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Appraisal of groundwater quality using GIS with a special emphasis on fluoride contamination in Ranebennur Taluka, Karnataka, India

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Abstract: *The present study was carried out to know the Fluoride content in the groundwater. The occurrence of fluoride is mainly due to the over exploitation of groundwater. The ground water is contaminated with Fluoride because rock beds containing fluoride minirals come in contact with groundwater. The more incidence of dental fluorosis among the rural mass made it necessary to find out the fluoride contamination of ground water. And adopt remedial measures to the people on the risk of fluorosis. A total of 50 Groundwater (GW) samples were collected during the study period. The objective of the study is to find out the spatial distribution of fluoride in pre-monsoon and post-monsoon period using GIS and remote sensing. The fluoride concentration in groundwater varies from 1.2 mg/l to 3.6 mg/L in pre-monsoon and 1.0 mg/L to 3.6 mg/l in post-monsoon. The overall distribution of fluoride concentration in the study area during the pre-monsoon and post-monsoon periods indicates slight dilution effect owing to fresh water recharge on account of rain fall. The analysis was made in GIS for identifying the evaluation fluoride contamination region in the study area. The concentration of fluoride above 1.5 mg/l of fluoride concentration, which is a maximum permissible limit recently suggested by Bureau of Indian Standard (BIS) (BIS: 10500, 2010) was observed in 45 samples in pre-monsoon 43 samples in post-monsoon and remaining 5 and 7 samples in safe limit respectively. This study identified that Fluoride concentration is 2 – 3 ppm (46%) and 3 – 4 ppm (28%) in pre-monsoon and 25% in post-monsoon in Ranebennur Taluka, Haveri district. Further remedial measures for fluoride have to be carried out in the study area. Mapping of high fluoride areas are useful to plan and to bring safe drinking water from low fluoride areas.*

Keywords: *Digital Elevation Model (DEM), Normalized Difference Vegetation Index (NDVI), Fluorosis.*

I. INTRODUCTION

The Ground water resources are dynamic in nature and are affected by such factors as the expansion of irrigation activities, industrialization and urbanization. Hence, monitoring and conserving this important resource is essential. Every one of us knows how important and precious the water is? At room temperature, it is colorless, tasteless and odorless liquid. Many substances dissolve in water and are commonly referred to as universal solvent (Viswanathan, 2009). Calcium fluoride (CaF_2) the primary mineral source of fluoride. The other mineral generally Fluoride present are fluorapatile ($Ca_5(PO_4)_3F$) and cryolite (Na_3AlF_6).
Fluorine is an ion of the chemical element fluoride which belongs to halogen group. Fluoride has a significant mitigating effect against dental caries if the concentration is higher than 1 mg/L. However, continuing consumption of higher concentration can cause dental fluorosis and in external causes even skeletal fluorosis. High fluoride concentrations are especially critical in developing countries largely because of lack of suitable infrastructure for treatment (Kannan S, 2011).

Fluoride is a common constituent of ground water. Natural sources are connected to various types of rocks and to volcanic activity agricultural (use phosphate fertilizers) and industrial activity (clays used in ceramic industries or burning of coals) also contribute high fluoride concentration in ground water. The ultimate concentration of fluoride in ground water largely depends on reaction times with aquifer minerals. High concentration can be built up in ground waters which have long residence time in the aquifers. Such ground water usually associated with deep aquifer system and slow ground water movement (Clarke et al., 1995). Arid regions are prone to high fluoride concentration. Here ground water flow is slow and the reaction times with rocks are therefore long. High fluoride ground water are mainly associated with sodium bicarbonate water type and relatively low calcium and magnesium concentration such water types usually have high pH values (Sundary et al., 2005).

II. Study Area

Ranebennur Taluka comes under Haveri District Karnataka State. The taluka lies between north longitude 14.28^0 to 14.50^0 and East latitude 75.07^0 to 75.38^0. The total area is about 907 km^2 and population is 12.8 lacks. The Taluka possess a forest area of 10614 hectares, which is about 11.73% of the total geographical area. The soil and climatic condition is same in all parts of the taluka. The temperature is minimum 16^0C to 18^0C during November and December and maximum 40^0C to 42^0C during April and May. The average rainfall in the taluka has been 623 mm.

