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Assessing Ground Water Quality using GIS

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Abstract- **Groundwater is an important component of our nation's fresh water resources. It plays a key role in meeting the water needs of various user-sectors in the nation. The natural resource cannot be optimally used and sustained unless the quality of water is assessed. In the present study, the impact of mining activities on groundwater quality around the Korba coalfields covering an area of 530 sq.km which lies between latitudes 22°15′ and 22°30′N and longitudes 82°15′E and 82°15′E in the state of Chhattisgarh, India was carried out. For the study, data collection includes maps, toposheets, water quality data, well locations, mining lease areas, village locations etc. The above said data has been collected from various government departments of Chhattisgarh. After the data collection, base map has been prepared using ArcMap 9.3. The water quality database is analyzed and then used as attribute database for the preparation of thematic maps showing distribution of various water quality parameters. Water Quality Index has been calculated for various parameters such as pH, Turbidity, Total hardness(TH), Chloride, Total dissolved solids(TDS), Calcium, Nitrate, Iron, and Fluoride. Water Quality Index map is also developed. The results obtained are presented in the form of maps, used for better understanding of present water quality scenario of the study area. Analysis reveals that the groundwater of the region needs field specific treatment before put to use.**

Keywords: Arc GIS, Ground water quality, Mining environment, WQI

I. INTRODUCTION

Groundwater is almost globally important for human being consumption as well as for the support of habitat and for maintaining the quality of base flow to rivers. Usually they are of excellent quality. Being naturally filtered in their way through the ground, they are generally clear, colourless, and free from microbial contamination and require minimal treatment. A threat is now posed by an ever-increasing number of soluble or dissolved chemicals from urban, industrial activities and from modern agricultural practices. The chemistry of groundwater reflects inputs from the atmosphere, from soil and water-rock reactions, as well as from pollutant sources such as mining, land clearance, agricultural practices, and acid rainfall, domestic and industrial wastes. Once the groundwater is polluted, its quality cannot be restored by stopping the pollutants from the sources. GIS has emerged as a powerful tool for storing, analyzing, and displaying spatial data and using these data for decision making in several areas including engineering and environmental fields.

GIS is used as an effective tool for developing solutions for water resources problems for assessing and mapping of ground water quality, understanding the natural environment and managing water resources on a required scale, assessing groundwater vulnerability to pollution.

In developing countries like India around 80% of water borne diseases is directly related to poor drinking water quality and unhygienic conditions. Assessment of water quality of drinking water supplies has always been paramount in the field of environmental quality management. A study on ground water quality analysis was carried out for coonoor taluk in Nilgiris district. A study on Ground Water Quality mapping in Municipal Corporation of Hyderabad using GIS techniques was done by S.S. Asadi; et.al. (2007).

There is need for a definite strategy and guidelines which would concentrate on specific part of a groundwater management, means the protection of ground water from contamination.

II. STUDY AREA

Korba district is located in East- central part of Chhattisgarh, India covers an area of 7145.44 sq. km and is known as the power capital of state. It lies between Latitude 22°01′50″ to 23˚01′20″ N and longitude 82˚07′20″ to 83˚07′50″E; and 304.8m above mean sea level. Korba district is inhabited mainly by tribes including the protected tribe Korwas. The river Hasdeo-a tributary of Mahanadi – enters and flow through the district. River Hasdeo is the principal river of the district entering from Surguja district and flowing through the rocky and wooded grounds of Matin Uprora and plain of Champa. Its total length is 233 km with its tributaries Gagechorai, Tan and Ahiran .The district is known for its coal mines, Ferruginous Sandstone with shale and coal seams

