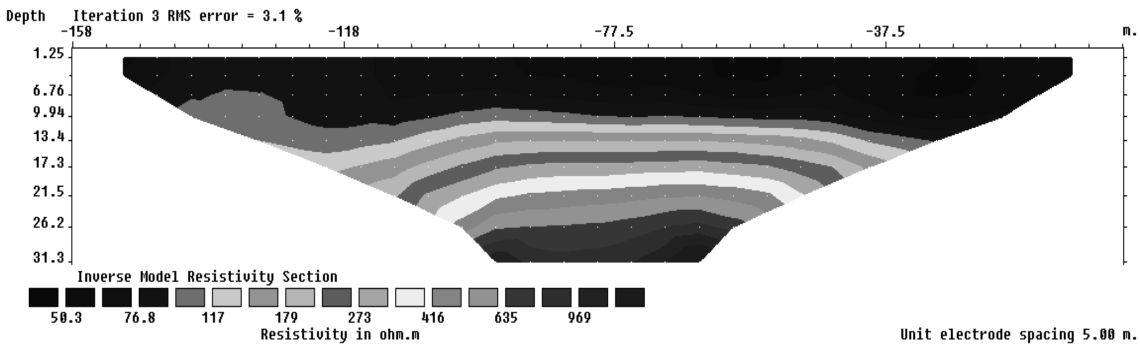

Fig. 6 Resistivity Imaging of Sub-surface Layers at Annaram Village by using Terrameter SAS 1000/4000

The above resistivity section represents a very amazing layered structure of the sub-surface with sharp resistivity contrast between the weathered and basements zones of the area. Hence there is slightly undulating topography in the sub-surface layers. Upto the depth of 13.4 m entire profile showing high weathered zone having resistivity up to 76.8 ohm-m.at the depth of 13.4 m to 21.5 m image indicating resistivity value 76.8 to 179 ohm-m. This also represents laminated layers upto depth of 21.5m. after the laminated zone there is clear indication of fissured granite upto 31.3 m depth.

Profile: 5

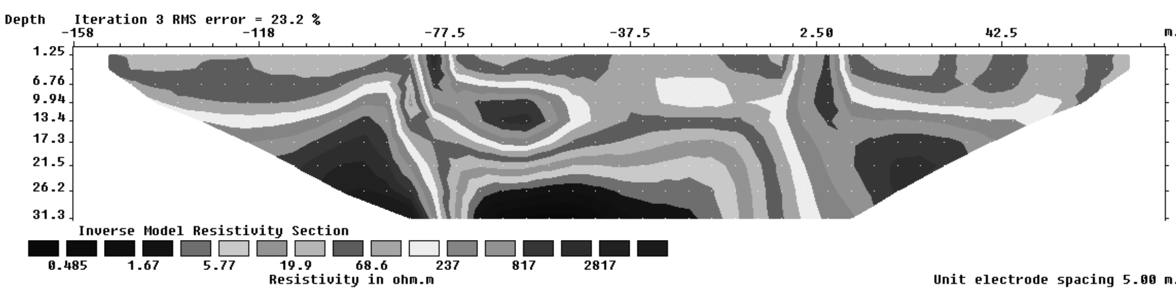

Fig. 7 Resistivity Imaging of Sub-surface Layers at Annaram Village by using Terrameter SAS 1000/4000

The above process 2 D section shows the resistivity. In this section there is a vertically low resistivity zone that is deep fracture zone at 16 -24 m lateral scale with resistivity of 1.67 to 19.9 ohm-m.

From 15 m to towards south upto 710 m and 160 m to towards north the profile there is high resistive basement zone at depth of 27m with the resisitivity of more than 800 ohm-m.

Results of 2 d Electrical Resistivity Imaging Profiles

Based on the correlation study, subsurface lithologies in the Annaram village is indicated in Table.1.

S.No	Sub-Surface layer	Feet	Resistivity Ω-m
1	Saprolite/Laminated layer	4-42.88	28.13-59.28
2	Weathered/Fissured layer	42.88-83.4	59.28-646.56
3	Fresh granite/Basement	83.84-137.92	646.56-6842.8

CONCLUSION

In order to obtain meaningful information about ground water resistivity values, a critical examination of the variation of resistivity values of all the different earth zones (clay, weathered, fractured, hard rock zones) is made with the help of 2D electrical resistivity images, which are prepared using the computer software called RES2DINV. The distribution of electrical resistivity values along the profile interprets clay, weathered, fractured, bedrock zones. Below 90 ohm-m resistivity are interpreted as highly weathered formation and above 300 ohm-m resistivity are interpreted as hard rock zone. The resistivity values for the successful groundwater wells in Granitic terrain are 170 to 360 ohm-m.

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2-D Resistivity and Induced Polarization Surveys for Charecterisation of Hard Rocks in Kudliar Watershed, Medak District, A.P.

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ABSTRACT

Ground water is a precious resource and the most widely distributed resource of the earth. It plays a major role in the livelihood of mankind by providing water for drinking, irrigation and industrial purposes. In many countries, the decline of water level indicates that the resources are depleted very fast. It is, therefore, necessary to assess the available subsurface resource in a more judicious scientific manner and then apply it for evolving optional utilization purposes. The present study is to carry out the Geo-physical investigations in the Kudliar watershed, Medak District, AP to understand the sub-surface lithology of the watershed. It serves as a base line data for future water resources planning and development. The entire watershed is underlain by consolidated rocks. Yield potential of the aquifers in the consolidated rocks vary widely as the resistivity values at 16-48 feet indicate the resistivity of 12-150 Ω-m and conductivity of 3.47-8.80 mv/v representing laminated zone, at 48-80 feet indicating the resistivity of 150-500Ω-m and conductivity of 8.80-14.1mv/v representing weathered zone, and above 80 feet resistivity and conductivity values are very high representing fresh granite/basement zone. Due to over exploitation, the yields have fallen drastically leading to failure of wells. In the present watershed, the groundwater occurs in phreatic condition in weathered and fractured rocks. Based on the results of the study, the groundwater conservation and management techniques have been suggested.

Keywords: Resistivity, Hard Rock, Chargeability, Watershed.

INTRODUCTION

Resistivity and Induced Polarization techniques are powerful borehole siting tools for groundwater although there are many other geophysical techniques employed for the same purpose. Of late electrical imaging has become very popular, since they provide a more detailed view of subsurface water bearing structure than can be obtained using other geophysical techniques and may therefore lead to a better understanding of local hydrology. Usually 1 D resistivity provides survey information at point, while 2 D imaging facilitates very close measurement with ease providing details of resistivity cross section along a profile.

Objectives of the Study

In the present study, 2D Resistivity Imaging was carried out at Granitic terrain of kudliar watershed at Medak district, Andhra Pradesh. The study include delineation& Characterization of sub-surface formations in the Kudliar watershed. To study the aquifer geometry and aquifer properties in the study area. Preparation of Resistivity, Induced Polarization and Thickness maps of sub-surface layers.

Location and Description of the Study Area

The study area kudaliar watershed is located in Medak district, Andhra Pradesh, India , which is situated about 90 km North West to Hyderabad on Hyderabad-karimnagar state high way and is bounded by East longitude 78^0 33’ 39.6’’ – 79^0 07’ 22.8’’ and latitude 17^0 53’ 45.6’’ -18^0 15’ 36’’. The study area predominantly occupied by granite with small pitches of supracrustal of Achaean age. The supracrustal occur as enclaves of varying size sand shapes with in granite predominantly in hornblende granite. The entire watershed the degree of weathering is quite high thereby giving rise to saprolite by the removal of feldspar here by generating very good secondary porosity. Saprolite extends down to a depth of 15m at this place. Joints are well developed in granites excepting in massive verities. The drainage pattern developed over granite/gneiss is sub-dendritic to dentric. The total area of kudaliar watershed is 990 km^2, this area is represented in survey of India toposheet No. 56 K/9, 56 F, K, of Survey of India and the maximum and minimum elevations of topographic contours are 455 m and 605 m above mean sea level respectively. Resistivity imaging survey was conducted in granitic terrain at kudliar watershed in Medak district in Andhra Pradesh Viz., Raipol, and Bhumpalli. Dubbak, Gollapalli and Sangapur

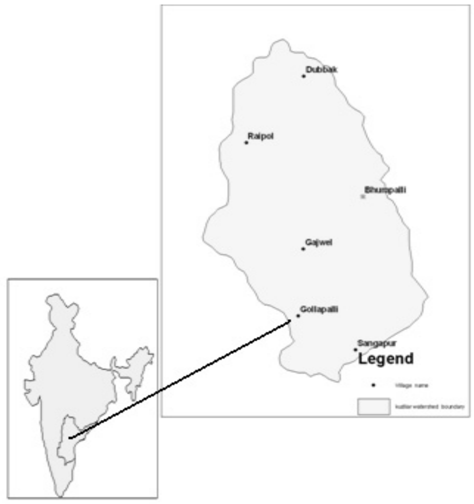

Fig. 1 Location Map of the Study Area

Literature Review

Singh et al., (2006) studied the groundwater condition at Central Mining Research Institute campus in detail and recommended a new deep tube well by using 2D resistivity imaging surveys. Exploration surveys were conducted by Sushobhan Dutta et al., (2006) from Indo-French Center for Ground Water Research, NGRI, Hyderabad at one of the important sites in Maheshwaram watershed, Andhra Pradesh, India with a multi electrode resistivity imaging system and recommended a few artificial recharge sites. A multi electrode resistivity survey carried out by owen et al.(2006) over meta sedimentary strata and metavolcanics in the Harare greenstone belt in northeastern Zimbabwe as part of a groundwater resources investigation, illustrates the ability of this technique to produce high-resolution images of the sub-surface useful for groundwater resources assessment.

The resistivity results provide a clear view of the thickness of the weathered regolith and the distribution of the various lithological units. It can be inferred from the above and other similar studies that 2D resistivity imaging is applied to define the local hydrology in general and groundwater location in particular. However, in the present study it is attempted to obtain the ranges for kudliar watershed.

METHODOLOGY

Conventional resistivity sounding and lateral profiling, 2D resistivity imaging is a fully automated technique that uses a linear array of about 72 electrodes connected by multi core cable. The current and potential electrode pairs are switched automatically using a control module connected to a earth resistivity meter(that provides output current).In this way a profile of resistivity against depth(Pseudosection) is built up along the survey line data is collected by automatic profiling along the line until the last electrode is reached. The spacing is than increased by minimum electrode separation and the process is repeated in order to provide an increased depth of investigations. The maximum depth of investigation is determined by the spacing between the electrodes and the number of electrodes in the array. For 72 electrodes array

With an electrode spacing of 10 m this depth is approximately 90 m. The raw data is initially converted to apparent resistivity values using a geometric factor that is determined by the type of electrode configuration used. Once converted the data is modeled using finite eliminate and least squares inversion methods in order to calculate a true resistivity versus depth pseudosection.

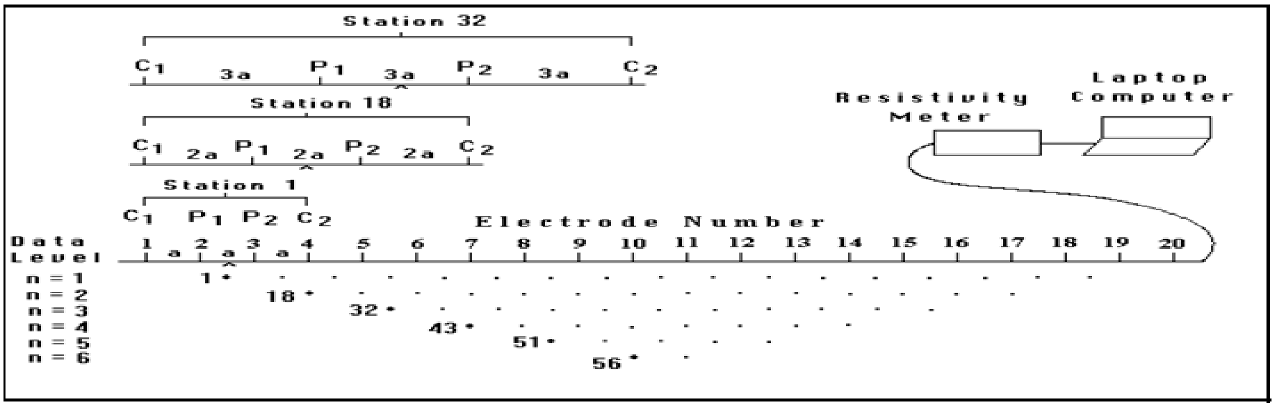

Fig. 2 sequence of Measurements to Build up a Pseudosection

Hydrogeophysical Investigations and Results

A total of five 2D Electrical Resistivity Imaging (ERI) profiles were conducted utilizing Wenner-Schlumberger configuration with maximum of 720 m with 72 electrodes. The SYSCAL junior switch -48 Resistivity meter is designed by IRIS is used for detecting the resistivity values from the earth sub-surface. The raw data is initially converted to apparent resistivity values using a geometric factor that is determined by the type of electrode configuration used. Once converted, the data is modeled using finite element and least squares inversion methods in order to calculate a true resistivity versus depth pseudosection.

Investigations in Study Area:

At Raipol

The Resistivity 2D section (Fig.3) obtained from Wenner-Schlumberger configuration along NW-SE direction shows a layered structure with slight undulating topography up to a total depth of 86.2 m. This section also shows that the resistivity of the subsurface gradually increases (from 10 Ohm-m to 2000 Ohm-m) with depth. The top level up to 15 m depth the subsurface layers possesses resistivity in the range of 10-15 Ohm-m, Indicates possible saprolite and laminated granite which contain groundwater.

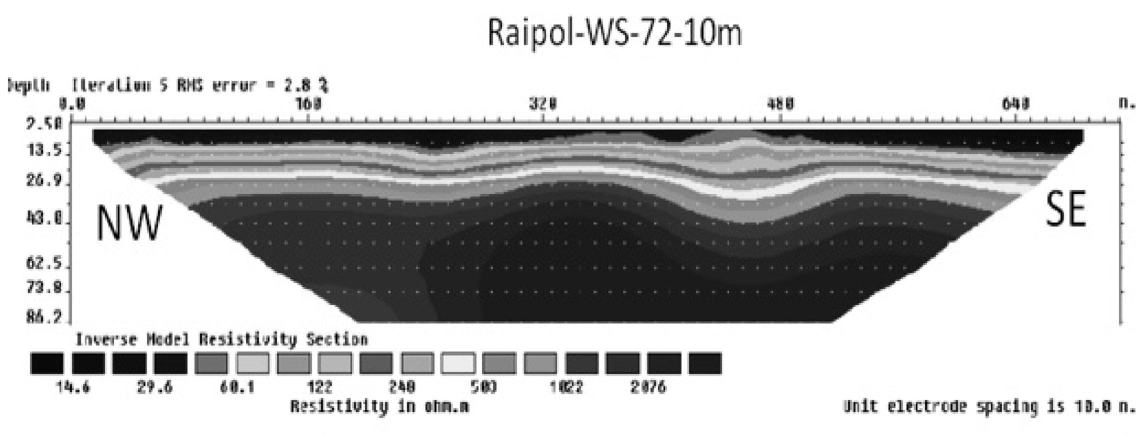

Fig. 3 Resistivity Imaging of Subsurface at Raipol Village by using Wenner-schlumberger Array

The middle layers from 15-25m depth with resistivity of 200-500 Ohm-m represent fissured granite and underlain bottom layers possessing more than 500 Ohm-m. It represents the presence of highly massive granite (basement) rock to the entire depth of investigation (86.2 m) However; there is possibility for deep potential aquifer zones. These Electrical Resistivity Tomography survey results are exactly correlating with the study area.

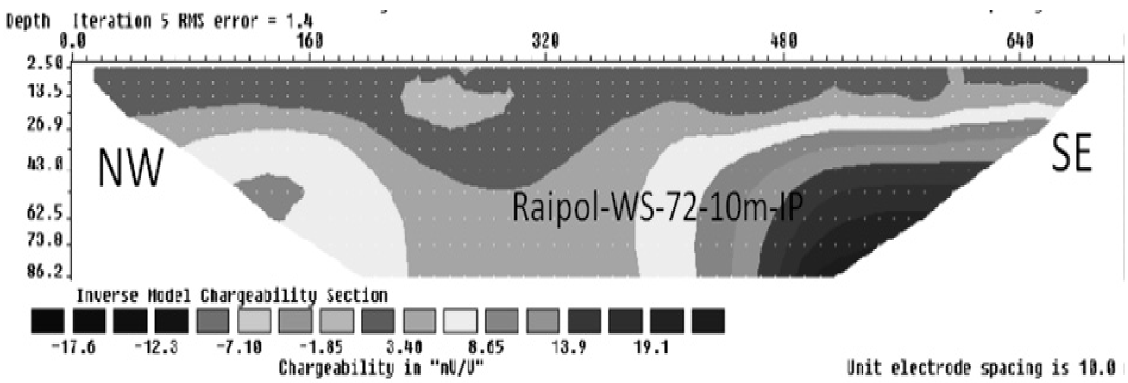

Fig. 4 Chargeability Imaging of Subsurface at Raipol Village by using Wenner-schlumberger Array

This IP survey was also carried out simultaneously with apparent resistivity at the same location to know the general dipping direction and chargeability of subsurface layers. It revealed that the center of image is having low chargeability up to -1.85 mv/v to 3.40 mv/v and both sides of image are showing high chargeability's up to 8.65 mv/v to 19.1 mv/v, from the depth of 30 m onwards. The high chargeability could be due to presence of highly mineralized and that has to confirm by doing other surveys like EM (Electromagnetic) etc.

At Bhumpalli

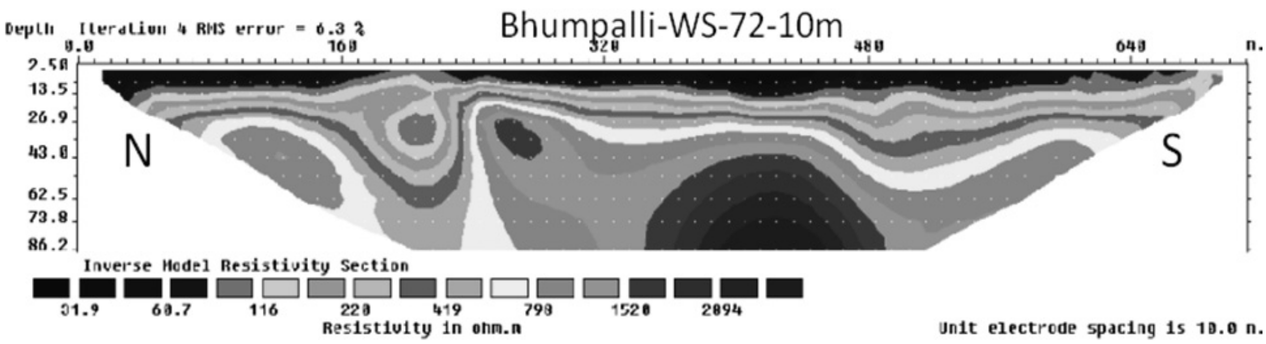

Fig. 5 Resistivity Imaging of Subsurface at Sangapur Village by using Wenner-schlumberger Array

In the resistivity section (Fig:5) there is a vertically low resistive zone. I.e. deep fractured basement from 160-230 m on lateral scale with the resistivity of 20-200 Ohm-m. There is a possibility for groundwater potential zones. In the ERT section; from 230 m to towards south up to 710 m and 160 m to towards north the profile there is a high resistive basement zone at depth of 27 m below onwards with the resistivity more than 800 Ohm-m. The above image (fig 5) shows high resistivity values up to 2000 ohm-m between 410-450 m on lateral scale in the depth 73.8 m onwards. Hence, 2D imaging survey has revealed the resistivity distribution of the sub-surface of the kudaliar watershed.

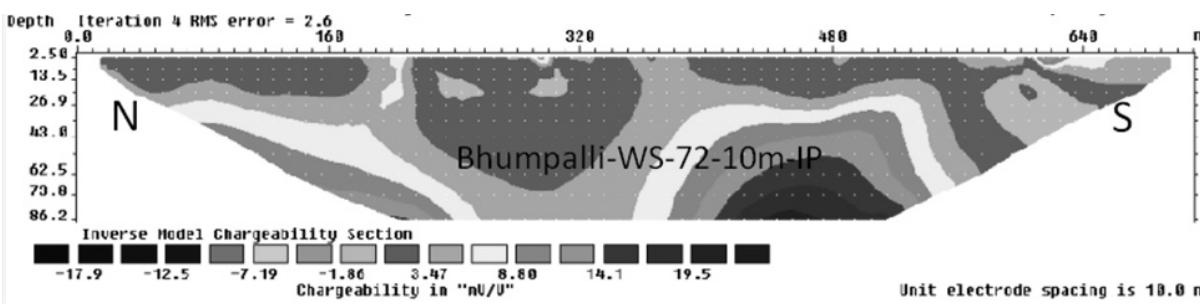

Fig. 6 Chargeability Imaging of Subsurface at Bhumpalli Village by using Wenner-schlumberger Array

This IP image is correlating with the resistivity image of the area. In the IP section between 210 m to 350 m laterally there is low chargeability is due to the fresh water recharge. This location chargeability values exists from -1.86 mv/v to 3.47 mv/v. During the water recharge; all mineralized contents will go down from surface and the surface layers will show low chargeability due to the leaching effect. The high resistive zones are showing high chargeability that may be due to the presence of oxidized minerals in granites. Both sides of the image exhibits chargeability values up to 19.5 mv//v.

At Dubbak

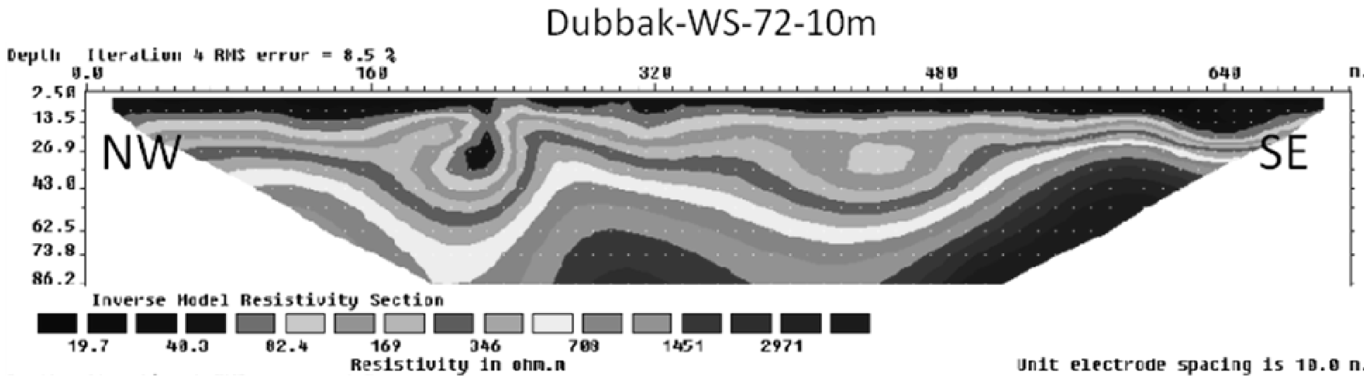

Fig. 7 Resistivity Imaging of Subsurface at Dubbak Village by using Wenner-schlumberger Array

The above resistivity section represents a very amazing layered structure of the subsurface with sharp resistivity contrast between the weathered and the basement zones of the area. Hence, there is slightly undulating topography in the sub-surface layers; electrical resistivity tomography survey revealed the fractured zones at 220 m and 440 m lateral scale up to a depth of 40 m. The resistivity of this fracture zones is ranging from 15-150 Ohm-m. This also represents laminated layers up to depth of 18 m. These layers shows resistivity up to 82.4 Ω-m After the laminated zones there is a clear indication of fissured granite up to 43.8 m at the center of the profile with the resistivity of 150-700 Ohm-m. However the basement is starting from 44 m with more than 700 Ohm-m resistivity. There is high resistive (>1451 ohm-m) basement zone existing from the 50m below onwards.

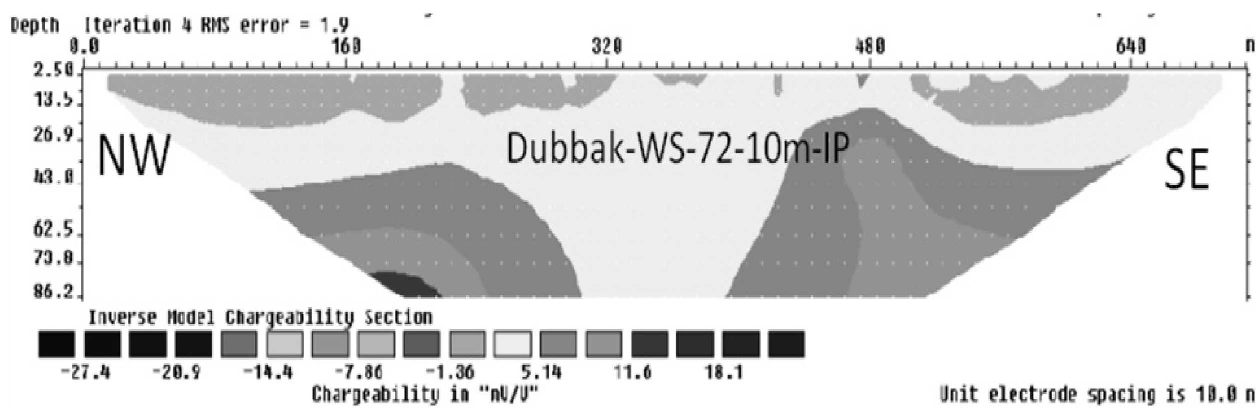

Fig. 8 Chargeability Imaging of Subsurface at Bhumpalli Village by using Wenner-schlumberger Array

The above figure shows the IP image. It represents high chargeability zones at both sides of image compare to center of the profile. Up to a depth of 15 m image shows low chargeability in the range of -7.86 mv/v -1.36 mv/v. Both sides of the image shows high chargibilities at a depth of 43.8 m onwards. The low chargeability is indication of fresh water zone and the high chargeability is may be due to the presence of chargeability minerals in the subsurface.

At Gollapalli

The location of the ERT profile is along the road between munigadapa and Gollapalli villages, Gajawel mandal, Medak district. The 2D section (fig 4.7 a) obtained from Wenner-Schlumbger configuration along S-N direction and the maximum depth of investigation is 91.2 m. The above ERT section shows an undulating layered structure and the layers are dipping towards the southern side of the profile.

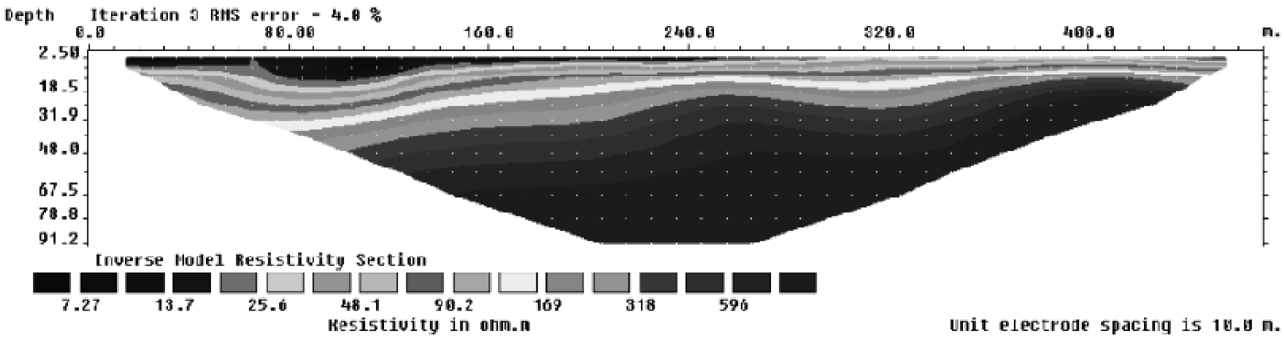

Fig. 9 Resistivity Imaging of Subsurface at Gollapalli Village by using Wenner-schlumberger Array

The image shows thick blue to green layers up to 25 m depth with resistivity of 150 ohm-m(Laminated layer). The middle of the layers possesses resistivity in the range of 300-500 ohm-m,(Fissured) and bottom of the layers indicates high resistivity (>500) values.(Fresh granite/Basement).

At Sangapur

The below 2D section obtained from the Wenner-Schlumbger configuration along N-S direction up to a total depth of 86.2 m. The above geo-electrical section shows two distinct lithology. Northwestern part has low resistivity values while the southeastern part has high resistivity values.

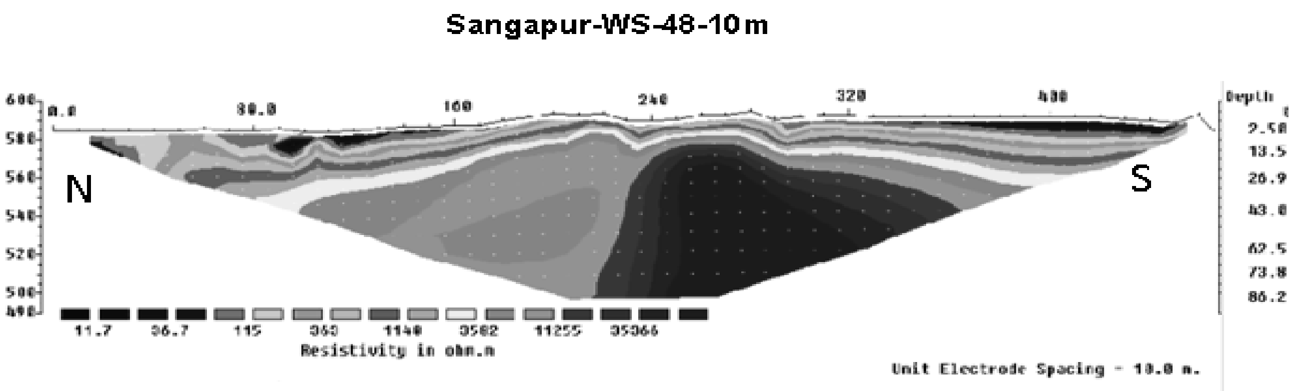

Fig. 10 Resistivity Imaging of Subsurface at Sangapur Village by using Wenner-schlumberger Array

There is a sharp contrast in the resistivity surrounded by high resistivity is encountered at a depth at a range of 27-62 m. This indicates that the northwestern part is composed weathered granite where as the southeastern part is composed of hard and massive granite.

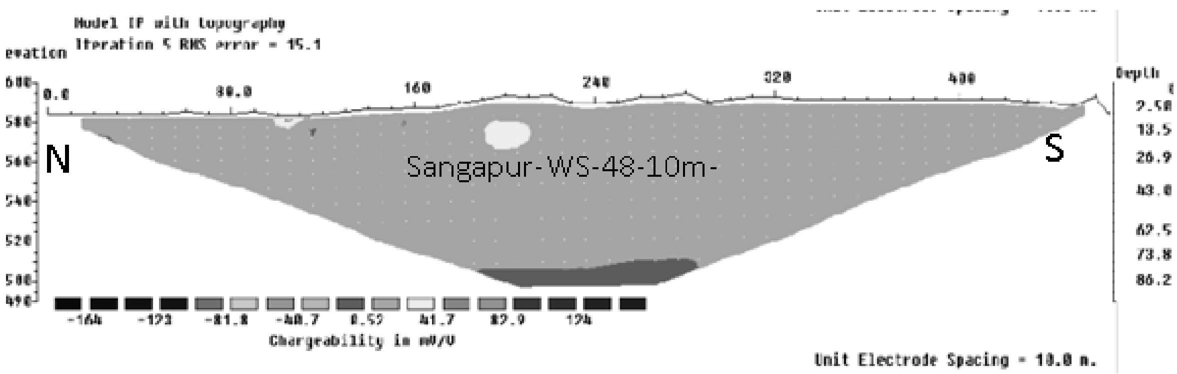

Fig. 11 Chargeability Imaging of Subsurface at Bhumpalli Village by using Wenner-schlumberger Array

The IP shows almost equal chargeability throughout the entire area. Hence, the basement depth is very shallow at this place and there are no favorable groundwater zones available at this site.

Results of 2 d electrical resistivity imaging profiles

Based on the correlation study, subsurface lithologies in the kudaliar watershed are indicated in table.1.

Table 1 Average Resistivity and Chargeability values of Kudliar watershed

S.No	Sub-Surface layers	Meters	Feet	Resistivity values	Chargeability values
1	Saprolite/laminated layer	5-15	16-48	12-150 Ω-m	3.47-8.80 mv/v
2	Weathered/fissured layer	15-25	48-80	150-500 Ω-m	8.80-14.1mv/v
3	Fresh granite/basement	>25	> 80	> 500 Ω-m	>14.1 mv/v

CONCLUSION

All the 2 -D resistivity and chargeability imaging surveys are carried out in the vicinity of the well. The 2-D resistivity imaging results have corroborated every well with geological evidence obtained by drill holes and bore wells. At all these locations, the resistivity values from 2D imaging are compared with that by Resistivity well logging method and found that they are almost same. Multi-Electrode resistivity survey is more suitable for the study of groundwater potential zones in larger areas. The application of resistivity technique has been found to be useful to delineate and characterize the aquifer geometry and sub surface lithology. The 2D resistivity images are used for studying the shallow structures of the underground located a few tens meters down to about one hundred meters depth. Combining all the above results, a few sites are identified for drilling observation wells particularly where the depth to bed rock is higher (more than 25 m) and resistivity of the weathered and fractured zones are favorable (not exceeding 300 ohm-m).

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Vertical Electrical Sounding for Finding Groundwater Potential Zones in IIT Kandi Campus, Hyderabad, Andhra Pradesh

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ABSTRACT

The aquifer parameters in the Indian Institute of Technology Hyderabad Campus at Kandi, Medak district of Telangana were delineated by using the Vertical Electrical Sounding (VES) technique. VES is one of the best suitable methods over all other geophysical methods to find the subsurface groundwater and hydrogeological parameters. In this study 11 VES soundings carried out using SSR-MP resistivity meter, min and max spread length was 200 and 240 respectively by schlumberger configuration. The data generated analyzed and interpreted using the IPI2win open source software. These results showed three to five layers up to a depth of 60m. HA type curve were dominate in most geoelectric soundings. Different hydro-resistivity maps were prepared from VES data interpretation are total longitudinal conductance map (S), total transverse resistance map (T) and iso-resistivity contour maps at 10, 20 and 30 m depth. Different geoelectric cross sections Prepared from North to South and West to East direction by using interpreted results entire study area. These results depicts that the potential zones were observed at depths of 15 to 40m entire area. And the groundwater movement observed.

Keywords: VES, Groundwater, Aquifer.

INTRODUCTION

Groundwater is the main source for potable water supply, domestic, industrial and agricultural uses. Because of the overexploitation of groundwater, the groundwater level has been declined in recent. Geophysical methods are very useful for identification of groundwater potential zones and groundwater contamination. In present study we were choosing the Vertical Electrical Sounding (VES) methods to identification of groundwater potential zones. In this method instrumentation is simple; field operations are easy and straight forward while the analysis of data is less wearisome and economical (Zhody et al 1974, Ekine and Osobonye 1996, and Ako and Olorunfemi 1989). The objective of this study were designed to determine different subsurface geoelectric layers, the aquifer units, deterimination of Dar-Zarrouk parameter (Longitudinal Conductance (S) and Transverse Resistance (T))at different depths as well as preparing isoresistivity contours to identify potential zones.

STUDY AREA

The study area (Fig.1) Indian Institute of Technology (IIT) Hyderabad was situated towards North of Kandi village located at 60 km from Hyderabad on NH-9 in Medak district, state of Telangana. The campus situated at 17° 34′40.008" to 17° 36′ 21.99" North Latitudes and 78° 6′ 56.9" to 78° 7′ 59.98" East longitudes.

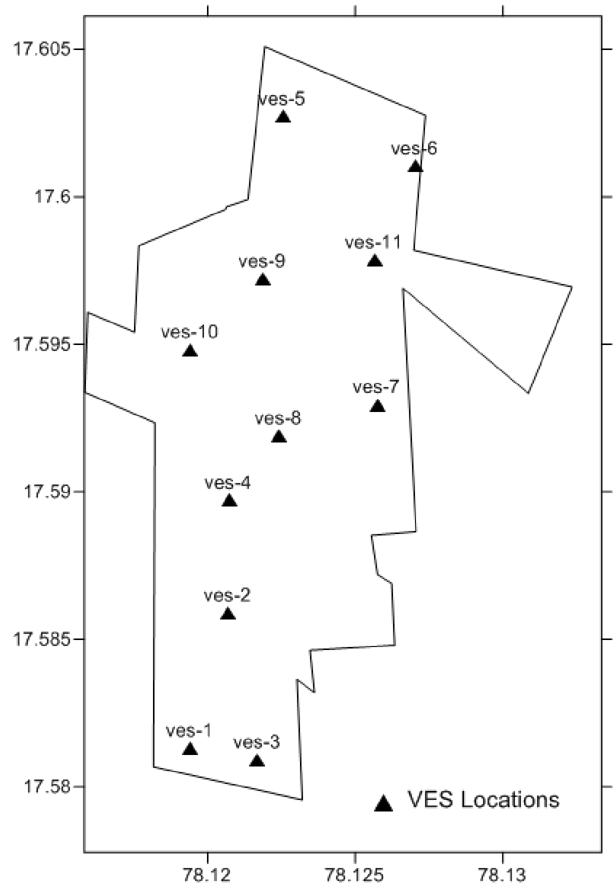


Fig.1 Study Area

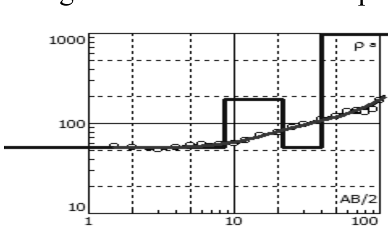
Geology of the Study Area

The important rock types in Medak District are Peninsular Gneissic Complex, DharwarSupergroup associated with younger intrusive of Archaean age separated by unconformable with overlying Basaltic flows of late Cretaceous to early Ecocene age with sub-Recent to Recent alluviam along with stream courses. The chief rock present in the study area was medium to course Granite. There are no major structural features such as faults, folds and joints etc. associated in rocks in this area.

MATERIALS AND METHODS

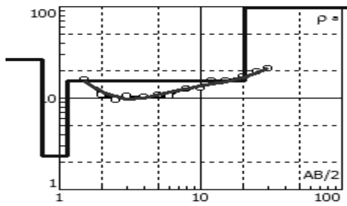
Data Acquisition and Interpretation

Geophysical investigations consisting of 11 (interpreted 9) Vertical Electrical Sounding (VES) using schlumberger four-electrode array were taken within study area. The electrode spread of AB/2 was maximum of 120m. The measurements made with SSR-MP Resistivity meter developed by IGIS, Hyderabad. VES data have been qualitatively and quantitatively analyzed and interpreted using software IPI2win version 3.1.0, a Russian software package of Moscow University. By using Surfer 11, resistivity contour maps and T & S maps have been generated for different depth ranges. Data were interpreted in terms of four to six layers (Fig.2).



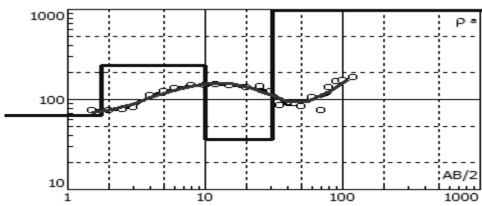
N	ρ	h	d	Alt
1	54	8.64	8.64	-8.64
2	186	13	21.6	-21.64
3	53.9	18.1	39.7	-39.74
4	25684			

VES-1



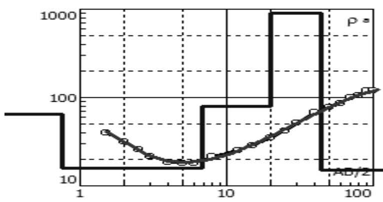
VES-2

N	ρ	h	d	Alt
1	26.4	0.75	0.75	-0.75
2	2.3	0.4	1.15	-1.15
3	15.3	19.4	20.5	-20.55
4	795			



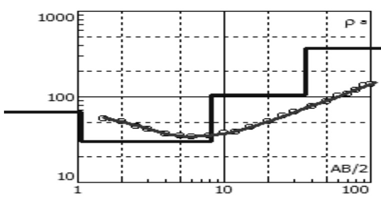
VES-3

N	ρ	h	d	Alt
1	67.1	1.77	1.77	-1.773
2	237	8.3	10.1	-10.07
3	35.8	21.1	31.2	-31.17
4	6691			



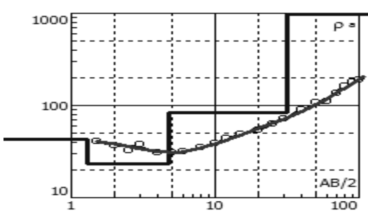
VES-4

N	ρ	h	d	Alt
1	64.5	0.75	0.75	-0.75
2	15.7	6.07	6.82	-6.824
3	79.7	12.9	19.8	-19.77
4	912	24.6	44.4	-44.38
5	15.1			



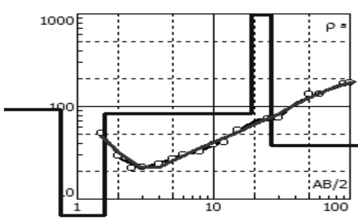
VES-5

N	ρ	h	d	Alt
1	65.64	1.046	1.046	-1.0457
2	29.69	7.146	8.192	-8.192
3	106.5	28.16	36.35	-36.351
4	369.2			



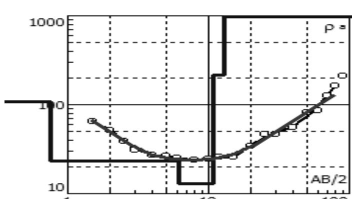
VES-6

N	ρ	h	d	Alt
1	43.5	1.3	1.3	-1.305
2	23.1	3.51	4.81	-4.813
3	84.5	27	31.8	-31.84
4	1728	15.5	47.4	-47.37
5	6858			



VES-7

N	ρ	h	d	Alt
1	92.4	0.75	0.75	-0.75
2	5.97	0.838	1.59	-1.588
3	84.2	17.1	18.7	-18.73
4	3774	7.63	26.4	-26.35
5	37.4			



VES-8

N	ρ	h	d	Alt
1	109	0.75	0.75	-0.75
2	23.5	5.43	6.18	-6.178
3	12.9	4.64	10.8	-10.82
4	214	2.12	12.9	-12.95
5	4479	48.3	61.2	-61.2
6	5902			

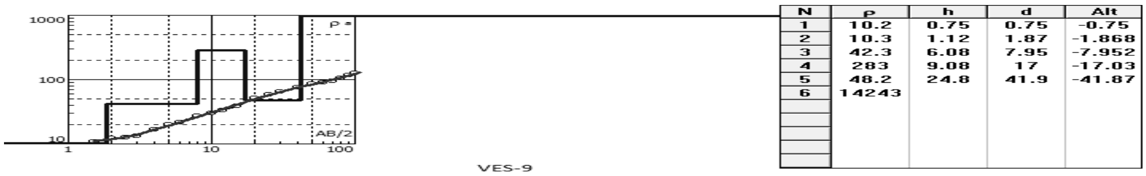


Fig.2 Interpreted VES layers

RESULTS AND DISCUSSIONS

The field data were interpreted and processed qualitatively and quantitatively by partial curve matching techniques and computer to obtain the resistivity values of different subsurface layers and their corresponding thickness (Table 1)

Table 1 VES Data Interpretations with Positions

S.NO	Location	Latitude	Longitude		Geo-Electrical layers					
					1	2	3	4	5	6
1	VES-1	17.581305	78.119416	ρ	54	186	53.9	25684		
				h	8.64	13	18.1			
				d	8.64	21.6	39.7			
2	VES-2	17.585888	78.1206944	ρ	26.4	2.3	15.3	795		
				h	0.75	0.4	19.4			
				d	0.75	1.15	20.5			
3	VES-3	17.580916	78.121694	ρ	67.1	237	35.8	6691		
				h	1.77	8.3	21.1			
				d	1.77	10.1	31.2			
4	VES-4	17.5897	78.12072	ρ	64.5	15.7	79.7	912	15.1	
				h	0.75	6.07	12.9	24.6		
				d	0.75	6.82	19.8	44.4		
5	VES-5	17.602716	78.12254	ρ	65.64	29.67	106.5	369		
				h	1.04	7.146	28.16			
				d	1.04	8.19	36.35			
6	VES-6	17.60103	78.127029	ρ	43.5	23.1	84.5	1728	6858	
				h	1.3	3.51	27	15.5		
				d	1.3	4.81	31.8	47.4		
7	ves-7	17.592947	78.1257396	ρ	92.4	5.97	84.2	3774	37.4	
				h	0.75	0.838	17.1	7.63		
				d	0.75	1.59	18.7	26.4		
8	ves-8	17.591892	78.122416	ρ	109	23.5	12.9	214	4479	5902
				h	0.75	5.43	4.63	2.12	48.3	
				d	0.75	6.18	10.8	12.9	61.2	
9	ves-9	17.597206	78.1218635	ρ	10.2	10.3	42.3	283	48.2	14243
				h	0.75	1.12	6.08	9.08	24.8	
				d	0.75	1.87	7.95	17	41.9	

Cross Sections

Fig.3 shows resistivity cross section constructed for VES points 1,2,4,8,9 and 5 along North to South of study area. From the figure, at shallow depths hard rock was observed in VES no 4 and 9. VES 4 indicates that after 40m depth a saturation zone is observed. This means that at study area from south to north potential zones were vary, south end we have observed 15 to 40m depths potential zone (Fig.4) while at north end it is observed at 10 to 35m depths (Fig.6). In the middle of study area at shallow depths hard was observed (Fig.5).

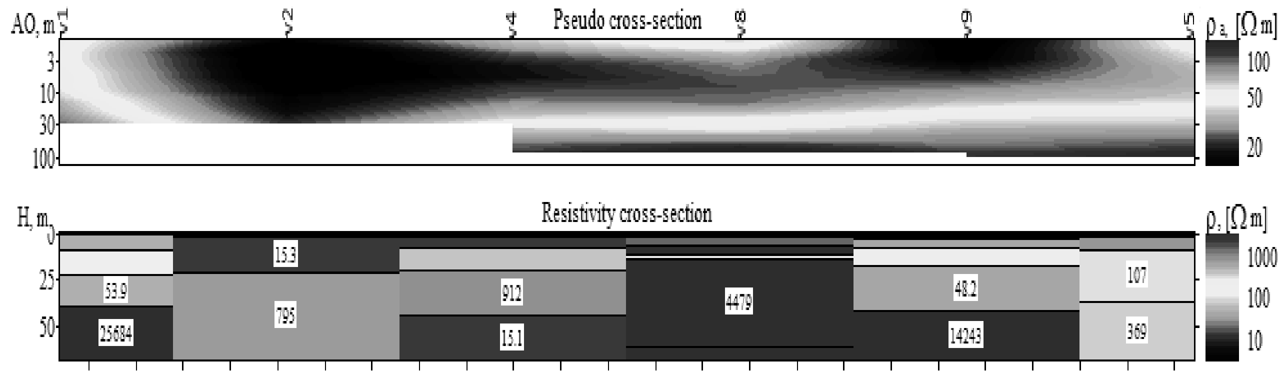


Fig.3 Resistivity and Pseudo Cross section along South to North

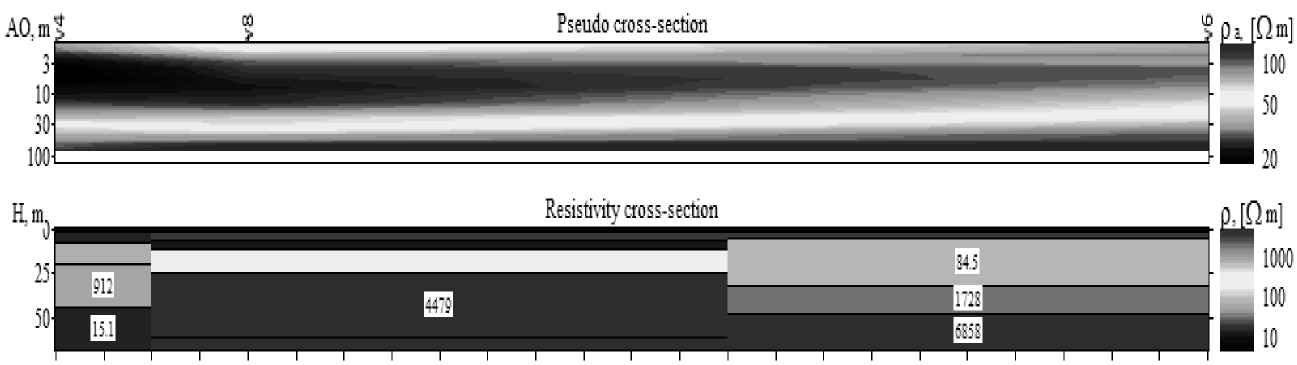


Fig.4 Resistivity and Pseudo Cross section middle of study area with 4, 8 and 6 VES

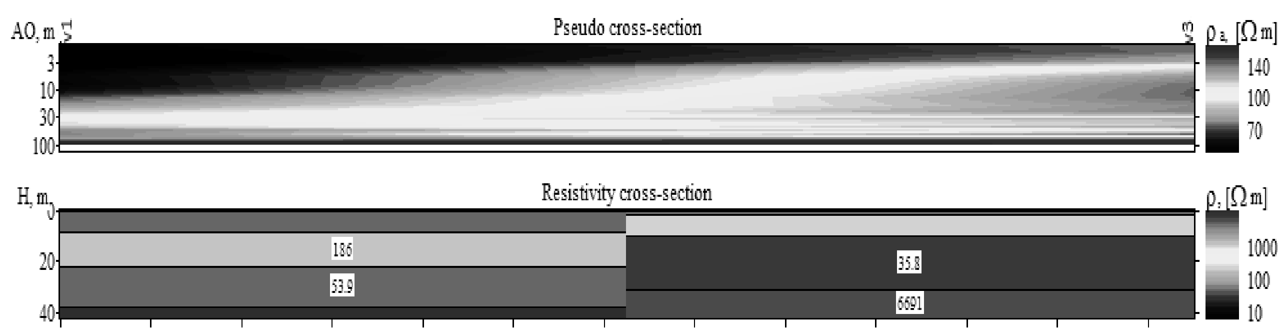


Fig.5 Resistivity and Pseudo Cross section of VES 1 &3

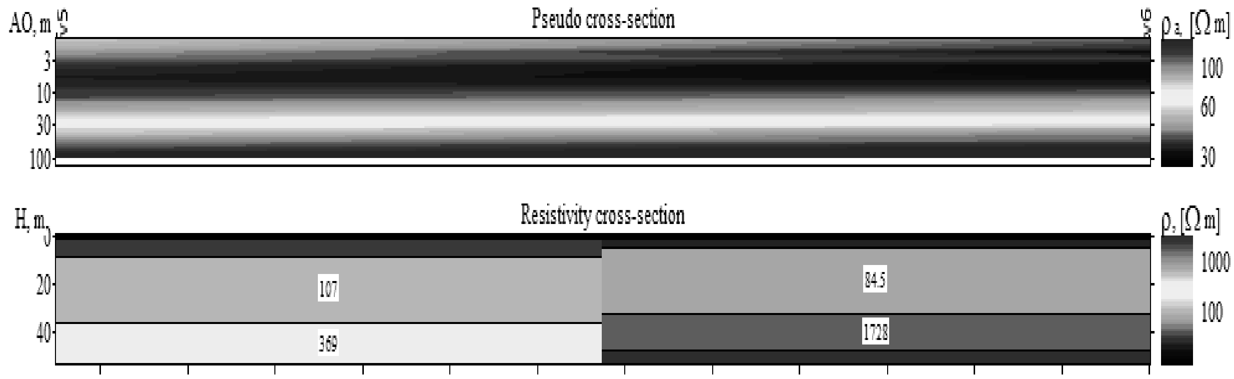
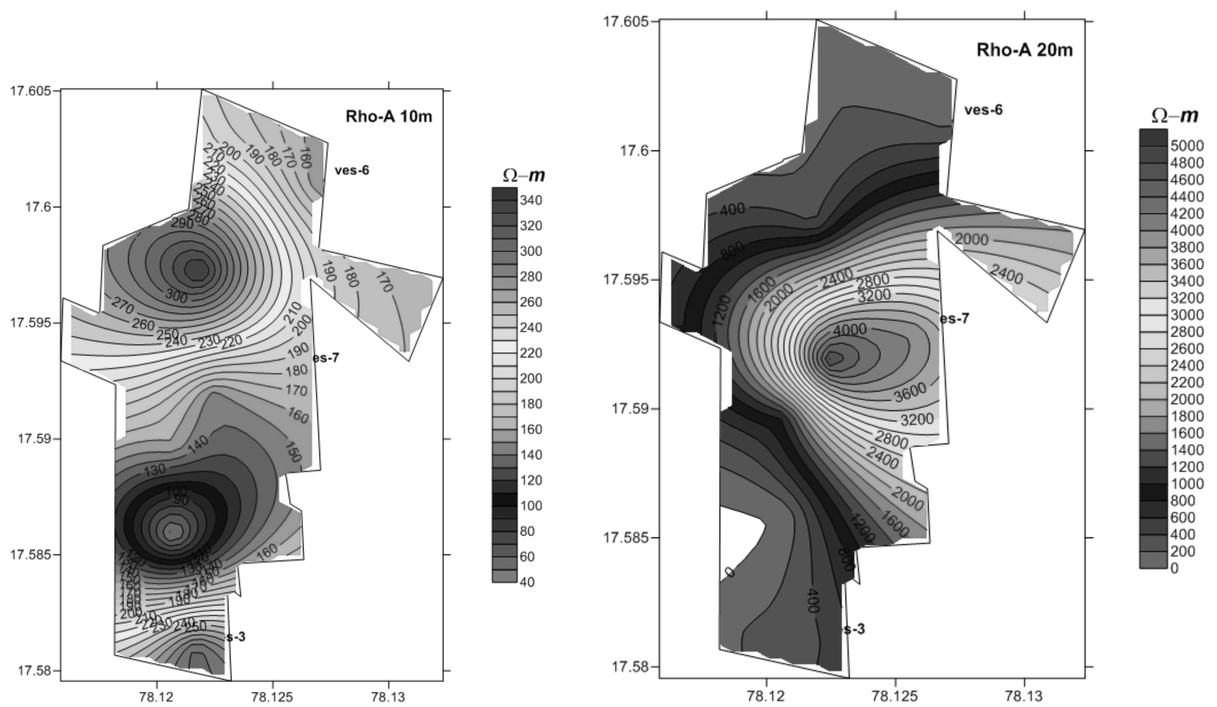


Fig.6 Resistivity and Pseudo Cross section of VES 5 & 6

Iso-Resistivity Maps

Iso-Resistivity maps are the resistivity contour maps and Iso is Greek word meaning ‘equal’ and contours are imaginary lines on map connecting equal value. The values may be any parameter, like elevation, layer resistivity and layer thickness and so on. Accordingly the layer resistivity contour maps of the study area have been generated incorporating all the 9 VES data for different depths at 10, 20, 30 and 40m (Fig.7). The contour maps were generated by using Surfer 11 software packages. The Iso resistivity maps can be used for qualitative interpretation of the groundwater potential zones. Fig.7 shows that east of study area have high resistivity values compare with west, also at middle it is very high observed clearly at deeper depths. This also observed in above cross sections.



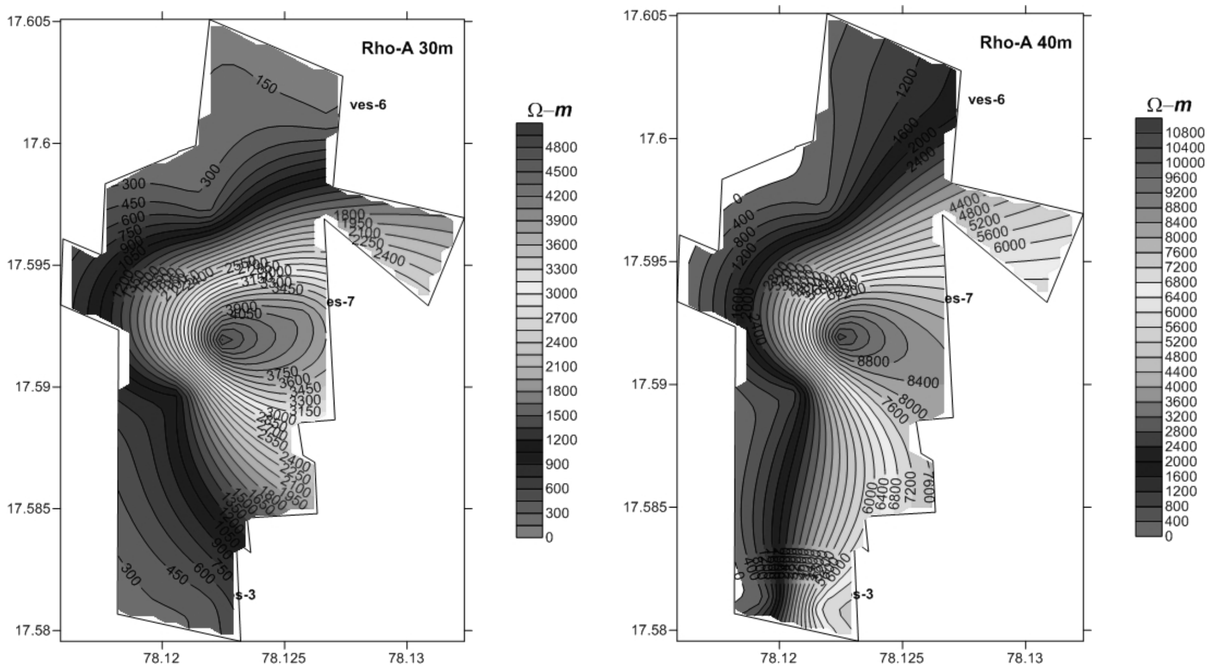
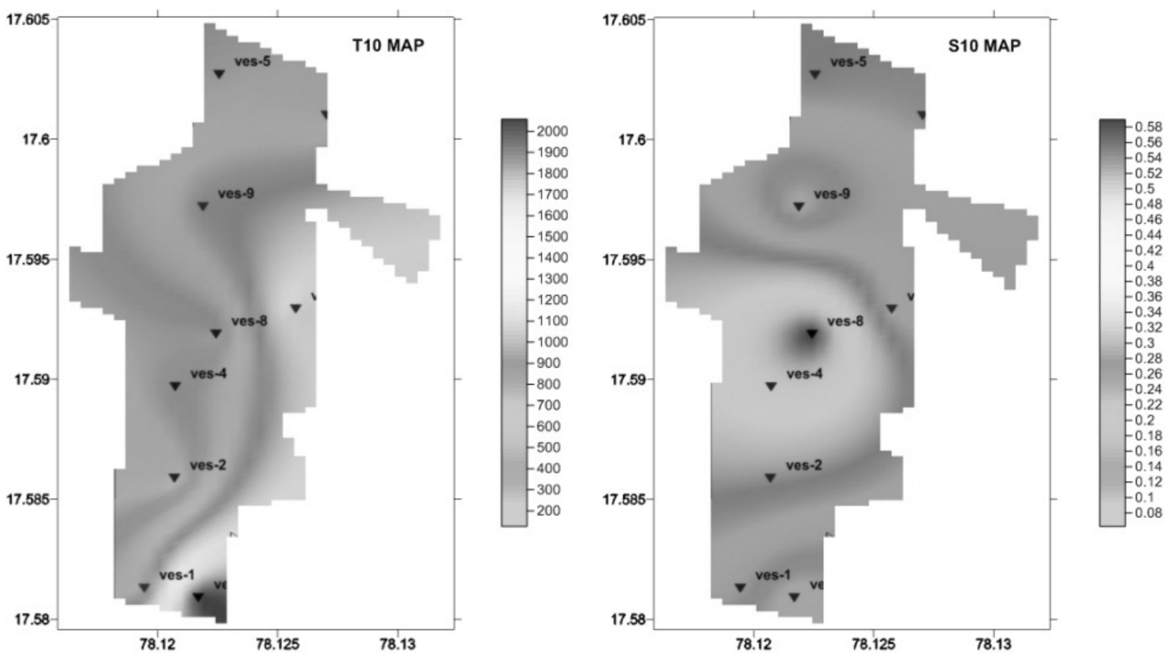


Fig.7 Iso-Resistivity contours at 10, 20, 30 and 40m Depths

T and S Maps

Dar-Zarrouk parameters consist of transverse resistance (T) and longitudinal conductance (S). The values of the longitudinal conductance were used in evaluating the protective capacity of the aquifer. Mogaji et al (2007), states that the earth medium act as a natural filter to percolating fluid and that its ability to retard fluid is a measure of its protective capacity. Fig.8 shows that longitudinal conductance maps at 10, 20 and 30m depths indicates a good conducting zone along the western part which may indicate possible concentrations of conductive materials in the study area.



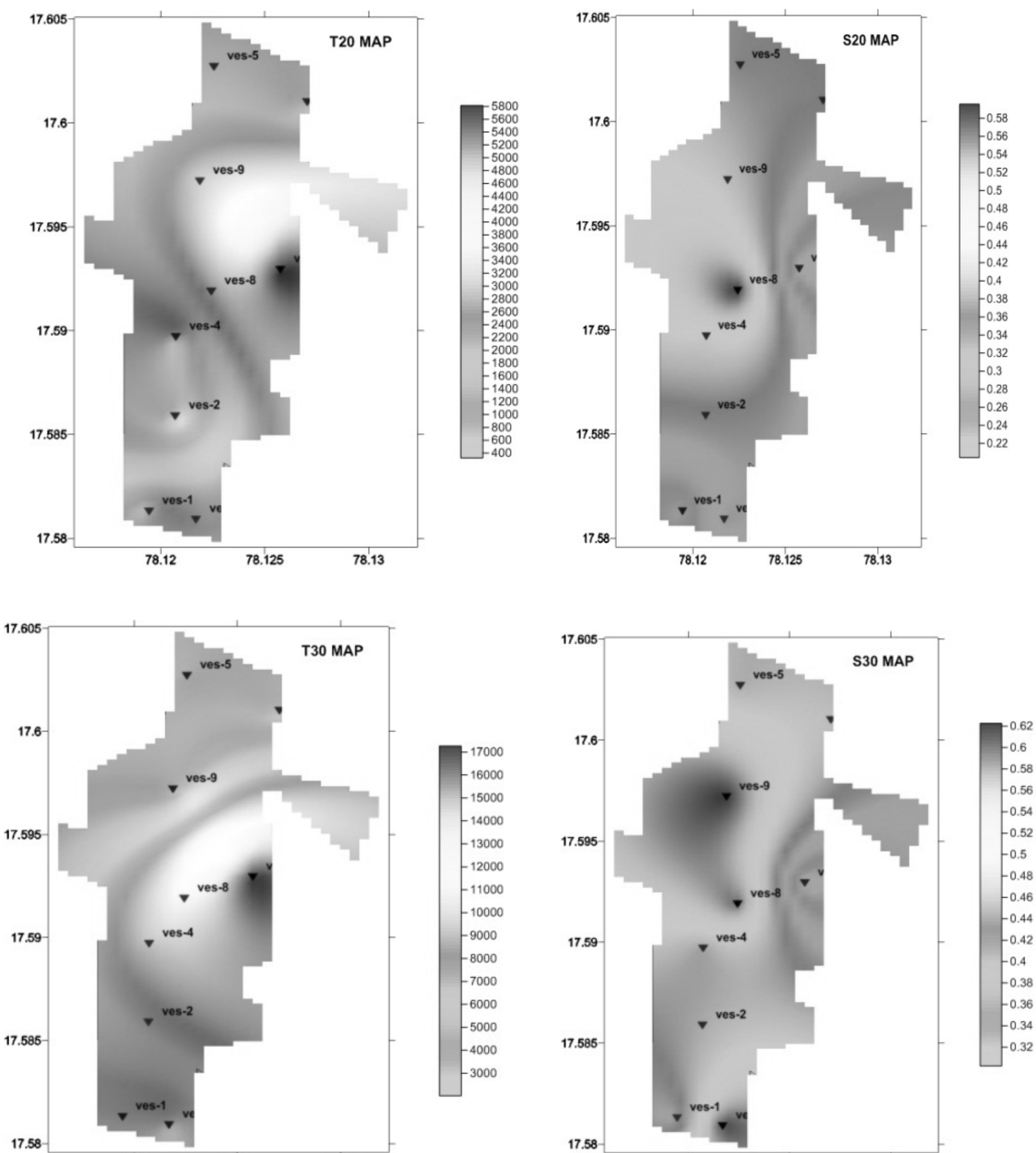


Fig.8 T & S maps of 10, 20 and 30 m depths

CONCLUSION

Vertical Electrical Sounding using Schlumberger electrode configuration was conducted in the study area to determine the potential zones. The study has shown that a good potential zone at ends of the study area and in middle of the area hard rock was found at shallow depths. By Dar Zarrouk parameters we expect that the groundwater movement was at center of study area following south to north ends.

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THEME - V

WATER QUALITY, WATER TREATMENT, POLLUTION AND SOCIETY

Need for Introducing Human Values & Professional Ethics in Engineering Education

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ABSTRACT

Today's technical education, in its widely prevalent form, is not able to adequately empower students to think independently. Consequently, being driven by peer pressure, it is leading to a blind race for jobs that are intellectually and mentally unfulfilling, and wealth that breeds chaos in family and in society. However, education is not just about learning skills (how to) but also about developing the ability to decide on what (what to do?) and why (why to do?). It should lead to the development of critical ability in students towards distinguishing between essence and form, or between what is of value and what is superficial, in life. It should develop their understanding which is a prerequisite for a movement from rule based society to a relationship based society. This paper discusses the need for human values in engineering education.

INTRODUCTION & BACKGROUND

The world today is ridden with problems galore. While the manners in which these problems are perceived, articulated and prioritized vary widely, there is a commonality of approach in how most civil societies in the world over are engaged in trying to solve them. Inherent in this approach is the assumption, that with enough knowledge and technology, one can manage planet earth. We not only disagree with this assumption, we also feel that it has perhaps played a major role in severely restricting the scope of education in general and technical education in particular.

To elaborate, let us take two major problems we see at the societal level: poverty and unemployment. No amount of knowledge and technology can solve these without addressing the prevalent human relation issues such as those of dominance and exploitation. We feel that a major, if not the sole, purpose of education is to enable individuals in understanding these causal relationships. More comprehensively stated, education implies holistic inputs towards preparing the future generation to understand the essential harmony in the world around them and to empower them to participate proactively in its dynamics.

Even at the level of higher technical education, mere imparting of skills does not fulfil this requirement. Technology only tells us how to do things which we want to do. However, without an understanding of what to do & and why and that of what is of value to the individual and to the society, the students cannot become proactive in their social environment. Instead, in the absence of a proper understanding, the student community tends to get oriented with the defaults in the society viz., emphasis on superficial and non- essential glamour, consumerist lifestyle, and a false sense of satisfaction (or dejection) in competition and one-upmanship.

DIAGNOSIS & STRATEGY

When one studies the situation we are in today, we arrive at the following:

1. **At the level of Individual:** We see today that humans on the one hand have unhappiness, dissatisfaction, lack of hope, and a sense of futility about them, and on the other are faced with domination and other problems. The health of the body is steadily declining in spite of improved levels of material and medical facilities. A majority of people and themselves engulfed in the problems of some type, and some people have even come to believe that no solutions are even possible.

2. **At the level of Family:** One sees complaints, fights inter-personal tensions, injustice, hatred and numerous attempts to solve these, ultimately leading to disintegration and a feeling of being deprived of material facilities.

3. **At the level of Society:** Problems are visible in the form of tendency to snatch from one another, opposition, exploitation, struggle, war, poverty and unemployment. There is talk of working in harmony with each other, but never end up being successful.

4. **At the level of Nature/environment:** Problems manifest in the form of imbalance, pollution, scarcity of physical and ecological disturbances. Poisonous material is on the increase in the air, water, soil and food while the fertility of the soil is decreasing.

As a result, one is unable to find happiness and perpetually suffer from a sense of lack of prosperity. In such case individuals are not able to contribute to the real progress of self as well as community as a whole. This sense of disempowerment in the individuals in some ways put them in the service of the dominant trend of perceiving the only the financial interests.

Strategy is to create an environment which generates confidence in individuals which allows them to make mistake but ensure that they learn from it. Initiation of process where all the members of the community are in the process of understanding of values. The essential component of this engagement would not be in terms of giving moralistic lectures of the narrow realm of professional ethics. But, to bring out the human values which we all possess inherently.

Workshop on Human Values

The workshop addresses the self in the human being. It draws attention to human needs; need for human relationships, inherent desire to seek knowledge, and the joy that we naturally derive from these. In our current situation, we might be seeking different things. Thus, it brings about a dialogue between what we are and what we want to be. It does not posit happiness in an after-world, but here and now, based on humanness" common to all human beings. The approach is rational, universal and humanistic.

The workshop is not a course in moral science. It does not tell you DOs and DONT's. It does not tell you what you should become, or what you should do. It only connects you with your SELF and encourages you to seek answers within SELF. The workshop does not talk about rewards and punishments in an after world. It does not say that physical facilities are unimportant and must be shunned. It rather talks of prosperity in every family.

Topics covered

1. **Self confidence:** Relative and absolute confidence, being self-determined, swatantrata.
2. **Peer pressure:** Examples of external pressure, relating to swatantrata (freedom), making one's own choices.
3. **Relationship with family and friends:** Major cause of unhappiness today.
4. **Anger:** Investigation of reasons, watching one’s own anger. Is anger a sign of power or helplessness, distinction between response and reaction.
5. **Right utilization of physical facilities:** Determining one needs, needs of the self and of the body, cycle of nature.
6. **Relationship with teachers:** Inside the class, and outside the class interacting with teachers.
7. **Time Management:** Issues of planning, as well as concentration (and aligning with self goals).
8. **Respect:** Do you respect yourself? Do you respect others? Feeling of respect is different from expression of that feeling.
9. **Expectations from yourself:** Excellence and competition, coping with stress, Identifying one' interests as well as strengths.

10. **Complimentarity of skills and values:** Distinction between information & knowledge
11. **Goals:** Short term goals and long term goals (discussing one's goals). How do we set our goal? How to handle responsibilities which have to be ful_lled while working for goals.

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Role of Society in Safeguarding and Strengthening of Basic Elements of Life

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ABSTRACT

A society's ethical foundation depends upon its environmental responsibility for sustainable Safeguarding and strengthening of basic elements in life. Currently, the pollution has been increasing rapidly as it is affecting water, air, and soil, thus upsetting everyone. Unless drastic changes are made and implemented in action, the future of any nation will be in danger. As agriculture is an important livelihood, natural farming combined with technology can be a solid source of strength as well as an advantage to the society. The ancient Indians valued rivers, trees and the ecology as a part of the divine. The worship of rivers, mountains, animals, trees, and the earth has been existed since times immemorial. The ancient Indian wisdom reminds that the divinity is omnipresent and takes infinite forms and the universe encompasses basic elements of life; Air, water, Space, fire, and earth. Hence, the five elements are essential for all lives on earth to exist as they are the foundation of a unified web of life.

The early literature and scriptures say that it is one's responsibility to care for the earth. It also means that pollution must be controlled by making the person aware of its importance. There is something called space pollution. If there is a constant enmity and hatred in the space there will be a disturbance and similarly a positive space or sacred space can be built by some methods. The author, here, shares his personal experience on this idea.

Keywords: Basic elements, Eco-system, Natural farming, Responsibility, positive space

World evolutions, revolutions and innovations through generations revealed that we have been advancing in the name of science, technology, medicine, economics and politics. It resulted in rapid mechanization and urbanization which gave rise to industrialization, urbanization and pollution at the cost of human lives and value system. Capitalism, Communism, Communalism, and Corporatization have become popular with the advent of LPG- liberalization, privatization and globalization. The Present day chemical farming has resulted in pollutions like environment, deforestation, water, air degradation and soil infertility. Apart from these there are challenges of economic, social and traditional values. The food we are consuming has toxins which are health hazardous.

Present situation

The adverse effects and un-holistic and chemical approach has given lots of negative results.

- The ill effects of Debts, serious illness, and suicides of farmers.
- Food Pollution.
- Contamination of soil, water, air etc.
- Excessive use of tractors, harvesters, sprayers can kill natural inhabitants that exist in the field
- High consumption of petrol, diesel (fossil fuel)

Literature survey

The above mentioned circumstances make people prefer organic food but some experts like Subhas Palekar esteems that 'Jeevamrutha' is good and assures that 'organic' is as dangerous as 'synthetic' chemicals. The organic farming emphasizes not to use pesticides, chemical fertilizers and the genetically altered seeds. He not only advocates giving importance to fertility of soil but also protecting the environment.

In natural farming the field of a farmer is considered as a unit. Everything is generated in the farm itself. Hence a farmer need not buy seeds from outside. Palekar says (2006), "Green revolution has resulted in the exploitation of farmers by forcing them to opt for hybrid varieties, use chemical fertilizers and spraying pesticides. The multinational companies are able to exploit farmers because they are still hesitant to opt for alternative methods of farming. It is time farmers opted for natural farming, because it was now proved that green revolution is detrimental to them. Rejecting chemical fertilizers, hybrid varieties of seeds and pesticides and using cow-dung and "ganjala" (urine of cattle) and spraying of neem oil, will not only help farmers to increase the fertility of soil, but also helps them get good yield. Farmers can fight MNCs only by rejecting their products, he noted. "It is important to exploit the agriculture land through natural course, not through artificial methods,"

Some of the causes of farmers' plight are poor irrigation, increased cost of cultivation, private money lenders, use of chemical fertilizers and crop failure. If the rates fluctuate in the international market it affects the poor farmers; for example green revolution has affected the farmers of Punjab. Regarding the affects of GR, a Punjabi farmer, Balwinder Singh (2014) says, "Punjab is now called the cancer capital of India. The Green Revolution has given farmers only three things: debt, serious illnesses and polluted and scanty water sources." But unfortunately, the foreign companies are encouraging the GR.

Due to the continuous usage of pesticides, the crops are losing resistance and companies come up with more powerful pesticides which further damage the nutrients of soil and farmers health. Large scale of production can be attributed due to the increased land under cultivation. Hence, it is the need of the hour to ensure safety of people without damaging the environment and the lives of people.

The Ayurveda says that everything in the universe is made of five elements i.e. earth, water, air, fire (sun), are self evident in gardening. The ancient Indians used to start the process with a Mantra. It is to clear the negative energy and energize the space. This includes the element of ether or sky. Stephen Knapp in his book (2009) says, "We worship and pray to the Supreme Lord for the welfare of all beings. May all miseries and shortcomings leave us forever so that we may always sing for the Lord during the holy fire ceremonies. May all medicinal herbs grow in potency so that all diseases may be cured. May the gods rain peace on us. May all the two-legged creatures be happy, and may all the four-legged creatures also be happy. May there be peace in the hearts of all beings in all realms."

The ancient Indian scriptures describe the entire earth as one part. The Vedas say "The Purusha (the Supreme Being) has thousands of heads, thousands of eyes and thousands of feet. He has enveloped this world from all sides and has (even) transcended it by ten angulas or inches."(Rig Veda, X-90 1,2,13,14). As per the traditional knowledge, the existence and even our bodies are made up of five basic elements i.e. Soil, Water, Fire, Air and Ether. Anjali Pathak(2009) "Ayurvedic sages wrote two thousand six hundred years ago that the food or medicinal plants grown in a polluted environment lose their rasa (taste or pharmaceutical properties) and gandha (flavour) and change their characteristic life and health promoting qualities. It is further added that when there is kala vikriti, meaning the seasons are not on time and the rainfall pattern is disturbed, then also the nutritional and medicinal qualities of various foods are destroyed." (P.45 Annam Brahma: Organic Food in India). She says that pesticides that kill insects also kill a tiny part of the living element in us. The poison that kills insects also destroys the life-giving nourishment the earth which is the giver of all, and finally the water which renders fluidity to life.

The Bagavad Gita says Vasudeva sarvam iti [Bg. 7.19].) *Vasudeva sarvam iti* - God is All (VII.19); everything is God. The Supreme self is everything *s*arva-bhūta-guhā-vāsam living within the core of the heart of everyone (SB 8.16.20).

The ancient Indians valued rivers, trees and the ecology as a part of the divine. The Isha Upanishad says*,"Om Isha vasyam idam sarvam, yat kincha jagatyam jagat"*. It means "All this- whatever exists in this changing universe, is pervaded by God". Cutting down trees mercilessly thus destroys the ecological balance.

The Atharvana Veda (A.V. 18.17) recalls that three things cover the universe the air, water and the plants and they are essential for all lives on earth to exist.

"*Plants and herbs destroy poisons (pollutants*)" (A.V. 8.7.10); "Purity of atmosphere checks poisoning (pollution)" (A.V. 8.2.25).

Some herbs purify the air. The fragrance of guru (Commiphora mukul) purifies the air and cure diseases (A.V. 19.38.1).

