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Fluoride in Groundwater: A case study in Integrated Dharmapuri District, Tamilnadu, India using GIS

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ABSTRACT

The problem of high fluoride concentration in groundwater resources has now become one of the most important toxicological and geo -environmental issues in India. During the last three decades, the high fluoride concentration in water resources and the resultant disease 'Fluorosis' is highlighted considerably throughout the world. The presence of excess of fluoride in groundwater leads to dental and skeletal fluorosis. The permissible level of fluoride in groundwater is 1.0 to 1.5mg/l (WHO). Dharmapuri finds itself in a bad position owing to depletion of ground water sources and increased risk of fluoride contamination, this study was initiated to identify the fluoride high and low risk areas using World Health Organisation (WHO) standard and high risk areas were mapped with the help of GIS software arcview 3.2a

1. Introduction

Fluoride in groundwater has drawn global attention due to its considerable impact on human physiology (Arnesen, *et al*., 1995; Ashley and Burley 1995; Klump *et al*, 1996; Miller 1997; Do-Mingos and Klump, 1998; Fornaisen 2001; Kundu *et al*., 2001; WHO, 2002; Camergo, 2003). The intake of fluoride is mainly through the drinking water. The fluoride content in the ground water is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water, etc., (Chanda *et al*., 1999). Fluoride in drinking water is known for both beneficial and detrimental effects on health (Ravindra *et al*., 2003). The presence of fluoride in exceeding limits and its related problems are prevailing in many parts of India (Shajii *et al*., 2007). In India about 62 million people are at risk of developing fluorosis from drinking high fluoride water (Andezhath *et al*., 1999, WHO 2000, UNICEF 2002). Dharmapuri district has a high concentration of fluoride in groundwater and ranks highest in the state. According to a recent survey by the Tamil Nadu Water Supply and Drainage Board (TWAD), the fluoride contamination is highest in Dharmapuri district (The Hindu, May 25, 2004). Since fluoride is a component of water and as the sources of contamination cannot be identified easily, a better procedure is required to visually interpret the analytical outcomes. For such user friendly and easy comprehendible approach, to understand the risk areas and to reach out immediate suggestive measures, mapping of such risk is necessary using GIS. GIS not only analyses the present environmental scenario but it also helps in projecting the future. In other words, one can effectively use the GIS tool for present, past and future studies on any spatial information.Therefore, this study was initiated to identify the fluoride high and low risk areas, using GIS.

2. Study Area

The study area lies at a geographical extent from 11° 45' to 12° 53' N and 77° 13' to 78 °45' E Dharmapuri district, lies at the trijunction of Karnataka, Andhra Pradesh and Tamil Nadu states of South India. The district is situated in the Northwestern portion of Tamil Nadu.. The total area of the district is 9581.26sq.km. The district is surrounded by Vellore, Tiruvannamalai and Villupuram districts in the East, Salem district in the South, the states of Karnataka and Andhra Pradesh in the North (Map 3.1). The Dharmapuri district has been recently bifurcated into two in the year 2004 to form an additional Krishnagiri district*. The altitude of the district ranges from 300-1200m above mean sea level. For administrative convenience, the integrated Dharmapuri district has been divided into 8 taluks namely Dharmapuri, Krishnagiri, Pennagaram, Harur, Hosur, Palacode, Denkanikotta, and Uthangarai. The two taluks were bifurcated from Harur (Papiredipatti) and Uthangarai (Pochampalli taluk).

3. Data used and Methodology

For the present study, Toposheets from Survey of India (SOI), Regional office Bangalore. 57L, 57H and 58I (Scale of 1:50,000) was used to prepare district, taluk and forest boundaries (Map.3.1). To prepare the fluoride distribution map nearly 142 well locations were used (Map 4.2), out of which 71 locations groundwater samples were randomly collected and fluoride level was estimated using Calorimetric(SPADNS2-(4-Sulfophenylzo)-1,8-Dihydroxy-3-6-Napthalenene-Disulphonic acid, Trisodium salt method). The remaining 71 locations fluoride level data was obtained

* The area for the present work is integrated Dharmapuri district (With Krishnagiri district).

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from Tamil Nadu Water Supply and Drainage Board (TWAD) Based on the mapping capability of GIS with avenue script extension, the fluoride high and low risk areas were identified using multiconstraint query. The stepwise methodology is illustrated in Fig.1.

4. Result and Discussion

The 142 groundwater fluoride values were recorded in the ASCII format using geographical co-ordinates. The created attribute for fluoride concentration is exported to Arc view 3.2a and fluoride distribution map was prepared using IDW (Map5.1.2).

A normal GIS method uses thematic maps and simple map presentations to visualize problem areas. For better comprehension and to understand estimate the intermediate regions, interpolation techniques have been suggested and used. IDW interpolation method was adopted for the present study identifying the fluoride values in other areas of the district excluding the reserved forests. Using the 142 locations, a groundwater fluoride distribution map was prepared and presented as map 5.1.2.

