PERVASIVENESS OF GROUNDWATER ARSENIC IN FOUR GEOGRAPHICAL ZONES ACROSS LONGAI AND KUSHIARA RIVERS IN KARIMGANJ DISTRICT, BARAK VALLEY, ASSAM INDIA: RELATES TO RIPARIAN AQUIFER P\textsuperscript{H}

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ABSTRACT

Recently arsenic has been detected in the groundwater of Karimganj district, Barak Valley, Assam, India. In this regard, a research work of estimation of arsenic, as well as earmarking of the arsenic loaded surficial area, has been undertaken in the four geographical zones across the Longai and Kushiara rivers of this district. 24 groundwater samples have been taken as representative from borewells of four zones and are analysed during the year 2016. Analyses are initially done by Ag-DDTC method and subsequently justified by an FI-HG-AAS method. The locations of samplings are recorded by GPS. Quantification by two different methods shows that the southern Longai Valley has the lowest level of individual arsenic ranging 0-3.4 µg/L. The northern Longai Valley experiences the pollution of arsenic with a span of 50 – 62µg/L and 54 - 98µg/L measured in respective methods. While it ranges 0 – 85 and <3 - 113µg/L on the southern bank of R. Kushiara near Bhanga which is far above the guideline concentration of 10 µg/L, pH ranges between 5.9 and 8.3 in this riparian area and has a negative correlation with arsenic. Three of the four zones of the district characterized by alluvium soil are found to be arsenic infested. This situation demands a regular survey of water quality to prevent health risks. The communication of these findings will generate heightened awareness among the consumers and help them to explore alternative sources.

Key Words: Arsenic, Quantification, Longai, Kushiara, Riparian, Alluvium soil

INTRODUCTION

Groundwater is considered a natural and high-quality source of water for drinking and other domestic needs.\textsuperscript{1-3} But this attribute should not be taken for granted. There are several disastrous events of poisoning due to toxic trace elements in drinking water. The contamination of groundwater arsenic in the Indian subcontinent, among other parts of the world, poses a serious concern for public health.\textsuperscript{4,4} Long-term exposure to arsenic has a negative impact on the human health and livelihood and causes diabetes, cardiovascular and peripheral vascular diseases, and associated with cancer of the skin, lung, liver, urinary bladder, and proteinuria\textsuperscript{7,10} and shows adverse birth consequences.\textsuperscript{11} A hundred million people worldwide are at potential risk due to the presence of arsenic in drinking water as a pollutant.\textsuperscript{12,13} The groundwater quality has become an important issue due to the increasing pressure of pollution due to trace metal contamination resulting from recurrent floods, ever-increasing urbanization, community density, rapid micro industrialization, city development, and haphazard use of fertilizers, herbicide, and pesticides in agriculture.\textsuperscript{14-18} More recently, arsenic has been detected in the groundwater of Manipur, Assam, and Tripura.\textsuperscript{19-23} Arsenic pollution has been spreading steadily to every nook and corner of the alluvial plains of the study area, yet the worst situation has not been surfaced. This demands a regular survey of
water quality\textsuperscript{24,25} to prevent health risks. Treated water is supplied to the urban and block level town areas by the PHE Division drawn from the nearby R. Longai. The water of this stream is found to be arsenic free. However, most of the semi-urban and rural populace draws groundwater with the help of a hand pump or Tara pump for drinking water purpose. These pumps are installed either individually or with the support of government agencies, most of which are found to be arsenic infested. In this regard, groundwater samples of Karimganj district are analysed randomly in the year 2016 to study the aquifer condition and level of arsenic pollution.\textsuperscript{27,28,30} During this study, we found that arsenic contamination in a particular locality (S 22) reaches the level 113 µg/L, which is far above the guideline concentration of 10 µg/L set by the World Health Organization for drinking water purpose. Hence, regular and effective monitoring of the quality of this valuable resource needs urgent attention. This present study has been conducted with an aim of locating polluted borewells so that the arsenic infested aquifer are identified thus making the residents aware of the actual geologic condition and thereby enlighten them to go for alternative sources in a more effective and judicious way.\textsuperscript{31,32}

**Study area**

Karimganj district with an area of 1,809 km\textsuperscript{2} is located on the southern edge of Assam, India and in the western part of the Barak Valley. Physiographically the district is characterized by tightly folded anticlines and broad synclinal valleys. In the western part of the district along the border of Bangladesh, runs Patharia Range lengthening about 45 km from south to north. In the mid-south of the district, Duhalia Range crosses through. The area covers between these two ranges is popularly called Longai Valley. In the eastern part, the Chhatachura Range stands its head high separating Karimganj from Hailakandi district (Fig. 1).

