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Fluoride geochemistry of Kollong river basin, Assam, India

***Mukut. M. Saikia[1] and Hari. P. Sarma[2]**

[1]Dept of Chemistry, Dhing college, Nagaon, Assam
[2]Dept. of Environmental Science, Gauhati University, Assam, India

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ABSTRACT

A total of 40 groundwater samples collected from deep tube well and bore well from Nagaon district, Assam, India were analysed for fluoride contamination, besides water quality parameters such as pH, calcium, magnesium, sodium, potassium, and major anions such as chloride, sulphate, nitrate etc. The concentration of fluoride in the water samples ranged between 0.03 and 5.68 mg/L and revealed that 42.5% of water samples contain fluoride above the maximum permissible limit. The R-squared values for the correlation of fluoride with calcium and magnesium showed a poor positive correlation, but with sodium and potassium a strong positive correlation was observed.

Key words: Fluorosis, fluoride, Nagaon district.

INTRODUCTION

Fluoride in drinking water has appeared as serious problem and around 200 million people, from 25 nations of the world over, are under the dreadful fate of fluorosis [1]. Fluorosis is an endemic disease due to long term intake of excessive fluoride. So far two main kinds of fluorosis, namely dental fluorosis and skeletal fluorosis have been identified. Patients with dental fluorosis chronically develop yellowing of teeth and pitting or mottling of enamel [2, 3]. Skeletal fluorosis is a bone disease exclusively caused by consumption of about ten times of the normal amount of fluoride [4]. Mild cases of skeletal fluorosis cause slight problems. However, in serious cases, skeletal fluorosis results in unbearable pain as well as severe damage to bones and joints [5]. There are several commonly accepted causes for endemic fluorosis such as long term intake of high fluoride groundwater [6], and exposure to high fluoride gas from coal burning [7].

Common natural fluoride sources in groundwater are the dissolution of some fluoride bearing minerals such as fluorite, apatite, and micas and hence the problem consequently occurs in area, where the element is most abundant in the host rocks. The study area is the Nagaon district which lies between latitude $25^0$56’30”N - $26^0$40’20”N and longitude $92^0$15’E - $93^0$20’E. Geomorphologically the study area belongs to the Brahmaputra Plain which is build up largely by fluvial agradation of a geological trough. The geology of the study area entails that Pre-

Cambrian metamorphic rock complex forms the basement of these area [8, 9]. The Pre-Cambrian rocks consisting of quartzites and phyllities are confined in a small area, but granitic gneisses are scattered along the north and south bank of Brahmaputra basin [8]. The sediments of these areas are mostly shale, sandstone, limestone and conglomerate [9]. Although, the presence of fluoride bearing minerals in host rocks and their interaction with water is considered to be the main cause for fluoride in groundwater, but the distribution and dissolution of fluoride bearing rocks around aquifers is also important [10]. In some previous studies Dutta et al. [11] found that about 18.6% groundwater samples contain fluoride above 1.5 mg/L in Central Assam. According to Das et al. [12] 10.7% of groundwater samples have fluoride concentration above 1.5 mg/L in Guwahati Assam. Similar observations were also recorded in Darrang district of Assam [13]. Therefore, to understand the current and potential source of fluoride contamination of groundwater in the study area the study is shaped.

MATERIALS AND METHODS

A total of 40 groundwater samples have been collected from deep tube wells and bore wells (hand pump) during March and April 2009 and analyzed to understand the chemical variations of water quality parameters using standard methods[14,15]. Pre-cleaned (acid-washed) polythene containers of 1L capacity were used for groundwater sample collection. Each of the groundwater samples were analyzed for pH, major cations and anions. Calcium content was estimated by ethelenediamminetetraacetic acid titrimetric method and magnesium was calculated by the difference in the hardness and calcium [15].The sulphate and nitrate were analyzed by the UV-visible spectrophotometer (Shimadzu UV-mini 1240). Chloride was calculated by argentometric titration method [15]. Sodium and potassium were determined with a flame photometer (Elico-CL-220) using standard calibration procedure. Fluoride content was determined by using SPADNS methods using UV- visible spectrophotometer (Shimadzu UV-mini 1240) calibrating against blank and standard sodium fluoride solutions. The chemicals used in all the purposes were of analytical grade (procured from Merck, India).