Geography of the area

The rocks in the area are greywacke inter-bedded with thin bands of argillite/phillites. The rocks beds are compact hard and quartz intermediate type. Frame work grains to some extent are replaced by carbonate of secondary origin.

Remote Sensing & GIS integration

Remote sensing means sensing of an object without coming into physical contact with the object. In remote sensing data about the earth surface features are obtained through sensors. The sensors are mounted on aircraft or space craft. The sensors usually record reflected or emitted electromagnetic radiation. Sensors are of two types and they are photographic and non photographic in nature. In case of photographic system camera lenses and film combination is made use of and here the film acts as a sensor. Geographical information system (GIS) is a database management system used to store, retrieve, manipulate and analysis of spatial data. The four important components of a geographical information system are data storage, data retrieval, data manipulation and data analysis. GIS has the capacity to relate layers of data for the same points in space, combining, analyzing and finally represent it in the map form.

III. Materials And Methods

Analysis of the fluoride content in a water of Ranebennur Taluka Haveri District, Karnataka State, India was carried out during the pre-monsoon as well as post monsoon seasons. The 50 sampling points were selected. The map shows locations of villages , where the water sample was collected for fluoride analysis is shown in Figure-1.

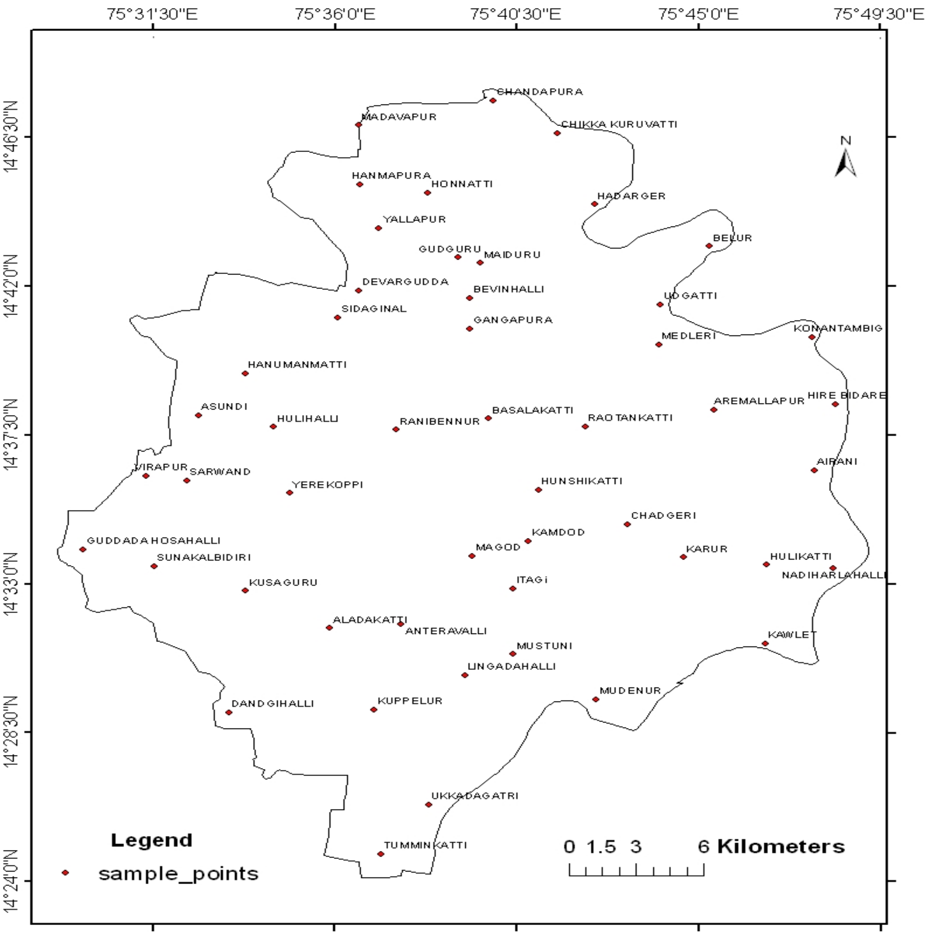


Figure - 1 The map shows locations of vilages were selected for fluoride analysis

