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# Fluoride, arsenic and iron content of groundwater around six selected tea gardens of Lakhimpur District, Assam, India

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**ABSTRACT**

*A comprehensive study on distribution pattern of pH, arsenic, fluoride, and iron in groundwater samples collected around the six selected tea gardens of Lakhimpur district, Assam has been presented in this paper. Forty eight groundwater samples were collected from tubewells and ringwells during June, 2012 to November, 2012 at different sites around six tea gardens of Lakhimpur district were analysed for pH, arsenic, fluoride, and iron by following standard procedure. The present study has shown that naturally occurring arsenic and iron in groundwater is more widespread in the study area than is generally recognized. The concentrations of fluoride in the groundwater of the area are within the guideline values of WHO. Statistical observations indicate that the distribution of various water quality parameters in the study area is widely off normal.*

**Key Words:** Arsenic, Iron, Fluoride, pH, Skewness, Kurtosis etc.

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## INTRODUCTION

The quality of water resources is a subject of ongoing concern. A large section of rural population in India is solely depended on ground water, which is depleting at a fast rate. It has been observed that contamination of groundwater more often than not goes unnoticed and remains hidden from the public view. The problem of groundwater pollution has now raised concerns all over the globe and results reported by various researchers have been alarming [1-4]. Contaminated ground water can have serious effects on health. There is also evidence of prevailing heavy metal contamination of groundwater in many areas of India [5-8]. There have been instances of heavy metals like lead, cadmium, zinc and mercury being reported in groundwater in Gujarat, Andhra Pradesh, Kerala, Delhi and Haryana [9]. Chemical quality of drinking water in the tea garden belt of Lakhimpur district, Assam was studied by Bhuyan *et al.*, 2006, where they found high level of iron in some locations [10]. In this present study, water samples were collected from tube wells, ring wells and supply water of different areas around the six selected tea gardens of Lakhimpur district of Assam. The various physical and chemical parameters were determined and the results were compared with the values of various water quality standards such as World Health Organisation (WHO), Bureau of Indian Standard (BIS). The implications presented are based on statistical analyses of the raw data. Normal distribution analysis (NDA) is employed for interpretation of data.

## 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 around 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 [11]. 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 [12]. Sample data were also subjected to statistical treatment using normal distribution statistic.

**Table 1 Water sampling locations outside 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 analytical data are presented in Table 2-7. To look into the trend and distribution patterns of pH, arsenic, fluoride, and iron, in the groundwaters of the study area data were exposed to Normal Distribution Statistics, which is given in Table 8.

**Table 2 Water quality data of samples collected around 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 | Supply water | Sauldhuwa PHC | 27° 26.697/ | 94° 13.609/ | 6.66 | 0.25 | 0.39 | 0.0100 |
| A2 | Ring well | Kuhiyan Bari | 27° 26.667/ | 94° 13.789/ | 6.57 | 0.38 | 0.72 | 0.0530 |
| A3 | Ring well | Sauldhuwa | 27° 26.705/ | 94° 13.667/ | 6.87 | 0.68 | 0.48 | 0.0360 |
| A4 | Tube well | Weekly Market | 27° 26.998/ | 94° 13.891/ | 7.52 | 0.44 | 0.67 | 0.0128 |
| A5 | Tube well | Ananda Tiniali | 27° 26.813/ | 94° 13.786/ | 6.93 | 0.32 | 0.59 | 0.0403 |
| A6 | Supply water | R.K. College | 27° 26.599/ | 94° 13.557/ | 7.44 | 1.02 | 0.74 | 0.0453 |
| A7 | Supply water | Sarbashiksa L.P. School | 27° 26.771/ | 94° 13.690/ | 7.45 | 0.59 | 0.79 | 0.0087 |
| A8 | Ring well | Basti | 27° 26.811/ | 94° 13.721/ | 6.10 | 0.18 | 1.06 | 0.0564 |

**Table 3 Water quality data of samples collected around 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 | Supply water | Dirgha Majgaon High School | 27° 20.662/ | 94° 07.556/ | 7.12 | 0.31 | 0.73 | 0.0100 |
| B2 | Ring well | Nahar bari | 27° 22.060/ | 94° 06.297/ | 6.68 | 0.18 | 0.71 | 0.0512 |
| B3 | Ring well | 253 No. Majgaon L.P. School | 27° 20.673/ | 94° 07.597/ | 7.46 | 0.22 | 0.63 | 0.0360 |
| B4 | Tube well | Sirajuli Govt. PHC | 27° 21.225/ | 94° 07.941/ | 6.96 | 0.56 | 0.62 | 0.0128 |
| B5 | Tube well | Majgaon | 27° 20.739/ | 94° 07.534/ | 6.83 | 0.40 | 0.82 | 0.0401 |
| B6 | Supply water | Sirajuli PHC | 27° 21.216/ | 94° 07.930/ | 6.49 | 0.25 | 0.73 | 0.0450 |
| B7 | Supply water | Majgaon | 27° 20.896/ | 94° 07.438/ | 7.08 | 1.01 | 0.47 | 0.0080 |
| B8 | Ring well | Majgaon | 27° 20.767/ | 94° 07.520/ | 8.02 | 0.08 | 0.93 | 0.0425 |