RESULTS AND DISCUSSION

Table-1 Ranges of chemical parameters and their comparison with WHO and BIS for drinking water

Chemical parameter	Concentration of ions		Average	SD	WHO standard(1997) (desirable - permissible)		BIS standard(1997) (desirable - permissible)	
	Minimum	Maximum						
pH	6.6	8.2	7.41	0.45	7	9.2	6.5	9.2
Ca^{2+} (mg/L)	11.22	71.21	34.09	14.82	75	200	75	200
Mg^{2+}(mg/L)	4.87	39.47	16.86	8.83	30	150	30	100
Na^{+}(mg/L)	5	80	33.23	15.67	50	200	-	-
K^{+}(mg/L)	1	16	4.75	3.54	10	12	-	-
$SO_4^{=}$(mg/L)	4.67	87.3	29.97	21.09	200	600	200	400
Cl^{-}(mg/L)	8.52	73.84	33.86	13.84	250	600	250	1000
F^{-}(mg/L)	0.03	5.68	1.51	1.13	0.9	1.5	1	1.5
NO_3^{-}(mg/L)	0.01	13.19	3.74	3.47	50	-	45	100

The analytical results of 40 groundwater samples of the study area are presented in Table-1. The pH of the analyzed sample varies from 6.6 to 8.2 with a mean value of 7.41. In general, pH of groundwater samples is alkaline in nature. Among the cationic concentration calcium and sodium are the dominant ion having a range of 11.22 to 71.21 (mg/L) and 5.0 to 80.0 (mg/L) followed by magnesium (mean, 16.86 mg/L) and potassium (mean, 4.75 mg/L). The cationic chemistry indicated that 37.5% of samples are Ca> Mg> Na> K while 20%, 17.5%, 17.5% and

5% belong to Ca> Na> Mg> K, Na> Ca> Mg> K, Na> Mg> Ca> K and Mg> Ca> Na> K respectively. Only 2.5% of the samples are Mg> Na> Ca> K type.

Among the anionic concentrations, chloride is the dominant ion, having a range of 8.52 to 73.84 mg/L with an average of 33.86 mg/L, followed by sulphate (mean, 29.97 mg/L), and nitrate (mean, 3.47mg/L) respectively. The status of fluoride in the study area reveals that its concentration varies from 0.03 to 5.68 mg/L with an average of 1.51 mg/L having a standard deviation of ± 1.13. About 42.5% of groundwater samples have fluoride content higher than the recommended levels of 1.5 mg/L [16, 17]. The distributions of fluoride in the study area are plotted in Fig-1.

