Spatial Distribution of Fluoride Contamination in Groundwater Sources in Hard Rock Terrain, Parts of Dharmapuri District, Tamil Nadu, India

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ABSTRACT

Surplus fluoride in groundwater affects the human physical condition and consequences in dental and skeletal fluorosis. In order to understand the fluoride contamination in the study area, total of 158 groundwater samples were collected from bore wells during summer (SUM) and Pre monsoon (PRM) season in 2013. The collected samples were analysed for pH, EC, and fluorid. The pH of groundwater shows slight increase with increase in fluoride concentration. Most of groundwater samples falls in the maximum permissible limit of drinking water standard for fluoride. A spatial variation map of the fluoride concentration elucidates higher concentration in the southern and northeastern part of the study area. The high concentration can be attributed to release of fluoride from the pinkmigmatite and relatively lesser concentration can be attributed hornblende biotite gneiss.

Key words: spatial distribution, groundwater, fluoride, Dharmapuri, GIS

I. INTRODUCTION

Fluoride is a naturally occurring element in the Earth’s Crust, it is not essential for growth and development of humans or other Organisms. Most fluorine occurs as in soluble fluorides, but there is some ionized Fluoride in soil and groundwater. Fluoride ion occurs in natural waters commonly in concentrations less than 1.0 mg/l and seldom outside the range from 0.01 to 10.0 mg/l. The problems of excessive fluoride in ground water in India were first reported in 1937 in the state of Andhra Pradesh (short et al.1937). According to WHO (2006) norms, the upper limit of fluoride concentration in drinking water is 0.5 – 1.0 mg/l. Fluoride (CaF2) is the only principal mineral of fluorine occurring in nature, mostly as accessory minerals in rocks of granitic, and occasionally alkali composition (syenite and nepheline syenites), precipitating mostly during the late hydrothermal stage and sometimes present in veins in economic quantities. Apatite, amphibole and mica contain fair amounts of fluorine in their structure, which are ubiquitous in igneous and metamorphic rocks. Many granitic rocks have elevated concentration of fluoride in ground water (murthy and murthy 1974), Natarajan and Murthy, 1974, world Helth Organization 1970. The world average of fluoride concentration in granitic rocks was found to be 810 mg/kg (wedepohl 1969). Granites /gneisses are the major types of rocks that occur in the study area which has the presence of fluoride containing minerals such as fluorite (0-3.3%), boitite (0.1-1.7%), and hornblende (0.1 – 1.1 %).

II. STUDY AREA

The study area lies between the latitudes of 12°30’0” N to 11°53’43” N and longitudes of 77°40’0”E to 78°17’30”E (fig.1) and located in north west of Tamilnadu. The study area experiences temperature ranging from 17°C to 42°C with an average annual rain fall of 980 mm (up to 2011). Rainfall is the main source of groundwater recharge in this area and groundwater is the only source for both irrigation and domestic purposes. Dug wells bore wells are the most common groundwater abstraction structure. As the study area is underlain by the Archaean crystalline rock, groundwater occurs in the fractured rocks. Geologically, the area is underlain by a wide range of charnockite, granitoidgneiss, pinkmigmatite and epidote of Archaean age. The soil type in the study area ranges from black to mixed loamy soil and red sandy soils. The slope of the area is towards south-east, Chinnar River is flowing in this region, which is one of the important tributary of river Cauvery.

III. METHODOLOGY

A total of 79 groundwater samples were collected per season, from bore wells during summer (SUM) and Pre monsoon (PRM) season in 2013. Each sample was collected in acid-washed polyethylene bottles. The collected samples were analysed for pH and EC, using hanna PH 213. F- measured by Orion Ion Electords using standard procedures (APHA,1998). The fluoride concentrations in the ground water were plotted spatially and graphically by using arc GIS software and MS excel to identify the fluoride plume in the study area.
IV. RESULT AND DISCUSSION

The pH of groundwater of the study area varied from 6.7 to 8.7 with a mean of 7.4 in SUM and 6.8 to 8.2 with mean of 7.5 in the PRM. The pH of groundwater shows slight increase with decrease in fluoride concentration (fig.2). This indicates that the fluoride content of groundwater will vary due to the changes in alkalinity, i.e., bicarbonate content. Also the Ca and Mg content increases as the fluoride concentration in the Groundwater sample increases.

