JOURNAL OF ENVIRON. SCIENCE & ENGG. VOL. 50, No.2, P. 121 - 126, April 2008

Fluoride Contamination in Ground Water of Malaprabha Sub Basin

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The fluoride contamination study has been carried out in ground waters of Khanapur, Bailhongal and Saundatti taluks of Malaprabha sub basin, Belgaum district, Karnataka (India). 21 samples were collected from different locations covering shallow and deep aquifers. The samples were collected during the pre-monsoon and post-monsoon season of 1999.The fluoride concentrations varied from 0.55 to 3.85 mg/L during pre-monsoon and 0.20 to 3.50 mg/L during post-monsoon seasons. Higher concentration of fluoride was observed in Ugargol village of Saundatti taluk. It was observed that about 28.60% of the samples have fluoride concentration less than 1 mg/L, 23.80% have concentration in the range of 1.0 – 1.50 mg/L, 42.85% have concentration in the range of 1.50 – 3.0 mg/L and 4.75% have concentration more than 3.0 mg/L during the pre-monsoon. During post-monsoon, it was found that about 35% of the samples have fluoride concentration less than 1.00 mg/L, 25% have concentration in the range of 1.0 – 1.50 mg/L, 35% have concentration in the range of 1.50 – 3.0 mg/L and 5% have concentration more than 3.0 mg/L. A positive correlation of fluoride was observed with bicarbonate, alkalinity and pH during the pre-monsoon and with EC, TDS, carbonate, bicarbonate and potassium during the post-monsoon. This suggests that source of fluoride may be partially from potassium rich rocks and constituents of fertilizers leaching down to ground water. The regression equations have been developed between fluoride and other water quality parameters.

Key words : *Fluoride contamination, potassium rich rocks, fertilizers, regression equations*

Introduction

Ground water is becoming an important source of water supply in many regions since there has been a tremendous increase in the demand for fresh water due to growth in population. The over exploitation of ground water resources induces degradation of ground water quality as well as the discharge of untreated effluents adding contaminants to the ground water system. Fluoride is one of the contaminants in ground water from natural geological sources, which is most hazardous, if found in excess. It invokes considerable interest due to its unique character as regard to its impact on physiological system of living things. Fluoride in small dosages has remarkable influence on the dental system by inhibiting dental carries, while in higher dosages causes dental and skeletal fluorosis. Fluoride is beneficial to certain extent when present in concentration of 0.8 – 1.0 mg/L for calcification of dental enamel especially for the children below 8 years of age. At higher concentrations (1.5 – 2.0 mg/L) fluoride effects adversely and leads to dental fluorosis. At still higher concentrations (3 – 6 mg/L) skeletal fluorosis occurs. Fluoride is one of the minor constituents in natural waters, but plays an important role in assessing the suitability of water for various domestic and irrigation purposes. Fluoride contaminated water when used for irrigation, percolates down and contaminates the soil and ground water. The permissible limits for fluoride concentration in drinking water recommended by various authorities are given in **Table 1**.

Table1 : Permissible limits for fluoride concentration in drinking water

Name of the Organizations	Desirable limits (mg/L)
Bureau of Indian Standards	0.6 – 1.2
Indian Council of Medical Research (1975)	1.0
US Public Health Service (USPHS-1962)	1.4 – 2.4 related to temperature
World Health Organization (WHO, 1984)	1.5
European Community Standards (EEC-1975)	1.4 – 2.4 related to temperature
WHO European Standards	0.7 – 1.7 related to temperature
The Committee on Public Health Engineering Manual and Code of Practice, Govt. of India	1.0

Source: "Endemic of fluorosis" Brochure by NIH, Roorkee, India.

