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Fluoride, iron and nitrate contaminated drinking water in Kamrup district, Assam, India

Sutapa Chakrabarty*, Hari Prasad Sarma

Department of Environmental Science, Gauhati University, Guwahati, Assam, India

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ABSTRACT

Drinking water quality with respect to fluoride, iron, and nitrate content has been carried out in Kamrup district of Assam, India. Forty six different sampling stations were selected for the study. Iron was analyzed by using an atomic absorption spectrometer, Perkin Elmer AA 200, while fluoride was measured by the SPADNS method at 570nm and Nitrate content was measured by the phenol-disulphonic acid method at 410nm using a UV–VIS spectrometer, Shimadzu 1240 model. The study revealed that the water sources in the area are heavily polluted with iron, and fluoride. Statistical analysis of the data is presented to determine the distribution pattern, localization of data and other related information. Statistical observations imply non-uniform distribution of the studied parameters with a long asymmetric tail either on the right or left side of the median.

Key Words: Drinking Water, Fluoride, Iron, Nitrate, Asymmetric Distribution.

INTRODUCTION

Approximately half of the world's population lives in urban areas and by the year 2025, will have risen to 60 per cent, comprising some 5 billion people [1]. Rapid urban population growth and industrialization are putting severe strains on the water resources and environmental protection capabilities of many cities particularly in developing nations.

The lack of source of clean drinking water is giving birth to public health concern worldwide. Waterborne diseases are a consequence [2]. Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. Human use of fresh water has registered a 35 fold increase in the last 300 years. Ground water is generally considered as a safe source of fresh drinking water. But the contamination of ground water is not away from the evils of modernization. Ground water is assumed to be of higher quality unlike surface water sources as it remains unexposed but with the increase in domestic sewage and agricultural and other industrial wastes the natural sources are getting contaminated every now and then. The chronic impact of these chemical contaminants of drinking water is dreadful. They cause very serious health problems, whether the chemicals are naturally occurring or derived from source of pollution.

India is currently facing critical water supply and drinking water quality problems. There is evidence of prevailing contamination of water resources in many areas of India. Although information on drinking water quality of Northeastern India is very little, results reported by various agencies have been alarming[3]. Available literature shows that groundwater in Assam are highly contaminated with iron[4] . The occurrence of fluoride contamination in Darrang, Karbi Anglong, and Nagoan districts of Assam in the form of fluorosis were already reported[5],[6],[7] . High level of fluoride and iron distribution in groundwater sources of certain districts of Assam has also been observed[8],[9]. The health problems arising as a result of fluoride contamination are far more widespread in India. Nearly 177 districts have been confirmed as fluoride-affected areas. Nitrate contamination in groundwater arises from intensive agriculture and use of chemical fertilizers, improper and unhygienic sanitation, landfills and irrigation of land by sewage effluents[10] . Nitrate (NO_3^-) converted from nitrogenous fertilizers leaches readily to deep soil layers and ultimately accumulates into the groundwater system.

Health hazards arising out of exposure to higher level of nitrate level can be many fold, viz, methemoglobinemia or "blue baby syndrome," which may cause mortality by asphyxiation especially in newly born infants, gastrointestinal cancer, Alzheimer disease, vascular dementia, absorptive secretive functional disorders of the intestinal mucosa, multiple sclerosis, Non-Hodgkin's lymphoma, hypertrophy of thyroid, etc.[10].

Table 1 Water Sampling stations in the study area.

Sl. No.	Sampling stations	Source	Sl. No.	Sampling stations	Source
1	Naukata	TW	24	Lokhra	TW
2	Rangia	*RW*	25	Bezera	RW
3	Karara	TW	26	Noonmati	SW
4	Kendukona	TW	27	New Guwahati	TW
5	kamalpur	TW	28	Pan Bazar	SW
6	Puthimari	TW	29	Narengi	TW
7	Baihata Chariali	TW	30	Dispur	SW
8	Hajo	RW	31	Silpukhuri	RW
9	Changsari	RW	32	Bhangagarh	TW
10	North Guwahati	DTW	33	Kamakhya	DTW
11	Sualkuchi	TW	34	Gauhati University	TW
12	Palashbari	TW	35	Basistha	DTW
13	Chhaygaon	TW	36	Khanapara	TW
14	Sonapur	TW	37	Bhralumukh	DTW
15	Chandrapur	RW	38	Chandmari	TW
16	Khetri	DTW	39	Fancy Bazar	SW
17	Narengi	TW	40	Panjabari	RW
18	Boko	TW	41	Azara	TW
19	Dumunichowki	TW	42	Lankeswar	TW
20	Dimu	RW	43	Satmile	TW
21	Maligaon	TW	44	Jalukbari	TW
22	Boragaon	DTW	45	Satgaon	TW
23	Tetelia	TW	46	Panikhaiti	TW