The satellite image is obtained from National Remote sensing centre Hyderabad. The toposheets from survey of India (SOI), Bangalore. ERDAS imagine processing software is used. The collected toposheets of the study area were scanned registered and mosaicked using ERDAS. Methodology adopted for the study as shown in the Figure 2. Satellite data were collected preprocessed and geo corrected with respect to registered toposheet. Secondary data were collected & geo-corrected with respect to registered toposheet, contours from toposheet were digitized and Digital Elevation Model (DEM) for the study area was obtained (Kannan S, 2011). Thematic layers on geology, slope & aspect, Normalized Difference Vegetation Index (NDVI) (Asadi S. S 2011 and Deepu 2011) were prepared for the study area are given Figure 3, 4 and 5 respectively. The Slope & aspect map gives information about steepness and direction of slope, speed & direction of runoff. DEM helps in extracting terrain parameters & creation of relief maps. NDVI value is the measure of density of green & water body on a patch of land.

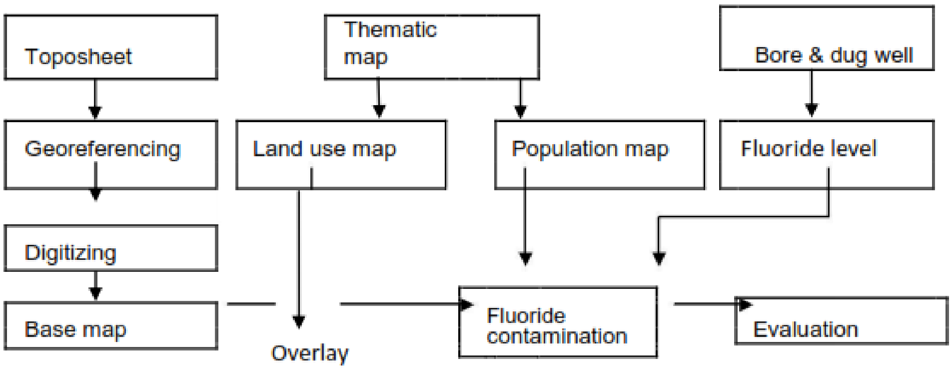
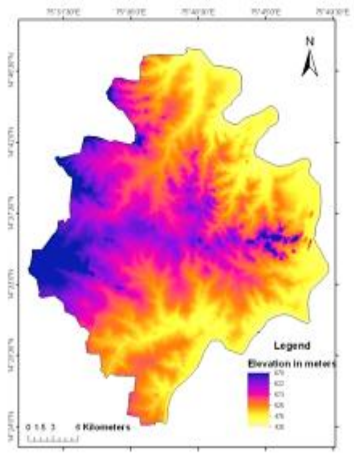
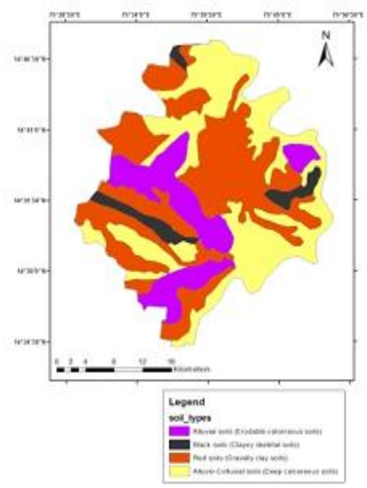