IDW interpolation technique results in a continuous surface for fluoride concentration and this resultant map was reclassified into three classes viz., low (0-1mg/l), moderate (1-1.5mg/l) and high (>1.5mg/l) which is presented as map 5.1.3. The resultant map shows the area with high fluoride content in groundwater is not recommended for drinking purpose.

From the map it is observed that, out of 9581.26 sq.km, the low fluoride risk area occupies nearly 638.85 sq.km (6.66%) whereas the moderate fluoride risk area occupies around 3375.37 sq.km (35.22%) and high fluoride risk area contributes nearly 1904.72 sq.km (19.87%) in Dharmapuri district. The remaining 3662.31 sq.km (38.22%) area is occupied by the reserve forest.

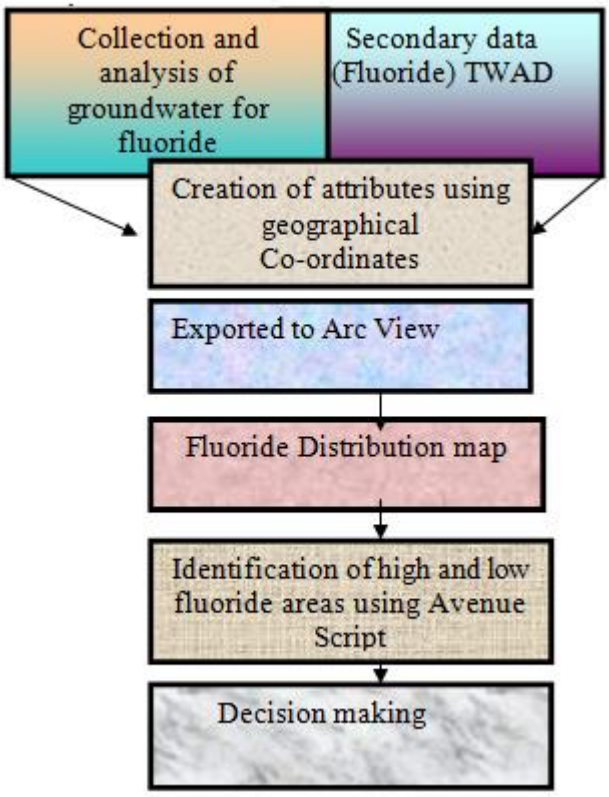
The map 5.1.3 shows that the higher concentration of fluoride (>1.5mg/l) is observed in Uthangarai, Palacode, Denkanikotta, Dharmapuri taluks and smaller portion of Harur, Hosur and Krishnagiri taluks. The low concentration of fluoride is observed in Hosur and Krishnagiri taluks. The moderate range is observed in Krishnagiri, Hosur and Harur taluks of the district. Hence, the result shows that the fluoride is not evenly distributed in the district.

Mapping of Areas exceeding WHO (World Health Organization) limits

Out of 142 locations in the district, nearly 48 locations exceeds the WHO prescribed limit for fluoride concentration. On observation of the locations at taluk levels, it is seen that two locations in Hosur , ten locations in Denkanikotta, two locations in Pennagaram, one location in Krishnagiri, ten locations in Uthangarai, six locations in Harur, eight locations in Dharmapuri and nine locations in Palacode taluks exceeds the WHO limits (Map5.1.6a). The remaining 93 locations were found to be lesser than the WHO prescribed fluoride limit (1.5mg/l) (Map5.1.6b).

The calculated area is around 1904.72sq.km (19.87%) which is presented in map 5.1.7

Fig.1 Methodological steps for the distribution and identification of fluoride high and low risk areas in Dharmapuri district



5. Conclusion and Recommendations

The presence of fluoride in drinking water of Dharmapuri district is due to fluoride bearing minerals in rocks .Based on WHO Prescribed limit a fluoride distribution map was prepared. The prepared map is useful for decision makers for easy decision making and to identify the areas at the desktop where to provide alternative drinking water and where the basic water quality can be improved and other management strategies to the fluoride affected areas. To check the fluoride contamination in Dharmapuri district the information system evolved through GIS facilitates the following,

- Make this information more accessible to individual researchers, planners and decision makers.Furnishes a framework of well-maintained and documented base groundwater data for others use.
- Provides easy to use tools to display, manipulate and query atlas data so that customers can produce their own relevant information.

The following recommendations can be adapted to the fluoride affected areas,

- Avoid, fluoride rich (>1.5mg/L)) water for drinking and cooking purpose
- Fluoride concentration can be diluted by way of induced groundwater techniques i.e. construction of percolation tanks, flooding of groundwater by mixing surface water.
- Implement different defluoridation technologies wherever necessary.
- Various methods of recharging the groundwater like check dams, rainwater harvesting, farm ponds be constructed
- Supply of fluoride free water to the affected areas from alternative water sources like, rivers, lake and impounding reservoirs.
- Social awareness and motivation to the fluoride affected areas.

