ISSN Application No. 21796

Journal of Geotechnical And Geo Computational Engineering

Volume No. 12

Issue No. 2

May - August 2024

ENRICHED PUBLICATIONS PVT.LTD

JE - 18,Gupta Colony, Khirki Extn,
Malviya Nagar, New Delhi - 110017.
E- Mail: info@enrichedpublication.com
Phone :- +91-8877340707

ISSN Application No. 21796

Journal of Geotechnical And Geo Computational Engineering

Aims and Scope

The Journal of Geotechnical and Geo Computational Engineering aims at opening an easy access to the valuable source of information and providing an excellent publication channel for the global community of researchers /scholars/phd guides and phd pursuing students and others in the civil engineering subjects and especially geotechnology and its applications.

Typical subjects covered by this journal include:

- Computational and Theoretical Geomechnics
- Foundations
- Tunneling
- Earth Structures
- Site Characterization
- Soil-Structure Interactions

ISSN Application No. 21796

Journal of Geotechnical And Geo Computational Engineering

ISSN Application No. 21796

Journal of Geotechnical And Geo Computational Engineering

(Volume No. 12, Issue No. 2, May - August 2024)

Contents

Modeling Of The Specific Sedimentation And Erosion Rate In Semirom Watershed Using EPM Model And Geography Information System (GIS)

Milad.Bahramian[1] , S.Hamid.Ghaemmaghami[2]

[1] M.Sc. of RS and GIS, Civil Engineering college, GIS&RS Department, Yazd Branch, Islamic Azad University, Hesabi Blv, Safaeie, Yazd, Iran.

[2] M.Sc. of Agronomy, agriculture Engineering college, Agronomy Department, Isfahan Branch, Isfahan University of Technology.

ABSTRACT

Soil erosion in watershed of dams in country causes sediment accumulation inside the lake of dams and it will result in early entropy of these important economic sources. This study aims to closely analyze the situation of erosion and sedimentation and their reasons in Smirom watershed hydrological unit via EPM model in order to be used in preparation of soil conservation patterns and watershed management. Most of the stones in this place were schist and it was around Zagros. There are many layers in EPM model and the map of erosion rate and sedimentation must be prepared, by them so it is necessary to overlap these layers together. Mapping was accomplished by GIS software. After perpering of raster from vector maps , watershederosion coefficient (Ø), land use coefficient (Xa), soil and stone sensitive coefficient to erosion (Y), gradient map and at last rate of soil erosion map (Z), were obtained . This map represents the value of EPM model distributively. From this map, Wsp map is prepared that shows us specific erosion based on cubic meter in year. Regarding the results, the most specific sediment is in the west part of watershed and the least is in the north and east. The reason is lithological changes and steep slope in west part of watershed.

Keywords: soil erosion, EPM model, rate of soil erosion, Wsp.

1. INTRODUCTION

Food is necessary for human to survive which is provided by water and soil sources. A factor which hazards the water and soil sources is erosion (Refahi, h2006). Although erosion and its bad effects are not probably considerable , they will beconsidered during a long time because erosion usually causes loss in crop . In sedimentary basin especially upon the levels of producing and carrying of sediments and data to be studied , we need a tool to accelerate the executive stages of models easily , precisely and quickly. To do so the variety of models are used such as Pacific Southwest Inter Agency Committee

(PSIAC) , Universal Soil Loss Equation (USIE) , Water Erosion Prediction Project (WEPP) and Erosion Potential Method (EPM). Geography Information System (GIS) Technology is used to do such studies with less costs and highest precision andrate due to its high capacity for work on geographical data. In fact , considering such an aim , it will be accomplished all the stages of utilizing the models by GIS (Tangestni 2006, Solaimani et all 2009 , Bayat et all 2000) . The study aims to identify precisely erosion states and sediment production in watershed in order to be used in preparation of soil conversation patterns and watershed management . The objective in the project is to determine erosion and sedimentation levels in Semirom subbasin and the effective factors on them .

MATERIAL AND METHOD

STUDED AREA

Semirom has 9 big and major subbasins. Semirom central part called basin is located 51030' , 21042' longitude and 310 21' , 310 27' latitude . The area is 1000 Hectares with average height on 2597.28m. The basin is extended to Behrooz maintain chains in North , Bastegan maintain in south , chanbareh & kateh Gabry mountains in west and shah Jafar mountain in east .It is located on thrust Zagros tectonic zone andSanandaj-Sirjan . The stones in basin are sedimentary and most are related to both shale and marl (Kshgu) Dolomite and lime (Edlsh). Shale and marl units are extended to south basin introduced as Gurpy formation equivalent. It includes about 25%of basin area . Dolomite and lime units are reached to west basin including dolomite and white marl lime stones introduced as Shahbazan formation equivalent in Eocen age. It includes about 13/5% of basin area.

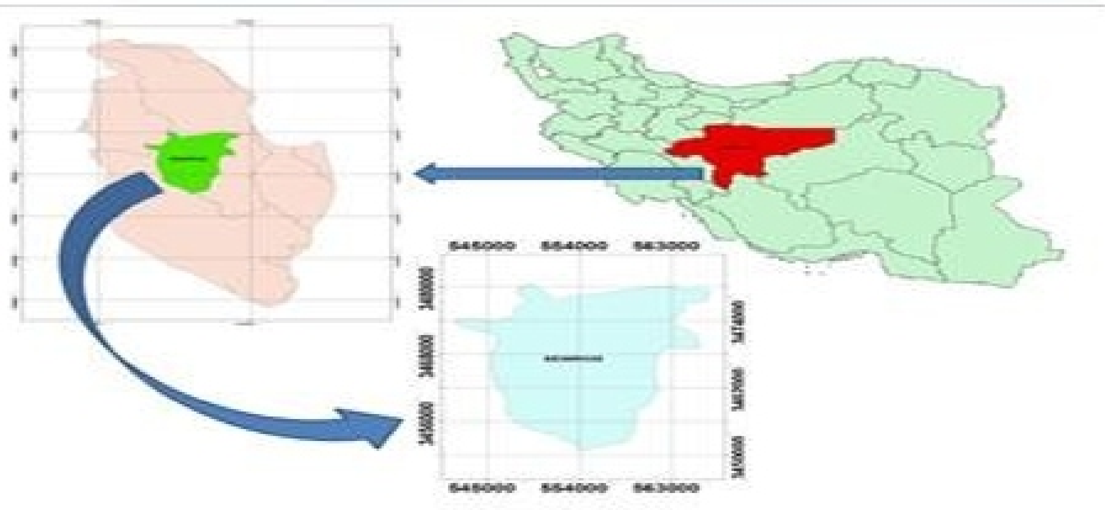


FIGURE 1:STUDED BASIN SITUATION IN SEMIROM

STUDY METHOD

In order to study sedimentological position and erodibility of stone units in a sedimentary basin , It is necessary to be got a total vision of geologic position in the area using geological maps and satellite photos, then, to be sampled from exciting subbasin and branches of original channels. It is determined the sedimentation rate in each subbasin by EPM and basin sedimentation level by annual sediment budget method. EPM is obtained via erosive lands information and sediment measurements during 40 years studies in Yoguslavi . It is introduced the first in international river regime conference held by Gavrilwich (Refahi 2003)

There are four factors in the method including basin erosion coefficient (φ) , land use coefficient (Xa) soil and stone sensitive coefficient to erosion (Y) drainage basin average slop (I) investigated on different land units . These factors help to calculate erosion rate and to prepare erosion maps . Also , erosion rate coefficient and Z value will be calculated by these four factors.

$$Z = Y.Xa(\phi + 1)^{0.5}$$

Calculating the erosion level will be as :

$$WSP = T.H.\pi .Z^{1.5}$$

The required information in the research is Semirom topography map , Semirom geological map , land use map and erosion sensitive map obtained from watershed studies on drainage basin. The large numbers of layers in EPM model should be overlapped to prepare erosion rate map and sedimentation content. Adapting of basin boundary with different layers , polygoning of given layers , giving the proper coefficients to each polygon and changing the polygon layers to raster were done by GIS software. The calculated coefficients are showed in tables below

TABLE 1: SOIL AND STONE SENSITIVE COEFFICIENT TO EROSION (Y)

row	Pedology and petrology conditions	Score
1	Sand , stone , granule , schist	2
2	Fractured limestone and marl	1.6
3	Serpentin red standstone and sediments	2
4	Podzol , parapodzol , crushed schist , micaschist , gneiss , argillite schist	1.1
5	Hard limestone , litter , humans and silicate soil	1
6	Brown forest and mountain soil	0.8
7	Bog soil and black or dark grey hydromorphic soil	0.6
8	Chernozem And placer deposit with good texture	0.5
9	Hard igneous rocks	0.25

TABLE 2 . LAND COEFFICIENT VALUES (XA)

row	Land use conditions	Score
1	Waste lands and badlands	1
2	Ploughed rough broken land for farming	0.9
3	Fruit gardens , vegetarian covered vineries	0.8
4	Ploughed farmlands on contour lines	0.7
5	Eroded and ruined forests and brushes on eroded soils	0.6
6	Dry mountain pastures	0.5
7	Permanent farms and grasslands	0.4
8	Grass-covered drained pastures	0.3
9	Good forest on steep slopes	0.2
10	Good forests on mild slops	0.1

TABLE 3 .EROSION COEFFICIENT VALUES IN AREA (Φ)

row	Watershed basin erosion conditions	Score
1	Region with a lot of gullies and severs erosion	1
2	The region with 80% rill and gully erosion	0.9
3	The region with 50% rill and gully erosion	0.8
4	The region with surface erosion , sediments and debris with low gully and rill erosion and karstic erosion	0.7
5	The total region with surface erosion without deep erosion traces (gullies , rills and debris)	0.6
6	The region with 50% surface erosion and the rest without erosion	0.5
7	The region with 20% surface erosion without erosion	0.4
8	Ground surface was without visible erosion but in rivers benches was observed slip and debris	0.3
9	Ground surface was without visible erosion with often farming coverage	0.2
10	Ground surface was without visible erosion with permanent vegetarian forest covers	0.1

Then, to prepare slope map, after digitizing adjustment curves of topography map and interpolating the maps in GIS medium, digitizing elevation model (DEM) is obtained. According to definition of slope (height to interval changes) the slope map was obtained by giving related formula to digitizing model and the layer became suitable for calculating EPM through transforming values with hundredth form. The resulted maps are below:

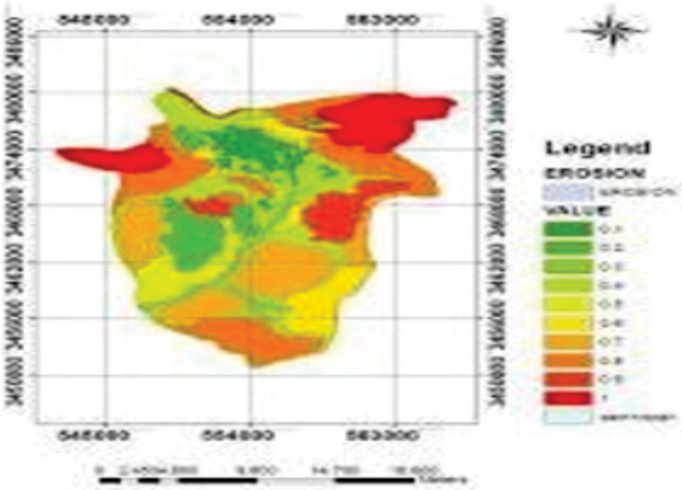


FIGURE2: EROSION COEFFICIENT MAP IN SEMIROM BASIN

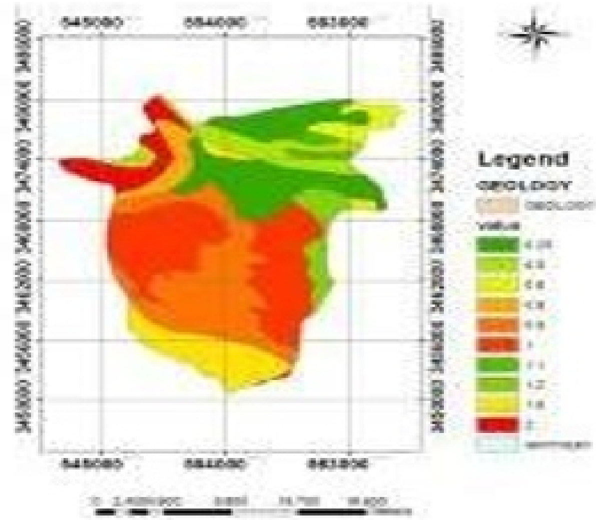


FIGURE 3: BASIN SOIL AND STONE SENSITIVE COEFFICIENT TO EROSION

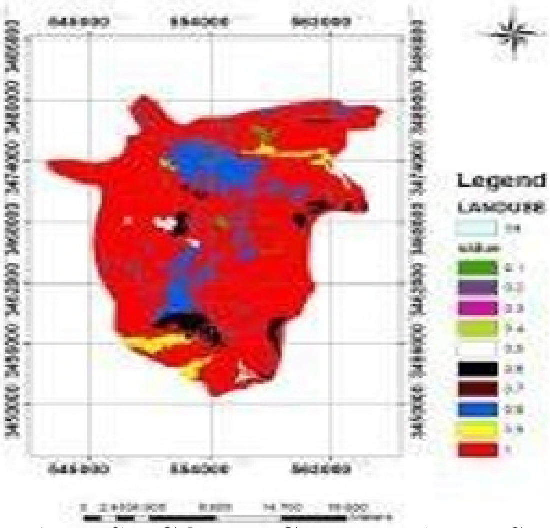


FIGURE 4: LANAD USE COEFFICIENT MAP IN SEMIROM BASIN

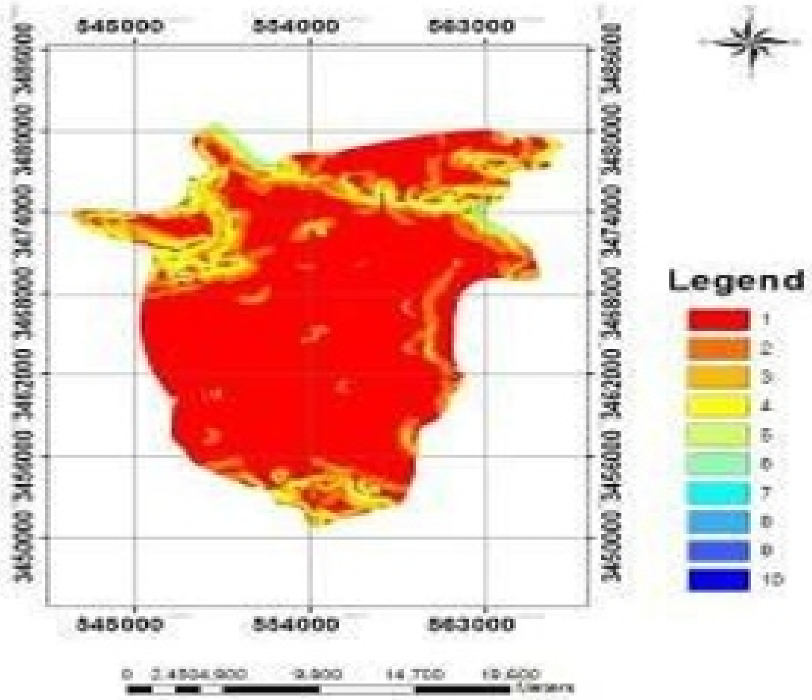


FIGURE 5: SLOPE COEFFICIENT MAP IN SEMIROM BASIN

In GIS software medium , Z value representing erosion rate in basin is obtained using the formula below :