Figure 2. Methodology adopted for the study





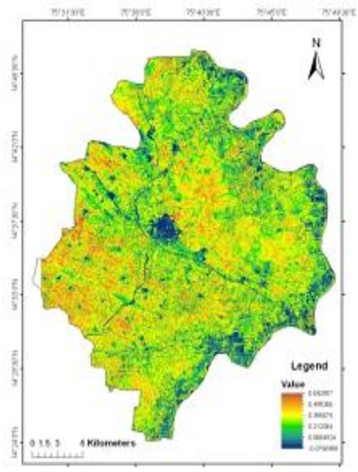


Figure 3. DEM Map Figure 4 ASPECT MAP Figure 5 NDVI Image

IV. Result And Discussion

The fluoride content of ground water ranged from 1.2 to 3.6 mg/L in pre monsoon and from 1.0 to 3.6 mg/L for post monsoon season (Table 1). Out of 50 samples analyzed, only five samples in pre monsoon and 7 samples in the post monsoon were observed below the permissible values of fluoride. All other samples analyzed showed higher concentrations of fluoride compared to the prescribed permissible values. Maximum fluoride concentration (3.6 mg/L) was observed in the sample collected at location 38 (Guddadahosalli village both pre monsoon and post monsoon, which is in rejection range or a minimum value as per the BIS: 10500 (2010), while the minimum value (1.0 mg/L) was observed in location 11 (Belur village). Fluoride concentrations in ground water of the study area are shown in figure 6. W.H.O has suggested maximum permissible limit of fluoride 1.5 mg/L in drinking water. About 87% of the samples of the study area are exceeding the permissible limits of fluoride. Studies such as Vasak *et al.* (2006) and Madhnure *et al.* (2007) have indicated that arid climates characterized by high evaporation rates are associated with high fluoride concentrations in groundwater. In arid/dry conditions, groundwater flow is low and the reaction time of groundwater with the rock is long (Vasak *et al.*, 2006). In the present study, high fluoride concentrations groundwater suggest that favorable conditions exists for the dissolution of fluoride bearing minerals present in the granite and gneissic rocks in the study area. Fluoride bearing minerals occupy the joints, fractures, faults and vertical openings in the genesis and granitic formations which are the oldest geological formations in Ranebennur Taluka, Haveri District have undergone maximum weathering. Granitic rocks are known to contain a relatively large proportion of fluorine minerals. Fluorite, the main mineral that controls the geochemistry of fluoride in most environments is found in significant amounts in granite, granite gneisses and pegmatite (V. Sunitha *et al.*, 2012). Under the prevailing semiarid climatic conditions, during weathering of granites, gneiss rocks, fluorine is released (Nezli *et al.*, 2009). In the study area fluoride contamination is mainly a natural process i.e. leaching of fluorine bearing minerals, since no man-made pollution has been noticed. Figure 6 shows concentrations of fluoride content of various locations.