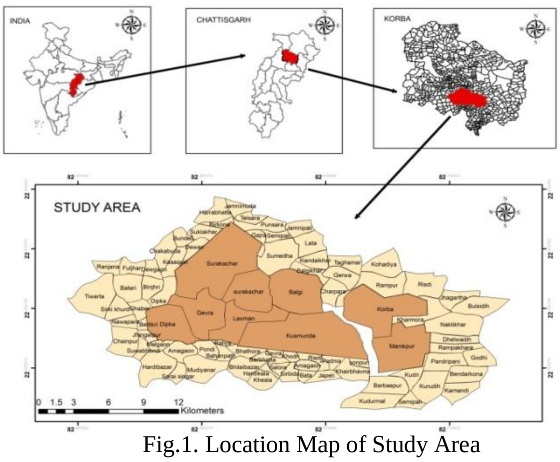

Fig.1. Location Map of Study Area

from Kamthi formation, Gondwana Super group are exposed in Eastern part of district. Base map of study area is prepared and shown in (Fig.1).

III. DATA AND METHODS

A. Groundwater Quality Data: The ground water samples are collected manually from bore wells, tube wells and dug wells which were approximately equally distributed all over 77 villages around mining region by PHE department. More than 145 samples were collected and analysed during the period of 2012. The ground water sampling locations are shown in (Fig. 2). Sterilized bottles used for water sample collection are first thoroughly washed with the water being sampled and rinsed for 5mins and then filled with water. After collection of samples, the samples are preserved and shifted to the laboratory for Department, Korba and CGWB Raipur. In situ measurement was adopted to determine unstable parameters includes; PH, turbidity and TDS by portable instruments. All the water quality parameters are expressed in mg/l except pH and turbidity. Each parameter was compared to desirable standard limit of that parameter stipulated for drinking water as prescribed by BIS Standards(1991) and WHO(1983) for drinking and public health purposes .The parameters which are analyzed during water analysis are pH, turbidity, chlorides, nitrate, fluoride, iron, calcium, total dissolved solids, and total hardness.

B. Preparation of spatial database: In order to capture the spatial variation of ground water quality in Korba district, spatial analysis with GIS was conducted. For the development of data base, twenty toposheets (64-J-1, 64-J-2,64-J-3, 64-J-5, 64-J-6, 64-J-7, 64-J-8, 64-J-9, 64-J-10, 64-J-11, 64-J-12, 64-J-14, 64-J-15, 64-J-16, 64-N-2, 64-N-3, 64-N-4, 64-K-5, 64-K-9, 64-K-10) of 1:50000 scale covering the entire Korba district were geo-referenced using four control points. Based on the location data, location map of study area, point feature showing the position of 77 wells are marked and map for the same has been generated.

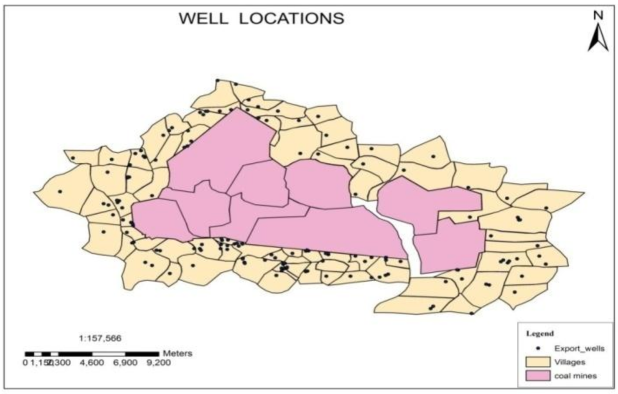

Fig. 2.Ground Water Sampling Locations

C. Preparation of Non Spatial Database: The study is carried out with the help of two major components: village boundary map and field data. The samples were tested using standard procedures in the laboratory and analysed. The ground WQI value for each village was calculated. The ground water quality data thus obtained forms the attribute database for the present study.

D. Determination of Water Quality Index: Determining water quality index is to convert complex or complicated water quality data into information that is understandable and usable by public. Thus WQI is useful and effective method which can be termed as an indicator of ground water quality.