$$Z=Z = Y.Xa(\phi +1)^{0.5}$$

The resulted map is one which represents EPM model value distributively. Therefore, numerical Z value is classified in GIS medium on the table below and final map of erosion rate is obtained based on very low and very high erosion rate according to figure 6.

TABLE 4: CLASSIFYING EROSION RATE IN BASIN

Average Z values	Limit values	Erosion rate	Erosion classifying
1.25	Z>1	Very high	I
0.85	1>Z>0.71	high	II
0.55	0.7>Z>0.41	average	III
0.3	0.4>Z>0.2	low	IV
0.1	0.19>Z	Very low	V

Preparing the final map of soil erosion rate in basin , the following formula is used to estimate annual sediment average in GIS medium .

$$WSP = T.H.\pi .Z^{1.5}$$

Where P is annual rainfall average in watershed basin on the basis of millimeter , H is annual rainfallmean (mm) , π is 3/14 and Wsp is annual specific erosion mean (m/lm/yr). T is temperature coefficient calculated upon equation below:

$$T=((t/10)+0.1)^{0.5}$$

Where , t is annual temperature average on the basis of centigrade . Finally , It is prepared the Wsp map, representing specific erosion rate on the basis of square meter in year (figure 7)

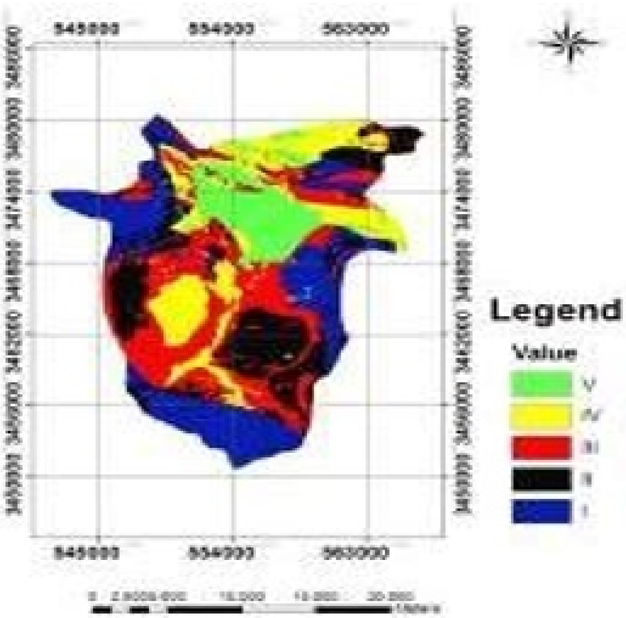


FIGURE 6: BASIN EROSION RATE MAP

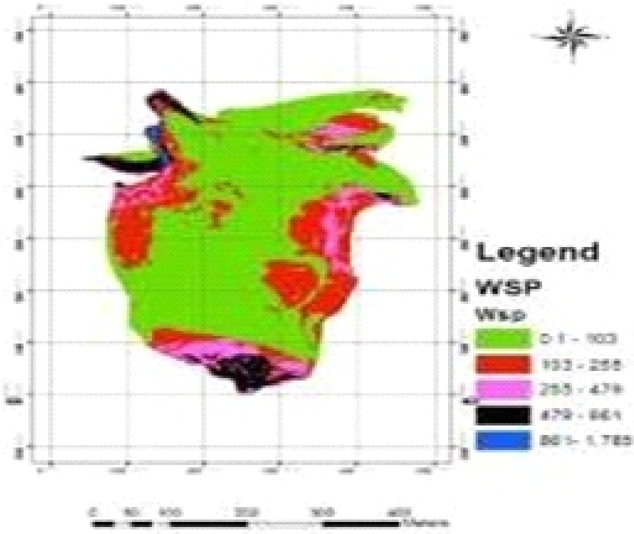


FIGURE 7: BASIN SPECIFIC EROSION RATE MAP

CONCLUSION

According to obtained maps of executive models , the results show that the more erosion level in western and southern area of watershed basin is researchable and is effective on basin hydrologic studies because carried sediment content in channels is determined and it is important to make a dam in southern area . Also , it is calculable by the model. However , intensive erosion areas are determined by the model . To reduce the erosion level in the area , biological and mechanical protection measurement are applied. The major reason of such erosion level in these areas is steepslope of lands and magnitudes and land material . Land material is with highersolubility and susceptible of erosion .

Identifying the eroded areas , it is determined the mineral materials of surface soil are removed , growing the plants is low and the land use is weak . So , to improve the agricultural products performance , Biologic and chemical nutrition is strongly required.

SOURCES

1. *Reza ,Bayat ; h , Refahi ; A.V.F , Darvish sefat , Sarmadian 2000 , Investigating The Effectiveness Of MDSIA And EPM Models To Estimate The Sediment Content In Taleghan Watershed Basin Using GIS . Iran Agricultural Science Magazine , V 32 , NO 1 , P 203-217.*
2. *Gholam Hussein, Haghania ,Avaz ,Kuchaki; Soil Stability Management , Daneshgahi Jahad publication , Mashhad 1996.*
3. *Zeinab ,Khodabakhshi , N . Arzani , Erodibility Study On Stone Units And Sediment Production Using EPM In Zayandehroud Drainage Basin-Heidari Basin In North in Shahrekord ; Stratigraphy Researches magazine , 2Gth years , P33 -48 summer 2010.*
4. *Hussein Gholi , Refahi , Windy Erosion And Control It , Tehran Daneshgahi Publication 2006.*
5. *A . Alizadeh ; Applicable Hydrology Principals , Astan Ghods Razavi publication , 18th edition , 2005.*
7. *Gharib . Fazel nia , Yaser , Hakim Dust, A Comprehensive Guidance For GIS Application , 2012 .*
8. *S . feiz Nia , Applicable Sedimentology Emphasizing On Soil Erosion And Sediment Production, Gurgan Natural Sources And agricultural Science College publication , 2008. 9.M.Mahdavi , Applicable Hydrology , 2th edition , Tehran university publication , 2002.*
10. *Geological map , Semirom 1:1000000 , Geological Mineral Exploration And Geological Survey Organization , 2006.*
11. *Coleman, D.J., and F.N., Scatena, 1986,Identification and evaluation of sediment sources.In: R.F., Hardly, (Ed.). Drainage Basin SedimentDelivery: IAHS Publication , v. 159. p. .3-18.*
12. *Fanetti, D., and L., Vezzoli, 2007, Sediment input and evolution of lacustrine deltas: The Breggia and Greggio rivers case study (Lake Como, Italy): Quaternary International, v.173,p.113-124.*
13. *K .Solaimani, S .Modallaldoust, and S.,Lotfi, 2009, Investigation of land use changes onsoil erosion process using geographical information : International Journal of Environmental Science and Technology v.6(3), p.415-424.*

Feasibility Of Recharge Shafts/injection Wells For Groundwater Recharge In Patan District, Gujarat, India

Anshoo Narula

Student: C.B.P Government Engineering College, Jaffarpur, Guru Gobind Singh Indraprastha University (G.G.S.I.P.U)

ABSTRACT

: For the industrial development, agricultural & economic growth the demand of groundwater has increased in north Gujarat alluvial plain. The groundwater Draft exceeds the groundwater recharge resulting in over exploitation of groundwater aquifers. This has resulted in continuous decline in water levels and reduction in the yield of the tube wells. Due to poor rainfall reliability and recurring drought conditions, the area could never recover the deficit of water extracted from groundwater resources. The artificial recharge to groundwater can only sustain the water levels or can arrest the rapid depletion of groundwater rate. The part of Patan taluka in Gujarat, India is selected for the construction of artificial recharge structures near the large storage village ponds. It is proposed to construct artificial recharge structures in seven villages of Patan taluka near these village ponds. The recharge potential is calculated taking 40 rainy days taking average rainfall as 770mm. If the recharge shaft is connected to the ponds at a depth, it is able to utilize the storage of ponds and recharge potential can then be calculated for a period of 180 days (pre-monsoon and post-monsoon period). Thus calculating the runoff potential of seven recharge structures and considering the catchment of the area, the plan is considered feasible for recharge in seven villages of Patan Taluka.

Keywords: groundwater, recharge, rainfall, Patan Taluka, Gujarat

1. INTRODUCTION

Many of us have an image of the world as a blue planet as 70 percent of the earth's surface is covered with water. The reality, however, is that 97 percent of the total water on earth of about 1400 Billion Cubic Meter (BCM) is saline and only 3 percent is available as fresh water. About 77 percent of this fresh water is locked up in glaciers and permanent snow and 11 percent is considered to occur at depths exceeding 800 m below the ground, which cannot be extracted economically with the technology available today. About 11 percent of the resources are available as extractable groundwater within 800 m depth and about 1 percent is available as surface water in lakes and rivers. Out of the 113,000 BCM of rain and snow received on the earth, evaporation losses account for about 72,000 BCM, leaving a balance of about 41,000 BCM, out of which about 9000-14000 BCM is considered utilizable. The annual precipitation including snowfall in India is of the order of 4000 BCM and the natural runoff in the rivers is computed to be about 1869 BCM. The utilizable surface water and replenishable groundwater resources are of the order of 690 BCM and 433 BCM respectively. Thus, the total water resources available for various uses, on an annual basis, are of the order of 1123 BCM. Although the per capita availability of water in India is about 1869 cubic meters as in 1997 against the benchmark value of 1000 Cu m signifying 'water- starved' condition, there is wide disparity in basin-wise water availability due to uneven rainfall and varying population density in the country. [3]

Groundwater plays an important role in sustaining India's economy, environment and standard of living. It is not only the main source for water supply in urban areas for domestic uses, but also is the largest and most productive source of irrigation water. Indiscriminate groundwater development has led to substantial groundwater level decline both in hard rocks and alluvial areas threatening sustainability of this resource. Long-term decline of groundwater levels is being observed in many areas, mostly in the states of Rajasthan, Gujarat, Tamil Nadu, Punjab, Delhi and Haryana. Apart from this, in most of the cities depending on groundwater for drinking water supplies, water level declines up to 30 m and more have been observed. Traditional water harvesting methods, which were in vogue in arid and semi-arid areas of the country have either been abandoned or have become defunct in most cases. There is an urgent need to revive these methods. Groundwater development, therefore, needs to be regulated and augmented through suitable measuresto provide sustainability and protection. Dependence on use of groundwater for agriculture due to monsoon failures is accelerating groundwater depletion. Excessive withdrawal of groundwater is further compounding the stress on groundwater system due to free/subsidized power in some States. In order to tackle the burgeoning problem of water level decline, it is necessary to take up schemes for water conservation and artificial recharge to groundwater on priority. [3]

LITERATURE REVIEW

In order to augment the depleting groundwater resources, it is essential that the surplus monsoon runoff that flows into the sea is conserved and recharged to augment groundwater resources. Groundwater storage that could be feasible has been estimated as 214 Billion Cubic Meters (BCM) of which 160 Billion Cubic Meters is considered retrievable. The Central Groundwater Board (CGWB) has prepared the master plan for artificial recharge to groundwater for all states in the country. [5]

The preparation of master plan for artificial recharge to ground water in different states, prepared by Central Ground Water Board in 2002, aims at providing area specific artificial recharge techniques to augment the ground water reservoir based on the twin important requirements of source water availability and capability of ground water reservoir to accommodate it. The specific problems in different areas in the states like excessive ground water development resulting in ground water decline, water scarcity due to inadequate recharge in arid areas, low ground water retention in hilly areas despite substantial rainfall, urban areas with limited ground water recharge avenues and related problems of urban pollution, etc., have been considered while preparing the master plan. To fully utilize the available surplus monsoon runoff in rural areas, emphasis has been given for adoption of artificial recharge techniques based on surface spreading like percolation tanks, nala bunds, etc. and sub-surface techniques of recharge shaft, well recharge, etc. In urban areas, hilly areas and coastal regions priority has to be given to rain water conservation measures through roof top harvesting techniques etc. [4]