The Fluoride content in the groundwater samples ranged from 0.13 to 2.71 mg/l with an mean value of 0.73 mg/l during SUM season and in PRM season it ranges from 0.12 to 2.5 mg/l with an mean value of 0.86 mg/l, (Table 1) showing that few groundwater samples of F⁻ concentration above the permissible limit of 1.5 mg/l prescribed by the WHO (1997). This recently made ‘Assessment’ for F content in ground water of two taluks of dharmapuri district, however, shows that considerable amount of contamination.

Table: 1 Descriptive Statistics of the analytical Data

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<td>pH</td>
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<td>0.4</td>
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<tr>
<td>F⁻</td>
<td>0.13</td>
<td>2.71</td>
<td>0.82</td>
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It has been observed that the fluoride contents of groundwater show inverse relationship with the availability and permeability of water within the aquifer with respect to fluoride content. Hence in the summer F content is 0.13 to 2.71 mg/l and in premonsoon ranges from 0.12 to 2.5 mg/l.

The frequency of distribution of the groundwater samples containing different amounts of F− showed that out of the 158 samples analyzed 6.3% contained F− lower than 0.25 mg/l, 31.6% contained 0.25mg/l to 0.50 mg/l. 39.3% contained F 0.50 to 1.00 mg/l and 22.7% contained greater than 1.0 mg/l F− (fig.3). A spatial variation map of the fluoride concentration was plotted and is shown in fig: 4, a high concentration was observed in the southern and NE part of the study area. The 1984 guidelines suggested by WHO that in area with warmer climate, the optimal concentration in drinking water should remain below 1.0 mg/l. while that in cooler climates could be up to 1.5 mg/l. Being in stove climate and drinking higher amount of water, people living in a few villages falls in the North eastern southern parts of the study area (fig.4) are exposed to risk from a potential fluorosis.

The spatial distributional of F− with respect to various rock types have shown different fluoride concentrations (fig. 5), possibly due to the different mineral constituents in these rocks and their relative fluoride ion releasing capabilities. The high concentration can be attributed to release of fluoride from the pinkmigmatite and relatively lesser concentration can be attributed hornblende biotite gneiss.

![Fig. 3 Frequency distribution of fluoride content in Groundwater with respect to rock types](image1)

![Fig. 4: Spatial Distribution of fluoride during A) SUM and B) PRM](image2)

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The spatial distribution of F concentration in the SUM and PRM periods shows that about 235sqkm and 324sqkm falls in the northeastern, southern and part of central region of the study area have F concentration above the maximum desirable limit (>1.0 mg/l) respectively. Of the 79 villages, 13 villages namely Namandalli, Annamalaihalli, Hanumanthapuram, Erraseegalaalli, mukkulam, Karimangalam, Manjanayakkanhalli, Pathramhalli, Kattunayakanhalli, Karukkanalli, Karagathalli, Dhumnahalli,and pommahalli are found to have F concentrations higher than the permissible limit, which exhibits about 74sqkm during SUM and 42sqkm during PRM are prevalence.
of fluorosis in the area. The presence of relatively lesser concentration of fluoride, suggests treatment facilities are necessary to control the groundwater contamination.

V. CONCLUSION

Fluoride content in most of the drinking groundwater samples of Palacode and Pennagaram of Dharmapuri district is below the permissible limit of 1.0 mg/l as prescribed by the WHO for tropical and subtropical countries. The frequency distribution of the groundwater samples containing different amounts of F showed that out of the 158 samples analyzed  6.3% contained F lower than 0.25 mg/l, 31.6% contained 0.25mg/l to 0.50 mg/l. 39.3% contained F 0.50 to 1.00 mg/l and only 22.7% contained greater than 1.0 mg/l F. This study identified that the high fluoride level in drinking water in the study area is having good geological relationship. Weathering of rocks and leaching of fluoride bearing minerals are the major sources which contribute to elevated concentration of fluoride in groundwater. The spatial mapping of high F area is useful in planning of safe drinking water. Simplest techniques like electro coagulation are sufficient to remove relatively lesser concentration of F present in the study area.

REFERENCES