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15 states in India have already been identified as endemic to fluorosis due to abundance in naturally occurring fluoride bearing minerals. These are Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. A survey conducted in 1999 by the Fluorosis Research and Rural Development Foundation, Delhi (FRRDF), concluded that about 62 million people in India including 6 million children are affected with dental, skeletal and non-skeletal forms of fluorosis and associated health problems (Patra *et al* 2000)[1]. Out of 6 lakh villages in India, at least 50% have fluoride content in drinking water exceeding 1.0 mg/L. Fluoride concentrations up to 20 mg/L have been reported in drinking water in Ananthpur, Nalgonda, Prakasam and Krishna districts of Andhra Pradesh. 34% population of the village Gudalur in Tamil Nadu reports high fluoride concentrations from 4.3 mg/L to 6.4 mg/L. The fluoride concentrations in the district Agra in Uttar Pradesh ranges from 0.28 mg/L to 22 mg/L and 1 to 27 mg/L in Jammu & Kashmir State. As high as 90 mg/L of fluoride was observed in ground water of western Rajasthan. The fluoride concentration in Udaipur district varies from 0 to 11.6 mg/L. The fluoride concentration in district Nagpur, Maharashtra varies from 0 to 44 mg/L. In Amroli district in Gujarat fluoride level observed up to 11 mg/L[2]. Concentration of 8.25 mg/L has been observed by Tamta (1994)[3] at Kulgeri in Bijapur district and 7.30 mg/L in Gulbarga district of Karnataka. In the present paper, an attempt has been made to determine the concentrations of fluoride in ground waters of Khanapur, Bailhongal and Saundatti taluks of Malaprabha sub basin, Belgaum District, Karnataka.

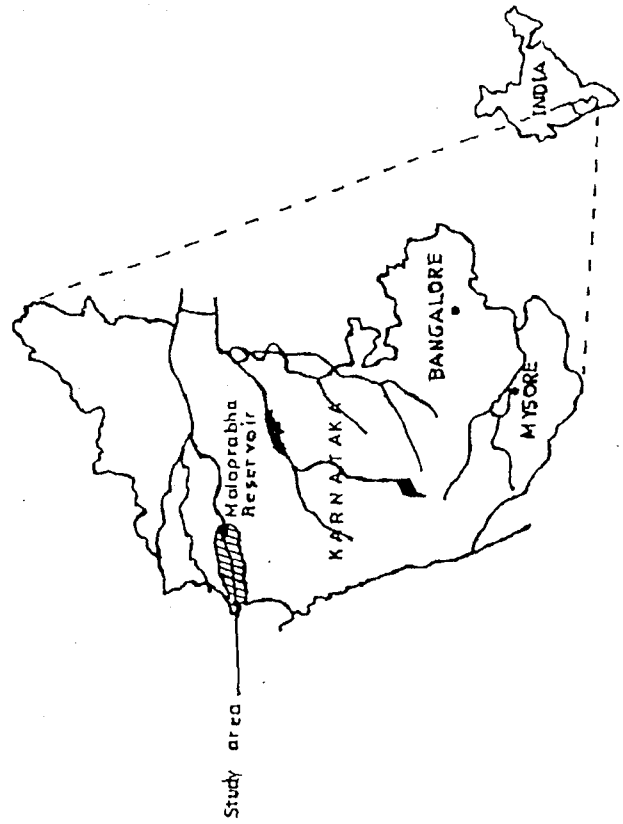

Fig. 1 : The study area

Study area

The study was undertaken in Khanapur, Bailhongal and Saundatti taluks of Malaprabha sub basin, Belgaum District, Karnataka. The Malaprabha river is a right bank tributary of the river Krishna. The Malaprabha sub-basin lies in the extreme western part of the Krishna basin. A map of the study area is shown in **Fig. 1**. It extends between 74° 20' and 75° E longitude and 15° 20' and 15° 40' N latitude in Belgaum district of Karnataka. The Malaprabha river originates from the Chorla ghats, a section of the western ghats at elevation of about 792 m, about 35 km south-west of Belgaum district in Karnataka. The catchment area of the river is about 3000 km^2. To harness the waters of the Malaprabha river, a dam is constructed at Naviluteerth, Belgaum district to impound 1377 MCM water. The catchment mainly experiences the southwest monsoon. The average annual rainfall of the catchment for the period 1901 – 1985 was 769 mm.

The important rock formations in the sub-basin are sedimentary rock formations (Kaladgi group) comprising granite, quartzite and schistose rock formations (Dharwar super group) comprising granite, gneiss and crystalline rocks. The aquifer system comprising kaolinite clay, basalt, sandstone, shale, limestone, dolomite, phyllite, schist, granite-gneiss, silt and clay occurs only along the stream courses to a limited extent. The range of ground water chemistry presented in the study area is underlain by basalt with interbedded clay. The major soil types include mixed red and black soil, black soil, red loamy soil, medium black soil and red sandy soil.