**Table 4 Water quality data of samples collected around 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 | Supply water | Silanibari PHC | 27° 12.997/ | 93° 72.927/ | 6.68 | 0.43 | 0.55 | 0.0413 |
| C2 | Ring well | 1No. namghar, Silanibari | 27° 12.835/ | 94° 00.876/ | 6.47 | 0.23 | 0.48 | 0.0500 |
| C3 | Ring well | Daily market | 27° 12.972/ | 94° 00.655/ | 6.80 | 0.26 | 0.68 | 0.0335 |
| C4 | Tube well | Silanibari tiniali | 27° 12.974/ | 94° 00.578/ | 8.03 | 0.42 | 0.98 | 0.0276 |
| C5 | Tube well | Daily market | 27° 12.989/ | 94° 00.697/ | 6.98 | 0.32 | 0.73 | 0.0528 |
| C6 | Supply water | Daily market | 27° 12.956/ | 94° 00.621/ | 7.34 | 0.68 | 0.60 | 0.0098 |
| C7 | Supply water | Sarbashiksa L.P. School | 27° 12.901/ | 94° 60.880/ | 7.33 | 0.20 | 0.83 | 0.0009 |
| C8 | Ring well | Weekly market | 27° 12.874/ | 94° 00.611/ | 6.34 | 1.10 | 0.39 | 0.0311 |

**Table 5 Water quality data of samples collected around 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 | Supply water | Gramin Bikash Bank | 27° 18.742/ | 94° 01.481 | 6.30 | 0.36 | 0.54 | 0.0092 |
| D2 | Ring well | Rampur | 27° 15.159/ | 94° 01.207/ | 6.18 | 0.10 | 0.76 | 0.0231 |
| D3 | Ring well | Kanduwa pathar | 27° 14.967/ | 94° 01.143/ | 6.83 | 0.28 | 0.98 | 0.0320 |
| D4 | Tube well | Rampur | 27° 15.139/ | 94° 01.172/ | 6.29 | 0.64 | 0.45 | 0.0415 |
| D5 | Tube well | No.1 Dikka | 27° 14.849/ | 94° 01.112/ | 7.89 | 0.27 | 0.76 | 0.0506 |
| D6 | Supply water | Kanduwa pathar L.P.School | 27° 14.967/ | 94° 01.182/ | 7.00 | 1.05 | 0.85 | 0.0243 |
| D7 | Supply water | No.1 Dikka Market | 27 ° 14.536/ | 94 ° 01.037/ | 7.22 | 0.47 | 0.70 | 0.0400 |
| D8 | Ring well | No.1 Dikka Namghar | 27 ° 14.943/ | 94 ° 01.134/ | 7.50 | 0.33 | 0.48 | 0.0006 |

**Table 6 Water quality data of samples collected around 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 | Supply water | Daloohat PHC | 27° 10.768/ | 93° 58.891/ | 6.57 | 0.25 | 0.64 | 0.0198 |
| E2 | Ring well | Uttar Kari L.P. School | 27° 09.881/ | 94° 06.204/ | 7.48 | 0.15 | 0.78 | 0.0080 |
| E3 | Ring well | Uttar Kari Namghar | 27° 09.927/ | 94° 06.336/ | 6.98 | 0.28 | 0.33 | 0.0150 |
| E4 | Tube well | Purona Halkhula | 27° 10.798/ | 93° 58.577/ | 6.66 | 0.41 | 0.46 | 0.0436 |
| E5 | Tube well | Halkhula PHC | 27° 10.778/ | 93° 58.705/ | 7.67 | 0.60 | 0.58 | 0.0276 |
| E6 | Supply water | Daloohat Tiniali | 27° 09.836/ | 94° 00.019/ | 7.35 | 0.35 | 0.69 | 0.0498 |
| E7 | Supply water | Uttar Kari | 27 ° 09.922/ | 94 ° 00.287/ | 7.40 | 0.80 | 1.00 | 0.0377 |
| E8 | Ring well | Uttar Kari Namghar | 27° 09.853/ | 94° 00.198/ | 6.77 | 0.33 | 0.98 | 0.0420 |

**Table 7 Water quality data of samples collected around 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 | Supply water | Merbil Tiniali | 27° 07.319/ | 93° 51.194/ | 6.45 | 0.45 | 0.72 | 0.0278 |
| F2 | Ring well | Merbil Chutia Namghor | 27° 06.445/ | 93° 51.931/ | 6.51 | 0.20 | 0.68 | 0.0378 |
| F3 | Ring well | Harmutty Gurudian Eagle Research School | 27° 07.570/ | 93° 50.893/ | 7.15 | 0.09 | 0.77 | 0.0100 |
| F4 | Tube well | No. 1 Bagori | 27° 07.385/ | 93° 52.015/ | 6.86 | 0.52 | 0.63 | 0.0510 |
| F5 | Tube well | No. 2 Bagori | 27° 06.4/ | 93° 51.802/ | 6.72 | 0.68 | 0.39 | 0.0350 |
| F6 | Supply water | Little Flower Hostel, | 27° 07.320/ | 93° 51.193/ | 6.50 | 0.80 | 0.75 | 0.0200 |
| F7 | Supply water | Chandmari L.P. School | 27° 07.537/ | 93° 51.084/ | 7.68 | 0.32 | 0.70 | 0.0480 |
| F8 | Ring well | Harmutty Shiva Mandir | 27° 07.550/ | 93° 50.818/ | 6.95 | 0.30 | 0.35 | 0.0066 |