Plants and waters are treasures for generations. (Rig Veda Samhita vii-70-4)

Positive environment

A society's cultural and spiritual foundation of environmental responsibility can be a solid source of strength as well as a benefit to the society as the pollution has been increasing rapidly i.e. water, air, soil as it is affecting everyone. Unless drastic changes are made and implemented in action, the future of any nation will be in danger. There is something called space pollution. If there is a constant enmity and hate in the space there will be a disturbance and similarly a positive space or sacred space can be built.

Divinity is omnipresent and takes infinite forms. The Sanskrit mantras recited by people to worship their rivers, mountains, trees, animals and the earth. The five elements i.e. space, air, fire, water and earth are the foundation of an interconnected web of life. The scriptures say that it is one's Dharma or responsibility to care for the earth. It also means that pollution must be controlled by making the people aware of its importance.

A Mantra has a certain vibratory power that inspires. The following mantra has been taken from Taittiriya Upanishad. It says, *"May He protect both of us. May He nourish both of us. May we both acquire the capacity (to study and understand the scriptures). May our study be brilliant. May we not argue with each other. Om peace, peace, peace. "*

One of the Shanti mantras says "May *everyone be happy! May everyone be free from all diseases! May everyone see goodness and auspiciousness in everything! May none be unhappy or distressed! Aum peace, peace, peace!"*

In Buddhist culture too they have a Maitri meditation, where they release positive energy after the meditation. But before that it is important to generate the energy and remained balanced and poised. There after they send the energy to the old, diseased not only human beings, but also animals and birds, to get food, water and rest; for all those physically and mentally afflicted to get well; for travelers to reach their destination safely and comfortably; and for general goodwill and tolerance between people.

Agricultural practices in the ancient and modern India

Ancient Indians used to serve food even to strangers. Despite of poverty, unemployment, these traditions have been existed. But now, farmers are committing suicides due to agricultural losses.

The National Crime Records Bureau of India (2012) reported that 5 out of 29 states accounted for 10,486 farmers' suicides (76%) - Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Kerala.

The farmers used to produce different varieties of crops without tractors, harvesters, sprayers for cultivation. In the olden days, the rice itself had many varieties which were helpful in curing different type of diseases. Hence, the people who consumed were strong and healthy. Now the seeds which come from labs do not have reproductive ability. The hybrid products contain neither tastes nor smells good.

The Genetically Modified Crops come from any origin. Where is the proof that it will not affect people? The pesticides kill the natural inhabitants of earth like earth worms.

The traditional methods like sowing different crops like grains, pulses and flower plants help to curb weeds. The farmers used to plant bigger trees as the trees helped in increasing ground water and soil erosion. The trees help birds to live and the excreta emitted by the birds helps in natural weeding and also the omitting of seeds from one place to other places help in the pollination process and which also helps the bio-diversity to grow.

SUGGESTIONS

- Natural farming is better than organic for example; vermi culture releases toxins and destroys the indigenous worms.
- Usage of machines like the usage of tractor farming can cause the destruction of bio diversity.

- The raising of trees can help soil erosion and as natural weeding.
- The Green Revolution can dampen the self-reliance of farmers as their independent character is being destroyed as they need to depend on foreign pesticides.
- Instead of mono cropping or genetically modified crops, growing of multi cropping can yield good results.

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Phytoremediation of Chromium (VI) in Water Using Germinated Seeds

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ABSTRACT

Phytoremediation is defined as the treatment of environmental pollutants using plants that alleviate the environmental problem without the need to excavate the contaminant material and dispose it elsewhere. Plants are specifically selected to remove specific pollutants such as metals, pesticides, solvents, explosives and crude oils. Phytoremediation has many advantages over other traditional pollution removal methods such as cost, decreased environmental disruption and it is more aesthetically pleasing. The present study was focused on removal of chromium from the industrial effluent water and artificially polluted water using the seeds of *Eleusine coracana* (Ragi), *Pennisetum glaucum* (Bajra), *setaria italica* (Korra), *sorghum bicolor* (Jowar). Seeds were germinated using a paper and cloth germination procedure. After germination, the seed plants were placed in Chromium contaminated water. Chromium levels were measured using spectrophotometer at regular time intervals. The experiments, removal of chromium metal ions by the above-mentioned seeds, were conducted at three different conditions i.e. aerobic, anaerobic, laboratory condition, and all the conditions favor the phytoremediation process. Among these, aerobic condition has shown good result with all the seeds. During phytoremediation process, drastic colour change was observed and the percentage removal of chromium ions was high, which indicates that the phytoremediation has followed the strategy of phytoextraction. During and after phytoremediation the effect of concentration, effect of dosage and effect of contact time were also studied. We observed that as the concentration increases, the percentage removal decreases, as the dosage increases the percentage removal also increases and as the contact time increases the percentage removal increases up to optimum level. All the seeds were found to be efficient in the removal of chromium from industrial effluent and each seed was observed to have a specific function in all the three conditions.

INTRODUCTION

Phytoremediation is the use of green plants to decontaminate soils and water. The primary objective of phytoremediation is to maximise the transfer of contaminant to the plant shoots so that the greatest total mass of contaminant is removed by each cropping. A plant is chosen which is tolerant to the particular contaminant in question. The plants absorb the contaminants through the root system and store it in the plant biomass. When the plant is harvested, it can be dried and processed so that the contaminant can be recovered. There are some plant species, which take up contaminants in larger than normal amounts; these are called hyperaccumlators. This practical activity investigates the use of hyperaccumulating plants to clean up Chromium contaminated water. There are several aquatic plants available for removal of heavy metals (Gandhi et al., 2013; Jain et al., 1989; Adel et al., 2008; Satya Narain et al., 2011), from the polluted water. Water hyacinth (Eichhornia crassipes) is just one of the great members of aquatic plant species successfully used for wastewater treatment. It is important to emphasize that *E. crassipes* has a huge potential for removal of the vast range of pollutants fro m wastewater (Chua 1998; Maine et al. 2001; Mangabeira et al. 2004). Aquatic plants (Peterson and Teal 1996), microorganisms (Perkins and Hunter 2000), and algae have the ability to remove organic and inorganic matter, nutrients, pathogens, heavy metals and other pollutants from wastewater (Redding et al. 1997;

House et al. 1999) in a completely natural way. But this macrophyte is also one of the most dangerous invasive aquatic weed in the world (Wilson et al. 2005). Metals cannot be easily degraded and the cleanup usually requires their removal. However, this energy intensive approach can be prohibitively expensive. Phytoremediation offers a cost-effective, nonintrusive and safe alternative to conventional cleanup techniques. Taking all these factors into consideration the present study deals with a eco friendly method for removal of chromium using germinated seeds.

MATERIALS AND METHODS

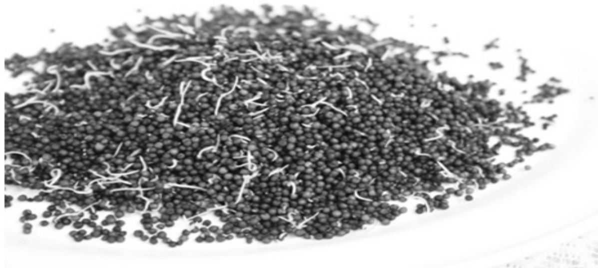
Preparation of Cr (VI) solution

A stock solution of Cr (VI) (0.35g/100ml) was prepared by dissolving appropriate quantity of AR grade $K_2Cr_2O_7$ in 100 ml of distilled water from Millipore purification unit. The stock solution was further diluted with distilled water to desired concentration for obtaining the test solutions. Final residual metal (Cr (VI)) concentration after coagulation was directly measured by using Lambda Scientific UV- Visible spectrophotometer (Manjusha et al, 2011).

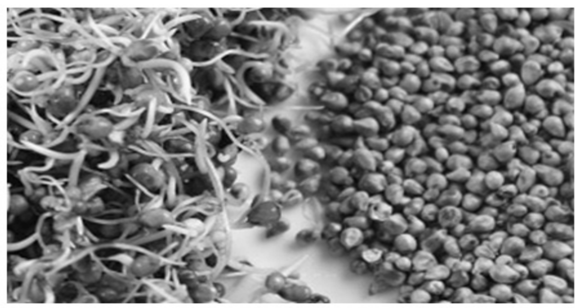
Seeds selected for removal of Cr (VI)

The seeds used for removal of chromium are shown in Figure-1, i.e.

(i) Eleusine coracana (ragi,)
(ii) pennisetum glaucum (bajra,)
(iii) setaria italic (korra,)
(iv) sorghum (jowar)

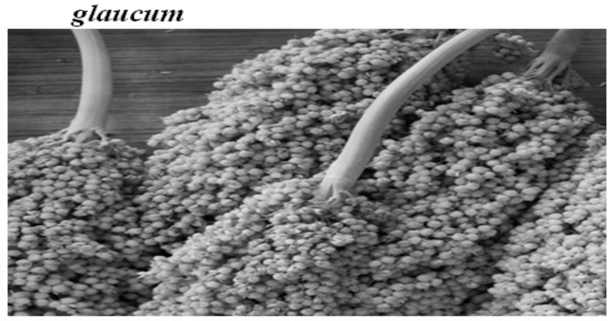


Germinated seeds of *Eleusine coracana*



Germinated seeds of *Pennisetum glaucum*

Germinated seeds of *Setaria italica*



Germinated seeds of *Sorghum bicolor*

Seed Germination

- Collect 200gms of each seeds that are used for the experiment.
- Drop the seeds into a vessel of distilled water and keep them aside.
- Let them soak for about 24 hours.

- Filter the seeds, place them in a towel, knot it tightly, and keep them in a dark place.
- After 24 hours we see the seeds germinated

Experimental Method

The removal of chromium(VI) were carried out by using the germinating seeds in three different conditions to know which environment is suitable for the removal and which conditions favors the removal process . The experimental setup were categorized as follows,

1. **Laboratory condition**
   - A normal grade reagent bottles are used for laboratory condition.
   - The bottles are filled with standard solution and desired concentration with selected seeds.
   - They are kept at normal room temperature.
   - The bottles are cov ered with particular caps.
2. **Aaerobic condition**
   - Conical flasks of 250ml are used for aerobic conditions.
   - The flasks are filled with standard solution and desired concentration with selected seeds.
   - Air is pumped into flask at a rate of 3lit/min at pressure of 0.02mpa.
   - They are kept in normal room temperature.
3. **Anaerobic condition**
   - Biological oxygen demand (BOD) bottles are used for anaerobic conditions.
   - The bottles are filled with standard solution and desired concentration with selected seeds.
   - They are kept at 30-33 ± 2^0c temperature.
   - There is no air supply as this is anaerobic condition.
   - The bottles are covered with suitable caps, which will not allow the air to enter into it.

RESULTS AND DISCUSSION

To check the efficiency of *Eleusine coracana* (ragi), *pennisetum glaucum* (bajra), *setaria italic* (korra), *sorghum bilocor* (jowar) seeds to remove Cr (VI) metal ions from aqueous solution, Batch experiments were performed by taking a series of reagent bottles with constant chromium metal ion concentration (10mg/1lit) and 5 gm of germinated seeds of above mentioned separately, and samples are drawn after regular time intervals to check the % removal of chromium from solution at Laboratory condition as described in materials and methods. The percentage removal of chromium with four different germinated seeds at different time intervals (i.e. 24 hours, 48 hours, 72 hours) at laboratory condition shown in a graphical representation in Figure-1. From the figure-1, it can be concluded that all the four seeds as the capacity to remove chromium (VI), at laboratory condition. The percentage removal is increased with increase in contact time with all the germinated seeds used in this experiment. At 24 hours the high percentage removal observed with *sorghum bilocor* (jowar) seeds at lowest percentage removal with *pennisetum glaucum* (bajra) seeds. There is no significant change in percentage removal was observed at 48 hours and 72 hours time intervals in samples treated with *sorghum bilocor,* and *pennisetum glaucum* seeds. However, significant change was observed in samples treated with *Eleusine coracana* (ragi) and *setaria italic* germinated seeds.

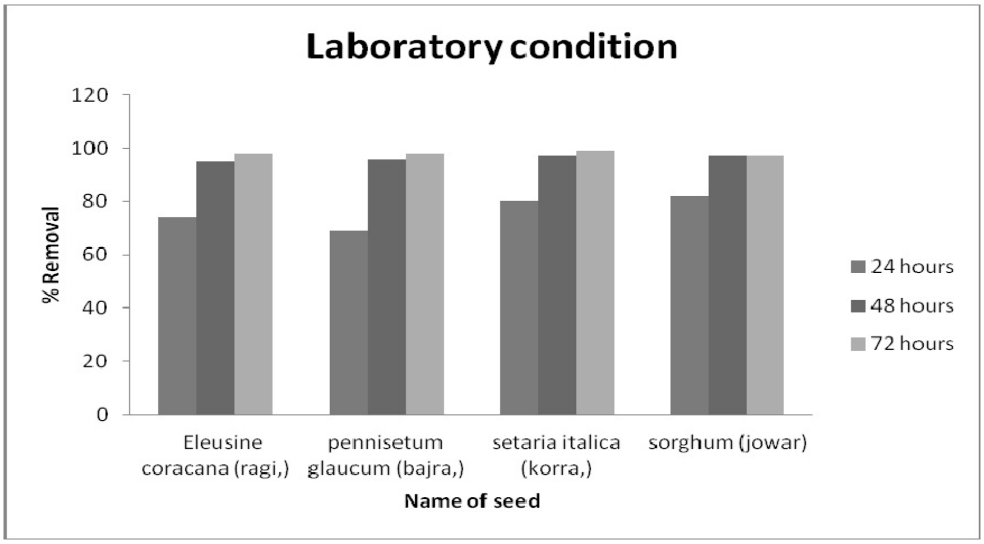


Fig. 1: Removal of Chromium in Laboratory condition by using different germinated seeds at different time intervals.

The same batch experiments were conduted in aerobic condition where the external supply of air (3lit/min at pressure of 0.02mpa), to check the efficiency of germinated seeds to remove Chromium (VI), from aqueous solution. The percentage removal of Cr (VI) at regular time interval (i.e. 24, 48 and 72 hours) are shown Figure-2. From the figure-2, it was observed that the aerobic condition also favors the removal process. The percentage removal is increased with increase in contact time with all the germinated seeds used in this experiment in aerobic condition. However, the percentage removal of Cr (VI) from the aqueous solution is lower in aerobic condition compared to laboratory condition except *setaria italic* and *pennisetum glaucum* seeds. At 48 hours, time interval the high percentage removal was observed in sample treated with *setaria italic* germinated seeds. At 48 hours, the percentage removal is lower than laboratory condition percentage removal with all four germinated seeds but it became equal percentage removal in both aerobic and laboratory conditions after 72 hours contact time.

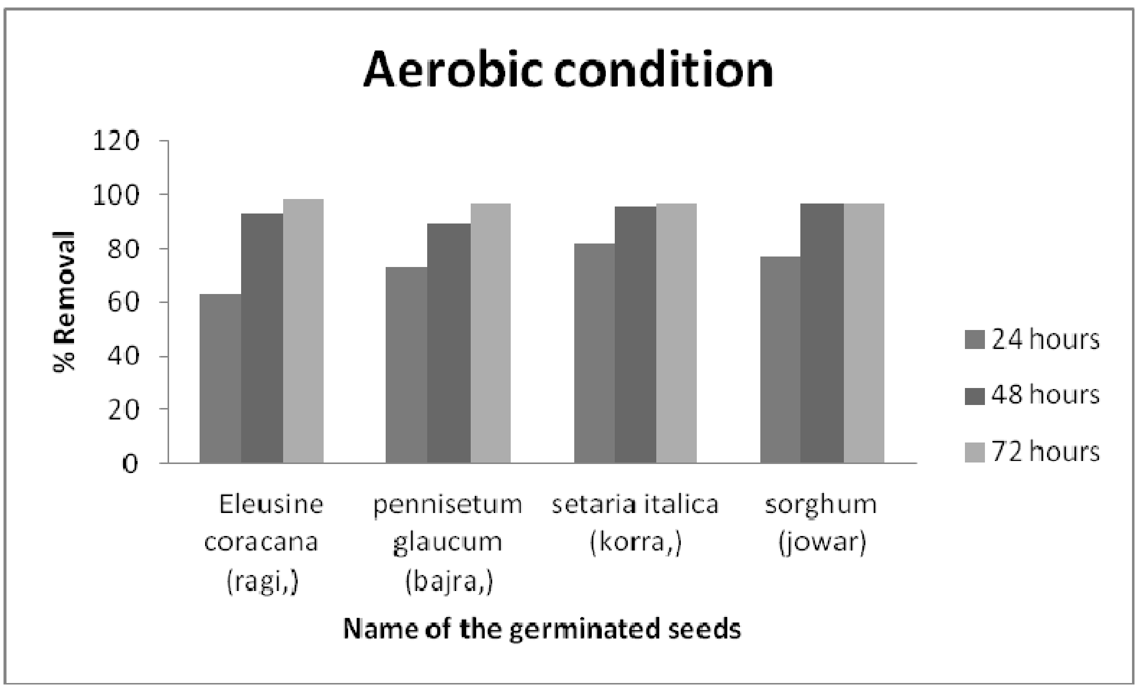


Fig. 2: Removal of Chromium in Aerobic condition by using different germinated seeds at different time intervals.

The same batch experiments were conduted in anaerobic condition where there is no supply of air and light, to check the efficiency of germinated seeds to remove Chromium (VI), from aqueous solution. The percentage removal of Cr (VI) at regular time interval (i.e. 24, 48 and 72 hours) are shown Figure-3. From the figure-3, it was observed even the anaerobic condition also favors the removal process. The percentage removal is increased with increase in contact time with all the germinated seeds used in this experiment in anaerobic condition. The percentage removal at three different time intervals with all treatment are higher than aerobic conditions and almost equal to laboratory condition. From the above experiments it can be concluded that anaerobic and laboratory conditions are favorable and easy way to remove chromium from aqueous solution with all the germinated seeds used in the present study, except *setaria italic* germinated seeds. Whereas high percentage removal observed in aerobic condition with this seeds.

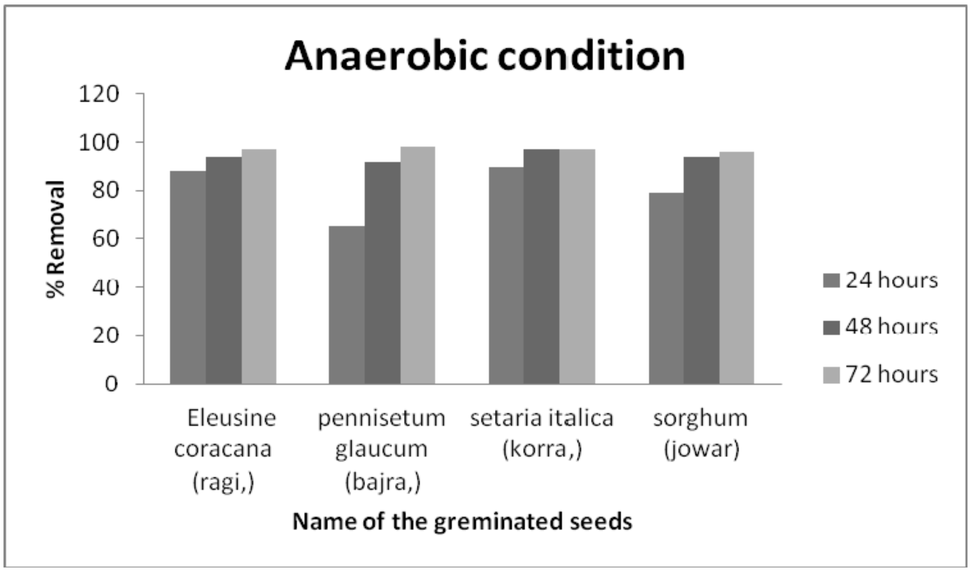


Fig. 3: Removal of Chromium in Anaerobic condition by using different germinated seeds at different time intervals

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Decolorization of Nigrosine WS (AB2) Dye by Solar Photo-Fenton Process

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ABSTRACT

Number of physical and chemical treatment methods has been reported for the treatment of dye effluents. Among them one of the widely used and effective chemical treatment methods are AOPs for the removal of recalcitrant organic constituents from textile industrial and municipal wastewater. On the basis of solubility of dye in water, highly soluble Nigrosine WS (Acid Black 2) dye was studied which is widely used in dying of leather, wood and textile. The homogenous Photo-Fenton process was investigated for the decolorization of Nigrosine WS (Acid Black 2) dye under solar irradiation in aqueous solution. A detailed investigation of decolorization of dye was carried out using H_2O_2 and $FeSO_4.7H_2O$ as catalyst. The combination of these reagents generates $HO^{\bullet}$ radical, a strong oxidizing agent which is responsible for decolorization of dye. Results show that decolorization of dye depends on concentration of dye, H_2O_2, $FeSO_4.7H_2O$ and pH of the aqueous solution. The optimum condition for the decolorization of dye was determined. This method gave complete dye removal in just 2 hour of time period.

Keywords: Acid Black 2, Advance Oxidation Process, decolorization, Photo-Fenton, recalcitrant organic constituents.

1. INTRODUCTION

The industrial water demand is on a rise and will account for 8.5% and 10.1% of the total freshwater abstraction in 2025 and 2050 respectively. India is also projected to move into the category of water stressed nation by 2020 [1]. So the recycling or treatment of waste water is not only important but also necessary to meet the fresh water demand of future generation. Over 7,00,000 tons of approximately 10,000 types of dyes and pigments are produced annually worldwide. From this amount, about 20% are discharged as industrial effluents during the textile dyeing and finishing processes without previous treatment [2]. The color and toxicity of dyes not only influences the quality of life but also influences the efficiency of conventional waste water treatment methods. Many dyes are difficult to remove due to their complex structure and synthetic origin and the limitations have attached to the conventional treatment methods to treat such waste water, especially for decolorization. So to overcome the inconvenience of conventional treatment methods various chemical oxidation techniques have emerged in the last few decades, particularly for the treatment of industrial wastewater. Among these techniques, the advanced oxidation processes (AOPs), are considered to be a potential treatment method for the removal of color which are characterized by production of the hydroxyl radical ($HO^{\bullet}$) as a primary oxidant. Among the various AOPs, the use of Fenton reagent (H_2O_2/Fe^{2+}) with UV or solar irradiation is one of the most effective methods for color removal from wastewater. Kaiqun W. et al., (1998) have studied the photo degradation of Malachite Green (MG) under visible light irradiation in the presence of Fe^{+3} / H_2O_2 or Fe^{+2} / H_2O_2 and compared with the dark reaction. It was found that visible light irradiation can accelerate significantly the rate of MG degradation, comparing to that in the dark. Mariana N. et al., (2003) have reported the study of degradation of two azo dyes, Reactive Yellow 84 (RY84) and Reactive Red 120 (RR120) by Photo-Fenton and Fenton-like oxidation. The results reveal that Photo-Fenton process is more effective for degradation of azo dyes. Ashok et al., (2013) have investigated the degradation of Acid Violet 54 (AV54) by Photo-Fenton under irradiation of visible light in aqueous solution. The experimental data demonstrated that Photo-Fenton process is effective technique for the degradation of AV54 dye in aqueous solution because AV54 get 100% mineralized in 55 minutes. Sunil Kumar et al., (2013) have investigated the photocatalytic bleaching of Nigrosine WS (Acid Black 2) dye by ZnO in aqueous solution. The experimental data demonstrate that photocatalytic process is effective technique for the degradation of Nigrosin WS dye by ZnO from aqueous solution which gave 67% mineralization of the dye in 240 minutes.

Till now no research has been done to evaluate the efficiency of Photo-Fenton process for decolorization of Nigrosine WS (Acid Black 2) dye. From the above literature review it can assume that the Photo-Fenton process could be the efficient method for decolorization of Nigrosine WS (Acid Black 2) dye with the advantage of less chemical requirement and short treatment period.

2. OBJECTIVES

- To decolorize the Nigrosine WS (Acid Black 2) dye by using Homogeneous Solar Photo-Fenton Process.
- To evaluate the optimum condition for decolorization of Nigrosine WS (Acid Black 2) dye by Homogeneous Solar Photo-Fenton Process.

3. MATERIALS AND METHODS

3.1 Chemicals

1. Nigrosine WS (Acid Black 2): The solid Nigrosine WS was used throughout the investigation without any further purification. The Nigorsine WS (C.I. No. 50420) was purchased from High Purity Laboratory Chemicals (HPLC), Mumbai.
2. $FeSO_4.7H_2O$: 98% pure crystalline $FeSO_4.7H_2O$ (M.W. = 278.02) was bought from Qualigens fine chemicals, Mumbai.
3. H_2O_2 (30% w/v): Used directly without any dilution and bought from Merc Specialities Private Limited.
4. N H_2SO_4: 2.77 ml of conc. H_2SO_4 (96%) was diluted in 1000 ml of deionised water.
5. N NaOH: 4.0 gm of NaOH dissolved in 1000 ml of deionised water.

All laboratory reagents were used of analytical grade without any further purification. The deionised water is used for dilution throughout the investigation.

3.2 Apparatus

1. pH meter: to check the pH of aqueous dye solution.
2. Spectrophotometer: to measure the absorbance of dye solution for determining color intensity.
3. Magnetic stirrer: to provide continues stirring throughout the investigation.
4. Centrifuge machine: to settle down the iron and dye particles.
5. Weighing machine: to weigh the Nigrosine WS dye for different dye concentration.
6. Lux meter: to measure the solar irradiation throughout the investigation.

3.3 Preparation of solutions

3.3.1 Preparation of dye solution

There were six different concentrations of Nigrosine WS dye was prepared such as 5, 10, 25, 50, 75 and 100 ppm using de-ionized water for dilution. For each concentration of Nigrosine WS dye, 200 ml of freshly prepared dye solution was used throughout the investigation for decolorization.

3.3.2 Preparation of $FeSO_4.7H_2O$

There were six different concentration of $FeSO_4.7H_2O$ (M.W. = 278.02) was prepared such as 0.1, 0.01, 0.001, 0.2, 0.02, 0.002 M as catalyst.

3.3.3 Preparation of H_2O_2 (30% w/v)

The different dose of H_2O_2 (30% w/v) was applied directly without any dilution such as 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 ml for each 200 ml of Nigrosine WS dye concentration.

3.4 Determination of maximum absorbance wavelength

Two dye concentration that is 50 and 100 ppm of Nigosine WS was used to determine the maximum absorbance wavelength. The absorbance was measured at each 25 nm of interval, between 400 – 700 nm that is visible wavelength range. Then the graph of wavelength and absorbance was plotted.

3.5 Experimental setup

The experimentation was carried out in Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER) campus, Bharati Vidyapeeth University, Pune, India. The investigation was done using solar light in the month of December 2013, mostly between 11:00 am to 4:00 pm.

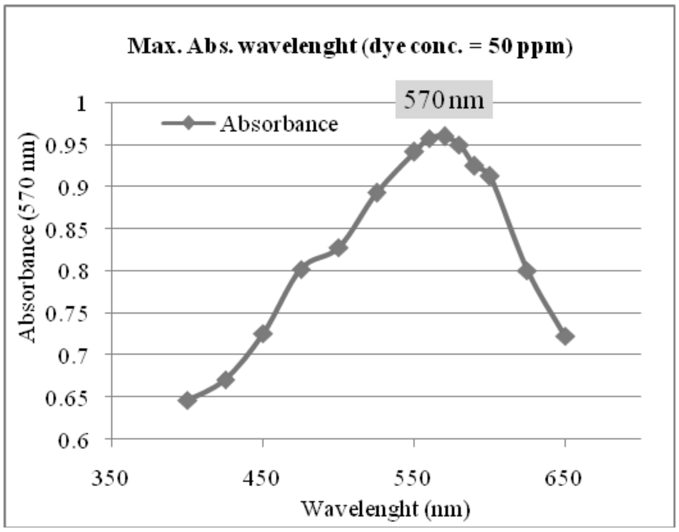
To investigate the decolorization of Nigrosine WS dye, 200 ml of dye solution of six different concentrations such as 5, 10, 25, 50, 75 and 100 ppm were taken in 500 ml capacity of borosilicate glass beaker (Figure 1). The initial absorbance of dye solution was measured at 570 nm by spectrophotometer after the calibration. The initial pH of dye solution was measured and adjusted.

Fig. 1: Experimental setup

To find out the optimum condition for decolorization of Nigrosine WS dye six different concentration of $FeSO_4.7H_2O$ and H_2O_2 (30% w/v) was applied. After addition of $FeSO_4.7H_2O$ and H_2O_2 (30% w/v) in 200 ml of dye solution, the glass beaker was stirred at 2000 rpm for 3 hours with the magnetic stirrer. The absorbance of solution was checked at each half an hour by spectrophotometer at 570 nm. For that 5 ml of sample had been taken out each time and 0.1 N NaOH was added to raise the pH above 7 in order to stop further $HO^{\bullet}$ radical formation. The sample was centrifuged at 3000 rpm for 3 minutes to settle down the dye particles before measuring the absorbance of the solution. The solar irradiation was noted down at each half an hour by digital Lux meter in Lux unit and then an average was calculated.

4. OBSERVATIONS AND RESULTS

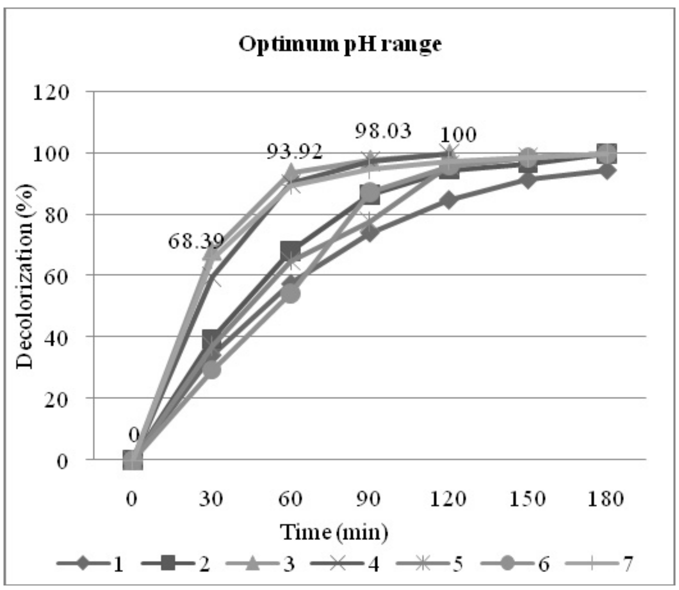
4.1 Maximum absorbance wavelength for Nigrosine WS dye



A single peak was observed at 570 nm which was used as the maximum absorbance wavelength and at which decolorization of Nigrosine WS dye was determined by measuring absorbance at each half an hour.

4.2 Effect of aqueous pH

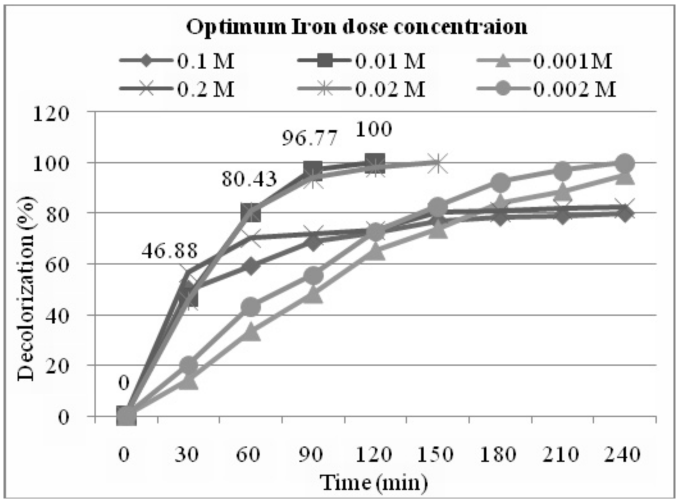
[Dye] = 25 ppm [$FeSO_4$] = 0.01 M H_2O_2 = 0.2



The pH range of 3-4 is more efficient for decolorization and as the pH increases the rate of decolorization decreases. At low pH, 1 and 2 dye solution was taking more time to decolorize and same for the increasing pH i.e. 5 to 7. However, pH 3 was used as the optimum pH because decolorization of AB2 was more in first hour than the pH = 4. At lower pH 1 and 2, dye removal was less because reaction between hydrogen peroxide and iron was significantly affected resulting reduction in the hydroxyl radical production. At lower and higher pH, dye removal was less also because of hydroxyl radicals scavenging of H^+ ions (Spinks J.W.T. and Woods R.J., 1990).

4.3 Effect of concentration of $FeSO_4.7H_2O$

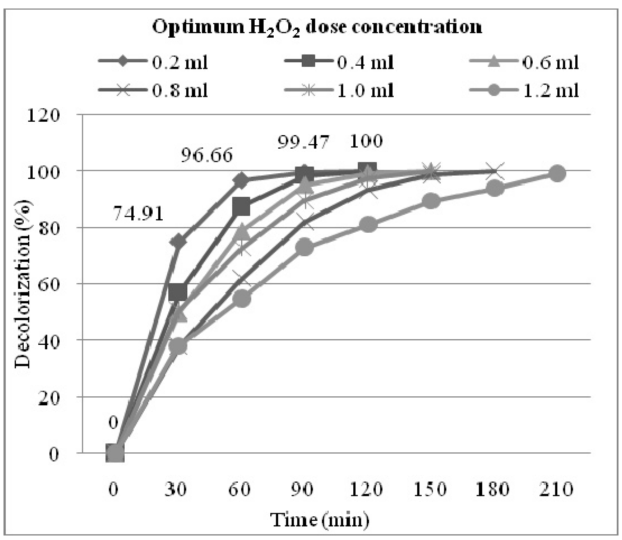
[Dye] = 25 ppm H_2O_2 = 0.2 ml pH = 3



The maximum efficiency of decolorization of 100% was achieved by 0.01 M and 0.02 M iron concentration in shortest time period of 2 hours, but 0.01 M was taken as optimum iron concentration because of less time taken for 100% of decolorization. The less decolorization observed at small iron dosage may be because of less production of $HO^{\bullet}$ for the oxidation process i.e. 0.001 M and 0.002 M. The large concentration of $FeSO_4.7H_2O$ has negative effect on decolorization process. An increase of $FeSO_4.7H_2O$ concentration did not improve the decolorization process i.e. 0.1 M and 0.2 M **(Malik P.K. and Saha S.K., 2003).**

4.4 Effect of concentration of H_2O_2 (30% w/v)

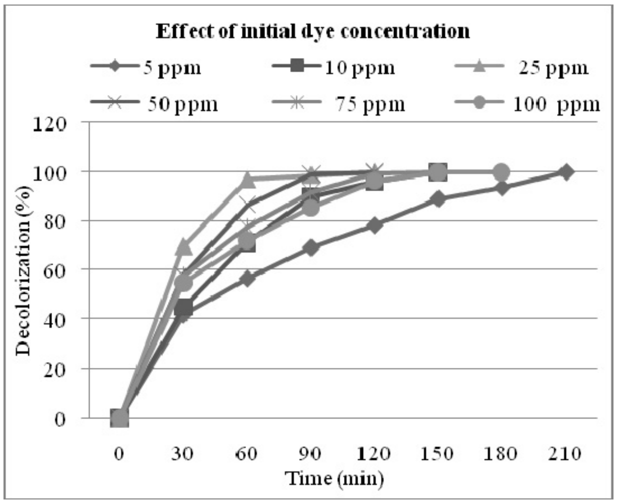
[Dye] = 25 ppm [$FeSO_4$] = 0.01 M pH = 3



The result shows that the small amount of H_2O_2 has taken the shortest time for decolorization. The optimum dose range of H_2O_2 was found as 0.2 – 0.6 ml, from which more than 99 % color removal can be achieved just within 2 hours. However, 0.2 ml of dose was taken as the optimum dose due to more decolorization just within first one hour. The increased amount of H_2O_2 did not give improved decolorization i.e. 0.8 -1.2 ml. This may be due to the recombination of hydroxyl radicals and also hydroxyl radical's reaction with H_2O_2 contributing to the hydroxyl radical scavenging capacity (Modirshala et al., 2006).

4.5 Effect of initial dye concentration

[$FeSO_4$] = 0.01 M H_2O_2 = 0.2 ml pH = 3

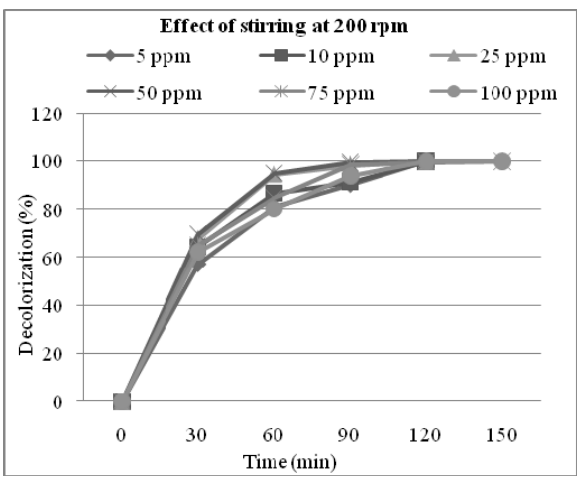


Result shows that optimum dye concentration range for optimum iron and H_2O_2 dose is 25-75 ppm. But the decolorization rate decreases with the increasing dye concentration. The 100% decolorization can be achieved with increased dye concentration but more time is required i.e. 75 ppm and 100 ppm. It may be attributed to the fact that as the concentration of AB2 increases, it starts acting like a filter for the incident light, where its large concentration permits the desired light intensity to react with the dye molecule in the bulk of the solution. Thus, increasing reaction time results in the decrease of decolorization rate of AB2 (Ashok et al., 2013). The decolorization rate also decreases as the dye concentration decreases i.e. 5 ppm and 10 ppm. It may be due to unconsumed Fe^{+2} ions present into the solution.

4.6 Effect of stirring

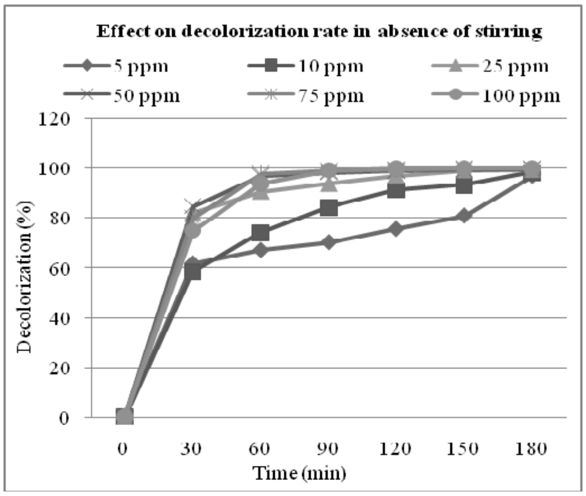
To study the effect of stirring on the rate of decolorization, the investigation was done in the absence of stirring and 10 % of the initial stirring, i.e. 200 rpm at optimum iron and H_2O_2 dose at fixed pH 3 for the duration of 3 hours for six different dye concentrations.

[Dye] = 25 ppm [$FeSO_4$] = 0.01 M H_2O_2 = 0.2 ml pH = 3



Result proves the effect of stirring on the decolorization rate, 100% of decolorization can be achieved within 2 hours up to 50 ppm, while more half an hour is required to 75 and 100 ppm solution for 100% decolorization.

[Dye] = 25 ppm [$FeSO_4$] = 0.01 M H_2O_2 = 0.2 ml pH = 3



Result shows that in the absence of stirring, 100% decolorization cannot be achieved but 99% of decolorization can be achieved within 3 hours of time duration. Absence of stirring also gives rise to the Fe^{+2} sludge formation.

5. DISCUSSION

The use of solar light instead of UV light reduces the operating cost of treatment method. Results of this study prove that decolorization rate of AB2 dye depends upon the several factors such as initial dye conc., aqueous pH, and conc. of iron, H_2O_2 and on stirring. The 10% of initial stirring gives improved and fast decolorization but the absence of stirring increases the decolorization time as well as gives iron sludge which is unconsumed after the reaction. So stirring below 200 rpm is must require to avoid iron sludge production for the decolorization of AB2.

6. CONCLUSION

The optimum condition of Photo-Fenton process gives 100% decolorization of AB2 dye in 2 hour of time period. The optimum dose of $FeSO_4.7H_2O$ is 0.01 M, (30% w/v) H_2O_2 is 0.2 ml, and optimum pH range is 3-4 which gives complete decolorization in the presence of direct sunlight. The results of this study are sufficient to conclude that Homogenous Photo-Fenton method is prominent and cost effective method for complete removal of Nigrosine WS (C.I. Acid Black 2) dye with major advantage of simple handling without any specific technical equipment. The treatment method requires less investment and energy demand. The only criteria required throughout the reaction for efficient result is continuous and large solar irradiation exposure. So this method is efficient and cost effective treatment method in tropical region where sun light is abundant.

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Relative Physical Qualities of Water Samples of Different Ponds with Varying Utilization

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ABSTRACT

The experimental ponds viz., Periya Kollukudipatty (PKPTY), Chinna Kollukudipatty (CKPTY) and Vettangudipatty (VGDPTY) selected for the present study. Those ponds are situated very close to each other, measuring within a range of 500m – 1 km distance apart and are located in Kollukudipatty and Vettangudipatty Villages of Sivagangai District, Tamil Nadu, India. The ponds are similar in their ecoclimatic condition which is semi-arid and they all belong to same category of temporary or ephemeral ponds, where the ponds fill with water during rainy seasons and remain dry during summer months. However, the utility nature of the ponds are different as the PKPTY pond serves as the Vettangudi Birds Sanctuary and several bird species including migratory birds abode this pond for a brief period mainly for breeding. Besides this, the pond water is utilized for irrigation and for domestic requirements to the communities live on the banks of the pond. Both the CKPTY and VGDPTY ponds have only domestic utility and are not formed as bird sanctuary, however situated close to PKPTY pond. Water samples were collected from those three experimental ponds at different sampling periods for one year to analyze the physical qualities of water samples viz., temperature, pH, electrical conductivity, TDS, alkalinity and salinity. The varying nature of the physical qualities of water samples is discussed in relation to the varying nature of biological interaction and utility nature of the ponds.

Keywords: Vettangudi Birds Sanctuary – Temporary ponds – Physical water quality.

INTRODUCTION

Water maintains a link between the five biomes, eventually makes the largest part of the biosphere. The aquatic biomes are largely classified into freshwater and marine. Ponds are one among the fresh water wetland ecosystems and these are shallow water bodies, either natural or man-made and also in terms of the water residence period, they may be perennial or seasonal. (De Meester et al., 2005). Natural pools contain water for few months in spring, and become dry for the reminder of each year, are found in many parts of world (Alan 1944). They are recognized all over the world under different names such as, pools, dayas, polges, dilines, ephemeral waters and Mediterranean temporary ponds (Williams 1987). Recently pond limnology has given new interests, since the key factors explaining ecological process have a different relative importance then in larger and deeper aquatic habitats (Downing 2010). Ponds may support more species than rivers and more uncommon species and in terms of regional diversity, they often make a greater contribution than any other aquatic habitat (Biggs et al., 2005). Ponds are very dynamic system that are greatly altered due to different land use, mainly due to human activities (Carchini et al., 2005). Pollution from human and animal waste is a major factor to make deterioration of the ecological quality of water and increased nutrient loads (Abdullah, 1995). Considering the importance of water quality, based on the ecological health of ponds, monitoring of water quality on the prevailing conditions becomes highly essential for making strategies in the effective pond management system. Considering this need, The present study was carried out to monitor and analyze the physical nature of water quality for the water samples, collected from three different experimental ponds of Vettangudi Birds Sanctuary, located in Sivagangai District, Tamil Nadu.

MATERIALS AND METHODS

Study area

The study was conducted at Vettangudi bird sanctuary, which is located in the villages of Periya Kollukudi Patty and Vettangudi Patty of Sivagangai district, Tamilnadu. Vettangudi ponds are declared as the bird sanctuary in June 1977. The Vettangudi bird sanctuary has comprised three drainage ponds viz., Vettangudi Patty pond (10º06.10'N; 78º01.23"E; Alt. 385 ft msl), Chinna Kollukudi Patty pond (10 º06.57'N; 78º30.41'E; 340 ft msl) and Perriya Kollukudi Patty pond (10º06.57'N; 78º30.81'E; 341 ft. msl). Vettangudi Patty pond (VGDPTY) is relatively larger among the experimental ponds, spreading to an area of 18.42 ha; Perriya Kollukudi Patty pond (PKPTY) occupies to an area of 13.66 ha and Chinna Kollukodi Patty pond (CKPTY) is a small pond spreading into an area of 6.315 ha. All the three experimental ponds are temporary and water residing period is generally between November and February. PKPTY pond is utilized for conservation of birds, as in a year, about 20,000 birds, belonging to 35 families visiting to this pond, sheltering on the Acacia niltoica trees planted in the pond basin. Besides this, all the three experimental ponds are utilized by the village communities for their domestic needs and for cattle ranching in the dried-up ponds.

Water sampling and analysis

Water samples were collected from the experimental ponds in regular monthly intervals, from February 2013 to January 2014, whenever water was available in the ponds. Depending upon the availability, water samples were collected from 0-1 ft. and also at a depth of 1-2 ft. in clean plastic bottles at 06:00 hrs, during every sampling period and brought to the laboratory for further analyses. Sampling and analytical procedures were done using available standard method (APHA, 2005). pH was determined with the help of pH meter (Elico, India). Water temperature was measured as soon as sampling was done. TDS, Conductivity, Salinity and DO were analyzed using Water Analyzer kit (Systronics Make; Model No. 371).

RESULTS AND DISCUSSION

The availability of water in the experimental ponds was varied during the sampling period. In VGDPTY pond, water was available during February, March, June, July, August, September, October, November and December 2013 and January 2014. In the case of CKPTY pond, water was available except during March, April, May, and August 2013 and January 2014. In PKPTY pond, water was present during all study period, except on May, 2013.

Water temperature

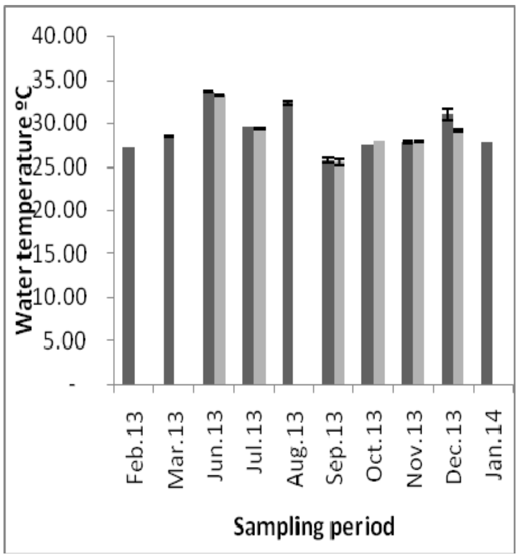
Water temperature of the VGDPTY pond first depth was maximum (33.63ºC) during the June at and minimum (25.52 ºC) was recorded during September for the top surface of the pond. In the second depth, greater temperature (33.24 ºC) was recorded in June at and lower value (25.52 ºC) was observed during the period of September. (Figure 1). Water temperature of the CKPTY pond was observed maximum (32.63 ºC) in July and the lower mercury level (26.5 ºC) was found during the month of September. In the PKPTY pond the top surface water had maximum temperature (32.82 ºC) in June and low temperature (25.33 ºC) was recorded in September. Sample collected from the second depth showed high temperature of 28.3 ºC during October and the minimum temperature (25.3 ºC) was recorded during September (Figures 1,2 and 3).

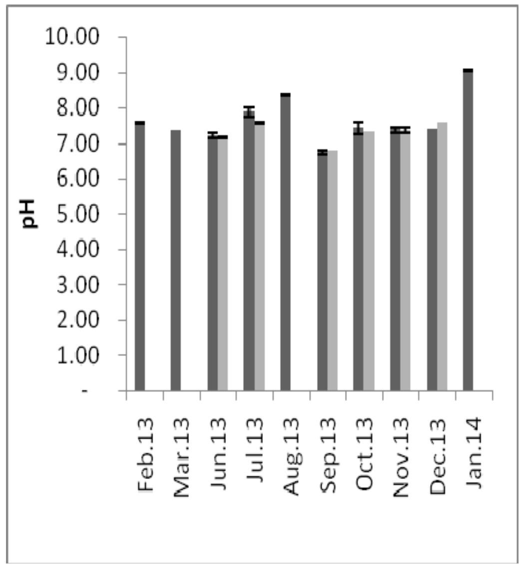
pH

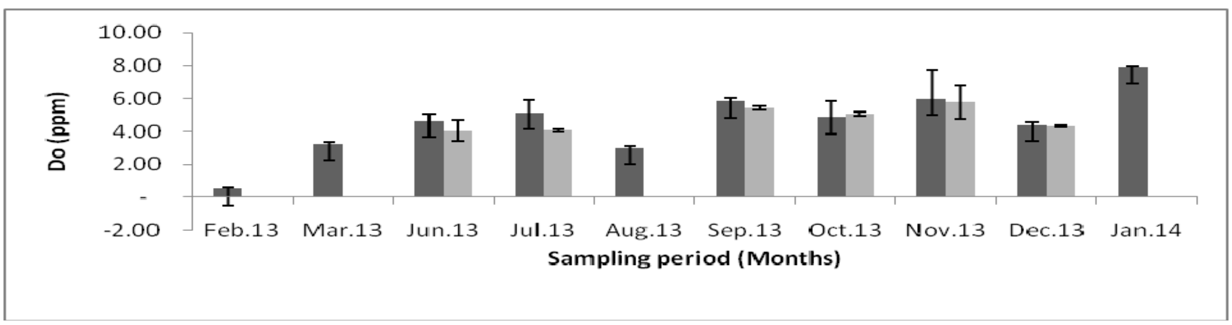
The pH value from the water samples, collected at the top surface from VGDPTY pond showed acidic range with the value of 6.74; conversely alkaline range of 9.03 was record during September. During January, 2014 alkaline range with the value of 9.03 was observed for the top surface water. In the case of second depth, acidic range 6.81 was found in the month of September and alkaline 7.57 were present during the months of June and December 2013. In CKPTY pond water first depth showed a high pH value of 7.28 during the months of July and December. The acidic range of pH value 6.78 was noted during the period of September. In the water sample, collected from second depth, 6.73 pH value was observed. In PKPTY pond first depth of water showed acidic pH value 6.55 and alkaline range 8.37 was found respectively in September and July. In second depth, pH was measured at a range between 6.6 and 7.61 during the month of September and alkaline range at the month of October 2013.

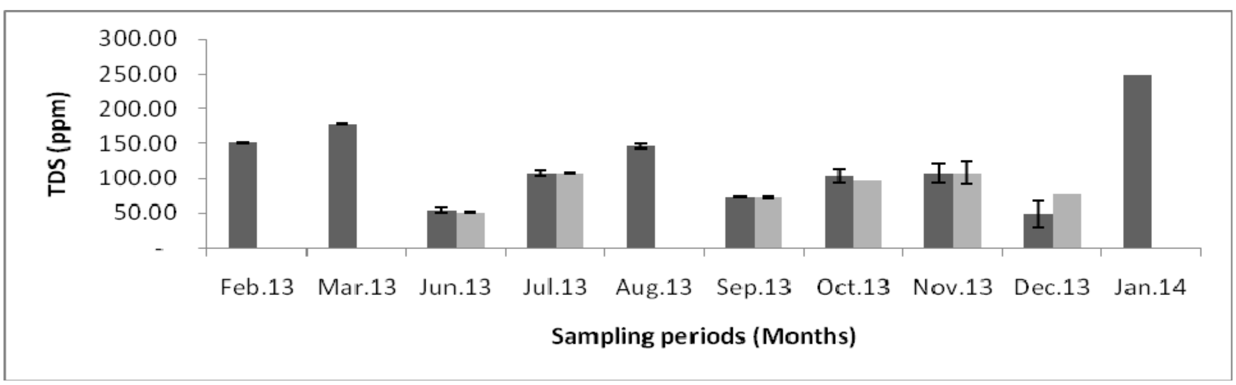
Dissolved Oxygen (DO)

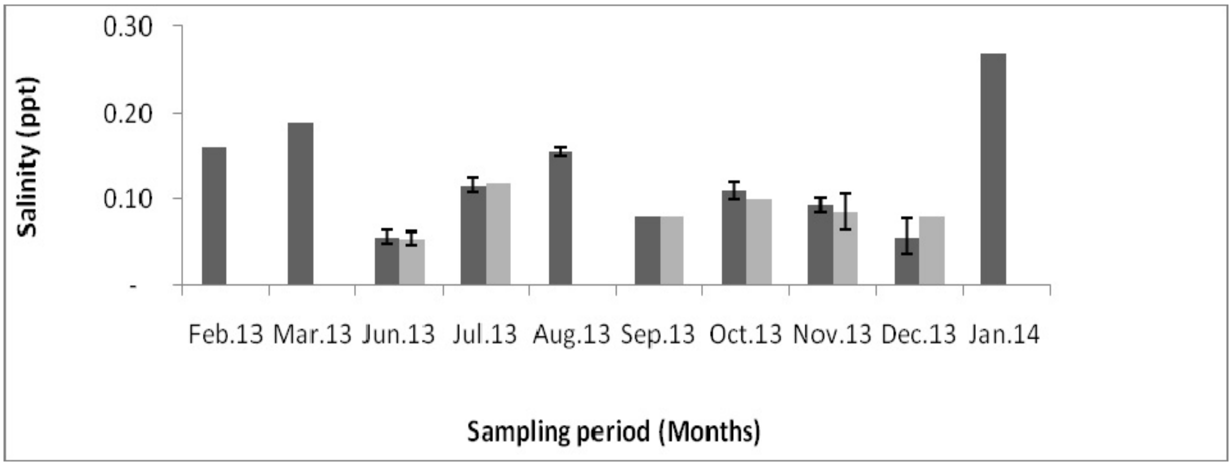
The VGDPTY pond surface showed a fluctuating trend of DO. Minimum amount of DO was present in the month of February 2013 and maximum DO presence was recorded during the period of January 2014. Water samples collected from the second depth in VGDPTY pond showing a range between 4.05 and 5.77 ppm during the periods of June and November 2013. Lower DO value was recorded in CKPTY pond in February and highest amount was observed in December and during the same period, the second depth DO was 3.17 ppm. The DO of PKPTY pond water was varying from 0.53 ppm to 7.88 ppm. The higher amount of DO was present in the month of January 2014 and minimum was observed in February 2013. In the second depth, DO of the pond was ranged between 5.01 ppm and 3.07 ppm during the periods of September and October.

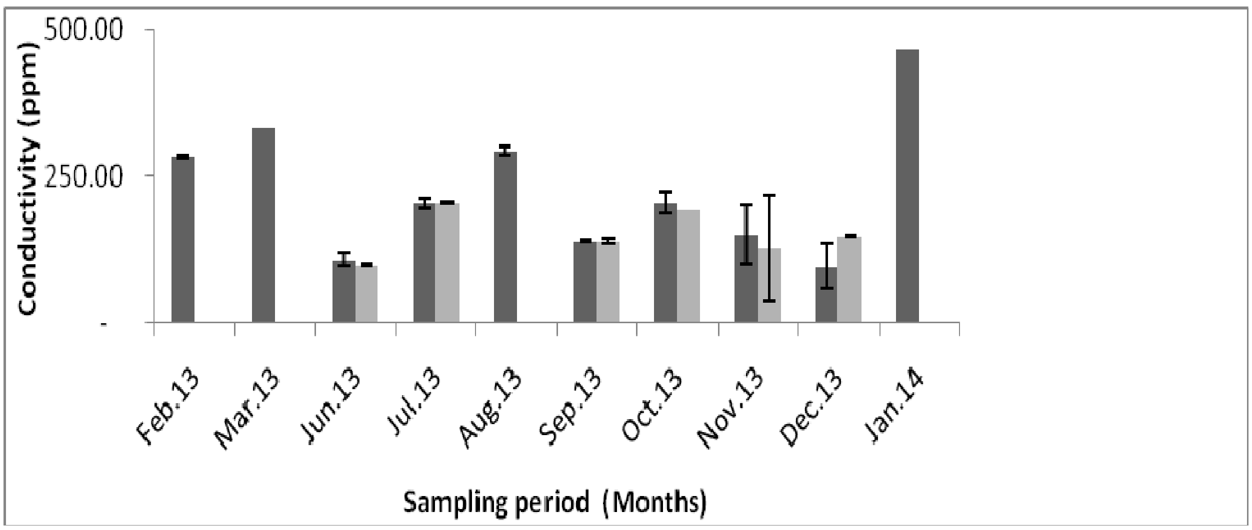












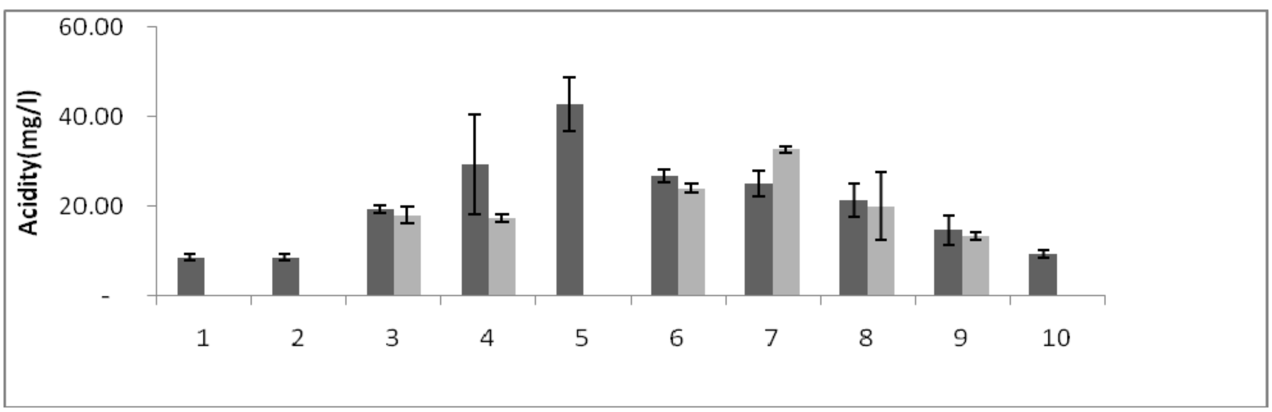
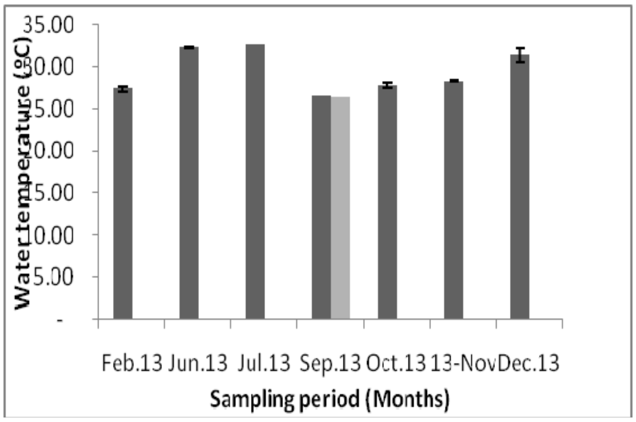
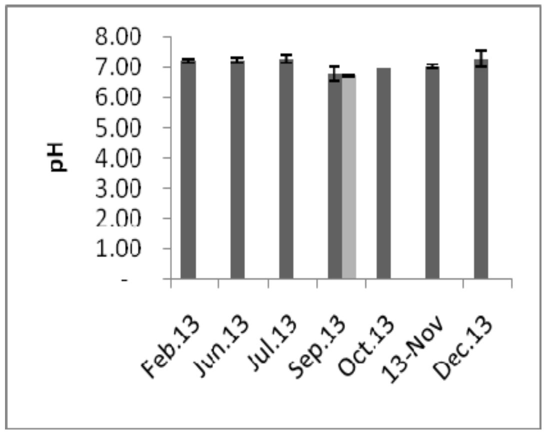


Fig. 1: Physical water quality attributes of VGDPTY water samples (Dark band representing 0-1 feet depth and light shaded band representing 1-2 feet depth samples). Vertical lines over the bars represent SE of means (n = 3).


Water temperature (ºC)
35.00
-
Feb.13 Jun.13 Jul.13 Sep.13 Oct.13 13-Nov Dec.13
Sampling period (Months)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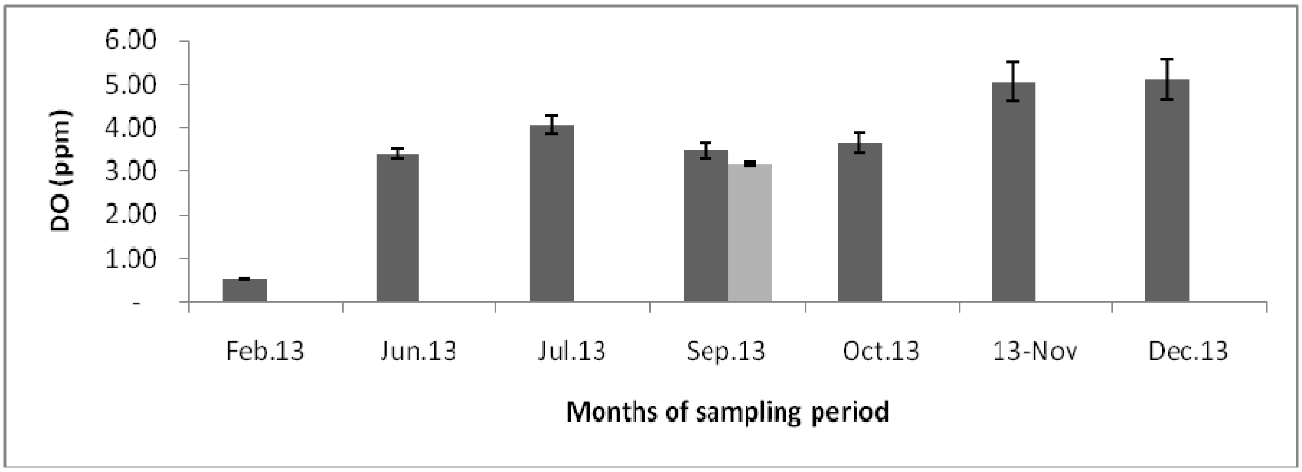
13-Nov
Dec.13


6.00
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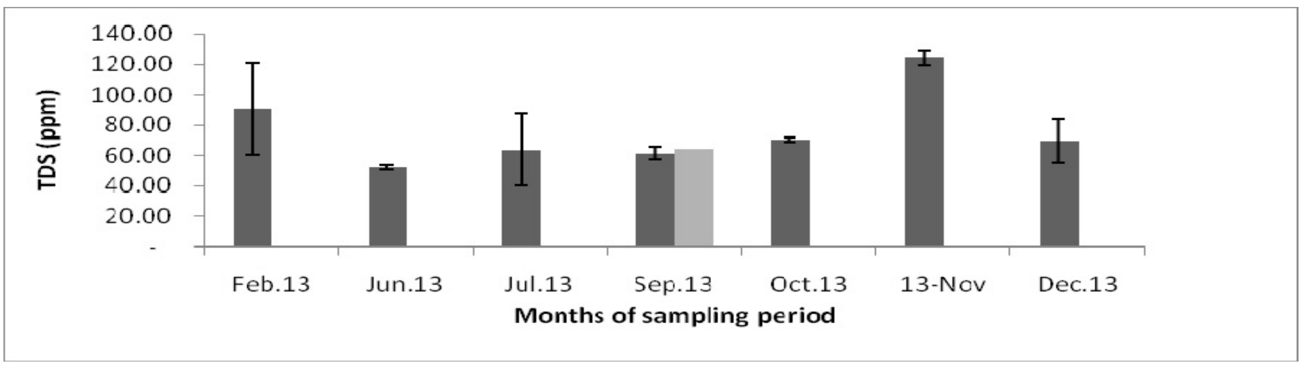
DO (ppm)
Feb.13 Jun.13 Jul.13 Sep.13 Oct.13 13-Nov Dec.13
Months of sampling period


140.00
120.00
100.00
80.00
60.00
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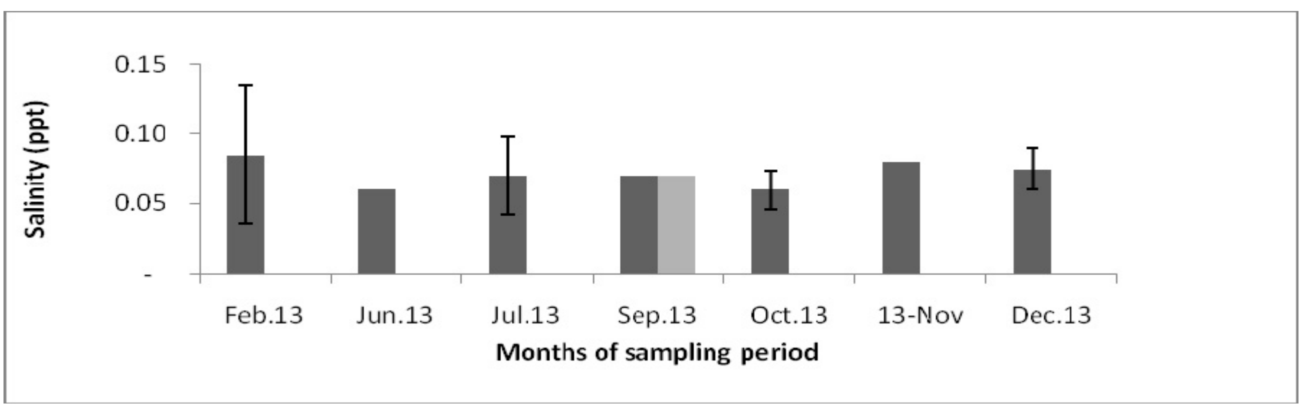
-
TDS (ppm)
Feb.13 Jun.13 Jul.13 Sep.13 Oct.13 13-Nov Dec.13
Months of sampling period


0.15
0.10
0.05
-
Salinity (ppt)
Feb.13 Jun.13 Jul.13 Sep.13 Oct.13 13-Nov Dec.13
Months of sampling period

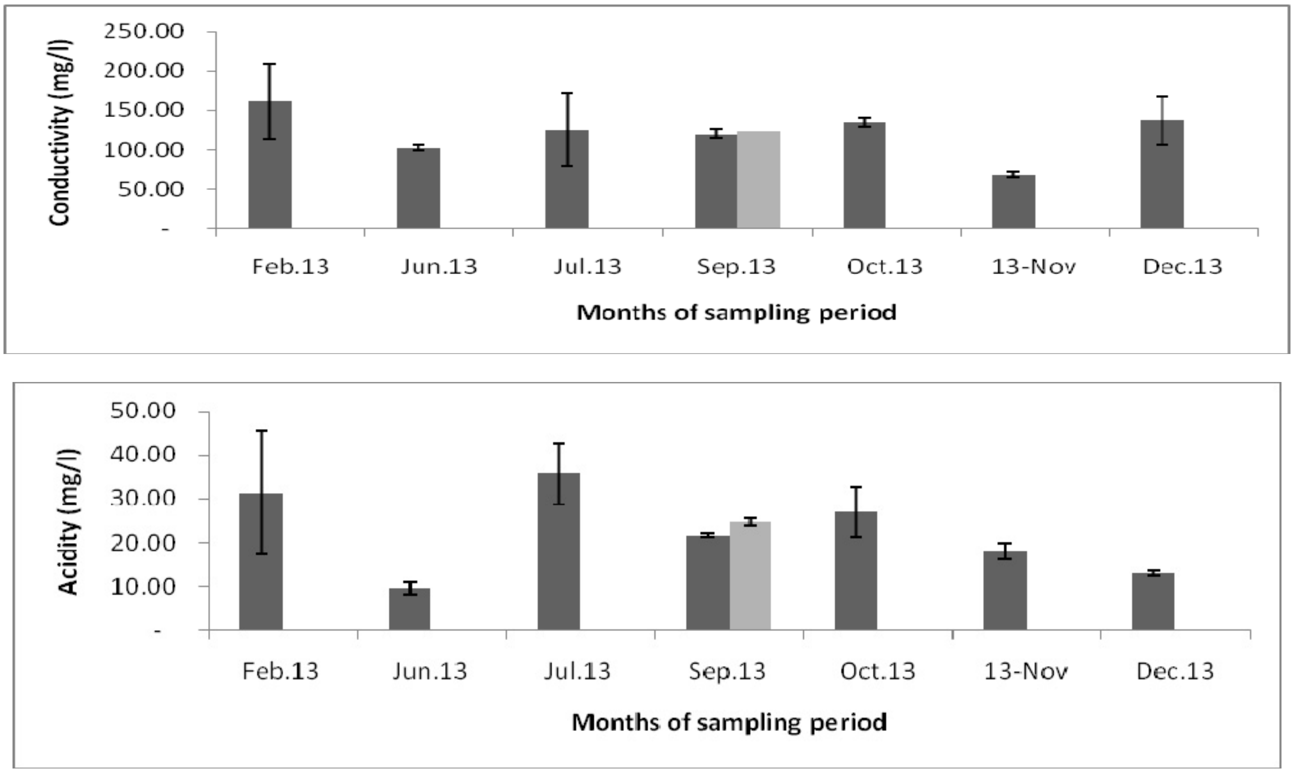
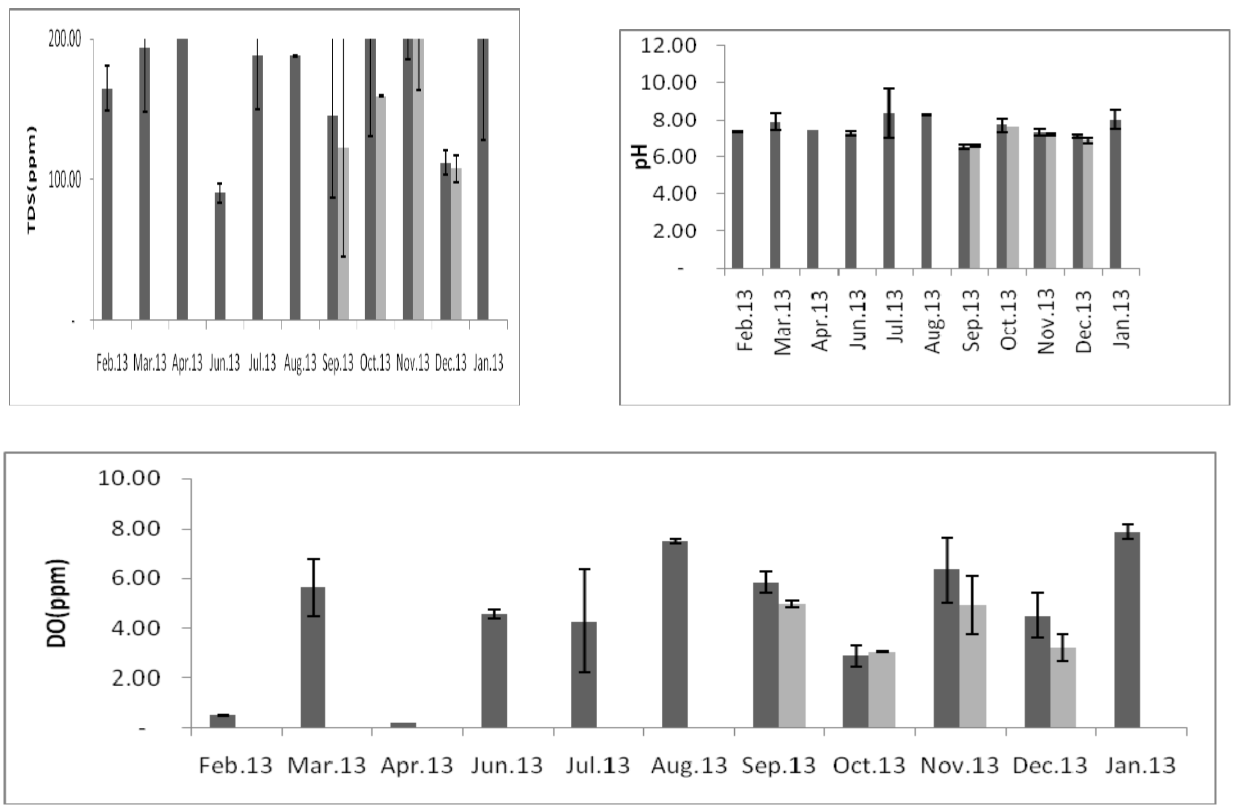
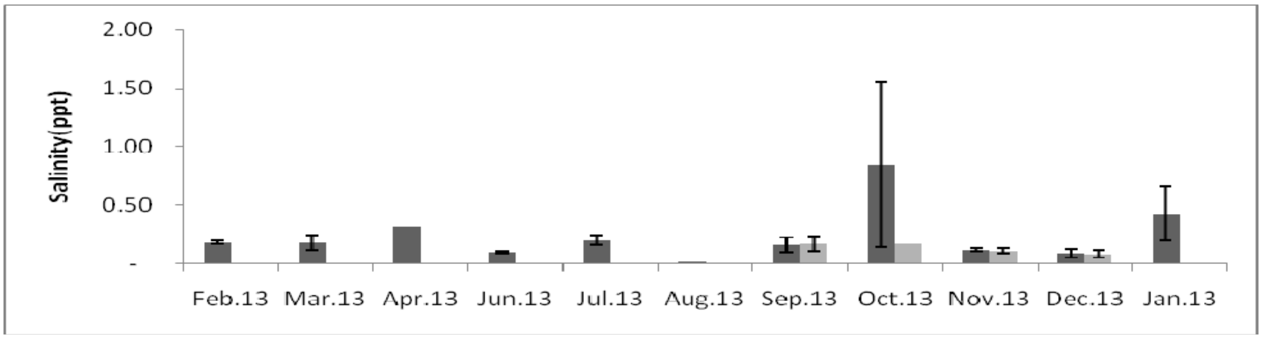
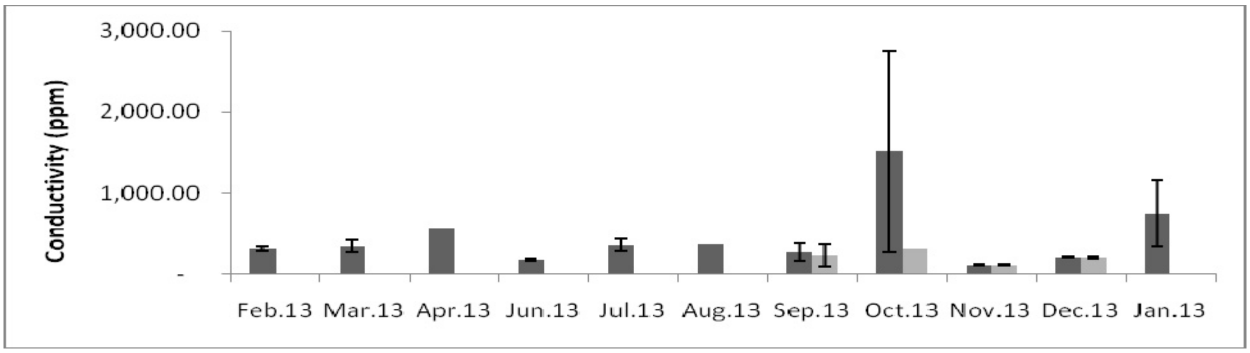
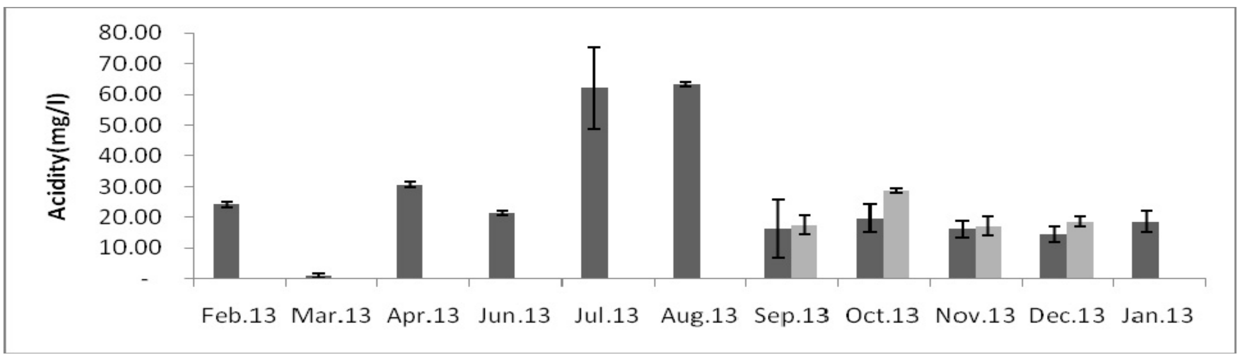


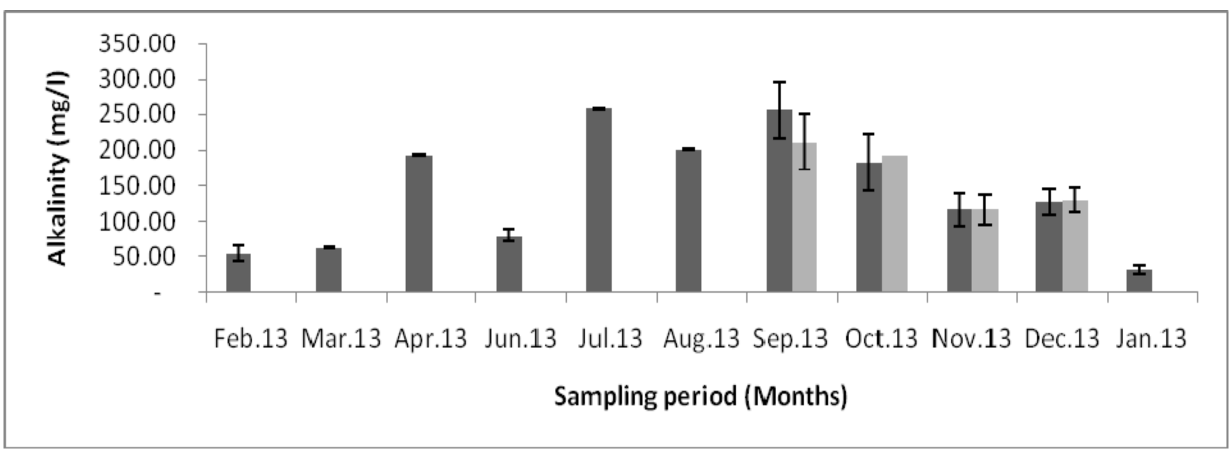
Fig. 2: Physical water quality attributes of CKPTY water samples (Dark band representing 0-1 feet depth and light shaded band representing 1-2 feet depth samples). Vertical lines over the bars represent SE of means (n = 3).