Kamrup district is the capital district of Assam. It is situated between 25.43 and 26.51 degree north latitude and between 90.36 and 92.12 degree east latitude. The greater part of the district consists of wide plains, through the lower portion of which the mighty river Brahmaputra makes its way flowing a steady course from east to west. It covers an area of 4345 sq km. and receives an average rainfall of 1500 mm – 2600 mm. The region enjoys a climate of the sub tropical type with semi-dry summer & cold in winter. For the present study, 184 water samples were collected from forty six sampling locations (Table 1) in Kamrup district spread over two seasons (Pre monsoon and monsoon season and Post monsoon and winter season) during 2006-2008.

The present research has been carried out to study the drinking water quality parameters with respect to fluoride, iron and nitrate in Kamrup district, Assam to help users at the national or local level in developing strategies for risk.

MATERIALS AND METHODS

Experimental

Separate water samples were selected by random selection and compiled together in clean and sterile one liter polythene cans rinsed with dilute HCl to set a representative sample and stored in an ice box. Samples were protected from direct sun light during transportation to the laboratory and metals were analyzed as per the standard procedures(11). Iron was estimated by using Atomic Absorption Spectrometer (Perkin Elmer AA 200). Fluoride was measured by the SPADNS method at 570nm and Nitrate content was measured by the phenol-disulphonic acid method at 410nm using a UV–VIS spectrometer, Shimadzu 1240 model. The instruments were used in the limit of précised accuracy and chemicals used were of analytical grade. Doubly-distilled water was used for all purposes.(11) .

In this study, the tools used for data analysis are mainly experimental, aimed at defining possible relationships, trends, or interactions among the measured variables of interest. The observed parameters are related graphically (Figs. 1-3). Descriptive statistics in the forms of mean, variance (V), standard deviation (SD), standard error (SE), median, range of variation, and percentile at 95%, 75% and 25% (P95%, P75%, P25%) are calculated and summarized in tabular form (Table 2). Univariate statistics were used to test distribution normality for each parameter. The correlation analysis was performed for measured parameters to determine the relationship between these variables (Table 3). The significance level reported ($p<0.05$) is based on the Pearson's coefficients.

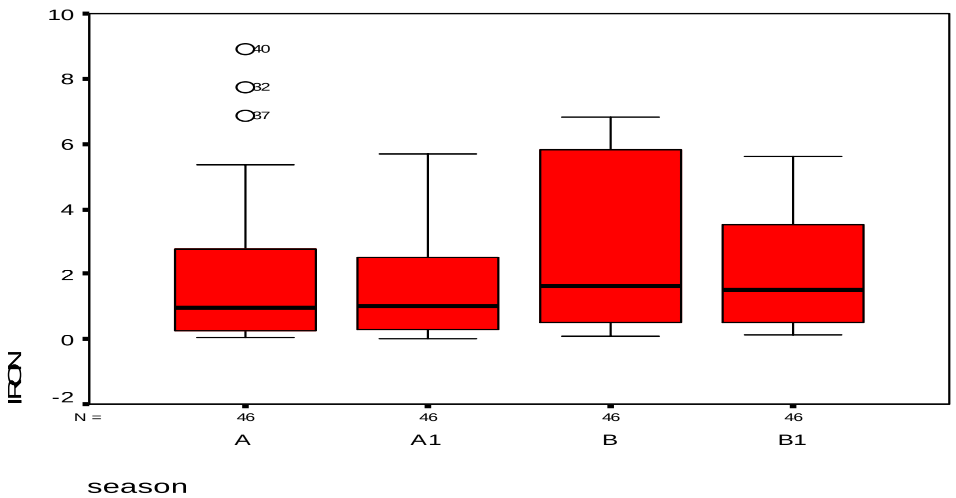

Fig 1 Box plot showing status of Iron in the study area.