The Master Plan while bringing out the areas suitable for artificial recharge to ground water reservoir, prioritizes the areas wherein schemes need to be implemented as a first priority to ameliorate the water scarcity problems. The proposals and schemes recommended are not the ultimate ones but are the first stage of implementation. These need to be further extended in other areas depending on the availability of infrastructure, finances and future problems. [4]

The master plan envisaged the number of artificial recharge and water conservation structures in the country as 39 lakh at an estimated cost of Rs. 24,500 crores. [4]

The CGWB has prepared a Manual and subsequently a Guide on Artificial Recharge to Groundwater which provides guidelines on investigation techniques for selection of feasible sites, planning & design of artificial recharge structures, economic evaluation & monitoring of recharge facility. These are of immense use to States/ U.T.s in planning and implementation of artificial recharge and rain water harvesting schemes for augmentation of groundwater in various parts of the country. [5]

During the Ninth Five Year Plan, a Central Sector Scheme "Studies on Recharge of Groundwater" was undertaken by the CGWB, in which 165 artificial recharge pilot projects were implemented in 27 States/UTs in coordination with organizations of State governments & NGO / VOs, etc. with 100% central funding. Civil works were done by state implementing agencies under technical guidance of the CGWB. Efficacy of the recharge structures constructed in different hydrogeological conditions of the country was assessed through impact assessment studies taken after completion of recharge facility and has indicated rise in water levels and sustainability of dug wells/ tube-wells locally including other benefits like decrease in soil erosion and improvement in social-economic status of farmers of benefited zone due with increase in crop production. [5]

In Tenth Five Year Plan, special emphasis is given to implementation of rainwater harvesting schemes at schools for utilization of rain runoff and creation of mass awareness amongst school children. In Fresh Water Year – 2003, the Ministry of Water Resources had approved and sanctioned projects on construction of roof top rain water harvesting structures at Government buildings in the states of AP, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Orissa, Punjab, Sikkim, Tamil Nadu and Uttar Pradesh and UT of Chandigarh under technical guidance of CGWB and funds provided under Grant-in-Aid to the concerned state Governments. Similarly, demonstrative projects of Roof top rainwater harvesting were also implemented through NGO's in 100 schools in rural area of 13 states viz Andhra Pradesh, Delhi, Gujarat, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Sikkim, Tamil Nadu, Uttaranchal and West Bengal. [5]

In 2005-2007, project on rainwater harvesting from roof tops of remote government rural schools for collection of rainwater for drinking and use in two toilets for girls in 413 schools in rural areas of 15 states were sanctioned by the Ministry of Water resources. The CGWB facilitated the work by providing technical guidance in designing, monitoring and implementation through its expert scientists. The Government released Rs.3.47 crores as Grant-in Aid to NGO's for construction of roof top rain water harvesting facilities in govt. schools under this program.

In 2006, a demonstrative scheme on “Rain Water Harvesting and Artificial Recharge to Groundwater” has been taken up at following areas:

1) Lingala, Pulivendula Vemula and Vemalli blocks in Kadapa district, Andhra Pradesh
2) Gangavalli block in Salem district, Tamil Nadu
3) Mallur Block in Kolar district, Karnataka
4) Bel watershed, Amla & Multai Blocks in Betul District, Madhya Pradesh.
5) Upper reaches of Choti kali Sindh river in parts of Sonkatch & Bagli blocks in Dewas district, Madhya Pradesh.[5]

The approved cost of projects was Rs. 5.95 crores for implementation by the departments of states under overall technical guidance of CGWB during 2006-08 with 100% funding by the Central Government. The norms adopted in implementation of National Rural Employment Guarantee Scheme (NREGS) by the Ministry of Rural Development were followed in implementation of civil works. Under this priority was given to hard rock areas having over-exploited groundwater resources. On completion of civil works of recharge facility, impact assessment studies are taken up to demonstrate the efficacy of artificial recharge and rain water harvesting as well in above mentioned sites selected on scientific basis in different hydrogeological situations. [5]

During XI Five Year Plan a provision of Rs. 100 Crores has been made for demonstration of artificial recharge and rain water harvesting techniques in Overexploited and critical areas, urban areas and areas affected by water quality. [5]

Designing of Artificial recharge and rainwater harvesting systems in different hydrogeological settings and demonstrating their efficacy will help State government to replicate the structures in similar areas. The first instalment of 70% of the approved cost of the project is released after approval of the project to the implementing agencies. The next installment of 30% of the approved cost is released on recommendation of State Level Technical Coordination Committee on physical progress and after utilization of 75% of initial funds released to the implementing agency. It is expected that artificial recharge structures constructed will additionally recharge 75 MCM surface runoff and raise the water levels by 0.5 – 5.0 m in the vicinity of the structures. This Scheme will also help in capacity building of State govt. organizations, local bodies, NGOs, VOs and stakeholders. [5]

METHODOLOGY

A pilot project to study the technical feasibility and economic aspects of artificial recharge to the depleted aquifers in the Mehsana area was taken up by Central Groundwater Board in collaboration with UNDP and Gujarat Water Resources Development Corporation (GWRDC), Govt. of Gujarat. The Project was completed between 1980 & 1984.

Both Surface spreading and injection methods were feasible in the area. The former was feasible in the recharge zone and later in the central part. The confined aquifers were recharged by injection method, whereas, the phreatic aquifers were recharged by surface methods.

In the experiment conducted using the injection wells, the waters from the phreatic aquifer below the Saraswati river were utilized. A quantity of 225 cubic meters per day was injected continuously for 250 days, through pressure injection technique. At the end of this recharge cycle, an average rise of 5 meters (m) was observed in the injection well along with a rise of 0.6-1 m in the wells 150 m away from the injection well .Since the source of water itself was an aquifer, the problems of silt and clogging were minimized. [6]

The results indicate 3.0 to 5.0 LPS recharge rate in the area. Hence, considering average recharge rate of 4.0 LPS, one recharge structure can recharge about 1, 20,000 Cubic meter of water per year.

RECHARGE CAPACITY DURING MONSOON &POST MONSOON STORAGE IN POND:

Recharge capacity of one well during monsoon (40 days period if long term storage facility is not available with the structure)

1. Considering average 4 lps intake rate of the over exploited aquifer, the capacity of recharge for monsoon considering average 40 days period it comes to 13824 kilolitres and for seven wells it will be 96768 cubic meters.

2. The location of well is near the storage in ponds generally found for monsoon and post-monsoon period up to January. Taking 180 days the recharge potential will be 62208 cubic meters.

3. If the ponds are not linked with Narmada pipe line the recharge potential will come to 435456 kilo litres.

4. The village ponds of Sankhari, Mithivavdi and Gaja village are large pond linked with Sujlam Sufalam Yojana getting water supply from Sujalalam Suflam spreading recharge canal feed from Kadana reservoir spill water and Narmada pipeline. The potential recharge will be 608832cu.m.

If rest four villages will be linked the recharge will be 8, 40,000 cubic meters. For 25 years recharge potential will be 21000000 liters.

DESIGN OF RECHARGE STRUCTURE

A) Recharge tube well or injection well.
The water level ranges 110-120 meters in proposed project area. The aquifers below 120 meters need recharge to control the depletion rate of water level and reduction in yield. A recharge well with 150.0 meter depth is designed with following specifications recommended for the construction in seven proposed village ponds. Surface water head of 110- 120 meter is sufficient for the injection of water in to recharge tube wells.

SPECIFICATIONS:

Diameter: 200 mm, Thickness: 6.0mm, Depth: 150 meter,
Expected SWL(m)-110 m,
First screen-120 m bgl,
Expected TDS-1500 ppm,
Yield-1000 lpm

RESULTS

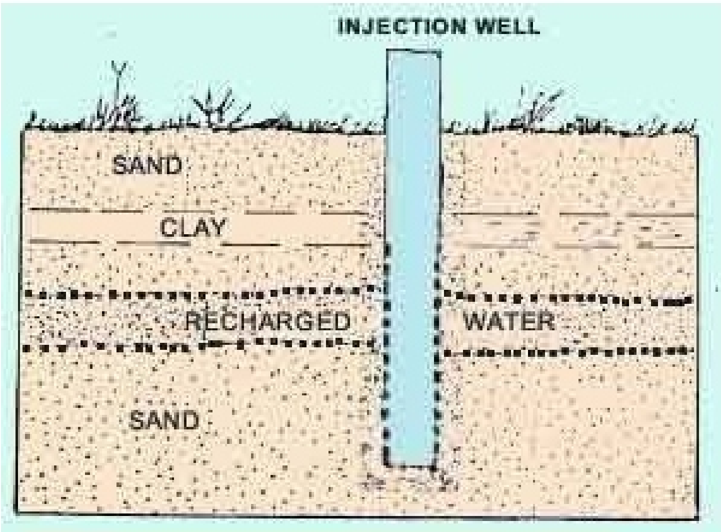
The details of village ponds are collected and are found feasible for the construction of recharge structures. For the feasibility of recharge structures following criteria are considered:

1) The storage /gross storage capacity of pond to feed the recharge structure throughout its storage period up to the month January.

2) For the generation of runoff volume the coefficient 0.90 of the precipitation is considered as practically there are no evaporation losses from the surface of reservoir during monsoon.

3) For the generation of runoff volume from catchment 0.30 coefficient is considered looking to the soil texture and type of catchment.

4) For the calculation of runoff volume, decadal average 770 mm from year 2005-2013 is considered.



Source: [6]

Name of Village	Area Sq.meters	Depth (m)	Storage capacity (cum)	Gross storage capacity cu.m (1.5 of Storage)	RFCoeff icient(Yr2005-2013)m	Direct precipitatio n(0.9)-90 % of water spread area	Catchment sq.m.	Runo ff coeffi cie nt	Runoff volume cubic m	Total volume cubic meter (40 days of scattered rainfall)	Recharg e potenti al at 4 LPS
Lakhdap	28531	4.5	128389.5	192585	0.77	19772	640000	0.3	147840	167612	62208
Endla	180200	3	540600	810900	0.77	124879	2566000	0.3	592746	717625	62208
Badipur-Vastrasar(Vadli)	45565	3.5	159478	239216	0.77	31577	792100	0.3	182975.1	214552	62208
Shiyol	35125	3	105375	158063	0.77	24342	722500	0.3	166897.5	191239	62208
Sankhari	39965.9	3	119898	179846.93	0.77	27696	756500	0.3	174751.5	202448	126144
Mithivavdi	96655.32	3	289966	434948.98	0.77	66982	1083300	0.3	250242.3	317224	126144
Gaja	48375	3	145125	217688	0.77	33524	825500	0.3	190690.5	224214	126144
TOTAL	**474417.2**	**23**	**1488831.5**	**2233247.91**	**0.77**	**335976**	**7385900**	**0.3**	**1706143**	**2034914.033**	**627264**

SOURCE:

Undisclosed, compiled by researcher

Where; direct precipitation (cu.m)=Area* RF Coefficient*0.9

Runoff volume (cu.m)=Catchment*RF Coefficient*Runoff Coefficient

Total Volume (cu.m)=Runoff Volume+ Direct Precipitation

Total estimated run off volume available for recharge from these 7 ponds is 2034914 cu.m. Out of this volume, proposed recharge for three ponds is 120000 cu.m (for 365 days) which are connected to Narmada canal network and for four others, which are not connected to Narmada canal network as of now, the recharge potential is 62208 cu.m per pond, considering 180 days of recharge.Recharge shafts are to be built in the vicinity of the ponds/ lake, where pond water will be diverted at mid-level of the pond to the recharge shaft through de-silting chamber.

CONCLUSION

Looking at the available monsoon runoff potential from surface reservoir body and catchment & recharge capacity of one recharge structure construction of 7 recharge structures near 7 ponds located in Patan Taluka are feasible. An attempt is also made to work out recharge potential considering 40 rainy days (13284cu.m). Runoff volume has been calculated from the catchment & direct precipitation on pond surface with coefficient based on type of catchment.

If in future, the remaining three ponds also get connected to Sujalam Sufalam Yojana, larger amount of water will be available for recharge of water-deficient areas in Patan District.