Total dissolved solids (TDS)

Maximum TDS of the VGDPTY surface water was during January 2014 and minimum value for this parameter was recorded in December. In the second depth of this pond TDS range were between 48.87 ppm and 105 ppm during the months of December and July 2013. The TDS of the CKPTY pond was highest in February 2013 and lowest during the month of June 2013. Higher TDS value was observed from the surface of PKPTY pond during October, 2013 and the lowest TDS value was present in the month of June 2013; TDS range was 218.67 ppm to 108.04 ppm, which was observed from the same pond at the deeper depth, during the months of November and December 2013.

Salinity

Higher rate of salinity was observed from the surface water samples collected from VGDPTY pond during January 2014 and from this same sampling point, low salinity was recorded in June and December 2013. In second depth of the pond lower and higher salinity values were recorded respectively in June and July. In CKPTY pond surface water showed maximum salinity in December 2013 and lower value was recorded during the months of June and October 2013 (Figure 2). In PKPTY pond, greater salinity value was recorded for the water samples collected on the surface during October 2013 and lowest was found in the month of August 2013. In the second depth, the pond water showed the maximum salinity at the months of September and November 2013 and minimum value on this parameter was recorded during the December.

Conductivity

Conductivity of the VGDPTY pond surface water was during the period of January 2014 at 465.67 µS and minimum 96.2 µS at the period of December - 2013 and in the second depth, TDS range was observed between 100.57 to 205.33 µS during the months of June and July 2013. CKPTY pond water samples showed higher conductivity value in February 2013 and lower value in June 2013. In the PKPTY pond, higher TDS was noted in surface water sample in the month of October 2013 and the lowest value was recorded in the month of June 2013. Similar values of conductivity was recorded for the water samples, collected from the depth of 1-2 ft, during the months of November and October (Figure 3).

Acidity

In VGDPTY pond, water collected from the top surface showed the maximum acidity value in the month of August and minimum was present in the period of February and March 2013. In the second depth this parameter ranged between 13.33 mg/l to 32.67 mg/l. The highest amount of acidity was observed in the CKPTY pond in July 2013 and lowest amount was observed in the month of June 2013. Water samples, collected from top surface of PKPTY had maximum acidity value in August and minimum during March. The second depth of the PKPTY pond showed corresponding higher and lower values of acidity, respectively during November and October 2013.

Alkalinity

During December month sampling, from the surface water of VGDPTY pond showed higher alkalinity in December and the lower quantity in February. In the deeper depth, alkalinity was observed at a range between 70 mg/l and 125.67 mg/l during the period of June and November 2013. CKPTY pond surface water alkalinity was observed minimum during the months of February and June 2013 and maximum at the month of September (Figure 2). In PKPTY pond, top surface water showed higher alkalinity in July and lowest amount was found in the month of January. At lower depth, alkalinity was higher and lower respectively during September and November months (Figure 3).

Discussion

Water quality is an important attribute which has a greater control mechanism on the aquatic environment. A rise in temperature of the water leads to the speeding up of the chemical reaction of gases and increase the metabolic activity of the organisms increases, requiring more Oxygen decreases, thus accentuating the stress (Trivedy and Goal 1986). During the study period the pH values of the ponds the ranges between 6.55 to 9.03. It indicates that these pond waters are suitable for the aquatic life, as it was shown in previous report (Weiner, 2013). CKPTY pond contains good pH range, when compared to other ponds because of the protection measures from human intervention done in the pond, as it serves as the major pond for wildlife. The most acidic pH (6.55) was observed in the PKPTY pond during the period of September because of the pond containing more number of the wader birds. The VGDPTY pond was used for the washing clothes and because of this reason, which would cause a considerable change in the pH of water.

The enhanced level of TDS observed in PKPTY pond water samples, when compared to the other two experimental ponds samples, clearly indicates that the birds dropping would have caused this nature, since this pond largely accommodates the avian population during the sampling period. Alkalinity of water depends on its acid-neutralizing capacity (Eaton *et al*., 1995). Pertinent to the recommended BIS Water Standard (1992), alkalinity range of VGDPTY and CKPTY pond water were below the desirable limit but in the case of PKPTY pond water, it had exceeded the desirable limit (258 mg/l). This might be due to eutrophication impact due to the migratory birds, sheltered in the ponds.The electrical conductivity of water depends upon the concentration of ions and nutritional status of water. The volume of electrical conductivity indicates the concentration of TDS and ionized salts present (Armani, *et al*., 2009). In PKPTY pond during the month of October, the maximum value of TDS (783.52 ppm), salinity (0.85 ppt) and Conductivity 1508.44 µS) was recorded and further the eutrophication effect is confirmed further from the result of the present study.

CONCLUSION

The present study results, substantiated with the previous reports are strongly emphasizing strongly on the importance of the physical attributes of water of a pond ecosystem. The study requires to elaborate further in the fields of chemical and biological qualities of water, since each ecological component is very important and interdependent among each other.

ACKNOWLEDGEMENT

This work is a part of a funded research project sanctioned by Environment and Forests, GOI, New Delhi (MoEF/ERS-RE/2009/14-43) to D, Kannan, which is gratefully acknowledged. We thank PCCF and Chief Wildlife Warden and Dr. T. Sekar, IFS, PCCF and DFO Sivagangai Forest Division, TN Forest Department for their permission to undertake the research work at Vettangudi Birds Sanctuary ponds.

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Identification of Rainwater Harvesting Structures to Increase the Groundwater Levels at RVS Nagar, Chittoor

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ABSTRACT

The exploitation of ground water resources more than its annual replenishment has caused continuous decline of water level, declined well yields, dry of shallow wells, deterioration of ground water quality and so on. So in order to compensate the loss of water through various means and overcome the scarcity of water, artificial recharge of ground water can be adopted. Groundwater Recharge by roof top harvesting and by water harvesting structures (WHS) like trenches, percolation tank and mini percolation tanks can be preferred which are normally cheap and can be constructed locally. Different structures are used depending upon the location of the area and the purpose of water being used for particular area.

In the present work it has been proposed to identify the suitable locations for rain water harvesting structures in RVS Nagar, Puthalapattu Mandal, Chittoor District, Andhra Pradesh and to design a roof top harvesting system. A total number of 10 WHS have been proposed in the study area with an estimated cost of Rs.33.25 lakhs. It is calculated that the storage capacity from all the WHS is 85.218 ha.m. It is found that the percolation tanks have more storage capacity with around 82.62 ha.m followed by mini percolation tanks around 2.58 ha.m and trenches 0.018 ha.m. A roof top of area 0.4902ha can collect a net quantity of water of about 3137.28 m^3 per year. Four PVC pipes of 100mm diameter are provided and a filter of size 3.5m X 3.5m is designed.

1.0 INTRODUCTION

Groundwater recharge is a process by which excess surfacewater is directed into the ground – either by spreading on the surface, by using recharge wells, or by altering natural conditions to increase infiltration – to replenish an aquifer. It refers to the movement of water through man-made systems from the surface of the earth to underground water-bearing strata where it may be stored for future use.

Groundwater Recharge by roof top harvesting and by water harvesting structures (WHS) like trenches, percolation tank and mini percolation tanks can be preferred which are normally cheap and can be constructed locally. Different structures are used depending upon the location of the area and the purpose of water being used for particular area.

1.1 Rain Water Harvesting

Rain Water Harvesting is simply the act of capturing rainwater and either storing it for use or recharging it into the ground. RWH helps households in securing their water supply, reducing their dependence on piped / tanker / bore well water and can significantly reduce the intensity of flooding during the rainy season. Rainwater can be broadly harvested in two ways:

1.1.1. Rooftop RWH with direct storage

Rainwater on terrace areas is brought down using down pipes. This water is then passed through a filter and stored for consumption in an appropriate storage (eg: sumps or rain barrels)

1.1.2. Groundwater recharge

Water from the storm water drains, paved and unpaved, is redirected into what is called a recharge well that percolates the water to the groundwater aquifer.

1.2 Study area

RVS Nagar is situated in Puthalapattu Mandal of Chittoor district, one of the chronically drought affected Rayalaseema districts of Andhra Pradesh, India. It is located 10km towards north from District head quarters Chittoor. The ground water draft in the mandal for all uses exceeds the net groundwater availability. The stage of development is 106% and put the mandal at over-exploited category.

1.2. Objectives

In the present work it has been proposed to identify the suitable locations for rain water harvesting structures in RVS Nagar, Puthalapattu Mandal, Chittoor District, Andhra Pradesh and to design a roof top harvesting system.

2.0 LITERATURE REVIEW

Many researchers given importance for artificial recharge structures / water harvesting structures in the world.

The water Technology Centre, Tamil Nadu Agricultural University has studied existing 10 percolation tanks in Coimbatore district of Tamil Nadu State for economic evaluation. Eight percolation tanks in Coimbatore taluk and two in Avinashi taluk of Coimbatore district were selected and studied. The study indicates that the total number of wells benefitting from percolation ponds during 1988-89 was 36 out of the 258 wells (14%). The total area benefitted due to these 36 wells was only about 14.4 ha.ju

Central ground water board has studied Artificial recharge to ground water in Channian and Kalasinghian, Jalandhar and Kapurthala Districts, Punjab. The village Channian and village Kalasinghian is located in Nakodar block of Jalandhar district and Kapurthala block of Kapurthala district respectively. The water levels are declining at a rate of 0.2 m/year. The spare canal water and surface runoff generated during monsoon, accumulated in the village ponds will be recharged. Annual water available for recharge is estimated to be around 0.28 m.cm.

Central Groundwater Board have studied Artificial Recharge in Sikheri, Mandsaur Block, Mandsaur District, Madhya Pradesh. In Mandsaur block, depletion of water levels is taking place due to over development of ground water. Water levels have declined in the range of 1.25- 4.60 m in last 20 years. Level of ground water development is about 119%. A percolation tank is proposed to be constructed.

Dr.S.Venkateswara Rao and K.Lokesh has studied groundwater recharge through rainwater harvesting structures in the parts of Chittoor district, Andhra Pradesh. This study identified 24 harvesting structures (WHS) have been proposed with an estimated cost with 56 lakhs. The estimated storage capacity from both existing and proposed WHS IS 174.52 ha. m. It is found that Percolation tanks have more storage width 122.4 ha.m followed by check walls with 19 ha.m, check dam's width 16.2ha, Mini percolation tanks with 11.8ha.m, and staggered trenches width 5.04 ham.

3.0 METHODOLOGY

The Methodology includes collection of rainfall data, collection of groundwater data for Puthalapattu Mandal and Demographic details and Identification of suitable sites for Water Harvesting Structures (WHS) for surface storage to recharge and to increase the groundwater levels at RVS Nagar. And to design roof top harvesting at RVS hostel to increase the ground levels in nearby three bore wells.

4.0 RESULTS AND DISCUSSIONS

Three types of water harvesting structures are proposed in study area namely Percolation tanks of five in number, Mini percolation tanks of four in number and one Trench.

4.1 Surface water Estimation

The total available water for the village is estimated by taking the village geographical area (ha) and Annual rainfall (mm) for the last 13 years of the respective Mandal of the Village. The water towards evapo-transpiration, ground water recharge, storage of WHS is calculated. The balance available surface water is arrived by subtracting the water stored in the proposed water harvesting structures from the total surface flow of rainfall. The calculations are presented in the Table 1.

Table.1 Runoff Estimation of RVS Nagar.

S.NO	DETAILS	FORMULA		QUANTITY
1	Area of the GP(in ha)	Acres ✕ 0.41		677
2	Average rainfall Mandal(in m)	13 years Average		0.923
3	Volume of rainfall (in ha.m)	Area of the GP(in ha)X average rainfall (in mm)		624.871
4	Evapo-transpiraton of rainfall (in ha.m)	0.5 X volume of rainfall in (ha.m)		312.43
5	Rainfall converted as ground water (ha.m)	0.1 X volume of rainfall (in ha.m)		62.49
6	Surface flow of rainfall(in ha.m)	0.4X volume of the rainfall(in ha.m)		249.95
	Particulars of the proposed WHS			
S.NO	Name of the Structure	Storage Capacity (Ha.M)	No.of Structures	Total Quantity (Ha.M)
I.	Percolation tank	16.524	5	82.62
II.	Mini percolation tank	0.646	4	2.58
III.	Trench	0.018	1	0.018
	Total		10	85.218
	Total storage capacity from the proposed WHS in ha.m			85.218
	Balance surface runoff for future use (ha.m)			164.73

4.4 Cost Estimation for Water Harvesting Structures

Estimation has been carried out for all the 10 WHS. The total estimated cost for the proposed structures is Rs.33.25 lakhs. Structure wise details and estimated cost, expected impounding of ground water is shown in following Table 2.

Table 2 Cost Estimation for Water Harvesting Structures.

S.No	Type of Structure	Number	Estimated Cost in Lakhs	Expected Impounding Ground Water
1	Percolation tank	5	25	36
2	Mini percolation tank	4	8	5.28
3	Trenches	1	0.25	0.84
Total		10	33.25	42.12

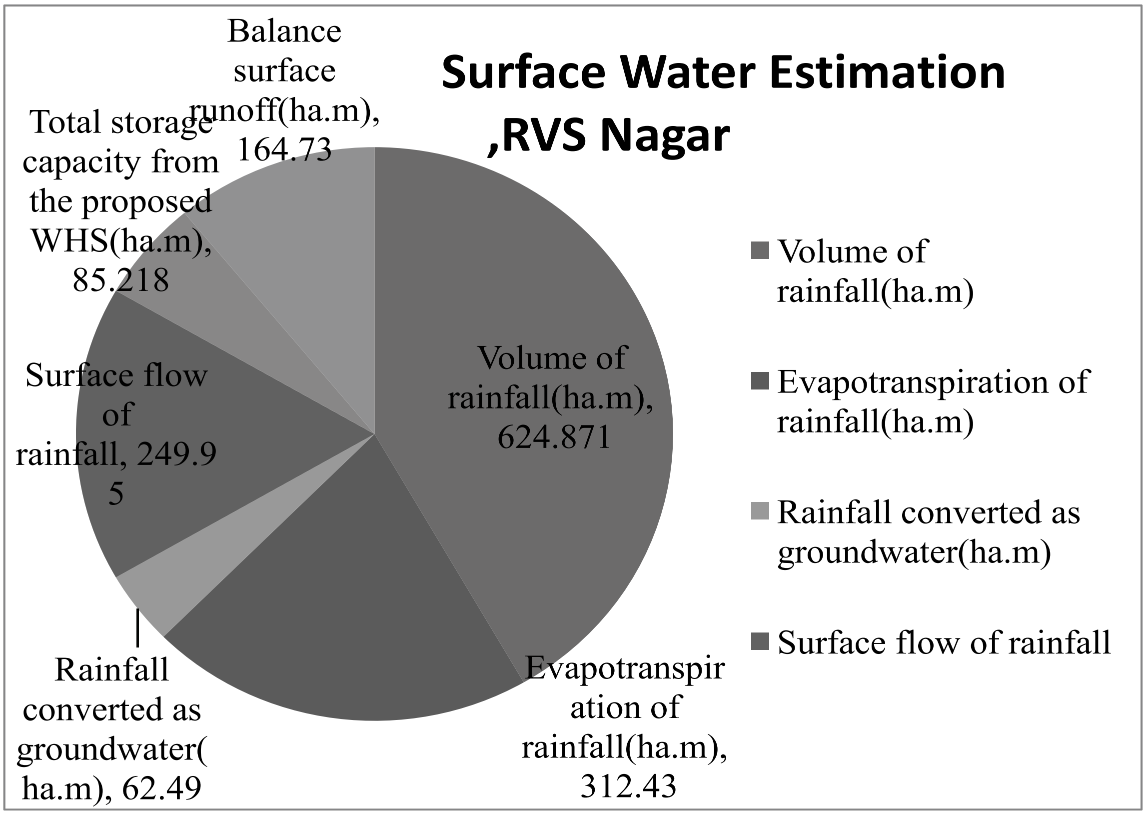

Fig 1: Diagrammatic representation of Surface Water Estimation.

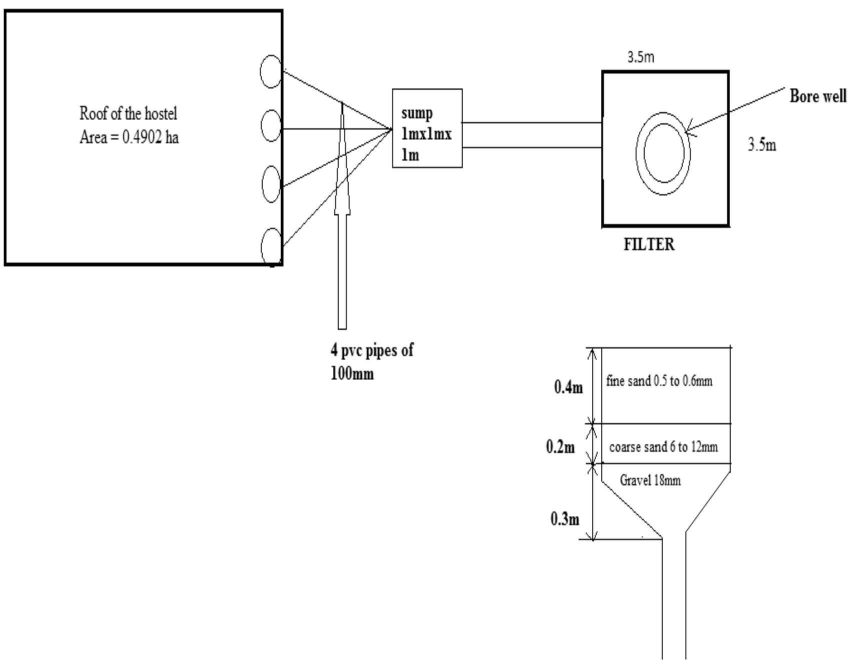

Fig. 2 Cross section of roof top Harvesting system

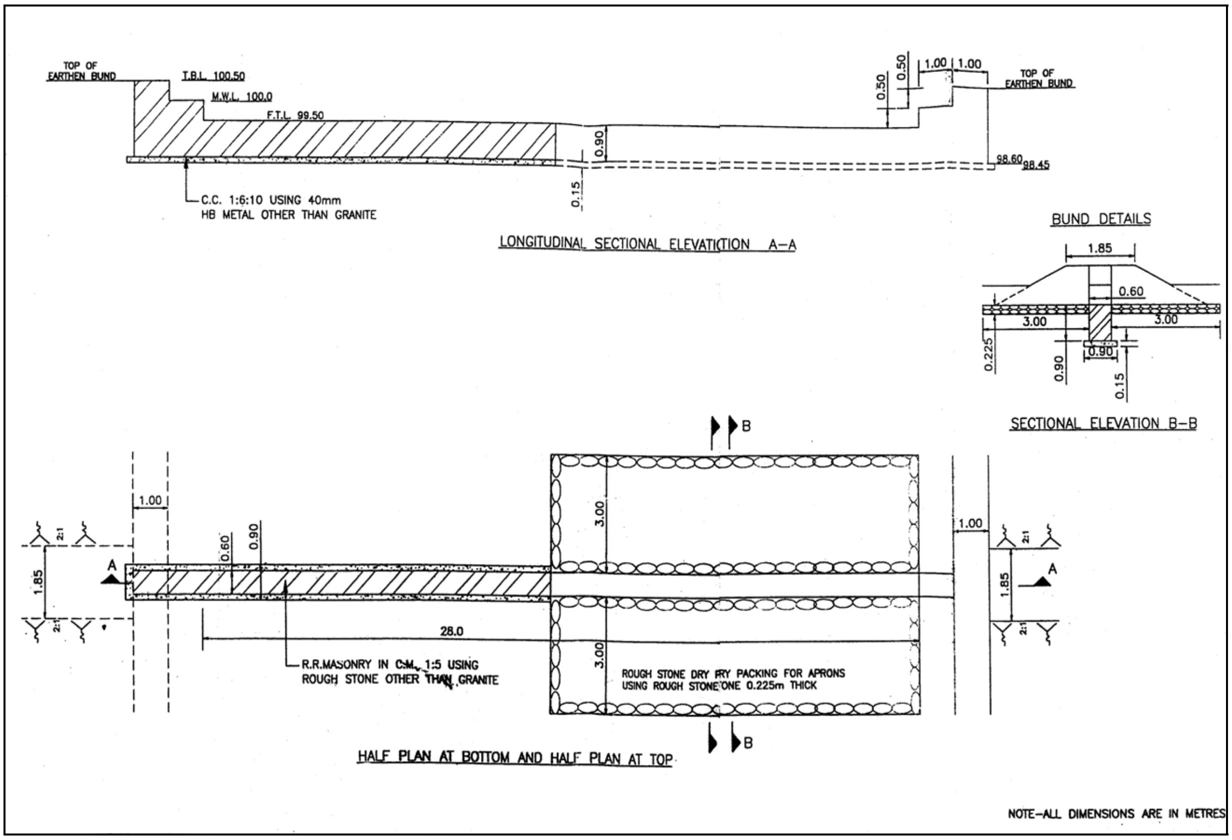

Fig. 3 Plan of the Percolation tank

5.0 CONCLUSION

The study area is with moderate rainfall but however large amount of it lost through runoff. Suitable sites have been identified and proposed to impound for surface storage through water harvesting structures (WHS), viz., percolation tank, mini percolation tanks and trenches to raise and increase the declined groundwater levels in the study area. In order to open up the dried up bore wells, roof top harvesting is proposed at RVS Hostel (boys mess).

A total number of 10 WHS have been proposed in the study area with an estimated cost of Rs.33.25 lakhs. Details of design of the water harvesting structures have been presented. Also the design of the PVC pipe and filter for roof top harvesting has been presented.

It is calculated that the storage capacity from all the WHS is 85.218 ha.m. It is found that the percolation tanks have more storage capacity with around 82.62 ha.m followed by mini percolation tanks around 2.58 ha.m and trenches 0.018 ha.m. A roof top of area 0.4902ha can collect a net quantity of water of about 3137.28 cu.m per year. So 4 PVC pipes of 100mm diameter are provided and a filter of size 3.5m X 3.5m is designed.

Expected outcomes

The following affirmative impact is expected by execution of proposed WHS in the study area:

1. Improved groundwater levels.
2. Additional area brought under cultivation by the ground water.
3. Increase in cropped area and crop yields.
4. Assured and potable drinking water supply to every house hold.
5. Quality improvement owing to dilution of groundwater.
6. Failure of bore wells will be reduced

6.0. REFERENCES

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Resistivity Survey to Assess the Seawater Intrusion on Coastal Aquifer of Minjur Block in Tamil Nadu

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ABSTRACT

Seawater intrusion is a serious problem in the coastal aquifer system of Minjur block, Sub urban area of Chennai city. Over extraction of ground water for industries, drinking water supply and irrigation for a decadal time scale has aggravated the issue. Geophysical investigation is one of the scientific technique, which can provide details of sub surface lithology as well as saline water intrusion in the coastal aquifer. A total of Ten Vertical Electrical Soundings uniformly distributed within the study area with Schlumberger configuration by resistivity survey were carried out to assess the salinity of the coastal aquifer.

***Keywords**:* Sea water intrusion, Resistivity survey and Coastal aquifer, Minjur, Chennai city.

INTRODUCTION

Groundwater is one of the most precious renewable natural resource in the earth. Seawater intrusion is a major problem in coastal areas due to over extraction of groundwater Ground water in this area is under stressed condition and is over exploited for agriculture and industrial purpose which leads to salinity in this coastal aquifer. One such area is the Minjur area north of Chennai. Since 1968, more than one third of Chennai city water demand was met by groundwater from three well fields known as Minjur, Panjetty and Tamaraipakkam. These well fields of Chennai aquifer situated about 40 km North, North-West of Chennai. Madhavi Ganesan and S. Thayumanavan (2009) confirmed Of the three, the Minjur well field lies nearest to the Bay of Bengal, at a distance of 9 km from the coast and it is hydraulically connected with the sea. Heavy extraction of groundwater in the coastal aquifers of Minjur block has lead to inward movement of denser saline water to maintain the hydrodynamic balance of the aquifer system and the deterioration of fresh groundwater began. With this background information the present study was carried out with an objective to decipher the fresh-saline water interface in the unconfined aquifer using geophysical techniques (D. Gnansundar and L. Elango 1998).

STUDY AREA

The study area, Minjur block belongs to Thiruvallur district, is located to north of Chennai city. The total area of this block (439 Sq.km) is located at 13.27°N 80.27°E with an average elevation of 11 metres (36 feet). The drainage pattern, in general, is dendritic. All the rivers are seasonal and carry substantial flows during monsoon period. The nearby Arani and Korattalai rivers are non-perennial, flowing for only a few days during the northeast monsoon period of October to December. The chief irrigation sources in the area are the tanks, wells and tube wells.

Soils

Soils in this area are black soil and alluvial soil. The major part is covered by sandy/clay loam type. Ferruginous red soils are also seen at some places. Black soils are deep to very deep and generally occur in the depressions adjacent to hilly areas, in the western part. Alluvial soils occur along the river courses and eastern part of the coastal areas. Sandy coastal alluvium (Arenaceous soil) are seen all along the sea coast as a narrow belt.

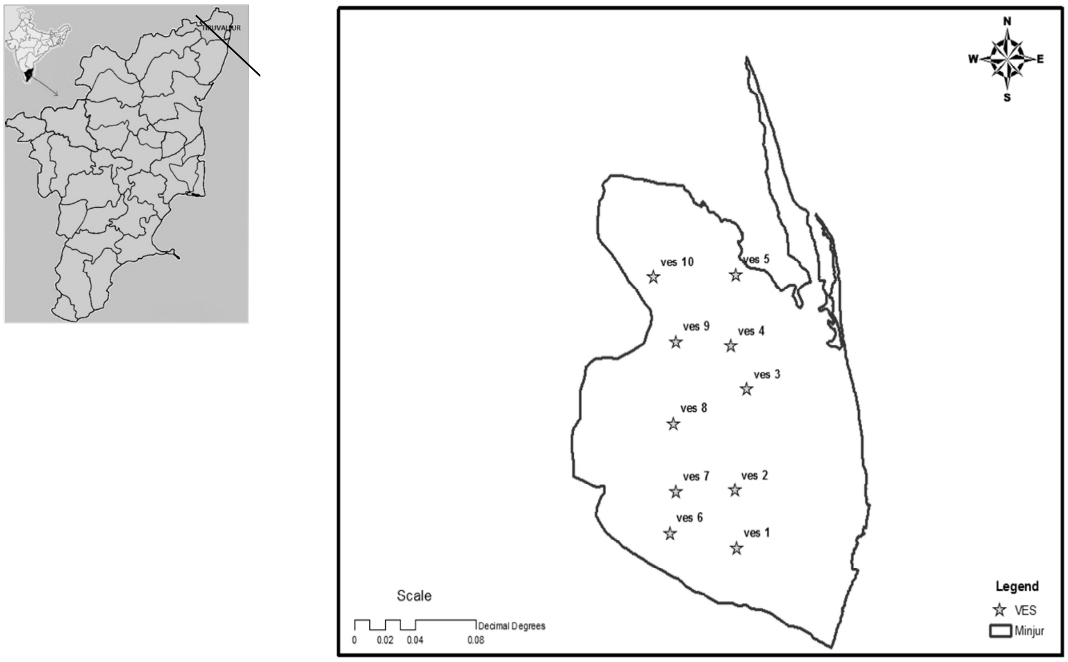

Fig. 1 Study area showing VES locations

Rainfall and Climate

The atmospheric temperature varies with season. In summer, a value ranging from 35˚C to 42˚C and in winter it ranges from 25˚C to 34˚C (Sathish .S et.al 2011). The study area receives the rain under the influence of both southwest and northeast monsoons. The south west monsoon prevails from July to September and the north east monsoon is active from October to December. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Bay of Bengal chiefly during northeast monsoon period. The southwest monsoon rainfall is highly erratic and summer rains are negligible. Rainfall data analysis shows that the normal annual rainfall varies from 950mm to 1150mm.

Geology, Geomorphology and Hydrogeology

The area is underlain by formations of quaternary, tertiary and upper Gondwana as well as by the basement complex of crystalline rock. Gondwana rocks are covered by the extensive stretch of alluvium that forms the aquifer in the study area. The alluvium consists of gravel, fine to coarse sand, clay, silt, clayey silt and silty clay (Madhavi Ganesan and S. Thayumanavan 2009). The prominent geomorphic units identified in the study area through interpretation of Satellite imagery are alluvial Plain, old river courses, coastal plains and shallow and deep buried pediments. The aquifers of this area along with adjacent area are called as Minjur Aquifer System.

METHODOLOGY

A total of Ten Vertical Electrical Soundings uniformly distributed have selected to study seawater intrusion by geophysical method. Two type of locations were selected for this study. Resistivity surveys were carried out below 10 km from the coast and above 12 km from the coast.

Table 1 VES Locations with distance from coast

Sl.No	VES No	VES Location	Latitude	Longitude	Distance (Km) from Coast
1	1	Minjur	13°16'10.46"N	80°15'43.69"E	8.41
2	2	Kalpakkam	13°18'13.25"N	80°15'38.45"E	9.31
3	3	Somanchery	13°21'50.96"N	80°16'6.67"E	7.62
4	4	Vanjivakkam	13°23'23.39"N	80°15'29.65"E	8.13
5	5	Siralapakkam	13°25'56.91"N	80°15'40.70"E	7.35
6	6	Sanarapalayam	13°16'41.42"N	80°13'4.22"E	13.51
7	7	Anuppampattu	13°18'10.74"N	80°13'19.24"E	13.58
8	8	Matravedu	13°20'36.62"N	80°13'13.78"E	13.44
9	9	Vempedu	13°23'32.22"N	80°13'18.46"E	12.11
10	10	Panapakkam	13°25'51.82"N	80°12'25.22"E	13.32

The geophysical survey with Schlumberger configuration was used for the investigation of possible seawater intrusion in groundwater with regular interval. The electrical resistivity technique was used to determine the sub surface resistivity by sending an electric current into the ground (D.Gnansundar and L.Elango 1999).A series of measurements of resistivity are made by increasing the electrode spacing in successive steps about a fixed point. The apparent resistivity values obtained with increasing values of electrode separation are used to estimate the thickness and resistivities of the subsurface formations.

The survey was conducted at regular interval. Ten Vertical Electrical Soundings were used a maximum electrode half-spacing AB/2 of 70 metres in the study area. Vertical Electrical Soundings were carried out by Resistivity meter – DDR3 model is the made of IGIS , Hyderabad, India. Ten VES location data points were interpreted using a curve matching technique, and layer thickness and layer resistivity were determined. The true resistivities of various layers are calculated by correlating the apparent resistivity pa (x-axis) and electrode spacing AB/2 (y-axis) in a log-log graph (M.Senthil kumar et.al 2001)

RESULTS AND DISCUSSIONS

The apparent resistivity for this configuration is computed with this formula

$$\text{Apparent resistivity pa} = \frac{\pi\,(AB/2)^2-(MN/2)^2\,R}{MN}$$

The computed apparent resistivity values were plotted at logarithmic scale paper to gain an view of variation in resistivities. The interpretation of the measured values is facilitated through use of micro soft excel chart in the computer. The interpretation was made using the database management and sounding interpretation including plotting of sounding curves (Rajiv Khatri et.al 2011).

Locations of Vertical Electrical Sounding are found below 10 km from the coast are known as Type (I) shown in Figure (2) and Locations of Vertical Electrical Sounding are found above 12 km from the coast are known as Type (II) shown in Figure (3)

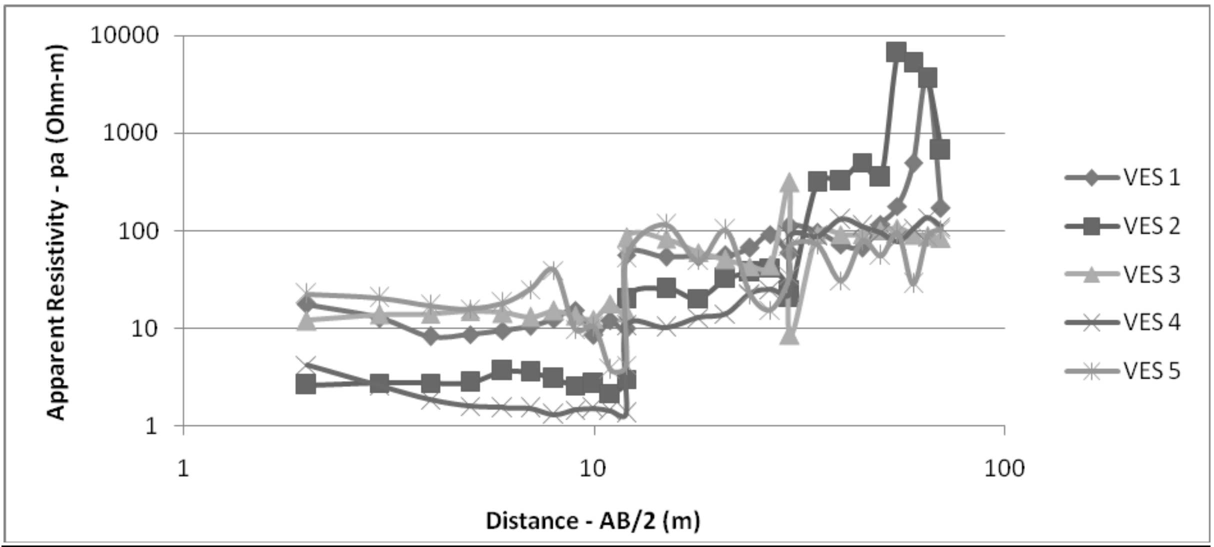

Fig. 2 Type (I) - Resistivity profiles below 10 km from coast

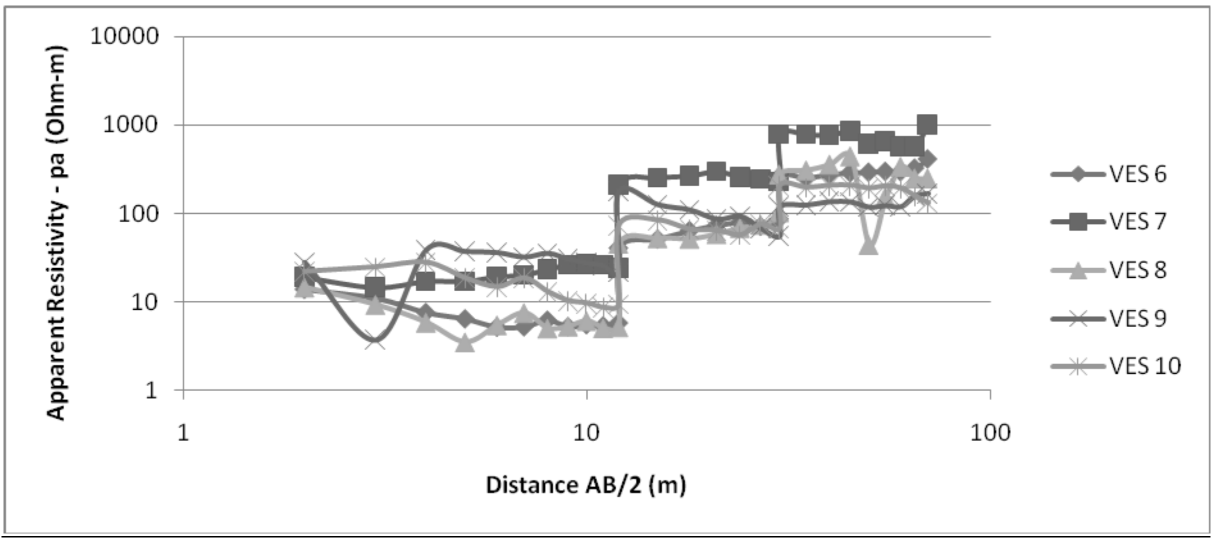

Fig. 3 Type (II) - Resistivity profiles above 12 km from coast

The Type (II) sounding curve differs from Type (I) sounding curve. The comparison of apparent resistivities of Type I and Type II were correlated to study the saline water interface. It is clear that Type I is affected by saline water intrusion. Type II shows no salinity compared to Type I. This reveals that the formation occurred at AB/2 of 18 and 27 meters in Type II contains groundwater of good quality. The graph indicates more complicated in Type (I) sounding curve.

The two Vertical Electrical Sounding in same horizontal line as shown in figure (4) are correlated with one logarithmic graph for comparison. The high values of apparent resistivity observed middle portion of the AB/2 shows the presence of unconsolidated, dry sand at this depth. Very low resistivity values exist along the eastern margin of the study area are an indication of permeable sand formation with saline water. Clay lenses are also indicates the low resistivity values along the western margin of the study area

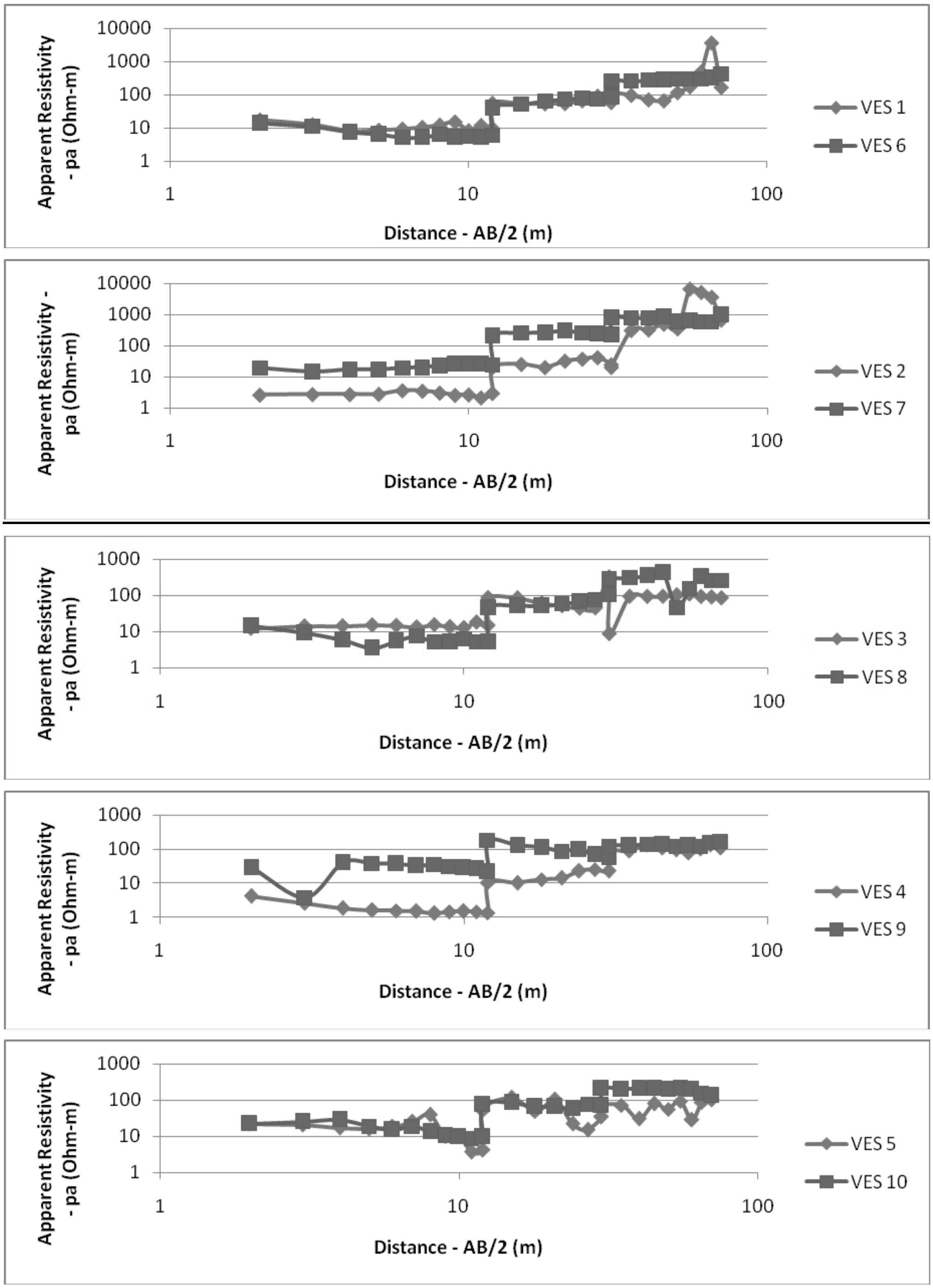

Fig. 4 Comparison of Resistivity profiles with same horizontal line of the study area

The detailed perusal of the ten resistivity curves indicate that low apparent resistivity values are observed in the all the ten locations. This indicates that denser saline water is observed in these regions. The saline water intruded into the freshwater aquifer in this region is cause for low resistivity values. The zone of low resistivity indicates the seawater intrusion in all profiles. The layers of unconfined coastal aquifer of the study area consists of alternate bands of Clay, Silt, Silty clay, Sandy clay and Sand are not evident in the sounding curves. Thus, it could be concluded that same horizontal line from the coast is intruded sea water with respective distance as shown in figure (4). The declination of resistivity with respective distance AB/2 shown in Table (2).

Table 2 Resistivity variation with distance

VES No	VES Location	Distance - AB/2 (m)	Resistivity - pa (Ohm-m)
1	Minjur	10	8.54
		45	67.09
		70	169.71
2	Kalpakkam	11	2.17
		18	20.323
		50	355.4
		70	671.38
3	Somanchery	10	12.6
		24	43.31
		60	91.51
4	Vanjivakkam	11	1.45
		55	77.47
		70	111.13
5	Siralapakkam	11	3.77
		18	49.46
		27	15.41
		40	30.91
		50	55.51
		60	28.93
6	Sanarapalayam	11	5.33
		27	71.9
7	Anuppampattu	24	257.69
		50	610.62
8	Matravedu	8	5.06
		11	5.09
		50	44.16
9	Vempedu	21	87.2
		50	119.3
10	Panapakkam	11	8.76
		24	57.74
		60	193.54

CONCLUSION

This study shows that geophysical methods can be used, not only for Groundwater potential measurements, but also for deciphering the freshwater- seawater interface in the coastal aquifer. Detailed geophysical survey of the study area shows the shallow groundwater table conditions in the aquifer are mostly affected by seawater intrusion. Geophysical information with available litholog indicates that clayey soil and silty sand are contaminated by salinity. The recharge to this unconfined aquifer is from rainfall and irrigation return flow. The authors would like to suggest the following strategies to prevent the deterioration of the aquifer-system of the coastal areas of this area will be controlled with the reduction and rearrangement of groundwater withdrawals or the injection of freshwater and maintenance of freshwater ridge above mean sea level.

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Identification and Mobility of Major Water Contaminants-Radionuclide and Metal in and Its Affected Area of the Tailing Ponds of Uranium Mines

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ABSTRACT

Protection of aquatic ecosystem from hazards radioactive and heavy metals contamination is of prime importance in the management of uranium mine and mill waste, which gives rise to potential long and short term health and environmental hazards. The present work is carried out as a part of the project seek to identify contamination levels of hazardous elements in the water body of the tailing ponds and its outlet channel of effluent treatment plant at Jaduguda uranium mine, Jharkhand. Geochemical analysis of the surface water has been undertaken to assess the quantity of toxic elements that are likely to contaminate and hazardous to the aquatic environment. After appropriate preparation, all samples were analyzed for total radionuclide (U, Cs, Sr, Pb Co, and As) and toxic metal (Cr, Hg, Zn, Fe, Mn, Cu, Ni, V, Ag, Al, Hg) by Inductively Coupled Plasma Mass Spectrometry (ICPMS). Relatively the highest concentration of elements in the water was found in contrasting sites of mine waste deposits. Comparison with the reference standards was estimated to assess the level of the contamination and the possible anthropogenic impact in water from the mining activity. Mainly three elements (i.e. U, Mn and Al) concentrations of TP and ETP waters exceed the threshold values and of CPCB water standards, implying significant input from the mining activity. Among the above elements, only 2-elements i.e. U (concentration of total U was found to vary from 0.00 to 4.40 $\mu g\ g^{-1}$) and Mn (concentration of total Mn was found to vary from 0.60 to 8.10 $\mu g\ g^{-1}$) were considered as major contaminants that need to be remedied. These results indicate that the enrichment of U and Mn beyond threshold and CPCB guidelines in downstream of ETP denotes significant contamination of the surface water leached from the tailing ponds.

Keywords: Water, Mine, Tailing pond, Metal, Radionuclide, Contamination.

INTRODUCTION

Extraction of minerals from mining and then milling to final minerals formulation will be the source of contamination of environmental resources mainly aquifers. A major environmental problem relating to mining processing in many parts of the world is discharge of contaminated water from the milling to impoundment pond and that leads continuous release of decant from abandoned mine tailing ponds (Banks, 1997, Pulles, 2005). It is wide acceptance that this release of contaminants from mine waste is responsible for costly environmental and socio-economic impacts, commonly known as acid mine drainage (AMD). While India has made significant progress in frameworks to address mine tailing pond closure and mine water management (Lal Singhi, 2010; V.P. Venugopalan, 2005), and the mining industry has changed its practices to conform to new legislation and regulations, vulnerabilities in the current system still remain.

Open or underground uranium mining waste leachate (AMD) is characterized by the possible contaminants are Vanadium, Chromium, nickel, Arsenic, Selenium, Strontium, Lead, and Uranium and elevated concentrations of iron, aluminium and manganese, raised levels of toxic heavy metals such as cadmium, cobalt, copper and zinc, and possibly even other radionuclides (Economopoulos AP, 1993; Akcil, 2006). AMD is not only with high acidity levels that dissolves salts and mobilizes metals from mine workings and released to surface and groundwater and residue deposits as pollution, but is also responsible for the degradation of soil quality, aquatic habitats and as pollution in the environment (Akcil, 2006; Adler, 2007). Major pollution sources associated with abandoned mine tailing ponds include the weathering of waste piles which produce large quantities of acid drainage of pH<3, discharge and dispose of the great amount of alkaline effluent with high content of fine ore tailing's particles of pH>12, the non point sources of pollution in mine area and seepage from the tailings impoundment. As well as discharges from the smelting processes in nearby smelters (Wang Zi-jian, 1999).

Uranium milling waste (tailings) containing hazardous contaminants such as radionuclides and heavy metals may be leached into the soil and enter into the environment is via the leaching of the metals from tailings and subsequent transport in the aquifer into surface and groundwater causing serious pollution that can last for many generations (S. Mishra, 2009; Bill Price, 1997). Protection from the hazards from radioactivity and water contamination is of prime importance in the management of uranium mine and mill waste. Such waste also contains non radiological contaminants (heavy metals and acids) which give rise to potential long and short term health, aquatic ecosystem and environmental hazards (B. N. Noller, 1991). AMD is the mining industry's greatest environmental problem, especially to our waterways and an acid-generating mine has the potential for long-term, devastating impacts on rivers, streams and aquatic life (Bill Price, 1997). If improperly secured, contaminants in mine waste can leach and release to the environment can result in profound, generally irreversible destruction of ecosystems. In many cases the polluted sites may never be fully restored, for pollution is so persistent that there is no available remedy (EEB, 2000). More than 2.2 million people, mostly in developing countries, die each year from diseases associated with poor water and sanitary conditions (WHO/UNICEF/WSSCC, Global Water Supply and Sanitation Assessment 2000 Report, P.V.). Freshwater ecosystems have been severely degraded: it is estimated that about half the world's wetlands have been lost, and more than 20 per cent of the world's 10 000 known freshwater species have become extinct, threatened or endangered (UN International Year of Freshwater Fact Sheet, 2003).

While Acid Mine Drainage is not the only threat to waterways from mining, it is the biggest threat, because - as one mining consultant explained - "the present state- of-the-art does not provide any universal solutions" for AMD (Gilles Coutrurier, 1996). Environmental degradation and a lack of clean water pose fundamental challenges to sustainable development. Socioeconomic advances cannot be sustained without clean air to breathe, safe water to drink, healthy soils for crops and livestock production and a clean and stable environment to support work and life.

Once a mine is in operation water protection must remain the highest goal of the company, even if it means reduced mineral productivity. Adopting this common sense ethic is the only way we can ensure that the golden dreams of mining do not turn into the nightmare of poisoned streams" (Carlos De Rosa, 1997). A WHO study shows that every US $1 invested in improved drinking water and sanitation services can yield economic benefits of US $4 to US $34 depending on the region. Not only is AMD treatment and collection very costly to the environment, it is a big bill for industry. According to T.D. Pearse Resource Consulting, "Site stabilization costs can be as high as $410,000 per hectare. The U.S. Bureau of Mines estimates that the US industry spends over $1 million each day to treat acidic mine water (T.D. Pearse Resource Consulting, "Mining and the Environment', 1996).

India is undergoing sustainable and rapid changes in its society and economic policies. Among various environmental problems, water pollution is one of the most critical issues facing India today. These pollutants poison aquatic organisms and accumulate in fish and other edible organisms, having a serious impact on human health. Metal mining and smelting in India have been a major concern for the environment protection.

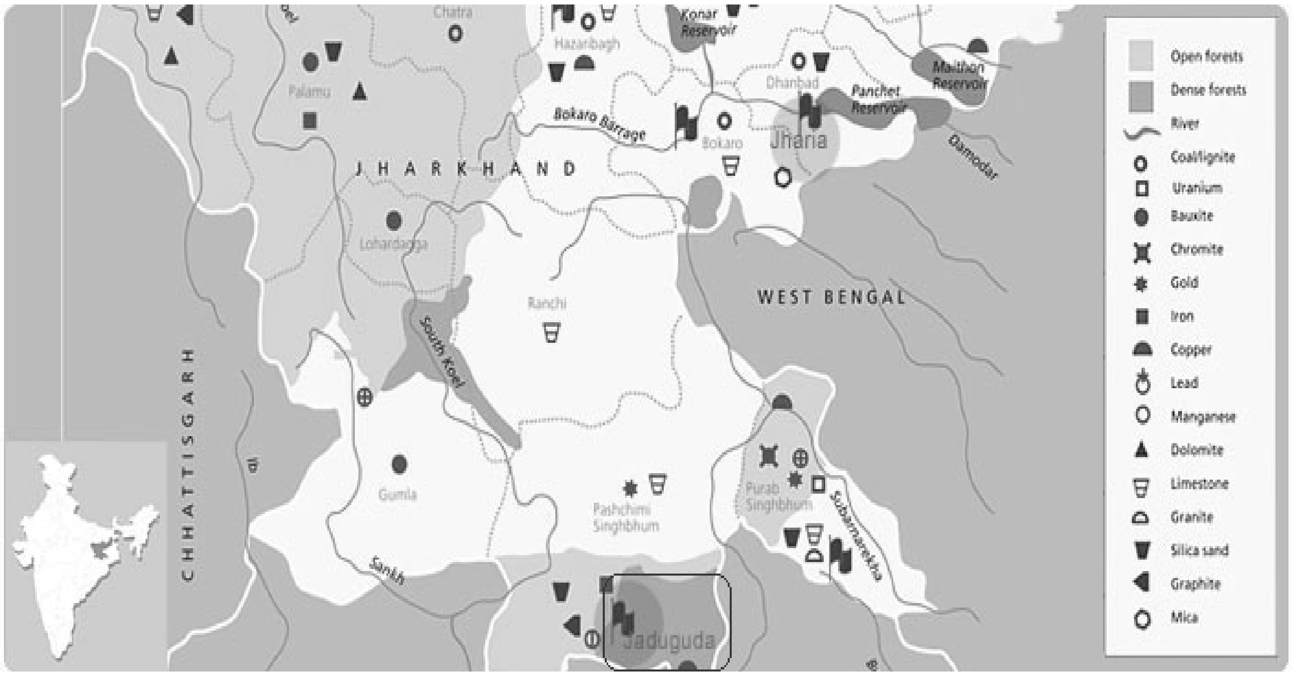

Fig. 1: Showing Jharkhand Uranium mining network, India

The Uranium tailing pond managed by the Uranium Corporation of India Limited (UCIL), located at Jadugoda in Sighbhum east district, Jharkhand is one of the largest Uranium mining and exploration in India (Figure-1: Jharkhand Uranium mining network) ((S.K. Basu, 2000; Hiroaki KOIDE, 2004). It has been the site of extensive mining and milling of uranium for over 4 decades (N K Sethy, 2011). Continuous operation since 1967 providing the basic raw material for the nuclear power program of the country (A. K. Sarangi, 2003). In the process of mining to the final formation of uranium in various interval periods, it generateslarge quantitiesy of hazardous waste that are mixed with water and disposed off in the form of slurry in vast areas of land called tailing pond (TP) adjoining the UCIL, commonly known as acid mine drainage (AMD). The present work, tailings and effluent samples were collected for the calculation of source concentration to confine the distribution and identification of radionuclide's and toxic elements in the surface hydrosphere of Uranium mine tailing ponds and its downstream channel.

MATERIALS AND METHODS

Site Description

In India, Jaduguda Uranium mine is located at 24 km south of Tatanagar, in Jharkhand State, India. The bulk of the ore processed emerges as tailings (residues from ore processing) and are pumped into a tailings pond (Fig – 2) (http://www.mapsofindia.com/; Hiroaki KOIDE, 2004). There are three valley-dam types of tailings ponds at Jaduguda. The first and second stages of the tailings pond are located adjacent to each other in a valley with hills on three sides and engineered embankments on downstream side of natural drainage. These two tailings ponds are filled up and now left abandoned. The third stage of the tailings pond which is currently in use is also located nearby in a similar setting. The precipitates settle down in the tailings pond and the clear liquid is continuous to decant from abandoned (closed) and active uranium mine tailing ponds through a series of decantation wells and the decanted effluent has subsequently been manifested at various stages to treat through effluent treatment plant (ETP). The treated AMD found its way into an adjoining natural water course through Gala River and flowed towards downstream and finally mixing into Suwarnarekha River (S. Mishra, 2009).

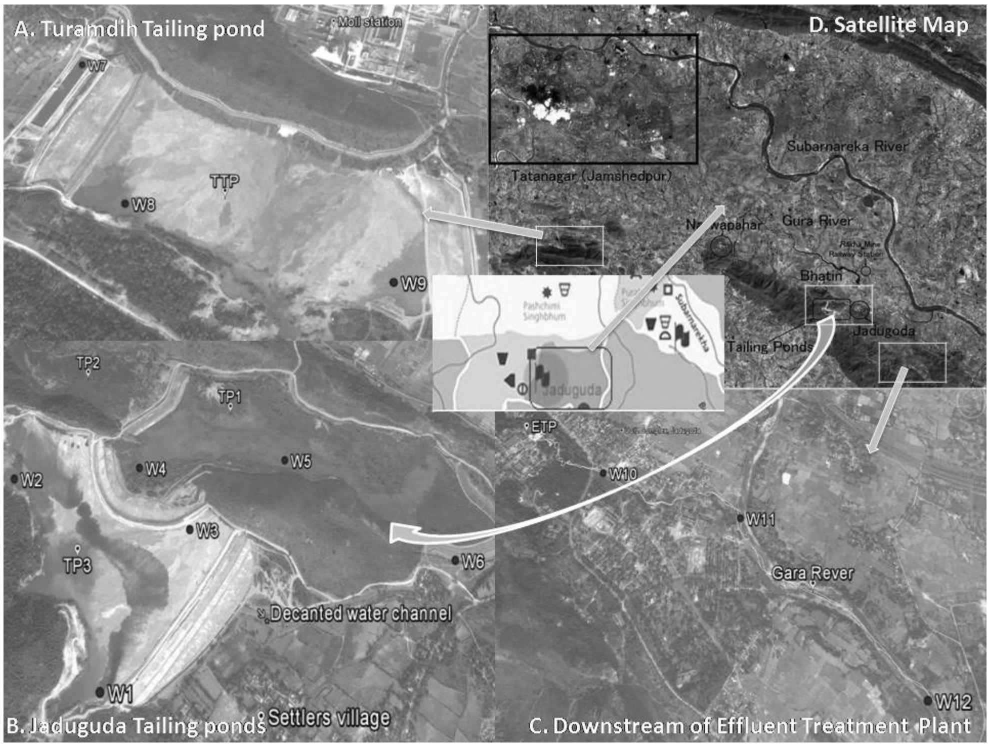

Fig. 2: Location Figure. B). On the upper right: main geological features (based on geological maps of India; Hiroaki KOIDE, 2004); A). TTP (On the upper left), C). JTP1 and JTP3 (bottom left) and D). ETP (bottom right) are the location of the main sampling points along with detail of the most impacted sector by mining activities.

Sampling locations and Sampling

Disposal of mine tailing wastes by landfill in the form of slurry is the most widely practiced method in the world including India. For the present study two open landfill (JTP & TTP) sites and an ETP were selected. Based on accessibility and available water sources, there were 9-sampling points were chosen in tailing pond (3-in Jaduguda TP-1, 3-in Jaduguda TP-3 and 3-in Turamdih TP) and 3-sampling points were chosen in ETP. A total of 5-time sampling have been doing from each sampling point in the month of March and September over a period of 3-years (2009-2010, 2010-2011 and 2011-2012) in every 5-month interval. Samples were collected according to standard methods and analyzed for physical and chemical parameters (NEERI, 1983). Duplicate sampling done at each different sampling point of the respective sites (Figure – 2; and also details in Table – 1).

Table 1: Details of sampling locations and sampling points

Locations	Major sampling point	Time	Sampling	Description of location
TP	Jaduguda TP-1 (JTP1)	Quarterly	5 time	Abandoned and left openly
	Jaduguda TP3 (JTP3)			Active and presently in use
	Turamdih TP (TTP)			Active and presently in use
ETP	Effluent Treatment Plant			Downstream channel of ETP
Pipe	Effluent inlet of TP			Effluent Inlet of TP-3
C (Control)	Rankini mandir trench	March	1 time	~2Km upstream of TP-3
	Chatikocha village			~1Km downstream of TP-3)
	Bhatin Village			~2Km upstream of TP-1)

Surface waters were sampled regularly (every 5-month) in March/April and September/October 2009-2010, 2010-2011 and 2011-2012. Water was collected according to standard methods ("Soil, Plant and Water analysis" by P.C. Jaiswal and "Practical Environmental Analysis" by Miroslav Radojecic available materials at BARC) and according to EPA (Sample Collection Procedures for Radiochemical Analytes in Environmental Matrices. December 2006 EPA/600/S-07/001). Samples of surface water were collected in pre-conditioned plastic carboys.

Instrumentation and Analytical Procedure

All reagents were of analytical grade. As soon as collected, pH and EC were measured in water before acidification for metal fixation. The pH of water samples was measured by electrode method using a pH meter (Following APHA 4500H and B protocols) and Electrical conductivity (EC) was measured by conductivity meter (Following APHA 2510B protocols). After collection, samples were transported to laboratory at Environment Protection Training and Research Institute (EPTRI) and stored in room and not exposed to light. Samples were filtered using whattman filter paper (No.1 filter paper-120 mm Ø) immediately after collection and preserved by acidification with 2 % (v/v) conc. 8N HNO3 (Soma Giri, 2007). Radionuclides and metals in the waters were determined by ICP-MS (PerkinElmer Sciex ELAN DRC II) using the international geostandard NIST-1640a at the Central Research Facility available at National Geophysical Research Institute (NGRI), Hyderabad (Friel, J.K., 1990). The international geostandard certified values of SO-1 (Govindaraju K, 1994) was used for standard references. Subsequently results were corrected using blanks.

TL (Threshold Limits)

Definition of Threshold Limits (TL) for identifying the water contaminants: Limits are most usefully defined in terms of the point or range of conditions beyond which the benefits derived from a natural resource system are judged unacceptable or insufficient (HAINES-YOUNG. R., 2006). There were definite reference standard (CPCB, WHO, CPHEEO, BIS, USSR and EPA) was already available for water. However, to identify the actual contaminants in the samples, the maximum value of control along with available stands need to be considered here as Threshold Limits or TL.

RESULTS AND DISCUSSION

Physico-chemical and characteristics of water samples:

The ranges of water chemical and physical values are shown in annexure – 2. Table-2 shows the average concentrations of Al, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, As, Sr, Cd, Pb and U and pH and EC in different sites of the three studied areas. The pH results of TP1, TP3, TTP and Pipe showed slightly acidic values varying from 5.8 to 6.7 and the pH of ETP water was neutral to slight alkali in nature. Except ETP, pHs for all sampling locations are falling below the pH of PL (Permissible Limits of CPCB), and it is also compared with C (Control samples) and it shown that the pH of all sampling locations were falling below the control values. The EC values also varied between samples, in a range from 3.33 to 6.00 µMohs/cm. The EC value of Pipe water followed by TP water was found significant higher than ETP water and all the samples are shown beyond the EC values of Permissible Limits of reference standards and Control (C) values or TL (Annexure – 1).

Table 2: Water sample analysis values (mean) of the Uranium tailing ponds and its affected areas.

Location	Parameters (metals in mg/kg and EC in mMohs/cm)															
	Al	**V**	**Cr**	**Mn**	**Fe**	**Ni**	**Co**	**Cu**	**Zn**	**As**	**Se**	**Sr**	**Cd**	**Pb**	**U**	**pH**	**EC**
TP1	0.00	0.00	0.00	8.10	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	1.80	6.40	5491
TP3	2.90	0.00	0.00	S	0.50	0.50	0.10	0.00	0.10	0.00	0.00	0.80	0.00	0.00	1.00	5.80	5990
TTP	0.40	0.00	0.00	3.70	0.50	0.10	0.00	0.20	0.00	0.00	0.00	0.60	0.00	0.00	4.40	6.70	4833
Pipe	0.50	0.00	0.00	S	0.50	0.20	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.10	6.60	6000
ETP	0.00	0.00	0.00	2.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.30	7.20	3333
C	0.37	0.02	0.29	0.56	2.08	0.04	0.12	0.00	0.14	0.04	0.12	0.29	0.00	0.13	0.00	8.37	1057
PL	0.20	0.20	2.00	2.00	3.00	3.00	1.00	3.00	5.00	0.20	0.10	4.00	2.00	0.10	0.00	7.00	2250
TL	0.37	0.20	2.00	2.00	3.00	3.00	1.00	3.00	5.00	0.20	0.12	4.00	2.00	0.13	0.02	7.25	2250

The average metal concentration of water from tailing ponds and its downstream areas has shown significantly higher concentration levels of certain heavy metals (Aluminum and Manganese) and radionuclides (Strontium and Uranium) than other metals. The very acidic samples (from TP3) were having high dissolved element concentrations then the samples with slight acidic or basic pH. But, the higher concentration of dissolved U has been seen in TTP even it is having near neutral pH. However, the control samples which background having a basic pH shown comparatively higher concentrations of Cr, Fe, Co, Zn, Se and Pb.

Spatial and statistical distribution elements

The behavior and bioavailability of the TEs and Spacial distribution of metals and radeonuclides in surface water of tailing ponds and its affected area (ETP) (are presented in Figure – 3) are controlled by pH and the decreases in pH, mobilize the significant amount of the metals (Bolormaa Oyuntsetseg, 2012 and X. Li, 2001). The concentration of V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb in water from all the sampling sites are comparable to the content found in control water samples of the unpolluted sites and also the values found below the CPCB permissible limits of 0.2, 2, 3, 3, 1, 3, 5, 0.2, 0.05, 4, 2 and 0.1 mg/kg respectively.

The concentration of Al in TP3 (average: 2.9 mg/kg) and Pipe (average: 0.5 mg/kg), Mn in all locations (average: 2.40 mg/kg to saturation level) and U in all locations (average: 0.1 to 4.4 mg/kg) were sown exceeding concentrations to the control water and also to the CPCB permissible limits. Mn is showing elevated levels of concentration in all tailing ponds i.e. up to the saturation (S. Mishra, 2009). The other metals were having very lower concentration than the TL.

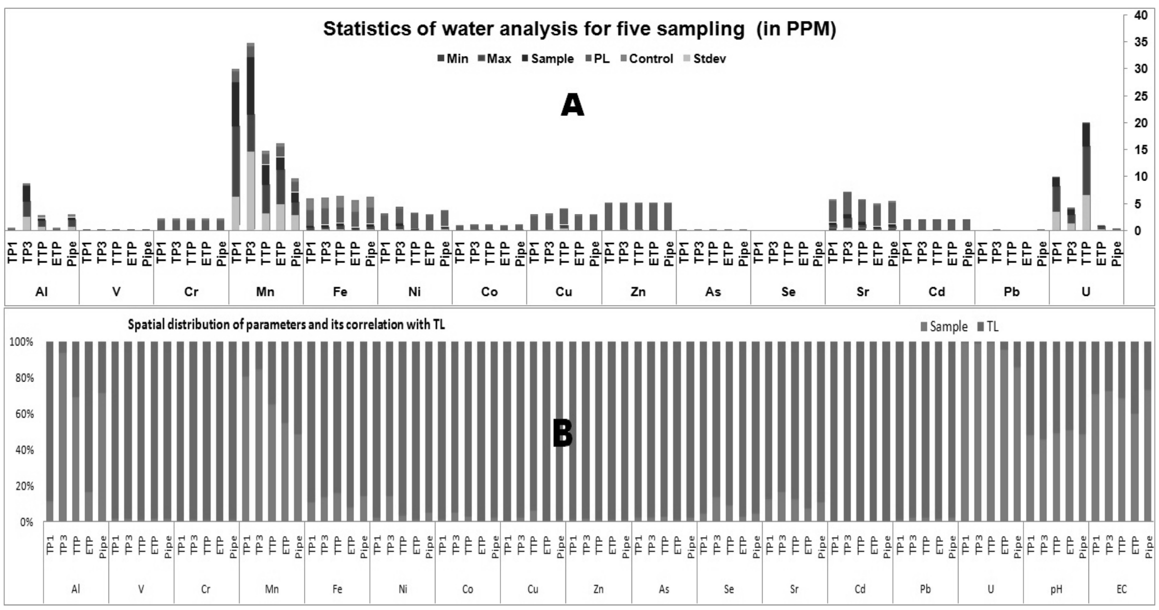

Fig. 3: Spatial distribution of elements in TP's and ETP. A. The statistical analysis; B. Correlation with TL value. BDL as below detection limits of the instrument.

The order of contaminants according to the control of hazardous elements in water was identified as follows

Mn > U > Al > Sr > Fe > Ni > Cu > Zn > Co > Cr > Se > As > V > Pb > Cd.

Sampling time and screening of contaminants:

In each individual sampling points, the analysis have been done following standard methods discussed above, compared with control values as well as permissible limits of CPCB standard simultaneously (range is presented in Annexure – 2). Metals and radionuclides which were exceeds their concentrations beyond the TL, subsequently were identifies as contaminants in each sampling locations (Table – 3 Figure – 4).

The average metal concentration of water from tailing ponds and its downstream areas after subsequent deduction of TL values were shown significant higher concentration levels of certain heavy metals (Aluminum and Manganese) and radionuclides (Strontium and Uranium) than other metals and remained all are falling under TL. The decreasing order of concentration (in mg/kg) of hazardous elements in sampling locations with reference to the TL are as follows.

TP1: Mn (6.10mg/kg) > U (1.78mg/kg) > Al (0.00mg/kg)

TP3: Mn (Sturation) > Al (2.49mg/kg) > U (0.96mg/kg)

TTP: U (4.42mg/kg) > Mn (1.70mg/kg) > Al (0.07mg/kg)

ETP: Mn (0.41mg/kg) > U (0.29mg/kg) > Al (0.00mg/kg)

Pipe: Mn (Sturation) > Al (0.12mg/kg) > U (0.05mg/kg)

Table 3: Elements found beyond and below the TL in each sampling locations in every sampling period or field trip (FT). Values which are found below the TL are not presented here.

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Field trip</th><th colspan="17">Parameters (in mg/kg)</th></tr>
<tr><th>pH</th><th>EC</th><th>Al</th><th>Mn</th><th>U</th><th>V</th><th>Cr</th><th>Fe</th><th>Ni</th><th>Co</th><th>Cu</th><th>Zn</th><th>As</th><th>Se</th><th>Sr</th><th>Cd</th><th>Pb</th></tr>
<tr><td rowspan="5">TP1</td><td>FT1</td><td rowspan="23">--</td><td>10525</td><td rowspan="6">--</td><td>18.4</td><td>8.17</td><td colspan="12" rowspan="25">-
- -Applicable to all sampling locations (TP1, TP3, TTP, ETP and Pipe)

TP1 & TP3: indicates Jaduguda tailing pond No-1 & 2 respectively

TTP: indicates Turamdih tailing pond

ETP: indicates Downstream channel of ETP

Pipe: indicates Effluent Inlet of TP-3

TL: indicates Threshold Limits value (permissible limits)

FT1, 2, 3, 4 & 5: indicates Field trip/sampling No-1, 2, 3, 4 & 5 respectively

-: Presented in columns of V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd & Pb: Indicates the concentration values were found below the TL concentration values.

S: Saturation concentration

EC: µMohs/cm

The values presented in columns of pH, EC, Al, Mn & U: indicates, the concentrations were exceeds the TL values</td></tr>
<tr><td>FT2</td><td>5710</td><td>--</td><td>0.06</td></tr>
<tr><td>FT3</td><td>4605</td><td>5.91</td><td>0.04</td></tr>
<tr><td>FT4</td><td>3687</td><td>7.49</td><td>0.63</td></tr>
<tr><td>FT5</td><td>2930</td><td>7.7</td><td>0.1</td></tr>
<tr><td rowspan="5">TP3</td><td>FT1</td><td>11100</td><td>--</td><td>2.87</td></tr>
<tr><td>FT2</td><td>5500</td><td>5.44</td><td rowspan="3">S</td><td>0.08</td></tr>
<tr><td>FT3</td><td>5450</td><td>2.98</td><td>--</td></tr>
<tr><td>FT4</td><td>4195</td><td>5.34</td><td>1.8</td></tr>
<tr><td>FT5</td><td>3707</td><td>0.48</td><td>21.2</td><td>0.18</td></tr>
<tr><td rowspan="5">TTP</td><td>FT1</td><td>9603</td><td>--</td><td>3.43</td><td>15.59</td></tr>
<tr><td>FT2</td><td>5023</td><td>1.84</td><td rowspan="2">--</td><td>5.74</td></tr>
<tr><td>FT3</td><td>4319</td><td rowspan="10">--</td><td>0.13</td></tr>
<tr><td>FT4</td><td>2770</td><td>4.93</td><td>0.65</td></tr>
<tr><td>FT5</td><td>2450</td><td>8.45</td><td>0.09</td></tr>
<tr><td rowspan="5">ETP</td><td>FT1</td><td>8480</td><td rowspan="3">--</td><td>0.55</td></tr>
<tr><td>FT2</td><td>--</td><td>0.17</td></tr>
<tr><td>FT3</td><td>2368</td><td>0.07</td></tr>
<tr><td>FT4</td><td rowspan="2">--</td><td>11.26</td><td>0.66</td></tr>
<tr><td>FT5</td><td>--</td><td>0.1</td></tr>
<tr><td rowspan="5">Pipe</td><td>FT1</td><td>9740</td><td>S</td><td>--</td></tr>
<tr><td>FT2</td><td>5700</td><td>5.31</td><td>0.24</td></tr>
<tr><td>FT3</td><td>5550</td><td>1.98</td><td>S</td><td rowspan="2">--</td></tr>
<tr><td>FT4</td><td>8.44</td><td>4560</td><td colspan="2" rowspan="2">--</td></tr>
<tr><td>FT5</td><td>--</td><td>4450</td><td>0.1</td></tr>
<tr><td colspan="2">TL</td><td>7.00</td><td>2250</td><td>0.20</td><td>2.00</td><td>0.00</td><td>0.2</td><td>2.0</td><td>3.0</td><td>3.0</td><td>1.0</td><td>3.0</td><td>5.0</td><td>0.2</td><td>0.1</td><td>4.0</td><td>2.0</td><td>0.1</td></tr>
</table>

In context of pH, only the pipe water at 4th sampling found beyond the TL and remaining all locations have found lower pH than the TL. For EC it is reversed and ETP in the 2, 4 and 5th sampling found below the TL and remained locations shown exceeding the EC then TL. In the ICPMS analysis results of metals and radionuclides, there are only 3 elements (Al, Mn and U) were found their exceeding concentrations and remaining the entire all 12 elements (V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb) were shown below or near to matching the TL of water standard. Of the 3 elements, Al found to be more concentrated in TP3 (FT2, 3, 4 and 5), TTP (FT2) and Pipe (FT1 and FT3) sampling locations and for Mn and U, it was shown all of the all sampling locations and in every sampling period.

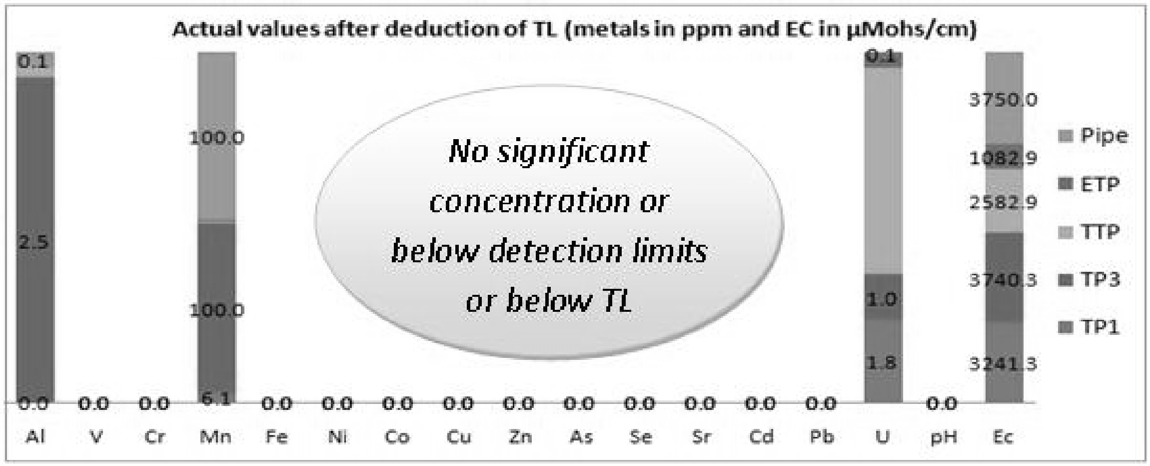

Fig. 4: Actual values after deduction of TL or identified contaminants in each sampling location.

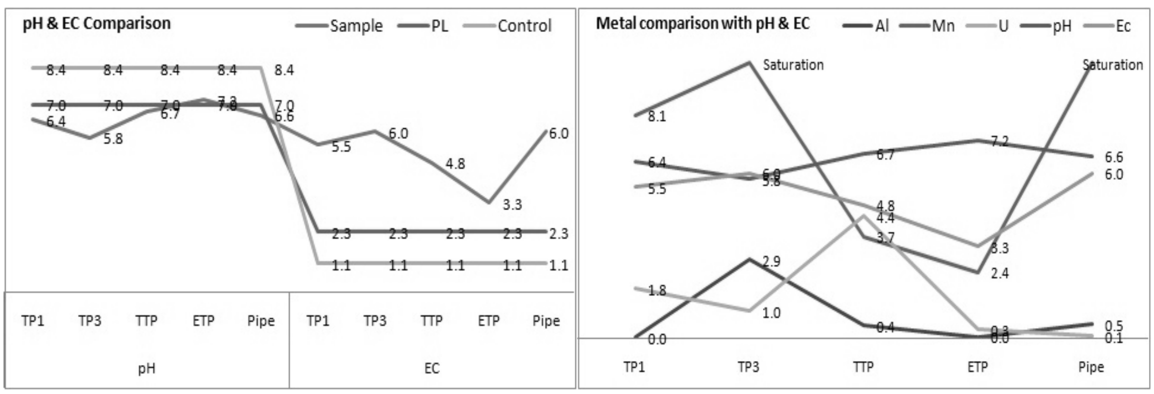

Fig. 5: Correlation of pH and EC effect in metal distribution and contamination in selected sampling locations.

pH and EC effect in metal distribution and contamination

The samples with acidic pH have shown increased available concentrations of Al, Mn and U elements (Figure – 5). The highest or the alkali pH in FT4 of the pipe sample was found non availability of elements and found below the TL of the water standards. TP3 samples with acidic pH and higher value of EC shown increased available concentrations of Al and Mn elements. Few samples from ETP with higher alkaline pH and lower EC were shown the decreased concentration of Al, Mn and U. In the context of higher EC in TP3 and Pipe sample were shown the increased concentration of Mn (Chart – 2 and 3). Hence therefore, there was a direct correlation of pH or EC with increasing or decreasing effect of elements have been seen in samples except few cases as described above. From the above analysis, pH might be one of the major parameters for above elemental availability.

