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Assessment of groundwater quality with reference to fluoride, arsenic and iron in tea garden belt of Lakhimpur district, Assam, India

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ABSTRACT

Ground water quality with respect to pH, iron, fluoride and arsenic has been carried out in six selected tea gardens of Lakhimpur district of Assam, India. Forty eight different sampling stations were selected for the study. Statistical analysis of the data is presented to find out the distribution pattern, localisation of data, and other related information. The study revealed that the water sources in the area are contaminated with iron and arsenic. The contamination of groundwater by arsenic and iron are attributed to geogenic origin. Statistical observations imply non uniform distribution of the studied parameters with a long asymmetric tail on the right side of the median. Thus, suitable protective measure for drinking water sources in the area is recommended.

Key words: Arsenic, Iron, Skewness, NDA, Kurtosis etc.

INTRODUCTION

Water is a precious and finite resource on Earth. Presently both water quantity and quality are subjects of ongoing concern in many countries. As water sources are limited, it is of supreme importance to keep its quality at the highest level possible. Ground water is an important resource for drinking purpose which contains over 90% of the fresh water resources [1]. Groundwater has been used as a source of drinking water for millions of rural and urban families in India. As it is very limited and vulnerable resource, every effort should be made to achieve groundwater quality as safe as practicable. It has been observed that the tea garden belt in Assam has lately been subjected to large-scale human interference and its consequential hazards like degradation and gradual loss of soil and water quality. Tea is an economically important, high-value plantation crop in India with an old history; many tea estates in Assam are more than 100 years old. The soil and water quality in tea garden areas of Darrang and Sonitpur district in Assam is well published [2-7]. A statistical analysis of some water quality parameters viz. pH, arsenic, fluoride and iron, in the groundwaters collected inside the six selected tea gardens of Lakhimpur district, Assam has been presented in this communication. The implications presented are based on statistical analyses of the raw data. Normal distribution analysis (NDA) is used for interpretation of data. The primary objective of this study is to present a statistically meaningful water quality database of the area.

MATERIALS AND METHODS

The study area Lakhimpur district is situated in the remote corner of north east India. Geographically, the district is situated between $26^0 48^/$ and $27^0 53^/$ northern latitude and $93^0 42^/$ and $94^0 20^/$ eastern longitude and covers an area of 2,977 km^2, out of which 2,957 km^2 is rural and 20 km^2 is urban. After careful study of the topography and other

aspects, forty eight groundwater samples were collected from tubewells and ringwells during June, 2012 to November, 2012 at different sites inside six tea gardens of Lakhimpur district as presented in Table 1. Samples were collected once in a week by random selection and combined together in clean and sterile one-litre polythene cans to obtain a composite sample and stored in an ice box [8]. All probable safety measures were taken at every stage, starting from sample collection, storage, transportation and final analysis of the samples to avoid or minimize contamination. pH of the samples were measured quickly after collection by using a digital pH meter (ELICO, LI-127). Arsenic was analysed by using an atomic absorption spectrometer (Perkin Elmer AAnalyst 200) with flow injection analyze mercury hydride generation system (Model FIAS-100) at 189 nm analytical wavelengths. Iron is measured by 1, 10 Phenanthroline method using a uv-visible spectrophometer (Shimadzu 1240) at 510 nm. Fluoride in water was determined by SPADNS method (colorimetric) by using a U.V. visible spectrophotometer (ELICO SL159) at 570 nm [9].

Univariate statistics were used to test distribution normality for each parameter. Moment coefficients of skewness and kurtosis were calculated to express how the shapes of sample frequency distribution curves differ from ideal Gaussian (normal). Skewness was calculated as third moment of the population mean. In asymmetrical distributions, skewness can be positive or negative. Kurtosis was calculated as fourth moment of the population to describe the heaviness of the tails for a distribution. Some more statistical estimates derived from the normal distribution in the form of Sample variance, 1^{st} , 2^{nd} , 3^{rd} Percentile, Inter Quartile Range (IQR) were also made in the present study to find out the distribution pattern of the data and other related information Details of these may be found in standard books on statistics and software packages [10].