REFERENCES

1. *Central Groundwater Board, Guide on Artificial Recharge of water cgwb.gov.in/documents/Artificial Recharge-Guide.pdf*
2. *Central Groundwater Board, Revised Guidelines With Amendments For Artificial Recharge Of Groundwater Through Dugwells(Dugwell Recharge Scheme) Sources: MoWR letter No. 11/6/2007-GW dated 6-10-2008 & MoWR letter No. 11/6/2007-GW(Vol. II) dated 3-8-2009 http://cgwb.gov.in/documents/AR/Revised%20 Guidelines%20for%20dug%20well%2 0recharge.pdf*
3. *Central Groundwater Board, Manual on Artificial Recharge of Groundwater http://cgwb.gov.in/documents/ Manual%20on%20Artificial%20Recharge%20of%20G round%20Water.pdf*
4. *Central Groundwater Board, Master plan for Artificial recharge of groundwater in India http://cgwb.gov.in/documents/MasterPlan-2013.pdf*
5. *Central Groundwater Board, Artificial recharge of Groundwater http://cgwb.gov.in/artificial_recharge.html*
6. *Kavuri M, Boddu M and Annamdas V G M (2011) "New Methods of Artificial Recharge of Aquifers: A Review" IPWE 2011, Proceedings of 4th International Perspective on Water Resources & the Environment, January 4-6, 2011, National University ofSingapore(NUS)Singapore ; http://www.ntuceegrad.o rg/venu/artificial.pdf*
7. *Central Groundwater Board, Groundwater Profiles-Gujarat http://cgwb.gov.in/gw_profiles/st_Gujarat.htm*
8. *Gujarat State Profile, http://www.gujaratindia.com/state-profile/state-profile.htm*
9. *Statistical data of villages in states of India:http://www.indiastat.com/administrativesetup/1/villages/32/stats.aspx*
10. *Sujalam Sufalam Yojana:http://gujnwrws.gujarat.gov.in/showpage.aspx? contentid=1473&lang=english*
11. *Census of India- List of townsand villages: censusindia.gov.in/2011census/Listofvillagesandtowns.aspx*

Quantitative Assessment Of Physicochemical Constituents As Fluoride, Iron And Nitrate Contaminated Drinking Groundwater In Nashik District, Maharashtra, India

K. T. Bharati[1], N.D. Phatangare[2], Dr.D.B.Gujarathi[3]
P.G. Department of Chemistry, S.N.Arts, D.J.M. Comm., and B.N.S. Science College Sangamner, Maharashtra, India

ABSTRACT

Rapid industrialization and advanced agricultural practices are in vogue. The use of water is also in large quantity. Groundwater sources get polluted by the industrial waste water and agricultural fertilizers. The examination of ground water quality with respect to pH, TDS, Fluoride, Iron and Nitrate content has been carried out in Nashik District of Maharashtra, India. Three different types of sources such as Dug well, Power pump and Hand pump were selected for sampling. Overall fifty samples were collected for the study. Iron was analyzed by using Atomic Absorption Spectrometer (AA 2001 model) and fluoride was measured by SPANDS method at 570 nm while nitrate concentration was found by the phenol-disulphonic acid method at 410 nm using UV-VIS Spectrophotometer, (Chemito UV2100 model). Fifty percent samples show high nitrate concentration (53-141mg/L); one sample from hand pump category shows 2.0 mg/L fluoride content and four samples from hand pump category show high contents of iron. Therefore, the study revealed that the groundwater sources in the study area are heavily polluted with nitrate and iron.

Keywords: Groundwater, fluoride, iron and nitrate etc.

1. INTRODUCTION

We are well known about the importance of the water for living beings and also for plants. More than 50% population lives in urban areas and the percentage of this is increasing very rapidly day by day. Rapid urban population growth, industrialization and increasing agricultural techniques are putting severe strains on water resources and environmental protection capabilities of many cities particularly in developing nations1. So availability of clean groundwater resource for future generations is not only a regional problem but also a worldwide problem.

Now a day, very few clean drinking water sources are available and the polluted water are giving birth to public health concern worldwide. Hence, the percentages of water borne diseases are increasing. Safe and clean drinking water is very important for all living organism. Groundwater is generally considered as a safe source of drinking water but with increasing rate of modernization, agricultural practices and industrialization, the natural groundwater sources are getting polluted very fastly.

In India, sixteen states namely Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Orissa, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh have already been identified endemic to fluorosis2. Nitrate contamination in groundwater arises from intensive agriculture, use of chemical fertilizers, improper and unhygienic sanitation, landfills and irrigation of land by sewage effluents3.Nitrate converted from nitrogenous fertilizers leaches into deep soil and percolates into the groundwater system.

Health hazards arising out of exposure to higher level of nitrate level can be many folds, viz. methaemoglobinemia of blue baby syndrome which may cause mortality by asphyxiation especially in newly born infants, gastrointestinal cancer, Alzheimer disease, absorptive- secretive functional disorders of the intestinal mucosa, multiple sclerosis and Non-Hodgkin's lymphoma, hypertrophy of thyroid etc3.

Nashik district is one of the major district of Maharashtra. It is situated between 20.00 degree North latitude and between 73.78 degree East latitude. It covers an area about 312812 sq. km and receives an average rainfall between 2600 to 3000mm. The greater part of the district is under the wet farming. For increasing the crop yield, the farmers use large quantity of chemical fertilizers.

The present research work has been carried out to study the drinking water quality parameters with respect to pH, TDS, Fluoride, Iron and Nitrate in Nashik district, Maharashtra and to help people in developing strategics at local level for minimizing the risk.

SCOPE OF THE WORK

People are less bothered about quality of drinking water sources and hence it is directly related to the health problems. So our aim of the work is to give the information about the physicochemical parameters of groundwater sources by analyzing the water sample from local area.

MATERIALS AND METHODS

1. SAMPLING

Three types of groundwater sources like Dug Well, Power Pump and Hand Pump were chosen for the collection of samples. Total fifty samples were collected of which 11 were dug wells, 07 were power pumps and 32 were hand pumps.

2. SAMPLING PROTOCOL AND SAMPLING METHODS

The protocols adopted for sampling were taken from the APHA4. Samples were collected in plastic containers. Iron was estimated by using Atomic Absorption Spectrometer (AA 2001 model). Fluoride was measured by the SPANDS method at 570 nm and nitrate content was measured by the phenol disulphonic acid method at 410 nm using a UV Visible Spectrophotometer, (Chemito UV 2100 model). The other parameters which were tested were pH and Total Dissolved Solids (TDS).

RESULT AND DISCUSSION

The results obtained for above said parameters of the tested samples are discussed below with graphical representation.

Water parameters are important to reflect the contamination of groundwater sources. As per the guideline of WHO, the range of the pH 6.5-8.5 is acceptable. In study area, 50 samples from different water sources show the pH range from 6.37 to 9.17 among which Dug well samples show pH range 6.53-7.54, the water samples from Power pumps show pH range 6.37-8.27 and the water samples from hand pumps show pH range 6.67-9.17.

TABLE1: PHYSICOCHEMICAL PARAMETERS OF DUG WELL WATER SAMPLES

Groundwater sources	Parameters				
	pH	TDS (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Nitrate (mg/l)
DW_1	6.95	288	0.01	0.02	17
DW_2	6.93	124	0.17	0.04	3
DW_3	7.42	485	0.19	0.05	125
DW_4	7.35	185	0.09	0.03	3
DW_5	7.31	413	0.2	0.02	77
DW_6	7.54	330	0.03	0.03	43
DW_7	6.53	312	0.02	0.03	60
DW_8	7.5	352	0.24	0.05	28
DW_9	7.33	445	0.03	0.07	44
DW_{10}	7.44	461	0.64	0.09	41
DW_{11}	7.31	373	0.85	0.05	28

TABLE2: PHYSICOCHEMICAL PARAMETERS OF POWER PUMP WATER SAMPLES

Groundwater sources	Parameters				
	pH	TDS (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Nitrate (mg/l)
PP_1	7.52	161	0.07	0.03	6
PP_2	7.26	220	0.27	0.05	3
PP_3	7.34	552	0.15	0.03	101
PP_4	8.27	553	0.24	0.04	107
PP_5	7.62	282	0.36	0.03	14
PP_6	6.37	245	0.4	0.05	20
PP_7	6.91	339	0.11	0.06	24

TABLE3: PHYSICOCHEMICAL PARAMETERS OF HAND PUMP WATER SAMPLES

Groundwater sources	Parameters				
	pH	TDS (mg/l)	Fluoride (mg/l)	Iron (mg/l)	Nitrate (mg/l)
HP_1	7.45	408	0.27	0.05	74
HP_2	7.41	299	0.19	0.04	18
HP3	7.24	415	0.03	0.12	81
HP_4	7.19	424	0.2	0.08	89
HP_5	7.04	534	0.06	0.09	86
HP_6	7.03	592	0.24	0.08	93
HP_7	7.16	673	0.06	0.09	126
HP_8	7.12	661	0.02	0.07	88
HP_9	9.17	802	2	0.02	9
HP_{10}	7.86	551	0.12	0.28	104
HP_{11}	7.63	518	0.26	0.02	71
HP_{12}	6.67	426	0.06	0.09	69
HP_{13}	6.93	270	0.02	0.08	29
HP_{14}	7.06	424	0.28	0.04	41
HP_{15}	7.34	666	0.03	0.06	63
HP_{16}	7.39	649	0.02	0.14	42
HP_{17}	7.5	606	0.04	0.11	53
HP_{18}	7.53	449	0.05	0.05	29
HP_{19}	7.45	447	0.03	0.12	61
HP_{20}	7.2	427	0.2	0.06	42
HP_{21}	7.1	423	0.63	0.12	26
HP_{22}	7.13	754	0.29	0.14	141
HP_{23}	7.39	449	0.46	1.25	56
HP_{24}	7.4	504	0.39	0.18	30
HP_{25}	7.29	729	0.93	0.14	121
HP_{26}	7.17	658	0.29	0.09	140
HP_{27}	7.46	273	0.93	1.35	7
HP_{28}	7.19	507	0.89	1.1	71
HP_{29}	7.36	480	0.63	1.45	29
HP_{30}	7.9	600	0.02	0.06	74
HP_{31}	7.64	489	0.04	0.09	89
HP_{32}	7.93	175	0.31	0.04	5

Regarding Total Dissolved Solids (TDS) of water samples, all the sampling sources show the values in range 124-802 mg/L which are within the limit prescribed by WHO.

Out of the 50 samples, Sample HP9 from hand pump shows the maximum content of fluoride i.e. 2.0 mg/L and remaining 49 samples show fluoride ranging from 0.01 to 0.93 mg/L which are within the prescribed limit given by WHO. The concentration of fluoride in the range of 0.8 to 1.20 mg/L is not harmful but if more than 1.5mg/L is reported to be harmful to the teeth and bone of human and animals.

Fluoride has adverse effects on the brain, mostly in combination with aluminum, fluorosis, turns out to be the most widespread geochemical disease in India, affecting more then 66 million people including 6 million children under 14 years age[1].

Iron is usually present in groundwater sample. Water containing iron in traces does not pose any hazardous problem on human health. The iron content of the samples number HP23, HP27, HP28 and HP29 (collected from the hand pumps) show the higher concentration as 1.25, 1.35, 1.1, 1.45 mg/L respectively. As per the standard set by WHO and BIS, the permissible limit of iron is 0.3 mg/L. More than the 1.00 mg/L of iron in drinking water is unsuitable for drinking purpose.

Nitrates in drinking water, as such are not toxic to health and about 85% of ingested nitrates are rapidly adsorbed from gastrointestinal tract in normal healthy individuals and get excreted by the kidneys. But, if the nitrates are converted in to nitrites which occur commonly, the toxic effect are encountered and may cause potential health hazards5. According to WHO, the standard for nitrate is 45 mg/L. From the studied area, 50% sampling sites show high nitrate concentration.