Contaminants

The TP1 shown contaminants' of Mn (Range of 1.04 to 18.4mg/kg) and U (Range of 0.04 to 8.17mg/kg); TP3 was found with contaminants of Al (Range of 0.04 to 5.44mg/kg), Mn (Range of 0.33 to 21.2mg/kg) and U (Range of 0.08 to 2.87mg/kg); TTP was found with contaminants of Mn (Range of 0.11 to 8.45mg/kg) and U (Range of 0.09 to 15.59mg/kg); ETP was found with contaminants of U (Range of 0.07 to 0.66mg/kg) only and Pipe was found with contaminants of Mn (Range of 0.01 to 5.31mg/kg) and U (Range of 0.00 to 0.24mg/kg). The sampling locations with their Identified contaminants are as follows.

TP1 site: shown contamination of Mn and was found in FT1, FT3, FT4 and FT5 (range of 5.91 to 18.4mg/kg) and U was found in all the FT samples (range of 0.04 to 8.17mg/kg and 200 to 279mg/kg respectively). However, there were no contamination of Al, V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb have been detected in any of the FT samples.

TP3 site: also shown the contamination of Al and Mn and were found in FT2, FT3, FT4 and FT5 (range of 0.48 to 5.44mg/kg, and 0.33 to 21.20mg/kg and to saturation), U was found in FT1, FT2, FT4 and FT5 (range of 0.08 to 2.87mg/kg), and there were no significant contamination of V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb have been detected in any of the FT samples.

TTP site: shown the contamination of Al and was found only in FT2 (with an average of 1.87mg/kg), Mn was found in FT1, FT4 and FT5 (range of 3.43 to 8.45mg/kg), U was found in all the FT samples (range of 0.09 to 15.59mg/kg) and there were no significant contamination of V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb have been detected in any of the FT samples.

ETP site: shown the contamination of Mn and was found only in FT4 (with an average of 11.26mg/kg) and U was found in all the FT samples (range of 0.07 to 0.66mg/kg). There were no significant contamination of Al, V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb have been detected in any of the FT samples.

Pipe water: shown the contamination of Al and was found only in FT3 (with an average of 1.98mg/kg), Mn was found in FT1, FT2 and FT3 samples (range of 5.31mg/kg to saturation) and U was found in FT2 and FT5 samples (range of 0.1 to 0.24mg/kg). There were no significant contamination of V, Cr, Fe, Ni, Co, Cu, Zn, As, Se, Sr, Cd and Pb have been detected in any of the FT samples.

From the above analysis Uranium contaminant was found in all of the all sampling locations i.e. the highest concentration of Uranium contamination was seen in TTP followed by TP1 and TP3 and lower concentration of Uranium was seen in Pipe followed by ETP. Manganese contaminant was found in TP1, TP3, TTP and Pipe sampling locations i.e. the highest concentration of manganese concentration was seen in TP3 followed by TP1 and ETP and lower concentration of Manganese was seen in Pipe followed by TTP. Aluminum contaminant was found in only TP3, TTP and Pipe sampling locations i.e the higher concentration of aluminum concentration was seen in TP3 followed by Pipe and TTP and lower concentration of aluminum was seen in ETP followed by TP1 (Figure – 6).

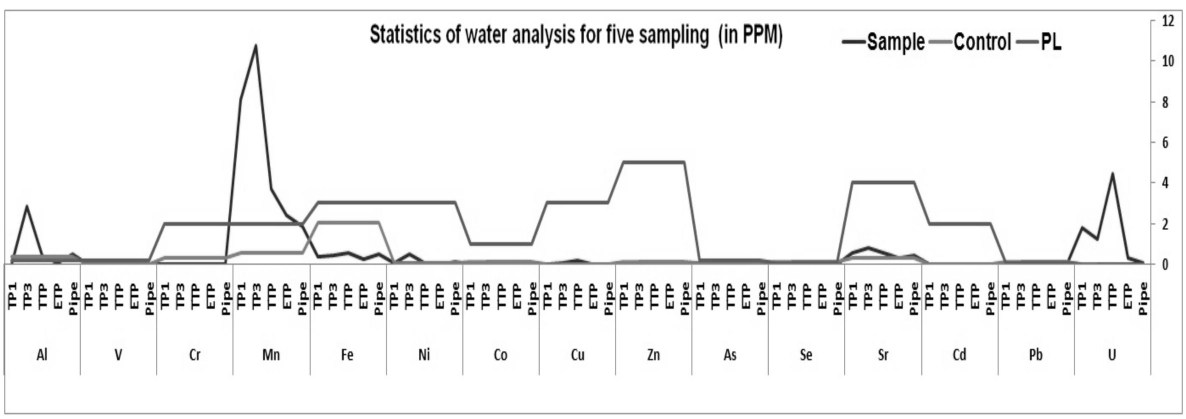

Fig. 6: Comparison of metal concentrations in water from five sampling sites JTP1, JTP3, TTP, ETP and Pipe water.

Therefore, by comparing the results with the reference standards and TL values, mainly three elements (U, Mn and Al) were identified to be higher (Chart – 2 and 4). The Identified contaminants with their average decreasing concentration order of sampling locations after subsequent deduction of TL values are as follows.

Al: TP3 (2.49mg/kg) > Pipe (0.12mg/kg) > TTP (0.07mg/kg) > ETP (-0.33mg/kg) > TP1 (-35mg/kg)

Mn: Pipe (Saturation) > TP3 (Saturation) > TP1 (6.1mg/kg) > TTP (1.7mg/kg) > ETP (0.41mg/kg)

U: TTP (4.4mg/kg) > TP1 (1.8mg/kg) > TP3 (1.0mg/kg) > ETP (0.3mg/kg) > Pipe (0.1mg/kg)

Samples with high Al concentration may due to aquatic process such as neutralization, precipitation, flocculation as well as adsorption occurred in the receiving water (Wang Zi-jian, 1999). And the samples with high Mn and U concentration may due to technical limitations that all of the uranium present in the ore cannot be extracted. Therefore, the sludge also contains 5% to 10% of the uranium initially present in the ore (Dr. Anne Shirinian-Orlando, 2007), hence the index of the contamination related to uranium mine is uranium ((Hiroaki KOIDE, 2004)). The samples with high Mn concentration may due addition of manganese dioxide or $KMnO_4$ used as oxidant in acid leaching uranium circuit and also common contaminates in the mining process (A. Mandal, 2005; E. R. Landa, 2003; S . Mishra, 2008).

Of the above three elements, only two elements: U and Mn were identified as major contaminants in the selected sites that need to be remedied. However, with reference to the range of TL exceedance, the order of contaminant enrichment was U > Mn > Al.

CONCLUSION

The present work describes the preliminary results of spread of Hazardous elements in surface water around Uranium mine tailing pond area. It shows that surface water was identified as the vector for potential harmful elements transport; as a consequence, the contamination was obvious downstream from the mine. As indicated by the strongly exceeded water guideline values for human consumption, which can cause multiple and very serious effects on the environment, and furthermore to human health. Mainly Mn (TP1: 1.04 tp 18.4mg/kg; TP3: 0.33mg/kg to saturation; TTP: 0.11 to 8.45; ETP: 0.003 to 11.26mg/kg and Pipe 0.01mg/kg to saturation) and U (TP1: 0.04 tp 8.17mg/kg; TP3: 0.08 to 2.287mg/kg; TTP: 0.09 to 15.59; ETP: 0.07 to 0.66mg/kg and Pipe 0.00 to 0.24mg/kg) concentrations were found to be highly enriched, relative to background levels. In surface waters of JTP, TTPs and downstream ETP with an average concentration of Mn (943 to saturation, 3.70mg/kg and 2.41mg/kg respectively) and U (1.51, 4.44 and 0.31mg/kg respectively). Acidic conditions (i.e. TPs and Pipe) were identified as a main control on high dissolved element concentrations and lower pH in surface waters (i.e. downstream ETP) favored the high concentrations of Mn followed by U.

AMD is the main source of water pollution in the area. Hence, initial remediation must focus on sealing the main mine galleries to avoid water percolation and limit acid mine drainage. This effort will mainly act to reduce the element release of mining wastes along the valley. However detailed study has to be carried out to assess ecological implicit of heavy metal pollution in the aquatic ecosystem, chemical, biological and ecological assessment and integration of this multi disciplinary knowledge are needed for more accurate prediction. Anticipate the consequences of pollution, not only above information but also major environmental and eco-toxicological processes need to identify the connection between pollution and its ecological implications.

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ANNEXURE

Annexure – 1

Definition of Threshold Limits (TL) for identifying the water contaminants

Definition of Threshold Limits (Values in mg/kg)									
S. No.	Analyte	Threshold limits (TL)	Control Conc.	Permissible limits (PL)					
				CPCB	WHO	CPHEEO	BIS	USSR	EPA
1	Al	0.37	0.37	-	0.20	-	0.03	-	-
2	V	0.20	0.02	0.20	-	-	0.20	-	-
3	Cr	2.00	0.29	2.00	0.05	0.05	0.05	-	-
4	Mn	2.00	0.56	2.00	0.40	0.05	0.10	-	-
5	Fe	3.00	2.08	3.00	0.30	0.10	0.30	-	-
6	Ni	3.00	0.04	3.00	-	-	3.00	-	-
7	Co	1.00	0.12	-	-	-	-	1.00	-
8	Cu	3.00	0.00	3.00	1.00	0.05	0.05	-	-
9	Zn	5.00	0.14	5.00	5.00	5.00	5.00	-	-
10	As	0.20	0.04	0.20	0.01	0.05	0.05	-	-
11	Se	0.12	0.12	0.05	0.01	0.01	0.01	-	-
12	Sr	4.00	0.29	-	-	-	-	-	4.00
13	Cd	2.00	0.00	2.00	0.00	0.01	0.01	-	-
14	Pb	0.13	0.13	0.10	0.05	0.10	0.05	-	-
15	U	0.02	0.00	-	0.02	-	-	-	-
16	pH	5.5-9.0	8.37	5.5-9.0	6.5-8.5	7.0-8.5	6.5-8.5	-	
17	EC	2250.00	1057.00	2250.00	-	-	3000.00	(micromhos/cm)	
CPCB- Central Pollution Control Board (Inland surface water) http://www.appcb.ap.nic.in/Env-Standards/cat_in_unitop/lga33.htm									

Contd…

BIS- Bureau of Indian Standards
CPHEEO- Central Public Health and Environmental Engineering Organization
EPA - Environmental Protection Agency, US
WHO- World Health Organization
USSR- Union of Soviet Socialist Republics
Control: Rankini mandir/Rainibeda/Bhatin/Chatikocha/Thilaitand water samples results

Annexure – 2

The range and average metals and radionuclide values (in mg/kg), and pH and EC (in µMohs/cm) in water samples from the Uranium tailing ponds and its affected areas.

Water Samples Values in Ranges in mg/kg							
Metal	**Location**	**Min**	**Max**	**Avg**	**Stdev**	**PL**	**Control**
Al	TP1	0.00	0.07	0.02	0.03	0.20	0.37
	TP3	0.04	5.44	2.86	2.57	0.20	0.37
	TTP	0.02	1.84	0.44	0.78	0.20	0.37
	ETP	0.01	0.07	0.04	0.03	0.20	0.37
	Pipe	0.04	1.98	0.49	0.83	0.20	0.37
V	TP1	0.00	0.00	0.00	0.00	0.20	0.02
	TP3	0.00	0.00	0.00	0.00	0.20	0.02
	TTP	0.00	0.00	0.00	0.00	0.20	0.02
	ETP	0.00	0.00	0.00	0.00	0.20	0.02
	Pipe	0.00	0.00	0.00	0.00	0.20	0.02
Cr	TP1	0.00	0.02	0.00	0.01	2.00	0.29
	TP3	0.00	0.01	0.01	0.01	2.00	0.29
	TTP	0.00	0.02	0.01	0.01	2.00	0.29
	ETP	0.00	0.02	0.01	0.01	2.00	0.29
	Pipe	0.00	0.02	0.01	0.01	2.00	0.29
Mn	TP1	1.04	18.40	8.10	6.35	2.00	0.56
	TP3	0.33	S	10.76	14.76	2.00	0.56
	TTP	0.11	8.45	3.70	3.23	2.00	0.56
	ETP	0.00	11.26	2.41	4.96	2.00	0.56
	Pipe	0.01	S	1.88	2.98	2.00	0.56
Fe	TP1	0.00	0.55	0.35	0.21	3.00	2.08
	TP3	0.00	0.65	0.46	0.26	3.00	2.08
	TTP	0.01	0.86	0.54	0.34	3.00	2.08
	ETP	0.00	0.39	0.24	0.15	3.00	2.08
	Pipe	0.00	0.82	0.48	0.30	3.00	2.08
Ni	TP1	0.02	0.06	0.04	0.02	3.00	0.04
	TP3	0.01	0.88	0.48	0.37	3.00	0.04
	TTP	0.01	0.24	0.09	0.09	3.00	0.04
	ETP	0.00	0.03	0.01	0.01	3.00	0.04
	Pipe	0.00	0.68	0.15	0.30	3.00	0.04

Contd…

Water Samples Values in Ranges in mg/kg							
Metal	**Location**	**Min**	**Max**	**Avg**	**Stdev**	**PL**	**Control**
Co	TP1	0.00	0.01	0.00	0.01	1.00	0.12
	TP3	0.00	0.09	0.05	0.04	1.00	0.12
	TTP	0.00	0.10	0.02	0.04	1.00	0.12
	ETP	0.00	0.00	0.00	0.00	1.00	0.12
	Pipe	0.00	0.08	0.02	0.04	1.00	0.12
Cu	TP1	0.00	0.01	0.00	0.00	3.00	0.00
	TP3	0.00	0.11	0.05	0.05	3.00	0.00
	TTP	0.00	0.91	0.19	0.41	3.00	0.00
	ETP	0.00	0.00	0.00	0.00	3.00	0.00
	Pipe	0.00	0.03	0.01	0.01	3.00	0.00
Zn	TP1	0.00	0.05	0.02	0.02	5.00	0.14
	TP3	0.04	0.09	0.06	0.02	5.00	0.14
	TTP	0.00	0.10	0.04	0.04	5.00	0.14
	ETP	0.01	0.08	0.02	0.03	5.00	0.14
	Pipe	0.00	0.05	0.02	0.02	5.00	0.14
As	TP1	0.00	0.01	0.00	0.00	0.20	0.04
	TP3	0.00	0.01	0.00	0.00	0.20	0.04
	TTP	0.00	0.01	0.00	0.00	0.20	0.04
	ETP	0.00	0.00	0.00	0.00	0.20	0.04
	Pipe	0.00	0.01	0.00	0.00	0.20	0.04
Se	TP1	0.00	0.01	0.00	0.00	0.05	0.12
	TP3	0.00	0.02	0.01	0.01	0.05	0.12
	TTP	0.00	0.01	0.00	0.00	0.05	0.12
	ETP	0.00	0.00	0.00	0.00	0.05	0.12
	Pipe	0.00	0.00	0.00	0.00	0.05	0.12
Sr	TP1	0.42	0.63	0.54	0.10	4.00	0.29
	TP3	0.37	1.92	0.78	0.65	4.00	0.29
	TTP	0.42	0.70	0.56	0.11	4.00	0.29
	ETP	0.10	0.38	0.29	0.11	4.00	0.29
	Pipe	0.28	0.57	0.46	0.14	4.00	0.29
Cd	TP1	0.00	0.00	0.00	0.00	2.00	0.00
	TP3	0.00	0.00	0.00	0.00	2.00	0.00
	TTP	0.00	0.00	0.00	0.00	2.00	0.00
	ETP	0.00	0.00	0.00	0.00	2.00	0.00
	Pipe	0.00	0.00	0.00	0.00	2.00	0.00
Pb	TP1	0.00	0.00	0.00	0.00	0.10	0.13
	TP3	0.00	0.00	0.00	0.00	0.10	0.13
	TTP	0.00	0.00	0.00	0.00	0.10	0.13
	ETP	0.00	0.00	0.00	0.00	0.10	0.13
	Pipe	0.00	0.00	0.00	0.00	0.10	0.13

Contd…

Water Samples Values in Ranges in mg/kg							
Metal	**Location**	**Min**	**Max**	**Avg**	**Stdev**	**PL**	**Control**
U	TP1	0.04	8.17	1.80	3.57	0.02	0.00
	TP3	0.08	2.87	1.23	1.34	0.02	0.00
	TTP	0.09	15.59	4.44	6.67	0.02	0.00
	ETP	0.07	0.66	0.31	0.27	0.02	0.00
	Pipe	0.00	0.24	0.09	0.11	0.02	0.00
pH	TP1	5.20	7.08	6.42	0.73	7.00	8.37
	TP3	4.83	7.28	5.77	0.94	7.00	8.37
	TTP	5.86	7.45	6.71	0.62	7.00	8.37
	ETP	6.80	7.90	7.18	0.44	7.00	8.37
	Pipe	3.87	8.44	6.60	1.78	7.00	8.37
EC	TP1	2930	10525	5491	3000	2250	1057
	TP3	3707	11100	5990	2961	2250	1057
	TTP	2450	9603	4833	2872	2250	1057
	ETP	1616	8480	3333	2891	2250	1057
	Pipe	4450	9740	6000	2165	2250	1057

Physico Chemical Assessment and Comparison of Quality of Underground Drinking Water at Periodic Interval in the Village of Srikurmam, Gara Mandal in Srikakulam District, Andhra Pradesh, India

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ABSTRACT

Safe drinking water is essential to the protection of public health and well-being of citizens. Clean safe and adequate fresh water is vital to the survival of all living organisms and the smooth functioning of ecosystems, communities and economies. Ground water is the one of the major sources of water for drinking, agricultural and industrial needs. Drinking water affects the health of human beings due to the presence of various chemical constituents. Therefore, every person should have the minimum knowledge of quality of drinking water. The subject of the quality of water in village of Srikurmam in Gara mandal of Srikakulam district, Andhra Pradesh is taken up for the study. An attempt is made to investigate the physico-chemical parameters of ground water on seasonal base and its comparison. The results in this presentation are reported and comparison on the seasonal base like June 2011, July 2012 , July 2013 and in the month of May 2014. The results obtained are related to electrical conductivity, pH, turbidity, total dissolved solids, total hardness, calcium and magnesium hardness, chlorides, alkalinity, fluorides, nitrites, dissolved oxygen, phosphates, phenol, metals like iron, Zinc, Cadmium, Cobalt, Nickel, Lead and Copper. The results obtained are compared with standards of World Health Organization (WHO) and Bureau of Indian Standards (BIS) for suitability of water for potable purpose. Finally, the results indicate that the water at Srikurmam is not fit for drinking without using a standard purification method.

INTRODUCTION

Water is a natural resource that sustains the necessary needs of all living creatures. It is not only for drinking and it plays a vital role in various sectors as in the form of an essential Engineering material. It is required for sustaining all forms of life, food production, economic development of industry and agriculture. The water eco system has perceptibly altered in several respects in recent years[1] and as such they are exposed to all local disturbances regardless of where they occur.

Water is the elixir of life and plays a vital role in the earth’s ecosystem. It is one of the most critical, scarce, precious and replenishable natural resources which cannot be created[2]. Water sources exist mainly in the form of surface water (like seawater, rainwater, ponds, lakes, rivers, glaciers etc...) and ground water. Groundwater serves as a vital source for domestic, agricultural and Industrial uses. It is an important source of drinking water, but now a day it is polluted in most areas due to increased human population, industrialization, use of fertilizers in agriculture and manmade activities[3]. Physical, chemical and biological characteristics determine the quality of water. The quality of ground water is very important for the survival of living beings.

Ground water is the major source of drinking water in both urban and rural India. Population requires cleaner water for better living conditions. In this aspect, we are continuously observing the quality of underground water in Srikurmam, Gara Mandal of Srikakulam district, Andhra Pradesh. In this paper, the authors present the results related to the analysis of quality of underground water for drinking purpose in Srikurmam, Srikakulam district in Andhra Pradesh.

Experiment

Study area: Srikurmam village is located approximately 13 kilometers east of Srikakulam town near Bay of Bengal and is in the Gara Mandal of Srikakulam District, Andhra Pradesh, India. Srikurmam is located at latitude of 18° 16' N, longitude of 84° 1' E and an altitude of 17 meters (59 feet).

***Water sampling*:** The groundwater samples are collected as per the standard manner[4] in the month of June 2011, July 2012, July 2013 and of May 2014. After sample collection, they are either analyzed immediately for various parameters or preserved safely by taking care with suitable standard precautions to avoid deterioration/ alterations. The list of sample collection places in Srikurmam are given in the Table 1.

Table 1 Areas of sample collection in Srikurmam

S.No	Sample no.	Location of sample	Source
1	1	Brahmin Street	Bore Water
2	2	Kurmanatha Temple opposite	Bore Water
3	3	Vyshnavi Street	Bore Water
4.	4	Near Bus Stand	Bore Water
5	5	Secondary Government School	Bore Water
6	6	Karnala Street	Bore Water
7	7	Karnala Street	Well Water
8	8	Kandra Street	Bore Water
9	9	Market Street	Bore Water
10	10	Devara Street	Bore Water
11	11	Segidipeta	Bore Water
12	12	Indiranagar colony	Bore Water
13	13	Velama Street	Well Water
14	14	Panchayati office	Well Water
15	15	Bankers colony(Pratap house)	Bore Water

***Instruments used*:** The following instruments are used to analyze various constituents present in ground water samples. Atomic Absorption Spectrometer (AAS) (PerkinElmer), UV-Visible Double beam Spectrophotometer(Model AU – 2701,, Systronics), Digital pH meter (Model 335, Systronics), Nefleometer (Model 132, Systronics), Digital Conductometer(Model 306, Systronics), Micro processor based bunch P^H / Ion meter, Cyber scan 2100, Eutech instruments (USA) with fluoride sensitive electrode.

Chemicals used: All the following Chemicals used are of Analytical Reagent Grade (Merck, BDH and Qualigens) and all the solutions are prepared by using triply distilled water and water without carbon dioxide is used when required. The following solutions are used for analysis and wherever standard solutions are required, the standardization methods[5] are followed. The list of chemicals follows:

Potassium hydrogen phthalate, Potassium hydrogen phosphate, Potassium dihydrogen phosphate, Calcium Carbonate, EDTA, Na_2CO_3, HCl, NaCl, $AgNO_3$, Sodium oxalate, Potassium permanganate, Ferrous Ammonium sulphate, $K_2Cr_2O_7$, APDC (Ammonium 1- pyrolidiene dicarbomate), MIBK (Methyl Isobutyl ketone) and concentrated HNO_3, Hypo, 10 % $BaCl_2$, 10% KI , 1000 ppm of fluoride and Nitrite solution, stock phenol solution, 4-aminoantipyrine, Potassium ferricyanine, chloroform, Borax buffer, Ammonium chloride-ammonium hydroxide buffer solution, TISAB Buffer, $AgNO_3$ – Nitric acid reagent, Vanadate – molybdate reagent, 0.5% Sulphanalamide reagent and indicators of phenolphthalein, methyl orange, EBT, Muroxide, K_2CrO_4 and 1% Starch.

Procedures of estimation of various constituents in water

For estimation of following various components present in the groundwater samples are followed by the standard methods

Estimation of pH and Electrical conductivity:

The pH and electrical conductivity of all water samples are measured by using digital pH meter and conductivity meter.

Estimation of total dissolved solids:

100 ml of sample water is taken into a clean porcelain dish and heated at 180 ± 2 ^{0}C up to dryness and it is cooled to room temperature and finally placed in a desiccator for complete removal of any moisture present in

it. After that from the obtained weight, the amounts of total dissolved solids in the samples are determined by using appropriate formula.

Determination of Total hardness, Calcium and Magnesium:

The known volume of water samples are titrated in presence of Ammonia Buffer against standard EDTA. The Calcium in the water samples are estimated by using same concentration of EDTA in presence of KOH buffer solution. Finally, the Magnesium content in the samples is estimated.

Estimation of Chlorides:

Known volume of water samples are titrated in presence of Potassium Chromate indicator against the standard Silver Nitrate solution.

Determination of Total alkalinity:

Using phenolphthalein and methyl orange indicators, the total alkalinity in water samples is estimated with standard HCl.

Estimation of Sulphates:

Known volume of water samples are taken and these are adjusted to a pH value of 4.5 to 5.0 by dilute HCl and these samples are heated up to desired conditions, while in hot, 10% $BaCl_2$ solution is added till a white precipitate is obtained and the precipitate is separated by Whatman no. 42 filter paper and is dried and weighed.

Estimation of fluoride:

Water samples are added with 5 ml of TISAB buffer in a polythene container and then the concentration of fluoride in the samples are estimated by ion analyzer.

Estimation of Sodium and Potassium:

Sodium and Potassium content in water is determined in ppm by Flame photometer.

Estimation of Nitrites:

Known volume of water samples are added with 2 ml of a reagent mixture of 0.5% of Sulphanalamide and 0.3% of N-(1-napthyl)-ethylenediamine dihydrochloride and the concentrations of nitrites in the samples are directly measured at 583 nm by UV-Visible Spectrophotometer.

Determination of Turbidity:

After calibration of the Nefleometer with standard solutions, after that the turbidity of the water samples are directly measured.

Extraction of metals:

In the water samples the metals like Iron. Zinc, Copper, Cadmium, Nickel, Cobalt and Lead are estimated by Atomic Absorption Spectrometer (AAS). The metals in the samples are extracted with APDC (Ammonium 1-Pyrolidine Dicarbamate), MIBK (Methyl Isobutyl ketone) and Concentrated. Nitric acid. After extraction of these metals, the concentrations are estimated by AAS.

Based on the results obtained in Periodic intervals (Table 2, 3, 4 and 5) the analyzed parameters are compared with the values of WHO[6]and BIS[7] to know the quality of water. In all periodic intervals (June 2011, July 2012, July 2013 and in the month of May 2014) an individual base compares the each analyzed parameters and we are identified they maintains the same/nearer values in the respective interval times. Many parameters do not match desired limits of potable parameters as per standard guidelines of WHO[6] and BIS[7]. Therefore, the underground water at Srikurmam in almost all areas is not suitable for drinking. Hence, the authors attempted to know the possibility of removal of hardness from the samples by using a conventional method such as boiling. It is not helpful in any manner i.e. the obtained results after boiling, clearly indicates that the rate of decreasing of hardness is very less in the chosen samples. It clearly indicates that the underground water in Srikurmam has a characteristic property of more permanent hardness than temporary hardness. In addition, the remaining parameters such as TDS, Ca, Mg, Chloride, alkalinity and other parameters are also high in this area. However, the metals like Fe, Zn, Cu, Cd, Ni, Co and Pb are within the range as per standards of WHO[6].

Table 2 Values of various constituents present in the water samples (June 2011)

Sample No.	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_3^-	Sulphate	Phosphate	Phenol
1	7.18	4580	0.08	2514	948	609	92	92	0.23	407	2.78	689	21	Nil
2	7.11	4360	0.12	3060	609	790	136	108	0.39	417	0.04	598	15	Nil
3	7.16	4160	0.06	2092	590	647	132	76	0.47	359	0.016	521	21	Nil
4	7.08	3360	0.21	2400	490	809	158	99	0.36	363	2.79	370	18	Nil
5	7.19	3540	0.02	1719	339	567	128	60	0.22	304	0.02	440	16	Nil
6	7.01	5540	0.10	4208	157	1302	104	263	0.22	780	0.49	353	24	Nil
7	7.13	5890	0.09	4482	490	1307	229	176	0.44	850	0.29	407	23	Nil
8	7.29	1030	0.05	216	387	414	151	89	0.53	76	Nil	177	16	Nil
9	7.18	2970	0.23	1627	442	953	130	151	0.68	367	0.046	517	19	Nil
10	7.19	1120	0.04	546	339	390	91	39	0.68	87	0.046	161	14	Nil
11	7.12	1040	0.06	151	351	365	132	16	0.46	101	Nil	206	16	Nil
12	7.03	2820	0.07	2114	460	1023	126	170	0.71	421	0.017	253	19	Nil
13	7.12	3180	0.13	1156	545	716	945	115	0.43	446	Nil	236	20	Nil
14	7.38	0980	0.07	110	375	348	56	50	0.53	95	Nil	320	21	Nil
15	7.23	2280	0.03	835	333	544	110	65	0.79	198	0.080	402	16	Nil

Sample No	**Values of some Metals in the water samples(June 2011)**						
	Fe	Zn	Cu	Cd	Ni	Co	Pb
1	0.045	0.063	0.015	0.008	Nil	Nil	Nil
2	0.052	0.066	0.014	0.007	Nil	Nil	Nil
3	0.041	0.202	0.021	0.007	Nil	Nil	Nil
4	0.173	0.166	0.019	0.007	Nil	Nil	Nil
5	0.121	0.054	0.016	0.007	Nil	Nil	Nil
6	0.037	0.033	0.022	0.007	Nil	Nil	Nil
7	0.034	0.059	0.013	0.007	Nil	Nil	Nil
8	0.038	0.043	0.016	0.007	Nil	Nil	Nil
9	0.030	0.133	0.013	0.007	Nil	Nil	Nil
10	0.064	0.035	0.013	0.007	Nil	Nil	Nil
11	0.031	0.038	0.013	0.007	Nil	Nil	Nil
12	0.111	0.038	0.012	0.007	Nil	Nil	Nil
13	0.082	0.184	0.054	0.015	Nil	Nil	Nil
14	0.106	0.103	0.028	0.015	Nil	Nil	Nil
15	0.224	0.098	0.016	0.007	Nil	Nil	Nil

Except EC and Turbidity remaining all are expressed in terms of ppm units, EC in µmhos/cm^2 and Turbidity in NTU

Table 3 Values of various constituents present in the water samples (July 2012)

Sample No.	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_3^-	Sulphate	Phosphate	Phenol
1	7.40	3070	0.11	2412	1090	419	91	46	0.52	618	1.89	571	22	Nil
2	7.07	3250	0.16	2589	781	628	140	66	0.65	704	0.02	307	14	Nil
3	7.11	3180	0.09	1894	732	493	97	60	0.63	568	0.01	321	19	Nil
4	7.61	2420	0.26	3808	401	511	81	72	0.77	614	2.23	175	15	Nil
5	7.18	3260	0.32	1788	368	487	255	87	0.2	430	0.02	455	17	Nil
6	7.04	4940	0.16	4110	946	884	163	114	0.67	118	0.28	423	21	Nil
7	7.14	5440	0.12	4916	710	944	186	115	0.61	133	0.21	323	22	Nil
8	6.98	2070	0.09	1637	500	202	40	25	0.45	128	0.001	172	15	Nil
9	7.09	2070	0.28	1961	649	493	79	71	0.87	409	0.02	258	18	Nil
10	7.17	1050	0.08	1706	484	330	69	37	0.99	162	0.043	133	16	Nil
11	7.06	1020	0.09	1516	633	287	58	34	0.82	119	0.02	202	14	Nil
12	7.23	3100	0.06	2234	486	113	201	178	0.81	375	0.02	266	18	Nil
13	7.33	2960	0.18	1081	693	539	108	65	0.85	690	Nil	149	18	Nil
14	7.55	1010	0.04	588	467	269	454	37	0.87	121	Nil	482	19	Nil
15	7.25	1840	0.08	2403	539	490	79	70	0.89	387	Nil	474	18	Nil

Values of some Metals in the water samples(July 2012)

Sample No	Fe	Zn	Cu	Cd	Ni	Co	Pb
1	0.035	0.013	0.010	0.002	Nil	Nil	Nil
2	0.043	0.066	0.043	0.023	Nil	Nil	Nil
3	0.052	0.232	0.024	0.054	Nil	Nil	Nil
4	0.181	0.174	0.032	0.065	Nil	Nil	Nil
5	0.129	0.062	0.065	0.006	Nil	Nil	Nil
6	0.032	0.041	0.054	0.065	Nil	Nil	Nil
7	0.029	0.061	0.055	0.067	Nil	Nil	Nil
8	0.041	0.047	0.065	0.008	Nil	Nil	Nil
9	0.037	0.134	0.018	0.009	Nil	Nil	Nil
10	0.072	0.039	0.06	0.007	Nil	Nil	Nil
11	0.03	0.041	0.041	0.008	Nil	Nil	Nil
12	0.123	0.039	0.045	0.006	Nil	Nil	Nil
13	0.065	0.179	0.087	0.017	Nil	Nil	Nil
14	0.178	0.187	0.028	0.013	Nil	Nil	Nil
15	0.228	0.111	0.019	0.007	Nil	Nil	Nil

Except EC and Turbidity remaining all are expressed in terms of ppm units, EC in µmhos/cm^2 and Turbidity in NTU

Table 4 Values of various constituents present in the water samples (July 2013)

Sample No.	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_3^-	Sulphate	Phosphate	Phenol
1	7.99	3980	0.11	2388	408	950	167	126	0.39	660	1.65	512	19	Nil
2	8.09	4000	1.09	2872	356	1299	235	168	0.60	676	0.02	421	15	Nil
3	7.99	3998	0.39	2599	329	1102	201	120	0.51	569	0.02	351	16	Nil
4	7.78	3350	0.29	2099	285	1248	290	146	0.50	640	2.81	160	14	Nil
5	7.91	3350	0.18	1702	311	592	145	81	0.29	414	0.01	220	16	Nil
6	7.63	5990	0.24	4204	351	1829	351	198	0.49	1095	0.51	183	18	Nil
7	8.00	6580	0.50	4812	323	1698	329	221	0.61	942	0.31	81	19	Nil
8	8.00	1000	0.99	210	188	436	91	72	0.58	180	0.02	80	13	Nil
9	7.67	3040	2.74	659	278	1200	220	149	0.80	683	0.005	96	16	Nil
10	7.59	1120	1.13	700	245	664	100	80	0.79	169	0.021	278	14	Nil
11	7.92	960	0.40	656	212	501	101	49	0.46	172	0.004	269	13	Nil
12	7.69	3480	3.69	2412	239	1499	278	187	0.79	787	0.01	240	15	Nil
13	7.91	3480	0.59	1213	299	1063	194	136	0.45	699	0.002	369	15	Nil
14	7.98	1190	0.64	679	191	506	111	63	0.510	245	0.002	294	17	Nil
15	7.99	2000	0.58	708	229	898	152	131	0.84	401	0.005	311	16	Nil

Values of some Metals in the water samples(July 2013)

Sample No	Fe	Zn	Cu	Cd	Ni	Co	Pb
1	0.041	0.011	0.011	0.001	Nil	Nil	Nil
2	0.039	0.070	0.044	0.021	Nil	Nil	Nil
3	0.049	0.213	0.021	0.049	Nil	Nil	Nil
4	0.178	0.167	0.029	0.066	Nil	Nil	Nil
5	0.140	0.059	0.059	0.004	Nil	Nil	Nil
6	0.026	0.038	0.052	0.069	Nil	Nil	Nil
7	0.028	0.059	0.050	0.071	Nil	Nil	Nil
8	0.038	0.050	0.069	0.006	Nil	Nil	Nil
9	0.037	0.142	0.015	0.010	Nil	Nil	Nil
10	0.072	0.044	0.062	0.004	Nil	Nil	Nil
11	0.03	0.048	0.039	0.006	Nil	Nil	Nil
12	0.123	0.041	0.040	0.006	Nil	Nil	Nil
13	0.065	0.162	0.080	0.019	Nil	Nil	Nil
14	0.178	0.173	0.030	0.016	Nil	Nil	Nil
15	0.213	0.119	0.021	0.005	Nil	Nil	Nil

Except EC and Turbidity remaining all are expressed in terms of ppm units, EC in µmhos/cm^2 and Turbidity in NTU

Table 5 Values of various constituents present in the water samples (May 2014)

Sample No.	pH	EC	Turbidity	TDS	Alkalinity	TH	Ca	Mg	F^-	Cl^-	NO_3^-	Sulphate	Phosphate	Phenol
1	8.05	4001	0.13	2466	426	937	175	119	0.31	649	1.81	486	21	Nil
2	8.02	4100	1.03	2856	348	1320	240	174	0.52	682	0.04	398	17	Nil
3	7.95	4002	0.45	2626	340	1067	213	128	0.49	573	0.03	264	17	Nil
4	7.88	3380	0.30	2172	297	1286	282	139	0.46	633	2.09	105	13	Nil
5	7.81	3460	0.20	1695	321	601	135	72	0.31	401	0.02	201	14	Nil
6	7.50	5960	0.21	4195	334	1813	366	215	0.40	1048	0.53	177	16	Nil
7	8.09	6770	0.47	4844	315	1745	344	211	0.60	950	0.03	66	18	Nil
8	8.03	1005	1.07	225	192	420	84	49	0.61	187	Nil	78	11	Nil
9	7.81	3130	2.90	687	291	1211	227	154	0.76	673	Nil	92	13	Nil
10	7.87	1180	1.26	732	232	622	106	85	0.81	178	0.031	282	12	Nil
11	8.13	980	0.46	637	218	513	112	55	0.54	178	0.002	269	12	Nil
12	7.87	3440	3.8	2395	245	1540	284	198	0.84	766	0.02	242	14	Nil
13	7.98	3590	0.63	1189	302	1047	202	129	0.48	707	0.021	370	16	Nil
14	8.09	1150	0.60	689	199	499	106	56	0.52	230	0.022	294	15	Nil
15	8.06	2020	0.61	723	240	917	139	136	0.79	383	Nil	305	14	Nil

Values of some Metals in the water samples(May 2014)

Sample No.	Fe	Zn	Cu	Cd	Ni	Co	Pb
1	0.049	0.227	0.016	0.011	0.028	Nil	Nil
2	0.056	0.215	0.013	0.006	0.016	Nil	Nil
3	0.039	0.233	0.020	0.006	Nil	Nil	Nil
4	0.163	0.215	0.019	0.006	Nil	Nil	Nil
5	0.118	0.088	0.018	0.006	Nil	Nil	Nil
6	0.034	0.193	0.024	0.007	Nil	Nil	Nil
7	0.034	0.195	0.011	0.007	Nil	Nil	Nil
8	0.039	0.198	0.016	0.007	Nil	Nil	Nil
9	0.030	0.228	0.012	0.006	Nil	Nil	Nil
10	0.065	0.197	0.013	0.007	Nil	Nil	Nil
11	0.021	0.196	0.011	0.007	Nil	Nil	Nil
12	0.099	0.197	0.011	0.006	Nil	Nil	Nil
13	0.070	0.185	0.056	0.014	Nil	Nil	Nil
14	0.104	0.158	0.028	0.014	Nil	Nil	Nil
15	0.201	0.102	0.018	0.006	Nil	Nil	Nil

Except EC and Turbidity remaining all are expressed in terms of ppm units, EC in µmhos/cm^2 and Turbidity in NTU

Further, an attempt is made to remove the excess amounts from the various constituents present in the water; the water is subjected to Reverse Osmosis (RO) process. After treatment by RO, the treated water samples are analyzed and the results obtained results clearly indicate that maximum excess amounts are eliminated by RO technique. The authors suggest that water is Srikurmam are treated to make it suitable for drinking. Hence, the overall results indicate that the water at Srikurmam is not fit for drinking without using an established purification method.

After thorough observations of the study area and physical chemical analysis of groundwater samples at Srikurmam, the causes of contamination of the ground water may be either because of seepage of sewage and sullage or of natural geological conditions. In addition to this, the wastewater from different sources such as kitchens, septic tanks and cesspits is discharged in to drainage canals. Unfortunately, the drainage canals are not properly constructed and maintained. As a result, there is an every possibility of seepage of sewage and sullage to the ground water and it will pollute the underground water in the areas under study.

Now at present, the study is extended up to the removal of excess amounts in the constituents in water by applying adsorption studies and the analysis are in the preliminary stage.

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Determination of Physico-Chemical Parameters in Water Samples from Selected Periphery of Beemaram, Warangal

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ABSTRACT

The physico-Chemical parameters like temperature, pH, electrical conductivity(EC), oxidation-reduction potential (ORP), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), carbon dioxide (CO_2), total acidity, salinity, total alkalinity (TA), total hardness(TH), bromine, free chlorine, ammonia, fluoride(F^-), nitrate (NO^-_3), nitrite, phosphate(PO_4^{-3}) were measured. The results of the physico-chemical parameters were compared with WHO (World Health Organization) standards, BIS: 105000, 1991 and ISI (10500-91) limits. Potentiometric analysis of fluoride content (as F^- ion) in **sample** by using fluoride ion-selective electrode is simple, reliable and cheap. The content of fluorides in the samples can be determined by the method of direct Potentiometer, and in the case of very low concentration by standard addition method. In this paper it was analyzed the determination of physico-chemical parameters in sample waters by using the ion selective electrodes and reagent methods.

Keywords: Sample water, fluoride selective electrode direct potentiometer, physico-chemical parameters. Total Dissolved Solids (TDS), Dissolved oxygen (DO).

INTRODUCTION

The quality of water is a vital concern for mankind, since it is directly linked with human welfare. It is a matter of history that fiscal pollution of drinking water caused water born diseases which wiped out entire population of these cities. At present, the menace of water born diseases and epidemics still booms large on the horizons of developing countries. Water is the most widely distributed and abundant substances found in nature Recommended limited value for fluoride in drinking water by World Health Organisation (WHO) and European Union (EU) is 1.5 ppm (WHO,1984), while in our country the standard is 1 ppm (Official Gazette of FRY, 1998; Official Gazette of FRY, 1999). Normally water is often used for domestic purposes especially for drinking. Water is the source of all biological lives and their sustenance too. Water for different purposes has its own requirements for the composition and purity and each body of water has to be analyzed on a regular basis to confirm the suitability. Natural resources are the important wealth of our country, water is one of them. Water is a wander of the nature. " No life without water '' is a common saying depending upon the fact that water is the one of the naturally occurring essential requirement of all life supporting activities[1] Since it is a dynamic system, containing living as well as nonliving, organic, inorganic, soluble as well as insoluble substances. So its quality is likely to change day by day and from source to source. Any change in the natural quality may disturb the equilibrium system and would become unfit for designated uses. The availability of water through surface and groundwater resources has become critical day to day. Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal [2]. In this area, most of the population is dependent on groundwater as the only source of drinking water supply, due low level of ground water dissolved ion are more. The groundwater where it is more concentrated the intake of toxic ions are more and cause more diseases to the people [3-5]. The physico-chemical parameters and trace metal contents of water samples from Delhi were assessed [6]. During last decade, this is observed that the ground water get polluted drastically and ground water level is increased because of increased human activities [7-9].

Hasanparthy, Warangal which is situated in the Andhra Pradesh has become an important city because of the natural resources available around it. There are various existing industries and people depended on agriculture. These industries and agriculture use huge quantity of water for processing and release most of the water into the form of wastewater and ground level of water decreases concentration of water increases. These will cause toxic nature to water. Considering the above aspects of ground water contamination, the present study was undertaken to investigate the impact of the surface water quality of some river and other bodies of surface water samples in and around Hasanparthy district in Warangal region. Thus, in this research work an attempt has been made to assess the physical and chemical parameters of ground water like, Temperature (T), pH, electrical conductivity (EC), total dissolved solids (TDS), Oxidation reduction potential (ORP), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), Iodide(I^-), Bromide (Br^-), chloride (Cl^-), fluoride (F^-), nitrate (NO^-_3) and phosphate (PO_3^{-4}) was determined. The analyzed data were compared with standard values recommended by WHO [10].

MATERIALS AND METHOD

The present study was planned around the Hasanparthy, Warangal Dt. around 10 meters well water was collected as samples.

Preparation of water samples

The sample were collected from all the stations at 10.00am -12.00am in both the seasons for physic-chemical examinations, different methods collection and handling were adopted based the standard procedures[11] by minisampler PE 5305-0100&Smart Labtech Private Limited.

The samples were collected in plastic HDPE bottles without any air bubbles. The temperatures of the samples were measured in the field itself t the time of sample collection. Water samples from fourteen sapling sites were collected during a period of four months (Aprial-2013-July 2013). The sampling locations in and around Hasanparthy for assessment of physico-chemical parameter status of ground water are given in Tables-1-3. Due to weathering may also leached out some chemical/ physical parameters in ground water may change the original characteristics of water which could be rather harmful to human health after consumption.

The literature survey reveals that no water quality management studies are made in this region so far very seriously. Hence it is very essential to maintain the quality of ground water for human consumption, for the aquatic life.

Physico-chemical parameters

These are classified in to two

1. Common field parameters 2. Laboratory analyzed parameters

Analysis was carried out both water quality parameters such as Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), ORP, turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness(TH), salinity, Total acidity, alkalinity, Iodide, Bromide, chloride (Cl-), fluoride(F-) nitrate (NO^-_3) and phosphate (PO_3^{-4})using standard method[12-14]. All The reagents used for the analysis were AR grade and double distilled water was used for preparation of solutions. Table 1-3.

RESULTS AND DISCUSSION

The physico-chemical parameters of the above mention sites in and around Hasanparthy can be calculated and it is describe as bellow.

1. **Common field parameters**

   Temperature (T) in^{0}C :

   Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism. The temperature was ranging from 26.0°C to 29.00°C during the study period. Lowest water temperature was observed in the sites S11and S12was 21.0 °C and 22 ^oC respectively. A study increase in water temperature in the course of temple was noticed i.e. 29.0 °C. An increase in temperature was observed from Beamaram (28.0 °C) to Gov. School (26.5 °C). This might be due to presence of the effluents. Our property of water is that with change in temperature, its density varies and it becomes less with warming up and more with cooling. The sites around the Hasanparthy i.e.

S7 to S14 was asses. It was found that the sites S9and S14have higher temperature, where as the sites S11 and S12 has lower temperature.

pH:

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. Most of the water samples are slightly alkaline due to presence of carbonates and bicarbonates. The pH values of water samples varied between 9.5 to 5.4 and were found above the limit prescribed by WHO. The higher range of pH indicates higher productivity of water [16].

The site S12 has lower pH where as S1has higher pH. Results are shown in Table-1.

Electrical conductivity (EC) (mS)

Electrical conductivity (EC) is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts[14]. EC values were in the range of 1.35-0.60 mS. High EC values were observed for six sampling points namely S1, S2, S3,S4, S6,and S7indicating the presence of high amount of dissolved inorganic substances in ionized form in and around Hasanparthy. Measurement of Conductivity Method 2510 (APHA, 1998). By using HI 98311. Results are shown in Table-1.

Total dissolved solids (TDS) (mv)

Total dissolved solids indicate the salinity behavior of groundwater. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed [15]. A TDS value varies from 360 mg/L to 840 mg/L. The sampling points S1, S2,S3,S4, S6, S7,S9, S10 and showed higher TDS values than the prescribed limit given by ISI. On the other hand sites S11, S12, S13, S14 and S5 have lower values of TDS. Results are shown in Table-1.

Turbidity by Secchi disk depth:

In most water turbidity is due to colloidal and extremely fine dispersions. The turbidity values varied between 13.4 to 4.7 NTU and found above the limits prescribed by ISI (10500-91). The site S9 has the higher values of turbidity.

Dissolved oxygen (DO) in mg/l :

Dissolved oxygen is important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. The DO values indicate the degree of pollution in water bodies. DO values varied from 8.2 to 4.9. The sampling points S1, S2, S3, S4 and S8 showed high DO values. Results are shown in Table-1.

Salinity

In measuring the salinity of water, we consider the concentration of salt dissolved in the water. Concentrations are usually expressed in parts per thousand (PPT) which can also be donated by the symbol ‰ (per mille). Results are shown in Table-1.

2. Laboratory analyzed parameters

Total Alkalinity (TA) in mg/l :

Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity values for all the investigated samples were found to be greater in samples S1, S2,S3,S4,S6,S7,S8, S9,S13 and S14 than the value prescribed by WHO. Total hardness (TH) in mg/l Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water[16].

Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The hardness values shown range from 680 mg/L to 180 mg/L. The values for sample from point S1, S2,S3, S4 and S8 were higher than the prescribed limit.

Bromide (Br-):

Bromine is measured by HI93102 Multi parameter with suitable reagent (HI 93701-01) by colorimetric procedure. Results are shown in Table-3.

Iodide (I^-):

Iodine is measured by HI93102 Multi parameter with suitable reagent (HI 93718-01) by colorimetric procedure. Results are shown in Table-3.

Chloride (Cl^-) in mg/l:

The chloride concentration serves as an indicator of pollution by sewage. People accustomed to higher chloride in water is subjected to laxative effects20. In the present analysis, chloride concentration was found in the range of 308.00 mg/L to 38.5 mg/L. The values are above the limit except water sample collected from sites S11 to S14 has higher chloride concentration in samples from sites S1 may be due to big discharge of domestic sewage near the sampling sites.

Fluoride (F^-) in mg/l Probable source of high fluoride in Indian waters seems to be that during weathering and circulation of water in rocks and soils, fluorine is leached out and dissolved in ground water. Excess intake of fluoride through drinking water causes fluorosis on human being. In the present analysis, fluoride concentration was found in all samples sites in Hasanparthy. It is found zero for all sites i e from S2to S14. The site S1has the fluoride and it was found that 0.05 mg/lit. Potentiometric analysis of fluoride content (as F^- ion) in solutions by using fluoride ion-selective electrode (HI 4110) with Bentch top HI 2216 meter by using Equitransferent electrolyte HI 7075. The meter is standardized with HI 4010-10, 10ppm Fluoride std. TISAB II.

Nitrate (NO_3-) in mg/l :

Surface water contains nitrate due to leaching of nitrate with the percolating water. Surface water can also be contaminated by sewage and other wastes rich in nitrates. The nitrate content in the study area varied in the range 7.1 mg/L to 0.19 mg/L and found within the prescribed limit except sample S1.

Phosphate (PO_4^{3-}) in mg/l :

Phosphate may occur in surface water as a result of domestic sewage, detergents, and agricultural effluents with fertilizers. The phosphate content in the study area was found in all S1 sites except site S5, S11, S12, S13 andS14. The higher values of phosphate is found in sites S1and S2.All the data can be summarized in Table-2

Table 1 Electrical conductivity (EC), Dissolved oxygen (DO), pH, Salinity, Temperature(Temp), Turbidity and Secchi disk depth

Sample No	EC(mv)	DO(mg/L)	pH	Salinity(g/kg)	Temp(^oC)	Turbidity(mg/L)
S_1	0.92	0.53	7.69	8.01	27.9	0.28
S_2	0.93	0.52	7.16	8.03	27.7	0.26
S_3	1.03	0.61	7.64	8.01	27.6	0.31
S_4	0.60	0.48	7.98	7.96	27.2	0.41
S_5	1.69	0.50	9.63	8.10	27.8	0.61
S_6	1.32	0.52	7.96	7.89	27.6	0.41
S_7	1.35	0.48	7.77	8.06	27.3	0.29
S_8	1.25	0.61	7.89	7.98	27.4	0.36
S_9	1.24	0.53	7.98	7.99	27.6	0.26
S_{10}	1.32	0.49	7.85	8.02	27.4	0.31
S_{11}	0.98	0.59	7.76	8.09	27.6	0.35
S_{12}	0.71	0.46	8.22	8.06	27.9	0.29
S_{13}	0.55	0.51	7.60	8.01	27.0	0.32
S_{14}	0.68	0.54	7.51	7.99	27.2	0.38

Table 2 Total phosphorus (TP), Total oxidized nitrogen (NOx-N), [Nitrat+Nitrite (NO_2-)]
Total water hardness (as $CaCO_3$), Total acidity and total alkalinity (as $CaCO_3$)

Sample No.	TP(mg/L)	Nitrate(mg/L)	Nitrite(mg/L)	Hardness(mg/L)	Total acidity (mg/L)	Total alkalinity(mg/L)
S_1	1.2	1.3	1.5	762	50	120
S_2	1.4	1.2	1.2	563	60	120
S_3	1.3	1.6	1.6	825	50	130
S_4	1.2	1.4	1.4	469	60	120
S_5	1.6	1.6	1.6	652	70	140
S_6	1.4	1.5	1.5	348	50	120
S_7	1.6	1.3	1.6	653	60	130
S_8	1.5	1.8	1.5	828	70	150
S_9	1.3	1.3	1.3	638	60	120
S_{10}	1.8	1.2	1.8	509	70	130
S_{11}	1.3	1.4	1.3	598	60	140
S_{12}	1.7	1.3	1.2	657	50	120
S_{13}	1.6	1.2	1.4	986	60	130
S_{14}	1.8	1.6	1.5	328	50	120

Table 3 Iodide (I^-), Bromide (Br^-), Chloride (Cl^-), Fluoride (F^-)

Sample No.	Bromide (mg/L)	Iodide (mg/L)	Free Chlorine(mg/L)	Fluoride(mg/L)
S_1	2.44	0.140	2.44	6.19
S_2	2.42	0.130	2.01	5.40
S_3	2.50	0.130	2.50	5.74
S_4	2.43	0.130	2.43	4.34
S_5	2.50	0.100	2.50	5.48
S_6	2.50	0.100	2.50	5.94
S_7	2.51	0.110	2.50	3.33
S_8	2.50	0.110	2.45	5.39
S_9	2.52	0.130	2.48	5.54
S_{10}	2.38	0.076	2.50	5.55
S_{11}	2.42	0.081	2.48	3.60
S_{12}	2.46	0.100	2.37	5.33
S_{13}	2.30	0.110	2.58	4.68
S_{14}	2.41	0.089	2.48	5.88

CONCLUSION

High values of conductance can be indicative that water has salinity problems but also are observed in entropic waterways where plant nutrients (fertilizer) are in greater abundance. Fluoride in the range 2- 13.7 ppm staining, cracking, mottling, and pitting of the teeth can result. Dissolved salts are high, Anions concentration is also indicated that more than WHO guidelines that means the water is not suitable to drinking purpose.

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Ediction Prediction and Comparison of Municipal Solid Waste – A Case Study

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ABSTRACT

India is one of the fastest growing economies in the world today. Increasing prosperity and standard of living of millions of people will increase consumption of energy and consumer goods. Waste generation in India is expected to increase rapidly in the future. “Solid waste” refers to non-soluble material such as agricultural refuse, industrial waste, mining residues, demolition waste, municipal garbage or even sewage sludge. “Municipal Solid Waste” includes commercial and residential wastes generated in a municipality or notified area in either solid or semi-solid form, excluding industrial hazardous wastes but including treated bio-medical wastes. “Solid waste management” refers to the supervised handling of waste material from generation at the source through the recovery processes to disposal. The prediction of municipal solid waste generation plays an important role in a solid waste management. Yet achieving the anticipated prediction accuracy with regard to the generation trends facing many fast growing regions is quite challenging. Successful planning of a solid waste management system depends critically on the prediction accuracy of solid waste generation. This study presents a new theory GREY FUZZY DYNAMIC MODELLING for the prediction of solid waste generation in the urban area based on a set of limited samples. It shows that such a new forecasting technique may achieve better prediction accuracy than those of the conventional grey dynamic model, least-squares regression method, and the fuzzy goal regression technique. Grey models predict the future values of a time series based_only on a set of the most recent data depending on the window size of the predictor. The main objective is to estimate the amount of waste generated by using Grey Model and GFM of two areas of Hyderabad i.e. Kapra and Malkajgiri and compare the results obtained with the obtained data from GHMC.

Keywords: Municipal, Solid Waste, Prediction.

1.0 INTRODUCTION

Solid Waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. Municipal Solid waste, commonly known as trash or garbage is a waste type consisting of everyday items that are discarded by the public. India is one of the fastest growing economies in the world today. Increasing prosperity and standard of living of millions of people will increase consumption of energy and consumer goods. Concurrently, this growth will likely put a strain on the environment and on the availability of natural resources. Already, India has 16.8% of the world’s population (est. 2006) and only 2.2% of the world’s total land area. The amount of waste generated in a region or country is directly proportional to economic growth and consumption levels. On a per capita basis, low income countries generally consume fewer goods and hence generate less waste than developed countries. Low income countries also generally use less recyclable materials, especially in packaging. Larger cities tend to produce higher amounts of waste per capita than smaller ones because per capita incomes and consumption are higher in urban areas.

Waste generation in India is expected to increase rapidly in the future. As more people migrate to urban areas and as incomes increase, consumption levels are likely to rise, as are rates of waste generation. This has significant impacts on the amount of land that is and will be needed for disposal, economic costs of collecting and transporting the waste, and the environmental consequences of increased MSW generation levels. It is estimated that the amount of waste generated in India will increase at a per capita rate of approximately 1-1.33% annually. A World Bank publication reports that the waste generation rate in urban areas of India will be approximately 0.7 kg/person/day in 2025, which is roughly four to six times higher than it was in 1999.Therefore Solid Waste Management is considered to be of greatest concern in coming future.

1.1 Classification of Solid Waste

(a) Based on origin: Domestic, Industrial, Commercial, and Construction.

Figure 1 Domestic Waste

Figure 2 Industrial Waste

Figure 3. Commercial Wastes

Figure 4. Construction Wastes

(b) Based on contents: Organic Material, Glass and Plastics

Figure 5 Organic Wastes

Figure 6 Glass

(c) Based on Hazardous Wastes: Toxic, Non-Toxic, Flammable, Infectious, Radioactive

Figure 7 Flammable Wastes

Figure 8 Infectious Wastes

1.2 OBJECTIVES

a) To predict the amount of municipal solid wastes using Mathematical modeling.

b) To validate and estimate the solid wastes that would be generated for the next few years.

2.0 LITERATURE REVIEW

Generally, a pre-defined mathematical model is used to make accurate predictions. Time series prediction models are widely used in financial area, such as predicting stock price indexes, foreign currency exchange rates (FX rates) and so on. The ability to do prediction with a reasonable accuracy can change the economic policy of large companies and governments and ensure a more reasonable behavior by the financial actors.

Statistical and artificial intelligence (soft computing) based approaches are the two main techniques for time series prediction seen in the literature. While AR (Auto Regressive), MA (Moving Average), ARMA (Auto Regressive Moving Average), ARIMA (Auto Regressive Integrated Moving Average) and **Box–Jenkins models** (1976) can be mentioned as statistical models, neural network (NN) based models by **Quah & Srinivasan (1999); Rabiner, (1989); Roman & Jameel, (1996)** are widely used as an artificial intelligence-based approach, back propagation being the most widely used technique for updating the parameters of the model. However, not only are the statistical models not as accurate as the neural network-based approaches for nonlinear problems, they may be too complex to be used in predicting future values of a time series.

One major criticism about the NN model is that it demands a great deal of training data and relatively long training period for robust generalization **(Jo, 2003)**. Other intelligent approaches seen in the literature for the analysis of time series include Linear regression, Kalman filtering by **Ma & Teng, (2004)**, fuzzy systems by **Kandel, (1991)**, hidden markov models by **Rabiner, (1989)** and the support vector machines by **Cao,(2003)**. Some hybrid models are also seen in the literature: in Versace, Bhatt, Hinds, and Shiffer (2004), a combination of genetic algorithms and neural networks has been proposed. In **Huang and Tsai (2009)**, support vector regression (SVR) and a self-organizing feature map (SOFM) technique have been hybridized to reduce the cost of training time and to improve prediction accuracies. High-order fuzzy logical relationships and genetic-simulated annealing techniques are combined in **Lee, Wang, and Chen (2008)** for temperature prediction and the Taiwan futures exchange (TAIFEX) forecasting, where genetic-simulated annealing techniques have been used to adjust the length of each interval in the universe of discourse to increase the forecasting accuracy. FX rates are highly nonlinear, stochastic and highly non-stationary financial time series, and as such, it is very difficult to fit a model to them by the use conventional linear statistical methods or artificial neural networks.

The prediction of municipal solid waste generation plays an important role in a solid waste management. Yet achieving the anticipated prediction accuracy with regard to the generation trends facing many fast growing regions is quite challenging. In addition to population growth and migration, underlying economic development, household size, employment changes, and the impact of waste recycling would influence the solid waste generation interactively. The development of a reliable model for predicting the aggregate impact of economic trend, population changes, and recycling impact on solid waste generation would be a useful advance in the practice of solid waste management. The planning of municipal solid waste management systems (MSWMS) to satisfy increasing waste disposal and treatment demands is often subject to a variety of impact factors, such as collection technique to be used, service policy to be implemented, and management facilities to be adopted. Quantity of prediction of municipal solid waste (MSW) is crucial for the planning of MSWMS, and the development of a reliable model (such as data-driven models) for this purpose would be a useful advance in the practice of MSWMS. Both planning and design of solid waste management systems require accurate prediction of solid waste generation.

Conventional forecasting of solid waste generation frequently uses demographic and socioeconomic factors in a per-capita basis. The per capita coefficients may be taken as fixed over time or they may be projected to change with time. **Grossman** extended such considerations by including the effects of population, income level, and dwelling unit size in a single linear equation model. **Niessen** conducted similar estimates by providing some other extensive variables characterizing waste generation. **Khan and Burney (1989)** have established the influence of per capita income, population density, and persons per house, GDP and population on the composition of the solid waste using linear regression.

3.0 METHODOLOGY

Forecasting is an ability to recognize patterns through a logical and analytical approach. Forecasting of municipal waste generation is a critical challenge for decision making and planning, because proper planning and operation of a solid waste management system is intensively affected by municipal solid waste (MSW) streams analysis and accurate predictions of solid waste quantities generated. Traditional methods and quantitative forecast methods are available for the estimation. The lack of sampling and analysis in many developing countries due to insufficient budget and unavailable management task force has resulted in a situation where the historical record of solid waste generation and composition can never be completed in the long term.

To effectively handle these problems with only limited samples and fulfill the prediction analysis of solid waste generation with reasonable accuracy, a special analytical technique must be developed and applied before the subsequent system planning for urban solid waste management is carried out. This study presents a new theory GREY FUZZY DYNAMIC MODELLING for the prediction of solid waste generation in the urban area based on a set of limited samples. It shows that such a new forecasting technique may achieve better prediction accuracy than those of the conventional grey dynamic model, least-squares regression method, and the fuzzy goal regression technique.

4.0 STUDY AREA

The present study is carried out for Hyderabad City which has Greater Hyderabad Municipal Corporation (GHMC) being one of the largest cities in India and Headquarters of Andhra Pradesh with the responsibility of providing basic civic services like roads, water supply, & sewerage, health & sanitation, storm water and solid waste disposal etc. Greater Hyderabad Municipal Corporation (GHMC) has been divided into 5 zones and 18 circles for the purpose of effective administration and management. The real executive power of the GHMC is vested with the Commissioner, an IAS Officer, appointed by the Government of Andhra Pradesh. The corporation has the following major branches. The present study is carried out for two area namely Kapra and Malkajgiri municipalities.

Kapra was a town and a municipality in Ranga Reddy district in the Indian state of Andhra Pradesh. It is now a part of Greater Hyderabad Municipal Corporation. It is located at 17.49° N 78.57° E. It has an average elevation of 540 meters (1771 feet). Kapra had a population of 1,59,002 as per 2001 census. Males constitute 52% of the population and females 48%. Kapra has an average literacy rate of 74%, higher than the national average of 59.5%.

Malkajgiri circle falls under North Zone of GHMC. As per 2001 census, it had a population of 2,87,069. Males constitute of 51% of the population and females of 49%. It had an average illiteracy rate of 69% higher than the national average of 59.5%. This circle is famous for Vijaya Vinayaka Temple in Vaninagar. Anandhbagh is a locality in Malkajgiri with predominantly residential areas and commercial establishments.

5.0 COMPUTATIONS AND DISCUSSIONS

The inconsistent values of solid waste generation (MT/day), which were recorded at dump yard in the years 2003, 2004, 2005, 2006, 2007 are been given as input data to GM (1,1) and GFM(1,1) models and the SW generation in the years 2008, 2009, 2010, 2011, 2012, 2013 were forecasted .GM and GFM models are capable of making inconsistent data to consistent for computational purpose. A comparison is made between the available data and predicted data that is been clearly shown in tables below. In the similar way amount of waste that is going to be generated in coming five years is also been predicted using GM and GFM models and is tabulated below for both Kapra and Malkajgiri circles.

Table 1 Computation of Dump yard and GHME data with GM(1,1) and GFM(1,1) Data – Kapra and Malkajgiri

S. NO	YEAR	DUMPING YARD DATA (MT/DAY)	GHMC DATA (m/day)	GM(1,1) DATA (m/day)	GFM(1,1) DATA (m/day)
1	2008	156.56	190.80	179.96	172.69
2	2009	177.69	206.70	194.01	183.82
3	2010	188.82	222.60	209.14	194.95
4	2011	189.95	238.50	225.46	207.70
5	2012	213.08	254.40	243.05	219.01
6	2013	227.23	270.33	262.01	230.32
MALKAJGIRI					
1	2008	269.13	344.48	307.58	289.22
2	2009	289.22	373.18	339.08	309.31
3	2010	309.32	401.89	373.81	329.41
4	2011	329.42	430.60	412.09	349.50
5	2012	349.51	459.31	454.29	369.60
6	2013	369.60	488.01	486.05	389.69

In the similar way amount of waste that is going to be generated in coming five years is predicted using GM and GFM models and is tabulated below in tables 2 for both Kapra and Malkajgiri circles. 'C' program is developed for the models for the computations of solid wastes by GM and GFM models and the comparison is shown in the charts 1 and 2.

Table 2 Prediction of Solid Waste Generation
Using GM (1,1) and GFM(1,1) Kapra and Malkajgiri

S.NO	YEAR	GM(1,1) (MT/DAY)	GFM(1,1) (MT/DAY)
KAPRA			
1	2014	282.48	241.63
2	2015	304.48	252.94
3	2016	328.24	264.25
4	2017	353.84	275.56
5	2018	381.45	286.87
MALKAJGIRI			
1	2014	552.11	409.79
2	2015	608.65	429.88
3	2016	670.98	449.98
4	2017	739.69	470.07
5	2018	815.45	490.17

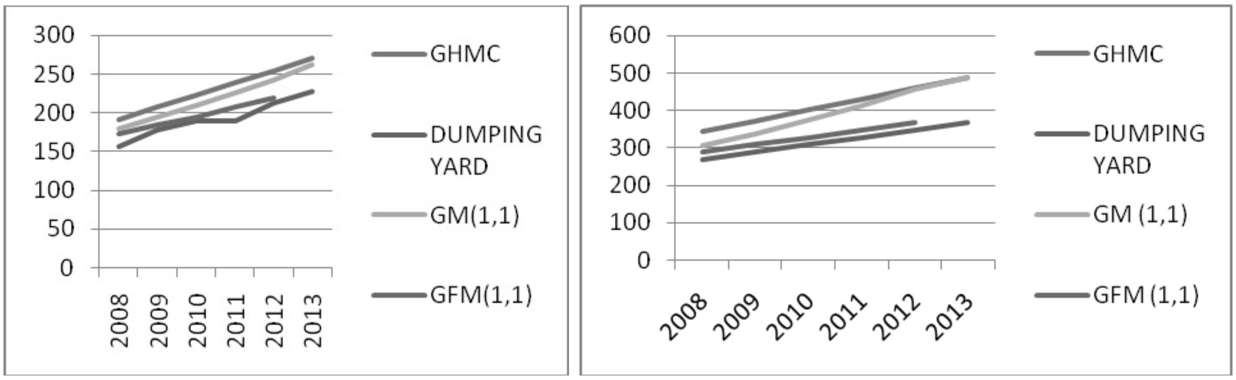
DISCUSSIONS

1. The value recorded at GHMC office and the amount of waste dumped at dump yard is not the same because, some of the waste that is been collected in the entire area is being disposed off in the nearest low lying areas, some of it is burnt, and some of the recyclable waste is being sold to the retailers before reaching the dump yard itself.

2. The difference in two values may comprise of about 30 to 36 percent of total waste collected.
3. It is observed from the calculations that the amount of waste predicted using GM, GFM models lies between the GHMC recorded data and the dump yard data.
4. This gives proper guidance for design of dump yard, reducing the loss which is expected to incur on the system.
5. Moreover on keen observation we could find that the amount of waste predicted using GFM model is much more near to the dump yard value than GM model.
6. Even though both the models are efficient in prediction, GFM model can be mentioned as more and more cost effective, as it is more nearer to the practicality.

Chart 1 Graph showing comparison of dump yard and GHMC data with

GM(1,1) & GFM(1,1) data – KAPRA and MALKAJGIRI



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Modeling Longitudinal Dispersion Coefficient in Meandering Rivers using Fuzzy Logic

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ABSTRACT

Physical processes such as advection and dispersion will govern the fate and transport of pollutants, when discharged into natural streams. Though a large number of empirical equations are available to model longitudinal dispersion coefficient, they largely ignore the channel sinuosity parameter. This paper considers various hydraulicand cross-sectional data of the meandering rivers including the channel sinuosity to model longitudinal dispersion using fuzzy logic (FL). A generalized MATLAB based fuzzy algorithm was used in the present study to investigate the effect of channel sinuosity on mixing process. Fuzzy rule base was developed considering variable membership functions for each subset. Applicability of the developed tool was tested for two cases, one with three input sets (U / u*,B/H, and σ) and other with four input sets (U / u*,B/H, β and σ) and the results are compared with previous research. Given dataset was partitioned into simulation and calibration data using statistical parameters. Model performance was evaluated by considering the statistical parameter Root Mean Square Error (RMSE). Effect of fuzzy inference and composition processes on simulation results was analyzed in the present study. It was concluded that FL is an effective tool in simulating longitudinal dispersion coefficient in sinuous channels. Also, changes in the number of input parameters considered for FL was observed to significantly alter the simulation results.

Keywords: Advection, Dispersion, longitudinal dispersion coefficient, sinuosity, fuzzy logic.

INTRODUCTION

Any effluent or hazardous contaminant when discharged into the natural stream will undergo various processes of mixing like advection, dispersion which results in spreading out of the pollutants while transported towards the downstream. The transport process in rivers is primarily due to the advection which is predominantly governed by the higher water velocity relative to the velocity of the solute particles. However in the downstream stretches of the river, where it approaches the estuary or sea the water velocity is found very less and sometimes it is close to zero. Consequently considering the transport process due to advection alone is not appreciated. The consideration of dispersion phenomenon is found essential in defining the complete transport process in the river under such condition. Dispersion is a physical transport process which results in the spreading and mixing of the pollutant mass entered into the river. In mathematical modeling of the transport process, the effect of dispersion is accounted into the equation by means of the dispersion coefficients.

The spread of the effluent or the pollutant starts first in the transverse direction and then in the vertical and in longitudinal direction. Once the cross-sectional mixing is completed, longitudinal dispersion becomes dominant in the transport process. The intensity of dispersion in each direction is quantified by the dispersion coefficients in their respective direction. Many extensive experimental and theoretical researches have been put forward to find the dispersion coefficients that resulted in the integral expressions for those coefficients.

These studies were based on some intrinsic assumptions and the predicted results are sensitive to stream flow conditions. In the absence of experimental data, the coefficients are determined with data driven models (DDM), which uses geometrical and hydrological parameters of the rivers. DDM works on the basis of analysis of data of the system, in particular arriving at the connection between system state variables, even without any explicit knowledge about the physical behavior of the system. DDM made with the various Computational Intelligence (CI) techniques including Neural Networks (NN), Genetic Algorithm (GA) and Fuzzy rule-based systems (FRBS).

A fuzzy rule-based system uses fuzzy logic which is based on the fuzzy set theory for the inference. The idealized fuzzy system (Figure 1) takes numerical values as inputs to the system and after the four operations (Fuzzification, Fuzzy Rule Base, Inference and Defuzzification), results in crisp numerical outputs.

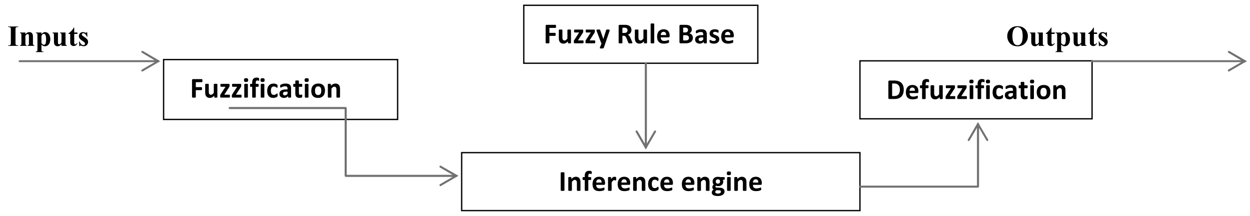


Fig: 1: Work flow of Fuzzy System components

This paper considers the hydraulic and cross-sectional data of the meandering rivers as the inputs and utilizes the fuzzy logic (FL) concept to determine the longitudinal dispersion. Data set used in this study is taken from “Soft Computing in Water Resources Engineering” by TAYFUR and VP SINGH.

Table 1 Data of channel characteristics and observed dispersion coefficient in natural stream

S.no	Stream	B/H	U / u*	□	σ	K_x (m^2 / s)
1	Antietam Creek, Md.	42.7	7.37	3.75	1.4	17.5
2	Antietam Creek, Md.	24.6	6.02	3.2	2.25	101.5
3	Antietam Creek, Md.	18	5.06	2.89	2.25	20.9
4	Antietam Creek, Md.	43.8	8.99	3.78	1.26	25.9
5	Monocacy River, Md.	88.5	5	4.48	1.28	37.8
6	Monocacy River, Md.	131	3.48	4.88	1.28	41.4
7	Monocacy River, Md.	78.8	14.09	4.37	1.28	29.6
8	Monocacy River, Md.	84.8	5.52	4.44	1.61	119.8
9	Monocacy River, Md.	98.8	5.75	4.59	1.61	66.5
10	Conococheague Creek, Md.	61.2	3.59	4.11	2.25	40.8
11	Conococheague Creek, Md.	121.2	1.85	4.8	2.25	29.3
12	Conococheague Creek, Md.	38.1	7.78	3.64	1.31	53.3
13	Chattahoochee River	38.8	5.36	3.66	1.27	88.9
14	Chattahoochee River	37.7	5.53	3.63	1.57	166.9
15	Salt Creek, Neb.	64	6.32	4.16	1.38	52.2
16	Diffcult Run, Va.	46.8	4.03	3.85	1.09	1.9
17	Bear Creek, Colo.	16.1	2.33	2.78	1.08	2.9
18	Little Pincy Creek, Md.	72.3	7.36	4.28	1.13	7.1
19	Bayou Anacoco, La.	38.9	13.33	3.66	1.41	5.8
20	Bayou Anacoco, La.	27.6	5.07	3.32	1.41	32.5
21	Bayou Anacoco, La.	40.2	5.97	3.69	1.41	39.5
22	Comite River, La.	68.3	9.23	4.22	1.31	69
23	Bayou Bartholomew, La.	23.9	6.45	3.17	2.46	54.7
24	Tickfau River, La.	25.4	3.38	3.23	1.75	10.3
25	Tangipahoa River, La.	38.8	6.67	3.66	1.46	45.1
26	Tangipahoa River, La.	74.8	17	4.31	1.46	44
27	Red River, La.	156.5	19.06	5.05	1.2	143.8
28	Red River, La.	40.8	4.83	3.93	1.44	130.5
29	Red River, La.	41.6	7.89	3.73	1.44	227.6
30	Red River, La.	89.1	13.06	4.49	1.24	177.7
31	Sabina River, La.	70.5	10.74	4.26	1.19	131.3
32	Sabina River, La.	69.1	19.63	4.24	1.17	308.9

Contd….