Table 1 Water sampling locations inside the selected tea gardens

Name of the tea garden	Sample No's	Number of Samples
Ananda Tea Estate	A1-A8	08
Sirajuli Tea Estate	B1-B8	08
Silanibari Tea Estate	C1-C8	08
Dirzoo Tea Estate	D1-D8	08
Dolohat Tea Estate	E1-E8	08
Harmutty Tea Estate	F1-F8	08

RESULTS AND DISCUSSION

The results of analysis of various parameter in groundwater samples of the tea garden belt of Lakhimpur district, Assam are given in Table 2-7. To look into the trend and distribution patterns of pH, fluoride, iron and arsenic in groundwater of the study area, data obtained from 48 sampling stations were exposed to several statistical treatments as discussed briefly in the methodology section. A conventional descriptive statistics based on normal distribution has been shown in Table 8.

Table 2 Water quality data of Ananda Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
A1	Tube well	Factory Line	27° 26.850/	94 ° 13.861/	6.75	0.35	0.64	0.0327
A2	Ring well	Babu Line	27° 26.735/	94° 13.819/	6.22	0.42	0.56	0.0431
A3	Supply water	Factory Line	27° 26.755/	94° 13.796/	7.12	0.65	0.62	0.0092
A4	Tube well	Line No. 27	27° 26.885/	94° 13.892/	6.51	0.52	0.73	0.0365
A5	Supply water	Ananda Tea Estate Hospital	27° 26.665/	94° 13.783/	6.78	0.21	0.66	0.0234
A6	Ring well	Khari Line	27° 26.936/	94° 13.992/	6.28	0.54	0.77	0.0376
A7	Tube well	Babu Line	27° 26.755/	94° 13.810/	7.12	0.48	0.98	0.0126
A8	Ring well	Pothalipam	27° 26.135/	94° 13.277/	6.83	0.74	0.57	0.0289

The smallest value is shown pH is a numerical expression that indicates the degree to which water is acidic or alkaline and is an operational parameter. pH alone does not provide a full picture of the characteristics or limitations with the water supply. In all the sampling stations, pH values were within the guideline values for safe drinking

water. The variation of pH was narrow and significant positive skewness value for pH indicates an asymmetric tail extending towards higher values. A negative kurtosis value is also indicative of flat distribution of pH in the area.

The distribution of fluoride in groundwater of the study area is found to be within the permissible limit of W.H.O. with an average of 0.72 mg/L. Asymmetric nature of fluoride distribution is also apparent from the normal distribution statistics with positive skewness and negative kurtosis values. No fixed trend of variation of fluoride among the sampling stations could be ascertained which may be due to human activity, use of artificial fertilizers and waste disposal.

Table 3 Water quality data of Sirajuli Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
B1	Tube well	Sirajuli Hospital	27° 21.233/	94° 07.106/	6.20	0.09	0.64	0.0376
B2	Ring well	Khari Line	27° 21.461/	94° 06.871/	7.34	0.20	0.56	0.0470
B3	Supply water	Factory	27° 21.496/	94° 06.172/	6.74	0.15	0.68	0.0098
B4	Tube well	Khari Line	27° 21.449/	94° 06.818/	7.39	0.49	0.73	0.0371
B5	Supply water	Asst. Manager Bunglow	27° 21.474/	94° 06.165/	8.02	1.21	0.74	0.0096
B6	Ring well	Line no.7	27° 21.884/	94° 06.508/	7.55	0.33	0.65	0.0378
B7	Tube well	No. 8 Line	27° 21.819/	94° 06.494/	7.23	0.38	1.08	0.0199
B8	Ring well	Puna Line	27° 21.622/	94° 06.800/	6.44	0.63	0.88	0.0296