GRAPHICAL REPRESENTATION OF GROUNDWATER PARAMETERS FOR SAMPLES FROM TYPES OF DIFFERENT SOURCES

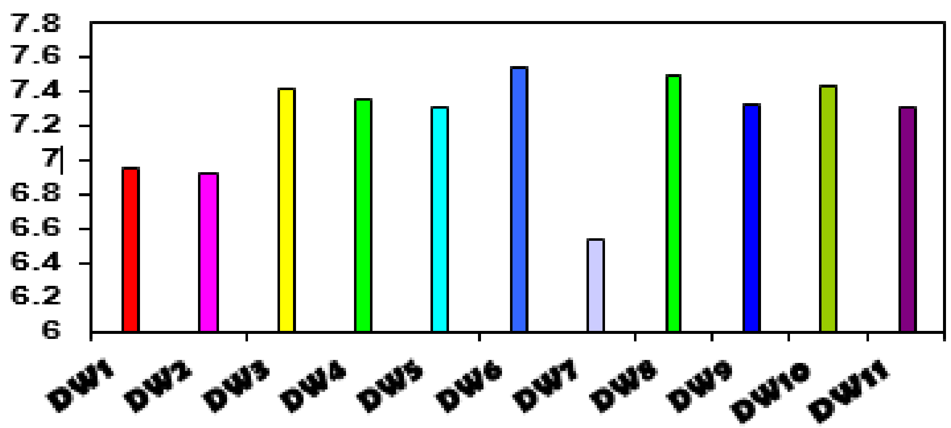


FIGURE 1. CONTENT ANALYSIS OF DUG WELL SAMPLES WITH RESPECT TO PH

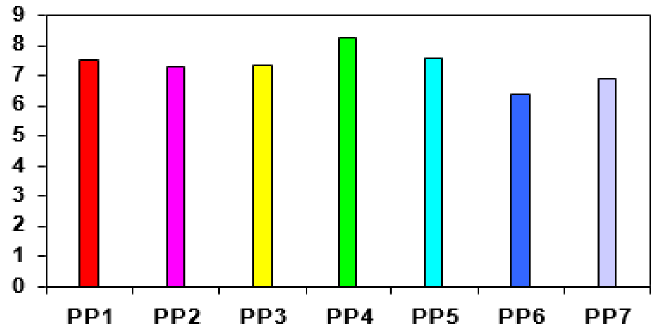


FIGURE 2. CONTENT ANALYSIS OF POWER PUMP SAMPLES WITH RESPECT TO PH

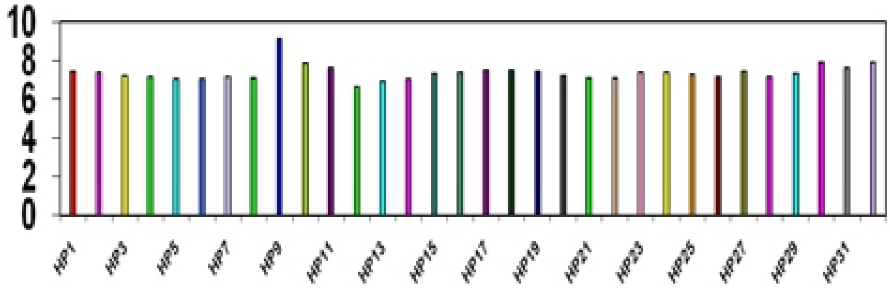


FIGURE 3. CONTENT ANALYSIS OF HAND PUMP SAMPLES WITH RESPECT TO PH

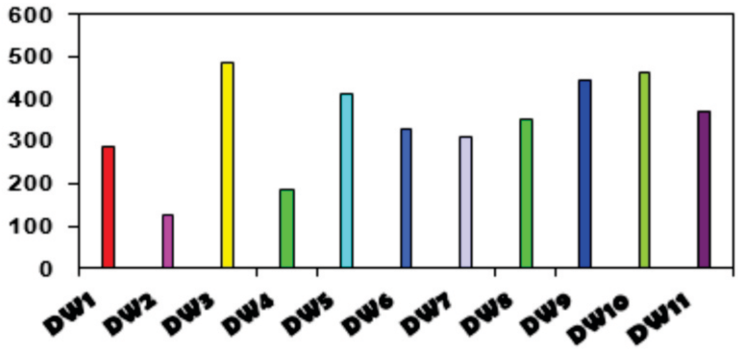


FIGURE 4. CONTENT ANALYSIS OF DUG WELL SAMPLE WITH RESPECT TO TDS

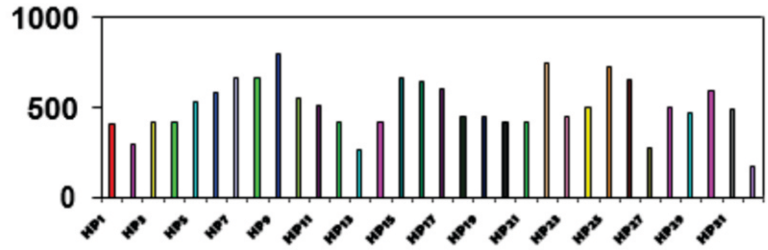


FIGURE 5. CONTENT ANALYSIS OF HAND PUMP SAMPLES WITH RESPECT TO TDS

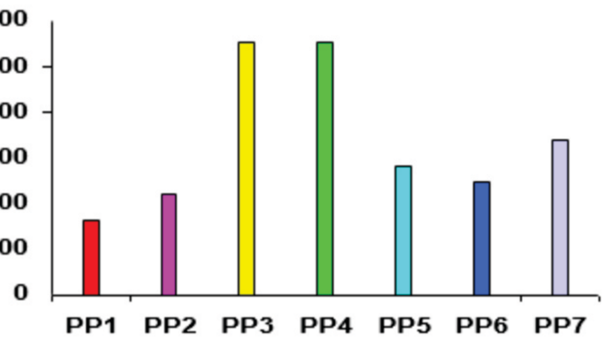


FIGURE 6. CONTENT ANALYSIS OF POWER PUMP SAMPLES WITH RESPECT TO TDS

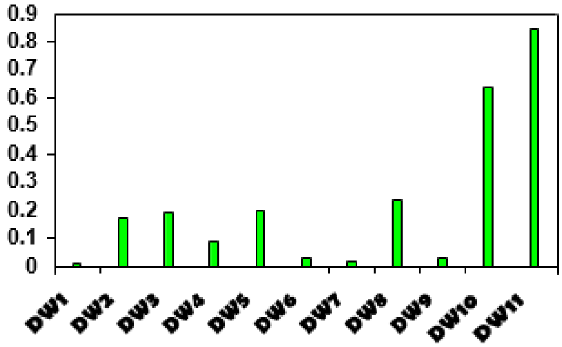


FIGURE 7. CONTENT ANALYSIS OF DUG WELL SAMPLE WITH RESPECT TO FLUORIDE

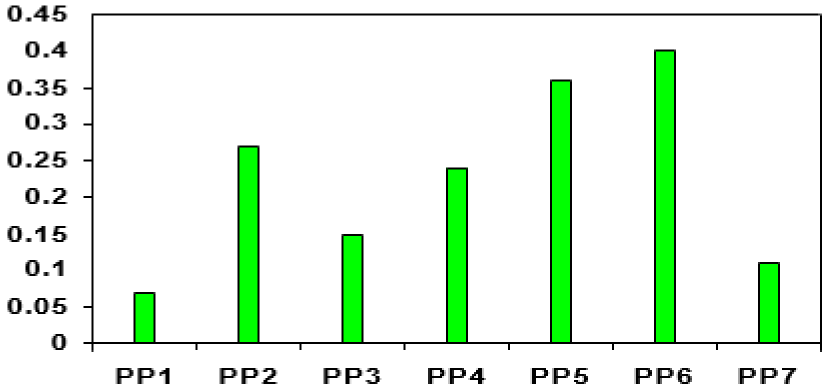


FIGURE 8. CONTENT ANALYSIS OF POWER PUMP SAMPLES WITH RESPECT TO FLUORIDE

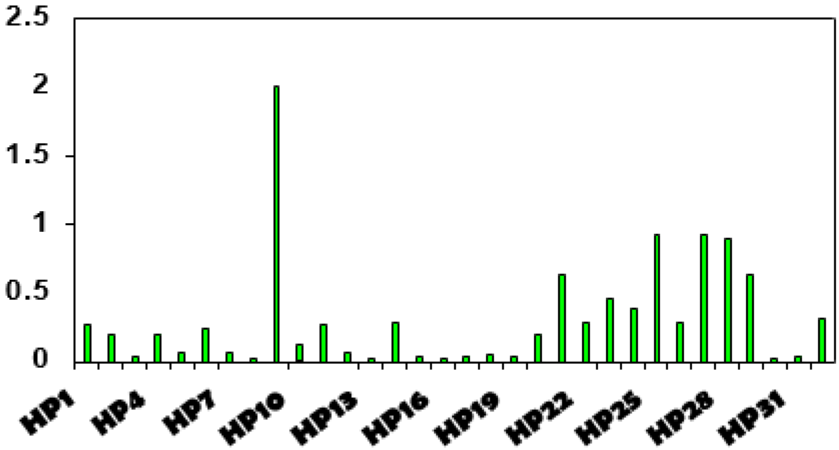


FIGURE 9. CONTENT ANALYSIS OF HAND PUMP SAMPLES WITH RESPECT TO FLUORIDE

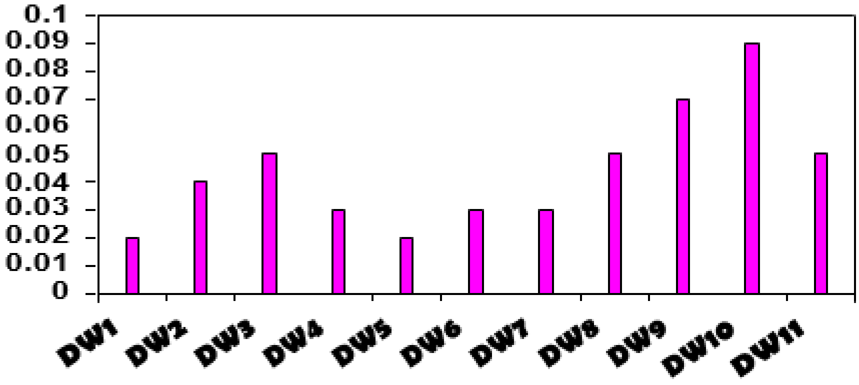


FIGURE 10.CONTENT ANALYSIS OF DUG WELL SAMPLES WITH RESPECT TO IRON

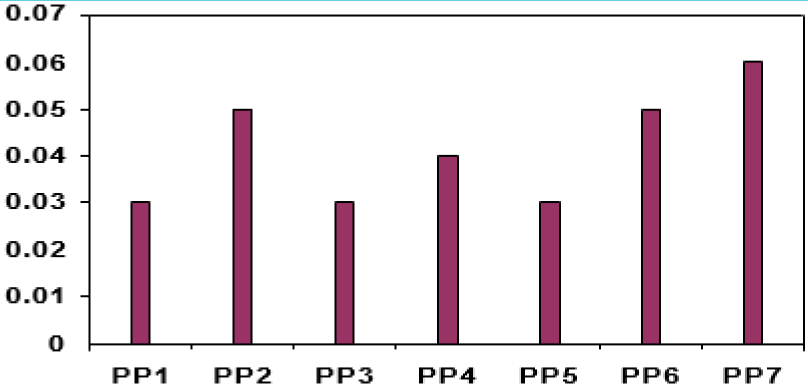


FIGURE 11. CONTENT ANALYSIS OF POWER PUMP SAMPLES WITH RESPECT TO IRON

Figure 11. Content analysis of Power Pump samples with respect to Iron

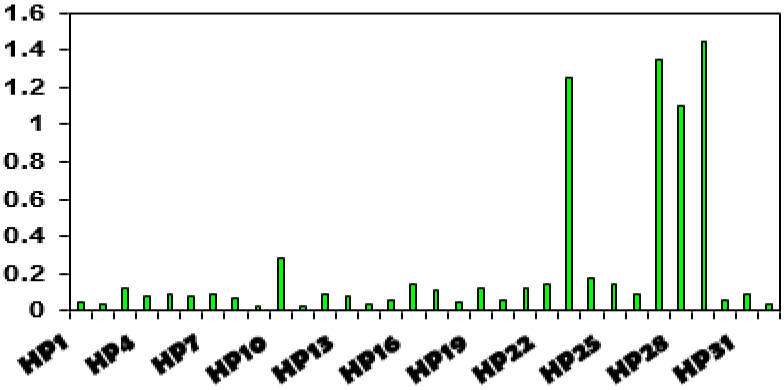


FIGURE 12. CONTENT ANALYSIS OF HAND PUMP SAMPLES WITH RESPECT TO IRON

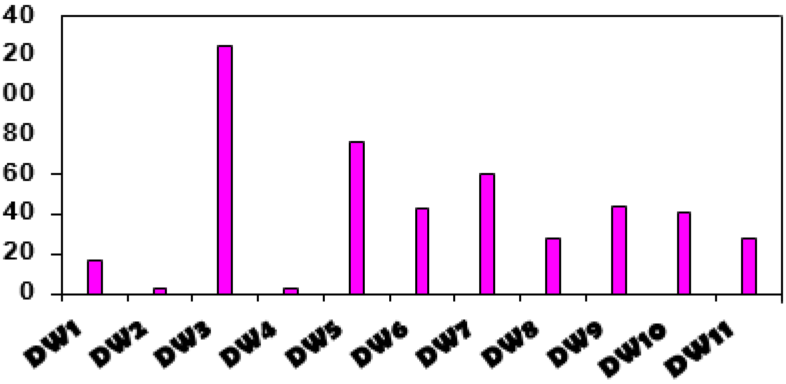


FIGURE 13. CONTENT ANALYSIS OF DUG WELL SAMPLES WITH RESPECT TO NITRATE

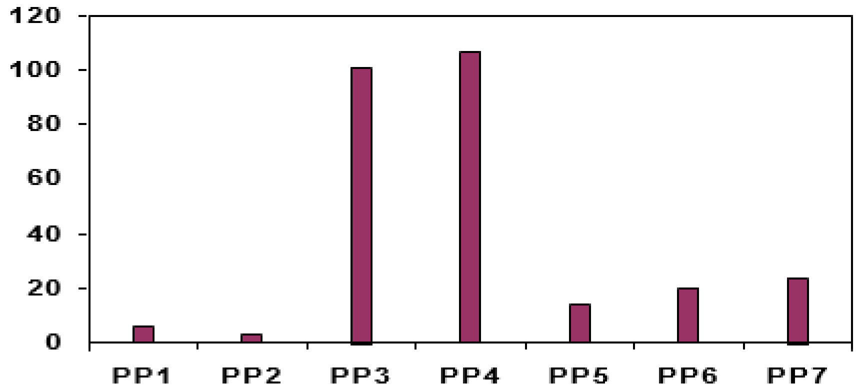


FIGURE 14. CONTENT ANALYSIS OF POWER PUMP SAMPLES WITH RESPECT TO NITRATE

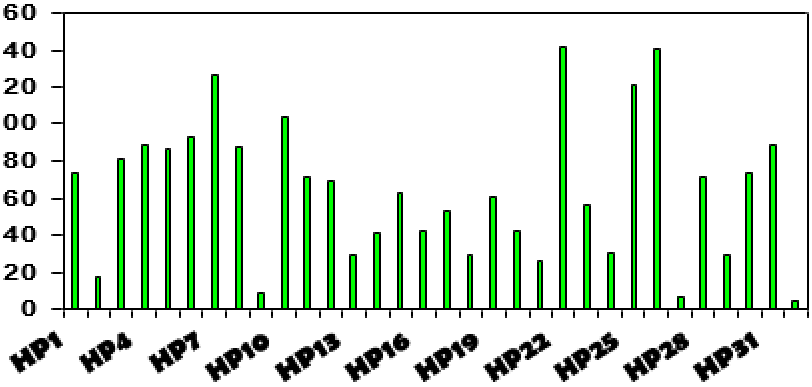


FIGURE 15. CONTENT ANALYSIS OF HAND PUMP SAMPLES WITH RESPECT TO NITRATE

CONCLUSION

The groundwater parameters in the studied area are found to be unbalanced. The groundwater sources are polluted and affecting human health. 50% sampling sites contain high concentration of nitrates. Four sampling sites from Hand pump category are not safe for drinking purpose in relation to the concentration of Iron. For most of the samples, concentration of fluoride is within the permissible limits prescribed by WHO except sample HP9. According to the study it can be suggested that the metals enter in to the groundwater and create the water pollution and increase the health problem of human and animals. Hence it is important to do the proper management of the groundwater in the studied area immediately.

ACKNOWLEDGEMENT

The authors are thankful to Prin. Dr. K. K. Deshmukh for providing the facilities and motivation.