In the study, WQI was calculated by using the Weighted Arithmetic Index Method as described by (Cude, 2001). In this method, the water quality components are multiplied by weighting factor and then aggregated by simple arithmetic mean. For assessing the ground water quality in this study, first of all, the quality rating scale (Qi) for each parameter was estimated by using the following eq ,

$$Q_i = \{[(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal})] \times 100\} \quad (1)$$

Where,

Q_i=Quality rating of ith parameter for total of n water quality parameters

V_{actual} = Actual value of water quality parameter obtained from laboratory test

V_{ideal}= Ideal value of that same water quality parameter can be obtained from standard table

V_{ideal} for pH = 7 and for other parameters it becomes zero.

$V_{standard}$ = Recommended BIS standard of water quality parameter (BIS 10500., 1991) and shown in Table I.

Table I. Water Quality Parameter and their BIS Standards

Parameter	Standard
pH	8.5
Turbidity	5
Chloride	250
Total Hardness(as Caco$_3$)	300
Iron	0.3
Fluoride	1.0
Calcium	75
TDS	500
Nitrate	45

All parameters are in mg/L except pH(unitless) and turbidity (NTU).

Then after calculating the quality rating scale (Q_i), the Relative weight (W_i) was estimated by a value inversely proportional to the recommended standard (S_i) for the corresponding parameterusing the following equation;

$$W_i = 1/S_i \quad (2)$$

Where, W_i = Relative weight of nth parameter

S_i= Standard permissible value of nth parameter

At last, the overall WQI was determined by aggregating the quality rating with the relative weight linearly by using the following expression;

$$WQI = \sum Q_i W_i / \sum W_i \quad (3)$$

In this study the WQI was considered for human consumption and for drinking purpose. The maximum ground WQI for the drinking water was considered as 100score. Based on the WQI values, the ground water quality is rated as excellent, good, poor, very poor and unfit or unsuitable for drinking and is shown in table II.

Table II. Water Quality Index Levels

Water Quality Index	Description
0-50	EXCELLENT
51-100	GOOD
101-200	POOR
201-300	VERY POOR
>300	UNFIT FOR DRINKING(UFD)

E. Generation of Maps: The spatial and non spatial (attribute) data bases generated were integrated for the generation of the spatial distribution maps of all water quality parameters including WQI map. The water quality data (non spatial data) is linked to the sampling location (spatial data) to generate various thematic maps. The flow chart explaining methodology is given in (Fig.3).

IV. RESULTS AND DISCUSSION

A. Groundwater Quality Variation: Ground water quality maps are important and helpful in assessing the usability of water for various purposes mainly for drinking. The variations of physicochemical characteristics along with WQI of ground water in the different villages surrounding mining region were presented .The quality of ground water shows variations from place to place and time to time. Means even at same location the ground water quality deviates from seasons to seasons. It is dependent upon both surface and sub subsurface characteristics. The quality of ground water changes because of many reasons such as due to presence of landfills, open dumps, use of fertilizers, disposal of industrial wastes, due to mining activities, no underground drainage system, continuous burning of MSW(Municipal solid waste) etc. The variations of physicochemical parameters (water quality) were discussed below.

1. pH: pH is one of the most vital operational water quality parameters with the optimum pH required within the range from 6.5 -8.5. The maximum permissible limit for in drinking water as given by BIS is 8.5.The value of pH in the ground water data collected varied from the range 5.05 to 8.00.Most of the villages around mining region are having pH less than 6.5 which may cause tuberculation in water supply systems. This shows that ground water of study area is mainly acidic. Spatial distribution of pH concentrations are shown in (Fig. 4).

2. Turbidity: The concentrations of turbidity are not within the range for most of the villages. Most of the villages have high turbid waters ranging from 10-80 NTU. Out of 77 villages, 27 villages are well within the range 0-10 NTU. Hence special care is compulsorily needed while disinfecting the water before supplying to the public. Spatial distribution of Turbidity is shown in (Fig. 5).