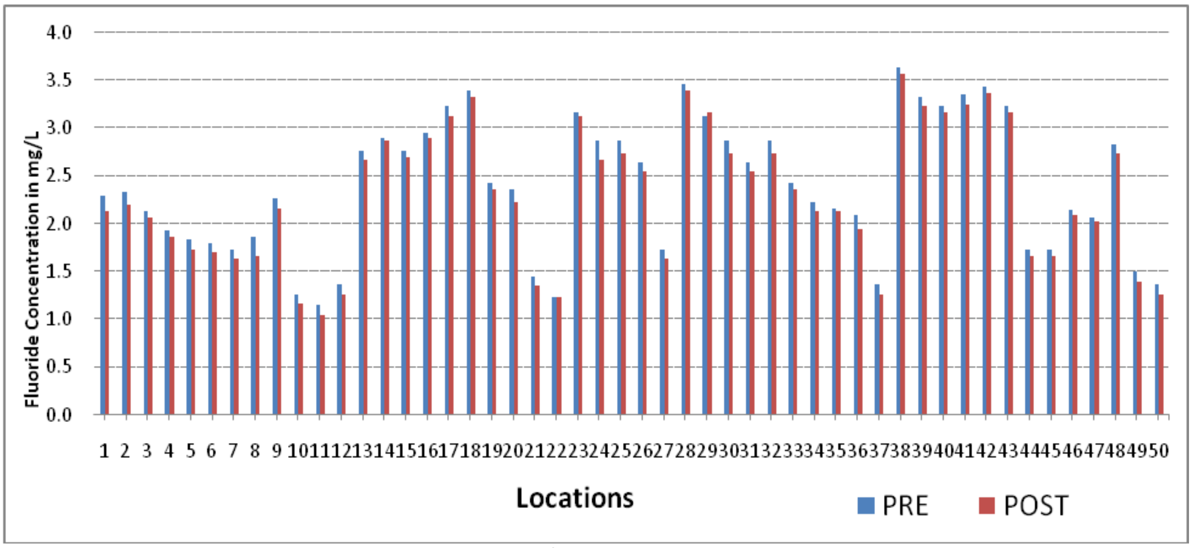


Figure 6: Fluoride concentration in groundwater of Ranebennur Taluka Haveri District, Karnataka State, India

Table 1 Statistical data of the Fluoride concentration of groundwater in Study area (in mg/l)

Pre Monsoon				Post Monsoon			
Min	**Max**	**±SD**	**Average**	**Min**	**Max**	**±SD**	**Average**
1.2	3.6	0.703	2.3	1.0	3.6	0.710	2.3

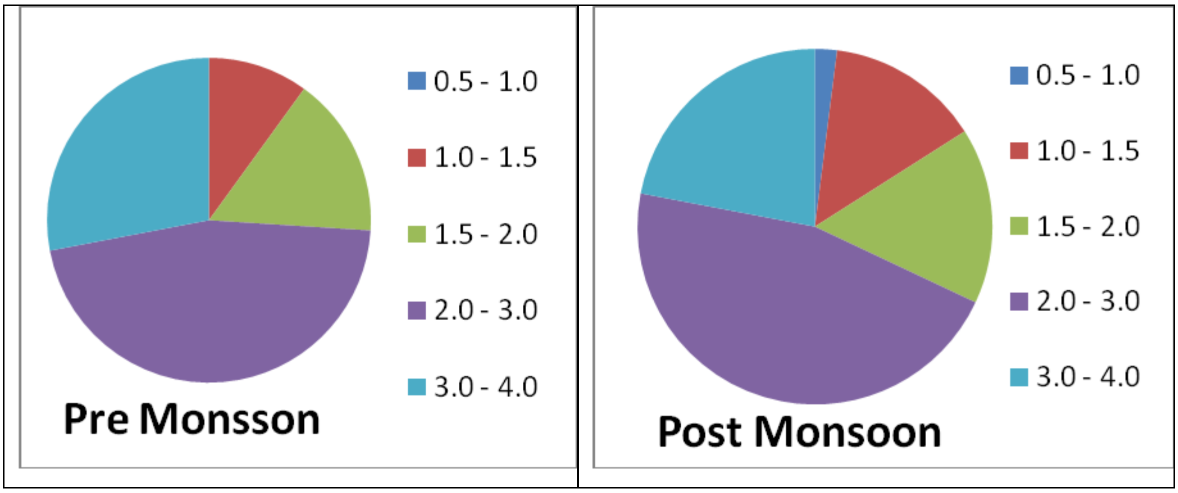


Figure 7 Percentage Distribution of Fluoride Concentration during Pre Monsoon and Post Monsoon

During the study identified that Fluoride concentration is 2 – 3 ppm (46%) and 3 – 4 ppm (28%) in pre-monsoon and 2 – 3 ppm (46%) and 3 – 4 ppm (22%) in post-monsoon (Anandha Parameshwari, N. and Kalpanadevi, K., 2006) in Ranebennur Taluka, Haveri district (Figure 7). People of all age groups are faced with higher risk of fluorosis in Ranebennur Taluka Haveri district and infant's child and adults were highly affected in pre-monsoon period. In pre-monsoon period built-up areas are highly affected compare to post-monsoon period. GIS Mapping shows the high and low fluoride concentration are indicated (Figure 8).