REFERENCES:

1. *Suata Chakarbarty, Hari Prasad Sarma, fluriode, iron and nitrate contaminated drinking water in kamrup district, Assam, India, Archives of Applied science Research, 2011, 3(4):186-192.*
2. *Mariappan, P., Yegnaraman, V and Vasudeven, T.2000, Occuerence and removal possibilities of Fluoride in ground water of India. Poll. Res., 19(2), 165-177.*
3. *Suthar S, Bishnoi P, Singh S, Mutiyar P.K., Nema A.K., Patil N.S., India Journal of Hazardous Materials 171 (2009). 189-199.*
4. *APHA (American Public Health Association), Standard method for examination of water and wastewater, New York, 20th Ed. (1998).*
5. *A.K. Singh, S. Bhagawati, T.K. Das, D. Yubbe, B Rahman, M Nath, P Obing, W.S.K. Singh, C.Z.Renthlei, L.Pachuau and R. Thakur, Assessment of arsenic, fluoride, iron, nitrate and heavy metals in drinking water of northeastern India, Envis. Bulletin: Himalayan Ecology 16(1), 2008, 6-12.*

Ground Water Prospects Maping Of Chigicherla Watershed Using Remotesensing And Gis Techniques

Dr. V. Gope Naik[1], B. Ramanarasimha Rao[2], Dr. K. Bhupal[3]

[1]Assistant Professor, Dept. of Geology S.V. University, Tirupati, A.P.

[2]Research Scholar, Dept. of Geology S.V. University, Tirupati, A.P.

[3]Post Doctoral Fellow, Dept. of Geography, S.V. University, Tirupati, A.P.

ABSTRACT

Anantapur District experiences semi-arid climate. The summer months are very hot and the Mercury rises to + 420 Celsius. Winter months are pleasant, when the night temperature is about 130 Celsius to 150 Celsius. Winter months are ideal for fieldwork. However, a few field traverses were taken for this work in the summer months also. Rainfall is generally scanty. The average rainfall per annuam is 530.00 mm. In the year 2008, the recurrence of drought increased considerably and unless collective measures are initiated on a permanent basis the situation will become grim in future. Chigicherla watershed in Anantapur District is selected to demonstrate the capability of high resolution satellite data in ground water mapping at village level. This watershed is located in Survey of India toposheet Nos. 57F/10,57F/11,57F/14 and F/15. This watershed with an area of about 209 sq.km is underlined by hornblende biotite gneiss, Closepet Granite and metabasalt traversed by dolerite dykes. Ground water prospecting mapping was carried out on 1:10,000 scale using IRS-P6 LISS-IV satellite data. The satellite data facilitates to update the extent of built-up area, road and drainage network. Further, the revenue villages enclosed in the watershed are digitized, mosaiced and superimposed on Ground water prospecting map. This helps to give site specific recommendation on ground water prospects land forms wise i.e.for individual units. In addition, the impact analysis of check dams constructed in the watershed is also discussed. Studies showed that after construction of tentative check dams the water levels in well-increased Well inventory data confirmed that the various geomorphic units are classified as favorable, moderately favorable, and poor zones of groundwater.

Keywords: Integrated Ground water Prospect mapping, Watershed, Rainfall, Geomorphology

1. INTRODUCTION

The synoptic view provided by satellite remote sensing offers technologically the appropriate method for studying land and water resources, characterizing the coherent agricultural zones, and identifying the constraints/ecological problems at micro level. socio-economic and meteorological data in GIS helps arriving at locale specific prescriptions to achieve sustainable development of natural resources of any drought affected region. Remote sensing data in conjunction with sufficient ground truth data provides information on Geology, Geomorphology, Hydrology, structural/lineaments, Drainage pattern and recharge conditions which ultimately define ground water regime. Anantapur is a hot and semi arid District, falls in rain shadow zone with a very low annual rainfall of 550mm . Monsoon evades Anantapur District due to its location in the rain shadow region. South- West monsoon is prevented by the high altitudes of Western Ghats, making Anantapur District a rain shadow area and hence, agricultural conditions are more often precarious. Being far away from the East Coast, it does not also enjoy the rainfall benefit of the North-East monsoon. The recurrence of droughts increased considerably and unless collective measures are initiated on a permanent basis the situation will become grim in future. In order to demonstrate the capability of high resolution satellite data in ground water prospecting map at mandal level part of Chigicherla watershed in Anantapur District is selected. The objective of the study is groundwater prospect map corresponding to survey of India toposheet on 1:50000 scale, covering all habitations. The map shows (a) prospective zones for ground water occurrence (b) Tentative locations for constructing recharge structure. the information provided in the ground water prospects maps from a suitable database for narrowing down the target zones and systematic selections of sites for d riling of counteracting fallow up ground surveys to establish drinking water source to all non covered and partially covered habitation besides providing information for selection of sites for construction of recharge structure therefore ultimately resulted in sustainable development of watershed.

STUDY AREA:

Chigicherla watershed area Anantapur District, Andhra Pradesh state longitude 77° 48' 8.373N" latitude14 °36'45.762E" watershed area around 209 sq km. Five mandals are covered namely Anantapur, Rapatadu, Kanaganipalle, Battalapalle and Dharmavaram. TheStudy area is mostly 90% plain land and western part is residual hills ,denudational hill and some pediment are there, Anantapur district The area experiences semi-arid climate .The summer months are very hot and the Mercury rises to + 420 Celsius. Winter months are pleasant, when the night temperature is about 130 Celsius to 150 Celsius. Average rain fall per annum 550 mm in the year of 2013.

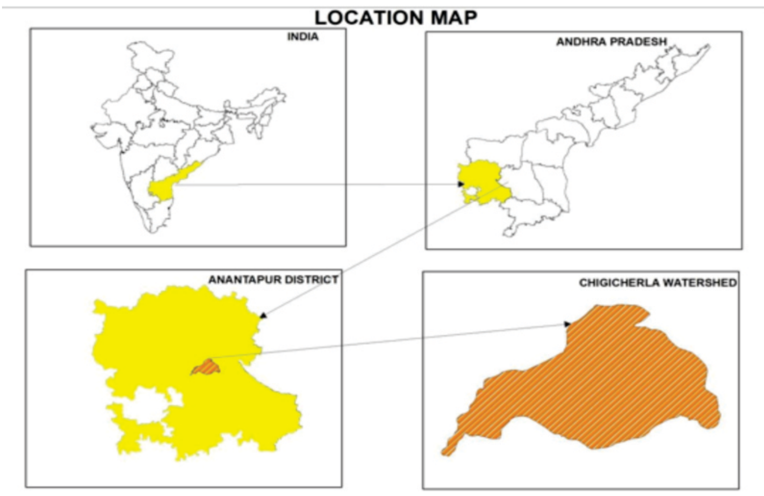
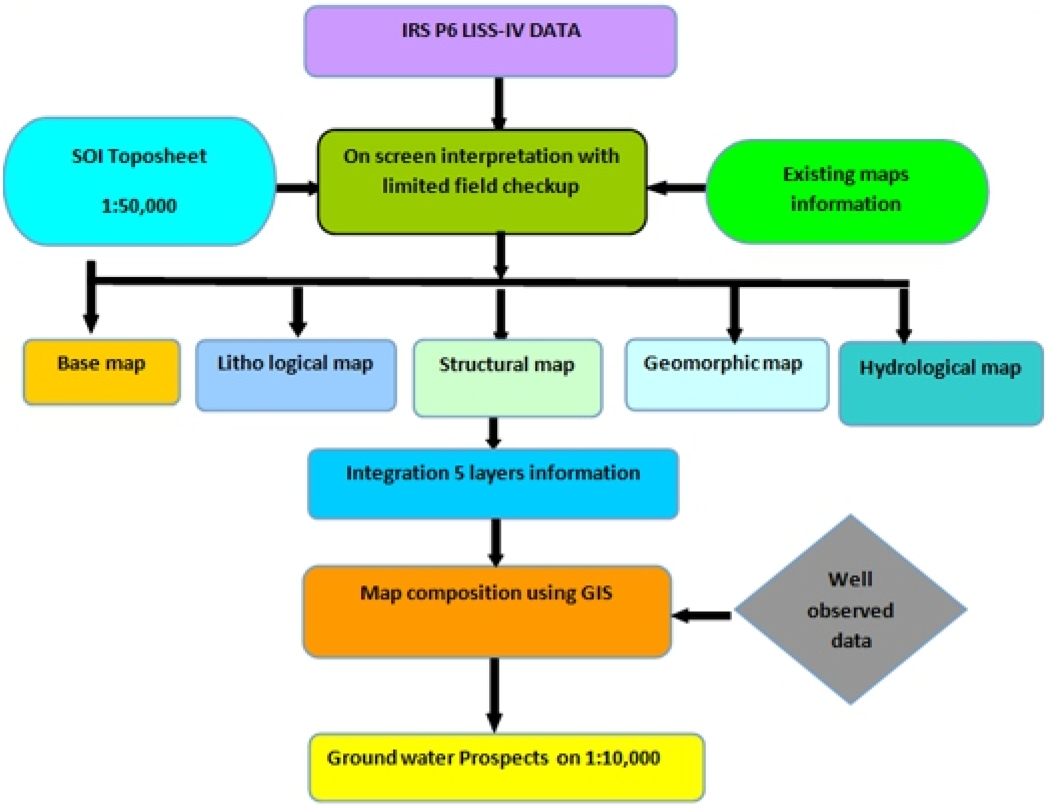


FIGURE: 1 - LOCATION MAP

METHODOLOGY:

Thematic layers is digitized and delineated using the Survey of India (SOI) toposheet of scale 1:50,000. , and IRS-P6-LISS-IV Satellite data Block and Check boundaries were delineated from the features resulted from surface modeling tools, topo map and digitized Road network. The digitized canal network The methodology is designed keeping in view the concept surplussed above it is basically a systematic procedure evolved to prepare a ground water prospects map using satellite data and GIS techniques in conjunction with limited field work various steps involved in the preparation of ground water prospects maps are furnished as a now flow chart in below:

FLOW CHART OF GROUNDWATER PROSPECTS



The total methodology can be divided into two main parts. The first part deals with the declination of hydrogeomorphic units considered parameter influencing the hydro geological properties. It consist of a) preparation of individual thematic maps i.e. lithology, Geomorphology, structures, hydrology and base map details based on the visual interpret ion of standard FCC of satellite data in conjunctive with limited field existing data and b) derivation hydrogeomorphic units by integrating the thematic data the second part deals with the evaluation of ground water condition in each hydrogemorphic unit. It consists of i) evaluation of ground water prospects based on hydrogeologial characteristic of each and every parameter. and ii) semi quantification of ground water availability by taking in account the well observatory data and iii) selection of tentative location for taking up artificial recharge structures.

The data thus generated at different stages, is converted into a digital database as per the specified standards .It is in the form of two outputs 1) all the four parameters as individual thematic maps base map also gen-rated as separated map and 2) ground water prospect map as a final output.

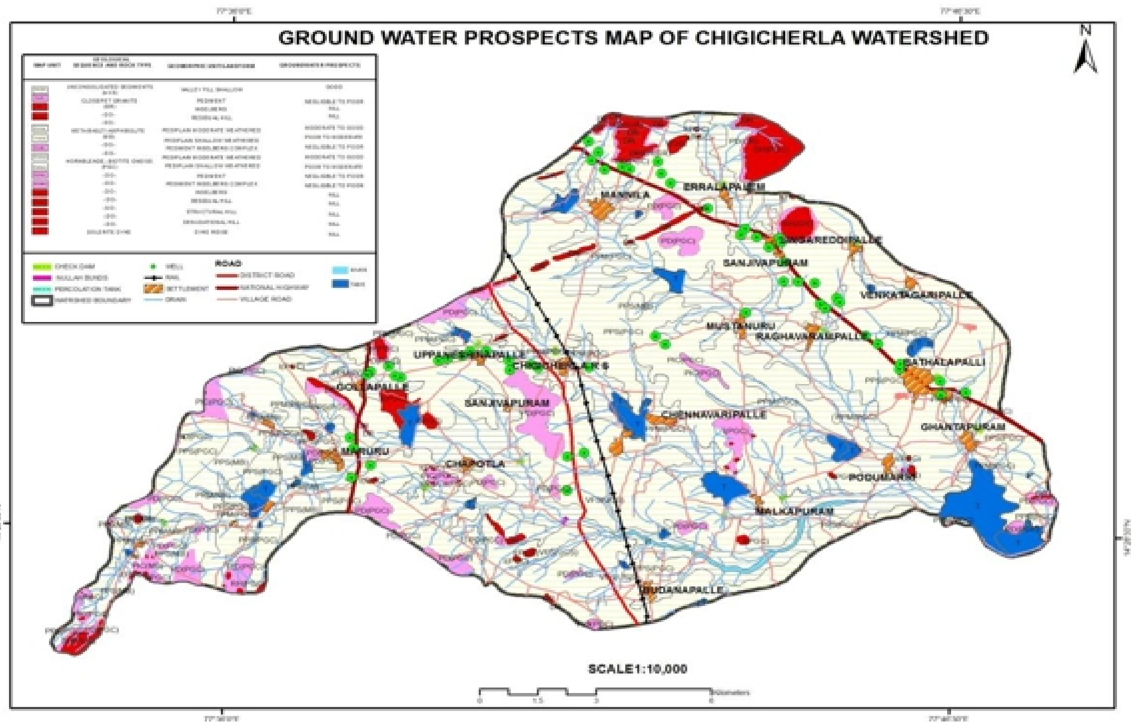


Figure:2 - Groundwater prospects map of chigicherla watershed, anantapur district, a.p

HYDRO GEOMORPHOLOGY:

Geomorphology deals with the study of land forms. The applied aspect of geomorphology is the application of descriptive geomorphology in analyzing and in understanding the conditions of occurrence of ground water. Satellite data has been used in the identification of land forms considering their spectral signatures and have been verified by extensive field work. The land forms based on their origin can be classified as Denudational, Depositional and structural in the decreasing order of incidence.