3. Chloride: Chloride is present at varying concentration in natural waters depending upon the geochemical conditions. Chloride concentrations may occur due to industrial waste, sewage disposal, leaching of saline residues in the soil. Presence of high concentration of chloride produces salty taste in drinking water. Chloride concentrations can be removed by electrolysis and reverse osmosis process. Water quality data collected indicates that chloride concentration ranges from 0 mg/l to 130 mg/l which is within desirable limit. spatial distribution of Chloride are shown in (Fig. 6).

4. Total Hardness: Hardness in water is caused due to presence of carbonates and bicarbonates of calcium and magnesium, chlorides, nitrates and sulphates of calcium and magnesium. High concentration of total hardness is found in some villages like Ranjana, Kasaipali, Dewgaon, Binjhari, Bhilaibazar, Barbaspur, Kudurmal and Kurudih are above permissible limit. Most of the villages are within the desirable limit. Softening of water may be required to impart palatability to water. Spatial distribution of Total Hardness is shown in (Fig. 7).

5. Iron: Most of the villages are found to be above permissible limit i.e. >1.00 mg/l. But villages like Tiwarta, Amagaon, Saraisingar, Padnia, Japeli, Pandripani, Godhi, Bendarkona, Gerwa, Taghmahar, Balgikhar, Kharmora and Gajra have very high iron content more than 1.5.Iron must be removed for avoiding rusting in distribution pipes. Spatial distribution of Iron is shown in (Fig. 8).

6. Fluoride: The natural pollutant of water is the most common form of fluorine that is the Fluoride. Ground water usually contains fluoride dissolved by geological formation (K.Sundara Kumar et.al.2010). Kudurmal, Barbaspur, Kudri, Naktikhar, Risdi, Dewgaon, Malgaon, Chainpur, and Padnia are the villages whose fluoride concentration is more than the permissible limit i.e. > 1.5 mg/l. Excess concentration of fluoride may lead to diseases like dental fluorosis and skeletal fluorosis. Spatial distribution of Fluoride is shown in (Fig. 9).

7. Calcium: The formation of calcium in water is mainly due to the presence of minerals like limestone, dolomite, gypsum, and gypsiferrous. The permissible limit of calcium as per BIS is 75-200 mg/l. High concentration of calcium was found in some villages. Spatial distribution of Calcium is shown in (Fig .10).

8. TDS: Concentration of mineral compositions dissolved in water is known to be the dissolved solids. High concentration of TDS can be removed by reverse osmosis, electro dialysis, exchange and solar distillation process. Subsurface water containing TDS value more than 1000 mg/l is termed as brackish water. Villages like Binjhari, Batari, Tiwarta, Sirbida, Kudri, Barbaspur, Kandaikhar, Semipali, Gajra, Jamnimuda, Kasaipali, Kurudih and Bhiaibajar have TDS content more than desirable limit and within permissible limit (500-2000 mg/l). Spatial distribution of TDS is shown in (Fig. 11).

9. Nitrate: The main source of nitrate in water is from atmosphere legumes, plant debris and animal excreta (WHO, 1983). Presence of Nitrate content in water, more than 100mg/l is bitter to taste and cause physiological distress in human bin. Water in shallow wells containing more than 45 mg/L causes methemoglobinemia and is called as blue baby syndrome in humans. Higher Nitrate content is found mainly due to over application of fertilizer, inadequate manure management practices, sewage effluent, septic tank, open dump sites of solid wastes etc. Higher level of Nitrate ions was not found in the study area (more than 100 mg/l). Spatial distribution of Nitrate is shown in (Fig. 12).

10. Water Quality Index: WQI indicates the quality of water with reference to an index number which reflects the overall status of GWQ for drinking purposes. The overall view of WQI of the present study area show higher WQI. The main reasons for the present situation may be due to presence of mining areas, misused ponds, open dumping of solid wastes, improper use of fertilizers. Spatial distribution of WQI is shown in (Fig .13).The integration of various thematic layers i.e. all the nine parameters in GIS reveal that whether the water is fit or unfit for drinking is shown in (Fig . 14).