Table 4 Water quality data of Silanibari Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
C1	Tube well	Factory line	27° 12.325/	94° 00.011/	7.23	0.52	0.74	0.0129
C2	Ring well	Labour line	27° 12.162/	94° 00.012/	7.05	0.18	0.66	0.0080
C3	Supply water	G.M Bunglow	27° 12.822/	94° 59.044/	6.50	0.30	0.82	0.0199
C4	Tube well	Babu line	27° 12.702/	94° 35.512/	6.77	0.38	0.76	0.0405
C5	Supply water	Babu line	27° 12.921/	93° 59.590/	6.43	0.34	0.45	0.0040
C6	Ring well	No. 7 line	27° 12.226/	94° 00.132/	6.75	0.29	0.66	0.0196
C7	Tube well	Staff line	27° 12.349/	94° 00.339/	6.77	0.36	0.90	0.0433
C8	Ring well	Staff line	27° 12.472/	93° 89.492/	7.78	0.74	0.57	0.0177

Table 5 Water quality data of Dirzoo Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
D1	Tube well	Factory line	27° 16.654/	94° 01.479/	6.49	0.43	0.52	0.0305
D2	Ring well	Labour line	27° 16.267/	94° 01.439/	6.58	0.25	0.63	0.0148
D3	Supply water	Factory	27° 16.714/	94° 01.495/	7.91	0.55	0.82	0.0078
D4	Tube well	Staff line	27° 16.520/	94° 01.679/	6.77	1.00	0.60	0.0371
D5	Supply water	Staff line	27° 16.599/	94° 01.523/	6.55	0.44	1.02	0.0219
D6	Ring well	No.2 Labour line	27° 16.278/	94° 01.513/	7.34	0.31	0.68	0.0166
D7	Tube well	Babu line	27° 16.564/	94° 01.370/	6.65	0.30	0.93	0.0390
D8	Ring well	Line no.10	27° 16.161/	94° 01.497/	6.91	0.08	0.66	0.0418

Table 6 Water quality data of Dalohaat Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
E1	Tube well	Amarjyoti L.P. School	27° 10.141/	93° 56.970/	6.46	1.28	0.72	0.0517
E2	Ring well	Line No. 20	27° 10.636/	93° 57.245/	6.54	0.11	0.55	0.0123
E3	Supply water	Staff Line	27° 10.979/	93° 57.849/	7.09	0.56	0.88	0.0186
E4	Tube well	Sonapur L.P. School	27° 10.111/	93° 56.979/	7.28	0.37	0.65	0.0200
E5	Supply water	Factory Line	27° 10.973/	93° 58.078/	6.72	0.40	0.70	0.0222
E6	Ring well	Puna Line	27° 10.954/	93° 58.158/	6.83	0.31	1.02	0.0339
E7	Tube well	Old Line	27° 10.422/	93° 57.093/	6.70	0.71	0.78	0.0186
E8	Ring well	Market Line	27° 10.844/	93° 58.356/	7.48	0.19	0.85	0.0096

Table 7 Water quality data of Harmutty Tea Estate

Sample no.	Source	Name of place	Latitude N	Longitude E	pH	Iron in mg/L	Fluoride in mg/L	Arsenic in mg/L
F1	Tube well	Chandmari Namghor	27° 07.517/	93° 51.114/	7.10	0.76	0.98	0.0150
F2	Ring well	Harmutty L.P.School	27° 07.391/	93° 50.276/	6.57	0.15	0.65	0.0362
F3	Supply water	Factory Line	27° 07.795/	93° 50.100/	6.64	1.00	0.83	0.0091
F4	Tube well	Girja Line Point 2	27° 07.753/	93° 50.202/	7.48	0.47	0.59	0.0006
F5	Supply water	Harmutty Tea Estate Sub Hospital	27° 07.659/	93° 50.435/	6.90	1.37	0.44	0.0422
F6	Ring well	Harmutty Shiva Namghor	27° 07.660/	93° 50.588/	7.28	0.28	0.56	0.0432
F7	Tube well	Girja Line Point 1	27° 07.770/	93° 50.163/	6.61	1.05	0.84	0.0290
F8	Ring well	Girja Line	27° 07.816/	93° 50.056/	6.70	0.29	0.40	0.0180