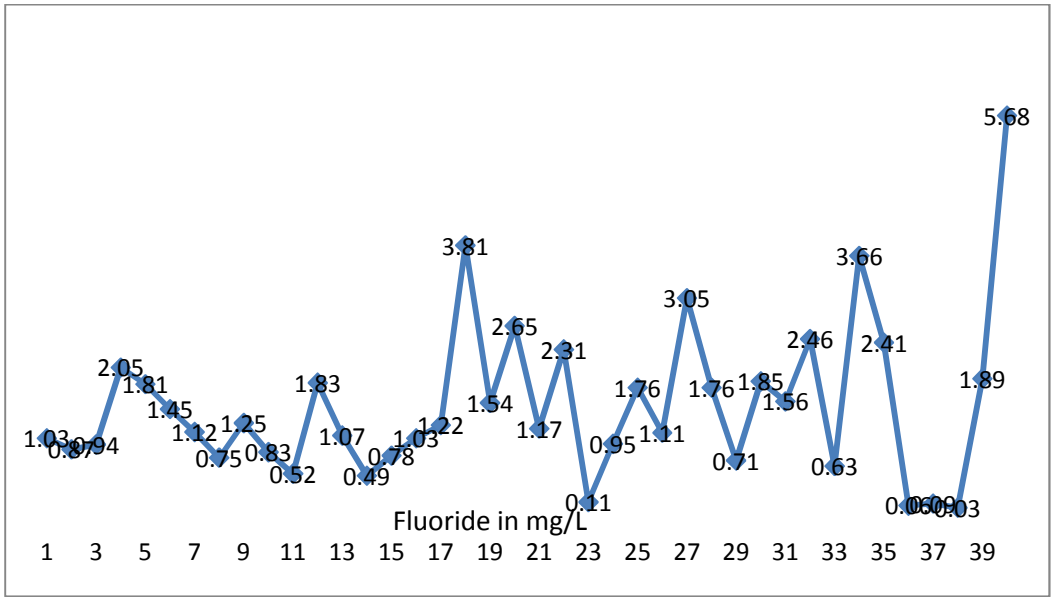
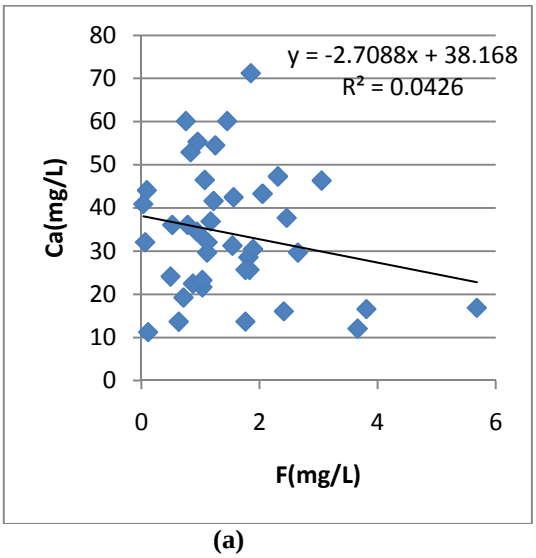
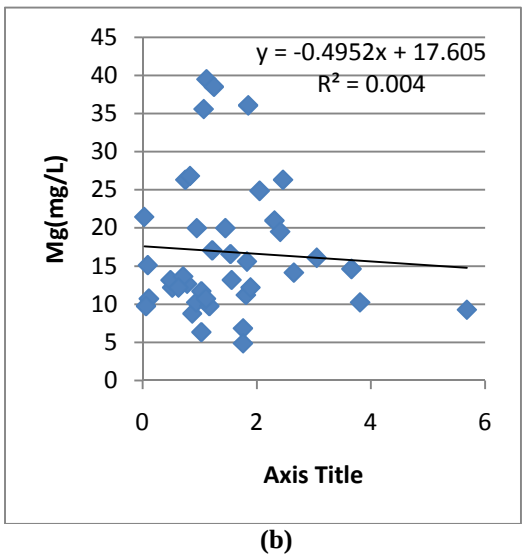


Fig-1 Fluoride distribution in groundwater samples



(a)



(b)