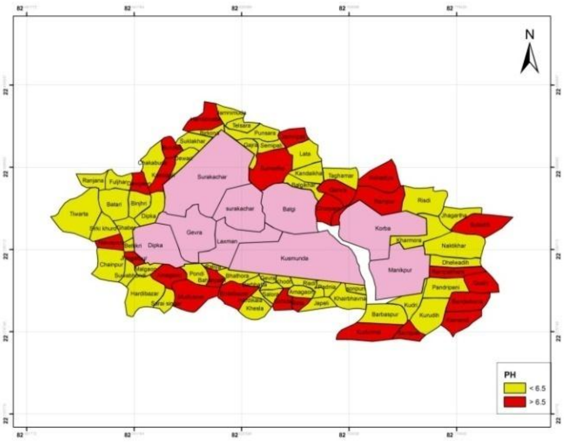

Fig. 4. Spatial distribution of pH

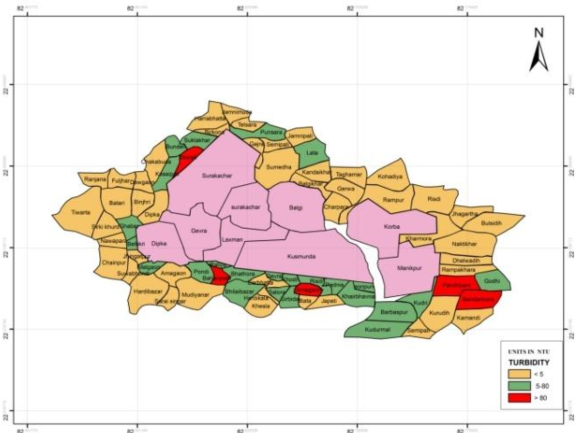

Fig. 5. Spatial distribution of turbidity

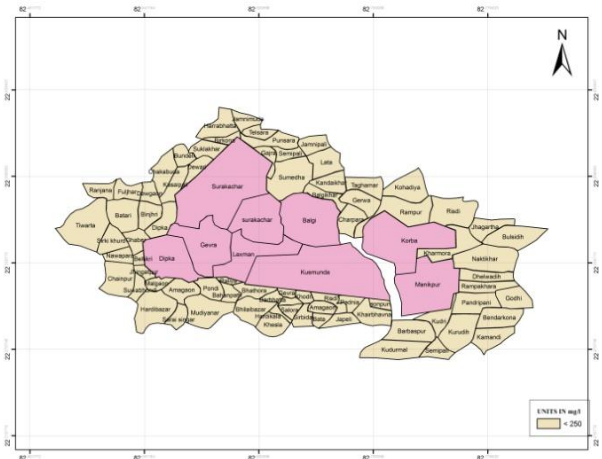

Fig. 6. Spatial distribution of chloride

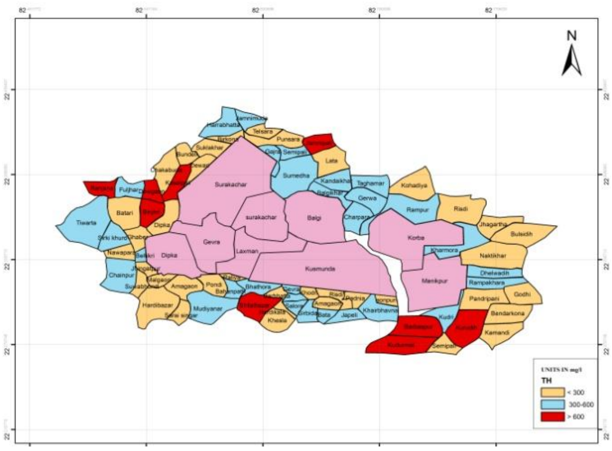