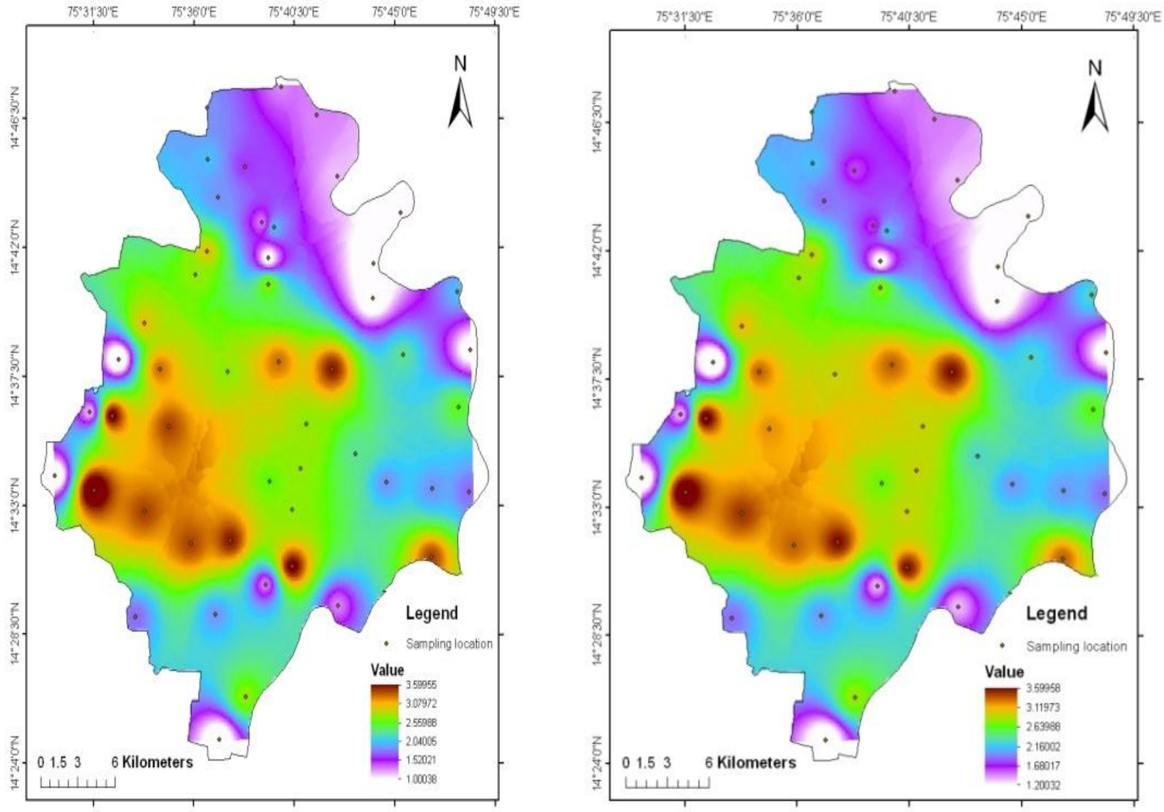


Figure 8 Map Showing Fluoride concentration in premonsoon & post monsoon

V. CONCLUSION

The present geo-hydrological investigation was carried out with appropriate and state-of-the-art methodologies to meet the declared objectives. The work also integrates rainfall, land use, identifying the fluoride contamination region in the study area. The study was carryout in accordance with the declared methodology. The analysis was made in GIS for identifying the evaluation fluoride contamination region in the study area. The concentration of fluoride above 1.5 mg/l was observed in 45 samples in pre-monsoon 43 samples in post-monsoon and remaining 5 and 7 samples in safe limit respectively. The higher concentration is due to the over exploitation of the groundwater and the geological formation. The concentration of fluoride is mainly due to the rock water interaction. Recharging the groundwater in the higher concentration area may improve the groundwater quality. This study identified that Fluoride concentration is 2 – 3 ppm (46%) and 3 – 4 ppm (28%) in pre-monsoon and 25% in post-monsoon in Ranebennur Taluka, Haveri district. Several reports on dental and skeletal manifestations of fluorosis are also reported in the study area, which shows that the population of the study area is at higher risk due to excessive fluoride intake. Further remedial measures for fluoride have to be carried out in the study area. Mapping of high fluoride areas are useful to plan and to bring safe drinking water from low fluoride areas.

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