S.no	Stream	B/H	U / u*	□	σ	K_x (m^2 / s)
33	Sabina River, Tex.	28.4	3.51	3.35	2.53	12.8
34	Sabina River, Tex.	23.9	7.67	3.17	2.05	14.7
35	Sabina River, Tex.	22.9	10.29	3.13	1.47	24.2
36	Wind/Big. River, Wyo.	32.3	6.97	3.48	1.56	184.6
37	Wind/Big. River, Wyo.	35.8	11.37	3.58	1.56	464.6
38	Wind/Big. River, Wyo.	54	7.39	3.99	1.18	41.8
39	Wind/Big. River, Wyo.	31.8	9.23	3.46	1.18	162.6
40	Copper Creep, Va.	34.1	2.5	3.53	2.54	16.8
41	Clinch River, Va.	41.8	3.04	3.73	1.25	14.8
42	Clinch River, Va.	47	5.07	3.85	1.14	10.7
43	Clinch River, Va.	23.6	7.21	3.16	1.14	40.5
44	Clinch River, Va.	22.1	6.17	3.1	1.14	36.9
45	Copper Creek, Va.	48.2	1.29	3.88	2.54	20.7
46	Copper Creek, Va.	35.7	3	3.58	2.54	24.6
47	Powell River, TN	42.3	2.41	3.74	2.2	15.5
48	Copper River, Va.	23.3	4.85	3.15	1.26	20.8
49	Nooksack River, Wash.	84.2	2.5	4.43	1.3	34.8
50	John Day River, Ore.	43.1	7.21	3.76	1.08	13.9
51	John Day River, Ore.	13.8	4.56	2.62	1.89	65
52	Yadkin River, N.C.	29.8	4.26	3.39	2.17	111.5
53	Yadkin River, N.C.	18.6	5.94	2.92	2.17	260.1
54	Minnesota	29.2	14.17	3.37	—	22.3
55	MinnesotaRiver	29.2	14.43	3.37	—	34.9
56	AmitaRiver	45.7	4.14	3.82	—	23.2
57	AmitaRiver	52.5	6.09	3.96	—	30.2
58	WhiteRiver	113.6	7.95	4.73	—	30.2
59	NooksackRiver	29.4	2.26	3.38	1.3	153
60	SusquehannRiver	150.4	6	5.01	1.13	92.9
61	BayouAnacoco	47.6	6.44	3.86	1.41	13.9
62	MuddyRiver	16	4.57	2.77	—	13.9
63	MuddyRiver	16.7	4.55	2.82	—	32.5
64	ComiteRiver	50	7.05	3.91	1.31	7
65	ComiteRiver	37.2	6.61	3.62	1.31	13.9
66	MissouriRiver	78.5	13.48	4.36	1.35	465
67	MissouriRiver	56.5	15.24	4.03	1.35	837
68	MissouriRiver	63.3	19.62	4.15	1.35	892
69	Copper Creek, Va.	32.4	2.7	3.48	—	19.5
70	Copper Creek, Va.	21.8	5.2	3.08	—	21.4
71	Copper Creek, Va.	33.1	3.2	3.5	—	9.5
72	Clinc River,TN	54.5	4.2	4	—	13.9
73	Clinc River,TN	25.5	7.4	3.24	—	46.5
74	Clinc River,TN	27.9	8.3	3.33	—	53.9
75	Copper Creek, Va.	47.7	1.2	3.86	—	9.9
76	Coachell Canal,CA	15.6	15.6	2.75	—	9.6
77	Antietam Creek, Md.	40.5	5.3	3.7	—	9.3
78	Antietam Creek, Md.	38.1	6.2	3.64	—	16.3
79	Antietam Creek, Md.	34.4	6.4	3.54	—	25.6
80	Monocacy River, Md.	109.7	4.9	4.7	—	4.7

Contd….

S.no	Stream	B/H	U / u*	□	σ	K_x (m^2 / s)
81	Monocacy River, Md.	81.3	6.3	4.4	—	13.9
82	Monocacy River, Md.	54.6	6.3	4	—	37.2
83	Elkhorn River	108.7	9.3	4.69	—	9.3
84	Elkhorn River	121.2	10	4.8	—	20.9
85	Sabine River	50.8	10.4	3.93	—	315.9
86	MuddyRiver	16.5	4.8	2.8	—	13.9
87	MuddyRiver	16.3	4.8	2.79	—	32.5
88	Sabine River	35.8	5.1	3.58	—	39.5
89	Chattahoochee River	58	5.2	4.06	—	32.5
90	Bayou Anacoco, La.	38.9	13.3	3.66	—	5.8
91	Powell River, TN	39.8	2.9	3.68	—	9.5
92	Clicnch River,Va	62.1	6.1	4.13	—	8.08

Note:(B =width; H =depth; U =velocity; u* =shear velocity; U / u* =relative shear velocity; σ =shape parameter;□ =sinuosity; K_x=dispersion coefficient). The missed values in the variable shape factor are filled with the mean of the available values (1.5459)

METHODOLOGY

FRBS uses the fuzzy logic which is based on fuzzy set theory where the element can have partial memberships ranging from zero to one. The key idea in FL is the allowance of partial belongings of any input data to different subsets of universal set instead of belonging to a single set completely. The methodology in the model development follows with the data separation, fuzzification, fuzzy rule base, fuzzy inference engine and defuzzification.

1. **Data separation:** FRBS being the data driven model has to be supplied with the available data which are then divided into two sets viz. calibration and validation data sets based on the statistical parameters like mean, standard deviation and also the maximum and minimum value of each variable in the given data. In case of any missing values of the variable, the mean of the available data can be used for that particular variable. The threshold value for percent difference in the statistical parameters is kept as 30 and the max and min of the validation data are found within the bound of the max and min of the calibration data set.
2. **Fuzzification:** This defines the process, where fuzzy subsets of universal set of a fuzzy variable are constructed. For the given data obtain the distribution for each variable from which the cluster centers are obtained. The number of cluster centers is user specific and the number of fuzzy subsets is formed accordingly. Any variable with large number of subset results in unnecessary computations. Also a fewer in number of subsets results in an unrepresentative predictions. Hence fuzzification to optimum number of fuzzy subset is essential.
3. **Fuzzy Rule Base:** This is obtained by considering the available data and this contains all the possible fuzzy relations between the input and output variables. If there are ‘n’ number of variables and each having ‘m’ number of subsets, the possible rules to be constructed are given by (m^n). All the variables of the data point are fitted with respect to their fuzzy subset and the subset giving maximum membership for the corresponding input and output variables are obtained. The corresponding rule weight is obtained by the product of membership of each subset for each variable. Rule weight helps in reducing the number of fuzzy rules to be taken into fuzzy inference engine. For rules with same antecedent part, theapplicable rule is decided based on the highest rule weight or by considering the most occurring rule.
4. **Fuzzy inference engine:** This will consider the fuzzy rule base and transform the set of inputs to the corresponding output. The two sub processes in this are inference and composition. In the inference sub-process, truth value of each rule is computed and is applied to the consequent part of each rule. This results in assigning one subset to each output variable for each rule. If the logical operator

considered in inference sub-process is ‘and’, the two inference method to be adopted are ‘min’ and ‘prod’ inference. In the composition sub-process, all the subsets assigned to each output variable are combined together to form a single subset for each output variable which is carried out by either ‘max’ or ‘sum’ composition process.

5. **Defuzzification:** It is the process of converting the combined output fuzzy subset to a crisp value using the defuzzification methods like center of gravity (COG), weighted average (WA), center of greatest area (CGA), bisector of area (BOA), mean of maxima (MOM), maximum membership (MM), leftmost maximum (LM) rightmost maximum (RM).

In the present study, the steps (1), (2), (3) are developed using the generalized matlab code. The constructed fuzzy rule bases are taken to FL toolbox in matlab to carry out the steps (4), and (5). After the selection of inference and composition processes for inference engine, followedby the selection of defuzzification methods in the toolbox platform, crisp outputs are obtained.

Model development

The first data set considered with five parameters (4 inputs with sinuosity and 1 output)is partitioned such that the data are within the threshold limit of the statistical parameters.

Table 2 Statistical parameter and min-max comparison of calibration and validation data

Calibrating data set						Validating data set					
mean	46.6	7.2	3.65	1.58	90.17	mean	54.05	6.92	3.86	1.5	69.77
std dev	32.5	4.3	0.60	0.37	152.49	std dev	29.12	4.04	0.51	0.4	142.66
percent difference in mean						percent difference in std dev					
	14.8	4.5	5.64	5.03	25.50		11.08	5.25	16.06	4.4	6.66

min	13.8	1.3	2.62	1.09	1.9	min	16.1	1.2	2.78	1.1	2.9
max	157	20	5.05	2.54	892	max	131	19.63	4.88	2.5	837

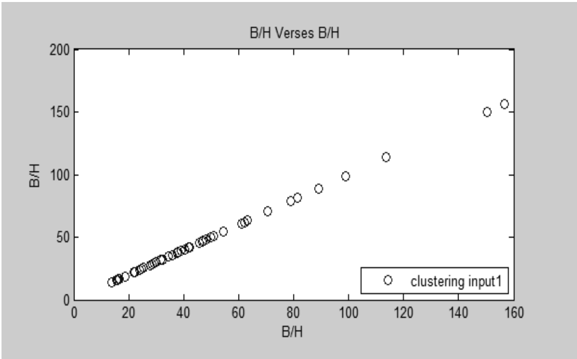
Note: (Most of the min and max values in the validating set are found within the bound value of the calibrating data set and hence considered for the fuzzification process).

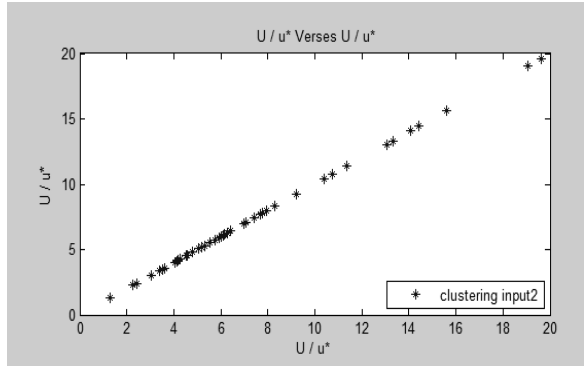
The calibrating data set (50 percent of the total) is considered for the model development. Each variable is made distributed, and their cluster centers are obtained to get the number of fuzzy subsets (figure 2). The number of cluster centers considered for each variable is 5with fuzzy subsets and hence the possible numbers of rules to be formed are 5^4.

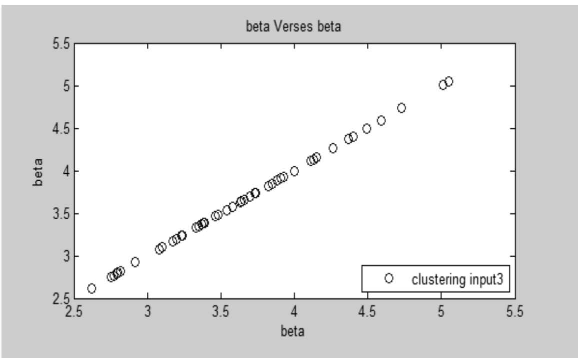
Each variable is represented in the fuzzy subset along with the memberships. Variables in the partial membership are given the maximum membership value. All the data points in the calibrating sets are considered so that 46 rules are developed. When the antecedent portions of the rules aresame,the rule is decided based on the rule weight parameter. Hence the total numbers of rules are found reduced to 35.

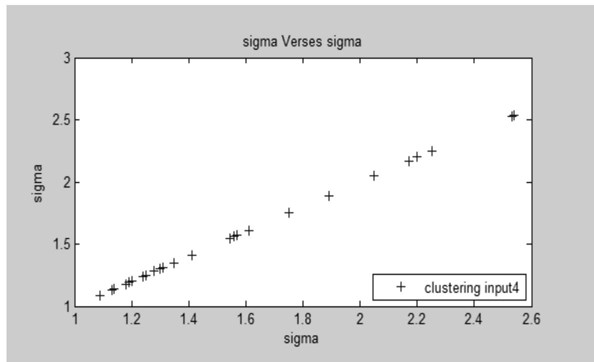
The 35 rules formed on the basis of the calibrating data set are used in the construction of the fuzzy model. The developed model is used to generate the crisp output of the validating data set. The fitness values are then obtained between the predicted output and the given experimental values using the statistical parameter Root Mean Square Error (RMSE).

Clustering inputs









Clustering output

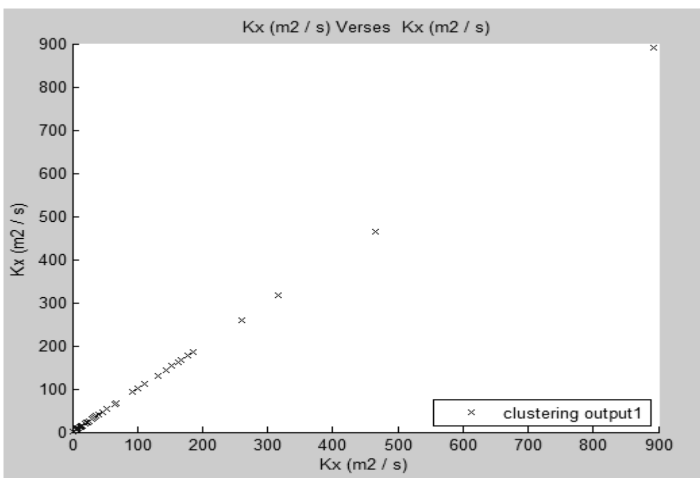


Fig. 2: Fuzzy clustering of data set variables

Cluster centers

22.0000	4.0000	2.7942	1.2146	20.0000
41.0000	6.0000	3.3190	1.5471	94.0000
64.0000	10.0000	3.7773	1.8398	175.0000
95.0000	14.0000	4.2893	2.1949	435.0000
153.0000	19.0000	4.9270	2.5337	892.0000

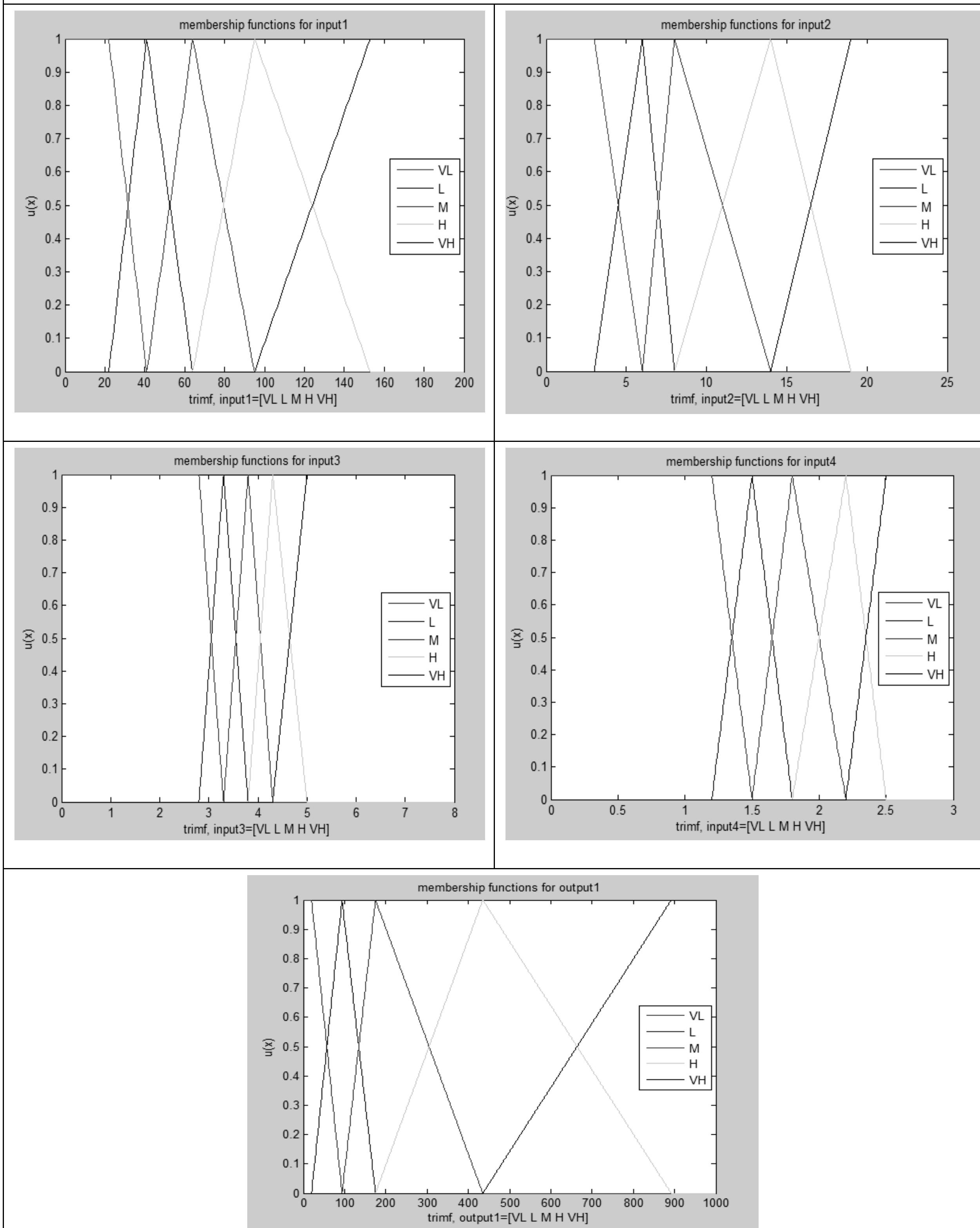


Fig 3: Distribution of membership functions for each variables

RESULTS

The developed fuzzy model using the calibrating data set is then applied to generate the crisp output for the validating data sets.The fitness is then obtained by plotting the best fit between the observed and the predicted k_x values, which result in the coefficient of determination of about 0.931.Also two different RMSE values are presented for the model predicted outputs in which first RMSE is between all the measured and the predicted output data, while the second RMSE excludes the extreme measured output values.

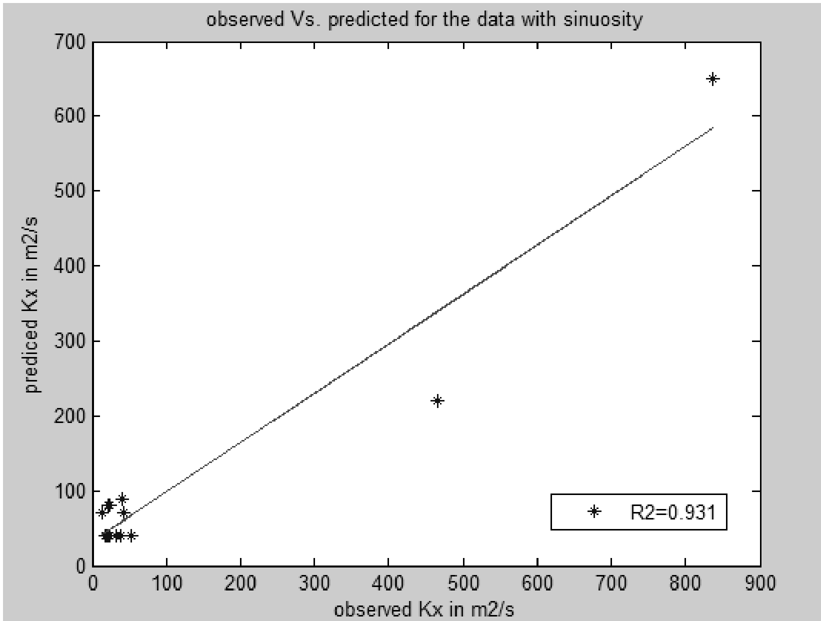


Fig. 4: Observed Kx vs. Predicted K_x (with sinuosity)

The model is then applied for three input variables (by ignoring the sinuosity) with three membership functions and the corresponding validating data set is then evaluated for the crisp outputs.A similar set of RMSE values are presented for the model predicted outputs in which first RMSE is between all the measured output data and the predicted output data, while the second RMSE is excludes the extreme measured output values

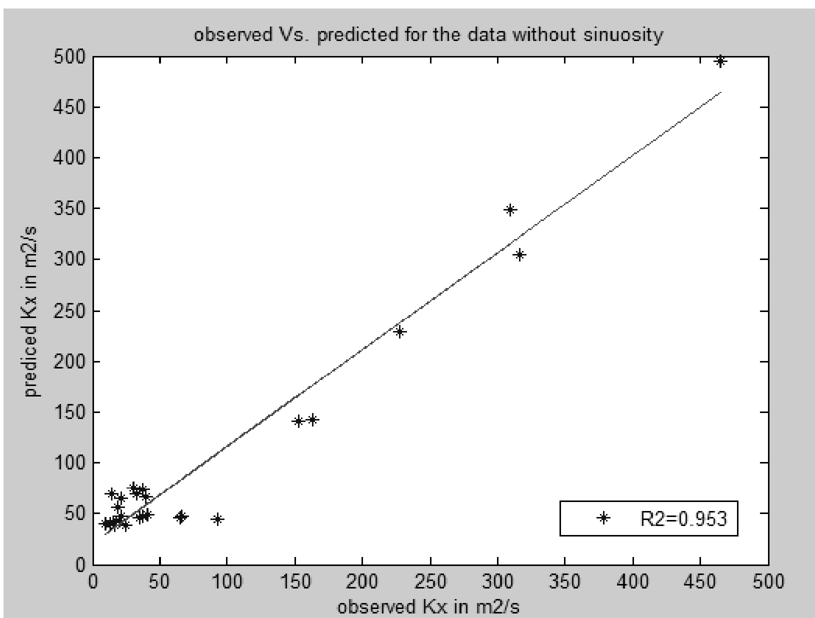


Fig. 5: Observed Kx vs. Predicted K_x(without sinuosity).

Table 3: Comparison of statistical parameters for different conditions

S.no	No of variables	Sinuosity	No of MF	RMSE (m)		Co efficient of determination (R^2)
				All k_x values are considered	Extreme k_x values not considered	
Case 1	4	considered	5 MF	154	142	0.931
Case 2	3	not considered	3 MF	113	110	0.953

DISCUSSION

The developed fuzzy model is found to be highly sensitive to the number of data considered for the model development. The statistical parameters obtained for each case of study are comparable enough.The model developed with more number of data sets found to have higher RMSE (154) but a lesser R^2value (0.931). The model developed with lesser number of data set has lesser RMSE (113) and higher $R^2$of 0.953. When the model is developed with only one inputparameter,the RMSE still reduced to 49.2 with R^2 value of 0.96 (TAYFUR and VP SINGH,2007). Another inference is that the model gives slightly lesser RMSE values when the extreme values of the observed k_x values are not included in the fitness plot.

CONCLUSION

Fuzzy logic finds its application widely in the control theory.FRBS is created by processing the historical data that laid the basis of taking FRBS to solve water related problems. One such application is discussed in this section. The amount of dispersion measured in terms of the dispersion coefficient is obtained with experimental and empirical equation. In the absence of experimental data, the coefficient is determined by working with the data driven models, which utilizes the hydrologicaland geometricalparameters of the river stream and the prediction is obtained even without the knowledge of the physical process driving the system.

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Performance Evaluation of A Sewage Treatment Plant using Rhodamine-B Tracer

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ABSTRACT

Biological treatment is an important and integral part of any wastewater treatment plant that treats wastewater having soluble organic impurities. Activated Sludge Process treatment technology, is one such option for treating domestic wastewater. Biological treatment using aerobic activated sludge process has been in practice over a century. Increasing pressure to meet more stringent discharge standards or not being allowed to discharge treated effluent has led to implementation of a variety of biological treatment processes in recent years. In the present study, the performance of Sewage Treatment Plant for domestic sewage was evaluated in terms of Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total suspended solids (TSS), Total dissolved solids (TDS), and by water tracer studies using Rhodamine. STP showed a removal efficiency of BOD-95%, COD-90%, TSS-87%, TDS-35%. The study revealed that STP is well maintained and achieves the standards prescribed for effluent discharge by the Andhra Pradesh Pollution Control Board (APPCB).

***Keywords*: Rhodamine-B; Water Tracer; Activated Sludge Process; Performance Evaluation; Sewage Treatment Plant**

INTRODUCTION

Most of the metropolitan cities in India generate more than 38,254 million litres of sewage each day. Of this, it has been estimated that less than 30 per cent of what is collected undergoes treatment before it is disposed into freshwater bodies or sea [3]. As per Central Pollution Control Board rules, a city or town's municipality or water authority is responsible for collecting and treating 100 percent of the sewage generated within its jurisdiction. The level at which the sewage has to be treated depends on where it will be disposed; and treatment standards are higher for disposal into freshwater bodies than that into the sea. However, typically even where sewage treatment plants (STPs) exist, sewage collection networks are inadequate; so some portion goes for treatment and the rest flows into nallahs and drains. Sometimes wastewater stagnates in pools from which it leaches into the groundwater table and contaminates underground aquifers [11]. Among the various wastewater treatment technologies, the most common treatment technologies preferred by municipalities are conventional activated sludge process (ASP) and sequential batch reactor (SBR). These processes are at least partly automated and designed to meet specific output quality parameters.

Andhra Pradesh is one of the state's undergoing rapid urbanization and ranks as the most urbanized states in India. Study done by CPCB [15] on the performance evaluation of STPs in India revealed that the primary cause for degradation of our water resources is the pollution caused by sewage discharged from cities and towns [3]. Hence the treatment plant should be routinely checked for their performance and flaws in the treatment unit. This is usually carried out based on the removal efficiency of various wastewater characteristics and by water tracer studies.

Flow analysis and characterization in municipal and industrial wastewater facilities is part of the operational SOP. The effectiveness and efficiency of a treatment facility depends largely on adherence to hydraulic design. Dye fluorometry is used to check the hydraulic design of these systems [2, 16]. The application of water tracer in wastewater treatment system is mainly carried out for operational, environmental purposes, aeration and re-aeration basin mixing studies, contact chamber residence time analysis, operational, environmental purposes, and influent plume tracing, operational purposes. Among the various dyes available for fluorometric hydrologic studies, Rhodamine WT is recommended because it is easy to use and has many features which are desirable for water tracing[5], and because it is the most conservative of dyes available[5]. Studies have revealed that Rhodamine dyes can be effectively used as a water tracer and also found application wastewater treatment systems [6, 7, and 10].

Hyderabad, one of the four-mega cities in India, is the best example for pollution of surface water bodies caused by discharge from sewer outfalls. Central Pollution Control Board (CPCB) and Ministry of Environment and Forests [3] have reported that Musi river passing through the city receive wastewaters from 141+ and 276+, major and minor sewer outfalls, respectively. At present, there are 6 Major Sewage Treatment Plants in Hyderabad, with a maximum individual treatment capacity (overall) of 339 MLD and estimated generation of sewage in Hyderabad is 158 MLD [4]. Present study was carried out in Sewage Treatment Plant for domestic sewage at Amberpet municipality in Hyderabad district of Andhra Pradesh State in India. The main objective of the study was to evaluate the performance of treatment based on the removal of BOD, COD, TSS, TDS and using water tracer Rhodamine.

Experiments Design and Setup

Wastewater Characterization

The study was conducted in sewage treatment plant at Amberpet, Hyderabad, Andhra Pradesh, India. The treatment plant treats the water of Musi River which includes domestic waste water from Hyderabad municipality. Wastewater was collected from the inlet tank, aeration tank, and final outlet, was characterized for pH, Dissolved Oxygen (DO), Mixed liquor Volatile Suspended Sol ids (MLVSS), Mixed Liquor Suspended Solids (MLSS), Total Dissolved Soli ds (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Chloride and Sulphate as per standard methods of wastewater analysis [1].

Performance Evaluation of STP

Samples were collected from the inlet tank, aeration tank, and final outlet and performance evaluation of STP was carried out based on the removal efficiency of BOD, COD, TDS and TSS. Further, the performance evaluation was carried out using Rhodamine-B water tracer. Rhoda mine was mixed with 5 L of water and injected to the inlet of aeration tank of STP du ring inflow of domestic wastewater to the treatment system. The wastewater was collected at a regular time interval of 2 h for duration of 48 h and the samples were analyzed for the concentration of the tracer.

RESULTS AND DISCUSSION

Wastewater Characteristics

Physiochemical characteristics of sewage from the inlet tank of STP were given in table-1. Raw sewage characteristics were above the CPCB tolerance limits for effluent discharge.

Table 1 Characteristics of the Wastewater (STP)

Parameters	Influent Characteristics	APPCB Tolerance Limits
pH	6.0-7.5	6.0-9.0
TDS	1600-2700 mg/L	2100 mg/L
TSS	300-550 mg/L	100 mg/L
COD	600-800 mg/L	250 mg/L
BOD	250-300 mg/L	30 mg/L
Chloride	1000-2000 mg/ L	750-2000 mg/L
Sulphate	40-50 mg/L	2 mg/L

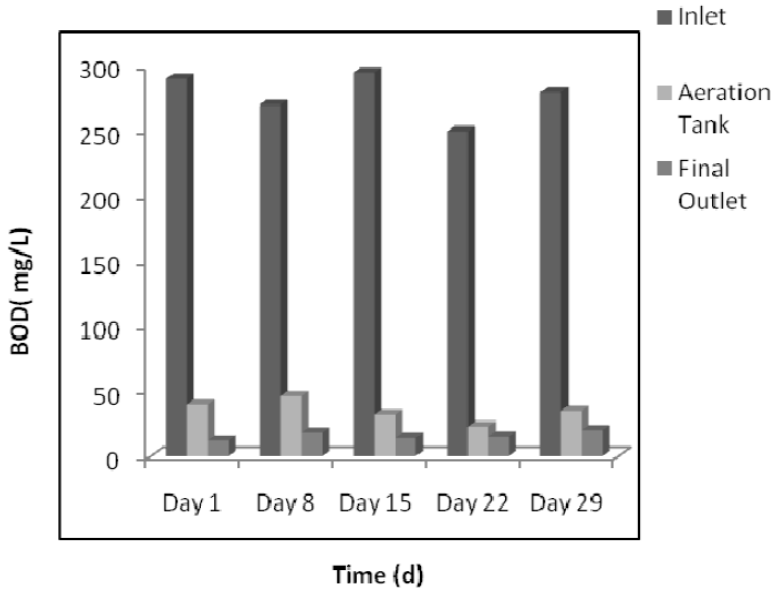

Fig. 1 BOD of the Wastewater in Various Units of STP

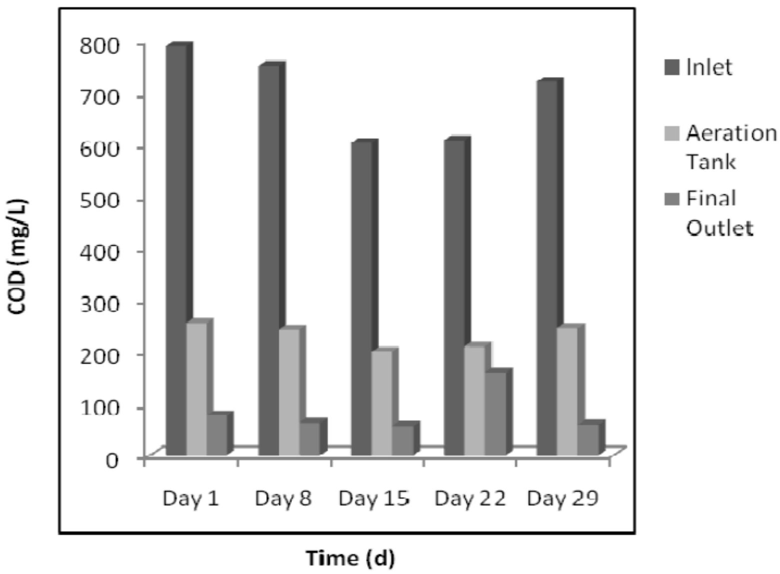

Fig. 2 COD of the Wastewater in Various Units of STP

Performance Evaluation of the Individual Units in the STP

1. BOD and COD Removal in the STP

BOD and COD of the domestic wastewater during the various stages of treatment are represented in fig. 1 and fig. 2. BOD of wastewater in the inlet tank varied from 250 mg/L to 290 m g/L, 23 mg/L to 40 mg/L in aeration tan k and final outlet BOD was 12 mg/L. There was a considerable reduction in the BOD during the treatment process. BOD rem oval during the study varied from 90% to 95% and the treatment system was able to achieve a maxim um BOD removal of 95.86 %. BOD removal of 95.86% can be attributed to the decomposition and mineralization of organic compounds [14]. The Biochemical Oxygen Demand (BO D) is the most important parameter in the treatment process design and effluent discharge or reuse [15]. Higher BOD removal may be mainly due to the higher volumetric loading higher rate than 0.3 to 0.7 Kg BOD/m3-d [7, 8].

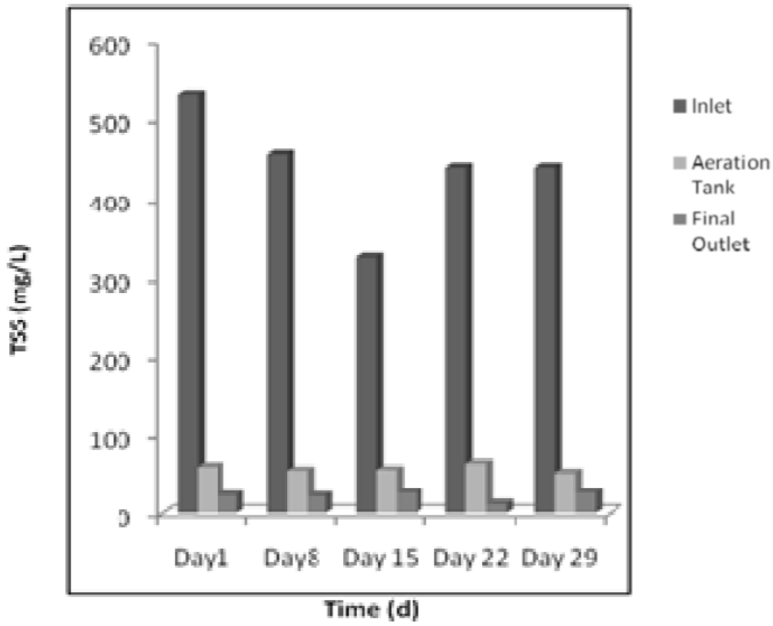

Fig. 3 TSS of the Wastewater in Various Units of STP

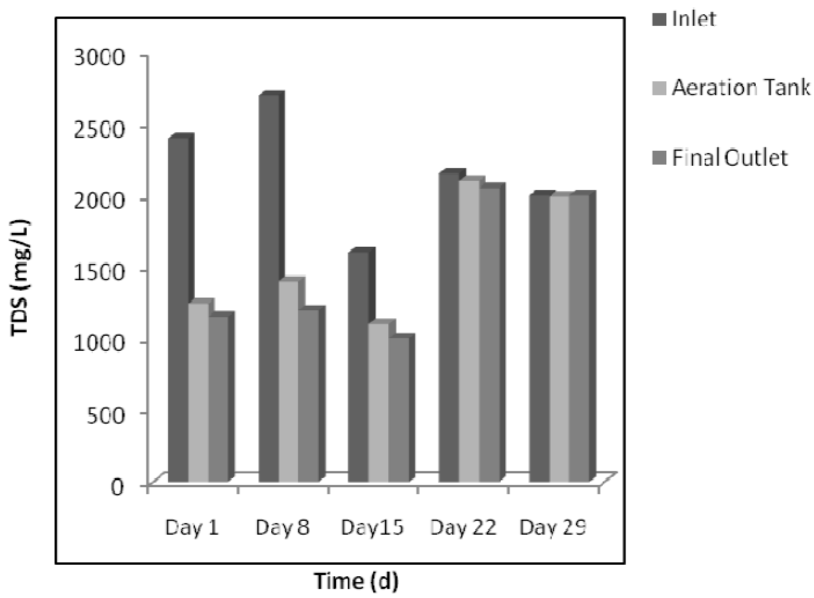

Fig. 4 TDS of the Wastewater in Various Units of STP

2. TSS and TDS removal in the STP

TSS and TDS removal in the various units of STP are represented in the fig. 3 and fig. 4, respectively. TSS of the domestic wastewater in the various units of STP also showed a reduction from 553 mg/L to 23 mg/L. A maximum removal efficiency of 95.6 8% was observed during the study. There was slight reduction i n the TDS of wastewater in the various units of STP compare d to the other parameters. TDS of the wastewater in the various treatment units varied from 1600 mg/L to 2700 mg/L in inlet tank, 1100 to 1900 mg/ L in aeration tank and 1000 to 200 mg/L in the outlet. A maximum removal efficiency of only 55.56 % was observed. Generally, TDS cannot be reduced in the biological wastewater treatment system. The norms for the discharge of effluent as prescribed by APPCB are 2100 mg/L.

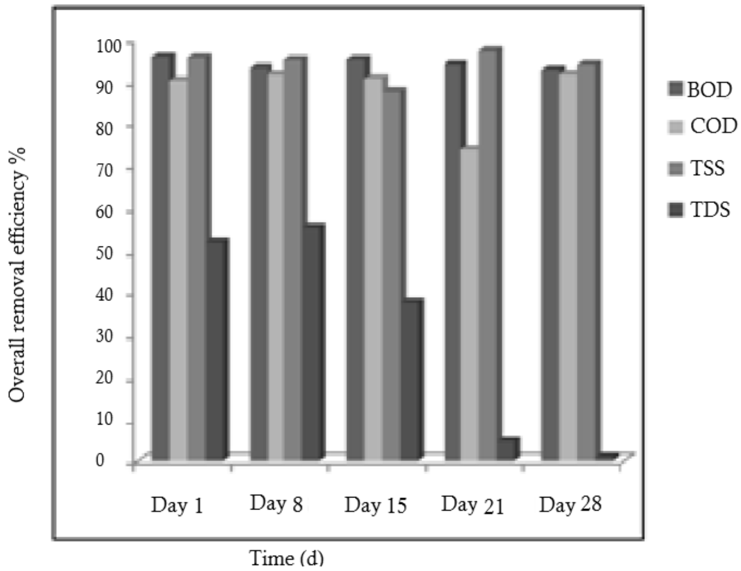

Fig. 5 Overall Removal Efficiency of STP

The parameters like BOD, COD and TSS in the treated effluent were found to be below the prescribed range by T NPCB for most of the time during the study period (fig. 4). The percent reduction i n total dissolved solids was 55% much below the expected removal of 70-80% indicating poor efficiency in terms of total dissolved solids removal. However, the removal of total suspended solids, COD, BOD was found to be satisfactory.

The influent wastewater of STP exhibited a COD to BOD ratio ranging from 2.04 to 2.78 and the values are comparable to those presented by Metcalf and Eddy (2003 and 1991) [7, 8]. The typical COD/BOD ratio of domestic wastewaters is usually in the range 1.25 to 2.5. However, for treated effluents, it ranges from 2.95 to 10.6. This indicates relatively higher proportion of the non-biodegradable content in treated effluent than raw wastewater. Hence the BOD removal efficiency is higher than that of COD [13].

Dissolved oxygen in the aeration tank varied from 2.3 mg/L to 2.5 mg/L, which was slightly above the desirable range of D.O (1.5-2.0 mg/L). MLSS/ MLVSS ratio varied from 0.51 to 0.62, which was also maintained to the desirable ratio of 0.60 (table 2). F/M ratio was maintained between 0.1- 0.18 (table 3). Evaluation of operating parameters like dissolved oxygen, MLSS, MLVSS and F/M ratio of the aeration tank revealed that the treatment unit is maintained in good operating condition and hence a good removal efficiency of BOD and COD.

Table 2 MLVSS and MLSS RATIO in STP

Duration of Sampling	MLSS (mg/L)	MLVSS(mg/L)	Ratio	Desirable Ratio
Day 1	1994	1012	0.51	0.60
Day 8	2100	1284	0.61	0.60
Day 15	2150	1330	0.62	0.60
Day 21	2140	1240	0.58	0.60

Table 3 F/M RATIO in STP

Date of sampling	F/M Ratio	Desirable
Day 1	0.16	0.1 - 0.18
Day 8	0.14	0.1 - 0.18
Day 15	0.15	0.1 - 0.18
Day 21	0.15	0.1 - 0.18

Rhodamine-B water Tracer Study

The volume of the aeration tank was 20,184 m^3 and the volumetric flow rate was 6.25 m3/min, which gave the theoretical mean residence time as 960 minutes. The experimental mean residence time was 840 min, meaning that the system has approximately 12.5% dead volume. The water tracer study revealed that aeration tank achieves the designed residence time and works efficiently as far as residence time is concerned. Lesser dead volume will be the area of stagnant zone within the aeration tank. According to Farook et al [9], a negligible volume of the stagnant zone in the aeration tank indicates that it works efficiently as far as residence time is concerned. In another study carried out in common effluent treatment plant for tannery effluent, the flaws in the aeration tank gave higher dead volume of 19.6% [10]. Rhodamine water tracer studies also revealed that the treatment system was in good condition maintaining a proper volumetric flow rate and there were no flaws in the treatment unit. Removal efficiency of the treatment unit also revealed that the unit is maintained in good condition.

CONCLUSION

All the individual units in the STP were checked for their design authenticity and no flaws were found and hence the design wise the STP was found to be satisfactory. The volumetric loading was found to be in the range of 0.30-0.33 kg BOD/m^3-d, which is within the normal range of 0.30 to 0.7 kg BOD/m^3/d. It was found that loading rates well enhanced the BOD removal efficiencies in the present study. Rhodamine water tracer study also revealed that the treatment system was maintained in a good condition without any flaws in the design of the treatment unit. The treatment plant was well maintained with a higher removal efficiency achieving the standards prescribed by the APPCB.

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Studies on Physico-chemical Analysis and Quality Awareness of Water in Villages around Nasik City, Maharashtra

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ABSTRACT

The present investigation was carried out to study physico-chemical characteristics of ground water samples collected from villages surrounding Nasik city. The ground water quality was assessed in terms of physio-chemical parameters. Ground water samples were collected from eleven (11) open as well as tube wells at various locations from the study area during pre and post monsoon season. The physico-chemical parameters such as pH, Electrical conductivity, TDS, Dissolved Oxygen, Alkalinity, sulphate, Chloride, BOD and COD were analyzed to know the present status of the groundwater quality. The results were compared with standards prescribed by Indian Standards (IS10500). It was found that the ground water in the study area was not contaminated. The sampling sites show physicochemical parameters within the water quality standards and the quality of water is good and it is fit for drinking purpose. Ground water quality of pre-monsoon season was better than post monsoon season. Few water samples were slightly alkaline along with high dissolved solids. During the present work a questionnaire was designed to test water quality awareness level in villagers. The questionnaire response analysis showed that water quality awareness level was not satisfactory.

***Keywords*:** Underground water, physico-chemical parameters, water quality awareness questionnaire.

INTRODUCTION

Water is a precious gift of nature to human being and safe potable water is absolutely essential for healthy life. Ground water is ultimate and most suitable fresh water resource for human consumption in both urban as well as rural areas. The importance of ground water for existence of human society cannot be overemphasized. In many states of our country, maximum population is dependent on groundwater for drinking and other purposes. There are over number of private wells in addition to the government tube and dug wells. The ground water is generally considered as potable, but there are various possible ways for ground water contamination, use of fertilizers and pesticides in farming, improper discharge of sewage and effluents from industries, results in the contamination of ground water. The incidence of ground water pollution is highest in urban areas where large volumes of waste are concentrated and discharge into relatively small areas. The hydro-geochemical conditions are also responsible for causing significant variations in ground water quality. This paper makes an attempt to carry out qualitative analysis of some physico-chemical parameters of ground water and awareness of drinking water quality from the village peoples.

STUDY AREA

The study area lies between latitudes 19° 59′ 39″ N and longitudes 73° 47′ 50″ E. and situated at an average height of 565 m above Mean Sea Level (MSL). The soil here is primarily black cotton which is favorable for agriculture. Vast mineral deposits, availability of water and good infrastructure conducive for industrialization in the Godavari and Darana river basin has resulted in heavy industrialization of the area. Many small, medium and large scale industries such as pharmaceuticals, paints, cables, and Eklahare Thermal Power Station (NTPS), sugar industry and metallurgical industries are situated in the region. The ground water quality of the study area could be affected by the industrialization. Increased population and improper drainage system have potential to influence the ground water quality. Geographical location of study area is shown in the Figure 1.

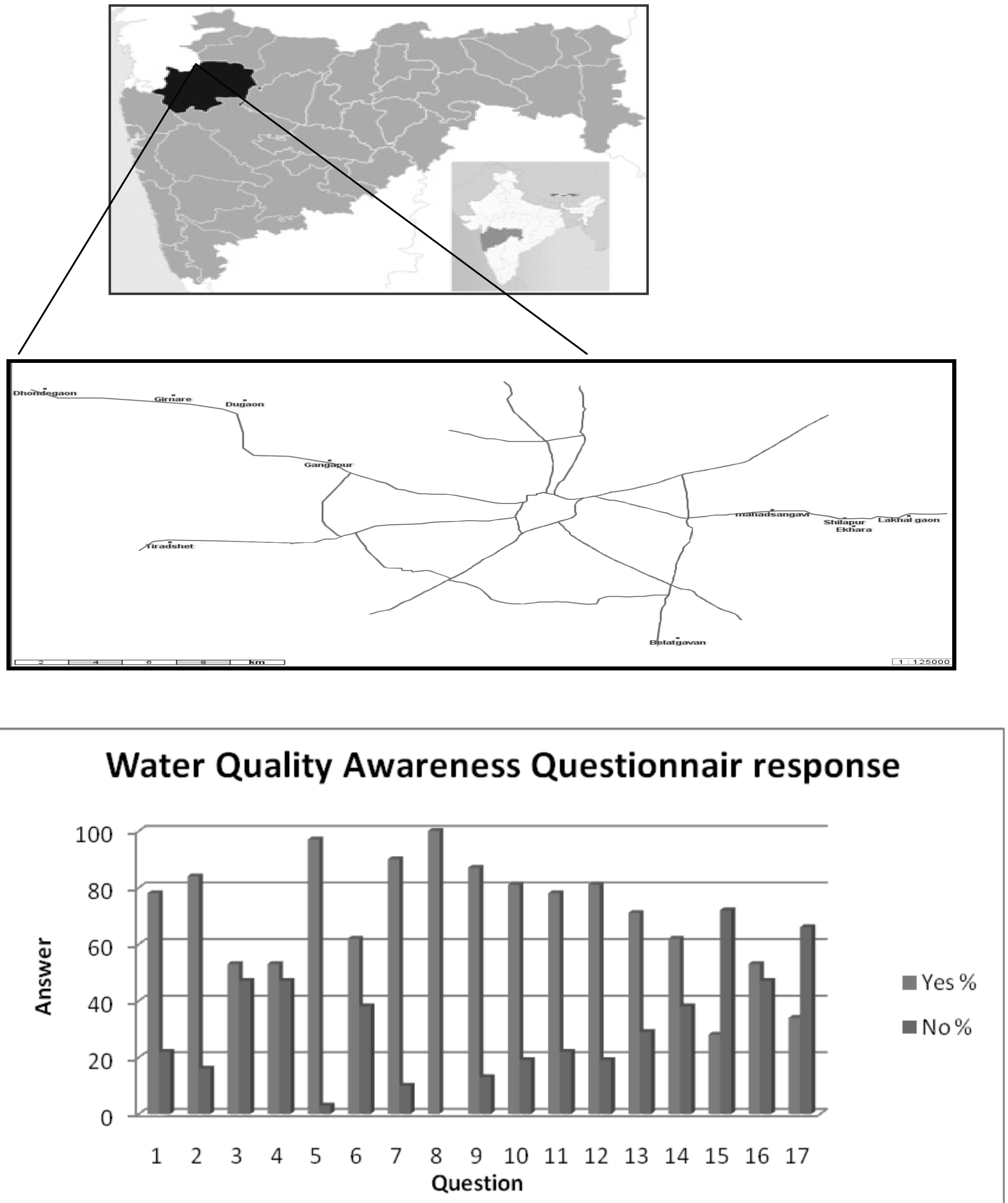

Fig. 1 Location of Eleven Villages and Water Quality awareness response graph

SAMPLE COLLECTION

The sampling locations are situated rural areas. Ground water samples were collected from eleven (11) wells at various locations within study area during pre and post monsoon season. Survey was conducted during study period for eleven villages around Nasik city. Details of sampling locations along with their latitude and longitude are illustrated in Table1. Samples were collected in plastic container to avoid unpredictable changes in characteristic as per standard procedure (APHA, 1998).A special questionnaire (Yes/No type) was prepared to test water quality awareness and was filled up by 200 peoples of different villages. The overall response is shown in Table 2.

Table 1 Well water Sampling Locations within the study area

Code	Sampling Location	Latitude	Longitude
1	Dugoan Village, Dug Well	20º 04’ 18” N	73º 41’ 07” E
2	Dhondegoan Village, BoreWell	20º 04’ 38” N	73º 36’ 56” E
3	Tiradshet Village, Dug Well	19º 58’ 45” N	73º 39’ 39” E
4	Gangapur Village, Bore Well	20º 01’ 52” N	73º 42’ 59” E
5	Mahadsangvi village Dug Well	20º 00’ 05” N	73º 52’ 26” E
6	Shilapur Village, Dug Well	19º 59’ 47” N	73º 53’ 57” E
7	Eklahare Village, Dug Well	19º 59’ 31” N	73º 54’ 10” E
8	Lakhalgoan village, Dug Well	$19^0$02’10” N	$73^0$55’18” E
9	Belatgavan village, Bore Well	$19^0$55’07” N	$73^0$50’37” E
10	Girnare Village, Dug Well	$20^0$04’27” N	$73^0$39’39” E
11	Musalgoan village, Bore Well	$19^0$50’38” N	$74^0$02’47” E

WATER QUALITY AWARENESS QUESTIONNAIR AND ITS RESPONSE

The water quality awareness questionnaire was designed to test what people know about purity, filtration methods, health effects of polluted water, water-borne disease, methods of disinfecting water, cleaness of water containers, essential minerals in water, hard and soft water, testing of water in laboratory etc.

Table 2 Water Quality Awareness Questionnaire Response (average)

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
% Yes	78	53	53	97	62	62	90	100	87	81	78	81	71	62	28	53	34

RESULTS AND DISCUSSION

The status of water quality of these ground water sources are presented in table 3. The various parameters studied are within the permissible limit and suitable for drinking purposes in the studied period. The finding of the present work is also recommends ground water, suitable for irrigation and domestic use. Maximum percentages of village people are not aware about health hazards of contaminated water. Therefore it is a need of human beings to expand water quality awareness among people to achieve healthy life.

Table 3 Concentration of water quality parameters in villages around Nasik City

Sr. no	Village	pH	Conductivity µs/cm	D.O mg/l	T.D.S mg/l	Chloride mg/l	Hardness mg/l	Alkalinity mg/l	BOD mg/l	COD mg/lit	Sulphate mg/lit
1	Dugoan	7.31	761	6.9	486	163	125	550	8.4	6.8	44.5
2	Dhondegon	7.48	456	4.2	298	211.9	134	560	3.8	5.8	55.0
3	Gangapur	7.5	549	6.7	560	192.7	230	670	4.4	10.4	85.0
4	Girnare	7.3	668	5.7	380	120	115	425	4.8	11.3	79.5
5	Tiradshet	7.27	506	2.5	315	119.5	142	540	3.4	9.4	47.0
6	Mahadsanvi	7.5	504	6.5	330	140.7	150	521	6.8	6.9	61.5
7	Lakhalgoan	6.75	345	7.5	380	147.7	135	530	3.2	9.7	90.0
8	Shilapur	7.63	241	5.5	260	134.4	120	650	4.5	10.5	66.5
9	Eklahare	7.75	275	5.8	494	124.5	290	552	3.3	11.6	89.0
10	Belatgavan	7.25	159	3.6	363	124.6	128	610	3.7	7.9	87.0
11	Musalgoan	7.5	189	6.7	560	191.7	230	670	5.3	12.4	65.8

CONCLUSION

Physico-chemical analysis of ground water in the study area gives clear picture of water quality in both dug well and bore well water. In conclusion the ground water tested from eleven villages surrounding Nasik city were found below the pollution level and thus are suitable for the domestic, agricultural and industrial perpose.The values are comparatively high in post monsoon.

Human health is more important issue related water quality. Analysis of water quality awareness questionnaire response by village peoples showed that the water quality awareness is basic need of time and preventive steps must be designed and applied by responsible authorities. Water quality awareness programmes using Audio-Visual aids and experimental demonstration by educational institutes would be useful to maintain and utilize better quality of water to achieve a healthy life in rural areas.

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Laboratory Bench Scale Experimentation on Phosphate Removal from Contaminated Water using Nano- Structured Synthetic Bimetal Oxide

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ABSTRACT

Phosphate is an important constituent of water. It acts as a vital nutrient for plant and animal life under optimum dose limits. In case of drinking water, phosphate thus needs to be ensured within safe limits. For surface water also, phosphate is a limiting parameter and nutrient energizer, and causes accelerated plant growth and formation of algal blooms - a hypoxic condition popularly known as eutrophication. Novel and innovative methodologies are being worked out to facilitate removal of phosphate from water. Development of low-cost synthetic materials by lab bench scale experiments and validation under different natural conditions is a subject of interest of many researchers. In the present study, nano-structured hydrous Iron (III)-Manganese (III and/or IV) bimetal oxide were synthesized and tested in the laboratory to find the efficacy of phosphate removal from contaminated water through batch adsorption procedure. The operational variables such as initial pH, adsorbent dose, initial phosphate concentration, contact bed (adsorption) time and quantum of adsorbed material, etc. were controlled in a systemic manner to optimize the results. It was observed that phosphate sorption was efficient, and attained equilibrium at 80 min of contact time. The maximum removal took place at adsorbent loading rate of 2.0g/L ml. The phosphate removal efficiency was respectively noted 99.9% and 99.6% for 5mg/L and 10mg/L concentration of phosphate solution under the laboratory test conditions. The overall uptake of phosphate was found to be maximum within the pH range 2 to 5. However, the present study observations were made at pH 6.0 which relates to that of drinking water. It is inferred that the developed nanoparticles of hydrous Iron (III)-Manganese (III and/or IV) bimetal oxide may serve as an important synthetic fixed bed material for phosphate removal from contaminated water under specific control conditions. Some other water quality parameters like hardness, chloride and iron which were high in the initial experimental water were measured after the batch process. Their concentrations remained unaffected which corroborates non-reactivity and non-interference of these water parameters with the developed medium. The success achieved in the above treatability study needs validation within filter beds under laboratory and field conditions for a holistic conclusion.

***Keywords*: Batch Process, Phosphate, Mixed Oxide, Nano-Structure, Reaction Kinetics.

INTRODUCTION

Phosphate is an important constituent of water and acts as an essential nutrient for plant and animal growth. However, excess phosphorus in surface water bodies causes overgrowth of phytoplanktons and algal blooms that leads to the hypoxic condition of eutrophication (or hypertrophication). In aqueous solutions, its mobility is limited and takes place both in dissolved and suspended states in inorganic (orthophosphate, metaphosphate) and organic forms (organophosphate). The main sources of phosphate in water are the phosphate salts derived from rock and soil weathering. Presence of phosphates beyond the stipulated range is toxic and causes physiological ailments through bioaccumulation (Kumar and Puri, 2012, Calvo et al. 2013, University of Sheffield, UK, 2011). Phosphorus in form of phosphine gas, though rare and unstable, is highly toxic in nature. Various chemical and biological techniques are in use for phosphate removal that relies on chemical precipitation of phosphate with active red mud (Liu et al. 2007), fly ash and slug (Ragheb, 2012), alum (Tanada et al. 2003), iron salts (Sperlich and Jekel 2010, Long et al. 2011) and biological interventions (Yeoman et al. 1988). The use of low cost lab bench scale developed synthetic materials has been attempted by some researchers (Yan-ling et al. 2009, Liu et al. 2010). The present study seeks to synthesize nano-structured particulates of Iron (III)-Manganese (II/IV) bimetal oxide and assess their phosphate removal efficacy from contaminated pond water and noting the differential controls of pH and adsorption kinetics thereof.

MATERIALS AND METHODS

Preparation of Bimetal Oxide

Nano-structured Fe-Mn mixed oxide for present experimentation procedure was prepared by mixing of Ferric Chloride ($FeCl_3$) and Manganese Chloride ($MnCl_2$) in appropriate proportions followed by successive additions of Sodium Hypochlorite (NaOCl) and Sodium Hydroxide (NaOH). The nano-structured form of the precipitated particulates was confirmed with the analysis by X-Ray Diffraction (XRD) followed by Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM).

Preparation of Phosphate Solutions and Analytical Methods

The phosphate stock solution (50 mg/l) was prepared by dissolving anhydrous potassium dihydrogen phosphate KH_2PO_4 salt in 0.01M Sodium Nitrate ($NaNO_3$) solution. From the stock solution, successive concentrations were selected for analysis as per the standard procedures (APHA 21th Edition, 2005). The methodology, reagents and laboratory apparatus were selected in line with the standard practices. All procedures were replicated twice for sake of better accuracy.

Methodology for Experiment

(I) Determination of Optimum pH

To determine the pH for optimum phosphate removal, 100 ml of standard phosphate solution (5mg/L and then 10 mg/l) was taken into 7 thoroughly cleaned glass beakers of 250 ml capacity and labelled accordingly. These solutions were respectively transferred into cleaned plastic bottles of proper capacity. 0.2 gm of MnFO was then added in each bottle and agitated in mechanical shaker at 250 rpm for 60 minutes. These solutions were filtered through membrane filter (pore size 0.45µm). 50ml of each of the solutions were taken and analyzed for phosphate content in double beamed UV-Vis Scan Spectrophotometer (Chemito make). The observations are noted below.

Case (I) A. Initial Phosphate Solution Concentration Fixed at 5 mg/L; pH varying; Amount of Bimetal Oxide Added: 0.2 gm/100ml; Agitation Time Fixed at 60mins

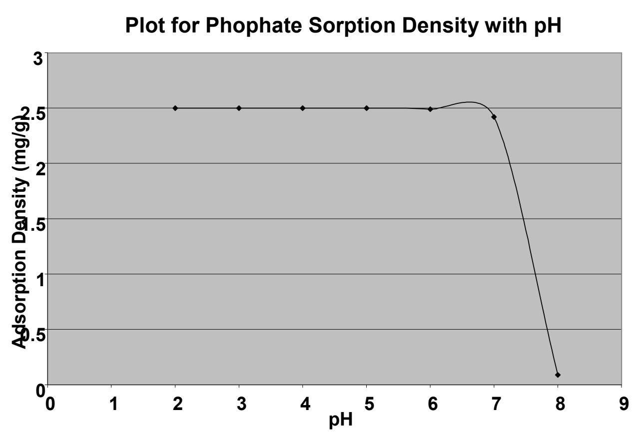

Fig. I A Plot for Phosphate Sorption Density with pH based on Experiment IA

Case (I) B. Initial Phosphate Solution Concentration Fixed at 10 mg/L; pH varying; Amount of Bimetal Oxide Added: 0.2 gm/100ml; Agitation Time Fixed at 60mins.

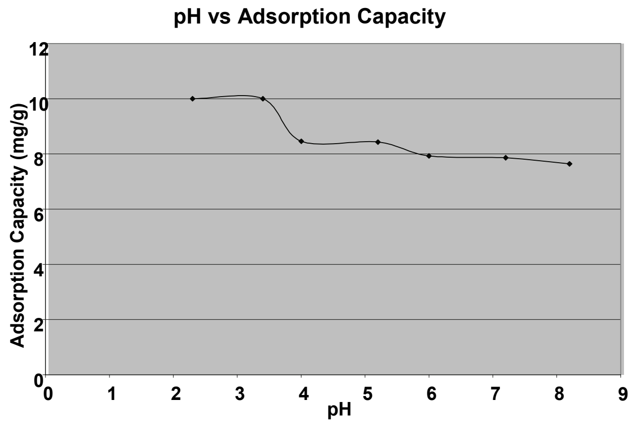

Fig. IB Plot for Phosphate Sorption Density with pH based on Experiment IB

(II) Determination of Reaction Kinetics

To determine the reaction kinetics, 100ml of standard phosphate solution (5mg/L and then10mg/L) was prepared from the stock solution and taken in each of 9 thoroughly cleaned glass beakers of 250 ml capacity. To control the pH of these solutions, 2 ml of pH 6 buffer solution was added to each bottle. 0.2 gm of MnFO was then added to each solution and agitated in mechanical shaker at 250 rpm. After every 10 min of interval, each bottle was taken out of the shaker, the solution filtered through membrane filter (pore size 0.45μm) and analyzed for phosphate content. Agitation time was thus made to vary from 10 to 90 min. The final phosphate concentrations were measured (Case-IA). The observations are noted below.

Case (II) A. Initial Phosphate Solution Concentration Fixed at 5 mg/L; Batch Solution pH Fixed at 6.0; Amount of Bimetal Oxide Added: 0.2 gm/100ml; Agitation Time: Varying.

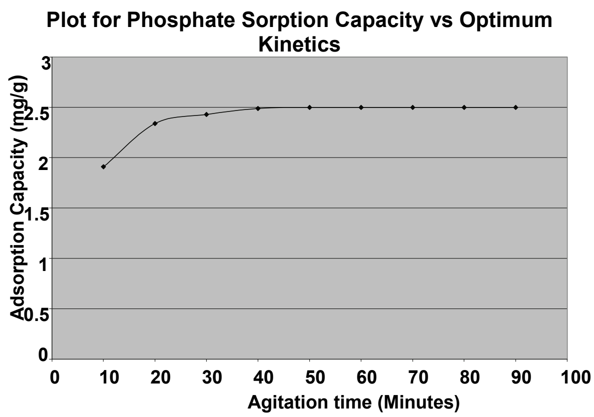

Fig. IIA Plot for Phosphate Sorption Capacity vs Optimum Kinetics Based on Experiment IIA

Case (II) B. Initial Phosphate Solution Concentration Fixed at 10 mg/L; Batch Solution pH Fixed at 6.0; Amount of Bimetal Oxide Added: 0.2 gm/100ml; Agitation Time: Varying.

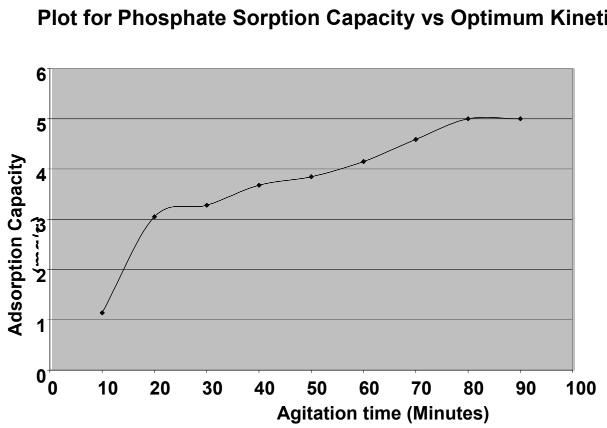

Fig. IIB Plot for Phosphate Sorption Capacity vs Optimum Kinetics Based on Experiment IIB

(III) Determination of Optimum Concentration

From the phosphate stock solution, 8 different standard solutions (100ml each) were prepared with phosphate concentrations varying from 5mg/L to 80mg/L. The reaction time was set at 80 min at pH 6.0. Amount of MNFO added was 0.2 gm/100ml and 0.5 gm/100ml. The follow-up procedures remained same as before. The observations are noted below.

Case (III) A. Initial Phosphate Solution Concentration Varying; Batch Solution pH Fixed at 6.0; Amount of Bimetal Oxide Added: 0.2 gm/100ml; Agitation Time: 80min.

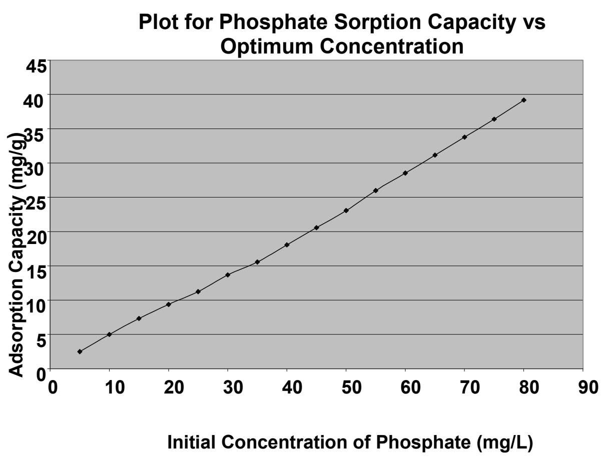

Fig. IIIA Plot for Phosphate Sorption Capacity vs Optimum Concentration Based on Experiment IIIA

Case (III) B. Initial Phosphate Solution Concentration Varying; Batch Solution pH Fixed at 6.0; Amount of Bimetal Oxide Added: 0.05 gm/100ml; Agitation Time: 80min.

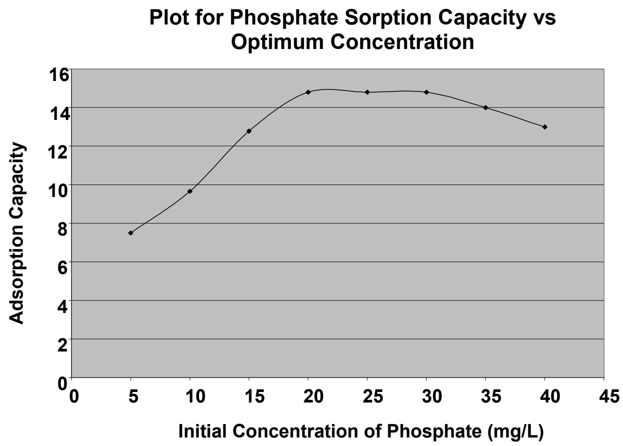

Fig. IIIB Plot for Phosphate Sorption Capacity vs Optimum Concentration Based on Experiment III B

(IV) Lab-Bench Scale Removal of Phosphate from Natural Water Using Developed MnFO Bimetal Oxides

Raw water was collected from different surface ponds of Kolkata city and surrounding municipalities. Two sets of samples were collected from each source. 1L of sample was collected without any preservative for determination of parameters like pH, total hardness and chloride. Another set of samples were collected with preservative (conc. HCl; 1ml HCl in 500ml sample) for parameters like iron and phosphate. The results are shown in Table 1.

Table 1 Analysis of Selected Water Quality Parameters in connection with Phosphate Removal of Collected Natural Water Samples

Sample No.	pH	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)	Iron (mg/L)	Concentration of Phosphate (mg/L)	
					Before Addition of Mixed Oxide	After Addition of Mixed Oxide Amount of Mixed oxide added: 0.2g/100ml Agitation Time: 80mins Batch Solution pH Fixed: 6.0
1.	7.2	130	379.9	0.173	0.032	BDL
2.	7.3	120	359.9	0.500	0.078	BDL
3.	7.5	170	319.9	1.381	0.075	BDL
4.	7.3	190	369.9	0.583	0.026	BDL
5.	7.4	190	169.9	0.053	0.416	BDL
6.	7.1	150	619.8	1.626	0.078	BDL
7.	7.2	170	349.9	0.520	0.066	BDL
8.	7.4	130	569.8	0.315	0.240	BDL
9.	7.5	290	889.7	2.549	0.410	BDL
10.	7.6	130	669.8	0.543	0.063	BDL
11.	7.5	140	849.7	0.646	0.185	BDL

CONCLUSION

The above study was conducted with newly synthesized nano-structured, non-toxic, bimetal oxide of MnFO developed on lab bench scale for phosphate removal from contaminated pond water. It was observed that for polluted phosphate water of 5mg/L, the phosphate removal capacity of MnFO was maximum at pH range between 2.0 and 5.0. At pH 6.0, the removal capacity remained almost same. But with further increase of pH value, the capacity of removal started to diminish (Fig. IA). In natural groundwater, the pH usually remains between 6.0 and 7.5. Hence from the above reactions the pH value of 6.0 was found to be the optimum one. Next, for polluted phosphate water of 10mg/L, maximum phosphate removal capacity of MnFO was noticed between pH 2 and 3. At pH 6.0, the removal capacity was almost 80 % (Fig. IB). The pH value was thus kept controlled at 6.0 for the experimental procedure.

In the following step, the polluted phosphate solutions of 5 mg/L and 10 mg/L were agitated at pH 6 for appreciable time period. The maximum phosphate removal was noted after 50 minutes (Fig. IIA) and 80 minutes (Fig. IIB) of agitation respectively. The reaction kinetics was accordingly allowed to occur for 80 min agitation time.

Finally, the equilibrium condition of the above phosphate removal process was worked out. It was observed that maximum 10mg/L of phosphate can be removed by 0.2gm of MnFO at pH 6.0 with agitation of 80 min. When the phosphate concentration was made to further increase, the conditions failed to achieve equilibrium even upto 80mg/L (Fig.IIIA). Hence, to reach an equilibrium state, the entire experiment was repeated with lesser amount (0.2 gm/100ml) of MnFO. Under such conditions, it was observed that the adsorption capacity of MnFO increased from initial phosphate concentration of 5mg/L to 20mg/L; thereafter it reached equilibrium from 20mg/L to 30mg/L and after that the adsorption gradually decreased with increasing phosphate concentration (Fig. IIIB).

The lab bench scale study findings with spiked water were next replicated with natural (pond) water samples following the same experimental procedures. Fe-Mn bimetal mixed oxide was found effective in removing phosphate under the normal pH range. Some key parameters of drinking water were also tested to find the potability of water. It was found that Total Hardness and Iron which were high in initial sample water (Table 1) were differentially removed after agitation. However, in no case these parameters were found to influence or compete with the phosphate adsorption. Further, there was no indication of solubility of adsorbent materials even after rigorous experimental agitation. This indicates that the synthesized nano-compound is water insoluble and there is no risk of contamination for applicability of these materials in fixed bed columns.

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Mobility of Cadmium in Sewage Sludge Applied Alluvial Soil and its Uptake by Radish (*Raphanus sativus L*)

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ABSTRACT

An investigation was carried out on "mobility of cadmium in sewage sludge applied alluvial soil and its uptake by radish (*Raphanus sativus* L)" at the research farm Sam Higgin bottom Institute of Agriculture, Technology and Sciences, Allahabad during 2011. In conjunction with lime, fertilizer, Phosphate Solublizing Bacteria (PSB) and Plant Growth Promoting Rhizobacteria (PGPR) on the behavior of cadmium. The availability of cadmium increased with increase the quantity of sewage sludge in the treatment T_1 and T_2 but in the treatment (T_3) lime @ 20 kgha^{-1} + 10 tha^{-1} sewage sludge decreased the availability cadmium from 0.95 ppm to 0.71 ppm. There was an increased the availability of cadmium in the treatment T_4,T_5 and T_6, T_7 applied sewage sludge with fertilizer and sewage with PSB. However, there was decreased the availability of cadmium when applied sewage sludge with PGPR in the treatment T_8 and T_9 as compared to only sewage sludge applied soil. The availability of cadmium was found twice with the application of fertilizer, PSB and PGPR in the treatment T_{10} and T_{11} recording 1.97 ppm (T_{10}) and 2.12 ppm (T_{11}) as compared to only sewage sludge T_1 (0.95ppm) and T_2(1.04 ppm).The main focus of present research paper to understand the chemistry of cadmium in sewage sludge applied soil with different treatment combination. Cadmium in sewage sludge and edible part of radish were above the internationally recommended (WHO) maximum permissible limits.. The results of investigation, we advise to farmers, don't apply sewage sludge, in agricultural land due to high level of cadmium in sewage sludge and its availability in soil , edible part of radish.

***Keywords*:** Sewage Sludge Allahabad (SSA), Lime ($CaCO_3$),Phosphate Solublizing Bacteria (PSB), Plant Growth Promoting Rhizobacteria (PGPR), Adsorption and Desorption.

1. INTRODUCTION

Application of sewage sludge as manure to agricultural soil is a common practice because of availability of plant nutrients and its low costs. However, this practice can pose a threat to environment and the major concern arises from the fact that sewage sludge, especially those from the heavily urbanized and industrialized areas, contains a relatively high concentration of heavy metals. Thus application of sewage sludge to agricultural soil may result in elevated concentrations of toxic heavy metals like cadmium, lead and chromium, which may lead to food chain contamination and harmful for human health. In addition, metal adsorption on soils is strongly related to soil properties; it increased with increase in pH, organic matter and cation exchange capacity.

Cadmium is considered as one of the important soil and an environmental pollutant as it is the most potential biotoxic heavy metal that is readily absorbed by soil and enters into human food chain (Chang *et al.,* 1885; Singh, 1998). The greatest concern due to cadmium concentration is because of its occurrence in free ionic form. The adsorption of Cadmium mainly involve the free divalent cation Cd^{2+} (Neals and Sposito, 1986).

Cadmium is highly toxic to human health . After gaining entrance into the body cadmium is accumulated mainly in the soft tissues. More than half the body's burden of cadmium is found in the kidneys and liver. A disease especially associated with cadmium poisoning has been recognized in Japan known as "itai-itai".The International Agency for Research on Cancer has classified cadmium and its compounds in group 2B: limited evidence of carcinogenetic in animals and human being . The daily intake into human body is 0.28 µg kg^{-1}.The main focus of present research work to know the adsorption and desorption properties of cadmium ion in different amendments with sewage sludge applied soil.

MATERIALS AND METHODS

The field work was conducted soil science and agricultural chemistry farm, School of Forestry and Environment, SHIATS, Allahabad. The total analysis of soil and plant sample were done in the laboratory of soil science and agricultural chemistry department. Radish (Raphanous Sativa L) was select to experimental trial for assess the uptake of cadmium from soil solution to different part of plant like root and leaf. Before sowing of crops representative soil samples were collected from each of the selected places. The soil samples were collected from (0-15)cm depth with the help of a stainless steel tube auger. The representative soil samples were transferred into tight polythene bags and brought into laboratory for proper processing. The soil sample were found sandy loam, bulk density 1.25 Mgm^{-3} particle density 2.85 $Mgm^{-3}$and available cadmium 0.15ppm. The chemical composition of soil depth 0-15 cm pH 7.3 , EC 0.20 dSm^{-1} organic carbon 5.5 g kg^{-1} ,available nitrogen 120 kgh^{-1},available phosphorous 9 kgh^{-1} and available phosphorous 150 kgh-1.

The soil samples were dried at 40˚C for 48 hrs. in the hot air oven and crushed to pass through a 2 mm nylon sieve. The available cadmium in the soil was determined by extracting the soil with DTPA –TEA –$CaCl_2$ (pH 7.3) as outlined by (Lindsay And Vorvell 1978). DTPA extractable cadmium was estimated in sewage sludge applied soil before sowing and after harvesting of radish. Plant roots were washed thoroughly with tap water; acidified water distilled water and double distilled water. These samples were then dried first at room temperature for several days and then in hot (60$\pm$5˚c) air oven for 48 hrs. The dried plant parts were then crushed and powdered separately in mortar & pestle .The powdered plant samples were then kept separately in well washed, dried and suitably labeled flasks for various analytical parameters. The digested samples soil and plant were then transferred into small tubes for total concentration of cadmium using by Atomic Absorption Spectrophotometer (Trierweter and Lindsay 1968).

The experiment was laid in randomized block design with 3 replications. The net cultivated area of each plot being $1m^2$.The crop was sown in the second week of October and harvested after 45 days. The experiment included the following treatments combination. The statistical analysis as per method of "Analysis of variance" (Fisher 1950).the significant and non significant of treatment effect was judged with the help of 'F' variance ratio test calculated 'F' at 5% level of significance.

Treatment Combination

T_0.	Control
T_1.	S.S.A. @ 10 tha^{-1} sewage sludge
T_2.	S.S.A. @ 20 tha^{-1} sewage sludge
T_3.	S.S.A. @ 10 tha^{-1} + 20 kg lime ha^{-1}
T_4	S.S.A. @ (10T) + NPK (recommended dose 120 kg: 70kg : 70 kg)
T_5.	S.S.A. @ (20T) + NPK (recommended dose120 kg: 70kg : 70 kg)
T_6.	S.S.A. @ (10T) + NPK + PSB @ 2kg ha^{-1}
T_7.	S.S.A. @ (20T) + NPK + PSB @ 2kg ha^{-1}
T_8.	S.S.A. @ (10T) + NPK + PGPR@ 2kg ha^{-1}
T_9.	S.S.A. @ (20T) + NPK + PGPR @ 2kg ha^{-1}
T_{10}.	S.S.A. @ (10T) + NPK + PSB@ 2kg ha^{-1} + PGPR@2kg ha^{-1}
T_{11}.	S.S.A. @ (20T) + NPK + PSB@2kg ha^{-1} + PGPR@2kg ha^{-1}

RESULTS AND DISCUSSION

DTPA extractable cadmium concentration at various depths

DTPA extractable cadmium in various depth of soil is summarized in table 1. Statistical analysis was found to be significant at 0-15 cm depths. The cadmium content (ppm) of post harvested soil of radish grown plot in treatment T_1 0.95 (ppm) and T_2 1.04 ppm treatment tended to be higher than without sewage sludge applied soil 0.03 ppm (control) in 0 -15cm soil depth. The data relevant cadmium content increased gradually with increasing dose of sewage sludge application . Similar finding had also been reported by Hussein *et al* 2009 Barma *et al* 2007 Ashok *et al* 2009.

The net effect of liming on metal transformation in the sludge depends on the relative changes in the pH and the increase in the concentration of Ca++ ions added through liming, creating a reduction of cadmium uptake which is attributed to increase adsorption / precipitation at high pH and competition between heavy and other cation for uptakes (Yassen *et al.,* 2006). The solubility of cadmium hydroxide complexes decreases as pH increases, owing to the formation of solid $Cd(OH)_2$.

Lime addition as ($CaCO_3$) in soil was found to decrease the availability of cadmium Cd and which form cadmium carbonates of calcium due to dynamic nature of equilibrium is thought to exist.

$$\underset{\text{(Soil)}}{Cd + CO_3} \rightleftarrows \underset{\text{(Lime)}}{CdCO_3}$$

The rates of reaction proceed from left to right in the equation.

$$R_f \ \alpha \ [Cd]^{2+} [CO_3]^-$$

$$R_f = K_1 [Cd]^{2+} [CO_3]^-$$

Here in this equation k_1 is constant called velocity constant. Both the formation of backwad and farward reaction $R_2[CaCO_3]$, the Rf and Rb are equal and this an equilibrium is established which accounts for the low solubility of Cd^{2+} in solution due to low solubility of $CdCO_3$ forward as insoluble compound . It's, therefore found to have low solubility of Cd in soil resulting in low uptake by plant.