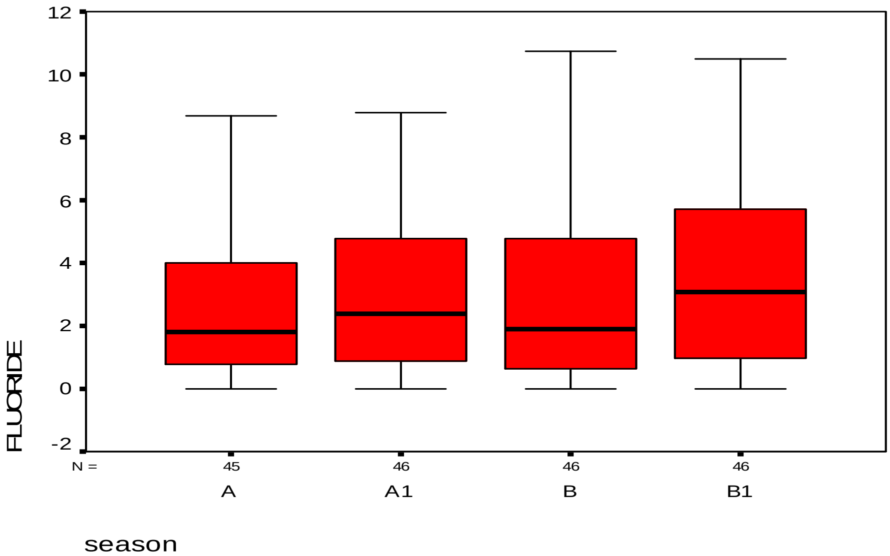

Fig 2: Box plot showing status of fluoride in the study area.

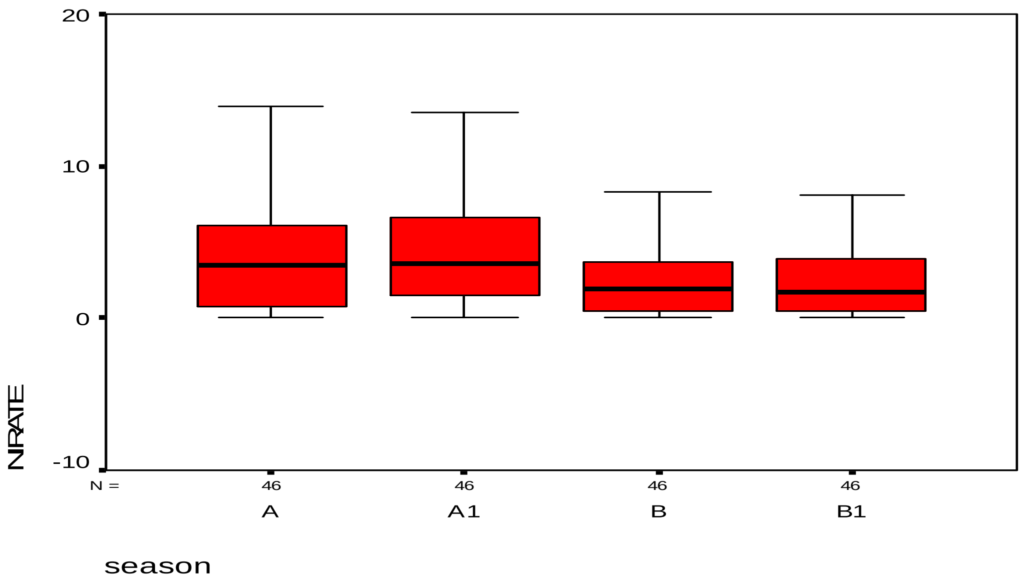

Fig 3: Box plot showing status of nitrate in the study area.

Table 2 Descriptive Statistics of Fluoride, Iron and Nitrate contents of drinking water in the study area

		FLUORIDE	IRON	NIRATE
N	Valid	184	184	184
Mean		3.04	3.44	2.08
Median		2.00	2.48	1.30
Mode		.00	.00	.20
Std. Deviation		2.80	3.57	2.08
Variance		7.84	12.71	4.33
Skewness		.921	1.355	1.076
Kurtosis		-.151	1.439	.176
Range		10.71	15.30	8.93
Minimum		.00	.00	.00
Maximum		10.71	15.30	8.93
Percentiles	25	.755	.500	.300
	50	2.005	2.485	1.300
	75	4.792	4.950	3.405

Table 3: Correlation of Fluoride, Iron and Nitrate contents of drinking water in the study area

		FLUORIDE	NITRATE	IRON
FLUORIDE	Pearson Correlation	1.000	.073	.130
	Sig. (2tailed)		.323	.079
	N	184	184	184
NIRATE	Pearson Correlation	.073	1.000	-.222
	Sig. (2-tailed)	.323		.002
	N	184	184	184
IRON	Pearson Correlation	.130	-.222	1.000
	Sig. (2-tailed)	.079	.002	
	N	184	184	184

t-Test is done under null hypothesis (H0) by taking the assumption that the experimental data are consistent with the mean rating given by WHO (Table 4). SPSS® statistical package (Window Version10.0) was used for data analysis. All statements reported in this study are at $P < 0.05$ levels.