Acknowledgement

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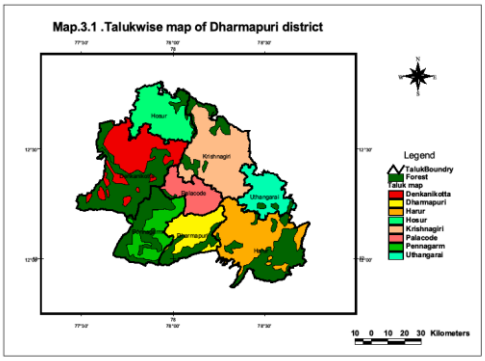
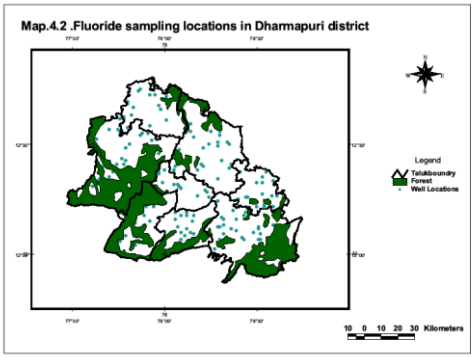
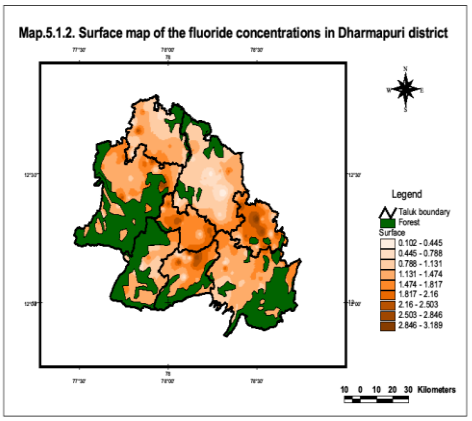
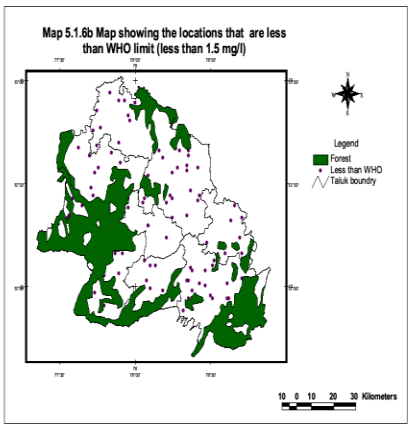
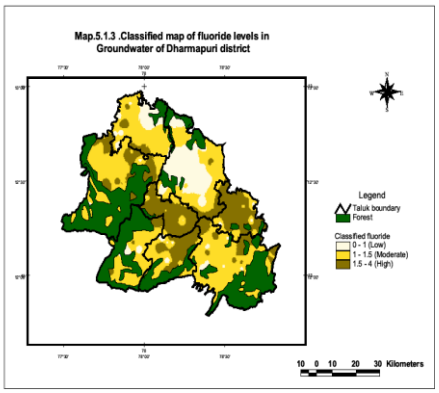
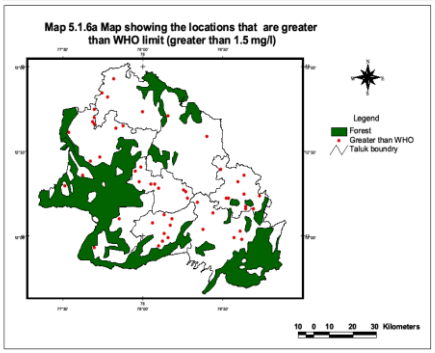


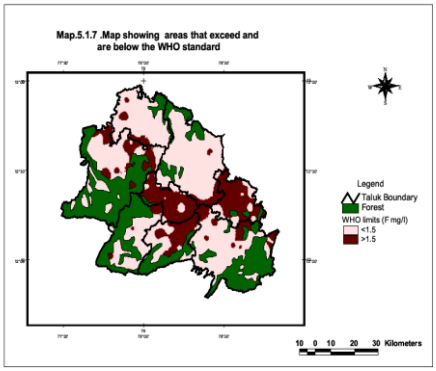







Map.5.1.3 .Classified map of fluoride levels in Groundwater of Dharmapuri district
Legend
Taluk boundary
Forest
Classified fluoride
0 - 1 (Low)
1 - 1.5 (Moderate)
1.5 - 4 (High)
10 0 10 20 30 Kilometers


Map 5.1.6a Map showing the locations that are greater than WHO limit (greater than 1.5 mg/l)
Legend
Forest
Greater than WHO
Taluk boundry
10 0 10 20 30 Kilometers


Map.5.1.7 .Map showing areas that exceed and are below the WHO standard
Legend
Taluk Boundary
Forest
WHO limits (F mg/l)
<1.5
>1.5
10 0 10 20 30 Kilometers