Methodology

The water samples were collected from 13 bore wells and 8 open wells during the pre-monsoon (June 1999) and post-monsoon (November 1999) seasons. The locations of ground water sampling stations are shown in **Fig. 2**. The water samples from open wells were collected by dip or grab sampling method. The samples were collected from wells, which are being extensively used for drinking and other domestic purposes. Fluoride was determined by using ion meter (JENWAY 3340). pH, temperature and EC were measured at the time of sample collection using portable kits and other chemical parameters were analyzed in the laboratory by standard methods (APHA, 1985[4] & Jain *et al.* 1988[5]). TDS and EC were determined by ion

meter (JENWAY 4320). Sodium and potassium were determined by flame photometer .

Table 2 : Analytical results of fluoride (mg/L)

Stations	Pre-monsoon (1999)	Post-monsoon (1999)
Kankumbi (BW)	0.70	1.00
Kankumbi (OW)	1.60	0.20
Jamboti (OW)	0.80	1.10
Jamboti (BW)	1.05	0.75
Jamboti (BW)	1.25	0.80
Kansuli (BW)	2.30	2.50
Khanapur (OW)	0.70	0.75
Desur (OW)	1.50	2.50
Gunji (OW)	1.60	1.85
Gunji (BW)	0.55	0.4
Bidi (BW)	1.40	1.05
Parishwad (BW)	2.70	2.75
Dastikopp (BW)	1.90	1.50
Dastikopp (BW)	1.00	1.15
Tegur (BW)	2.50	Nd
Holehosur (BW)	1.00	0.85
Bailhongal(OW)	1.10	1.20
Belwadi (BW)	1.80	2.05
Ugargol (OW)	2.40	1.65
Ugargol (OW)	2.80	2.10
Ugargol (BW)	3.85	3.50

(BW- Bore Well; OW : Open Well; Nd : Not detected)

Table 3 : Statistical analysis of fluoride

Statistical parameters	Pre-monsoon (1999)	Post-monsoon (1999)
Minimum	0.540	0.200
Maximum	3.850	3.500
Range	3.310	3.300
Mean	1.642	1.475
Variance	0.721	0.744
Standard Deviation	0.849	0.863
Standard Error	0.185	0.193
Skewness (G1)	0.856	0.647
Kurtosis (G2)	0.211	–0.305
Sum	34.480	29.490
Coefficient of Variance	0.517	0.585
Median	1.500	1.175

Table 4 : Correlation coefficients of fluoride with other parameters

Parameters	Pre-monsoon (1999)	Post-monsoon (1999)
pH	0.219	0.295
Electrical Conductivity	0.229	0.369
Total Dissolved Solids	0.229	0.411
Carbonate	0.236	0.409
Bicarbonate	0.330	0.441
Total Alkalinity	0.445	0.185
Chloride	0.038	0.275
Sulphate	0.266	0.183
Total Hardness	–0.021	0.162
Calcium	–0.004	0.170
Magnesium	–0.043	0.146
Sodium	0.019	0.047
Potassium	0.447	0.568

Results and discussion

The analytical result of fluoride is shown in **Table 2.** Statistical analysis of the data was carried out for both the pre-monsoon and post-monsoon seasons. It was found that about 28.60% of the samples have fluoride concentrations less than 1 mg/L, 23.80% have concentrations in the range of 1.0 – 1.50 mg/L, 42.85% have concentrations in the range of 1.50 – 3.0 mg/L and 4.75% have concentrations more than 3.0 mg/L during the pre-monsoon. During the post-monsoon, it was found that about 35% of the samples have fluoride concentrations less than 1 mg/L, 25% have concentrations in the range of 1.0 – 1.50 mg/L, 35% have concentrations in the range of 1.50 – 3.0 mg/L and 5% have concentrations more than 3.0 mg/L. The statistical analysis results are shown in **Table 3**. The minimum and maximum concentrations observed during the pre-monsoon were 0.55 mg/L and 3.85 mg/L respectively and during the post-monsoon season 0.20 mg/L and 3.50 mg/L respectively. The mean fluoride concentration was 1.64 mg/L during the pre-monsoon and 1.475 mg/L during the post-monsoon. Standard deviation of fluoride during the pre-monsoon was 0.849 mg/L and during the post-monsoon it was 0.863 mg/L. The variance and coefficient of variance were 0.721 and 0.517 during the pre-monsoon and 0.744 and 0.585 during the post-monsoon seasons respectively. The median value was 1.50 mg/L during the pre-monsoon and 1.175 mg/L during the post-monsoon. Correlation matrix analysis of fluoride with other chemical parameters was obtained and shown in **Table 4.** It was observed that, there is a low level correlation of fluoride with potassium (0.447) and Alkalinity (0.445) during the pre-monsoon period. Also there is a low level correlation of