FLUVIAL LANDFORMS:

VFS (Valley Field Shallow): It constitutes unconsolidated sediments such as boulders, cobbles, pebbles, gravel, sand and silt deposited by streams/rivers normally in a narrow fluvial valley. It forms moderately productive shallow aquifers with very good ground water prospects. But, the ground water prospects vary depending upon the thickness of the fill material and its composition.

DENUDATIONAL LANDFORMS:

DH (Denudational Hill): It is a narrow linear ridge with heap of boulders of dolerite composition or steep massive ridge standing above the ground level or sometimes highlyjointed. Negligible to poor yields are expected in this landform. Moderate yields are expected in the upstream direction.

PPM-Gr (Pediplain moderately weathered): This unit is mostly observed along the channel fills with a little lateral spread. It is also seen in the ayacut areas of tanks. The secondary porosity in the form of fractures and the loose gravely material help in the infiltration. As a result the percolation rate is much higher compared to the Shallow Weathered Pediplain. The aquifer will be in the underlying fractured rock. The ground water prospects can be considered as good.

PPS-Gr (Pediplain Shallow Weathered): The Pediplain shallow develops partly by erosional and partly. This will have a thin deposition of weathered material, i.e., up to 10mts. Weathered material can't have an aquifer. But the in the field quite a few bore wells are observed. Yielding considerable quantity indicating moderately good ground water prospects. This clearly points to the fact that there must be secondary porosity that helps the surface water to infiltrate in to the sub-surface. The underlying fractured rock acts as an aquifer.

PD- Gr (Pediment): It is a gently sloping smooth surface of erosional bedrock of granite gneiss between hill and plain with thin veneer of detritus. This unit forms runoff zones with limited prospects along favorable locales. In general, the ground water prospects in this landforms are poor.

PIC (Pediment Inselberg Complex): As in the above case, the ground water conditions are limited if the unit is dissected by lineaments and poor if it un-dissected and unweathered.

[

DR (Dyke Ridge): It is a narrow linear ridge with heap of boulders of dolerite composition or steep massive ridge standing above the ground level or sometimes highly jointed. Negligible to poor yields are expected in this landform. Moderate yields are expected in the upstream direction.

Structural Land forms: As stated earlier this has restricted distribution. The prospects are also restricted especially in an un weathered outcrop. The weathered pediment may have limited prospects, but the un weathered one will have poor prospects.

SH-MB (Structural Hill): These are linear to arcuate hills of Meta basalt with narrow valleys showing definite trend lines. The ground water prospects are negligible. Moderate prospects are observed along valleys.

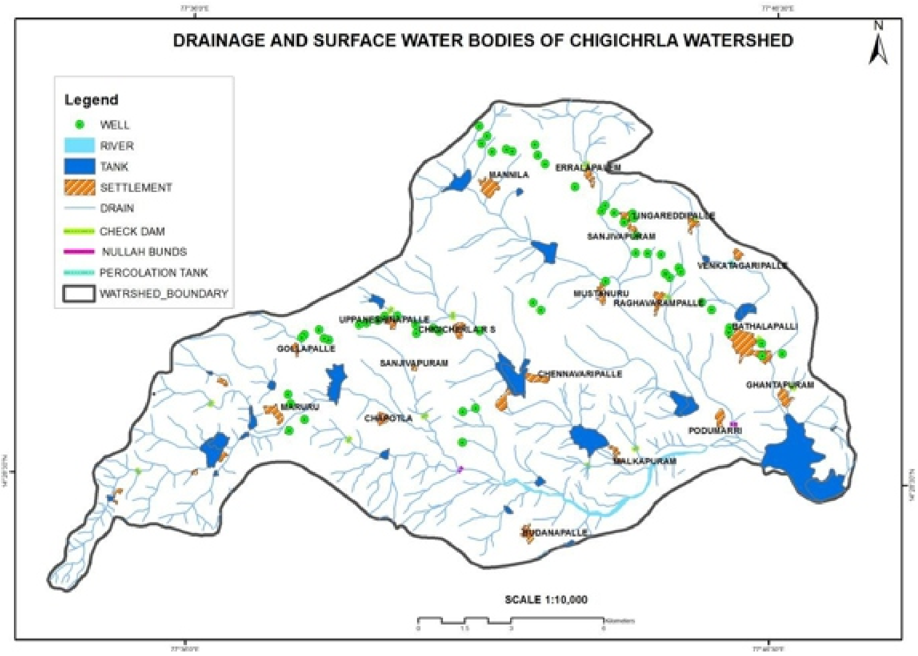


Figure: 3 - Drainage and surface water bodies of chigicherla Watershed anantapur district, a.p

CONCLUSIONS:

The Indian Remote Sensing satellite (IRS P6 LISS-IV) data with a spatial resolution of 5.8m can be enlarged even up to 1:4,000 scales. With the help of high resolution data, expansion of rural settlements, drainage and road network is updated. The boundaries of all geomorphic units are drawn more precisely. With the advent of high resolution satellite data, site-specific recommendations for ground water exploration at for effective management of ground water resources at smallest possible revenue boundary i.e. The effect of check dams resulted in stabilizing the water levels in the wells, increasing the pumping hours, rejuvenating the abandoned wells, and resulting increase in irrigated area.

REFERENCES:

[1] APSRAC (A.P. State Remote Sensing Applications Centre) 1997, Integrated Study to Combat Drought, Anantapur District, Andhra Pradesh, Project Report,102p.

[2] Eswar Reddy, G., 2011, Integrated hydrogeological studies of ground water using spatial technology, in parts of Anantapur district, A.P, India. Unpublished Ph.D. Thesis, S.V. University, Tirupati, Andhra Pradesh.

[3] NRSA (National Remote Sensing Agency) 2008, Ground Water Prospects Mapping Using Remote Sensing and Geographic Information System, Rajiv Gandhi National Drinking Water Mission Project, Manual,256p.

[4] Raghu, V., & Mruthyunjaya Reddy, K., 2011, Hydrogeological Mapping at village level mapping of Akuledu vanka Watershed Anantapur District A.P.

[5] Ramkumar, T., Venkatramanan, S., Anita Mary, I., Tamil Selvi, M., and Ramesh,

G. 2010, "Hydrogeochemical quality of groundwater in Vedaraniyam town", Tamilnadu, India. Res J Environ Earth Sciences 2: 44-48.

[6] Sambasiva Rao, T., 1987, Hydrogeology of upper Nagari river basin, Chittoor District, Andhra Pradesh, India. Unpublished Ph.D. Thesis, S.V. University, Tirupati.

[7] Sreenivasa Rao. Y., Krishna Reddy, T.V., and Naidu, P.T., 1997, Hydrogeomorphological studies by using remote sensing application in Niva River Basin, Chittoor District, A.P. J. Indian Soc.Remote Sensing,25(3P):187-194.

[8]Tijani, M.N., 1994, Hyrogeochemical assessment of groundwater in Moro area, Kwara State, Nigeria, Journal of Environmental Geology. Springer- Verlag 24, pp. 194- 202.

Influence Of Copper Slag As Fine Aggregate On The Workability And Compressive Strength Of Concrete

Er. Harpreet Singh[1], Er. Gurprit Singh Bath[2]
[1]Assistant Professor, Department of Civil Engineering, SUSEC, Tangori, Mohali.
[2]Associate Professor & Head, Department of Civil Engineering, GZSPTU Campus, Bathinda.

ABSTRACT

Many countries are witnessing a rapid growth in the construction industry which involves the use of natural resources for the development of the infrastructure. In order to reduce dependence on natural aggregates as the main source of aggregate in concrete, artificially manufactured aggregates and artificial aggregates generated from industrial wastes provide an alternative for the construction industry. The present study encouraged the utilization of industrial waste copper slag as replacement of natural aggregates in concrete. The results indicate that the workability of concrete increases significantly with the increase of copper slag content in concrete mixes. The use of copper slag in concrete increases the compressive strength of more than 30% as compared to control mixture. It is recommended that up to 40% of copper slag can be use as replacement of fine aggregates.

Keywords: Cement, Copper slag, Compressive Strength, Workability.

1. INTRODUCTION

Many countries are witnessing a rapid growth in the construction industry which involves the use of natural resources for the development of the infrastructure. This growth is jeopardized by the lack of natural resources that are available. The sustainable development for construction involves the use of non-conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways for conserving the environment. Aggregates are considered one of the main constituents of concrete since they occupy more than 70% of the concrete matrix. Therefore, utilization of aggregates from industrial wastes can be alternative to the natural and artificial aggregates. In the last few decades there has been rapid increase in the waste materials and by-products production due to the exponential growth rate of population, development of industry and technology and the growth of consumerism. The basic strategies to decrease solid waste disposal problems have been focused at the reduction of waste production and recovery of usable materials from waste as raw materials as well as utilization of waste as raw materials whenever possible. The beneficial use of byproducts in concrete technology has been well known for many years and significant research has been published with regard to the use of materials such as coal fly ash, pulverized fuel ash, blast furnace slag and silica fume as partial replacements for Portland cement. Such materials are widely used in the construction of industrial and chemical plants because of their enhanced durability compared with Portland cement. The other main advantage of using such materials is to reduce the cost of construction. (Al-Jabri et al 2009). Copper slag (CS) is one of the materials that is considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates (Shi et al 2008). It is a by-product obtained during the smelting and refining of copper. Therefore, numerous contemporary researches have focused on the application of copper slag in cement and concrete production as a suitable path towards sustainable development. Several researchers have investigated the possible use of copper slag as cement, fine and coarse aggregates in concrete and its effects on the different mechanical and long term properties of mortar and concrete. (Khanzadi and Behnood 2009., Najimi and Pourkhorshidi 2011). The use of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. The addition of copper slag as fine aggregate in various bituminous mixes improves interlocking and eventually improves the volumetric properties as well as the mechanical properties of the mixes (Pundhir et al 2005).

MATERIAL AND METHODS

MATERIALS USED

In the present study, ordinary Portland Cement (OPC) of 43 grade type cement and a copper slag obtained from Synco Industries Limited located at Jodhpur (Rajasthan) was used in concrete mixtures. Properties of the OPC cement were given in Table 1. The physical and chemical properties of copper slag are given in Table 2 & 3 respectively. The sand was conforming to grading zone II as per IS 383-1970. The sieve analysis of fine aggregates and coarse aggregates are given in Table 4 & 5respectively.

TABLE 1: PROPERTIES OF OPC 43 GRADE CEMENT

Sr. No	Characteristics	Value Obtained experimentally	Values specified by IS: 8112-1989
1	Specific Gravity	3.17	-
2	Standard consistency	31%	-
3	Initial Setting time	152 minutes	30 minutes (minimum)
4	Final Setting time	260 minutes	600 minutes (maximum)
5	Compressive Strength 3 days	26.60 N/mm2	23 N/mm2
	7 days	34.97 N/mm2	33 N/mm2
	28 days	47.65 N/mm2	43 N/mm2

Table 2: Physical properties of copper slag (source: synco Industries limited, jodhpur)

S.No	Physical properties	Copper slag
1	Particle shape	Irregular
2	Appearance	Black & glassy
3	Type	Air cooled
4	Specific gravity	3.51
5	Bulk density (g/cm3)	1.9 - 2.4
6	Hardness	6 - 7mohs

Table 3: Chemical Properties Of Copper Slag (source: Synco Industries Limited, Jodhpur)

S.No	Chemical component	% of Chemicalcomponent
1	SiO_2	28%
2	Fe_2O_3	57.50%
3	Al_2O_3	4%
4	CaO	2.50%
5	MgO	1.20%

Table 4: Sieve Analysis Of Fine Aggregates

IS- Sieve Designation	Weight Retained on sieve (g)	%age Weight retainedon sieve	Cumulative% age weight retained on	%age passing	%age passing for grading zone-II as per IS: 383-1970
10 mm	Nil	Nil	Nil	100	100
4.75 mm	45	9	9	91	90-100
2.36 mm	26	5.2	14.2	85.8	75-100
1.18 mm	70	14	28.2	71.8	55-90
600 micron	102	20.4	48.6	51.4	35-55
300 micron	124	24.8	73.4	26.6	30-Aug
150 micron	121	24.2	97.6	2.4	0-10

Table 5: Sieve Analysis Of Proportioned Of Coarse Aggregates

IS- Sieve Designation	50:50 Proportion (10 mm: 20mm) Weight Retained	Cumulative weight retained (g)	Cumulative %age weight retained	% age passing	IS: 383-1970 Requireme
80 mm	Nil	Nil	Nil	100	100
40 mm	Nil	Nil	Nil	100	100
20 mm	4.5	4.5	0.225	99.775	95-100
10 mm	1286	1290.5	64.525	35.475	26-55
4.75 mm	640.5	1931	96.55	3.45	0-10

CONCRETE MIXES AND MIX PROPORTIONS

In this experimental program, to determine the values of compressive strength of a control mix without copper slag was prepared. The 5 mixes were prepared other than control mix at different replacement levels of CS (0%, 20%, 40%, 60%, 80% & 100%). Fine aggregate was replaced with copper slag. The water/cement (w/c) ratio in all the mixes was kept 0.43. The specimens were tested after 7, and 28 days of curing. The ratio of different materials used in each mix and mix designation are shown in Table 6.