Fig. 7. Spatial distribution of TH

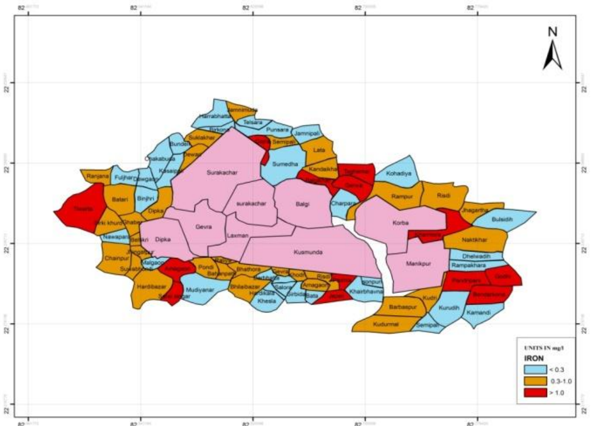

Fig. 8. Spatial distribution of iron

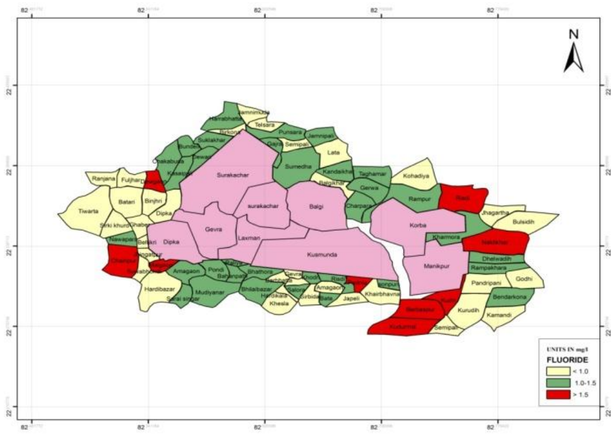

Fig. 9. Spatial distribution of fluoride

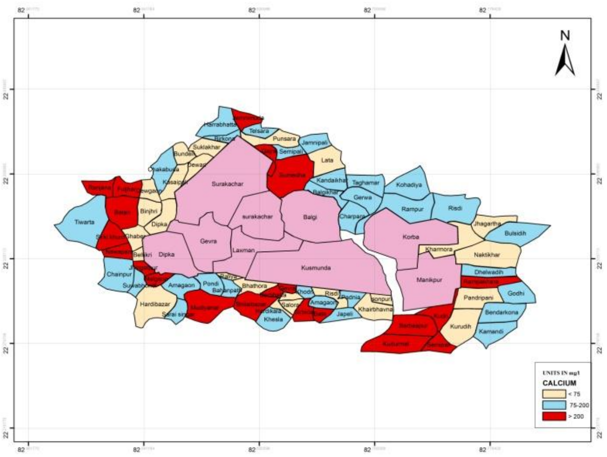

Fig. 10. Spatial distribution of calcium.