The DTPA extractable cadmium in the treatment T_3 @ 10 Tha^{-1} sewage sludge + 20 kg lime ha^{-1} were found 0.71 ppm in comparison to treatment T_1 @ 10 Tha^{-1} sewage sludge 0.95 ppm. The low mobility of cadmium in lime treated soil this might be to high pH of soil and formation of insoluble hydroxide and carbonate was prime research for low uptake of this metal in plants (Yada and Kawasakil 2008 and Hanc *et al*., 2006).

Application of sewage sludge with RDF had significant effect in the availability of cadmium content in radish grown plot in the treatment T_4 1.50 ppm and T_5 0.78 ppm in compassion to T_1 0.95 (ppm) and T_2 1.04 (ppm) at 0 -15 depth this might be due to phophatic fertilizers contain cadmium metal as impurity. In this treatment higher concentration of cadmium in the treatment T_4 1.50 ppm in comparison to T_5 0.78 ppm this might be due to increase dose of sewage sludge highly contain organic carbon which reduce the availability of cadmium in soil with similar dose of RDF.

The interaction between sewage sludge + RDF + PSM increased the availability of cadmium in the treatment T_6 1.42 ppm and T_7 1.12 ppm in compassion to T_1 0.95 (ppm) and T_2 1.04 (ppm) at 0 -15 depth increase the soluble form of phosphorous increased availability of cadmium it might be due to increase the cadmium contained phosphetic fertilizer increase the availability of cadmium.

The interaction between sewage sludge + RDF + PGPR decreased the amount of extractable cadmium in the treatment T_8 0.53, ppm and treatment T_9 0.75 ppm respectively in comparison to T_1 0.95 (ppm) and T_2 1.04, ppm at 0 -15 depth this might be due to plant growth promoting rhizobacteria producing Indo acitic acid (Vivas *et al* 2003) The interaction between sewage sludge + RDF + PSB + PGPR had showed highly desorption property of cadmium ion in radish grown plot in the treatment T_{10}1.88 ppm and treatment T_{11} 2.06ppm respectively in comparison to treatment T_1 0.95 (ppm) and T_2 1.04, ppm at 0 -15 cm depth (Thongavel and Subbhuraam 2004).

Cadmium concentration in radish root and leaf

In the table 1 depicted the statistical analysis of the data on cadmium (ppm) in radish root and leaf was found to be non significant in the experimental year. Applications of sewage sludge increase the concentration of cadmium in radish root and leaf was also increased $T_1$0.03 and $T_2$0.03 ppm in root and $T_1$0.04 and $T_2$0.05 ppm in leaf in comparison to control plot T_0 (0.02ppm in root and 0,03ppm in leaf) Shiwani 2006 and Hundal *et al* 2006, Hanc *et al* 2006.

Table 1: Concentration of Cadmium (ppm) in soil , root and leaf of radish

Treatments	Soil (0-15) cm depth	radish root	radish leaf
T_0	0.03	0.02	0.03
T_1	0.95	0.02	0.03
T_2	1.04	0.03	0.04
T_3	0.71	0.02	0.03
T_4	1.56	0.03	0.05
T_5	1.25	0.04	0.04
T_6	1.42	0.04	0.06
T_7	1.12	0.03	0.05
T_8	0.90	0.04	0.06
T_9	0.68	0.03	0.05
T_{10}	1.97	0.04	0.07
T_{11}	2.12	0.06	0.08
F-test	S	NS	NS
S.Em ($\pm$)	0.12	0.01	0.02
C.D (P=0.05)	0.28	0.02	0.04

The application of sewage sludge with lime, checks the availability of cadmium due to calcium carbonate reacts with cadmium form insoluble cadmium carbonate in the treatment T_3 @ 10 Tha^{-1} sewage sludge + 20 kg lime ha^{-1} 0.02ppm in root and 0.03 ppm in leaf in comparision to T_1@ 10 Tha^{-1} sewage sludge 0.03 ppm in root and 0.04 ppm in leaf. this might be to high pH of soil and formation of insoluble hydroxide and carbonate was prime research for low uptake of this metal in plants (Yassen *et al.,* 2006).

Application of sewage sludge with RDF had significant effect in the of cadmium content in radish root in the treatment T_4 0.03and and in the treatment T_5 0.04 ppm in compassion to T_1 0.03 ppm and T_2 0.04 ppm and radish leaf T_4 0.06and and in the treatment T_5 0.04 ppm in compassion to T_1 0.04 ppm and T_2 0.05 ppm this might be due to phosphoric fertilizers contain cadmium metal as impurity.

The interaction between sewage sludge + RDF + PSM the availability of cadmium in the treatment in rootT_6 0.04ppm and T_7 0.03 ppm and in leaf T_6 0.06ppm and T_7 0.05ppm this might be due to because that the PSB showed intrinsic ability of growth promoting and attenuation of toxic affect of heavy cadmium could be exploited for remediation of heavy metal from heavy metal contaminated sight. Similar finding had been reported by Wania and Khan 2010.

The interaction between sewage sludge + RDF + PGPR ($T_8$and T_9)decreased the amount of extractable cadmium observed by plants when expressed on a root weight basis because of increase root biomas due to production of indol acitic acid. Similar finding had reported by Vivas *et al* 2003.

The interaction between sewage sludge + RDF + PSB + PGPR (T_{10} and T_{11})showed a positive correlation between invitro1-aminocyclopropane-1 carboxylate (ACC) deaminase activity of the bacteria and their simulating effect on root elongation suggest the utilization of ACC is an important bacteria trait determining root growth promoting. The isolated bacteria promise as innoculant to improved growth of metal accumulating plant raddish in presence of toxic Heavy metal concentration for the development of plant innoculant system useful for phytoremediation of polluted soil. Khuda and Hassan 2005, Han sim Hee 2007.

CONCLUSION

On the above information we had concluded application of sewage sludge collected from sewage treatment plant Naini, Allahabad was not suitable for agricultural use spatially in case of vegetables. Vegetables are highly sensitive to heavy metals. Cadmium concentration was found above the permissible limit in sewage sludge, sewage sludge applied soil and radish root and leaf (WHO) standard.

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Suitability Evaluation of Physico-Chemical Parameters of Ashwaraopally Lake Water for Irrigation

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ABSTRACT

The present study was designed to assess the physico-chemical characteristic of water samples collected from Ashwaraopally Lake, Raghunath palli, Warangal District, Telangana, India. The physico-chemical parameters such Colour, pH, Odour, Dissolved Oxygen, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Calcium, Hardness, Alkalinity, chloride, Nitrate, Potassium, Phosphorus and Magnesium were studied. The results obtained showed a fluctuation in this parameter's which gave an idea about the intensity of pollution caused by agricultural activities in the surrounding areas and also the human interference. The study revealed that the lake water was alkaline and other parameters concentrations were also high. Every parameter showed a significant correlation with increased lake water pollution. The determined physico-chemical parameters were compared with the ICMR standards for the drinking water to know about the water quality and check for the suitability of water for irrigation purposes.

***Keywords*:** Ashwaraopally Lake, Physico-Chemical Parameters, water Quality, water pollution and suitability.

INTRODUCTION

Water is the essential component of life on earth but the . The use of fertilizers, pesticides and manure are main source of water pollution in this area. Water is generally used for drinking, fisheries and other domestic purposes in this area. And the runoff of this pesticide containing water is polluted the lake water. The available fresh water to man is hardly 0.3 to 0.5% of the total water available on the earth and therefore its judicious use Imperative. Lakes are one of the important water resources used for irrigation, drinking, fisheries and flood control purposes. On the other hand, lakes also provide a habitat for invertebrates, fishes and aquatic birds. Therefore scientific study needs to review strategies for conservation and better utilization of lakes .It is with this background, the present work was undertaken between Nov 2013 to Feb 2014. Water is the elixir of life, a precious gift of nature of mankind and millions of other species living on the earth. It is fast becoming a scare commodity in most part of the world. Water is an essential requirement of human and industrial development and also it is one of the most delicate parts of the environment. Water, due to its great Solvent power, is constantly threatened to get polluted easily. Pollution in broad sense refers to any change which causes misbalance in the natural quality of the environment brought about through physical, chemical or biological processes

Due to migration of population, it becomes necessary for the corporation to give clean drinking water for the entire population. The effluents of the leather industries, usage of the chemical fertilizers for agriculture and small scale dying industries falls heavily on the quality of the drinking water. The impact is felt very much on the drinking water. Different activities of man have created adverse effects on all living organisms. Today the environment has become foul, contaminated, undesirable and therefore harmful for the health of the living organisms including the man.

Besides pesticides, another group of contaminants which could jeopardize the fresh water aquatic resources include heavy metals such as Zn, Cu, Pb, Fe, Mn, Hg and Cr. Results of studies on metal in pollution are well documented revealing the toxic effects of these metals on aquatic organisms. These contaminants bring various pathological changes including tissue damages, asphyxiation, enzyme abnormalities and also behavioral abnormalities. Various physicochemical parameters were studied to assess the water quality status and the extent of deterioration in the water quality of lake around the lake. The polluted lake water may enter into aquifer or ground water body of fringe areas, specially the downstream areas by percolation and influent seepage. The natural quality of hand pumps bore wells and drinking water resources tend to be degraded in the fringe areas of lake. Several investigations and research studies have been made on water quality and increasing pollution level of the water body. Hence periodic monitoring and preventive measures are required to save the lake from eutrophication. Baseline regarding the quality of the water which is used for agriculture and other household purposes. In the present study to carry out qualitative analysis of physico-chemical parameters of ground water in the study area.

Water quality

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The origin of lake is an important key to understanding its water quality and response to different pollutant inputs. The origin is also an important clue to the lakes form and its sediment characteristics. These factors will in turn determine the lakes form and its sediment characteristics. These factors will In turn determine the lakes detention time and affect its nutrient content.

MATERIALS AND METHODS

Study area

The water samples were collected from Ashwaraopalli Lake, Raghunath palli, Warangal Dt., Telangana. Raghunath palli is village in Warangal – Hyderabad highway 45 kms away from Warangal. The present investigation was to estimate the mineral content of the contaminant water area in an around Ashwaraopally (lake).

Fig. 1 Showing sampling locations in the Lake

Seasonal crops: Rice, cotton, sunflower.

Type of Fertilizers: Urea, Potassium, Zinc, DAP, NPK

Sample collection

The samples which were used extensively for agricultural purposes were identified. The samples were collected in the pre-cleaned polythene bottles with necessary precautions. Five samples are collected from different positions of lake using spot sampling procedure. And immediately pH of the samples was recorded.

Analysis

The pH, temperatures, conductivity and total dissolved solids of the samples were noted at their sampling point itself. The samples were subjected to the physical and chemical tests. These include hardness, total dissolved solids and chlorides. Standard procedure involving Volumetric was used for the experiment.

Table 1 Methods used for physical and chemical analysis of lake water

Parameter(unit)	Method
Electric Conductivity (µs/cm)	Potentiometric
pH	pH probe
Dissolved oxygen (mg/l)	Titrimetric
Biochemical Oxygen Demand (mg/l)	Titrimetric
Total hardness (g/l)	Titrimetric
Calcium (g/l	Titrimetric
Magnesium (g/l)	Titrimetric
Phosphates	Uv spectro photometer
Potassium	Flame photo meter
Chemical oxygen demand	Titrimetric
Chlorides	Titrimetric
Nitrates	Uv spectro photometer
Alkalinity	Titrimetric

The results were compared to ICMR standards. Dissolved oxygen was fixed immediately after collection and then determined by Winkler's method. Nutrients (NH4+, NO3, and PO43) were determined by standard photometric method using Varian 50 Bio U.V visible Spectrophotometer. Samples for BOD were incubated in laboratory for five days at 20°C. Total hardness was estimated by the complex metric titration with standard EDTA solution using Eriochrome Black T as indicator.

RESULTS AND DISCUSSION

The collected samples were analyzed for different physico-chemical parameters such as pH, BOD, TDS, Total hardness, colour, odour, alkalinity, chloride, nitrate, calcium, and magnesium as per the standard methods and the results were compared with the ICMR Standards for potable water. The results are presented in the (Table 2). The physico-chemical characteristics of effluent treated water were compared with the Indian Standard Specification for Drinking Water. The colour of the effluent treated water was greenish and brownish. The Sample collected from the effluent discharged water Storage lake was found to have unobjectionable odour on prolong stay it gave foul smell; this may be due to organic waste from tanneries and chemical industries. Our water analysis's primary concern with the contaminated lake water analyzed with the drinking water and any adverse effects may affect the health. The physico chemical parameters of the contaminated lake water were analyzed by standard procedures.

PHYSICO-CHEMICAL PARAMETER

Colour

The contaminated lake water was slightly greenish in colour.

Odour

The odour of contaminated lake water was objectionable.

pH

The pH of the lake water sample is 7.48. The pH value of the lake water sample is under the normal range when compared with the drinking water standard (1993). Higher pH values of studied lake water during summer could be ascribed to increased photo synthetic assimilation of dissolved inorganic carbon by planktons. The amount of acid in water 7.0 is neutral; Ph values below 6.5 may result in corrosive water; values above 7.5 may indicate hard water. pH is defined as the negative logarithm of the effective hydrogen-ion concentration. The normal pH range for drinking water is 6.5-8.5; lake water sample has a pH of 7.48 which falls under the normal range. A high pH will affect the mucous membrane. Water below 6.8 is beyond slightly acidic and approaching extremely corrosive (4.0-5.9).

Electrical conductivity

Electrical conductivity is a measure of the saltiness of the water and is measured on a scale from 0 to 50,000 uS/cm. Electrical conductivity is measured in microsiemens per centimeter (uS/cm). Freshwater is usually between 0 and 1,500 uS/cm and typical sea water has a conductivity value of about 50,000 uS/cm. Low levels of salts are found naturally in waterways and are important for plants and animals to grow. When salts reach high levels in freshwater it can cause problems for aquatic ecosystems and complicated human uses.

Dissolved Oxygen

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water as rooted aquatic plants and algae undergo photosynthesis, and as oxygen is transferred across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (colder water holds more oxygen). Both the partial pressure and the degree of saturation of oxygen will change with altitude. Finally, gas solubility decreases as pressure decreases. Thus, the amount of oxygen absorbed in water decreases as altitude increases because of the decrease in relative pressure.

Biological Oxygen Demand (BOD)

BOD is a value of presence of organic materials in water which can support increasing of microbe organisms. Surface water (river, lake) containing BOD values 10 mgL-1 are consider being moderately and more than 20 mgL-1 as to be highly polluted water. The greater the decomposable matter present, greater the oxygen demands and greater the BOD values. The biological oxygen demand of the lake water is 50mg/l.The lake water has high BOD level when compared to the drinking water standard.

Chemical Oxygen Demand (COD)

The maximum permissible value of COD is 10 mgL-1 for drinking water the chemical oxygen demand of the normal drinking water standard is 250mg/l in comparison the lake water contain a high level of COD (365.6mg/l). COD can be applied for rapid analysis of heavily polluted samples. According to the general standards for discharge of environmental pollutions the cod level is 250 mg/l. The lake water level has a COD range (300 mg/l). Increased level of COD in sample shows the higher level of contamination.

Alkalinity

The total alkalinity of the contaminated water was noted that 530mg/l thus the total alkalinity is very high in the lake water sample. Alkalinity for a standard drinking water is 200mg/l. in the lake water the alkalinity is 530 mg/l. It indicates the presence of bicarbonates, carbonates and hydroxides above the normal value the water taste becomes unpleasant high alkalinity should be corrected for both economic and health concerns.

Hardness

The total hardness of calcium carbonate in the water sample is 558.6mg/l, the normal value is 300mg/l. hard water is arbitrary; the Indian Geological survey uses the following classification: 1-60 mg/l is considered moderately hard, 121-180 mg/l is considered hard, and above 180g/l is considered very hard. Total Hardness (CaC03 - calcium carbonate) “Hardness” refers to the amount of calcium and magnesium in the water and is measured in grains per gallon.

Chloride

Higher concentration of chloride in water is often found in combination with higher sodium concentration. ICMR prescribed 250 mg/l as the maximum permissible value. If the chlorine value exceeds 300 mg/l and the presence of a major camion is sodium, then the water becomes salty. Sources of chlorides are from soluble salts such as sodium chloride. The chloride content of the lake water showed a high level of 338mg/l. The high level of chlorine beyond 250mg/l affects the taste, palatability and corrosive effect of water. When combined with sodium, gives salty taste to drinking water and may increase the corrosiveness of water.

Nitrate

In general, increase downstream the pollution input gives a sufficient indication of the deteriorating quality of water due to entry of wastewater in river. The total concentration of nitrate is 53.8mg/l. The desirable amount of nitrate in drinking water standard is 45mg/l. High concentrations of nitrate suggest pollution. Some animals such as ruminants (cud chewers) can be poisoned by nitrate if the concentration is high. High level of Nitrate encourages growth of algae and other organisms. The tolerance limit for the nitrate is 45mg/l beyond this causes methanemoglobinemia. Infants below the age of six months who drink water containing nitrate in excess could become seriously ill and if untreated may die. Symptoms include shortness of breath and blue-baby syndrome.

Calcium

Magnesium as co factor for various enzymatic transformations within the cell especially in the trans-phosphorylation in algal, fungal and bacterial cell the normal concentration of calcium according to the drinking water standards is 75mg/l. The concentration of contaminated lake water is 204.3mg/l. thus the level of calcium is found to be very high which contributes to the hardness of water. Calcium is an important content in natural water which determines the rigidity of water.

Magnesium

Magnesium as co factor for various enzymatic transformations within the cell especially in the trans-phosphorylation in algal, fungal and bacterial cell. The level of magnesium in the contaminated lake water is 152.8mg/l. The contaminated lake water has high level of magnesium when compared with the drinking water standards (30mg/l). Magnesium is one of the main constituent in natural water and it's an important contributor for hardness of water. Thus the presence of high level of calcium and magnesium indicate the contamination of lake water which contributes to the hardness of water.

Phosphorus

Phosphorous in the water mostly exists in the form of phosphate which is the essence of soil nutrients and animals and plants bioplasm. Phosphorous is an important nutrient for the maturation of plants. Excessive phosphorous existing in a body of water will cause mass reproduction of algae and death to other organisms. Moreover, the decay and decomposition of algae would exhaust the dissolved oxygen in the water and lead to eutrophication.Water phosphate is commonly expressed as milligrams of phosphate per liter of water (mg/L of PO_4)

Potassium

Potassium content in natural bodies of water is far lower than that of sodium. Its concentration is usually only 4% to 10% of that of sodium. In some quartzite areas, the potassium content in natural water is near or exceeds sodium content but both of them are very low, only some single-digit mg/L respectively. In most fresh water with sodium concentration below 10mg/L, the potassium concentration is only 10% to 50% of the sodium concentration.

Table 2 Analysis of Physiochemical parameters in lake water of Ashwaraopally village.

Parameters	Sample1	Sample2	Sample3	Sample4	Sample5	Avg of samples
Colour	Darkish green	Greenish brown	Darkish green	Darkish green	Greenish brown	Greenish brown
Odour	Unobjectionable	unobjectionable	Unobjectionable	unobjectionable	unobjectionable	Unobjectionable
Ph	7.22	7.6	7.42	7.10	8.1	7.48
Electrical conductivity (µS/cm)	850	972	988	1680	1800	1258
BOD	45	56	64	60	68	58.6
COD	300	367	389	392	380	365.6
DO	5.8	7.8	8.2	8.12	7.9	7.56
Alkalinity	530	499	536	579	510	530
Chloride	312	365	340	325	350	338
Hardness	564	536	568	570	555	558.6
Phosphorous (mg/l)	1.52	2.3	1.9	1.1	1.0	1.56
Potassium (mg/l)	5.2	4.5	3.3	4.1	5.2	4.46
Nitrate(mg/l)	50	49	60	56	54	53.8
Calcium	198	219	200	195	210	204.4
Magnesium	148	152	160	154	150	152.8

Table 3 Comparison of ICMR Standard values with the average values of contaminated lake

S.No	Parameters	Drinking water standard (ICMR STANDARDS)	Effluent contaminated lake
1	**Colour**	Clear	Greenish brown
2	**Odour**	unobjectionable	unobjectionable
3	**pH**	6.5-8.5	7.48
4	**Electrical conductivity(µS/cm)**	0-300	1250
5	**Dissolved oxygen (ppm)**	4-6	7.56
6	**BOD**	30	45
7	**COD**	250	300
8	**Alkalinity**	200	530
9	**Chloride**	215	338
10	**Hardness**	300	558.6
11	**Nitrate**	45	53.8
12	**Calcium**	75	204.4
13	**Magnesium**	30	152.8
14	**potassium**	3.5	4.46
15	**Phosphorus(mg/l)**	0.1	1.56

Results of chemical examination expressed in mg/l except pH. BOD- Biological oxygen demand; COD- chemical oxygen demand.

CONCLUSION & RECOMMENDATIONS

Main aim of this study was to understand the level of organic pollution and nutrient concentration in the lake and results revealed that concentration of all the important parameters which mainly govern the lake chemistry are beyond the permissible limits and threshold levels. The surface water is deteriorating in Ashwaraopally and the sampling station Ashwaraopalli lake needs special attention, as all the parameters such as potassium, chloride, hardness and BOD,COD is found high. Polluted water could cause much disease to human being. It may cause laxative effects on health of the people consuming that water and it is not much suitable for irrigation purpose also. So we Special care should be taken to keep clean water.

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THEME - VI

WATER AND IRRIGATION MANAGEMENT

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 projects like “RIVER JOINING” were 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

Keywords: River, water, India.

1.0 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 in2014, 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.

2.0 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

3.0 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".

3.1 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 water to 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.

3.2 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.

3.3 Main Reservoir Canal

A 2 meter wide land strip, at 35mtres above MSL and about 30 to 50 km (as the case may be), inside the coast (land side) will have to be earmarked alongside the entire seashore length of 7500 km. 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, 00,000 cubic 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. km. 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.

3.4 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, affecting 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

- Gravity Irrigation of lakhs of hectors of Plateau regions of UP, AP, MP, KTR, and MAH states.
- On its gravitational fall pathway, there could be supplementary generation of Hydroelectricity
- On its gravitational descending path, huge areas could be turned into new forests. Phase wise, in eastern and Western Ghats supporting much concerned “Biodiversity”

- Combination of thermal and hydro electrical power models could bring down the cost of electricity as well as augment the availability of electricity, plentifully.
- 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.

4. 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.

5. OVERALL BENEFITS

- Eternal and abundant water availability for large scale irrigation of presently non irrigable land upto25 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 power cuts, 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.

6. 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.

7. 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 up liftment of human society purpose. Since 70% of coastal area is plain, only 30% area may call for provision of Tunnels, over ways 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.

Economic Viability of Lift Irrigation Schemes (LIS) in Andhra Pradesh taken up under "JALAYAGNAM"

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ABSTRACT

Lift Irrigation Schemes (LIS) were limited to mainly minor irrigation and a few medium Irrigation Schemes in the past. The average lift of LIS was about 30m and energy consumption varying between 150 to 800 kwh/Ac with an average of about *350 kwh /Ac./Crop*. It goes without saying that the LIS have not only become inevitable but also playing a key role in the field of irrigation. Further they have become an integral part of the Major Irrigation Projects (MIP), while some others are solely MIP. The JALAYAGNAM, a mammoth irrigation programme running in AP, is chosen for an in-depth study on Economic Water Rate (EWR) and also Economical Viability of the LIS.

1. THE NATIONAL SCENARIO

The total geographical area of the land in India is 329 M ha which is 2.45% of the global land area to support 16% of the world (Indian) population. The average annual runoff in the rivers of India is only 4% of the world's runoff. The annual average per capita water availability of fresh water at the national level was estimated at; 1,342 cum by 2025

Present Position of Irrigation in AP

Table-1 bellow shows the position of Natural Resources in India and the State of AP and also comparative availability of food grains in India with the other major countries like China. If we want to compete with the other countries of the world with our limited Land and Water resources for the availability of nourishing food for our citizens, we have to improve our productivity of Land and water by 200 to 300% within economically viable costs, which may be an uphill task in the present environment. To compete in the World Markets in the present Market Economy, we have to maximize the profits to our farmer by optimizing use of Agri. - inputs, Land and Water to improve productivity in agriculture and arrest the migration of our young farmers out of their traditional profession. An account of the Land and Water Resources in India and Andhra Pradesh and food grain availability in the major countries of the world like, China, US and India is furnished in Table-1

Data is collected pertaining to 30 Lift Irrigation Schemes (LIS) taken up under "JALAYAGNAM" in Andhra Pradesh based on the CAG Reports to have an extensive study of Economic Water Rate (EWR) and Economic Viability of LIS. If the EWR are high i.e. much more than the incremental returns to the farmer due to the supply of water through the LIS to the land the entire exercise of investigation, planning, construction and maintenance of the LIS will result in a futile exercise and lead to criminal wastage of money. Out of the 30 LIS considered 6 are from Andhra area, 6 are from Rayalaseema area and the balance 18 is from Telangana area. The relevant data of all the LIS is furnished in Table-2.

Table 1 Land and Water Resources in India and A.P.

PARTICULARS	QUANTITY
Geographical Area (GA) (2.5% of the Global land area)	329 Million ha (M ha)
Flood prone area (12.16% of GA)	40 M ha
Total Cultivable Land Area (TCLA) (56% of GA)	184 M ha
Ultimate Irrigation Potential (76% of TCLA)	140 M ha
Net Irrigated are (35.7% of Ultimate Ir Potential)	50 M ha
Natural run off (Surface and Ground water)	1869 Cubic KM (CKM)
Estimated Ultimate Surface Water Potential	690 CKM
Ground Water Resources	432 CKM
Available Ground Water Resources for Irrigation	361 CKM
Net Utilizable Ground Water Resource for Irrigation	325 CKM
PRESENT FOOD GRAIN AVAILABILITY IN GRAMS /HEAD/DAY	
India	525 gms
China	980 gms
USA	2850 gms
LAND AND WATER RESOURCES IN ANDHRA PRADESH	
Total Geographical area	27.70 M Ha
Net area sown	11.00 M Ha
Present Irrigated area (44.1% of the net sown area)	4.851 M Ha
IP created up to March 2007	6.865 M Ha.
Ultimate IP	11.00 M Ha
Dependable availability of water @ 75% dependability	2746 TMC
Utilization	2092 TMC

Table 2 Power Requirements of 30 LIS taken up under "Jalayagnam"

TABLE-2 POWER REQUIREMENTS OF 30 L I S TAKEN UP UNDER "JALAYAGNAM"									
Particulars of Lift Irrigation Scheme		Power Requirement							
C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
S No.	**Name of the L I Scheme**	**Ayacut in Ac**	**Cost in Rs. Cr**	**Pumpsets in MW**	**D cons in MU**	**T cons in MU**	**Cost Elc/ Crop Cr**	**KWH /Ac**	**Cost of Elc /Ac.Rs**
A-1	Pushkara LIS	186000	356.66	32.35	0.776	77.640	41.54	417	2233
2	Tadipudi LIS	206600	376.96	28	0.672	67.200	35.95	325	1740
3	*Venkatanagaram LIS*	*36000*	*124.18*	*10.45*	0.251	25.080	13.42	697	3727
4	Janjhavathi Project	24640	124	1.46	0.035	3.504	1.87	142	761
5	Chagalnadu LIS	35000	61.23	12	0.288	28.800	15.41	823	4402
6	Chintalapudi LIS	80939	1701	111.8	2.683	268.320	143.55	3315	17736
R-7 (a)	*Handri Neeva (Ph I)*	*198000*	*2774*	*453.19*	10.877	1087.656	581.90	5493	29389
R-7 (b)	*Handri Neeva (Ph II)*	*404500*	*4076*	*199.68*	4.792	479.232	256.39	1185	6338
8	Guru Raghavendra LIS	13700	65.21	28.69	0.689	68.856	36.84	5026	26889
9	Pulikanuma LIS	26400	261.19	13.5	0.324	32.400	17.33	1227	6566
10	Gandikota - CBR LIS	59400	626.82	103.08	2.474	247.392	132.35	4165	22282
11	Gandikota LIS	57000	140	36.3	0.871	87.120	46.61	1528	8177
12	Siddhapuram LIS	21300	89.72	6.56	0.157	15.744	8.42	739	3954
T-13	Alisagar	53793	261.3	25.42	0.610	61.008	32.64	1134	6068
14	Guthpa	38972	145	18	0.432	43.200	23.11	1108	5930
15	Choutapally Hanumantha R	11625	60	5.14	0.123	12.336	6.60	1061	5677
16	Bhima	207000	1426	96	2.304	230.400	123.26	1113	5955
17	Nettempadu	200000	1428	119	2.856	285.600	152.80	1428	7640
18	Kalwakurthy	250000	1500	450	10.800	1080.000	577.80	4320	23112
19	Koilsagar	50250	359	30	0.720	72.000	38.52	1433	7666
20	SLBC - HLC	220000	1042	72	1.728	172.800	92.45	785	4202
21	SLBC - LLC	50000	285	12	0.288	28.800	15.41	576	3082
22	Udayasamudram LIS	100000	699	32	0.768	76.800	41.09	768	4109
23	Devadula	621000	9178.8	305.37	7.329	732.888	392.10	1180	6314
24	Yellampally	450000	3177.7	166.8	4.003	400.320	214.17	890	4759
25	Rajiv Dummugudem	200000	1681	119.75	2.874	287.400	153.76	1437	7688
26	Indirasagar Dummugudem	200000	1824	229.1	5.498	549.840	294.16	2749	14708
27	Dummugudem - NS Tail Por	1413000	19521	1135.87	27.261	2726.088	1458.46	1929	10322
28	Pranahita - Chevella	1640000	38500	3466	83.184	8318.400	4450.34	5072	27136
29	Kaleshwaram	45000	500	28.35	0.680	68.040	36.40	1512	8089
30	Kanthanapally	750000	10409	878	21.072	2107.200	1127.35	2810	15031
	Total	**7850119**	**102774**	**8225.86**	**197.421**	**19742.064**	**10562.00**	56389	
	Average	253230	3315.30	265.35		636.8		1819	13455
	Average Captal cost / Ac in Rs.		130921						
cost of Elec./Crop For an average LIS @Rs.5.35/kwh Rs. Cr					340.71				
Power consumption during pumping season in MU				19,742.06		10562.0		crore / year	
Daily consumption of the 30 LIS/day in MU				197.421		105.62		crore / day	
cost of Electriciy/Ac./Crop for an average LIS in Rs.				13454.58					

From the data of the above Table-2, a model scheme with the average components of all the 30 LIS under study is considered to have an idea of the Economic Viability of the LIS taken up under JALAYAGNAM, which are in different stages of Execution. Capital cost of the average LIS is Rs.1, 30, 921/Ac, with an ayacut of 2, 53, 230 Ac. And the cost of Electricity/Ac./Crop works out Rs.13455/-

S N0.	TABLE-3 TABLE-3 & 4 & 5 DETAILS OF THE AVERAGE L I S OF THE 30 L I S		
1	AYACUT in Ac.	253230	
2	CAPITAL COST per Ac of the L I S in Rs.	130921	
	CAPITAL COST of the LIS (253230 Ac) in Rs. Cr	3315.30	
	PUMPSETS REQUIRED IN MEGA WATTS	265.35	
	Power consumed per Crop in MU (1000x265.35x24x100) in 100 days for	636.84	
	COST of Elec. In Rs. Cr @ Rs.5.35/kwh for 100 day pumping	340.71	
	COST of ELECTRICITY / Ac / Crop in Rs.	13455	
	TABLE-4 ASSUMPTION (Costs of different components of LIS)		
1	Head Works	8%	265.22
2	Electrical & Mechanical works including power lines and yards	12%	397.84
3	Distributory system	20%	663.06
4	Pressure & Gravity Mains	60%	1989.18
5	**Total component of Civil Works**	**88%**	2917.46
6	**Total component of Electrical & Mechanical (E & M) Works**	**12%**	397.84
7	The cost of electricity per KWH in Rs.		5.35
8	Establishment, Operation & Overhead charges /Ac/ crop in Rs.		150
9	Gestation period for completion of the average LIS in years	3	
10	Average life of the LIS in years	30	
11	Operation & Overhead charges are @ Rs.150/Ac		
	TALE-5 COMPONENTS OF ECONOMIC WATER RATE CALCULATIONS		
A	Compound interest @5% is added to the capital for 3 years (Interest on capital during the gestation period @ 5% for 3 years). The loan along with the capitalised interest during the gestation period is repaid in the pay-back period of 30 years in Equated seasonal or annual installments	3837.88	
B	Interest on the capital for 3 years which is added for capital for repayment	***522.57***	
1	Repayment of interest @ 5% along with capital in 30 equated annual installments in Rs. Crores	201.49	7957
2	Repayment of capital without interest in 30 equal annual installments in Rs. M (Repayment per each annual installment in Rs. Crores)	127.93	
3	Depreciation of the project cost in its life span of 30 years @ 3.33% per annum in Rs. Cr.	127.93	
4	R & M of the project @ 2.5% 0n Civil works and 3.5% on E & M works component in Rs. Cr	86.86	
5	Electrical charges in Rs. Cr	340.71	
6	Establishment, Operation & Overhead charges /Ac/ crop @ Rs.150/Ac in Rs. Cr.	3.80	
	EWR for the AVERAGE LIS in Rs. Cr	760.79	
	EWR for the AVERAGE LIS/Ac/Crop in Rs.	30043	

The data of an average LIS is calculated and presented in Table-3 above.

Assumptions

The assumptions about the costs of different components of the LIS as percentage of Capital costs along with their amounts are shown in Table-4.

Different components of the Economic Water Rate (EWR) of the LIS are calculated in Table-5

TABLE-6 ECONOMICS OF AN AVERAGE L I S TAKEN UP UNDER "JALAYAGNAM" IN A P		
Calculations of Water Rate (EWR): Assumptions	EWR/ Crop in Rs.Cr	EWR/ Ac/ Crop in Rs.
Case -1 Interest on capital during the gestation period of 3 years @ 5% is added to the Capital Then the loan along with the capitalised interest during the gestation period with interest along with Depreciation of the project cost in its life span of 30 years @ 3.33% per annum, R & M costs of the project @ 2.5% 0n Civil and 3.5% on E & M works components, Electrical charges for the crop season, and finally Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	760.79	30043
Case -2 Only the capital cost and interest during thegestation period without any interest during the payback period along with Depreciation of the project cost in its life span of 30 years @ 3.33% per annum, R & M costs of the project @ 2.5% 0n Civil and 3.5% on E & M works components, Electrical charges for the crop season, and finally Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	687.23	27136
Case -3 Only Depreciation of the project cost in its life span of 30 years @ 3.33% per annum, R & M costs of the project @ 2.5% 0n Civil and 3.5% on E & M works components, Electrical charges for the crop season, and finally Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	559.30	22085
Case -4 Only R & M costs of the project @ 2.5% 0n Civil and 3.5% on E & M works components, Electrical charges for the crop season, and finally Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	431.37	17033
Case -5 Only Electrical charges for the crop season, and finally Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	344.51	13603
Case-6 Only Establishment, Operation & Overhead charges @ Rs.150/Ac/ crop are considered for repayment in a period of 30 years in equated annual installments	3.80	150
EWR for the average LIS of 253230 Ac. ayacut is considered in the above table and is working out to Rs.30043/Ac/Crop where all its components are considered. i.e. in the first case.(including the interest for 3 years of gestation period on the capital cost of the scheme). From the second case onwards the components of EWR .i.e. the components 1 to 5 are supposed to be absorbed by the Government in a cumulative manner successively so that only establishment charges are left to the farmer in the 6th case.The logic here is that the Government will suppliment part of the EWR to the farmer to a reasonable extent while the net incrimental income has already accrued to the farmer which is more than the EWR.		

In the above 6 cases - except in the first case - it is proposed that the Govt. will subsidize for the payback of either some or all the components of the EWR as shown in the calculations. This will be helpful only when the subsidy extended by the Govt. is less than 50% of the EWR and EWR is less than the incremental return to the farmer due to the supply of Irrigation Water and the net balance available to the farmer is more than the subsidy per/Ac. by the Govt. to the farmer.

Even when the farmer is finding it difficult to make ends meet with the irrigated crops, the Govt. has to invest abnormal amounts on the regular R & M of the LIS to supply water for irrigation. If the farmer's net incremental income from the irrigated crops is much less than the expenditure incurred by the Govt. for supply of irrigation water (.i.e. EWR), this excess amount spent by the Govt. proves to be a criminal waste. It will be a big question why such LIS are conceived and constructed? To make these LIS economically viable, we should endeavor to increase the net incremental income of the farmer from irrigated crop beyond the EWR of the LIS.

2. ECONOMICS OF LIS

It is laudable that Govt. of AP is constructing LIS at abnormal capital costs to irrigate the water starved lands of the farmers through high lifts creating irrigation potential in a big way to lakhs of Ac. To run these LIS, huge expenditure needs to be incurred on their operation and regular maintenance. Compared to the EWR shown above in Table-6, it is proved, beyond doubt, that the net incremental income to the farmer on account of supply of water through the LIS is very less (it is around Rs.15000/Ac./Crop.) Hence, to make the LIS Economically Viable, Govt. should ensure that net incremental income to the farmer is substantially higher than the EWR calculated as above. It may be appropriate and justified to supplement the farmer's income through regular cash payments instead of investing in the economically unviable LIS. Present duties adopted for the ID crops under the LIS (11"to 21") are not viable as the mindset of the farmers is against such irrigation duties. Once the water is released under any LIS, most of the farmers are going in for raising paddy which will invariably become a white elephant to the Govt**.** With the increase in gap ayacut due to t he change of crop the EWR will increase further

3. REMEDY

We should radically change the traditional Bench Marks for Productivity of water & land by adopting new methods and technologies to make EWR viable for these LIS and to rationalize our investment. We are having existing minor LIS (APIDC) maintained by the farmers throughout the state. At least one best LIS in each district can be selected as a model for "Demonstration" with the participation of the concerned farmer's socities and other stake holders like APSIDC, Agricultural Dept. and Agricultural Universities, suppliers of; seed, fertilizer & pesticides, Marketing Federation and enthusiastic NGOs etc. Farmer's societies are to be strengthened & empowered for the purchase of quality inputs and also for primary processing and marketing of their produce on "cost + reasonable" profit (50% of the cost) basis. To measure the productivity of water, monitor and improve the same. Water meters are to be introduced in the delivery mains of the pump sets. This will help in observing the performance (efficiency) of the pump sets on real time basis and take up timely repairs to maintain their efficiency and avoid unexpected breakdowns, which will improve the reliability of water supply to standing crops in their critical stages of crop growth. Further the exact quantity of water pumped to the crops can be gauzed and monitored. Measuring devices need to be introduced in the distribution pipe lines and channels at least (one for 100 ac.), one for every field channel. This would help in ascertaining and minimizing any transmission losses between the Head works and field application point and helps to quantify the water supplied for irrigation of the last 100 Ac. This can be done at much less cost by utilizing the existing Social and Irrigation Infrastructure; Micro Irrigation systems may be introduced depending upon the economic viability and suitability for the crops proposed, based on the soil analysis, climatic conditions, profitability and mindset of the farming community. Optimization techniques through formulation of linear programming problems may be followed to maximize the income of the farmer with the limited resources of Land & Water.

4. EXPECTED OUTPUT

If we can demonstrate to maximize the productivity to shower profits upon the farmers through optimizing the use of water and land, the farming community will voluntarily follow the path to improve their economy, which will result in improving the economy of the entire Rural Community and thus the country. After successfully demonstrating maximization of returns to the farmers in the model demonstration farms, the same process can be adopted under Major LIS without any hesitation. This will definitely fulfill the dreams of our Govt. and shower the expected benefits to the farmers and ultimately to the state and help to reduce the vast technology gap between the Agri. Research Universities, Institutions (labs) and the farms resulting in quick commercialization of the Agri. Technologies providing employment to our Agricultural Graduates. This is something like Public-Private-Partnerships (PPP) or Public-Private-Panchayat Partnerships (PPPP) for inclusive growth through inclusive governance. This will push India to efficiently compete in the world Agri-markets.

5. CONCLUSION

The EWR for an average LIS and the biggest LIS under JALAYAGNAM will be anywhere around Rs.30, 043 /Ac/Crop and may reach Rs.56,763/Ac/ Crop. This EWR is based on the theoretical assumption that the LIS are completed as per the sanctioned estimates within the stipulated time and the total contemplated ayacut is irrigated. But our past experience indicates that the revised estimates due to escalation of costs and time will go up even by cent percent and the gap ayacut to be around 30% which leads to steep escalation of EWR. The Duties adopted for these LIS which are anywhere between 13" to 21" may result in further increase in the gap ayacut. This will result in devastating economic consequences if we proceed blindly without taking up parallel remedial measures.

Assured measures are to be taken to complete the LIS as scheduled without further escalation in capital costs and to improve the Productivity of water and land by utilizing available technologies from all relevant fields and maximize the income per acre to the farmer as well as to the Government, to make them economically viable.

Post and pree harvesting technologies for safe preservation and agri-processing technologies for value addition for the agri-produce are to be adopted & adapted for giving a better deal to the farmers and empowering them to compete in the World Markets. For the benefit of the farmers as well as the consumers, make a direct channel between **FARM TO HOME** which will avoid the middlemen and improve the health, wealth and wellbeing of the farmer as well as the consumer and thus the nation.

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Continuous Contour Trenches - A useful Measure for Developing Soil Moisture Regime in the Catchment

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ABSTRACT

The study was undertaken on the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The total area under study was divided into four catchments (A, B, C and D). The catchments A and C are treated with continuous contour trenches and catchments B and D are without continuous contour trenches. The catchment A and B are having Custard Apple (*Annona squamosa*) plantation and catchment C and D are having Hanumanphal (*Annona cherimola*) plantation. The soil moisture status at the depths 0-15, 15-30, 30-45, 45-60, 60-75, 75-90cm was observed in different months during 2013 in all the catchments. For the catchments having custard apple plantation, it was observed that the soil moisture content in the CCT treated catchment, A was better in all months at all depths as compared to untreated catchment, B. For the catchments having Hanumanphal plantation, it was observed that the soil moisture content in the CCT treated catchment, C was better in all months at all depths as compared to untreated catchment, D. On the basis of the moisture regimes of different catchments, it can be concluded that the catchments treated with continuous contour trenches have shown better moisture regimes as compared to non treated catchments. This clearly indicates the benefits of continuous contour trenches for better moisture enhancement in the catchment.

Keywords: Continuous contour trench, catchment, plantation, soil moisture.

INTRODUCTION

In rainfed agriculture, the amount of water that can be retained in the soil profile is most critical, especially among dry spells. However, the amount of water retained in a particular soil and its subsequent availability to crop plants depends upon the type of soil, soil texture, nature of minerals and other soil properties. Therefore understanding the soil water regime of rainfed regions is important for efficient rainwater conservation and for its optimum uses for practical soil water management. Soil moisture depletion studies are needed by many researchers in order to describe the availability of soil water to plants and to model the movement of water and salts in unsaturated soils. Soil texture and the properties it influences, such as porosity, directly affects water and air movement in the soil with subsequent effects on plant water use and growth. The proportion of pores filled with air or water varies, and changes as the soil wets and dries. When all pores are filled with water, the soil is ‘saturated’ and water within macropores will drain freely from the soil via gravity. Continuous contour trench system (CCT) system, developed for plantation in non arable lands in low rainfall areas, has been found to be very effective in soil and water conservation, leading to considerably high groundwater recharge (Nagdeve *et al*., 2009). Whenever rainfall-runoff event occurs, runoff begins and flows down from the slopes causing erosion giving not much chance for water to infiltrate down the soil. In such situations CCTs are adopted for reducing runoff and enabling the water to infiltrate down to the ground. In the top portion of catchment area, contour trenches can be excavated all along a uniform level across the slope of the land. Bunds can be formed downstream along the trenches with material taken out of them to create more favourable moisture conditions and thus accelerate the growth of vegetation. Contour trenches breaks the velocity of runoff and for small catchments the infiltrated water can be helpful for increasing the soil moisture regimes.

Contour trenches

Contour trenches are used both on hill slopes as well as on degraded and barren waste lands for soil and moisture conservation and afforestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e., in both high and low rainfall conditions), varying soil types and depths. Trenches can be continuous or interrupted. The interrupted one can be in series or staggered, continuous one is used for moisture conservation in low rainfall areas and require careful layout (Thomas, 2010). Intermittent trenches are adopted in high rainfall areas. The trenches are to be constructed strictly on contours irrespective of the category. The size of the trench depends upon the soil's depth. Normally 1,000 sq cm to 2,500 sq cm. in cross section are adopted. The trench may be of 30 cm base and 30 cm top width and square in cross section or it can be trapezoidal with side slopes 1:1. Based on the quantum of rainfall to be retained, it is possible to calculate the size and number of trenches. In Vidarbha region of Maharashtra the trench size of 60 cm top, and 30 cm deep is commonly adopted.

Study area

The study was undertaken on the experimental field of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in the Vidarbha region of Maharashtra. The site is situated at the latitude of 20°42' North and Longitude of 77° 02' East. The altitude of this place is 307.41m above sea level. Soil survey of the catchment was carried out by traversing and sites for soil profiling were selected based on variations in soil types. In the present study three types of soils were identified viz. Inceptisol, Entisol and Vertisol. Taxonomically these soils are classified into the family of Vertic Haplustepts, Typic Ustorthents, Typic Haplusterts (Soil survey staff, 1994).

METHODOLOGY

The study area (1.0 ha) was divided into two catchments. One catchment was treated by preparing continuous contour trenches (CCTs) and other was without continuous contour trenches. Both catchments are having plantations of Custard Apple (*Annona squamosa*) and Hanumanphal (*Annona cherimola*). The small catchments were again divided into two parts, thus in entire area there are four parts. In each part the soil moisture was determined with Gopher Soil Moisture Profiler.

Theory of operation

The Soil Moisture Profiler uses the proven and sensitive technique of measurement of the dielectric constant of the soil plus water to determine the moisture content of the soil. As the water content of the soil increases, the resultant measured dielectric constant increases. The dielectric constant of a material is defined as the ratio of the electric flux density produced in the material to that produced in free space (i.e. a vacuum) by the same electric force. The dielectric constant of air is normally taken as one. Thus the dielectric constant of a substance is the ratio in which the capacitance between two electrodes is increased when the space between them is filled with some other medium instead of air. In the case of the soil moisture measurement it is soil and water. The dielectric constant of dry soil is typically four (4), and that of water is eighty (80). The measurement of the combined dielectric constant of the soil and water offers a very sensitive determination of soil moisture content. Variations in electrical conductivity of the soil moisture due to dissolved salts have very little affect on the measurement because the measuring frequency used is very high. The Soil Moisture Profiler is a microprocessor controlled measurement system with an LCD dot matrix display, for display of graphs and information, and a 16-key keypad for operator interface (Technical handbook, GOPHER). Power for the microprocessor and sensor head is derived from four super heavy duty batteries located under the battery case lid on the underside of the Gopher.

Determination of soil moisture

The access tubes are inserted into the soil in all the four micro catchments. Weekly soil moisture content was determined by inserting the sensitive sensor into the access tubes and the soil moisture content at different depths were recorded.

RESULTS AND DISCUSSION

The area under study was divided into four catchments (A, B, C and D). Catchments A and C are treated with continuous contour trenches and catchments B and D are without continuous contour trenches. The catchment A and B are having custard apple plantation and catchment C and D are having Hanumanphal plantation. The soil moisture status at the depths 0-15, 15-30, 30-45, 45-60, 60-75, 75-90cm was observed in different months during 2013 in all the four catchments and is given in Table 1 and presented in Fig. 1. The soil moisture status was observed to be better in the catchments having continuous contour trenches as compared to untreated catchments. The CCT treated catchments A and C have shown better moisture regime over the untreated catchments B and D in the observed months. The soil moisture content at different depths in CCT treated catchments A and C was more as compared to the untreated catchments B and D in the observed months. The soil moisture content at the depths of 60-75 and 75-90cm in CCT treated catchment A and C had shown higher moisture regime as compared to other depths amongst all catchments. The rainfall was adequate at the start of the season and thus the soil moisture content was very good in the month of July, August and September and it was observed less in the month of October (Fig. 1).

Table 1 Soil moisture content in different months recorded at different depths during 2013

Catchment	Depth (cm)	Soil moisture content (cm^3/cm^3) in the month of			
		July	August	September	October
A	0-15	23.0	25.0	24.6	22.1
	15-30	23.2	25.3	25.4	23.6
	30-45	23.1	25.1	25.6	24.8
	45-60	26.2	27.2	27.0	25.9
	60-75	30.8	31.3	28.5	30.3
	75-90	32.8	31.0	31.0	30.0
B	0-15	22.8	24.6	24.1	21.6
	15-30	23.0	24.9	25.0	22.8
	30-45	22.8	24.7	25.2	23.1
	45-60	24.0	23.8	25.0	24.2
	60-75	26.0	26.2	27.0	27.4
	75-90	30.0	30.1	29.2	28.8
C	0-15	25.1	26.2	26.6	25.1
	15-30	26.0	26.8	27.1	25.8
	30-45	25.8	26.6	27.0	25.7
	45-60	26.5	27.4	27.2	26.0
	60-75	30.8	31.3	30.0	30.2
	75-90	33.0	32.0	32.1	31.0
D	0-15	23.1	24.8	24.2	26.0
	15-30	23.1	25.0	25.4	24.9
	30-45	22.9	24.7	25.0	23.6
	45-60	25.2	23.9	26.8	24.4
	60-75	26.4	26.6	27.5	26.8
	75-90	30.1	30	29.0	28.9

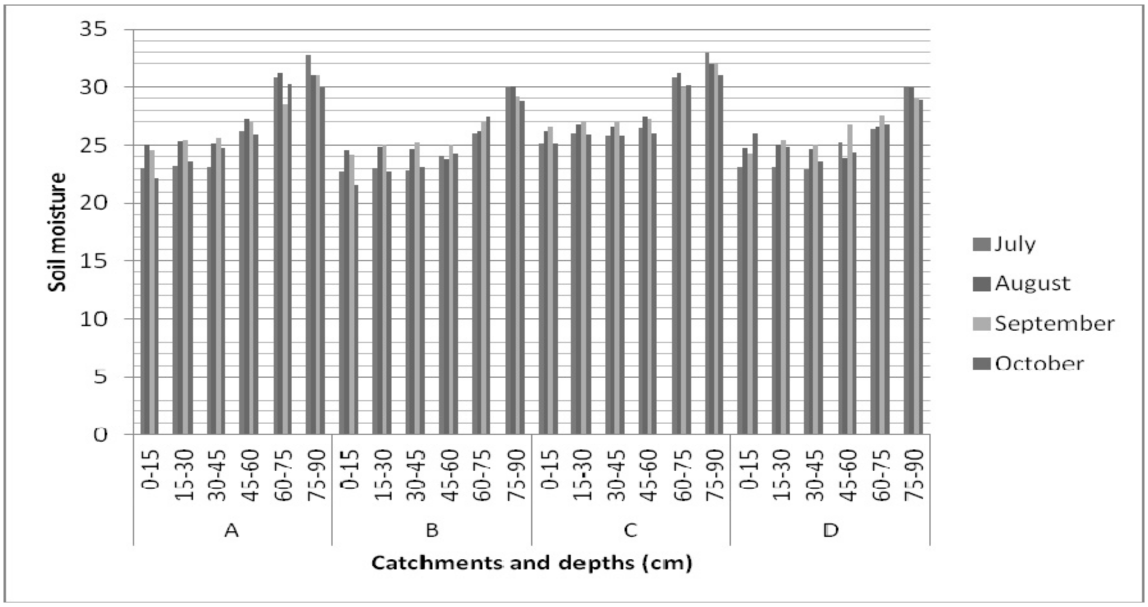

Fig. 1 Soil moisture contents at different depths in different months

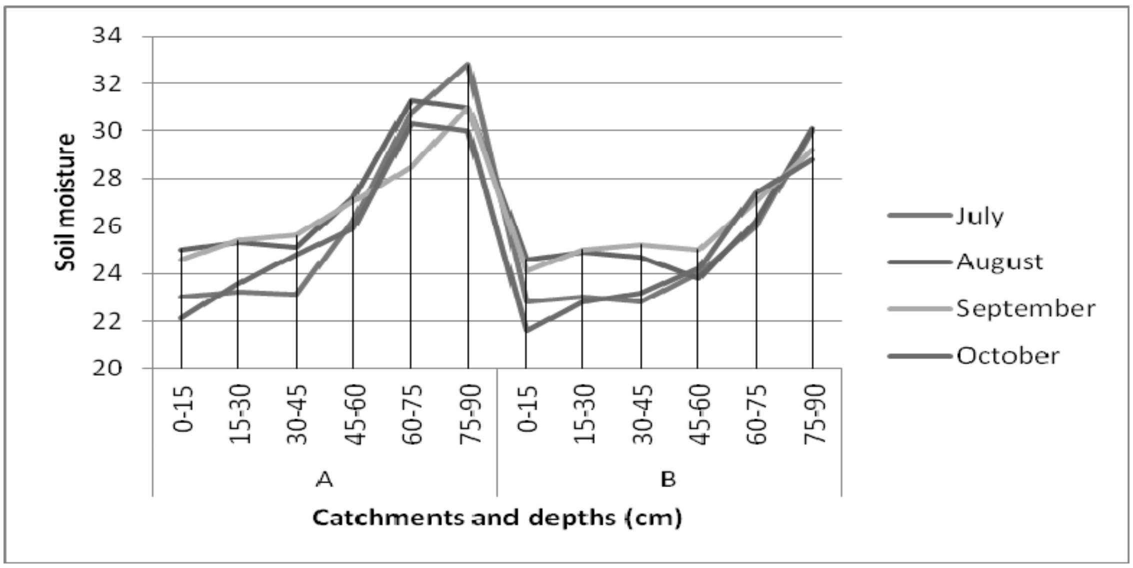

Fig. 2 Soil moisture regime at different depths in different months in the catchments having custard apple plantation

For the catchments having custard apple plantation, it was observed that the soil moisture content in the CCT treated catchment, A was better in all months at all depths as compared to untreated catchment, B (Fig. 2). This will clearly indicate the benefit of CCT treated catchment over non treated catchment. The soil moistre regime was more in CCT treated catchment over untreated catchment for custard apple plantation. For the catchments having Hanumanphal plantation, it was observed that the soil moisture content in the CCT treated catchment, C was better in all months at all depths as compared to untreated catchment, D (Fig. 3). This will clearly indicate the benefit of CCT treated catchment over non treated catchment. The soil moistre regime was more in CCT treated catchment over untreated catchment for Hanuman phal plantation.

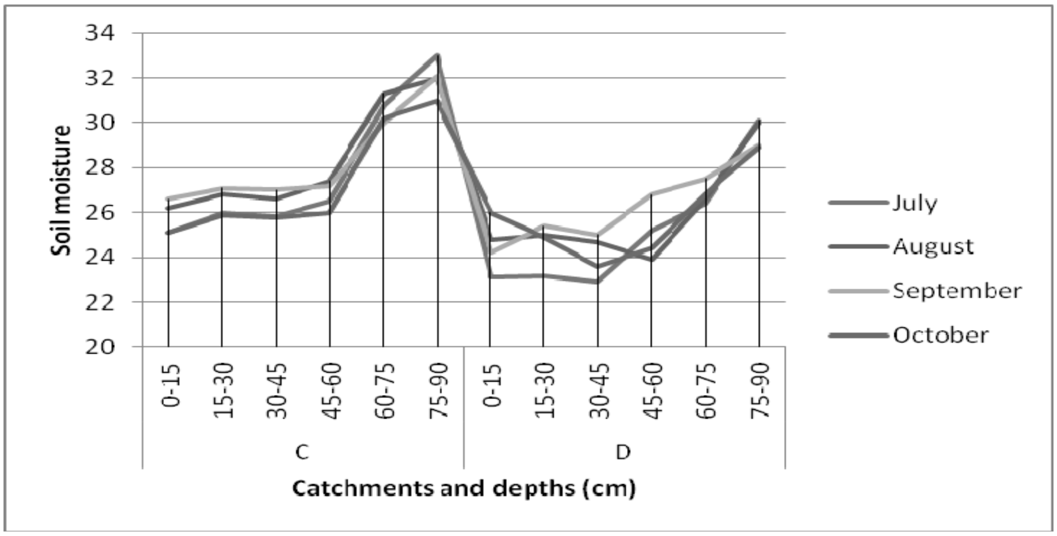

Fig. 3 Soil moisture regime at different depths in different months in the catchments having Hanumanphal plantation

CONCLUSION

On the basis of the moisture regimes of different catchments, it can be concluded that the catchments treated with continuous contour trenches have shown better moisture regimes as compared to non treated catchments. This indicates the benefits of continuous contour trenches for better moisture enhancement in the catchment.

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In-Situ Soil and Water Conservation Measures for Rainwater Harvesting

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ABSTRACT

Crop sustainability in drylands is subject to the vagaries of monsoon. Water stress periods are common in rainfed agriculture. Activities aimed at conserving the rainwater should be adopted for improving the productivity of dryland. As a part of better land management, *in-situ* practices should be adopted. Rainfed farming plays an important role in agricultural economy of Vidarbha region of Maharashtra. It was observed that the drought situation may arises during crop growth period which may result in partial failure of crop. It was therefore felt worthwhile to adopt the proper methods of *in-situ* moisture conservation so as to partially meet out the adverse effect of water stress in standing crop. In order to study the effect of *in-situ* moisture conservation measures on sustainable production and to find out suitable combination of *in-situ* moisture conservation measures to cope up with water stress in standing crop, the practices was adopted at the experimental field of AICRP for Dryland Agriculture, Dr.PDKV., Akola and the results are discussed in this paper. It is observed that one protective irrigation from the stored farm pond water for soybean crop during *kharif* season 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%.

Keywords: *In-situ,* moisture conservation, rainwater harvesting, yield

INTRODUCTION

Our country is facing floods and drought in the same year in many states. This is because of no concrete action was taken to conserve, harvest and manage the rainwater efficiently. The National Mission on Water will be mounted to ensure better integrated water resource management. This would lead to water conservation, less wastage of water, equitable distribution of water. The mission will also come out with a framework to improve water efficiency by 20%, through regulatory and pricing mechanisms. It sees the issue of groundwater management and use as important. It is necessary to study the management of surface water as it not only indicates the status of the environment but also has huge economic impacts. Improving water storage capacities and protecting wetlands form an important aspect that will be looked into by this mission.Therefore there is an urgent need to take up the artificial recharge of the rainwater for which water harvesting and water conservation structures are to be build up in large scale (Sivanappan, 2006). Drought situations caused due to aberrant weather and erratic rainfall has been routine crises in dryland agriculture. To cope up with such crunch, it is necessary to find out the possibilities to survive the crop under contingent conditions by using some of the simple methods of *in-situ* moisture conservation (Padmanabhan, M. V., 2008). It was therefore, felt worthwhile to adopt the proper methods of *in-situ* moisture conservation so as to partially meet out the adverse effect of water stress in standing crop. The positive effects of moisture conservation practices like ridges and furrows; in enhancing the plant height and yield attributes of sorghum, cowpea, bengalgram and sunflower have been observed by Somasundaram, *et. al.* (2000). *In-situ* moisture conservation practice viz; ridges and furrows + mulch, imparted beneficial effect on cluster bean for getting good growth and higher yields; which subsequently led to higher net returns and B:C ratio (Allolli, *et. al.* 2008). In most of the rainfed areas, rainwater conservation measures can not conserve all the rainwater and a certain amount of runoff is bound to occour. This runoff can be collected and stored in tanks for a life saving irrigation to rainfed crops (Bangar *et al.*, 2003).

Soil and Water Conservation Measures

Our failure to properly manage the country's basic natural resources of land, vegetation and water has been a major cause of our impoverishment. The treatment must be from ridge to valley. There can not be an artificial division of the forest and non-forest land, as well as private and community lands, while applying various methods of treatment. Therefore, the issue of degraded and wastelands has to be taken up to ensure that every drop of water and every square foot of land is best utilized. While taking due care of such "wasted" lands, we should not over look the need to improve the efficiency of even non-degraded lands whether they are under forest or agricultural cover. It is a matter of concern that even our good forests are subject to illegal exploitation and that the sustainability of our agricultural lands is threatened by the over use of irrigation, chemical fertilizer and pesticides, besides being susceptible to depletion through diversion for other uses. Special care should be taken to save both these categories of land from degradation. To save the soil from erosion hazards a number of methods can be adopted.

1. **Reducing soil erosion by water**: Since water is one of the main agents which causes soil erosion, measures aimed at preventing soil erosion by water are also water conservation measures. Reducing soil erosion by water generally involves the following measures
   (a) for controlling and guiding runoff,
   (b) reducing the impact of water on soil,
   (c) allowing for greater infiltration by slowing down water flows,
   (d) improving soil structure.
2. **Perennial vegetative cover to control soil erosion:** The most effective measures for soil and water conservation is to be create a perennial green cover over the affected land. Roots of plants also act as soil binders and prevent its washing away by rain and flowing water to a great extent.
3. **Vegetative barriers**: Live hedges on field bunds, live contour hedges and strip farming also work towards preventing soil erosion.
4. **Agronomic and other measures**: Contour farming and ploughing and mulching also with other treatments like bunds, trenches and waterways help in preventing soil erosion especially in arable land.
5. Gully erosions can be controlled through gully checks using soil, stones, vegetation, etc.

Rainwater Conservation and Management

Rainwater management mainly includes the conservation of water especially in hill slopes, upland, mid land and low lands. Hydrologic components including interceptions, infiltration, depression storage, overland flow and stream flow need to be managed scientifically according to the various land situations prevailing in the state. The process, in which water enters the surface strata of the soil and moves downward, towards the water table, is known as infiltration. The capacity of formation to absorb water is known as its infiltration capacity. It is not a constant factor and it not only changes with time but also changes with location. Each factor, which affects infiltration capacity, should be considered to manage for allowing more and more water to infiltrate in the ground to recharge the water table.

Strategies of Water Conservation and Management in Arable Lands

The following measures can be adopted for water conservation in arable lands:

A. **Preventive measures**
   (a) Crop management: Early planting, adequate stand, crop rotation, multiple cropping, strip cropping, balanced fertilizer application, use of organic farming and agroforestry.
   (b) 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

Based on the experiments conducted at AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Agriculture University, Akola, the results of *in-situ* soil and water conservation practices are given in this paper.

A. ***Agronomic measures:*** The results of *in-situ* moisture conservation practices for cotton, soybean and sorghum crop are discussed below.

Productivity

For cotton crop during the *kharif* season (2011), the *in-situ* moisture conservation treatments (Table 1) showed significant difference in seed cotton and stalk yield in cotton. The highest seed cotton yield (2352kg ha^{-1}) was recorded in crop residue mulching treatment (T_2) and found at par with the treatment combination of furrow opening, mulching and thinning T_4 (2151kg ha^{-1}). However, the highest stalk yield (4372kg ha^{-1}) was recorded in treatment combination of furrow opening, mulching and thinning (T_4) and it was at par with crop residue mulching treatment (T_2).

Table 1 Productivity of cotton as influenced by different *in-situ* moisture conservation treatments

Treatments	Seed cotton yield (kg ha^{-1})	Stalk yield (Kg ha^{-1})
T_1 - Furrow opening (F)	1916	3601
T_2 - Crop residue mulch (M)	2352	4308
T_3 - Thinning (T)	1919	3344
T_4- Combination of furrow opening, crop residue mulch and Thinning (FMT)	2151	4372
T_5 – Control	1971	3537
S. E. (m) $\pm$	99	228
C.D. at 5%	307	702
C.V. %	9.67	11.89

For soybean crop during the *kharif* season (2011), the *in-situ* moisture conservation treatments (Table 2) showed no significant differences in grain and straw yield of soybean. Numerically highest grain yield (3093kg ha^{-1}) was recorded in crop residue mulching treatment (T_2). However, numerically highest straw yield (4077kg ha^{-1}) was recorded in treatment combination of furrow opening, mulching and thinning (T_4) followed by crop residue mulching treatment (T_2).

Table 2 Productivity of soybean as influenced by different *in-situ* moisture conservation treatments

Treatments	Soybean yield (kg ha^{-1})	Straw yield (Kg ha^{-1})
T_1 - Furrow opening (F)	2578	3864
T_2 - Crop residue mulch (M)	3093	3967
T_3 - Thinning (T)	2769	3828
T_4- Combination of furrow opening, crop residue mulch and Thinning (FMT)	2611	4077
T_5 - Control	2755	3958
S. E. (m) $\pm$	134	205
C.D. at 5%	NS	NS
C.V. %	9.71	10.41

For sorghum crop during the *kharif* season (2011), the *in-situ* moisture conservation treatments (Table 3) showed non significant differences for grain and fodder yield of sorghum. Numerically highest grain yield (3318kg ha^{-1}) was recorded in control treatment (T_5) followed by crop residue mulching treatment (T_2) and treatment combination of furrow opening, mulching and thinning (T_4). However, numerically highest fodder yield (7298kg ha^{-1}) was recorded in control treatment (T_5) followed by crop residue mulching treatment (T_2).

Table 3 Productivity of sorghum as influenced by different *in-situ* moisture conservation treatments

Treatments	Sorghum yield (kg ha^{-1})	Fodder yield (Kg ha^{-1})
T_1 - Furrow opening (F)	3138	7156
T_2 - Crop residue mulch (M)	3286	7240
T_3 - Thinning (T)	2881	7066
T_4- Combination of furrow opening, crop residue mulch and Thinning (FMT)	3286	7118
T_5 - Control	3318	7298
S. E. (m) $\pm$	613	405
C.D. at 5%	NS	NS
C.V. %	11.96	11.28

Soil moisture

For cotton crop, the soil moisture status at 0-15 and 15-30cm depth is observed to be better in crop residue mulching treatment at vegetative growth stage of crop followed by thinning and other treatments. However at the boll formation stage of crop, the soil moisture content was observed maximum in the treatment of furrow opening followed by treatment combination of furrow opening, mulching and thinning.

For soybean crop, the soil moisture status at 0-15 and 15-30cm depth is observed to be better in crop residue mulching treatment at vegetative growth stage of crop followed by treatment combination of furrow opening, mulching and thinning and then by other treatments. However at the pod development stage of crop the soil moisture content was observed maximum in the treatment of furrow opening and treatment combination of furrow opening, mulching and thinning.

For sorghum crop, the soil moisture status at the 0-15 and 15-30cm depth is observed to be better in treatment combination of furrow opening, mulching and thinning at flag leaf stages of crop growth followed by crop residue mulching treatment and then by other treatments. However, at the grain maturity stages of crop the soil moisture content was observed maximum in the combination treatment of furrow opening, mulching and thinning followed by treatment of furrow opening.

B. ***In-situ* soil and water conservation measures:** The results obtained by adopting the different in-situ soil and water conservation measures are discussed below.

(a) On arable cropped lands with very shallow, shallow medium deep and deep soil cover, contour cultivation along vetiver hedge at 1 m VI is recommended to achieve higher crop yield and *in-situ* rainwater and soil conservation.

(b) The fields having the slope in one direction at least the sowing and cultivation across the slope needs to be adopted.

(c) Practice of opening of furrow with the help of hoe (rounded with rope) needs to be adopted at specific interval in the crop at the time of last hoeing.

(d) 0.5 to 1.00 per cent area of the treated catchment should be kept under Farm ponds / Dug - out

(e) 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 96 per cent *in -situ* rainwater conservation.

C. **Rainwater Harvesting**

The results of effect of protective irrigation for different crops are given below in Table 4. It is observed that one protective irrigation for soybean during *kharif* (2013) resulted in yield increase of 23.78% over rainfed crop. Similarly during *rabi* the increase in the yield of chickpea over rainfed crop was 45.44%.

Table 4 Effect of protective irrigation through Farm Pond on yield of various crops

Crop	Irrigation system	No. of protective irrigation	Yield, qha^{-1}		Increase over rainfed, %	Water use efficiency, $kgha^{-1}mm^{-1}$	
			Rainfed	Irrigated		Rainfed	Irrigated
Soybean	Sprinkler	01	18.84	23.32	23.78	2.28	2.83
Chickpea	Sprinkler	01	4.93	7.17	45.44	0.59	0.87

Note: Average annual rainfall 824mm and per irrigation depth is 50 mm.

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Smart Water Technology – The Need

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ABSTRACT

The last couple of decades has witnessed great advancements in information technology, electronics (microprocessors and embedded systems in particular), wireless communications and computational power which has been applied to revolutionize data collection, analysis, asset monitoring, remote control, automation and management. Management aspects from natural resources to manufacturing sectors are influenced into modernization due to the revolution. Water as a precious resource need also be managed using these modern tools to render it smart so that it is under constant surveillance for availability, conservation and quality degradation. This becomes even more important as this limited resource necessary for food, drinking water and industries is assured as the world population grows. All aspects of sustainable water resources such as planning, development, management, conservation, distribution, deliveries and water quality can be dealt with the help of these modern tools.

I. INTRODUCTION

India's achievements in development of its water resources (irrigation, flood control, hydro- power, drinking water, industrial use, etc) have been remarkable, since independence. The successive Five Year Plans have witnessed a large number of projects comprising dams, barrages, hydro-power structures, canal networks, etc. Among the stakeholders agriculture is the greatest user of water accounting for about 80% of all consumption.

The concept of Integrated Water Resources Development and Management (IWRM) - A process which promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems – is internationally adopted as a model solution for sustainable water resources though there are reservations in some quarters.

An adequate knowledge and information on the basin wise water resources inventory is desirable for embarking on IWRM. In many basins, however, it sometimes becomes inevitable to embark on developing a water resources management plan with available data and information for want of adequacy of quality data. Maintaining and accruing sound knowledge of the natural resources in the basin and ensuring that it is strongly supported by scientific knowledge and views are essential. Further scientific studies, audits and investigations can be targeted at key areas for accomplishing greatest improvements in resource management.

Firstly, comprehensive data base is essential for all aspect related to water. Well defined water related data collection network is thus a key to planning, development and management of water resources to generate data of adequate quantity and quality. In this regard, relevant national guidelines (IMD, CWC, BIS, CGWB & CPCB) and international guidelines (ISO, WMO, FAO, WB, USGS and IEC) are referred to. CWC guidelines on 'Preparation of River Basin Master Plan' provide a comprehensive list of various data required. It is in this crucial area that the information technology in conjunction with strides of advances in the fields of computing,electronics (microprocessors in particular) and communications- the gamut of digital world, play a major and important role.

II. WATER RESOURCES FACETS & DATA REQUIREMENTS

A. *Surface Water:* The appraisal of surface water resources generally includes estimation of i. Annual run-off and its monthly/daily distribution, ii. Aerial distribution of water resources within the basin, iii. Flood flows (forecasting and hind casting), iv. Low flows, v. Return flows vi. Distributed flows among beneficiaries vii. Sedimentation and load, viii. Export/Import of water through inter-basin transfer.

Where applicable, snow melt studies need also be carried out.

B. *Ground Water:* The basic information needed for assessing the ground water availability are the type and location of aquifers, their thickness/depth and their characteristics such as hydraulic conductivity and storage coefficient. These are obtained from water level observations in wells, surface geological mappings, test drilling and pumping test data. Effects of indiscriminate drilling can only be determined with quality data gathered with serious efforts.

C. *Quality of Water:* An appraisal of water resources is not complete without a mention of the quality of the available water. The quality of water is greatly affected by the presence of minerals in soils and rocks through which the surface and ground water flows. But, with rapid industrialization and urbanization, the greatest threat to the quality of water is from urban and industrial water effluent. Run-off from agricultural fields contaminated with pesticides and chemicals further aggravate the situation. Measurement and monitoring of various water quality parameters becomes inevitable.

D. *Irrigation Canal Automation:* An area of crucial importance is the irrigation methods currently practiced and their implications (80% uses). Water delivery methods employed, such as rotational delivery, continuous delivery and delivery on demand, and their effectiveness in efficient use of water, needs information monitoring. Water availability is mostly in deficit warranting conservation, which can only be achieved through measuring and accounting, leading to the aims of equitable distribution and enhancement in water use efficiency.

E. *Water Treatment and Recycling:* For the purpose of water conservation and sustainability emphasis is laid on water treatment and recycling and is being promoted vigorously rather than discharging the treated water to surface waters such as rivers and oceans. In some cases, recycled water can be used for stream flow augmentation to benefit ecosystems and improve aesthetics. "Recycled water" or "reclaimed water" typically mean wastewater sent from a home or business through a pipeline system to a treatment facility, where it is treated to a level consistent with its intended use. The recycling and recycling of wastewater is generally for designated non potable use such as municipal gardening and irrigation applications. The treatment process monitoring and automation is highly sophisticated and being deployed at such plant to ensure treated water quality.

F. *Reservoirs - Operations & Structures Health:* The project structures such as dams, barrages and hydropower plants built for storages need monitoring for their operation and structural health to assess hydraulic and structural behavior and warn against any distress such as overtopping seepage, cracks, uplift pressures, foundation deformations etc. Knowledge becomes crucial to adopt appropriate disaster management measures.

G. *Hydroelectric Power Plants:* Performance assessment of hydraulic turbines needs measurement of its efficiency to ensure plant's optimum performance. Degradation of design efficiency of the turbine entails higher water discharge resulting in resource waste. Further monitoring turbine efficiency on line is necessary for health monitoring of the turbine over the working period resulting in scheduled maintenance shutdowns than outages.

H. *Domestic Water Supply:* Domestic/industrial water supply demands monitoring volumetric deliveries of raw and treated water for metering and revenue collection purposes. Management of reliable supply needed to be given high priority which warrants continuous real time data acquisition on flows and pressures in the utility. The entire water supply network from treatment plant to households needs measurements of flows of various magnitudes are required to be monitored.

I. *Simulation Models:* Hydrological and hydraulic processes simulation either mathematically or with physical similitude help greatly in getting insight to the phenomena as well as for predictions with minimum time frame and resources. Computational Fluid Mechanics techniques have developed due to increased computational power. Reliable, consistent data are essential if Simulation models are to best benefit from this technological prowess.

III. MEASUREMENT & DATA COLLECTION – AN ENTERPRISE

Progress in water resources management using modern tools now available would heavily depend on reliable and consistent data to support decision making. Most data are obtained by measurement in the nature and empirically. Measurement science and data collection is an enterprise itself. Fortunately, awareness for requirement for accurate and quality data is gaining acceptance in recent times. This has encouraged improved and modern measurement technology development in hydrological, hydro-meteorological, water quality etc. as discussed above.

IV. APPLICATION OF DIGITAL TECHNOLOGY

The all invasive digital world of Information technology and communications has revolutionalised the way of life today. Water sector by extension did not remain exempt. The matic approach to the aforesaid facets of information, modernization is facilitated through vastly developed (and continued to develop) information, electronics and communications technologies. The following aspects are served by the technologies in water resources sector:

1. *Real Time Hydrological Data acquisition (RTDAS)*: Data being a basic need for all aspects related to water resources, real time data collection assumes primary importance.

For surface water data on rainfall/Snowmelt, stream flow (runoff/canal discharge), water level, Flow release, Sediment Concentration/deposition, water quality and other parameters of interest such as wind, RH, solar radiation, temperature, evaporation etc. are collected. Such data in real time leads to:

- Flood forecasting and inundation with the application of suitable hydrological models
- Determination of water yield
- Reservoir operation/automation, dam safety surveillance
- Irrigation canal operation/automation
- Water quality monitoring/assessment
- Hydroelectric power plant operation
- Data archiving and analysis
- Data availability in public domain on web

Similarly, for ground water assessment data parameters of water levels and pumping rate and water quality parameter are of prime interest and can be integrated to the RTDAS in place or form an independent system. The typical real time data acquisition system is shown in Fig. 1 as block schematic.

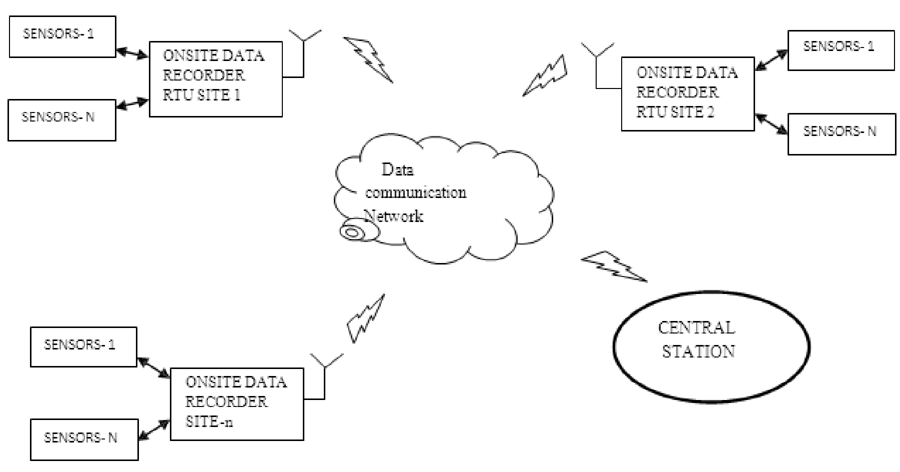

Fig. 1 : Typical real time data acquisition system

In reality the real time data acquisition system technology is integration of technologies comprising

(i) Sensors
(ii) Data logging
(iii) Data Communication & networking
(iv) Central computer facility with dedicated servers for different tasks such as for data acquisition, data base management, simulation, flood forecasting and supervisory control

The data parameters of interest mentioned above are measured using sensors that convert the physical/chemical parameters into electrical quantities.