TABLE 6: MIX PROPORTIONS OF DIFFERENT CONCRETE MIXES

Mix	W/C Ratio	CS%	CS (Kg/m3)	Fine Aggregates (Kg/m3)	Coarse Aggregates (Kg/m3)	Water (L/m3)	Cement (Kg/m3)
C1	0.43	0%	0	548.55	1167.7	186	432.56
C2	0.43	20%	109.71	438.84	1167.7	186	410.93
C3	0.43	40%	219.42	329.13	1167.7	186	389.3
C4	0.43	65%	329.13	219.42	1167.7	186	367.67
C5	0.43	80%	438.84	109.71	1167.7	186	346.04
C6	0.43	100%	548.55	0	1167.7	186	410.93

PREPARATION AND CASTING OF TEST SPECIMENS

For determining the Compressive strength of concrete, moulds of size 150mm x 150mm x 150mm were used. All the specimens were prepared in accordance with Indian Standard Specifications IS 516-1959. After casting, test specimens were removed from the moulds after 24 hours of casting and were placed in the water tank. Specimen was taken out from the curing tank for testing after 7 and 28 days of curing.

WORKABILITY OF CONCRETE

Workability is that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated, and finished. Workability is not just based on the properties of the concrete, but also on the nature of the application. The strength and durability of hardened concrete, in addition to labour costs, depend on concrete having appropriate workability. Workability test methods have been classified in terms of the type of flow produced during the test. Compaction factor test was used for finding workability of freshly prepared concrete in laboratory in this research.

COMPRESSIVE STRENGTH OF CONCRETE

The quantities of cement, coarse aggregates (20 mm and 10 mm), fine aggregates, copper slag and water for each batch i.e. for different percentage of copper slag were weighed separately. The cement, copper slag and fine aggregates were mixed in dry form. The coarse aggregates were mixed to get uniform distribution throughout the batch. Water was added to the mix and then mixed thoroughly for 3 to 4 minutes in mechanical mixer. Cube moulds were cleaned and oil was applied on its inner surface. The mould was filled 1/ 3 with the concrete and manual compaction was done with 25 strokes of tamping rod. Again the process was repeated 2 more times for completely filling the mould. The surface of the concrete was finished level with the top of the mould. The finished specimens were left toharden in air for 24 hours. The specimens were removed from the moulds after 24 hours of casting and were placed in the water tank filled with potable water in the laboratory. Specimens were taken out from the curing tank at the ages of 7 and 28 days. Surface water was wiped off and specimens were immediately tested on removal from the curing tank. The compressive strength of concrete cubes was found on Compression Testing Machine (CTM) by applying load gradually without shock till the failure of the specimen occurs.

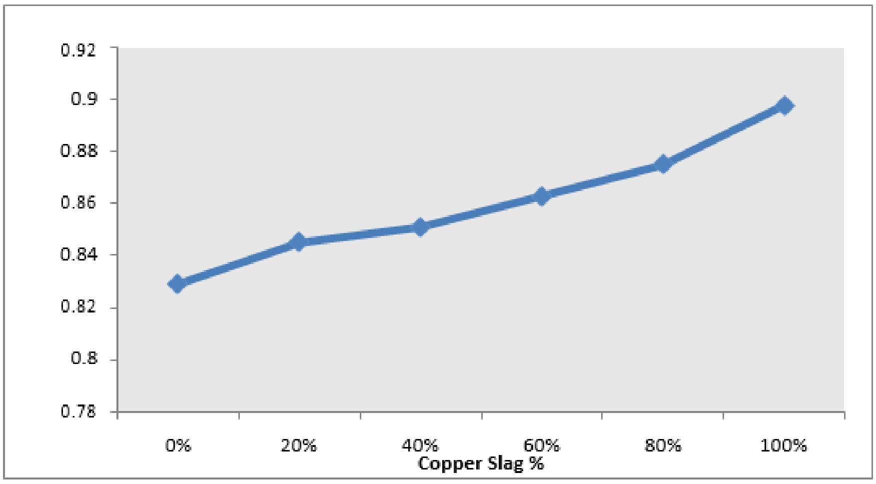
RESULTS AND CONCLUSIONS

WORKABILITY OF CONCRETE

Workability of concrete was tested using compacting factor test apparatus immediately after preparing fresh concrete. The value of compacting factor for each mix is given in Table 7. The compacting factor of concrete with different replacement levels of fine aggregate with copper shown in Figure 1. The compacting factor of each mix is given in Table 7.

Table 7: Workability Of Concrete

Mix Designation	Weight of Partially Compacted Concrete (Wp) (kg)	Weight of Fully Compacted Concrete, (Wf) (kg)	Compacting Factor (W_P/W_f)	Degree of Work ability
C1	7.33	8.842	0.829	High
C2	7.84	9.278	0.845	High
C3	7.73	9.083	0.851	High
C4	7.78	9.015	0.863	High
C5	7.91	9.041	0.875	High
C6	7.66	8.53	0.898	High



Compacting Factorfigure 1: Compacting Factor Of Concrete With Different Replacement Levels Of Fine Aggregates With Copper Slag

From Figure 1, it is clear that the workability of concrete increases significantly with the increase of copper slag content in concrete mixes. For the control mixture (i.e. Mix C1), the compacting factor was .829 whereas for Mix C6, with 100% replacement of copper slag, the compacting factor was .898. This considerable increase in the workability with the increase of copper slag quantity is attributed to the low water absorption characteristics of copper slag and its glassy surface compared with fine aggregates. The glassy surface of copper slag increases the free water content in the mix hence increases the workability of concrete.

COMPRESSIVE STRENGTH OF CONCRETE

The compressive strength of all the mixes was determined at the ages of 7 and 28 days for the various replacement levels of copper slag with fine aggregates. The values of average compressive strength for different replacement levels of copper slag (0%, 20%, 40%, 60%, 80% and 100%) at the end of different curing periods (7 days & 28 days) are given in Table 8 . These values are plotted in Figure 2 & Figure 3.

Table 8: Test Results For Compressive Strength Of Concrete

Mix	Compressive Strength in N/mm	
	7 Days	28 Days
C0 (Copper Slag 0%)	21.54	32.31
C20 (Copper Slag 20%)	25.5	38.25
C40 (Copper Slag 40%)	28.76	43.15
C60 (Copper Slag 60%)	24.61	36.91
C80 (Copper Slag 80%)	19.41	29.12
C100 (Copper Slag 100%)	16.78	25.18

From Figure 2 and Figure 3 it can be observed that the compressive strength of concrete is increased as copper slag content increases up to 40%, beyond that compressive strength was significant decreases due to increases free water content in the mixes. The excessive free water content in the mixes with copper slag content causes the bleeding and segregation in concrete. Therefore, it leads reduction in the concrete strength. The highest compressive strength was achieved with 40% replacement of copper slag, which was found about 43.15N/mm2. This indicates that there is an increase of compressive strength of more than 30% compared to the control mix. In 100% replacement of fine aggregates with copper slag shows the compressive strength of 25.18N/mm2. It is recommended that up to 40% of copper slag can be use as replacement of fine aggregates.

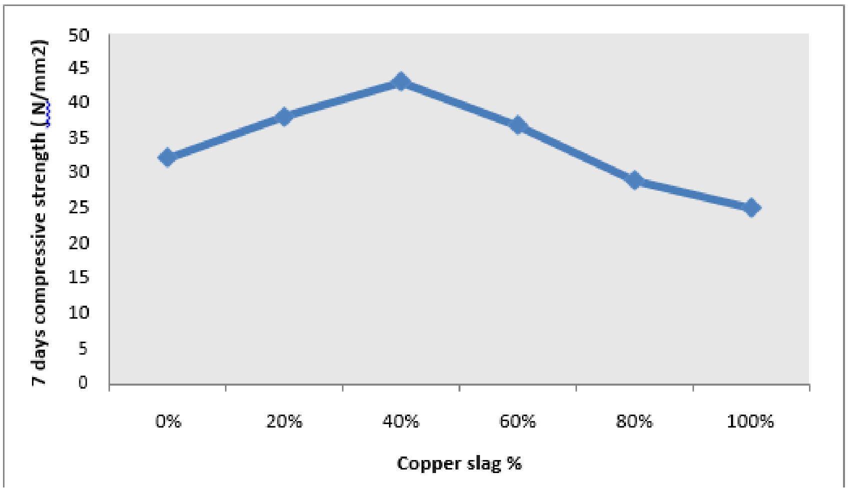


Figure 2: 7 Day's Compressive Strength Of Concrete With Different Replacement Levels Of Fine Aggregates With Copper Slag

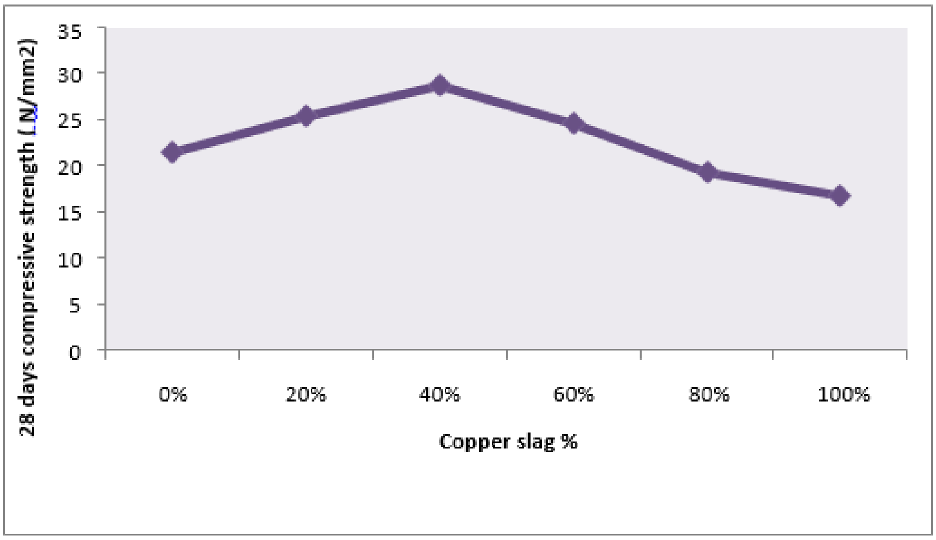


Figure 3: 28 Day's Compressive Strength Of Concrete With Different Replacement Levels Of Fine Aggregates With Copper Slag

CONCLUSIONS

1. The workability of concrete increases significantly with the increase of copper slag content in concrete mixes. The glassy surface of copper slag increases the free water content in the mix hence increases the workability of concrete.

2. The compressive strength of concrete is increased as copper slag content increases up to 40%, beyond that compressive strength was significant decreases due to increases free water content in the mixes.This indicates that there is an increase of compressive strength of more than 30% compared to the control mix. It is recommended that up to 40% of copper slag can be use as replacement of fine aggregates.

REFERENCES

1. *Al-Jabri K S, Al-Oraimi S K, Al-Saidy A H and Hisada M (2009) Copper slag as sand replacement for high performance concrete. CemConcr Compos 31:483–88.*
2. *IS: 383-1970 (Reaffirmed 1997): Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1997.*
3. *IS: 456-2000: Code of practice- plain and reinforced concrete, Bureau of Indian Standard, New Delhi-2000.*
4. *IS: 516-1959 (Reaffirmed 2004): Methods of tests for strength of concrete, Bureau of Indian Standard, New Delhi-2004.*
5. *IS: 8112-1989 (Reaffirmed 2005): Specification for 43 grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi-2005.*
6. *Khanzadi M and Behnood A (2009) Mechanical properties of high-strength concrete incorporating copper slag as coarse aggregate. Constr Build Mater23(6):2183–88.*
7. *Najimi M and Pourkhorshidi A R (2011) Properties of concrete containing copper slag waste. Mag Concr Res63(8):605-15.*
8. *Najimi M, Sobhani J and Pourkhorshidi A R (2011) Durability of copper slag contained concrete exposed to sulfate attack. Constr Build Mater25:1895–1905.*
9. *Pundhir N K S, Kamaraj C and Nanda P K (2005) Use of copper slag as construction material in bituminous pavements. J Sci Ind Res 64:997-1002.*
10. *Shi C, Meyer C and Behnood A (2008) Utilization of copper slag in cement and concrete. Resour Conserv Recycl 52:1115-20.*

Instructions for Authors

Essentials for Publishing in this Journal

1 Submitted articles should not have been previously published or be currently under consideration for publication elsewhere.

2 Conference papers may only be submitted if the paper has been completely re-written (taken to mean more than 50%) and the author has cleared any necessary permission with the copyright owner if it has been previously copyrighted.

3 All our articles are refereed through a double-blind process.

4 All authors must declare they have read and agreed to the content of the submitted article and must sign a declaration correspond to the originality of the article.

Submission Process

All articles for this journal must be submitted using our online submissions system. http://enrichedpub.com/ . Please use the Submit Your Article link in the Author Service area.

Manuscript Guidelines

The instructions to authors about the article preparation for publication in the Manuscripts are submitted online, through the e-Ur (Electronic editing) system, developed by **Enriched Publications Pvt. Ltd**. The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 16 pages of A4 paper format.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable. For indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well. The titles precede the abstract and the summary in an appropriate language.

Letterhead Title

The letterhead title is given at a top of each page for easier identification of article copies in an Electronic form in particular. It contains the author's surname and first name initial .article title, journal title and collation (year, volume, and issue, first and last page). The journal and article titles can be given in a shortened form.

Author's Name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form.

Contact Details

The postal address or the e-mail address of the author (usually of the first one if there are more Authors) is given in the footnote at the bottom of the first page.

Type of Articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification. Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on management methods).

2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);

3. Short or preliminary communication (original management paper of full format but of a smaller extent or of a preliminary character);

4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on management argumentation) and commentaries. Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250- Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

Citation in the text must be uniform. When citing references in the text, use the reference number set in square brackets from the Reference list at the end of the article.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

The article should be accompanied with a cover letter with the information about the author(s): surname, middle initial, first name, and citizen personal number, rank, title, e-mail address, and affiliation address, home address including municipality, phone number in the office and at home (or a mobile phone number). The cover letter should state the type of the article and tell which illustrations are original and which are not.

Notes