Table 8: Statistical analysis for pH, Fluoride, Iron and Arsenic of ground water collected from six selected tea gardens of Lakhimpur district, Assam

Descriptive Statistics		Ph	Fluoride	Iron	Arsenic
Mean		6.90	0.72	0.46	0.0252
Std. Error of Mean		0.06	0.02	0.04	0.0019
Median		6.77	0.68	0.38	0.0221
Mode		6.77	0.66	0.52	0.01(a)
Std. Deviation		0.43	0.16	0.29	0.0133
Variance		0.19	0.03	0.08	0.0002
Skewness		0.70	0.37	1.16	0.1050
Std. Error of Skewness		0.34	0.34	0.34	0.3430
Kurtosis		-0.02	-0.28	1.08	-1.1920
Std. Error of Kurtosis		0.67	0.67	0.67	0.6740
Range		1.82	0.68	1.20	0.0500
Minimum		6.20	0.40	0.08	BDL
Maximum		8.02	1.08	1.28	0.0500
Sum		331.38	34.35	21.93	1.2100
Percentiles	25	6.57	0.61	0.28	0.0134
	50	6.77	0.68	0.38	0.0221
	75	7.23	0.83	0.56	0.0375

(a) Multiple modes exist.

Iron is a non-hazardous element that can be a nuisance in a water supply. Iron is the more frequent contaminants in water supplies. Iron at concentrations above the W.H.O limit of 0.3 ppm stains plumbing fixtures and laundry and produces undesirable taste in drinks. The iron contents of the tube wells and the ring wells were found to be very high in the study area. Thus, iron contamination of groundwater in the area needs proper attention. A broad third quartile and positive skewness in case of iron represents a long asymmetric tail on the right of the median. Heaviness of the tail for iron distribution in the area is evident from very high positive kurtosis value.

The WHO guideline value (recommended limit) for arsenic in drinking water is 0.01 ppm and the national standard in most countries, including India, is 0.05 ppm. Comparing the groundwater content of arsenic with the recommended maximum values for drinking purposes, it is found that a good number of samples contain arsenic at an alert and toxic level in the study area. Arsenic in the study area can enter the water supply from natural deposits in the earth or from agricultural pollution. It is widely believed that naturally occurring arsenic dissolves out of certain rock formations when ground water levels drop significantly. Differences among mean, median and mode along with moment coefficients of skewness and kurtosis obtained for arsenic in the area show that sample frequency distribution curves differ from ideal Gaussian (normal). We have taken only those samples for statistical treatment in which arsenic could be detected and determined. Wide data range and significant standard deviation of the data are likely to bias the normal distribution statistic. It seems that arsenic distribution in the area is flat with a long asymmetric right tail.

From the study it was noticed that water quality of the study area was not good in terms of the iron and arsenic content. The following table gives the comparison of the observed water quality data with the Rating Chart.

Table 9: Comparison of water quality data with Rating Chart

Sl No.	Parameters	Mean Values	International Standards			
			W.H.O	I. S. I	USPHS	European Standard
1	pH (Units)	6.9	6.5-8.5	6.5-8.5	6.0-8.5	5.0-9.0
2	Fe (mg/L)	0.46	0.3	1.0	0.3	-
3	Flouride (mg/L)	0.72	1.5	1.0	1.5	1.0
4	Arsenic (ppm)	0.0252	50	10	50	50

CONCLUSION

Statistical observations on pH, arsenic, iron and fluoride in groundwaters collected from inside the teagardens of Lakhimpur district, Assam show that all these parameters exhibit an asymmetric distribution with a long asymmetric tail on the right of the median. It is observed that the groundwater of the area is contaminated with arsenic and iron. A sizeable number of groundwater samples contain arsenic at an alert level. The concentrations of fluoride in the groundwaters of the area is either low or moderate and within the guideline values of WHO. Keeping in view of the unusually high concentrations of arsenic and iron, suitable protective measure for drinking water sources in the area is recommended.

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