Table 4: Results of One-Sample t-Test for Fluoride, Iron and Nitrate contents of drinking water in the study area

	t	95% CL		Comment
		Lower	Upper	
FLUORIDE	14.695	2.6266	3.4413	Significant
NIRATE	13.093	2.9233	3.9606	Significant
IRON	13.536	1.7737	2.3791	Significant

RESULT AND DISCUSSION

Water quality parameters reflect the level of contamination in water resources. In the present investigation the pot ability of water for drinking purpose with respect to fluoride, iron and nitrate was compared with the standards set by WHO(12) for different chemicals in water.

Iron occurs naturally in groundwater. Higher concentration of iron in water stains laundry and plumbing fixtures. Iron content of 72 percent of the drinking water sources in the area exceeds the WHO guideline value of 0.3 mg/L. The iron content of the area may promote the growth of iron bacteria, leaving a slimy coating in piping. A broad third quartile and positive skewness in case of iron represents a long asymmetric tail on the right of the median. It is also evident from the box plot (Fig 1). The outlier of the box plot 8.9mg/l, 7.76mg/l, 6.87mg/l, is observed for sampling station Panjabari, Bhangagarh and Bharalumukh respectively.

Fluoride in drinking water neither produces any taste or odour nor does it produce any color or turbidity. Therefore it becomes very difficult to establish its presence in water. Fluorosis has emerged as an acute public health problem in India. The present study has revealed that almost about 68 per cent of the drinking water samples have exceeded the upper limit of standards set by WHO which is 1mg/l. Fluoride, as a dissolved constituent of drinking water, is perhaps the only substance producing divergent health effects on the consumer depending upon their relative proportions. While fluoride concentration in the range of 0.8 to 1.20 mg/l is considered to be beneficial, concentrations higher than 1.5 mg/l are reported to be harmful to the teeth and bone structure of men and animals. However, as a surprising paradox, incidence of dental, skeletal and crippling skeletal fluorosis was reported in India with average fluoride concentrations as low as 0.5, 0.7 and 2.8 ppm respectively(13). Decreased thyroid function is an adverse health effect, particularly to individuals with inadequate dietary iodine. These individuals could be affected with a daily fluoride dose of 0.7 mg/day (for a “standard man”). Fluoride has adverse effects on the brain, especially in combination with aluminum. Fluorosis, turns out to be the most widespread geochemical disease in India, affecting more than 66 million people including 6 million children under 14 years age.

Statistical analysis of the present investigated data indicates off normal distribution of fluoride in the study area. This is evident from the difference between mean and median values, positive skewness and the width of the third quartile, which is greater than the first and second quartile.

Flat distribution for fluoride in the area is indicated by negative kurtosis value. The fluoride contamination of groundwater in the area should be accorded maximum attention. The box plot (Fig 2) depicts that the median fluoride levels is around 2ppm and that the maximum and minimum fluoride levels are shown by the extended whiskers from the box which is longest for season B (Monsoon and post monsoon , 2006-2007). The skewness of the assessed fluoride data is also visible from the box plots. A positive correlation has been observed between fluoride and iron concentration in the study area.

High concentration of nitrate in the drinking water sources has posed many health problems in human being. Apart from life threatening methemoglobinemia, hypertension, gastrointestinal disorders, thyroid disorder and some fifteen types of cancer has also been reported(14). Research shows a definite relationship between increasing rates of stomach cancer with increasing nitrate intake(15),(16) . The permissible limit of nitrate for drinking water has been set by WHO to be 50 mg/l. In the present investigation in regards to nitrate concentration the drinking water sources of the study area are by and large safe, but its distribution is still not uniform in the area as observed from the box plot (Fig3). The median is observed to lie between 1ppm-2ppm. Asymmetric nature of nitrate distribution is apparent from the normal distribution statistics with positive skewness and kurtosis values. A negative but significant correlation has been observed between nitrate and iron concentration in the study area.

By comparing calculated | t | value with tabulated t at 5% probability level of significance, we may either reject or accept our null hypothesis H0. The statistical values show that all of the studied water quality parameters are significant implying that the null hypothesis may be rejected. The calculated confidential limit will give the range within which the unknown value of the parameter is expected to lie.

CONCLUSION

An asymmetric distribution pattern has been observed for all the studied parameters in the study area. Presence of fluoride at an alarmingly higher concentration in most of the samples than the prescribed WHO limit requires immediate attention. The drinking water sources are not safe in regards to the iron concentration in the study area. It is, therefore, immediately required that the water sources be properly protected from potential contamination of fluoride and iron. A positive and significant correlation has been observed between iron and fluoride concentration in the study area. Nitrate bears a significant negative correlation with iron. From the above study it can be suggested that there is an immediate necessity of surface water management with people’s participation for reduced dependency on ground water.

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