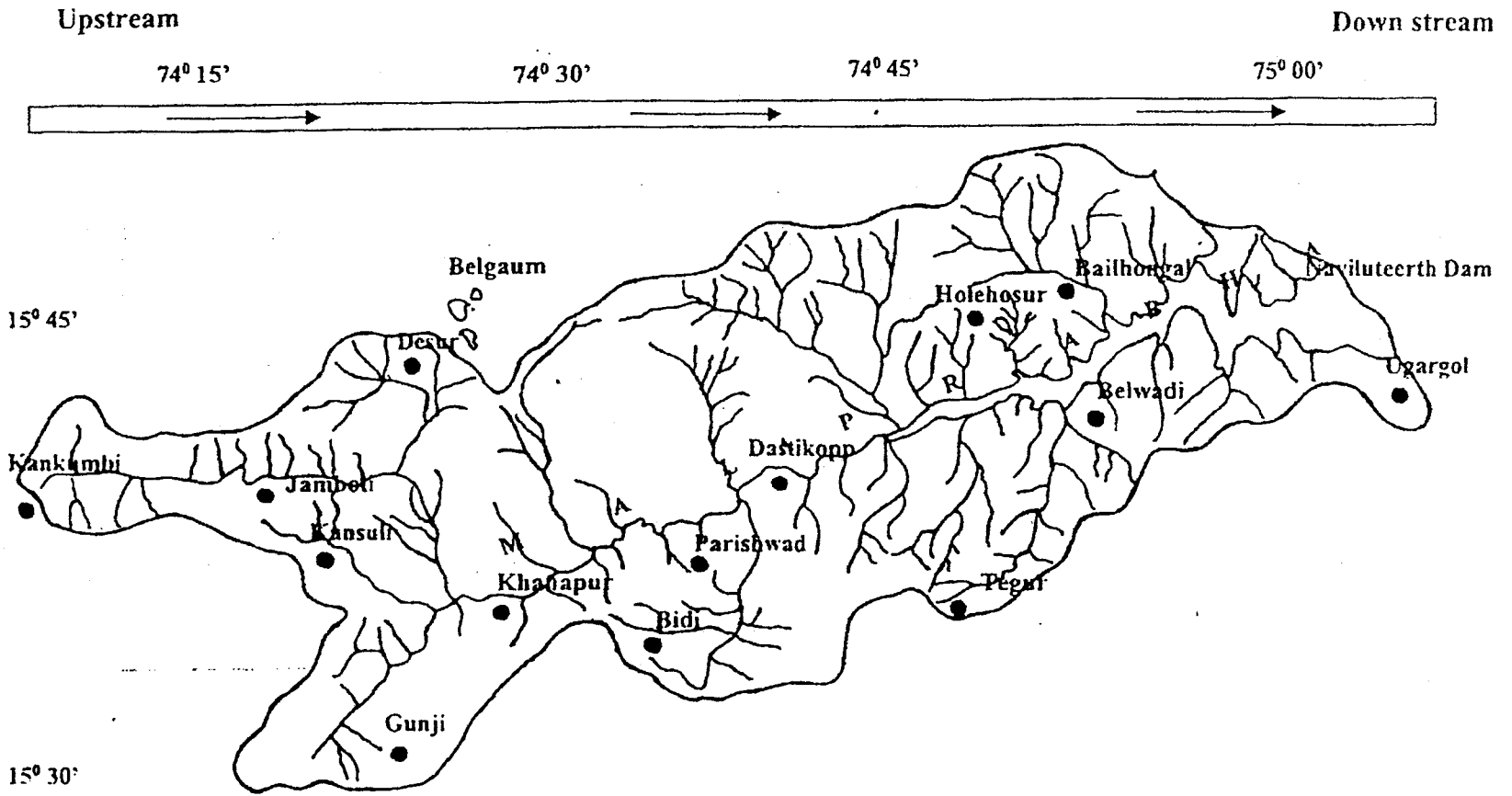

Fig. 2 : A location map of ground water sampling stations

fluoride with Potassium (0.568), Bicarbonate (0.441), TDS (0.411) and Carbonate (0.409) during the post-monsoon period. Correlation coefficient near to 0.5 was obtained with potassium, this may be due to the source of fluoride partially from potassium rich rocks and constituents of fertilizers leaching down to ground water.

Higher concentrations of fluoride (> 1.5 mg/L) were observed along the downstream area of the basin (Bailhongal, Belwadi and Ugargol of Soundatti taluk) and at very few locations in the upstream region (Kansuli, Gunji, Parishwad of Khanapur taluk and Dastikopp of Bailhongal taluk). In most parts of the upstream area low concentrations of fluoride were observed. The agricultural activities are more intense along the downstream region and due to excess application of fertilizers and chemicals, there is possibility of higher concentrations of fluoride in that region (Varadarajan, 2000)[6]. Fluoride content in groundwater beyond a permissible limit has been a serious problem in aquifer in drought prone areas with granitic bedrocks. A specific water quality problem in hard rock areas is due to high fluoride concentrations. Fluoride is mainly found in dark primary mineral, e.g. in biotite gneiss. However, if anorthite is also present, enough calcium will be released to check the fluoride concentration in the water. In ground water discharge area where kankar is formed, fluoride will also be precipitated. Hence, high fluoride concentration is sometimes found in kankar layers. Fluoride can enter through exchange of zeolite in basalt. The most important occurrence of fluoride is fluorspar CaF_2 and Cryolite of $NaF.AlF_2$. Fluorspar forms the cementing material in some sandstone.