This is because the electrical quantities are amenable to scaling, manipulation, digitization, computer analysis, storage and transmission over wire and/or air.

There have been tremendous advancements in sensors and instrumentation technology. Table I gives parameter wise advanced sensors/ instruments/ measurement systems in use today for water resources data. Some hydro-meteorological data parameters use conventional established sensors such as for relative humidity, solar radiation, evaporation and temperature. Some of these sensors can also be used for ground water levels.

Table I: Parameters and Advanced Sensors/Instruments

Parameter	Sensor/System
Rainfall	Tipping Bucket Gauge, Weighing Rain Gauge
Snow	Ultrasonic Snow depth Sensor
Water Level	Submersible Hydrostatic Pressure sensor
,,	Ultrasonic Level Gauge
,,	Purge Bubble Water Level measuring system
,,	Float with Shaft Encoder
,,	Microwave Radar
Stream Flow	Acoustic Doppler Current Profiler (ADCP) mounted On moving boat
,,	Horizontal ADCP – mounted on one bank for continuous measurement.
,,	Bottom Mounted ADCP – for continuous measurement
,,	Transit Time Ultrasonic Flow measuring system - single/multipath
,,	Radar for Non-contact continuous measurement and Ground Penetration Radar for stream bed profile
Penstock Flow	Transit Time Ultrasonic Flow measuring system - single/multipath
Short Penstock	Acoustic Scintillation System
Spillway Discharge	Acoustic Scintillation System
Sedimentation survey, Concentration	Integrated Automatic Survey System Laser Beam and surrogate acoustic technique for on line measurement
Water Quality	Multi-parameter Sensor
Wind and Direction	Ultrasonic Transit time
Dam Instrumentation	Fiber Optic Sensors, Vibrating Wire Sensors

The noteworthy development is in stream flow measurements with what is called hydro-acoustics technology responsible for emergence of Acoustic Doppler profilers in different configurations and transit time techniques, bringing in a paradigm shift in the stream gauging with resultant highest ever achievable accuracy, convenience of measurement operations at least risk in comparison to current meter gauging that ruled over hundred years.

The water resources data are geographically scattered and hence remote, warranting deployment of field worthy and battery operated measuring instruments and sensors for desired parameters in those locations. As shown in Fig. 1 each remotely deployed sensor(s) measures desired parameter that is logged with an instrument commonly known as Remote Terminal Unit (RTU) which stores data locally for retrieval and transmission through a suitable communication network to a central station. The central station is equipped with dedicated servers for different tasks of data acquisition, data base management, simulation models, flood forecasting and supervisory control.

The next technology that has advanced exponentially is the wireless data transmission. Originally designed for process control industry, it is equally relevant in water resources sector albeit with its own attributes. The remote locations of data stations and the central data centre are wide apart. The data have to be communicated between them by wireless transmission. The prevalent techniques are:

- Dedicated radio in which either licensed or license-free frequency band radio communications is used.
- GSM or CDMA with GPRS of cellular network in which existing cellular network data facility is utilized, collaborating with the service provider.
- Satellite communication with very Small Aperture Terminal (VSAT)

In all cases the Remote Terminal Unit (RTU) has to equip itself with communication unit called modem and transmission antenna either externally or inbuilt. Among the available alternatives for data transmission the cellular option works out the most economical.

Besides these, there shall be the requirement of other wireless data communication systems in vogue based on 2.4/5 GHz, the worldwide license free ISM (Industrial Scientific Medical) frequency band, developed for Wireless Local Area Network (WLAN) as standard protocol IEEE 802.11a/b/g/n. They are being used for transmission of hydrologic data covering short distances of about 100-300M in situations such as between sensor mounted at the measurement locations and the RTU installed generally in an enclosure at a safe location away thus eliminating the use of cables to connect them- a major source of disruption of working due to cable thefts.

Further development in data acquisition is the Wireless Sensor Networks (WSN). A WSN consists of spatially distributed autonomous sensors that monitor hydrologic, environmental, canal/spillway control gate position, dam structural and other parameters to cooperatively pass their data through the network to a central location. This technology is very much useful for reservoir operation activity as the sensors monitoring number of gates can be wirelessly networked and avoids cumbersome cabling. Another application is in gate position monitoring in barrages.

The real time data so acquired thus can be subjected to analysis using central station computer servers with suitable software leading to:

- Water shed characterization
- Determination of catchment water yield
- Real time flood forecasting and flood control
- Reservoir operations including automation of spillway gates ensuring dam safety aspects
- Irrigation canal delivery monitoring and automation resulting in conservation (by avoiding wastages), equitable distribution resulting in higher water use efficiency
- Ground water availability and usage
- Determination of design flood etc.
- Hydrological Simulation Model Applications.
- Dam structure safety surveillance
- Research, computational fluid modelling

2. *Supervisory Control And Data Acquisition (SCADA) Technology:* Further there are applications in water resources management that extend the utility of real time data acquisition viz.

- Reservoir operation automation
- Cascaded reservoir operation automation
- Irrigation canal automation
- Water treatment and recycling plant operation

In these cases there is involvement of controlled operation of gates. For reservoir it is for passing the flood by operation of spillway gates as dam safety measure. While in irrigation canal automation it is more complex that involve ensuring equitable distribution, scheduled deliveries, surveillance on unauthorized withdrawals and canal breach. For this application the Supervisory

Control And Data Acquisition (SCADA) Technology is employed. In effect it is real time data acquisition with supervisory control meaning that the control operation is knowledge based and under supervision of the operator. The SCADA system comprises:

- Human Machine Interface (HMI), is the apparatus which presents graphical layout screen display of the process with measured data to a human operator, and through this, the human operator monitors and controls the canal from a central station.
- A supervisory System, acquiring data on the canal and sending control commands to the remote gate controller located from central station.
- Remote Terminal Units (RTUs) connecting to sensors, converting sensor signals to digital data and transmitting them to the supervisory system located at central station.
- Programmable Logic controllers (PLCs) are field devices configured to adjust canal gates as per command received by RTUs from central station.
- Communication infrastructure linking the Supervisory System to the remote RTUs for exchange of data and control commands.

SCADA systems are also being used in laboratories engaged in hydraulic testing and research such as in physical model studies, hydraulic turbine testing and flow calibration rigs for controlled physical simulation and data acquisition from operation console. For the water/waste water treatment process plants it is now a standard practice to employ SCADA.

CONCLUSION

The recent trends and technological advances in sensor technology, instrumentation, communications and computing have to find increased presence in water resources sector to accrue their benefits in planning, development, management, research, treatment and recycling with the sole aim of conserving this precious resource. Sporadic attempts have been made either as pilot projects or sample installations in which success rate is in the opinion of the author very poor. Few advanced systems requirements have been tendered out in recent time such as for flood forecasting and online monitoring and control of flows in canal networks. They are awaiting final implementation. The author is a consultant to such a project for canal flow monitoring system. One such system involving online flow monitoring using Acoustic flow measuring devices and cellular data communication transmitting data to a central station was assigned to him for appraisal has a satisfactory performance. The bottom-line is one has to measure and monitor if he has to manage. The deployment of such advanced systems in all facets of water resources it is then coined as smart water technology enabled.

Strategies for Improving Water use Efficiency in Agriculture

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ABSTRACT

Water scarcity and the increasing global demand for water in many sectors including Agriculture, has become a global concern. The rapid growing world population and adverse impacts of climate change led to growing competition for water use by industrial and urban users for agricultural to secure enough food. Improving water use efficiency in agriculture will require an increase in crop water productivity and reduction in water losses from the crop root zone. Many ways of enhancing use efficiency and productivity of water in agricultural production system. These include: selection of crop, variety, agronomic practices like time of sowing, method of sowing/planting, seed rate, improved plant population, interculture, removal of nutrient constraints by supplying optimum fertilizer inputs, improved irrigation methods like sprinkler and drip irrigation, supplemental and deficit irrigation provided to crops at critical growth stages, practice of intercropping mixed cropping, moisture conservation practices as mulching, transpiration suppressants, moisture stress and vegetative barriers based on available water and increasing seasonal evapotranspiration,crop diversification in lowlands, reducing water use in rice cultivation, integrated farming systems for flood-prone lowland areas and multi-uses of water in agriculture by combining different farm enterprises like cropping, fishery and dairy.

Keywords: Water use efficiency, irrigation, moisture conservation

INTRODUCTION

Water is the most crucial input for agricultural production. Globally, agriculture accounts for more than 80% of all freshwater used by humans, most of that is for crop production (Morison *et al.,*2008). The Food and Agriculture Organization has predicted a net expansion of irrigated land of about 45 million hectares in 93 developing countries (for a total of 242 million hectares in 2030) and projected that water withdrawals by the agriculture sector will increase by about 14% during 2000 – 2030 to meet food demand (FAO, 2006). Agriculture sector in India has been and is likely to remain the major consumer of water but the share of water allocated to irrigation is likely to decrease by 10-15 per cent in the next two decades. Current use efficiency or productivity of irrigation water is so low that most, if not all, of our future water needs could be met by increased productivity or efficiency alone, without development of additional water resources. Improving water use efficiency by 40% on rainfed and irrigated lands would be required to counter- balance the need for additional withdrawals for irrigation over the next 25 years to meet the additional demand for food. Growing more crop per drop of water use is the key to mitigating the water crisis, and this is a big challenge to many countries. Vagaries of monsoon and declining water table due to over exploitation have resulted in shortage of fresh water supplies for agricultural use, which calls for an efficient use of this resource. Strategies for efficient management of water for agricultural use involves conservation of water, integrated water use, optimal allocation of water and enhancing water use efficiency by crops.

Selection of crops and variety

One of the most important crop management strategies under conditions of water limitations is the appropriate selection of crop species and varieties adapted to the timing, amount and frequency of rainfall. Rainy season and growing season should be matched to optimize the capture of water available for transpiration and to escape water stress during the water-sensitive. Drought escape, whereby a crop completes its life before the onset of terminal drought, is often regarded as the primary strategy of crop adaptation to water-limited environments (Loss and Siddique, 1994). The wide diversity in the length of crop and cultivar growing periods offers ample opportunities for this adjustment. For major field crops, there are many examples where the use of early maturing (or early flowering) cultivars increased and stabilized grain yield, especially in conditions of terminal drought (Fereres*et al.,* 1998). Improved varieties well adapted to specific conditions can improve soil water use and increase yield. These varieties should be tolerant to abiotic stresses such as cold, drought and heat, and biotic stresses such as diseases and insects (Dakheel*et al.,* 1993). Shivani*et al.* (2003) reported that wheat cultivars HUW 234 and Lok 1 had higher water use efficiency. Similarly, Chand and Bhan (2002) reported that varsha sorghum was distinctly superior in water use efficiency in terms of grain production as well as dry matter production to CSV 13 and CSV 15.

Time and method of planting

Time of sowing is the non-monitory input which is not only ensures the higher yields but also optimum utilization of the applied resources. Choice of crop cultivar is also a vital production input as all the cultivars of wheat cannot perform equally well under timely and late sown condition (Singh *et al.,* 1998). As an example, attempts made to persuade farmers to move from spring to winter sowing of chickpea gave 30-70% yield increases (Erskine and Malhotra, 1997). Grain yield increase of 20-25% was obtained by sowing lentil in mid-November instead of early January (Pala and Mazid, 1992b). Planting pattern has a direct effect on yield, solar energy capture and soil water evaporation and thus an indirect effect on water use efficiency. The correct method of planting according to the site moisture availability or other factors can help to increase the yield or reduce the total irrigation water to be applied to crop without affecting the yield of crop. Jat and Gautam (2001) reported that sowing of bajra in ridges and furrows 45 cm apart resulted in higher seed yield as compared to paired row sowing and uniform row sowing (45 cm). Ridge and furrow sowing also resulted in maximum water use efficiency. Gill *et al.,* (2006) reported that better water use efficiency and water productivity were observed in direct seeded rice. Ghadage*et al.* (2005) reported that the water use efficiency of cotton was more in paired row planting (90 cm x 105 cm) because this method consumed less water than the water used by normal method (120 cm x 90 cm).

Plant population and row orientation

Soil water evaporation is reduced with higher planting density. In humid regions where rainfall exceeds evapo-transpiration, plant densities can be increased with a concomitant increase in yield. However, in semi-arid areas where soil moisture is deficit the thicker stand are avoided. The desirable plant density which could be supported by available moisture up to production of economic part and not initial biomass only is recommended for these situations. Karrou (1998) observed that the lower seed rate of 200 kernals/m^2 gave the highest grain yield and WUE of durum wheat, which was statistically at par with 300 kernals/m 2 but significantly better than 400 kernals/m^2. The decreased seed yield and WUE with higher seed rate due to higher plant population resulted in earlier exhaustion of water causing terminal stress which resulted in reduced seed yield and decreased WUE. Under low population, water might have been used more rationally throughout the growing season which resulted in higher seed yield and WUE. Singh *et al.* (2003) reported that water use efficiency of wheat was higher at higher population density (15 cm, 205 kg seed/ha) than low population density (22 cm, 140 kg seed /ha).Rathore*et al.* (2008) observed that bajra crop geometry of 45cmx 12cm had the higher water use efficiency owing to larger crop canopy. This was mainly due to higher yield under this plant density owing to proper utilization of nutrients as well as moisture under optimum population.

Fertilizer

Fertilizer use can also have a very marked effect on crop yield and water use efficiency. Nitrogen, phosphorus, combination of chemical fertilizer with organic fertilizer or chemical fertilizer with biofertilizer has been shown to increase growth and development in both dry and irrigated areas. Patil and Sheelavantar (2000) reported that application of nitrogen increased the yield, water use efficiency and yield component of sorghum. Ghosh *et al.* (2003) reported that application of 75% NPK and poultry manure 1.5 t/ha recorded the highest water use efficiency of rainfed sorghum. Behera *et al.* (2002) reported that fertilizing the cotton crop at 160 kg N/ha recorded significantly higher water use efficiency than lower levels of nitrogen, 120 and 80 kg/ha. It might be due to higher seed cotton yield obtained under higher nitrogen level. Reduction in nitrogen dose tended to decrease water use efficiency; it was partially because of marked decline in transpiring surface, less stomatal conductance and less extraction of available soil moisture in plant. In another study, Rathore*et al.* (2007) reported that use of chemical fertilizer at 50, 75 and 100 per cent of recommended dose of fertilizer (20 kg N + 17.5 kg P/ha) to rain fed cluster bean *(Cymoposistetragonoloba*) recorded 14.9, 32.7 and 36.2 per cent higher water use efficiency over control. Integration of chemical fertilizer at 50 per cent of RDF with Rhizobium and phosphate- solubolyzing bacteria (PSB) registered 30.1 and 22.6 per cent higher water use efficiency over control.

Irrigation

Irrigation scheduling can be used to improve WUE, and various strategies may be adopted depending on the crop response to water stress, water holding capacity of the soil, the availability of irrigation water and the irrigation system used. In Queensland, Goyne and McIntyre (2003) have examined changes to irrigation system characteristics that contribute to improve WUE, including application efficiency, evaporation, drainage and seepage mitigation and avoidance of waterlogging and through addressing these, WUE in cotton has improved by over 10% from 2000 to 2002. Nadeem*et al.* (2007) reported that maximum water use efficiency of wheat was recorded at IW: CPE ratio 1.25, which was statistically on a par with that at IW: CPE ratio 1.0. The increase in water use efficiency with increase in irrigation level might be due to greater grain yield. In another study, Singh (1996) reported that application of first irrigation at 4 weeks after sowing of wheat resulted in more consumptive use of water as compared to 6 weeks after sowing. But water use efficiency was higher when irrigation was applied at 6 weeks after sowing than that of 4 weeks after sowing on loamy sand soil. Ramakrishna *et al.* (2007) reported that maximum irrigation water use efficiency and field water use efficiency were obtained with 3 days drainage followed by 1 day drainage and the least with continuous water submergence in rice. It is obvious that irrigation water use efficiency and field water use efficiency are the functions of the ratio of economic grain yield to water applied and water requirement of the crop. Mehla*et al.* (2006) reported increasing water use efficiency of rice crop with wider irrigation intervals. Ghadage*et al.* (2005) reported that the water use efficiency of cotton was higher due to each row and alternate row irrigation. This might be due to the significantly same seed cotton yield produced by irrigation techniques. However, Nalayini*et al.* (2006) reported that water use efficiency of cotton was highest with drip irrigation as than conventional irrigation during winter season. The scheduling of irrigation through drip at 0.8 Etc (Crop evapo-tranpiration) recorded the highest water use efficiency. Reddy *et al.* (2008) reported that higher water use efficiency of pigeon pea was recorded with 0.3 IW: CPE as compared to 0.6 and 0.9 IW: CPE ratio. Maintenance of favourable moisture and absence of water logging were the critical factors for higher yield in rabipigeonpea (Kantwa*et al.,* 2005).

Inter and mixed cropping

Inter and mixed cropping is a practice to have an opportunity to diversify cropping system by making the multiple land use possible utilizes water and other resources more effectively and also provides a cover against the failure of one crop particularly under the rainfed situations. Any factor that increases yield will increase water use efficiency. Likewise any factor reducing evapo-transpiration that has no seriously deleterious effect on yield will increase water use efficiency (Eastin and Sullivan, 1984). Higher water use efficiency has been reported for Maize + potato (Bharati*et al.,* 2007), pearlmillet + greengramand pearlmillet + cowpea (Goswami*et al.,* 2002) intercrops in relation to their respective monocrops.A new cropping system of corn mixed with grasses was proposed to make full and efficient use of water in grain and forage feed production practices (Lei *et al.,* 2003).Kumar and Rana (2007) one row of mothbean in paired row ofpearlmillet + and one row of greengram between paired rows of pigeonpea recorded higher water use efficiency over sole crop, respectively. This might be due to higher grain yields of both the crops than the amount of water used for biomass production. Consumptive use and rate of moisture use were higher in the intercropping system than sole crop because both the crops absorbed more moisture during the crop period.Singh *et al.* (2004) reported that rice-coriander-maize+cowpea (F) and rice-lentil-maize + cowpea (F) and had the lowest water use resulted in highest water use efficiency in flood prone and semi-deep water situation, respectively.

Moisture conservation practices

Moisture conservation practices have been widely practiced as a mean of improving yields in water limited environment. Continuous cover crops can reduce on- farm erosion nutrient leaching and grain losses due to pest attacks and build soil organic matter and improve the water balance, leading to higher yields (Oliver *et al.,* 2010). In Australia, Gibson *et al.* (1992) found that retaining sorghum stubble on the soil increased the sorghum yield by 393 kg ha due to increased WUE because of a greater amount of water stored in and extracted from the soil profile compared with conventional tillage. They also found that decreasing tillage frequency increased soil water extraction; however, no tillage did not result in the optimum yield or WUE.Raskar and Bhoi (2003) reported that the water use efficiency of groundnut was higher with use of plastic film mulch with kaolin and was lowest with the control. It could be due to the reduction in the evapotarsnpirationwith plastic film mulch and kaolin spray. Awasthi *et al.* (2007) reported that water use efficiency of Indian mustard was highest with the weeding, hoeing and paddy straw mulch at 20 days after sowing followed by weeding, hoeing and grass mulch at 20 days after sowing, weeding and hoeing at 20 days after sowing and control. Chand and Bhan, 2002 reported that water use efficiency of sorghum was appreciably improved due to different vegetative barriers over control. The maximum water use efficiency was recorded under *Sesbaniasesban* followed by *Leucaenaleucocephala* and *Cajanuscajan* barriers. Minimizing water use efficiency was observed under the control crop. The increase in the water use efficiency may be attributed to appreciable increase in grain yield which was in much greater proportion than the water use under different vegetative barriers.

Integrated farming systems

Comparing the different combination of farm enterprises, crop + fishery system gives more profit per unit of water followed by crop + dairy combination. The water productivity has increased considerably where allied enterprises involved along with crops. Among the allied enterprises, dairy component requires minimum water which in turn produced maximum water productivity per unit of water (Palanisami and Ramesh, 2009).

CONCLUSION

Water use efficiency is an important physiological characteristic that is related to the ability of crop to cope with water stress. It can be enhanced by selection of crop, variety, agronomic practices like time of sowing, method of sowing/planting, seed rate, plant population, fertilizer and irrigation, intercropping moisture conservation practices as mulching, transpiration suppressants, moisture stress and vegetative barriers based on available water and increasing seasonal evapotranspiration and integrated farming systems.

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Location Prioritisation of Water Conservation Measures in Rangapur Watershed in Middle Krishna Basin using Remote Sensing and GIS

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ABSTRACT

Fresh water being one of the basic necessities for sustenance of life, the human race through the ages has striven to locate and develop it. Over ninety percent of liquid fresh water available at given moment on the earth lies beneath the land surface. Groundwater, unlike surface water, is available in some quantity almost everywhere that man can settle in. Even in areas where normally there are abundant surface water supplies through major, medium and minor irrigation projects, groundwater is playing an increasingly vital role in supplementing surface water. The increasing demand placed on it has stimulated investigations oriented towards quantification of the resource, which is basic to formulation of plans for its exploration, management and conservation. The primary objective of the study is to identify location priority areas for water conservation measures in Rangapur watershed in middle Krishna basin using remote sensing and Geographical Information System techniques. The watershed partly covers three villages namely Rangapur, Yadlapur and Bevinbenchi of Raichur district, Karnataka with an aerial extent of 2079 ha. The present study involves creating various thematic maps like drainage map, contour map, slope map, soil map, hydro-geomorphology map, lineament maps and land use/land cover map by using Survey of India toposheets and IRS P6 LISS III satellite imagery in ArcGIS 10 and Erdas Imagine 2013 version. After integrating all the above thematic maps using weighted overlay analysis, priority location map generated to locate the water conservation measures in the watershed.

Keywords: Thematic maps, water conservation, check dams, prioritisation, remote sensing, GIS.

INTRODUCTION

Water is one of the precious and vital resources essentially required for sustenance of life and for the economic and social progress of any country. India occupies 329 M ha geographical area, which forms 2.4 % of the world's land area, it supports over 15 % of the world's population. India supports 1/25th of world's water resources. The total utilizable water resources of the country are assessed as 1086 km^3. National Commission for Integrated Water Resources Development (Anon., 1999) estimated the basin-wise average annual flow in Indian river systems as 1953 km^3. The utilizable annual surface water of the country is 690 km^3. The annual potential natural groundwater recharge from rainfall in India is about 342.43 km^3, which is 8.56 % of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km^3. The estimate by the Central Ground Water Board (CGWB) of total replenishable groundwater resource of the country is assessed as 432 km^3. The available groundwater resource for irrigation is 361 km^3, of which utilizable quantity (90 %) is 325 km^3. The provision for domestic and industrial uses is 71 km^3 and utilizable groundwater resources for future use is 396 km^3. The basin wise per capita water availability varies between 13,393 km^3 per annum for the Brahmaputra–Barak basin to about 300 km^3 per annum for the Sabarmati basin (Anon., 1995).

In Karnataka the total water resources in seven river basins are 7663 TMC. Approximately 58 % of water resources are found in west flowing rivers where, a larger percentage of water could not be harnessed for any effective use. It is estimated that in the state only 1695 TMC of surface water could be economically utilisable for irrigation purpose. In case of ground water, it has been estimated that 485 TMC of groundwater is available in the state. However, the distribution of groundwater and its exploitation are not uniform throughout the state. A substantial amount of groundwater is found in the coastal areas, which cannot be effectively utilised. Surface water potential for Karnataka accounts of about 102 km^3, out of which around 60 % of is provided by the west flowing rivers while the remaining comes from the east flowing rivers. The average annual yield of the rivers of Karnataka has been roughly estimated as 3475 TMC (Anon., 2002).

MATERIAL AND METHODS

Study area: The present study was taken up extensively in Rangapur watershed having an area of 2079 ha which is located in between the villages of Bevinbenchi and Yadlapur in Raichur taluk of Raichur district of Karnataka (Fig. 1). The study area is situated in the North-Eastern dry zone of Karnataka at 16˚ 20' 20" to 16˚ 23' 5" N latitude and 77˚ 17' 21" to 77˚ 20' 58" E longitude and elevation is from 338 m to 382 m above mean sea level (MSL). The SoI toposheet 56 H/7 of 1:50,000 scale with a contour interval of 10 m were used for the analysis of watershed characteristics. The multi-temporal satellite data of Resourcesat-1 LISS III, 23.5 m resolution of year 2005-06 pertaining to monsoon season (*kharif*: August – October), post-monsoon season (*rabi*: December – March) and pre-monsoon season (*zaid*: April - May) with 1:50,000 scale (Appendix I) were used for the mapping of hydro geomorphological characteristics of the watershed collected from the National Remote Sensing Centre (NRSC), Balanagar, Hyderabad (www.nrsc.gov.in) and digitized in ArcGIS. The maps of geology of Karnataka and maps of lineaments with 1:50,000 scale of 56 H/7 were collected from the Mines and Geology department, Raichur and used for preparation of geology and lineaments map of Rangapur watershed in ArcGIS. The above maps were derived from the Quick Bird image of 0.61 m resolution in the year of 2010. Resourcesat-1 (IRS-P6), LISS III data is received from Linear Imaging and Self Scanning Sensor which operates with three spectral bands in VNIR (Visible and Near Infra Red) and one band in SWIR (Short Wave Infra Red) with 23.5 m spatial resolution and a swath of 141 km in the year 16th Nov 2011 (Appendix II) were collected from the NRSC and prepared in Erdas imagine for land use/land cover classification.

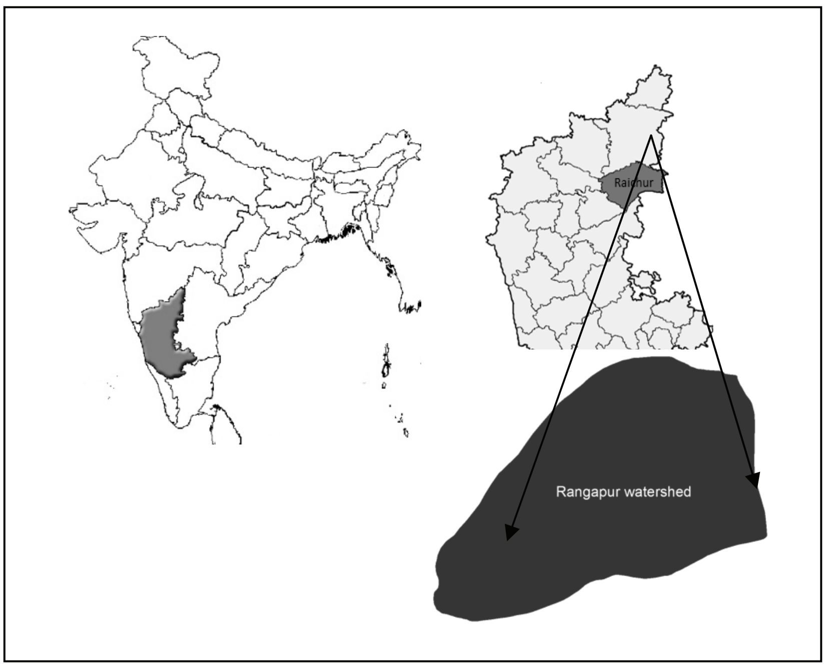

Fig. 1 Location map of study area

RESULTS AND DISCUSSION

Base map

The base map is represented by villages, roads, railway lines, spot elevations, *etc*. Through field visits it was noticed that the settlements are villages and roads are of unmetalled cart track and unmetalled 6 m track road. The base map (Fig. 2) was prepared using Arc GIS software.

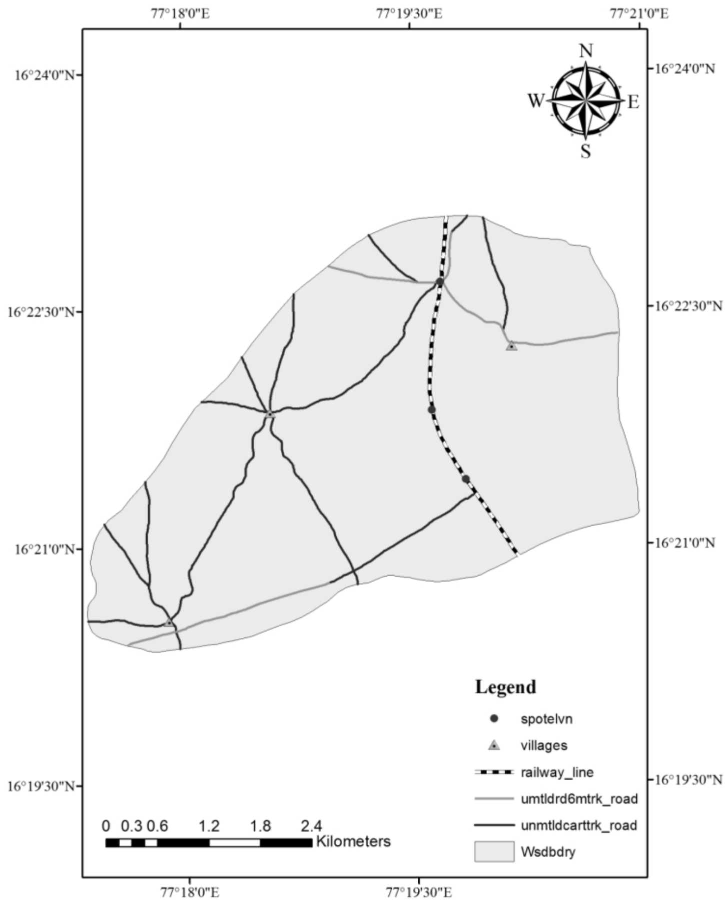

Fig. 2 Base map of Rangapur watershed

Drainage map

Drainage map was prepared by using Survey of India toposheet on 1:50,000 scale. The drainage pattern observed in the study area is *dendritic*. The highest stream order is 4th order. The total length of streams draining to Krishna river was found out using Arc GIS software. The Fig. 3 depicts drainage map of the Rangapur watershed.

Contour map

A contour is a line connecting all points on the ground that have the same elevation above mean sea level. The sea level contour is used as the 0 m level or reference level datum for most topographic maps. Contour map was prepared from Survey of India toposheet with 10 m contour interval. The corresponding contour intervals were recorded in the attribute table. The total length of contours was 37.39 km.

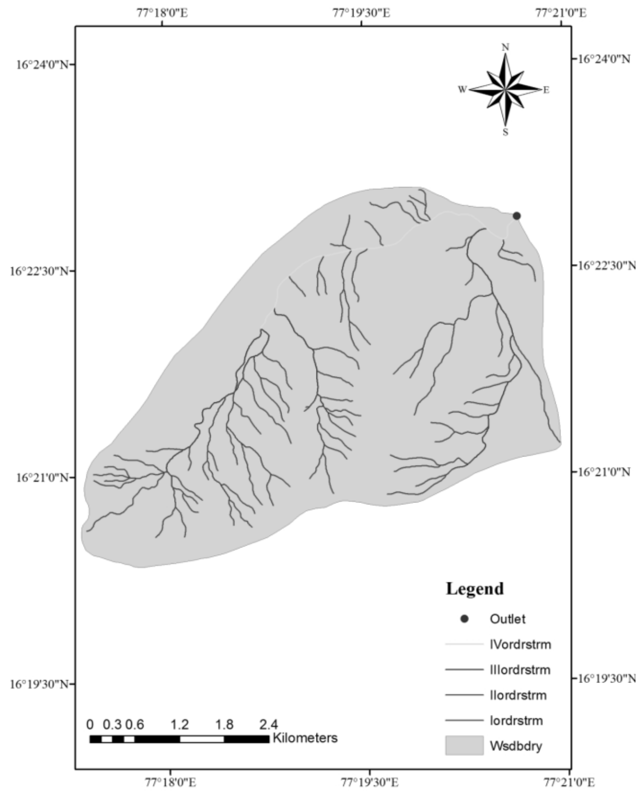

Fig. 3 Drainage map of Rangapur watershed

Slope map

Slope is the most important terrain characteristics plays a vital role in hydro geomorphological and runoff processes, soil erosion, infiltration and land use/land cover (Jha *et al*., 2007; Yeh *et al*., 2008). The slope map was prepared for the study area from the DEM with contour extracted from the 1:50,000 SoI topographic maps using guidelines laid down by the All India Soil and Land Use Survey on slope categories. About 32.54 % of the total study area fell into slope class 1 (< 1 %) while 35.98 % of the study area having a slope class of 2 fell in the range of (1 – 4 %). In similar way slope classes of 3 (4-10 %), 4 (10-20 %), 5 (20-45 %) and 6 (>45 %) were covered an area about 14.22 %, 8.76 %, 5.29 % and 3.21 %. The Fig. 4 represents slope map of the Rangapur watershed.

Hydro geomorphology map

The hydro-geomorphology deals with the geomorphic history of the area. The hydro-geomorphology map generated by Geological Survey of India to a scale of 1:50,000 were used to prepare the hydro-geomorphology map for the entire study area and were categorized into four classes as shallow weathered or buried pediplain, moderately weathered pediplain, valley and water body mask. If the pediments are covered by alluvium or weathered material, they formed as buried pediments. These buried pediments with thin overburden of (0 ~ 5 m) are known as Shallow Buried Pediment (SBP). The areal extent of this unit was 18.13 km^2 that covers 87.20 % in the study area and groundwater prospects in these areas were expected to be poor. The pediments are covered by alluvium or weathered material, they are formed buried pediments. These buried pediments with thick overburden of (5 ~ 10 m) are potential sites for groundwater prospecting. They are known as Moderate Weathered Pediment (MWP). The areal extent of this unit observed was 0.88 km^2 that covers 4.23 % of the study area and moderate groundwater prospects were expected in these areas.

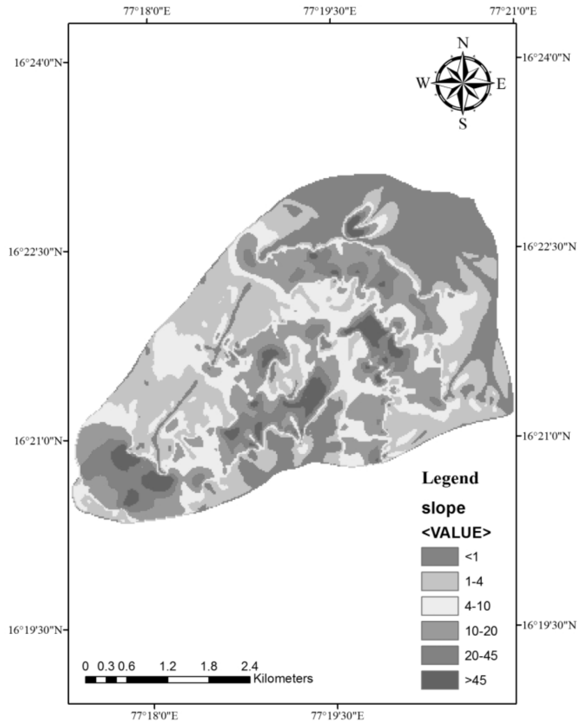

Fig. 4 Slope map of Rangapur watershed

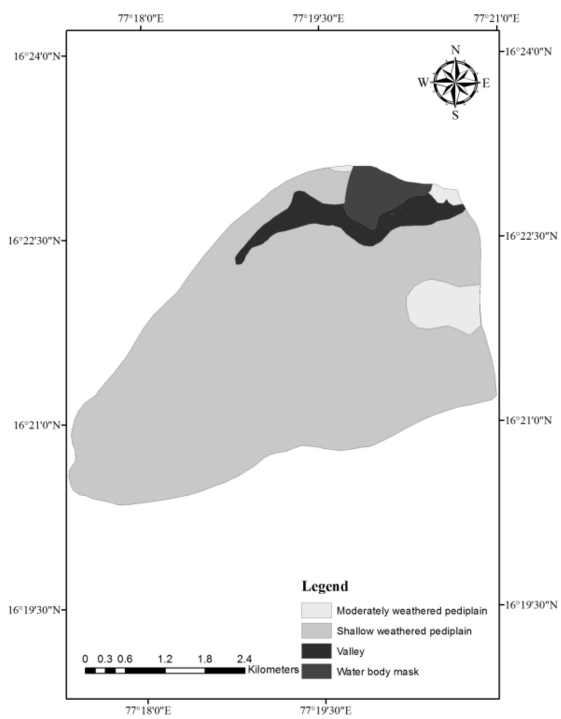

Fig. 5 Hydro geomorphology map of Rangapur watershed

Valley was demarcated on the basis of its typical flatness, smooth texture and drainage pattern of the watershed. The river valley in the surface exhibits features of matured flood plains. The areal extent of this unit was 1.11 km^2 that covers 5.34 % of the study area and water body covers 3.23 % with an aerial extent of 0.67 km^2 and moderate limitation of wetness and good potential site for groundwater prospect were found in the study area. The Fig. 5 shows different features of hydro geomorphology of Rangapur watershed.

Soil map

Soil is an important factor to influence water resources *i.e.* transformation and deposition of soil by surface runoff and rainfall can reduce depth of the catchment area of water bodies and it is a component of land system, which provides a medium for water movement and plant growth. The recharge capacity and groundwater quality is decided by the soil types and their texture. According to Soil and Land use Survey of India (www.slusi.dacnet.nic.in) in the study area mainly five textural classes were found out (Fig. 6). The most of the study area is composed of clayey soils which can erode and transferred by heavy rain and moderately percolated the water in to the ground. The other characteristic features of the soil are silty clay, silty clay loam, clay loam and sandy clay loam were observed in the watershed.

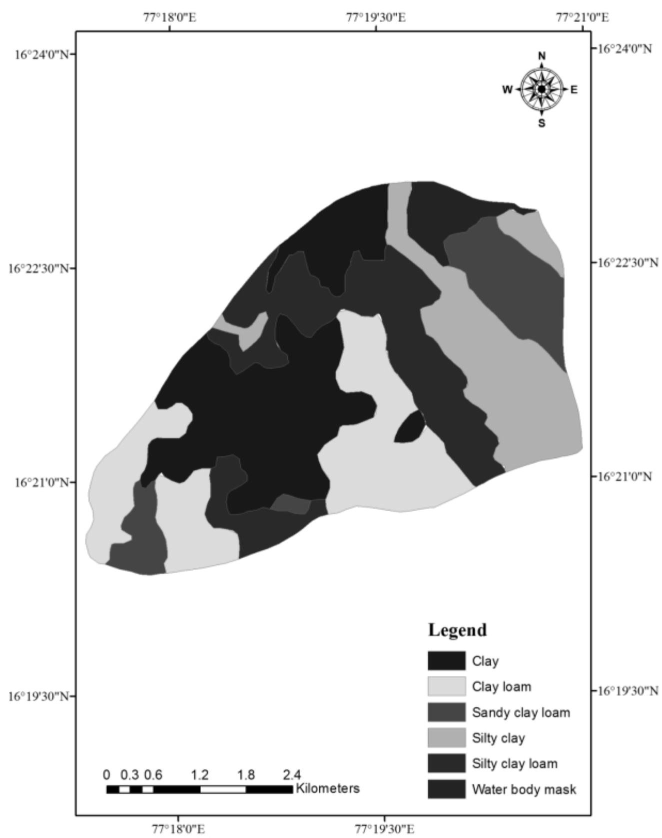

Fig. 6 Soil map of Rangapur watershed

Land use/ land cover map

The land use/land cover maps were prepared from the satellite data of cropping season (16^{th} Nov 2011). Supervised and unsupervised classification techniques were used for land use/land cover classification of the watershed and accuracy assessment was found out. The accuracy of unsupervised and supervised classifications was found as 84.24 % and 87.63 % respectively. The study indicated that the supervised classification (Fig. 7) method was more accurate as the accuracy was higher compared to the unsupervised classification.

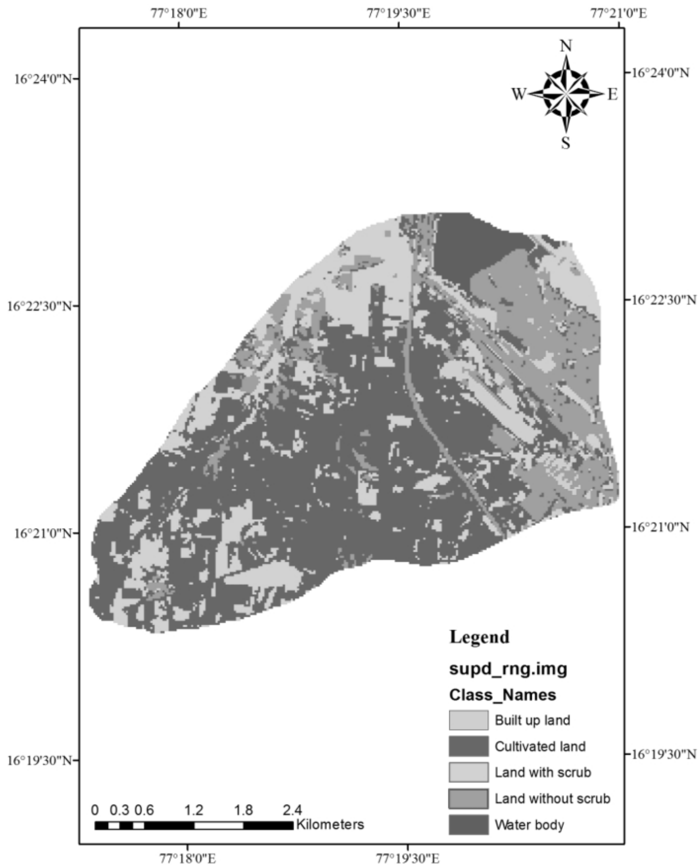

Fig. 7 Land use/land cover map of Rangapur watershed by supervised classification

Proposing water conservation structures based on priority

Water resources conservation plan was prepared on the basis of weightages given to different thematic maps like drainage, slope, hydro geomorphology, soil and land use/land cover. These maps were converted from feature to raster. The raster based thematic maps like drainage, slope, hydro geomorphology, soil and land use/land cover were considered for the prioritization having high and low values. In the drainage network high priority was found to 1st and 2nd order streams because of steeper slopes, the runoff generation will be more and low priority was found to 3rd and 4th order streams because of gentle slope and nearly flat slope. In case of slope of the watershed, high priority was found to 10 to 20 %, 20 to 45 % and more than 45 % slope. Whereas, low priority were considered for the slope range of less than 1 % and 1 to 4 %. For hydro geomorphology, low priority was found to valley and high priority was found to shallow weathered pediplain because of poor ground water status. In case of soil, high priority was found to clay soils, in this type of soils runoff expected is more because of low infiltration and low priority was found to sandy clay laom and clay loam because of higher proportion of sand and expected infiltration will be more. Lastly for land use/land cover, high priority was found to cultivated land and land without scrub because of no vegetation and most of the soils are rich in clay content so runoff in these areas are more and low priority was found to water body and land with scrub, it obstruct the runoff water to flow as runoff and make it to infiltrate in to the soil. All these features were calculated in raster calculation [(hydro geomorphology)*0.2 + (land use/land cover)*0.2 + (soils)*0.1 + (slope)*0.2 + (drainage)*0.3]. Finally thirty four (Fig. 8) check dams were provided at the high priority where two stream orders joins together and the slope is fairly level after steep slopes and drainage path is straight.

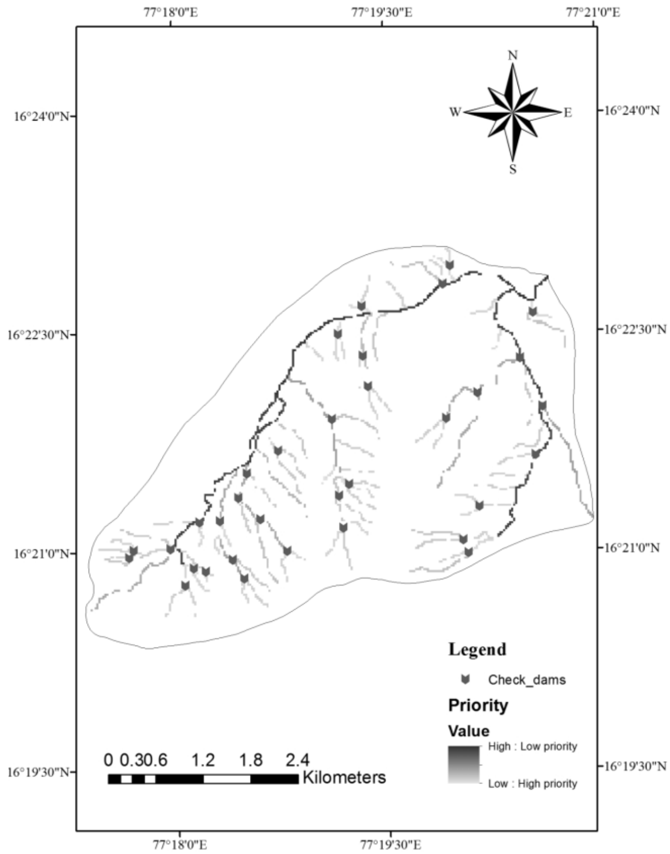

Fig. 8 Proposed location of check dams in Rangapur watershed

CONCLUSION

Rangapur watershed with rolling topography with gentle slopes tending towards North East direction and elevations of 338 to 382 m above mean sea level is drained by numerous streamlets. Thus from the study it is recommended that water harvesting should be given importance to avoid the wastage of rainwater from the watershed. This will also increase the groundwater recharge besides providing supplementary irrigation during rabi season.

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Study of Water Utilization of in Pench Irrigation Project

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ABSTRACT

Water is a precious natural resource, a basic human need and precious national asset for which planning, development and management should be governed by national perspectives. For effective planning and development of water resources at national level it is necessary to manage the each command area effectively. Considering the importance of water resources the research was conducted to study the water utilization of Right Bank Command of Pench Irrigation Project in Maharashtra State. The map of the RBC system showing network of canals and historical daily discharges at the system source of Right Bank Canal system for 5 years (2004-08) were collected from office of the Executive Engineer, Irrigation Department, Nagpur (Mah.). Flow rates at 7 different locations in the RBC system were collected from the respective Section Offices. Ten Years (2000-09) canal release data of the RBC system reveals that, on an average canal runs for 84 days and provides average 5 to 9 irrigations in both *kharif* and *rabi* season. An irrigation here represents canal supply over 7 to 19 days followed by an equal or longer duration of canal closure. In Pench Irrigation Project, a variable discharge, variable duration and variable frequency delivery scheduling (Intermittent) was practiced. It was suggested that instead of intermittent scheduling rotational irrigation scheduling should be followed in order to increase the prduction of crops, to save the water and increase irrigated area.

INTRODUCTION

Water is probably the only natural resource to touch all aspects of human civilization from agricultural and industrial development to cultural and religious values embedded in society. It is a precious natural resource, a basic human need and precious national asset which planning, development and management should be governed by national perspectives. The ultimate irrigation potential of the India is estimated as 139.9 M ha of which irrigation potential from major and medium irrigation projects is assessed as 58.47 M ha Irrigation potential created in the country from major and medium irrigation projects, which stood at 9.7 M ha in 1951, has risen to 36.98 M ha at the end of 2002 and 41.64 M ha, till the end of 2007. The ultimate irrigation potential in Maharashtra from major and medium irrigation project is 4.1 M ha which irrigation potential created up to the end of 2002 was 3.24 and it increases to 3.5 at the end of 2007 (Annual Report, 2012). The target for XII 'Five Year Plan' (2007-12) is to achieve an additional irrigation potential of 7.79 M ha in the MMI sector. The research was conducted to study the water utilization of Right Bank Command of Pench Irrigation Project.

DATA AND METHODOLOGY

Pench Irrigation project is situated in Nagpur district, of Maharashtra State has been chosen as study area. Pench irrigation reservoir is constructed on Pench river at village Navegaon khairy in Parshioni taluka. Command area under Pench Irrigation Project is located between 21º00′ to 21º45′N latitude and 79º00′ to 79º45′E longitudes and situated in 11th Agro-Ecological Region of India, (K6C3). Location of Pench Irrigation Project is depicted in Fig. 1.

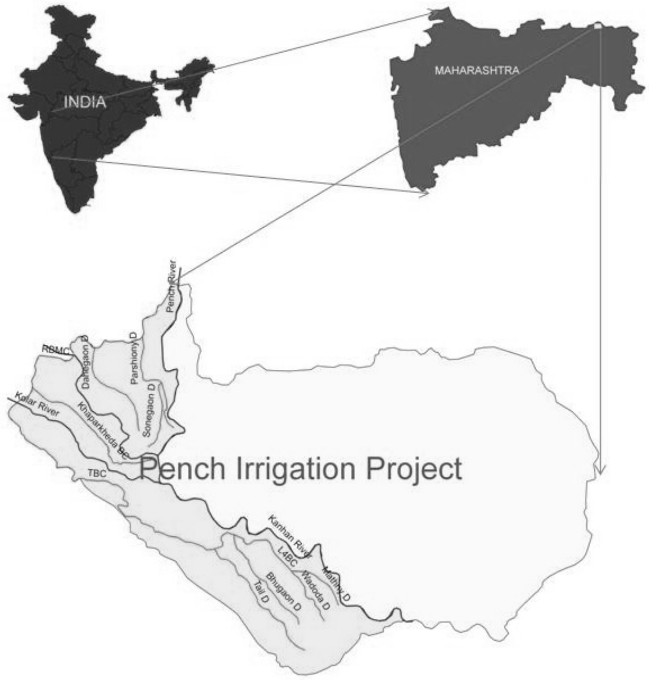

Fig. 1 Location of the Pench Irrigation Project

Average annual rainfall of the canal command is 1107 mm. The Pench Irrigation project is serving domestic, Industrial and Irrigation demand through right and left bank canals of the project. The Command Area of the project is 1044.76 km^2. The study was limited to Right Bank Canal Command Area which consist of Right Bank Main Canal, Tail Brach Canal (TBC), L4 Branch Canal (L4BC), and Khaperkheda Branch Canal (KBC). The total length of RBMC to Mathni is about 98 km.

The map of the RBC system showing network of canals, data and design of hydraulic structures (Inline and off-taking structures) and historical daily discharges at the system source of Right Bank Canal system for 5 years (2004-08) were collected from office of the Executive Engineer, Irrigation Department, Nagpur (M.S.). Flow rates at 7 different locations in the RBC system were collected from the respective Section Offices.

In Pench Irrigation Project, on an average annually eight irrigations were provided. An irrigation here represents canal supply over 7-19 days, followed by an equal or longer duration of canal closure. An intermittent delivery scheduling (variable discharge, variable duration and variable frequency) is being practiced. Major crops were cotton and paddy in *kharif* and wheat in *rabi* season.

RESULTS AND DISCUSSION

Pench project was designed to accommodate 965 M m^3 of water out of which the losses through evaporation is estimated to be 33 M m^3. Right Bank Canal operates daily to supply the water for following uses except irrigation.

- Domestic water supply : 112 M m^3
- Thermal power stations : 127 M m^3
- Fishery Development : 004 M m^3
- Irrigation : 689 M m^3

Domestic water supply

The domestic water supply to Nagpur city is being done through a head regulator at RD 48.40 km. The water leads to a sump well constructed by Maharashtra *Jivan Pradhikaran* (Environmental Engineering Division), Nagpur, from where it is being lifted by Nagpur Municipal Corporation and stored in the Gorewada tank which is being supplied to Nagpur city for domestic use.

Thermal power stations

The project water is being used by the thermal power stations located at Khaparkheda and Koradi. For Khaparkheda, the water is supplied to balancing tank through the underground pipe line off taking from Pench RBC at 3.21 km whereas, for Koradi water is supplied through an escape constructed at RD 44.66 km.

Irrigation

The Right Bank Canal (RBC) is designed to irrigate an area of 273 km^2 with the discharge 31.15 m^3s^{-1} through head regulator. The RBC system consists of Right Bank Main Canal (RBMC), Tail Brach Canal (TBC), L4 Branch Canal (L4BC), and Khaperkheda Branch Canal (KBC). The total length of RBC (RBMC HR to Mathni) is about 98 km. The lengths of RBMC, TBC, L4BC and KBC are 48.50, 26.50, 13.10 and 14.50 km, respectively. There are six distributaries *viz.* Parshioni, Dahegaon, Tail, Bhugaon, Wadoda and Mathni, other details of these distributaries are presented in Table 1. The designed irrigated command area is 273 km^2 but, the actual utilization gained so far is 78 per cent (212.56 km^2).

Table 1 shows existing rotational scheduling in the RBC command area on the basis of average seven years data (2002-08) indicated that the TBC operates for 19 days followed by 5 days canal closure. Similarly, L4BC 10 days followed by 20 days canal closure, KBC 14 days followed by 21 days canal closure, Parshioni distributary 14 days followed by 17 days canal closure, Dahegaon 10 days followed by 18 days canal closure and Tail Distributary 7 days (average of 5-9 days) canal operation followed by 20 days canal closure. The average operational days during calendar year was estimated to be 84 days followed by 126 days closure with seven irrigations per year.

The existing delivery schedule in the RBC command area is ‘intermittent’, canal operation and canal closure shows different scenarios for branch canal and distributaries (Table 1). This shows that, the branch canal and distributaries in the upper reach operates more days than the middle and lower reach which indicates that the water supply is not equally distributed throughout the command area. Canal was open for more days in upper reach and fewer days in tail reach, which indicates the farmers of tail reach suffer due to uneven distribution.

Table 1 Existing delivery scheduling in the study area

Name of canal	RD from HR, km	Av. operational days year^{-1}		Irrigation frequency	Av. operational days rotation^{-1}	
		Open	Close		Open	Close
TBC	48.50	85	24	5	19	5
L4BC	75.15	79	151	8	10	20
KBC	30.68	92	144	7	14	21
Tail D	71.95	44	127	6	7	20
Dahegaon	15.90	84	163	9	10	18
Parshioni	08.81	121	147	9	14	17
Average		**84**	**126**	**7**		

Canal release

Annual flow release data was collected for the RBC system over seven years (2002-08) and presented in Fig. 2. The lowest annual flow released was observed to be 291.62 M m^3 in 2005 whereas, the highest flow released is 553.78 M m^3 in 2003. The average annual flow release was estimated to be 381.02 M m^3 with the standard deviation and coefficient of variation 95.33 M m^3 and 0.246, respectively.

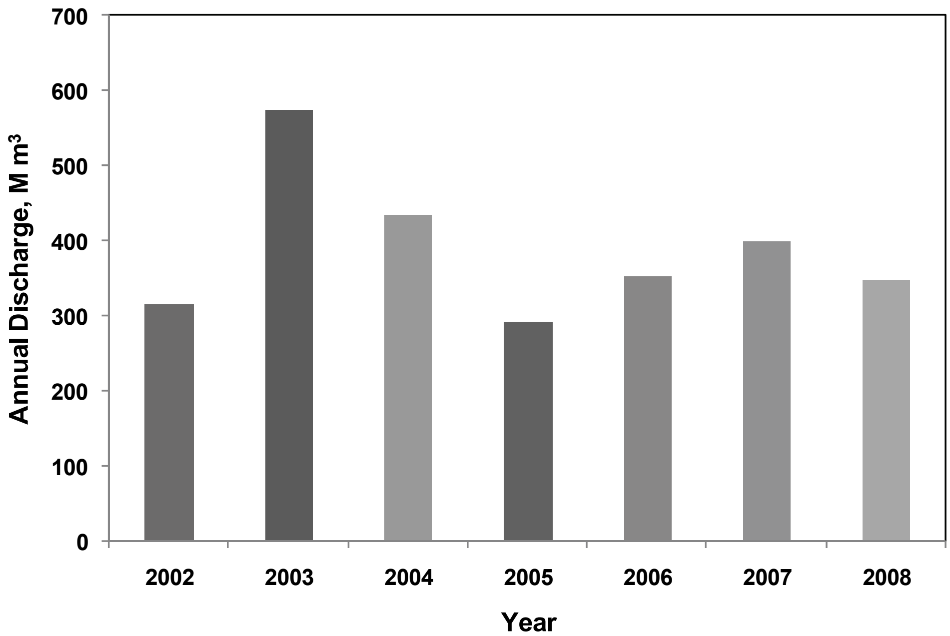

Fig. 2 Annual flow release to RBC system in different years

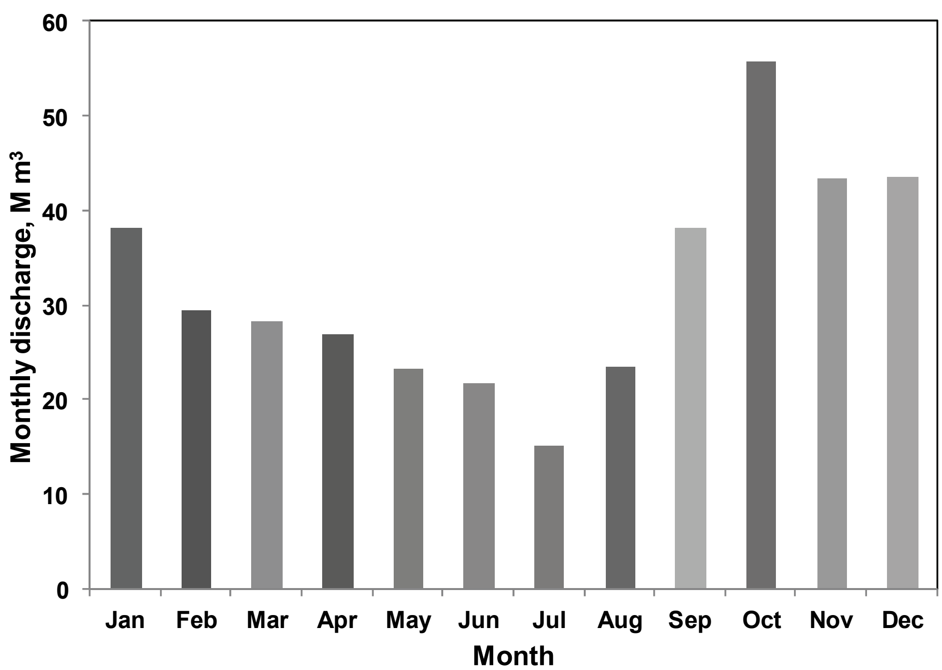

Fig. 3 Average monthly flow release to RBC system

The mean monthly canal release volumes were significantly higher for the months from September to January because of the application of protective irrigation to *kharif* crops in September and October; and to *rabi* crops in November onword (Fig. 3). The released volumes were minimum 15 to 25 M m^3 in the month of May, June and July. Remaining months registered flow release to the tune of 25 to 30 M m^3. The standard deviation and coefficient of variation for mean monthly flow volume was found to be as 11.61 M m^3 and 0.360, respectively.

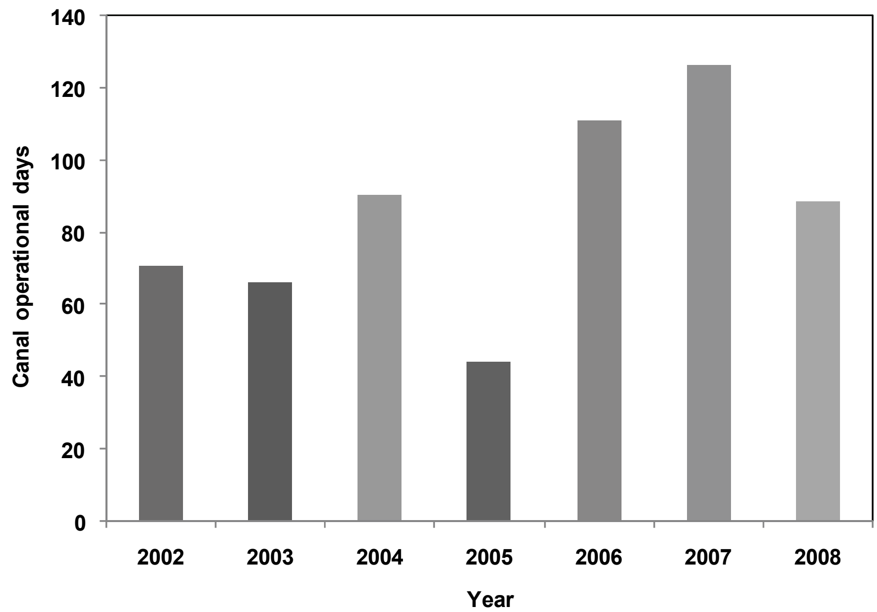

Fig. 4 Annual canal operational days in different years

Annual canal operation days varied from 44 days (2005) to 126 days (2007) with average canal operational 84 days (Fig. 4). The standard deviation and coefficient of variation was estimated to be 27.87 days and 0.326, respectively.

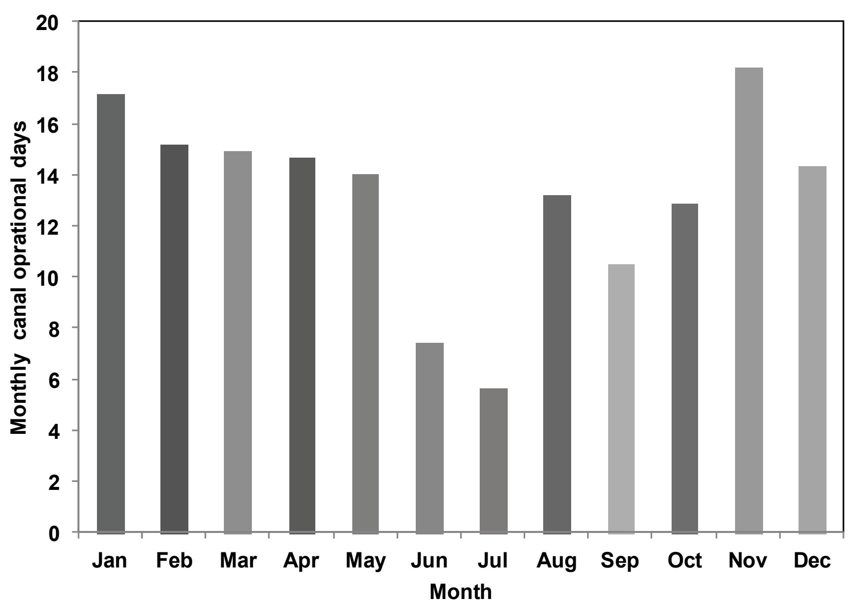

Fig. 5 Average canal operational days in different months

Maximum mean monthly canal operational days observed to be 18 in November followed by 17 in January (Fig. 5). The standard deviation and coefficient of variation was found to be 3.7 days and 0.281, respectively.

CONCLUSIONS

In Pench Irrigation Project, a variable discharge, variable duration and variable frequency delivery scheduling (Intermittent) was practiced. Ten Years (2000-09) canal release data of the RBC system reveals that, on an average canal runs for 84 days and provides average 5 to 9 irrigations in both *kharif* and *rabi* season. An irrigation here represents canal supply over 7 to 19 days followed by an equal or longer duration of canal closure. The duration and frequency are decided jointly by the officials of Irrigation Project and State Agricultural Department.

ACKNOWLEDGEMENT

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Land Cover Classification of RISAT-1 Data

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ABSTRACT

Land cover classification is a primary requirement for management and planning of various resources. Remote sensing techniques aided with ground information provide a reliable source of land cover classification in a cost and time effective way. While the utility of optical data in land cover classification is well known, the potential utilization of information given by space-borne and airborne RADAR systems in land cover classification is successfully attempted in several studies. Remote sensing using SAR data is useful for mapping and monitoring land cover over tropical regions, where continuous cloud cover hinders optical imagery acquisition. Radar sensors operating with different wavelengths and polarizations can be widely used for large-scale land cover mapping and monitoring using backscatter coefficients of different polarizations. It is proposed to classify the SAR image using thresholding method for land cover classification.

Keywords: Classification, Synthetic Aperture Radar, RISAT-1, Threshold.

I. INTRODUCTION

Synthetic Aperture Radar (SAR), an active sensor, transmits pulses of microwave and detects echo, which carries information about the surface. Due to relatively long wavelengths in microwave, radar signals are capable of penetrating clouds in the atmosphere and are independent of sunlight. SAR imaging has received a tremendous amount of research attention since it is unaffected by seasonal variations and weather conditions and is the only successful all weather imaging system. Information on landuse/land-cover is an important element in forming policies regarding economic, demographic, and environmental issues at national, regional and global levels. Mapping landuse/land-cover of the rural-urban fringe in a timely and accurate manner is thus of great importance for urban planning, landuse planning, conservation of biodiversity and sustainable management of land resources. With its all-weathered capability, SAR instruments have been receiving considerable attention in the remote sensing community. To evaluate the effectiveness of different image processing techniques for extraction of landuse/land-cover information, it is necessary to classify the raw SAR images, filtered images and texture images. The radiometric distortions depend strongly on the terrain and increase significantly in mountainous areas, in which the distortions should be corrected by a backscatter model for better classification results.

II. PROCEDURE

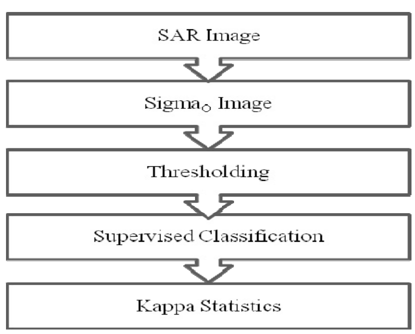

Fig. 1: Flow chart for total work

The back scattering coefficients have been calculated for the microwave image.

Several thresholding levels have been applied to the $sigma_o$ image to get classified image. By using signatures supervised classification has been done. Finally the accuracy measurement has been done for classified image to say how much accurate the classification is.

III. RESULTS AND DISCUSSION

The back scattering coefficients were calculated to have the $sigma_o$ image. By using slicing of the DN values it has been classified as shown in fig 2. Rearrangement of threshold is necessary to have the image in 4 classes.

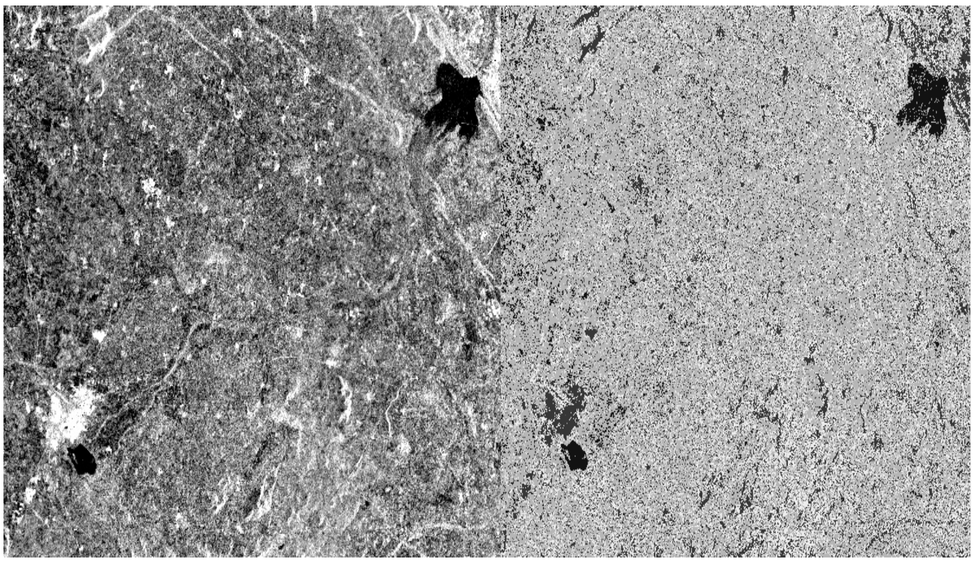

Fig. 2: RISAT-1 Image(Left) and Classified Image with Thresholds(Right)

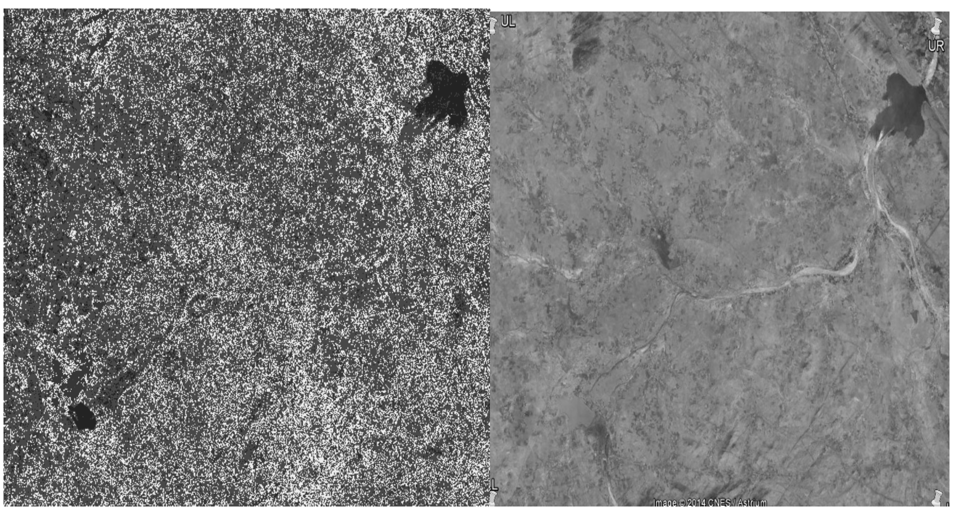

Fig. 3: Supervised Classified Image (Left) and Google earth Image(Right)

IV. ACCURACY ASSESSMENT

To assess the quality of the image classifications, various measures including overall accuracy and Kappa coefficient of agreement (or Kappa) were analyzed to compare classification results with the validation or reference data in confusion matrices. Overall accuracy is the total number of correctly classified samples (diagonal cells in a confusion matrix) divided by the total number of reference pixels. Utilizing all elements from the confusion matrix, Kappa coefficient is a measure of the difference between the actual agreement between reference data and a classification and the change agreement between the reference data and a classification (Lillesand & Kiefer 2000). Kappa takes into account both errors of commission and omission, and thus provides a more complete picture of the information comprising the confusion matrix than overall accuracy (Jensen, 2004).

After classification the kappa statistics have been performed to know the accuracy of the classification. We got accuracy of 70% and kappa value as 0.4514. The table1 gives accuracy calculations of all classes and table 2 gives kappa claculations.

Table 1: Accuracy Calculations

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
WATER	2	2	2	100.00%	100.00%
AGRICULTURE	52	64	44	84.62%	68.75%
BARRON	42	28	10	47.62%	71.43%
SETTLEMENTS	4	6	4	100.00%	66.67%
Totals	100	100	70		
Overall Classification Accuracy = 70.00%					

Table 2: Kappa Calculations

Class Name	Kappa
WATER	1
AGRICULTURE	0.349
BARRON	0.5074
SETTLEMENTS	0.6528

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Estimation of Net Irrigation Water Requirements for Different Soils in a Canal Command Area

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ABSTRACT

The irrigation water requirement of a command area mostly dependent on the nature of the crop, climate and the nature of the soil where the crop is grown. A thorough understanding of the cropping pattern and the nature of soil helps in estimating the irrigation water requirement and subsequently crop water requirement in that command area. This shows the need to use up-to-date and real time information pertaining to the climate, the type of soil and the type of crops being grown within the command area. Mostly command area is covered under rice cultivation and a very few percentage of cultivation is under commercial crops. Due to this, water requirements were analyzed for rice crop during the rabi season. Crop evapotranspiration and net irrigation demand is estimated using the Food and Agriculture Organization's (FAO) CROPWAT model and the software was run for all combinations of soils. The soils of the study area are initially classified in to six units and then reclassified and merged in to three classes sandy, clay and loamy. Irrigation requirements were calculated and projected from the daily water demand to ten-days and monthly time periods.

Keywords: Command Area, Evapotranspiration, FAO, CROPWAT

INTRODUCTION

As indicated by the World Water Assessment Program (WWAP) from United Nations (UN) Water Statistics, the global population is increasing 80 million per year resulting in fresh water requirement of about 64 billion cubic meters a year. Out of the total requirement, 70% is for irrigation, 20% for industry and 10% is allotted for domestic use. Irrigation is the main sector across the world that needs large quantities of water compared to any other sectors viz., industries and municipal use. Assured supply of water is becoming difficult due to population growth and urbanization. Efficient water use for agriculture is very low in India and there is an imminent need to improve it. Irrigation in India is mainly dependent on various sources, including the availability of canal water and ground water. Water use efficiencies are comparatively less in canal command areas than command areas that depend on groundwater. In India, most of the prominent canal command areas suffer from either excessive or inadequate water supply resulting in wide gap between irrigation demand and supply. To understand water scarcity and implement effective water management practices, it is important for the irrigation engineers to initially understand the climate, geography, landuse, and soil characteristics of the command area to estimate the irrigation demand.

STUDY AREA

Wazirabad command area is located between 16°39'2.84" and 16°56'40.81" N latitude and 79°25'16.01" and 79°40'52.90" E longitude.

METHODOLOGY

The present study uses CROPWAT software which was recommended by FAO's Penman-Monteith to calculate crop evapotranspiration. The inputs used at various stages of the software are rainfall, temperature, wind speed, sunshine, sowing and harvesting dates of rabi, crop factors, rooting depth and soil characteristics of the study area. Knowledge of local cropping pattern was obtained from the local authorities and by interviewing farmers, which has enabled the model for appropriate results. In order to calculate net irrigation water Requirements, the daily meteorological data is collected from the nearest and most representative meteorological station and validated. Mandal wise daily rainfall data is collected from the district information center. The climate data of the study area have been obtained from the Agricultural Research Institute (ARI), Rajendranagar, Hyderabad and also from district information center at the Collectorate, Nalgonda, Andhra Pradesh. The data related to rainfall, temperature, humidity, evapotranspiration, wind speed and sunshine were collected for the Rabi season.

The collected information on the dates of sowing and harvesting is systematically arranged in a cropping pattern.

The following information is used to calculate the ET_c of the command area:

Sowing/Planting date: 15/1/2007

Harvest Date: 24/4/2007

The following growth stages are taken for calculation:

- Nursery and Land Preparation(25 days)
- Initial (20 days) from 15th Jan 4th Feb
- Development(20 days) from 5th Feb to 24th Feb
- Mid Season(30 days) from 25th Feb to 25th Mar
- Late Season(30 days) from 26th Mar to 24th Apr

The average monthly temperatures, relative humidity, wind speed, evaporation and sunshine were calculated from the daily meteorological data and shown in Figs.1 to 3. The characteristics of each soil type have been elaborated in the Tables 1 to .3. The effective rainfall and the crop water requirement decide the amount of irrigation water that has to be applied. The effective rainfall is subtracted from the crop water requirement to calculate the Net Irrigation Water Requirements (NIWR). This formula is taken into consideration while running the CROPWAT model using the daily rainfall data in the program.

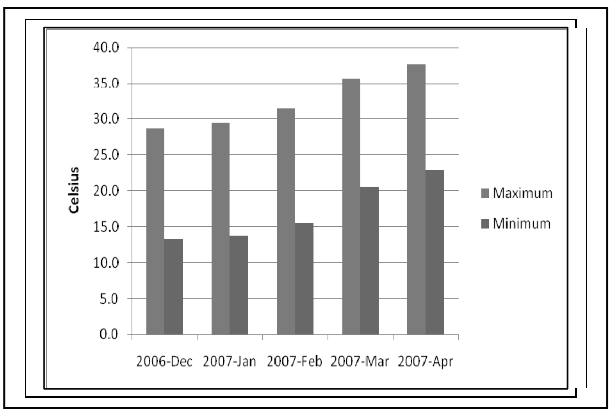

Fig. 1 Average temperature rabi 2007

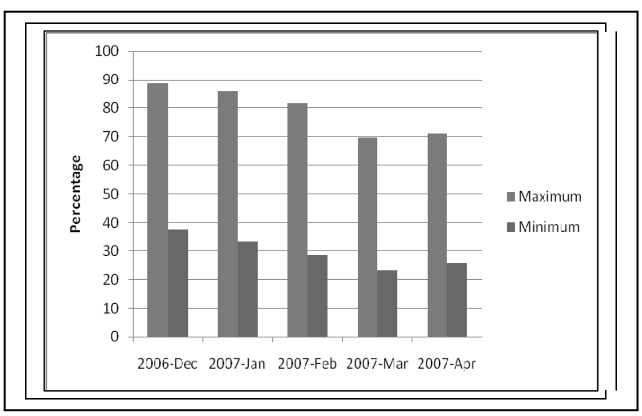

Fig. 2 Average relative humidity rabi 2007

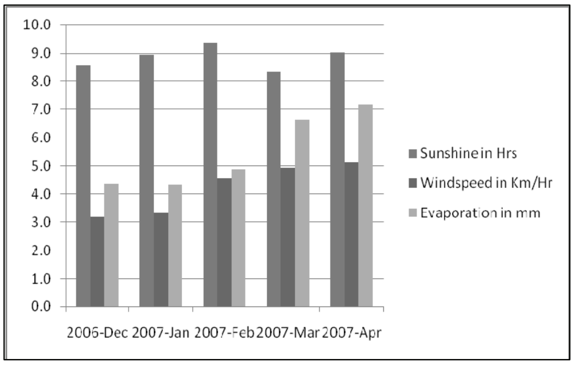

Table 1 Sandy soil characteristics

Sl. No	Parameter	Value	Unit
1	Total available soil moisture	100	mm/meter
2	Max rooting depth	900	cm
3	Initial soil moisture depletion	0	%
4	Initial available soil moisture	100	mm/meter
5	Drainage porosity	20	%
6	Critical depletion for puddle cracking	0.4	fraction
7	Max percolation rate after puddling	3.1	mm/day
8	Water availability at planting	10	mm WD
9	Max water depth	100	mm

Table 2 Clay soil characteristics

Sl. No	Parameter	Value	Unit
1	Total available soil moisture	200	mm/meter
2	Max rooting depth	900	cm
3	Initial soil moisture depletion	50	%
4	Initial available soil moisture	100	mm/meter
5	Drainage porosity	10	%
6	Critical depletion for puddle cracking	0.6	Fraction
7	Max percolation rate after puddling	3.1	mm/day
8	Water availability at planting	5	mm WD
9	Max water depth	120	mm

Table 3 Loamy soil characteristics

Sl.No	Parameter	Value	Unit
1	Total available soil moisture	180	mm/meter
2	Max rooting depth	900	mm
3	Initial soil moisture depletion	0	%
4	Initial available soil moisture	180	mm/meter
5	Drainage porosity	15	%
6	Critical depletion for puddle cracking	0.5	Fraction
7	Max percolation rate after puddling	3.1	mm/day
8	Water availability at planting	8	mm WD
9	Max water depth	110	mm

RESULTS AND REPORTS

The CROPWAT model was used to calculate the crop evapo-transpiration and Net Irrigation Water Requirements (NIWR) of rabi season in the year 2007. The evaluation was done on daily and decadal (10 days) intervals based on climate, rainfall and soil data. The NIWR for loamy soils for the entire crop period was estimated as 624.2 mm. The NIWR for clayey soils for the entire crop period was estimated as 612.4 mm. Whereas the NIWR was estimated for sandy soils are 640.8 mm. The results derived from the CROPWAT software for clay, loamy and sandy soils are shown in Tables 4 to 6.