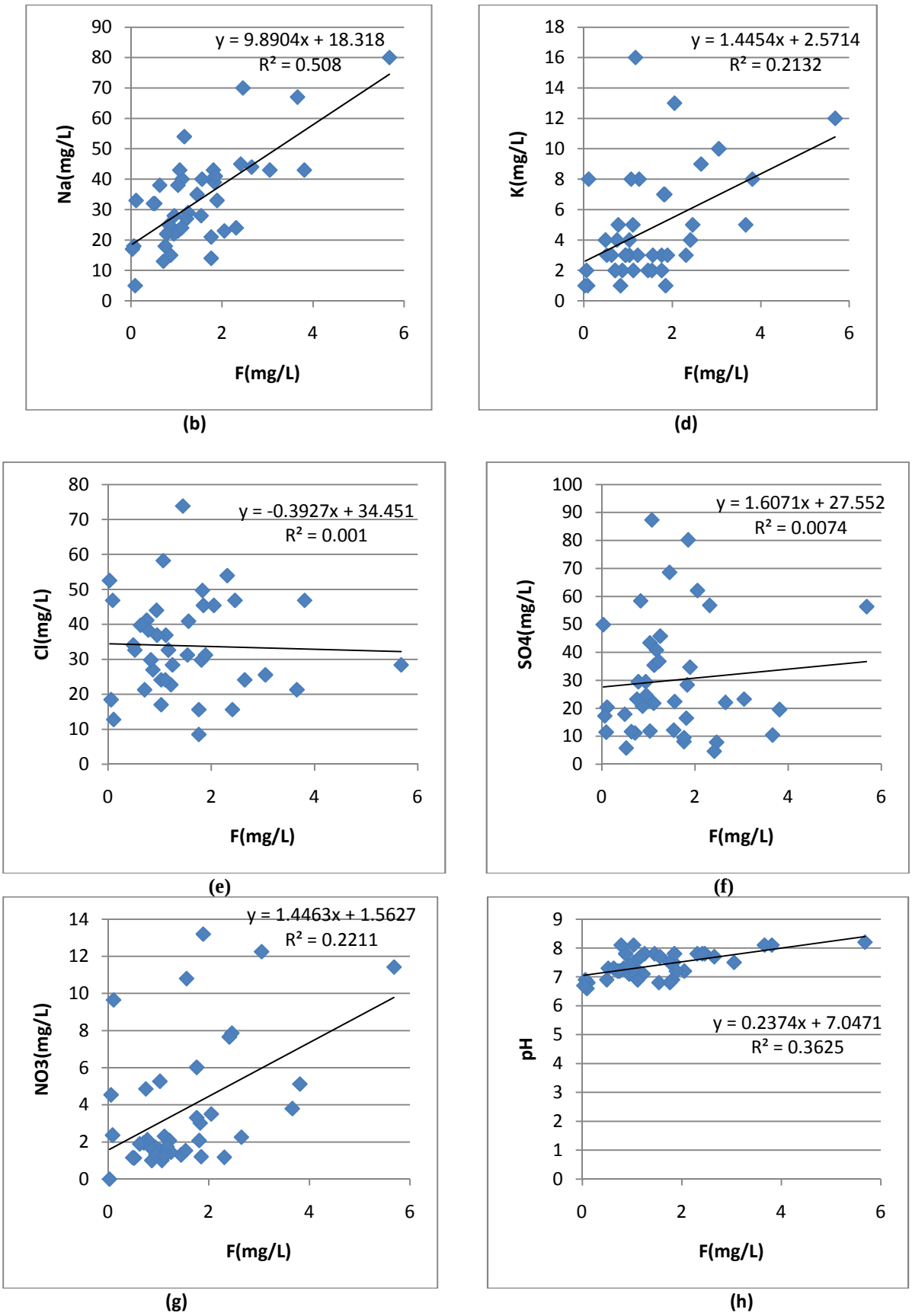


Fig-2 Correlation of different parameters with fluoride concentration

(a) Ca^{2+} Vs F^-, (b)Mg^{2+} Vs F^-, (c) Na^+ Vs F^-, (d) K^+ Vs F^-, (e) Cl^- Vs F^-, (f) SO_4^{2-} Vs F^-, (g) NO_3^- Vs F^-, (h) pH Vs F^-

The *R*-squared values for the correlation of fluoride with some inorganic ingredients were plotted. The alkaline earth metal Ca^{2+} and Mg^{2+} showed poor negative correlation with F^- (Fig-2a-2b). This may because the groundwater in the study area was predominantly Ca^{2+}-Mg^{2+}-HCO_3^- -type and in general they were soft in nature. Moreover, fluoride concentration is generally less in Ca-HCO_3-type waters compared to Na-HCO_3 -type waters [18-20]. Negative correlation of F^- with Ca^{2+} and Mg^{2+} is expected due to low solubility of fluorides of these ions [18, 21, 12].

The alkali metal ions, viz. Na^+ and K^+ showed positive correlation with fluoride (Fig-2c-2d).Alkaline pH and Na-HCO_3-type water often give rise to high fluoride in groundwater [22-25]. A positive correlation of F^- with Na^+ in some parts of Nagaon and Karbi-Anglong district of Assam was also reported [26]. The anions Cl^- and SO_4^{2-} did not show any correlation with fluoride content (Fig-2e-2f), ruling out evaporation as a reason for high fluoride content [27]. However, a positive correlation of F^- with NO_3^- was observed (Fig-2g) which may due to the geo-diversity of the study area. A moderate positive correlation was observed between F^- and pH (Fig-2h). Gupta et al. [28] also reported a positive correlation of pH with F^- in the groundwater of Birbhum (West Bengal). Therefore, since the underground basement of the study site is of Precambrian origin, therefore the minerals may be fluorite or (and) apatite [18, 9] which is responsible for high fluoride concentration in the study area.

CONCLUSION

Groundwater is the only reliable source of drinking water for the people residing in the study area. Geological formation is found to be a basic cause for the higher concentration of fluoride in most of the sampling points. The excess fluoride concentration in the groundwater of the study area implies that there is an urgent need to implement suitable remedial measures and de-fluoridation of the pumped water seems to be a viable option for immediate relief. In addition, such information should be made available to health professionals in order to avoid feasible overmedication.

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