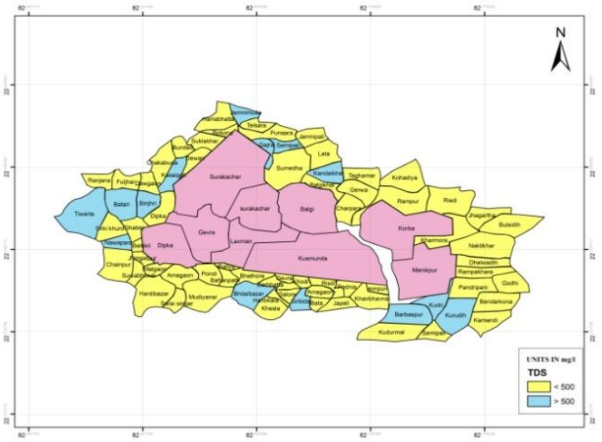

Fig. 11. Spatial distribution of TDS

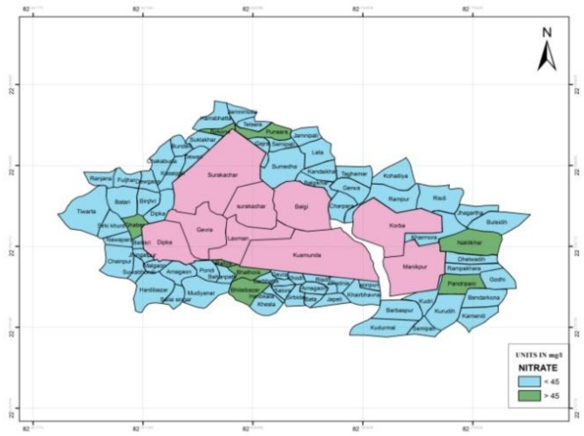

Fig. 12. Spatial distribution of nitrate

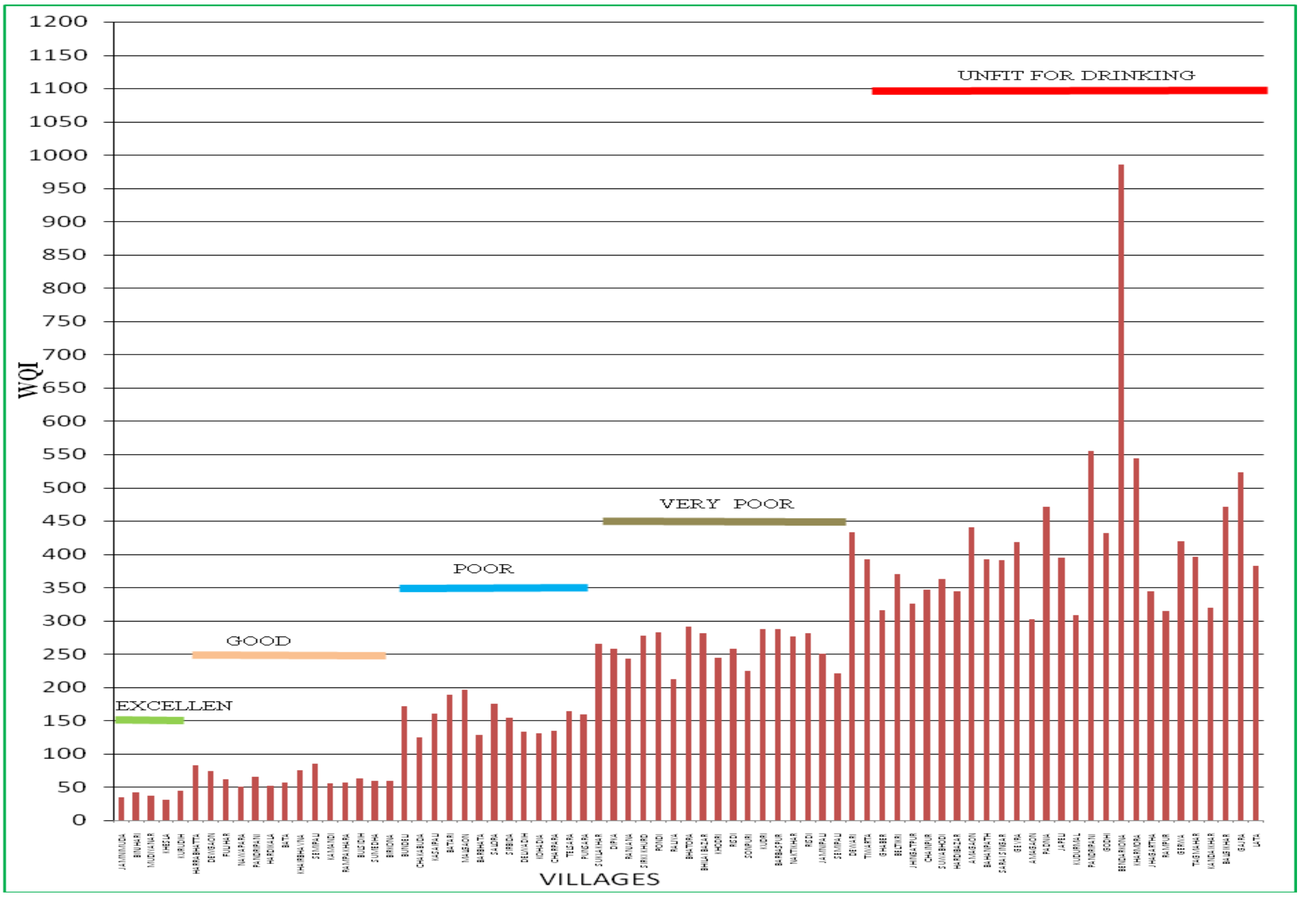

Fig.14. Bar chart of WQI

V. CONCLUSIONS

In the present work, an attempt was made to evaluate and to map the groundwater quality surrounding mining region in Korba district. The estimated WQI provides an easy way of understanding the overall potability of water quality. The integration of various thematic layers with the help of ArcGIS 9.3 is of immense help in determining suitability of ground water quality for drinking purpose. The highly affected parameters are pH (52), Turbidity (50) and Iron (13). It is observed that Fluoride concentration is high in 9 villages above permissible limit. All villages are found to be having chloride concentration within desirable limit. Most of the locations have turbid water more than desirable limit

(>5 NTU and < =80 NTU). But villages namely Dewari, Bahanpath, Bendarkona, Amagaon, and Pandripani bear very high turbidity more than 80 NTU. Out of 77 villages, Only 18 locations had a satisfactory result of WQI below 100 , water present in 28 other locations are unfit for drinking having WQI more than 300 and rest of the villages come under poor and very poor grade. North eastern sides and south-western sides of the study are non potable for drinking.

REFERENCES

[1] Asadi, S.S., Vuppala, P., Reddy, A.M.A., 2007. Remote Sensing and Techniques for evalution of Ground water quality in municipal Corporation of Hyderabad (Zone-V) India. International journal of environmental Research and public Health, 4(1), 45-52.