Table 4 Net irrigation water requirements for loamy soils

S No	Month	Stage	Kc coeff	ETc mm/day	ETc mm/decade	Eff rain mm/decade	Irr. Req. mm/decade
1	Dec	Nursery	1.05	0.52	5.7	0.0	76.8
2	Jan	Nursery	1.06	2.75	27.5	0.0	107.5
3	Jan	Initial	1.09	3.06	30.6	0.0	86.1
4	Jan	Initial	1.1	3.28	36.1	0.0	36.1
5	Feb	Development	1.11	3.64	36.4	0.0	36.4
6	Feb	Development	1.13	3.79	37.9	0.0	37.9
7	Feb	Mid	1.15	4.16	33.3	0.0	33.3
8	March	Mid	1.16	4.48	44.8	0.0	44.8
9	March	Mid	1.16	4.45	44.5	0.0	44.5
10	March	Late	1.15	4.47	49.2	0.0	49.2
11	April	Late	1.1	4.84	48.4	0.0	48.4
12	April	Late	1.05	4.53	45.3	41.8	3.5
13	April	Late	1.01	4.91	19.7	0.0	19.7

Table 5 Net irrigation water requirements for clay soils

S No	Month	Stage	Kc coeff	ETc mm/day	ETc mm/decade	Eff rain mm/decade	Irr. Req. mm/decade
1	Dec	Nursery	1.19	0.52	5.70	0.00	51.8
2	Jan	Nursery	1.06	2.75	27.5	0.00	122.5
3	Jan	Initial	1.09	3.06	30.6	0.00	84.3
4	Jan	Initial	1.10	3.28	36.1	0.00	36.1
5	Feb	Development	1.11	3.64	36.4	0.00	36.4
6	Feb	Development	1.13	3.79	37.9	0.00	37.9
7	Feb	Mid	1.15	4.16	33.3	0.00	33.3
8	March	Mid	1.16	4.48	44.8	0.00	44.8
9	March	Mid	1.16	4.45	44.5	0.00	44.5
10	March	Late	1.15	4.47	49.2	0.00	49.2
11	April	Late	1.10	4.84	48.4	0.00	48.4
12	April	Late	1.05	4.53	45.3	41.8	3.5
13	April	Late	1.01	4.91	19.7	0.00	19.7

Table 6 Net irrigation water requirements for sandy soils

S No	Month	Stage	Kc coeff	ETc mm/day	ETc mm/decade	Eff rain mm/decade	Irr. Req. mm/decade
1	Dec	Nursery	1.19	0.52	5.7	0.00	66.8
2	Jan	Nursery	1.06	2.75	27.5	0.00	137.5
3	Jan	Initial	1.09	3.06	30.6	0.00	82.7
4	Jan	Initial	1.10	3.28	36.1	0.00	36.1
5	Feb	Development	1.11	3.64	36.4	0.00	36.4
6	Feb	Development	1.13	3.79	37.9	0.00	37.9
7	Feb	Mid	1.15	4.16	33.3	0.00	33.3
8	March	Mid	1.16	4.48	44.8	0.00	44.8
9	March	Mid	1.16	4.45	44.5	0.00	44.5
10	March	Late	1.15	4.47	49.2	0.00	49.2
11	April	Late	1.10	4.84	48.4	0.00	48.4
12	April	Late	1.05	4.53	45.3	41.8	3.5
13	April	Late	1.01	4.91	19.7	0.00	19.7

CONCLUSION

This study aimed to develop an equation to calculate irrigation demand for different soils under different climatic conditions in a canal command area for optimizing the water releases. In the command area the clay soils are predominant and found 49% in the study area whereas sandy and loamy soils occupied 29% and 22% respectively. The CROPWAT model is widely accepted across the world and is very sensitive to climate and crop growth data and was used in the study for calculation of daily crop water requirements. The increase and decrease of net irrigation requirements is observed in each decadal during the crop season. Also the rainfall in the month of April has resulted in significant change in the irrigation requirements during the period 15th to 24th April.

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Salient Features of the Andhra Pradesh Farmers Management of Irrigation Systems Act & Rules, 1997 – Status, Present and Future Initiatives

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ABSTRACT

The Andhra Pradesh Farmers Management of Irrigation Systems (APFMIS) Act (Act 11 of 1997) enacted in April 1997 was the first such act in India. It followed a "Big-Bang Approach of up-scaling to all the project areas at one go. Concerted efforts in the initial years coupled with sustained policy support saw to it that the initial energy is consolidated and institutionalized. Of course, the 17 odd years of experience is not all success but is also laced with a large number of challenges some of which are overcome and solutions to others are being searched jointly by the WUAs and the Engineers. Assessment of the performance of Participatory Irrigation Management (PIM) at periodic intervals enabled passing policies that re-energized the system of PIM. Efforts in the last few years have been on active involvement of the Water User Associations (WUAs) in planning, execution and monitoring of the PIM by themselves, assisted by the Competent Authorities. Results over the years have reinforced the state's belief in Joint Management of water resources with WUAs playing key role. However, there are quite a few challenges in this path and it should be viewed as a continuous process with a long gestation period.

I. The APFMIS Act, 1997

The Background: The 1990s in Andhra Pradesh have seen large scale reforms in about 8 selected sectors where in the overall aim was to involve the primary stakeholders actively in the management of the activities. The sectors included, among others, Education, Forests, Youth Empowerment, Women Empowerment, Health, Irrigation & Command Area Development, etc. These reforms had the ingredients of "process re-engineering". The passing of the APFMIS Act 1997 is one such output.

The APFMIS Act enables:

(i) creation of Water Users Associations (WUAs) in all irrigation projects of the State;

(ii) gives water rights to the WUAs;

(iii) provides functional and administrative autonomy to the WUAs;

(iv) makes Irrigation & Command Area Development Department (I & CAD Dept.) staff accountable to the WUA's as the competent authority, requiring I & CAD Dept. staff to implement the decisions of the WUA;

(v) enables WUAs to resolve conflicts themselves;

(vi) enables improvement of the irrigation systems by the WUAs based on resources raised by the WUAs or from out of the grants given by the Government as a percentage of water charges collected from the WUAs;

(vii) allows access to information by the WUA on scheme operations;

(viii) permits preparation of the operational plan and the maintenance plan by the WUA;

(ix) provides freedom of cropping pattern to farmers; and

(x) Contains procedures and guidelines on accounting, social auditing water budgeting, election procedures, and other administration.

Irrigated areas under each project was delineated into viable WUAs after giving due notice to farmers and calling for objections. This process was coordinated by the District Collectors. After the notifications were finalized, elections were conducted to the WUAs by the District Collectors as election authority under the superintendence of the Commissioner, Command Area Development Authority (CADA) as the State Election Authority. Detailed election procedure has been prescribed as in the case of general elections.

The Salient Features of the APFMIS Act & Rules are as follows:

(a) *Classification of Irrigation Projects:* All the irrigation projects in the state have been classified based on the command area as follows:

Minor Irrigation	:	upto 2000 hectares
Medium Irrigation	:	more than 2000 hectares & upto 10,000 hectares
Major Irrigation	:	more than 10,000 hectares

(b) *Area of Operation:* Area of operation in relation to a Farmers' Organization means a contiguous block of land in the command area of an irrigation system as may be notified for the purpose of the Act. Thus every WUA, a Distributor Committee (DC) and a Project Committee (PC) will have an area of operation notified which forms the basis of exercising their powers.

(c) *Delineation of water users areas, distributor areas and project areas:* For the purpose of carving out the jurisdictions of various organizations, the respective areas of operation have to be delineated on hydraulic basis. Hydraulic basis means the basis for identifying a viable irrigated area served by one or more structures such as head work's distributaries, minors, pipe outlets etc. FOs is a generic term and includes WUA at the primary level; DC at the distributor level, PC at the project level and Apex Committee at the Government level.

(d) *Conduct of Elections:* The Act provides for elections to the WUA, the DC and the PC after the area of operation of each of the committees is notified. Accordingly, elections have been conducted to 2311 WUAs in Major Irrigation Scheme, 409 WUAs in Medium Irrigation Scheme and 8007 WUAs in Minor Irrigation Scheme; 323 DCs, 23 PCs in Major Irrigation Schemes and 60 PCs in Medium Irrigation Scheme in the State (election years 1997, 2003, 2005, 2006 & 2008). This is the first instance that such large scale elections are held anywhere in India.

(e) *Membership:* The Act provides for two types of membership:

- *Members with voting rights:* Those members who have been registered as owners or tenants in the record of rights. In respect where both the owner and the tenant are landholders in respect of the same land, the rights are given to the tenant.
- *Other water users:* All other members are categorized as other water users who have no voting right. Water users have been defined as any individual or body corporate or a society using water for agriculture, domestic, power, non domestic commercial, industrial or any other purpose from a Government or the Corporation source of irrigation. This would include cultivators who have not been recorded in the revenue records.
- *Election Procedure*: In detail is provided in the Act that is similar to the gram panchayat election procedure but with some modifications. The details of the election procedure are given in the election manual as a part of the rules to the APFMIS Act {G.O.Ms. 45, Irrigation & CAD (CAD IV) dated 30-4-1997 and G.O.Ms. 47, Irrigation & CAD (CAD IV) dated 04-4-2003}

Election to Farmers Organisations (FOs)

WUA: Every WUA will have a Managing Committee (MC) comprising members of the Territorial Constituencies (TCs) (i.e.) 12 members in a Major & Medium Irrigation Schemes and 6 members in a Minor Irrigation Schemes who are elected by the water users in the TC. The MC for WUA shall be a continuous body with one third of its elected members there off retiring for every two years. The term of office of these members shall, if not recalled or removed or disqualified under the provisions of the Act be six (6) years from the date of 1st meeting of the MC appointed by the Commissioner. The District Collector cause arrangements for the election of MC members consisting of one member from each of the TCs of a WUA by a simplified election procedure in the manner prescribed. She/he shall also cause arrangements for the election of a President and Vice-President of the MC from among the members of the MC of WUA in the manner prescribed. The President and Vice-President of the MC of WUA shall, if not recalled or removed or disqualified by the provisions of the Act, be in office for a period of two years from the date of election or his tenure as a member of TC, whichever is earlier.

DC: Every DC will have a MC consisting of all members of General Body (GB) of the Committee. All the Presidents of WUAs in the distributor area, so long as they hold such office shall constitute the GB. In addition, all the Presidents of the Mandal Parishads within the distributary are nominated by the District Collector, without voting rights. The District Collector shall cause arrangements for the election of President and Vice-President from among the member of MC of the DC, in the manner prescribed. The term of office of the President, Vice-President and the members of the MC of the DC shall, if not recalled, removed or disqualified under the provisions of the Act earlier, be coterminous with the term of the GB specified in Sub-section 3 of Section 5 of the Act.

PC: Every PC will have a MC consisting of all the member of the GB. In a Major Irrigation System, all the Presidents of the DC in the project area so long as they hold such office, shall constitute the GB of the PC, provided that such PC shall have a minimum strength of five members. All the Members of the Legislative Assembly, Member of the Legislative Council, all Members of the Parliament and Chairpersons of Zilla Parishads within the Major Projects area nominated by the Government shall be the members of the MC of PC (Major Irrigation System) without voting rights.

In a Medium Irrigation System, all the Presidents of WUAs in the project area, so long as they hold such office, shall constitute the GB of the PC. All the Members of the Legislative Assembly, Members of the Legislative Council, all Members of the Parliament and Presidents of Mandal Parishads within the Medium Project area nominated by the District Collector shall be the members of the MC of PC (Medium Irrigation System) without voting rights.

The District Collector will cause all arrangements for the election of Chairman and Vice-Chairman from among the members of MC of a PC (Major/Medium Irrigation). The term of office of the Chairman, Vice-Chairman and the members of MC of PC shall if not recalled, removed or disqualified under the provisions of Act, earlier be coterminous with the term of GB specified in Sub section (3) and Sub section (4) of Section 7 of the Act.

- *Election Disputes* are to be resolved in the manner prescribed in G.O.Ms. No. 130, Irrigation & CAD (CAD IV) Department, dated 08-09-1997 and G.O.Ms. 47, Irrigation & CAD (CAD IV) Department dated 04-4-2003.
- *Disqualifications of persons* who are not entitled to contest for elections to the post of the FOs is provided for under section 14 of the Act. No person holding a public post, or a defaulter of land revenue, or of unsound mind, or a registered contractor having a subsisting contract within the area of operation of FOs is disqualified from contesting to the post of Chairman or Vice-Chairman, or President or Vice-President or a member of a MC of the organization.
- *Recall* under Section 10 of the Act provides a Chairman or Vice-Chairman, or President or Vice-President or the member of the MC can be recalled by after a period of one year by giving a written notice signed by not less than one-third of the total number of members of the FO who are entitled to vote. The motion for recall is carried with the support of a majority of the members present and voting at a meeting specially convened for the purpose.

(f) *Tiers of FOs:*

Table 1

Nature of Irrigation System	Water user Association	Distributory Committee	Project Level Committee
Minor Irrigation Scheme	Yes	No	No
Medium Irrigation Scheme	Yes	No	Yes
Major Irrigation Scheme	Yes	Yes	Yes

(g) *Composition of a WUA:* A water users' area is divided into TCs for the purpose of giving equitable representation to all areas in an irrigation command, namely the head, middle and tail end reaches. Groups of outlets are clubbed into a territorial constituency. The number of TCs could vary depending upon the type of the irrigation system namely 12 TCs in Major & Medium Irrigation System and 6 TCs in Minor Irrigation System.

Membership:

Table 2

WUA of Major, Medium & Minor Irrigation Schemes:	Members with voting rights & other water users whom do not have voting rights
DC of Major Irrigation Scheme:	All the Presidents of WUAs in a Major Irrigation distributor area.
PC of Major Irrigation Scheme:	All the Presidents of the DC in a Major Irrigation project area
PC of Medium Irrigation Scheme:	All the Presidents of WUAs in a Medium Irrigation project area.

(h) *Functions of FOs:* The detailed functions and objectives of the FOs is given in Chapter III of the APFMIS Act, 1997. The main functions being:

(i) prepare and implement a Warabandi schedule for each irrigation system consistent with
(ii) the operational plan prepared by the PC or the DC as the case may be;
(iii) prepare a maintenance plan;
(iv) regulate the use of water and promote economy;
(v) assist the Revenue Department in the preparation of demand and collection of water
(vi) rates;
(vii) maintain a register of land holders;
(viii) maintain an inventory of the irrigation system;
(ix) monitor the flow of water for irrigation;
(x) raise resources;
(xi) maintain accounts as prescribed;
(xii) cause audit of accounts & expenditures;
(xiii) encourage avenue plantation along the bunds and irrigation properties;
(xiv) conduct GB meetings;
(xv) conduct water budgeting and social audit;
(xvi) Resolve conflicts and compound offences.

(i) *Constitution of Sub-Committees (SCs):* To carry out all or any of the functions vested with FOs the MC of the FO shall constitute SCs as per Section 11 of APFMIS Act.

The GB of the FO shall constitute the following SCs for the purpose.

(i) Finance & Resources Sub-Committee
(ii) Works Sub-Committee
(iii) Water Management Sub-Committee
(iv) Monitoring, Evaluation and Training Sub-Committee

As per the composition of each SC, the convener of a SC shall be a member of the MC other than the Chairman or President. The convener of Water Management Sub-Committee is Vice Chairman or Vice President of FO. The SC in a WUA shall have members not exceeding four and shall be drawn out of its members who have voting right. In a DC, the members not exceeding four shall be drawn from the TCs of WUAs. In case of PC the members not exceeding four shall be selected from Presidents of WUAs in that project. The SCs shall meet as frequently as necessary and the members of the MC in charge of SCs will preside over the meetings and maintain the record of discussions and decisions. All these SCs shall function under the General Superintendence, Control and Direction of the MC of the FO.

(j) *Resources of the FOs:* The main resources of the WUA shall be the grants given by the Government as a percentage of the water charges collected by the WUA. In addition the WUA has a power to levy a fee under section of 20 of the Act. Other funds as received from the Central Government as management subsidy or calamity relief would contribute to it resources besides resources being raised from the usufruct of the irrigation properties such as auction of usufruct from tree leases and rents on irrigation properties.

(j) *Levy of Fees by the FOs:* The Act empowers FO to levy a fee to achieve the objects of the organization or in performing its functions. All the members are mandated to pay the amounts as decided by the GB of the FO.

(l) *Bank Account to be maintained by a FO:* Every FO shall open a bank account which shall be jointly operated by the Chairman or President and Vice Chairman or Vice President. The account shall be opened in a nationalized bank.

(m) *Competent Authorities of the FOs:* The Government by notification appoint such officer from I & CAD Dept. or any other Department or Corporation including Irrigation Development Corporation, as they consider necessary, to be the Competent Authority (Engineering) with specific functions as prescribed, to every FO for the purpose of this Act. The Government also by notification appoints an officer from the Agriculture Department, to be the Competent Authority (Agriculture) with specific functions as prescribed, to every FO for the purpose of this Act. For strengthening the FOs, the Government may also by notification appoint an officer or officers from any Department or Departments to be the Additional Competent Authority or Authorities for discharging specific functions, as may be prescribed.

(n) *Settlement of Disputes:* Section 26 of the Act provides for the settlement of disputes by the MC of the FO themselves. The MC of the DC shall determine a dispute arising between a member and the MC of the WUA or between two or more WUAs. The MC of the PC shall determine a dispute or difference arising between a member and the MC of a DC or between two or more DCs. The Apex Committee whose decision shall be final shall determine a dispute between a member and the MC of a PC or between two or more PCs.

(o) *Appeals:* With a view to reduce time delay appeals have been provided for to the next higher level whose decision shall be final. Thus the DC shall be the final level for appeal in the case of a WUA and the PC for a DC and the Apex Committee for the PC. The appeal must be preferred within 30 days of the order to the person aggrieved. Every appeal shall be disposed of within 15 days from the date of filing of the appeal.

(p) *Offences and Penalties:* Chapter V of the APFMIS Act, 1997 provides for a comprehensive list of offences and penalties. The offences relate to damaging or obstructing system, interfering with the water supply, corrupts or fouls the water, obstructs or removes any water level marks or measuring devices, violates the Warabandi or the water distribution and regulation schedule made by the WUA or the DC or the PC on conviction shall be punished with imprisonment which may extend up to two years or with fine which may extend to five thousand rupees. The FO under Section 25 of the Act have been given the power to compound the offences with a sum not exceeding Rs. 1000/- (Rupees One thousand only) as compounding fee.

(q) *Maintenance of Registers and Records:* Every FO shall maintain registers and records. This is to systematize the working of the FO. This would also enable them to audit their accounts and also check their own properties.

(i) Ayacut Map

(ii) Property Registers: Inventory Register, Miscellaneous Property Register (Form 1 to 4)

(iii) Membership Records (Form 5)

(iv) Gauge Register (Form 6)

(v) Administrative and Technical Sanction Register (Form 7)
(vi) Cash Book (Form 8)
(vii) Special Fee and other Collection Registers (Form 9)
(viii) Minutes Book (Form 10)
(ix) Receipt Book (Form 11)
(x) Crop Area and Water Tax Register (Form 12)

II. REASONS FOR SUCCESS OF PIM IN AP

The Andhra Pradesh Farmers Management of Irrigation Systems Act, 1997 succeeded to a large extent due to the following reasons:

- Reform friendly governments irrespective of party affiliations
- Strong belief by the government in empowerment of primary stakeholders
- A cadre of committed officers
- Clear operating guidelines
- Constant review and amendments to strengthen the policy
- Continuous financial support
- Institutional building as an integral part
- Field Training Centers (FTCs) for Capacity Building(CB) and institutionalization of CB
- Exposure visits

III. CURRENT AND FUTURE INITIATIVES

- Participatory Action Plan (PAP) exercise is being carried out for the last 6 years through which the understanding and skills of the WUAs is being built in Planning and Execution of activities under PIM.
- Self- Assessment (SA) exercise is taken up for WUAs to mark their progress on various parameters
- Farmers' Field Schools (FFS) are the demonstration areas on–field for farmers to see new initiatives in crop management and use of farm technology including machinery.
- Water Use Efficiency (WUE) studies to show the WUAs how they are managing their water allocations
- 18 FTCs are set up with state funding to provide decentralized capacity building inputs to the WUAs. Each center is staffed with 2 full time professionals- one from Social Sciences background and the other from Engineering background.

Many other ideas are in the pipeline. The Ultimate idea is to equip the WUAs in all aspects so that they can take full control of their water management with the able guidance of the irrigation engineers.

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Development of Spectral Library for Different Crops using Spectroradiometer

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ABSTRACT

Spectroradiometer is an instrument used for determining the radiant energy distribution in a spectrum, combining the functions of a spectroscope with those of radiometer. A Spectroradiometer makes an objective, physical measurement in radiometric units at each wavelength, but this may be converted into a more subjective photometric equivalent which indicates how the radiation is perceived by the eye: its luminous quality. The measured radiation may be expressed in a number of ways, depending upon how the radiation entering the Spectroradiometer is collected, and how it is processed by the system software. The objective of the present study is to develop spectral library for Predominant crops in chevela mandal using Spectroradiometer. The study area considered for the present study covers 36 villages in Chevela mandal, Rangareddy district, Hyderabad. Latitude and longitude of the study area is 17°18′24″N 78°08′07″ E to 17.3067°N 78.1353°E, which covers about 36 villages and 30 panchayats.

***Keywords**:* Spectroradiometer, crops, reflectance, spectral library.

INTRODUCTION

Spectroradiometers are devices designed to measure the spectral power distribution of a source. From the spectral power distribution, the radiometric, photometric, and colorimetric quantities of light can be determined in order to measure, characterize, and calibrate light sources for various applications. Spectroradiometers typically take measurements of spectral irradiance and spectral radiance. Spectroradiometers are stand-alone systems that work independently without the need to be connected to a PC. This makes them highly portable while maintaining the accuracy of a spectrometer. The field of spectroradiometry concerns itself with the measurement of absolute radiometric quantities in narrow wavelength intervals. It is useful to sample the spectrum with narrow bandwidth and wavelength increments because many sources have line structures. Most often in spectroradiometry, spectral irradiance is the desired measurement. In practice, the average spectral irradiance is measured, shown mathematically as the approximation given in equation (1).

$$E(\lambda) = \frac{\Delta\Phi}{\Delta A \Delta\lambda} \qquad \text{…..(1)}$$

Where E is the spectral irradiance, Φ is the radiant flux of the source (SI unit: watt, W) within a wavelength interval $\Delta\lambda$ (SI unit: meter, m), incident on the surface area, A (SI unit: square meter, m²). The SI unit for spectral irradiance is W/m^3. However it is often more useful to measure area in terms of centimeters and wavelength in nanometers, thus submultiples of the SI units of spectral irradiance will be used, for example μ W/cm^2 nm. Spectral irradiance will vary from point to point on the surface in general. In practice, it is important note how radiant flux varies with direction, the size of the solid angle subtended by the source at each point on the surface, and the orientation of the surface.

REVIEW LITERATURE

Randall (2012), Spectroscopy is the study of light that is emitted by or reflected from materials and its variation in energy with wavelength. As applied to the field of optical remote sensing, spectroscopy deals with the spectrum of sunlight that is diffusely reflected (scattered) by materials at the Earth's surface

A ground based hyperspectral analysis is carried out by Adam et al. (2010), 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. For the optimum estimation of the concentration of three biochemical variables in the crop, the coefficient of determination (R^2), root mean square error (RMSE) and relative error of prediction (REP) were calculated to develop a qualitative model. The first derivative reflectance at 759 ηm, 1954 ηm and 2370 ηm were most suitable to develop the estimation model of Nitrogen (N), Crude Fat (EE) and Crude Fiber (CF).

According to Rama Rao (2012), when compared to multispectral remote sensing, a hyperspectral remote sensing system is unique in the large quantity of high spectral resolution data it contains the spectrum of a ground element can have hundreds of reflectance measurements. In sharp contrast to proven methods of multispectral data analysis for material mapping, however, hyperspectral remote sensing data analysis is complicated and is limited by the availability of appropriate methods for efficient analysis. Although there has been substantial progress in data dimensionality reduction and correlation of hyperspectral data with material type, the large quantity of data itself apparently is a deterrent to further progress by remote sensing community. Developed (i) image classification algorithms that are insensitive to the high dimensionality of hyperspectral data based on the information theoretic exploitation of spectral similarity with reference spectra, and (ii) parallel image processing algorithm that take benefit of advanced computing facility such as High Performance Computing (HPS).

Schmidt and Skindmore (2003) used the spectral reflectance measured at canopy level with GER 3700 spectrometer from 27 wetland species to evaluate the potential of mapping coastal salt marsh vegetation associations in the Dutch Wadden zee wet land. It was found that the reflectance in 6 band distributed in the visible, near Infrared & short wave infrared were the optimal bands for mapping salt marsh vegetation.

A ground based hyperspectral analysis is carried out 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. For the optimum estimation of the concentration of three biochemical variables in the crop, the coefficient of determination (R2), root mean square error (RMSE) and relative error of prediction (REP) were calculated to develop a qualitative model. The first derivative reflectance at 759nm, 1954nm and 2370nm were most suitable to develop the estimation model of Nitrogen (N), Crude Fat (EE) and Crude Fiber (CF).

STUDY AREA

Chevela is located 4.8 km distance from its District Main City Rangareddy. It is located 38 km distance from its State Main City Hyderabad. Total population of Chevela Mandal is 55,784 living in 10,765 Houses, Spread across total 36 villages and 30 panchayats. Males are 28,380 and Females are 27,404. Chevela is located at" N $17^{o}18'24"$N to $78^{o}13'53"$E. It has an average elevation of 623 meters (2047 feet). There are 36 villages in this mandal and the villages are: Hasthepur, Nowlaipalle, Anantawaram, Aloor I, Aloor II, Aloor III, Kowkuntla, Tangedapalle, Tallaram, Nyalata, Orella, Yenkepalle, Dearlapalle, Kammeta, Gollapalle, Ravulapalle (Khurd), Mudimyal, Kummera, Devuni erravelly, Ibrahimpalle, Damergidda, Bastepur, Mirjaguda, Kistapur, Nain cheru, Khana pur, Regadghanapur, Devarampalle, Chanvelli, Pamena, Allawada, Chevella, Kesavaram, Malkapur, Kanduwada, and Gundal.

For the purpose of study area extraction, Survey of India topographic map on a scale of 1:25,000 is collected. The collected topographic sheet is scanned and registered with tic points and rectified. The mandal boundary is delineated from topo sheet and the village boundaries are delineated from the BHUVAN site for the study area using the Arc MAP desktop 10.1 version. The study area map has been prepared and shown in Fig. 1.

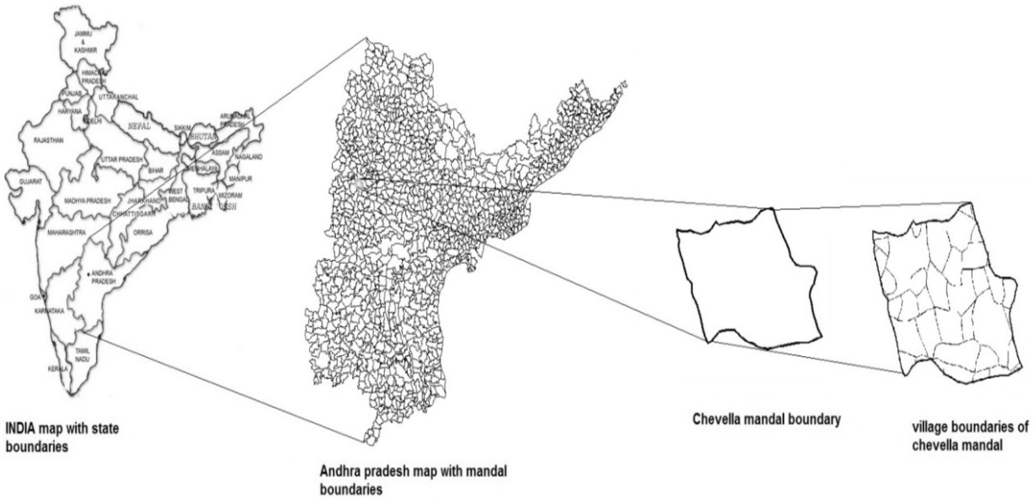

Fig. 1 Village boundaries along with Mandal boundary Study Area Map

METHODOLOGY

The quality of a given spectroradiometric system is a function of its electronics, optical components, software, power supply, and calibration. Under ideal laboratory conditions and with highly trained experts, it is possible to achieve small (a few tenths to a few percent) errors in measurements. However, in many practical situations, there is the likelihood of errors on the order of 10 percent. Several types of error are at play when taking physical measurements. The three basic types of error noted as the limiting factors of accuracy of measurement are random, systematic, and periodic errors.

Random errors are variations about that mean. In the case of spectroradiometric measurements, this could be thought of as noise from the detector, internal electronics, or the light source itself. Errors of this type can be combated by longer integration times or multiple scans.

Systematic errors are offsets to the predicted "correct" value. Systematic errors generally occur due to the human component of these measurements, the device itself, or the setup of the experiment. Things such as calibration errors, stray light, and incorrect settings, are all potential issues.

Periodic errors arise from recurrent periodic or pseudo-periodic events. Variations in temperature, humidity, air-motion, or AC interference could all be categorized as periodic error.

In addition to these generic sources of error, a few of the more specific reasons for error in spectroradiometry include:

- The multidimensionality of the measurement. The output signal is dependent on several factors, including magnitude of measured flux, its direction, its polarization, and its wavelength distribution.
- The inaccuracy of measuring instruments, as well as the standards used to calibrate said instruments, cascaded to create a larger error throughout the entire measurement process, and
- The proprietary techniques for reducing multidimensionality and device instability error.

Gamma-scientific, a California-based manufacturer of light measurement devices, lists seven factors affecting the accuracy and performance of their spectroradiometers, due to either the system calibration, the software and power supply, the optics, or the measurement engine itself.

The essential components of a spectroradiometric system are as follows:

- Input optics that gathers the electromagnetic radiation from the source.
- A monochromator, separating light into its component wavelengths
- A detector
- A control and logging system to define data and store it.

Input optics

The front-end optics of a Spectroradiometer includes the lenses, diffusers, and filters that modify the light as it first enters the system. The material used for these elements determines what type of light is capable of being measured. For example, to take UV measurements, quartz rather than glass lenses, optical fibers, Teflon diffusers, and barium sulphate coated integrating spheres are often used to ensure accurate UV measurement.

Monochromatic

To perform spectral analysis of a source, monochromatic light at every wavelength would be needed to create a spectrum response of the illuminant. A monochromator is used to sample wavelengths from the source and essentially produce a monochromatic signal. It is essentially a variable filter, selectively separating and transmitting a specific wavelength or band of wavelengths from the full spectrum of measured light and excluding any light that falls outside that region. A typical monochromator achieves this through the use of entrance and exit slits, collimating and focus optics, and a wavelength-dispersing element such as a diffraction grating or prism. Modern monochromators are manufactured with diffraction gratings, and diffraction gratings are used almost exclusively in spectroradiometric applications. Diffraction gratings are preferable due to their versatility, low attenuation, extensive wavelength range, lower cost, and more constant dispersion. Single or double monochromators can be used depending on application, with double monochromators generally providing more precision due to the additional dispersion and baffling between gratings.

Detectors

The detector used in a Spectroradiometer is determined by the wavelength over which the light is being measured, as well as the required dynamic range and sensitivity of the measurements. Basic Spectroradiometer detector technologies generally fall into one of three groups: photo emissive detectors (e.g. photomultiplier tubes), semiconductor devices (e.g. silicon), or thermal detectors (e.g. thermopile). The spectral response of a given detector is determined by its core materials. For example, photo cathodes found in photomultiplier tubes can be manufactured from certain elements to be solar-blind – sensitive to UV and non-responsive to light in the visible or IR.

Control and Logging System

The logging system is often simply a personal computer. In initial signal processing, the signal often needs to be amplified and converted for use with the control system. The lines of communication between monochromator, detector output, and computer should be optimized to ensure the desired metrics and features are being used. The commercially available software included with spectroradiometric systems often come stored with useful reference functions for further calculation of measurements, such as CIE color matching functions and the Vλ curve.

Applications

Spectroradiometers are used in many applications, and can be made to meet a wide variety of specifications. Example applications include:

- Solar UV and UVB radiation
- LED measurement
- Display measurement and calibration
- CFL testing
- Remote detection of oil slicks
- Plant research and development

Generation of Spectral library

The spectral library for the absolute crop reflectance is generated by View specpro Software for the crops like chick pea, cow pea, cotton, groundnut, rice, black gram and also for the soil in the field**.**

Absolute Reflectance

The spectral library for the absolute reflectance of the crop was generated by View specpro Software for the different crops like chick pea, cotton, groundnut, rice, black gram and also for the soil in the field. Figure 2,3,4, shows the Spectral library generated for the Absolute Reflectance for the crops Rice, Chick Pea, and Ground nut by View specpro Software.

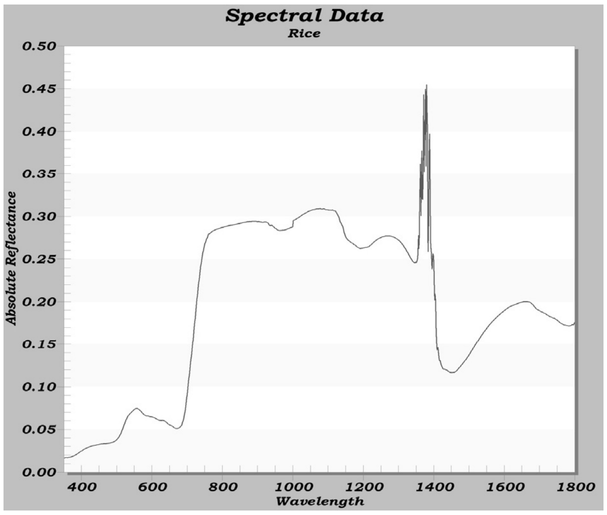

Fig. 2 Spectral library generated for Absolute Reflectance for the crop **Rice** by View specpro Software

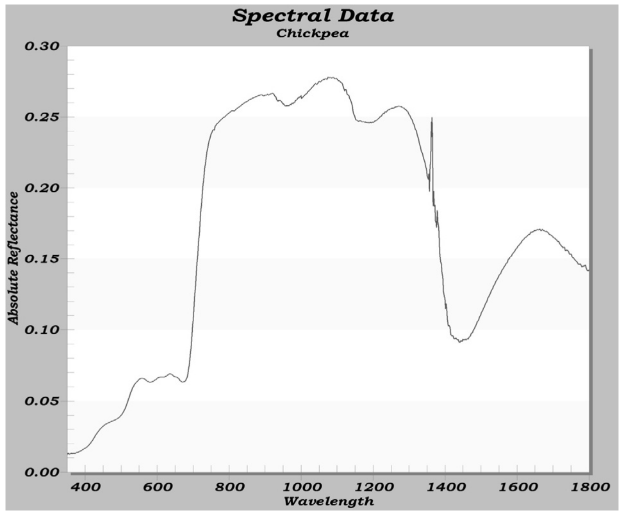

Fig. 3 Spectral library generated for Absolute Reflectance for the crop **Chick pea** by View specpro Software.

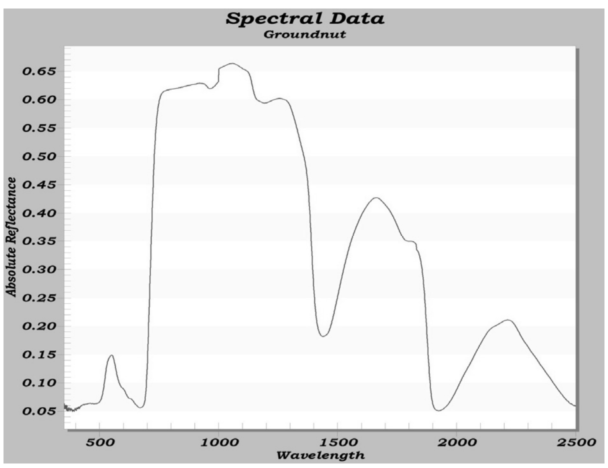

Fig. 4 Spectral library generated for Absolute Reflectance for the crop **Groundnut** by View specpro Software

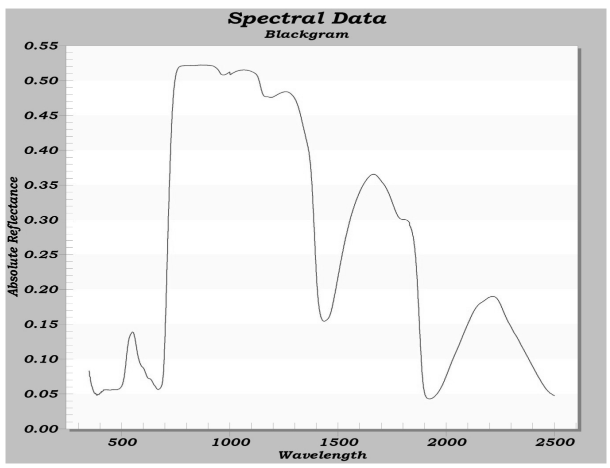

Fig. 5 Spectral library generated for the Absolute Reflectance for the crop **Black gram** by View specpro Software

Figure 2,3,4,5 shows the Spectral library generated for Absolute Reflectance for the crop Rice, Chick pea, Ground nut, Black graml by View specpro Software

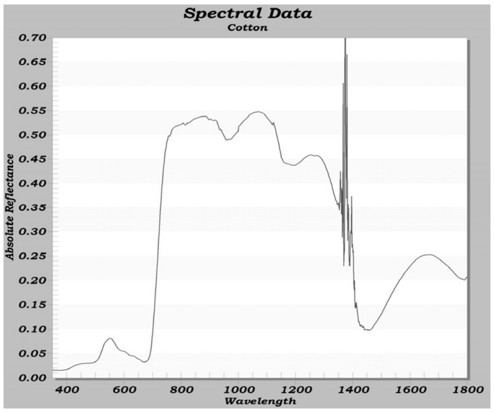

Fig. 6 Spectral library generated for the Absolute Reflectance for the crop **Cotton** by View specpro Software

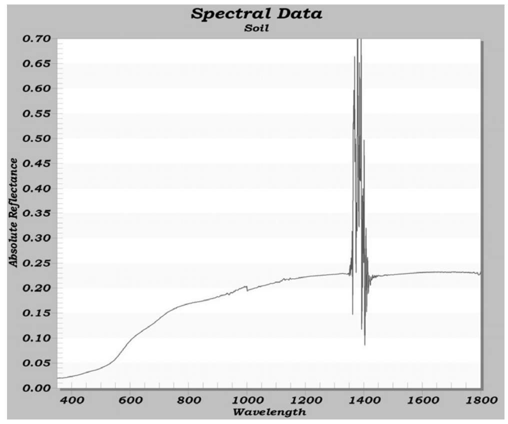

Fig. 7 Spectral library generated for Absolute Reflectance for the **Soil** by View specpro Software

Figure 6, 7 shows the Spectral library generated for Absolute Reflectance for the crop cotton and for Soil by View specpro Software

RESULTS AND CONCLUSIONS

The spectral library for the absolute crop reflectance is generated by View specpro Software for the crops like chick pea, cow pea, cotton, groundnut, rice, black gram and also for the soil in the field**.** The peak reflectance of the crops was found at different wave lengths.

- The maximum absolute reflectance for the crop Rice was found between 800-1400 nm wave length and for the crop chick pea it was found at the same wave length
- The maximum absolute reflectance for the crop Ground nut was found between 850- 1300 nm wave length,
- The maximum absolute reflectance for the crop Black gram was found between 900-1400 nm wave length,
- The maximum absolute reflectance for the crop cotton crop was found between 800-1400 nm wave length.
- The disturbances were found in the soil and the cotton crop.

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Use of Flyash in Vegetable Production and Improvement of Soil Fertility – A Review

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ABSTRACT

Fly ash (FA) – coal combustion of thermal power plants has been regarded as a problematic solid waste all over the world. Disposal of high amount of fly ash from thermal power plants absorbs huge amount of water, energy and land area by ash ponds. Therefore, fly-ash management would remain a great concern of the country. However, several studies proposed that FA can be used as a soil ameliorate that may improve physical, chemical and biological properties of degraded soils and is a source of readily available plant micro and macro nutrients. Practical value of FA in agriculture as an eco-friendly and economic fertilizer or soil amendments can be established after repeated field experiments for each type of soil to confirm its quality and safety. Fly-ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. The high concentration of elements (K, Na, Zn, Ca, Mg and Fe) in fly-ash increases the yield of many agricultural crops. Plant growth and Soil properties as influenced by fly-ash application have been studied by several workers for utilizing this industrial waste as an agronomic amendment.

INTRODUCTION

Fly ash is produced as a result of coal combustion in thermal power station and discharged in ash ponds. Combustion of bituminous and sub-bituminous coal and lignite for generation of electricity in thermal power plants produces solid wastes such as fly ash, bottom ash, boiler slag and Flue Gas Desulphurization (FGD) materials, which are commonly known as coal combustion by-products (CCPs). Now-a-days fly ash (FA) disposal into the environment is one of the major concerns throughout the world mainly in developing countries. Flyash production depends on the quality of the coal, which contain's a relatively high proportion of ash that leads to 10-30% Flyash formation (Singh and Siddiqui, 2003). In India 75% of electricity is generated by coal based thermal power plants, according to the Government of India 112 million tones of this kind of waste is produced in India during 2005-06 of which 4 mt is released into to the atmosphere (Jamwal, 2003). Percentage ash utilization of the total ash generated in different countries amounts to more than 85% in West Germany, 100% in Denmark, 85% in France, 50% in UK, 45% in China and 38% in India. Kalra *et al.* (1997) have reported that FA production in India will exceed 140 million tons by 2020. Nearly 50-60% of the fly ash is being stored at plant dump sites and other sites intended for this purpose. The disposal of such a huge amount of FA is one of the major problems of developing countries and is usually disposed in basin' s or landfills near the power plants. Fly ash is sometimes used in buildings, construction of roads, embankment and cement industries. Its alkaline character and a high concentration of min eral substances have resulted in attempts at using it as fertilizer or amendment to enhance the physicochemical properties of soil. The FA contains a high concentration of toxic heavy metals such as Cu, Zn, Cd, Pb, Ni, Cr etc. (Rautaray *et al.,* 2003) along with low nitrogen and phosphorus content and pH ranged from 4.5 to 12.0 depending on the S-content of parental coal. The current article reviews various application of fly ash in agriculture and deriving agronomic benefits.

Effect of Flyash on Physical Properties of Soil

Fly-ash application to sandy soil could permanently alter soil texture, increase microporosity and improve the water-holding capacity (Ghodrati *et al.,* 1995; Page *et al.,* 1979). Fly-ash addition at 70 t ha^{-1} has been reported to alter the texture of sandy and clayey soil to loamy (Capp, 1978). Addition of fly-ash at 200 t $acre^{-1}$ improved the physical properties of soil and shifted the USDA textural class of the refuge from sandy loam to silt loam (Buck *et al.,* 1990). Application of fly-ash at 0, 5, 10 and 15% by weight in clay soil significantly reduced the bulk density and improved the soil structure, which in turn improves porosity, workability, root penetration and moisture-retention capacity of the soil (Kene *et al.,* 1991). Prabakar *et al.* (2004) concluded that addition of fly-ash up to 46% reduced the dry density of the soil in the order of 15-20% due to the low specific gravity and unit weight of soil. A gradual increase in fly-ash concentration in the normal field soil (0, 10, 20 up to 100% v/v) was reported to increase the porosity and water-holding capacity (Khan and Khan, 1996). This improvement in water-holding capacity is beneficial for the growth of plants especially under ram fed agriculture. Amendment with fly-ash up to 40% also increased soil porosity from 43 to 53% and water-holding capacity from 39 to 55% (Singh *et al.,* 1997). The Ca in fly-ash readily replaces Na at clay exchange sites and thereby enhances flocculation of soil clay particles, keeps the soils friable, enhances water penetration and allows roots to penetrate compact soil layers (Jala and Goyal, 2006).

Effect of Flyash on Chemical Characteristics of Soil

Lime in flyash (FA) readily reacts with acidic components in soil and releases nutrients such as S, B and Mo in the form and amount beneficial to crop plants. FA improves the nutrient status of soil (Rautaray *et al.,* 2003). The FA has been used for correction of sulphur and boron deficiency in acid soils (Chang *et al.,* 1977). Application of fly ash increases the pH of acidic soils (Phung *et al.,* 1979). Most of the fly-ash produced in India is alkaline in nature; hence, its application to agricultural soils could increase the soil pH and thereby neutralize acidic soils (Phung *et al.,* 1978). Fly-ash has been shown to act as a liming material to neutralize soil acidity and provide plant-available nutrients (Taylor and Schumann, 1988). Researchers have shown that the use of fly-ash as liming agent in acid soils may improve soil properties and increase crop yield (Matsi and Keramidas, 1999). Sarangi *et al.* (2001) observed that gradual increases in soil pH, conductivity, available phosphorus, organic carbon and organic matter with in creased application rate of fly ash.

Effect of Flyash on Biological Properties of Soil

Numerous studies found that the addition of unweathered FA to sandy soils severely inhibited microbial respiration, numbers, size, enzyme activity and soil nitrogen cycling processes such as nitrification and N mineralization (Garau *et al.,* 1 991). These adverse effects were partly due to the presence of excessive levels of soluble salts and trace elements in unweathered fly-ash. However, the concentration of soluble salts and other trace elements was found to decrease due to weathering of fly-ash during natural leaching, thereby reducing the detrimental effects over time (Sims *et al.,* 1995). The application of lignite fly-ash reduced the growth of seven soil borne pathogenic microorganisms, whereas the population of *Rhizobium* sp. and P-solubilizing bacteria were increased under the soil amended with either farmyard manure or fly-ash individually or in combination. Garampalli *et al.* (2005) revealed on the basis of pot-culture experiment that using sterile, phosphorus-deficient soil to study the effect of FA at three different concentrations viz., 10, 20 and 30 g FA kg^{-1} soil on the in fectivity and effectiveness of vesicular arbuscular mycon hiza (VAM) Glomus aggregatum in pigeonpea *(Cajanus cajan* L.) cv. Maruti. Sarangi *et al.* (2001) reported that invertase, amylase, dehydrogenase and protease activity increased with increasing application of flyash up to 15 t ha y^{-1}, but decreased with higher levels of flyash application. The available phosphorus estimation of soil receiving fly ash at varying rates of 0-80 t ha^{-1} showed higher availability of this element compared to control (no fly ash). Both 40 and 60 t ha^{-1} of fly ash resulted in the same status of soil available P.

Use of Flyash in vegetable production

Agricultural utilization of fly ash has been proposed because of its considerable content of K, Ca, Mg, S and P (Kalra *et al.,* 1997; Singh *et al.,* 1997). Fly ash addition generally increases plant growth and nutrient uptake (Aitken *et al.,* 1984). Addition of unweathered western US fly ash up to 8% (w/w) to either calcareous or acidic soils resulted in higher yield of several agronomic crops (Page *et al.,* 1979) mainly due to in creased availability of S to plants. Furr *et al.* (1977) demonstrated that carrots *(Daucas carota),* onion *(Allium cepa),* beans *(Phaseolus vulgaris),* cabbage *(Brassica oleracea),* potatoes *(Solanum tuberosum)* and tomatoes *(Lycopersicon esculentum)* could be grown on a slightly acidic soil (pH 6.0) treated with 125 mt ha^{-1} of unweathered fly ash. These plants exhibited higher contents of As, B, Mg and Se. Khan and Khan (1 996) reported that application at 40% fly ash can increase the yield of tomato by 81% and market value (mean fruit weight). Increased selenium accumulation in plant tissues with increased fly ash application warrants close monitoring and use of appropriate quantity of weathered fly ash depending upon the end use of the produced biomass (Straughan *et al.,* 1978). Lau and Wong (2001) reported that weathered coal fly ash at 5% resulted in higher seed germination rate and root length of lettuce *(Lactuca sativa).* The amino acid content in soybean *(Glycine max)* was found to show an in crease when grown in fly ash amended soils in pot cultures (Goyal *et al.,* 2002). Fly ash applied at 25% showed higher yield of brinj al *(Solanum melongena),* tomato and cabbage. The level of 40% fly ash was found to have nematicidal effect and was suggested for the management of root knot disease in tomato caused by *Meloidogyne* sp. and providing nutrients (Khan *et al.,* 1997). Tomato cultivars grown on fly ash amended soils had higher tolerance to wilt fungus *Fusarium oxysporum* (Khan and Singh, 2001).

However, some harmful effects were also reported by earlier studies *viz*., reduction in bioavailability of some nutrients due to pH (from 8 to 12), high salinity, high content of phytotoxic elements, especially boron.

But the ultimate goal would be utilize FA in degraded/marginal soils to such an extent as to achieve enhanced fertility without affecting the soil quality and minimizing the accumulation of toxic metals in plants below critical levels for human health.

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Integrated Watershed Management by using Remote Sensing and Geographical Information System: A Case Study

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ABSTRACT

The Indian economy is largely rural, hence the development of rural areas depends upon the optimum management of natural resources particularly the Water resources. A Drainage basin (or) Watershed can be considered as a preferable unit for initiating water conservation and management practices .Watershed management is an integration of technology within the natural boundaries of a drainage basin for land, hydrological, biotic and vegetative resources development to fulfill the population needs on sustainable basis. The study deals with the Integrated watershed management of Parvathagiri mandal which is located in Warangal district of the Andhra Pradesh. The study area extends between 79^{o} 30' E and 17^{o} 30' N and 79^{o} 50' E and 17^{o} 50' N. Toposheets numbers are 56O/9SE, 56O/10NE, 56O/13SW & 56O/14NW on 1:25,000 scale provides the physiographic coverage of the study area. Total extent of the study area is 162 sq. kms.

In this study, the Akeru river basin area of Parvathagiri mandal in Warangal district having selected for detailed morphometric analysis. The study performed manual and computerized delineation and drainage sampling, which enables applying detailed morphological measures. Topographic maps in combination with remotely sensed data, were utilized to delineate the existing drainage system, thus to identify precisely water divides. This was achieved using Geographic Information System (GIS) to provide computerized data that can be manipulated for different calculations for morphometric analysis. The obtained morphometric analysis in this study tackled: 1) stream behavior, 2) morphometric setting of streams within the drainage system and 3) interrelation between connected streams. The advanced application of Remote Sensing (RS) and Geographical Information System (GIS) techniques has lead to estimation of morphometric analysis based on different parameters. Topographical map and IRS LISS-III satellite image are used for preparing different thematic maps using ARCGIS9.2 and Erdas imagine 9.1 software.

1.0 INTRODUCTION

Rainfall is nature’s gift to man to live and grow his food. It is the essential source of income for the life in a Watershed area to survive. Every Watershed is a family by itself as the incoming Water and outgoing water can be balanced and budgeted. Hence, the rainfall, runoff recharge, evaporation, transpiration, interception and surface storage is from a single unit. Watershed is a geo-hydrological unit draining run-off water at a common point. It could be demarcated based on ridge and gully lines. In other words, watershed is an area demarcated based through water divides line separating one drainage basin from another. The micro-watershed is the base for management and planning. Morphometry is defined as the measurement of the shape. Morph metric studies in the field of hydrology were first initiated by Horton (1940) and Strahler (1950). The morphometric analysis of the drainage basin and channel network play a vital role for understanding the geo-hydrological behavior of drainage basin and expresses the prevailing climate, geology, geomorphology, structural, etc. antecedents of the catchment.

1.1 Remote Sensing and GIS Advances in Watershed Management

Since the modest beginning of surface water inventory the remote sensing application scenario has witnessed a phase transition from resource mapping to decision-making. . High resolution and near infrared sensors such as those on IRS can be used to measure the extent of surface water because of strong near infrared contacts between water and adjacent land. Knowledge of watershed land use is important because a record of surface cover characteristics can be used to refine estimates of the quantity, quality and timing of water yield in response to a particular precipitation event or watershed treatment. Physiographic observations such as basin area and shape, stream network organization, drainage density and pattern and specific channel characteristics can enable an investigator to estimate the mean annual discharge and mean annual flood flows from a watershed, as well as the rapidity of watershed response to a particular rainfall event. A GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system. The power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship. A GIS, therefore, can reveal important new information that leads to better decision making. A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use.

1.2 Objectives of the Present Work

To study the Morphometric Parameters such as Drainage Density, Stream Frequency, Texture Ratio, Basin Length, Elongation Ratio, Circulation Ratio and Form Factor Ratio. To calculate the run-off, sediment yield, vegetative cover factor, annual rainfall and mean temperature.

1.3 Study Area

1.3.1 Location

Parvathagiri Mandal is part of Warangal District, Telangana which extends between 79^{o} 30' E and 17^{o} 30' N and 79^{o} 50' E and 17^{o} 50' N latitude. It has a total area of 162 sq. km. Parvathagiri Comprises of 13 revenue villages, 19 Gram Panchayats and 38 habitations. There are no towns in this Mandal. The Akeru river flowing through the Parvathagiri mandal and forms almost a plain boundary except for a few hill rocks to the North and west. These hills rise 213 to 350 meters above the general level of the boundary. The general slope is from north to south, there is a nearly level is seen on the basin.

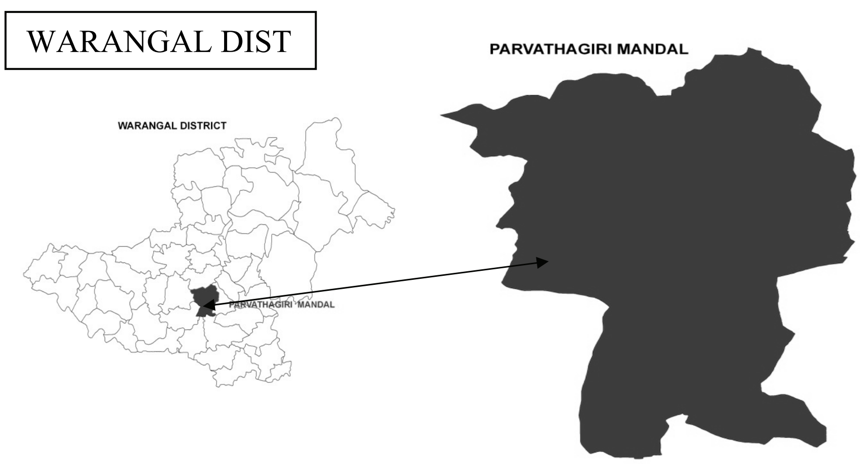

Fig. 1 Location Map of the Study Area

1.3.2 Rainfall

The rainfall is the source of all water in the form of rain. The study area mainly experiences the south west monsoon. The southwest monsoon sets by middle of June**.** The Area receives an average of **874** mm of rain fall for the year 2011-12.

1.3.3 Cropping pattern

Farmers diversify their cropping pattern through number of crops through two seasons main rainy season (kharif), post rainy season (rabi).The main cropping of the study area is cotton, groundnuts, maize, fruits and vegetables in few hectares.

1.3.4 Soils

The study area consists of red soil and light black soils having the fertility varying from good to poor.

1.3.5 Demography

An increase of about 500 households (or 2500 people) has been recorded over the last 10 years in the mandal. SC/ST's make about 40% of the total population of the area. The main livelihood in the area is agriculture. The average per capita availability of land is 0.35 ha.

2.0 LITERATURE REVIEW

Literature is collected from the previous works done on Integrated watershed management, GIS and RS for land and water resource Management, Morphometric analysis, computation of sediment yield and concepts of Remote sensing , GIS , soil erosion and Rain fall runoff measures and is presented here. Padmaja Vuppala, et.al applied "Remote sensing and GIS for land and Water resource management". The primary focus is on Rachel mandal of prakasam district for developing methodology for use of GIS for the management of land and water resources.IRS 1D LISS III geocoded FCC'S on 1:50,000 scale and other collateral data were used in this study for extracting thematic information such as soil, land use/land cover and hydro geomorphology etc., of the study area slope was prepared using SOI topographic maps on 1:50000 scale.

Bhagavan and Raghu (2002) studied integrated watershed management using Remote sensing techniques" Under these project 193 watersheds are selected in 19 districts of Andhra Pradesh. Indian Remote sensing satellite sensors of LISS-III & PAN merged data was used for generation of natural resource information on 1:25000 scale. Pandit et.al (1999) applied "remote sensing and GIS for integrated watershed development" of watersheds in the Nasik district, Maharashtra, India. He prepared the action plans for development of Nasik district, Maharashtra, India. He prepared the action plans for development of Nasik area by using remote sensing satellite data in connection with the other conventional and socioeconomic data to meet the demand of present local population as well as to achieve the sustainable development. Nageswara Rao.K , Swarna Latha.P et al.(2010) have extensively studied on "Morphometric Analysis of Gostani River Basin in Andhra Pradesh State, India Using Spatial Information Technology" Spatial information technology (SIT) i.e. remote sensing (RS), geographical information system (GIS) and global positioning system (GPS) has proved to be an efficient tool in delineation of drainage pattern and water resources management and its planning.

Kuldeep Pareta, Upasana Paret et al. (2011) have studied on "Quantitative Morphometric Analysis of a Watershed of Yamuna Basin, India using ASTER (DEM) Data and GIS". In this paper, an attempt has been made to study the detail morphometric characteristics of Karawan watershed in Dhasan basin, which itself is part of the mega Yamuna basin in Sagar district, Madhya Pradesh. Mahadevaswamy.G, Nagaraju.D et al. (2011) have extensively studied on "Morphometric analysis of Nanjangud taluk, Mysore District, Karnataka, India, using GIS Techniques" An attempt has been made to study drainage morphometry and its influence on hydrology of Nanjanagud taluk. Geographical information system was used in evaluation of linear, areal and relief aspects of Morphometric parameters.

3.0 METHODOLOGY

The methodology includes preparation of Thematic maps like Base map, Drainage and watershed boundary, contour map, slope map, land use/land cover map and to calculate the Morphometric Parameters such as Drainage Density, Stream Frequency, Texture Ratio, Basin Length, Elongation Ratio, Circulation Ratio and Form Factor Ratio. To calculate the run-off, sediment yield, vegetative cover factor, annual rainfall and mean temperature.

3.1 Collection of Rainfall data

Table 1 Rainfall data of Study Area (2002-2011)

Year	Rain fall (cm)
2002	99.3
2003	65.0
2004	102.8
2005	69.6
2006	76.1
2007	72.3
2008	100.0
2009	102.8
2010	90.0
2011	96.0
Average	**87.39**

(Source : Warangal weather station)

3.2 Thematic Maps

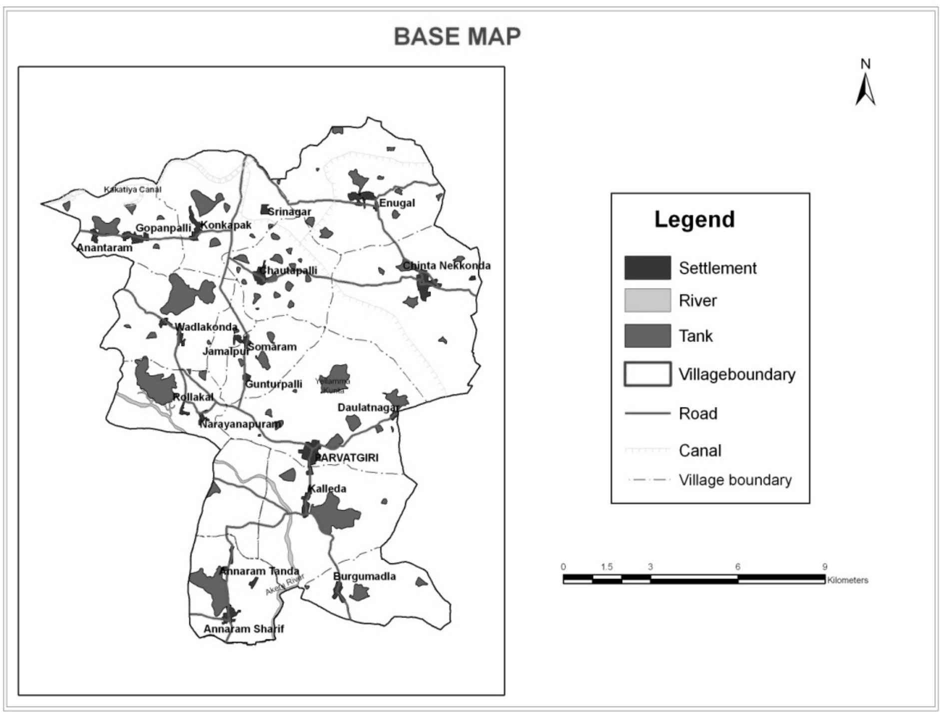

Fig. 2 Base map of the Parvathagiri mandal

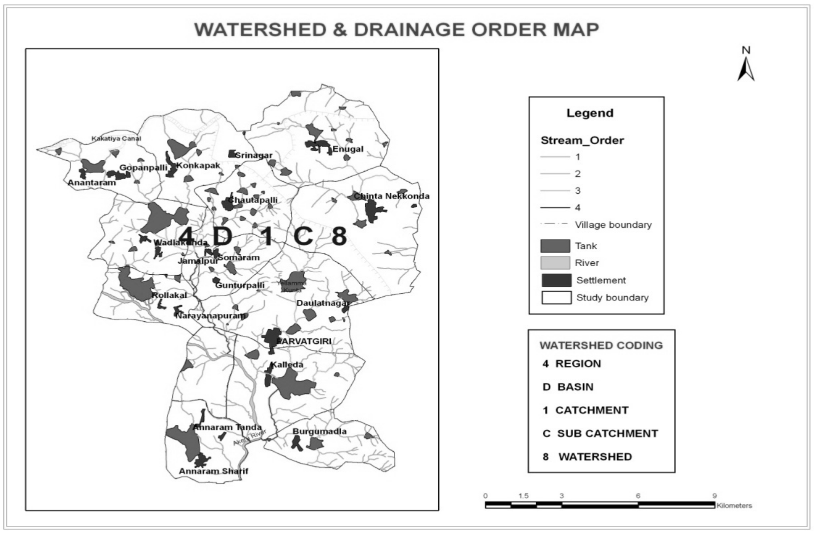

Fig. 3 Drainage pattern and their order identified from the Parvathagiri mandal

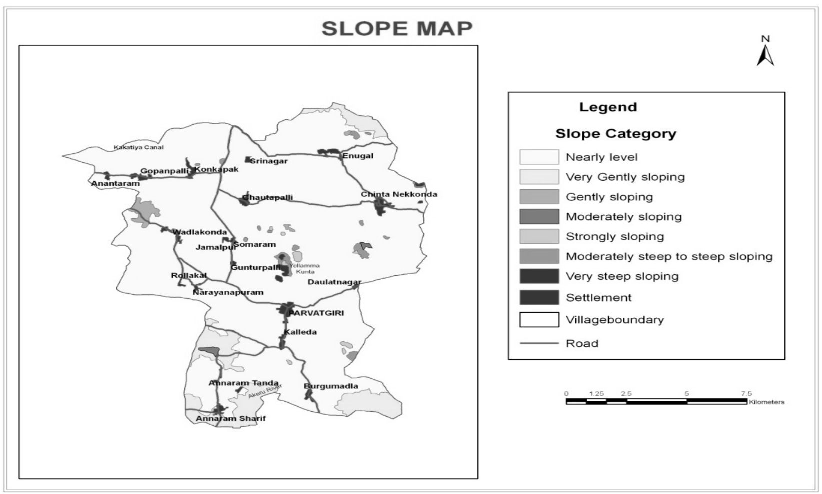

Fig. 4 Slope map of Parvathagiri mandal

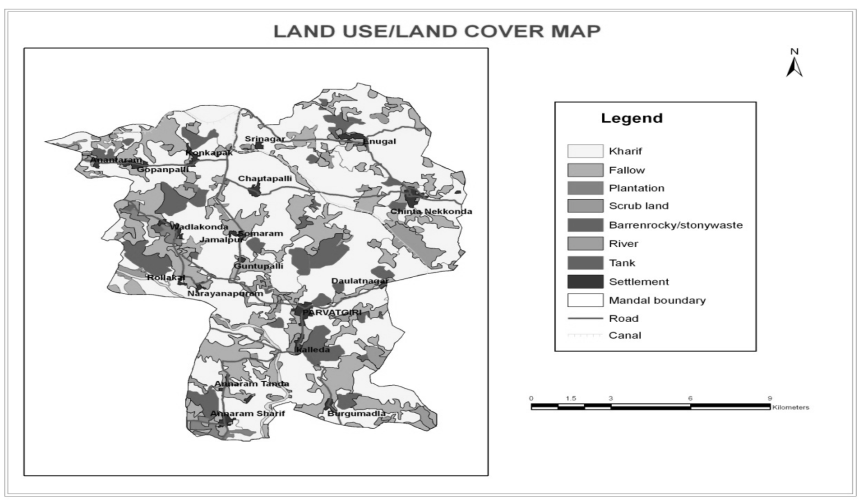

Fig. 5 Land use/Land cover map of Parvathagiri mandal

3.3 Results and Analysis

An attempt has been made to utilize the interpretative techniques of GIS to find out the relationships between the morphometric parameters at a basin level. The drainage have been delineated using IRS LISS-III satellite data on 1:25,000 scale and SOI toposheets have been used as a reference. Based on the All India Land use organization norms and standards. The associated drainage networks were digitized using Arc GIS and the stream orders were calculated using the method proposed by Strahler (1964). The morphometric parameters of the basin are given in Tables 2 and 3. The linear parameters analyzed include stream order, stream length, stream length ratio and bifurcation ratio. Based on drainage orders, the present study area has been classified as fourth order and the drainage pattern is mostly dendritic type. The number of stream orders has been counted and total length of each order streams has been calculated at basin level with the help of GIS software. All aerial parameters, drainage map with study area have been prepared with the help of ERDAS and Arc GIS software

Table 2 Linear Aspects of the Drainage Network of the Study Area

River Basin	Stream Order u	Number of streams	Total Length of Stream in km	Log N_u	Log L_u
Akeru	1	328	159.180	2.515	2.202
	2	82	53.813	1.913	1.731
	3	19	16.893	1.278	1.228
	4	2	90.26	0.301	1.95

Bifurcation Ratio			Mean Bifurcation Ratio
1^{st} order / 2^{nd} order	2^{nd} order/ 3^{rd} order	3^{rd} order /4^{th} order	
4.0	4.316	9.5	5.94

Table 3 Aerial aspects of the study area

Morphometric Parameters	Symbol / Formula	
Area (sq. km)	A	162
Perimeter (km)	P	72.667
Drainage Density (km/sq.km)	$D = \frac{Lu}{A}$	320.146/162 = 1.976
Stream frequency (sq. km)	$F_s = \frac{NU}{A}$	431/162 =2.66
Texture ratio	$T = \frac{N1}{P}$	8.36
Basin length (km)	L_b	72.67
Elongation ratio	$R_e = \frac{2\sqrt{A/\pi}}{Lb}$	0.197
Circularity ratio	$R_c = \frac{4\Pi A}{P2}$	0.385
Form factor ratio	$R_f = A/L^2_b$	0.031

3.3.1 Vegetative cover factor

Vegetative cover factor is determined from the land use/land cover map. It is one of the parameters used for the computation of sediment yield. Vegetative cover factor is inversely proportional to the sediment yield. The vegetative cover factor is given by

$$FC = \frac{0.2F1 + 0.2F2 + 0.6F3 + 0.8F4 + F5}{F1 + F2 + F3 + F4 + F5}$$

Where

F1 = Reserve & protected forest area = nil

F2 = Unclassified forest area = nil

F3 = Cultivated area = 97.65 sq.km

F4 = Grass &pasture land = nil

F5 = waste land = 32.182 sq km

$$FC = \frac{0.2(0) + 0.2(0) + 0.6(97.65) + 0.8(0) + 32.182}{0 + 0 + 97.65 + 0 + 32.182} = 0.69$$

3.3.2 Computation of Runoff

The runoff formula developed by Garde et al (1985) is used in the present thesis. Runoff obtained by this formula is accurate and reliable for estimation of sediment yield using remote sensing techniques. The parameters involved in the computation of runoff are annual rainfall, mean temperature and vegetative cover factor. The Garde formula for runoff is

$$\text{Run off }(Q) = \frac{Fc^{0.49} \times (Pm - 0.5\,Tm)^{1.59}}{26.5}$$

where

FC => Vegetative cover factor

Pm => Annual Precipitation

Tm => Mean temperature (°C)

Q => Runoff in Mm^3

3.3.3 Annual rainfall

Monthly normal rainfall data at Warangal weather station for a period of 10 years (2002-2011) is collected and calculated. The average annual rainfall of Parvathagiri mandal is 87.39cm.

3.3.4 Mean temperature

The temperature data recorded at warangal weather station. The average of mean monthly max-min temperature for 10 years is collected. The normal mean annual max-min temperature of Parvathagiri mandal for the last 10 years as shown in the following Table 4.

Table 4 Temperature data of study Area (2002-2011)

Year	Max.temp (°C)	Min. temp (°C)	Mean temp (°C)
2002	40.28	20.26	30.27
2003	42.10	20.50	31.30
2004	43.03	20.39	31.71
2005	44.11	20.19	32.15
2006	42.58	20.84	31.71
2007	42.33	19.88	31.11
2008	41.76	20.85	31.30
2009	41.38	20.65	31.02
2010	42.00	19.83	30.92
2011	44.98	19.99	32.49

Mean Annual temperature of Parvathagiri mandal = 31.398(°C)

$$\text{Run off (Q)} = \frac{Fc^{0.49} \times (Pm - 0.5\,Tm)^{1.59}}{26.5}$$

Where,

FC	=>	Vegetative cover factor	=	0.69
Pm	=>	Annual Precipitation	=	87.39cm
Tm	=>	Mean temperature (°C)	=	31.398°C
Q	=>	Runoff in Mm^3	=	………

$$\text{Annual Run off (Q)} = \frac{0.64^{0.49}(87.39 - 0.5 \times 31.398)^{1.59}}{26.5} = 27.03\ Mm^2$$

3.3.5 Estimation of Sediment Yield

In this study Sediment yield is obtained by using Garde's equation.

The Garde equation for the computation of sediment yield is

$$Vs = 1.182 \times 10^{-6} \times A^{1.03} \times P^{1.29} \times Q^{0.29} \times S^{0.08} \times Dd^{0.4} \times Fc^{2.42} \quad \text{…..(1)}$$

$$Vs = 1.067 \times 10^{-6} \times A^{1.29} \times P^{1.38} \times S^{0.13} \times Dd^{0.4} \times Fc^{2.51} \quad \text{…..(2)}$$

Where,

A = Watershed area = 162 Sq.Km

P = Annual Rainfall (cm) = 87.39

Q = Annual runoff (km^3) = 27.03

D = Drainage density (km^{-1}) = 1.976

Fc = Vegetative cover factor = 0.69

Sediment yield from the Parvathagiri mandal

$$= 1.182 \times 10^{-6} \times A^{1.03} \times P^{1.29} \times Q^{0.29} \times S^{0.08} \times Dd^{0.4} \times Fc^{2.42}$$

$$= 1.182 \times 10^{-6} \times 162^{1.03} \times 87.39^{1.29} \times 27.03^{0.29} \times 0.07^{0.08} \times 1.976^{0.4} \times 0.69^{2.42}$$

$$\text{Rate of sediment yield} = \frac{V_s}{A} = \frac{0.0778}{162} = 4.8 \times 10^{-0.4}$$

4. SUMMARY AND CONCLUSIONS

4.1 Summary

The present study is mainly based on the integrated approach, in which the problem of sedimentation because of soil erosion is a focal theme. In order to implement this approach, the input data is derived P6 IRS 1C satellite imagery, the estimation of runoff potential and sedimentation yield and the analysis of socio-economic data. IRS 1C false color composite, Survey of India Toposheets, Socio-economic survey, recorded data from weather station is the major sources for the data used. The result are derived from thematic mapping in the form of different layers of Land use/land cover, slope map, drainage map of the study area are integrated with the estimated sediment yield in accordance with socio-economic data using ARC/GIS 9.2 package.

1. Parvatigiri Mandal, located in Warangal Dist. Consists of Hills to an extent of 209 ha (1.29%). Pediments with 4415 ha (27.25%), flood plains with 1110 ha (6.85%).

2. The rainfall of the area is not consistent but found varying between 99.3cm to 102.8 cm for parvathigirimandal for 10 years. The mean annual rainfall of the watershed works out to 87.39cm.
3. The agriculture area accounts for 97.65% to the total Parvathagiri mandal. Major crop Practices in this watershed area are cotton, groundnuts, maize, greengram, fresh fruits, mangoes, vegetables, etc.
4. The annual run-off of the study area is 27.03mm^2 . In this study, the computations of sediment yield are 0.0778 which is calculated from grades equation. So, the rate of sediment is estimated for the study area is $4.8x10^{-4}$.
5. Based on the land use/land cover map the area covered by built-up lands is 325ha, the agricultural land occupies 13265ha, agriculture plantation 198ha, waste lands 1099ha, and water bodies 1313 ha.
6. Based on the slope map, the slope of the study area covers all types of slope classes 1,2 3,4,5,6 and 7. The study area forms almost plain boundary except for a few hill rocks to the north and west. These hills rises 213 to 350 meters above the general level of the boundary. The hills are bare and stand out prominently in the flat stretch of the boundary. The general slope is from north to south, there is nearly level is seen on the basin

4.2 Conclusions and Recommendations

1. GIS and RS prove to be very comprehensive in the study of large areas like watershed where integrated and simultaneous activities have to be executed. Water has to be preserved. Water preservation will remain incomplete if the preventive measures are not taken. so, RS and GIS techniques should be explored and implemented appropriately. The natural resources are our common property so we should brainstorm and work hand in hand towards their conservation and preservation.
2. Watershed is a basic unit for Morphometric Analysis. RS and GIS have proved to be efficient tool in drainage delineation and updating in the present study and these updated drainage have been used for Morphometric analysis.

   The Morphometric analysis of the study area exhibits the radial of dendritic drainage pattern and the variation in stream length ratio might be due to changes on slope and topography. The variation of bifurcation ratio is described to difference in topography and geometric development. There is a need for comparative evolution of Morphometric parameters, their control and influence on rainfall-runoff relation and behavior of stream flow.
3. As per study according to GEC report 2008-09 Andhra Pradesh, the ground water utilization in non command areas of Parvathagiri is around 110% which places the region in “over exploited” list. One of the major findings was that the heavy losses incurred by the farmers are due to the failure of the existing tube wells and unsuccessfully drilling new tube well. So to avoid these things the study area requires a watershed development program. As the government schemes take too much time in getting implemented due to some reasons, we have to give more stress on collective efforts of local people by demonstrating the same to them. System Management, Team work, Appreciation of new ideas through simple, respect for good old economical methods though elementary and understanding the value of hard work and integrated approach leads certainly to a great success in watershed management.
4. Finally in watershed development plan check dam, percolation tanks and Water Treatment plants are recommended to regulate the surface water flow thereby increasing its influence over the command area and the ground water levels. The suitable sites for the construction of percolation tank, check dam, water treatment plants are suggested.
5. The public private partnership will be a good development scheme which makes our villages a sweet fruit of progress.
6. By having an overview of above all it is evident that this study area has got lot of potentialities for development both under rain fed and irrigated zones by following proper measures suggested accordingly. So, a planned management based on these scientific facts with little care can have over all development of the watershed.

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