Also, a negative correlation was found near to zero of fluoride ion with total hardness during the pre-monsoon period (i.e. an increase in calcium concentration results in the decrease of fluoride ion and vice versa). The fluoride concentrations above 1.2 mg/L may be attributed to the use of phosphatic fertilizers or fluor-apatite, which are leached down to the main ground water body by return irrigation flows (Sunil Kumar *et al.*1989)[7]. Small amounts of fluoride ions in irrigation water are removed as calcite, fluoride ions either get absorbed or co-precipitated with calcite. If the carbonate concentration is high enough to precipitate calcium as calcite without a concomitant removal of the fluoride ions, these ions may move down to the water front and ultimately join the main groundwater body (Handa, 1979)[8].

The regression equations for estimating the fluoride concentrations using other water quality parameters having significant correlation (r) have been given in **Table 5.** The regression equations were developed by taking fluoride as dependent variable and other water quality parameters as independent variables. The higher r^2 values indicate better performance of the relationship and suitability in predicting the dependent variable.

Acknowledgements

The authors are grateful to Dr. K.D. Sharma, Director, National Institute of Hydrology (NIH) for granting permission to publish the paper. The authors also thank Dr. S.V.N. Rao, Scientist 'F' & Coordinator, and Mr.B.Venkatesh, Scientist 'E1' & Head, RC, NIH, Belgaum for their kind advice and cooperation.

Table 5 : Regression equations for estimating fluoride concentration

Pre-monsoon		Post-monsoon	
Regression equation	**r**	**Regression equation**	**r**
F = -0.669+0.273pH	0.219	F = -1.647+0.423pH	0.295
F = 1.465+EC	0.229	F = 1.157+EC	0.369
F = 1.465+TDS	0.229	F = 1.125+0.001TDS	0.411
$F = 1.536+0.009CO_3$	0.236	$F = 1.366+0.104CO_3$	0.409
$F = 1.296+0.002HCO_3$	0.330	$F = 0.949+0.002HCO_3$	0.441
F = 1.060+0.004Alkal	0.445	F = 1.297+0.001Alkal	0.185
$F = 1.393+0.002SO_4$	0.266	F = 1.285+0.001Cl	0.275
$F = 1.422+0.005PO_4$	0.447	$F = 1.289+0.001SO_4$	0.183
		$F = 1.123+0.007PO_4$	0.568

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