[2] Balakrishnan, P., Salaam, A., and Mallikarjun, N.D., 2011. Groundwater quality mapping using geographic information system (GIS). A case study of Gulbarga City, Karnataka, India. African Journal of Environmental Science and Technology. Vol. 5(12), 1069-1084.

[3] BIS (Bureau of Indian Standards) 10500. Indian standard for drinking water specification, 1991, first revision, 1-8.

[4] Burrough, P.A., McDonnell, R.A., 1998. Principles of Geographical Information Systems Oxford, Oxford University Press, 333.

[5] Cude, C., 2001. Oregon water quality index. A tool for evaluating water qualitymanagement effectiveness. Journal of the American Water Resources Association,37,125-137.

[6] Goodchild, M.F., 1993. The state of GIS for environmental problem-solving. In M. F. Goodchild, B. O. Parks, & L. T. Steyart (Eds.), Environ. Modeling GIS, New York. Oxford University Press, 8–15.

[7] Lo, C.P., Yeung, A.K.W., 2003. Concepts and techniques of geographic information Systems, New Delhi. Prentice-Hall of India Pvt. Ltd, 492.

[8] Stafford, D.B., 1991. Civil engineering applications of remote sensing and geographic Information systems, New York. ASCE.

[9] Subramani, T.,2012. Study of ground water quality with GIS application for Coonoor taluk inNilgiri district. International Journal of Modern Engineering Research, vol 2 , Issue 3, 586-592.

[10] Sundara Kumar, K., 2010.Assessment and mapping of Groundwater quality using Geographical Information System. International Journal of Engineering Science and technology Vol. 2(11), 2010, 6035-6046.

[11] WHO (World Health Organization)., 1983. Guidelines for drinking water quality, 2nd edition, vol 1, 188.