(a) Multiple modes exist. The smallest value is shown

In all the sampling stations studied pH are within the WHO guide lines values for safe drinking water. In the study area, the variation of pH is narrow and the mean pH value is 6.98, which can be treated as neutral. 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 drinking water in tea garden belt of Lakhimpur district was found to be within the permissible limit of W.H.O. and ISI, which is 1.5mg/L. Fluoride with these average values in water may cause dental carries. Although the groundwaters of the study area are by and large safe with regard to fluoride, its distribution is still not uniform in the area. Wide data range and dissimilar percentile values in case of fluoride is

likely to bias the normal distribution statistic. This observation is supported by positive skewness and negative kurtosis value, which point towards flat distribution with a long right tail in the study area.

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

| Descriptive Statistics | | pH | Fluoride | Iron | Arsenic |
|---|---|---|---|---|---|
| Mean | | 6.98 | 0.67 | 0.45 | 0.0303 |
| Std. Error of Mean | | 0.07 | 0.03 | 0.04 | 0.0024 |
| Median | | 6.94 | 0.70 | 0.36 | 0.0343 |
| Mode | | 6.57(a) | 0.39(a) | 0.25(a) | 0.0100 |
| Std. Deviation | | 0.49 | 0.18 | 0.29 | 0.0165 |
| Variance | | 0.24 | 0.03 | 0.08 | 0.0003 |
| Skewness | | 0.32 | 0.07 | 1.35 | -0.2570 |
| Std. Error of Skewness | | 0.34 | 0.34 | 0.34 | 0.3430 |
| Kurtosis | | -0.58 | -0.41 | 1.50 | -1.2740 |
| Std. Error of Kurtosis | | 0.67 | 0.67 | 0.67 | 0.6740 |
| Range | | 1.93 | 0.73 | 1.29 | 0.0600 |
| Minimum | | 6.10 | 0.33 | 0.08 | BDL |
| Maximum | | 8.03 | 1.06 | 1.37 | 0.0600 |
| Sum | | 335.06 | 32.29 | 21.77 | 1.4600 |
| Percentiles | 25 | 0.54 | 0.54 | 0.25 | 0.0128 |
| | 50 | 0.70 | 0.70 | 0.36 | 0.0343 |
| | 75 | 0.77 | 0.77 | 0.60 | 0.0433 |

From the study it was noticed that water quality of the study area was not good in terms of the iron content. The iron content of water in the area needs urgent attention. The concentration of iron in water in the area is not suitable for food processing, dyeing, bleaching and many activities. A broad third quartile and positive skewness in case of iron represents a long asymmetric tail on the right of the median. The width of the third quartile is greater than the second quartile, which for a symmetric distribution should be equal. Sharp distribution for iron in the area is indicated by positive kurtosis value.

Arsenic in the study area can enter the water supply from natural deposits in the earth or from industrial and agricultural pollution. In most of the samples under investigation, the arsenic contents were much above the highest desirable limit of 0.01 ppm. Negative skewness of the data is indicative of the asymmetric nature of arsenic distribution in the study area. The distribution is also found to be flat with negative kurtosis values outside the tea gardens. Wide data range case of arsenic indicates the presence of extreme values, which are likely to bias the normal distribution statistic. It seems that groundwater samples of the area fall under “Toxic and Alert Categories” with regard to arsenic. Thus, the arsenic contamination of groundwater in the area should be accorded maximum attention. 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 | Iron (mg/L) | 0.45 | 0.3 | 1.0 | 0.3 | - |
| 3 | Fluoride (mg/L) | 0.67 | 1.5 | 1.0 | 1.5 | 1.0 |
| 4 | Arsenic (ppm) | 0.0303 | 0.05 | 0.01 | 0.05 | 0.05 |

## CONCLUSION

A comprehensive statistical analysis of distribution of pH, arsenic, fluoride, and iron in groundwater samples collected around the six selected tea gardens of Lakhimpur district, Assam has been presented. The contamination of groundwater by arsenic and iron are attributed to geogenic origin. Concentrations of iron are found to be significantly elevated as compared to WHO recommended levels in the study area. The present study has shown that naturally occurring arsenic and iron in groundwater is more widespread in the study area than is generally recognized. Statistical observations indicate that the distribution of various water quality parameters in the study area is widely off normal. Thus, it is advisable to test the potability of groundwater of the area before using it for drinking.

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