![Map of the study area (map not to scale)](image-url)

**Fig. 1 :** Map of the study area (map not to scale)
The study area comprises a number of perennial rivers flowing through the district. The three main rivers are R. Kushiara, R. Longai, and R. Singla. The R. Kushiara, the bifurcated stream course of the River Barak at Haritikar near Bhanga, Assam flows westwards to Bangladesh forming the northern boundary of the district. The Karimganj district town and Mahakal village in Badarpur Block are situated on the southern bank of the lower and upper stretch of the R. Kushiara respectively (Fig.1). The R. Longai originates in the Jampui hills of Mizoram state drains the southern, central part of this district, runs northerly direction and ultimately drops in the Hakaluki Haor situated in Bangladesh. Several tributaries connect to this river. This riparian area is commonly affected by floods and water-logging throughout the year. The riparian communities of this valley face both the pre-monsoon and monsoon woes. The R. Singla originating from Mizoram state takes a northward direction, falls in Son-Beel wherefrom the stream emerges bifurcated forming two rivulets - Kachua and Kakra. The study area comprises of low land with swamps. The soil varies from alluvial to lateritic in nature. The texture is generally clayey loam to clay.

Ratabari and Ramkrishna Nagar plains are at the bottom of valleys. The uplands are inaccessible due to hilly terrain and dense forest. We have not found any detectable arsenic in Ratabari and Ramkrishna Nagar plains encompass by Duhalia to the west and Chhatachura Ranges to the east. Though samples are collected randomly from all the plain area of the district, the focus is being made to only those areas along the R. Longai and the R. Kushiara where the presence of arsenic is positive.

**MATERIAL AND METHODS**

24 sample sites are taken as representatives of the study area and GPS locations are recorded by GARMIN (eTrex H). The sites are spread over four geographical zones. Three of them run across the East-west axis of R. Longai and the fourth is on the Southern bank of upper stretch of R. Kushiara near Bhanga (Fig.1). The details of these locations are given in Table 1.

Samplings from 23 tube wells (Tara Pump) and 1 deep tube well are done after draining out for 5 minutes in a pre-washed 50 ml polyethene bottles adding 2 drops of concentrated HCl (Type A) and separate simultaneous samplings are also done in a 30ml bottles with 1 drop concentrated HNO₃ (Type B) during driest season January-March 2016, (N= 24). Physiochemical parameter pH is immediately measured in the field after water collection.

**Table 1 : The GPS location of sampling sites (S1-S24) belonging to four geographical zones (Z 1, Z 2, Z 3 and Z 4) in Karimganj district**

<table>
<thead>
<tr>
<th>Geographical zone</th>
<th>Area of coverage</th>
<th>Sites of tubewell</th>
<th>GPS locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>KARIMGANJ DISTRICT</td>
<td>UPPER LONGAI VALLEY (Z 1)</td>
<td>Kathaltali Bazar to Baithakhal Tea Estate via Lowairpoa</td>
<td>Kathaltali Bazar (S1) Lowairpoa, 18 No. (S2) Lowairpoa, Forest Office (S3) Hatikhira, 749 L.P School (S4) Public M.E School, Dengarbund, Solgai (S5) Baithakhal T. E, 8 No. (S6)</td>
</tr>
<tr>
<td></td>
<td>MIDDLE LONGAI</td>
<td>Patharkandi to Suprakandi</td>
<td>Patharkandi Model H S school (S7) Patharkandi Town Kali Bari (S8) Eraligool, Baroigram (S9)</td>
</tr>
<tr>
<td>VALLEY (Z 2)</td>
<td>Vidyanagar L.P School (S10) SVV Higher Secondary School, Nilambazar (S11) Palli Mangal H S School, Suprakandi (S12)</td>
<td>19.140′ (S09), N 24° 40.118′ E 92° 20.562′ (S10), N 24° 43.977′ E 92° 20.788′ (S11), N 24° 44.675′ E 92° 21.095′ (S12), N 24° 47.486′ E 92° 22.504′</td>
<td></td>
</tr>
<tr>
<td>LOWER LONGAI VALLEY (Z 3)</td>
<td>Karimganj Town (S13) Sadarashi Pt II Bazar (S14) Girishganj Model Hospital (S15) Maizgram Pt I, Ward No. 2 (S16) Panerogarh Masjid (S17) East Fakira Bazar Jam-e-Masjid (S18)</td>
<td>(S13), N 24° 51.591′ E 92° 21.580′ (S14), N 24° 52.787′ E 92° 19.768′ (S15), N 24° 52.880′ E 92° 18.561′ (S16), N 24° 51.157′ E 92° 18.677′ (S17), N 24° 51.734′ E 92° 19.072′ (S18), N 24° 51.701′ E 92° 17.475′</td>
<td></td>
</tr>
<tr>
<td>UPPER STRETCH OF R. KUSHIARA (NEAR BHANGA) (Z 4)</td>
<td>Badarpur Town (S19) Mahakal Pt I (S20) Mahakal Bhanga M.E.School (S21) South Mahakal Basail M.E. School (S22) Malua Public High School (S23) Duttapur Gyan Jyoti School, S Mahakal (S24)</td>
<td>(S19), N 24° 52.195′ E 92° 33.352′ (S20), N 24° 51.266′ E 92° 29.517′ (S21), N 24° 50.825′ E 92° 29.554′ (S22), N 24° 49.312′ E 92° 28.797′ (S23), N 24° 52.201′ E 92° 30.029′ (S24), N 24° 48.927′ E 92° 28.940′</td>
<td></td>
</tr>
</tbody>
</table>
Initially, estimation of arsenic with Type A is done by arsine-generator using Silver-diethyldithiocarbamate (Ag-DDTC) followed by spectrophotometric measurement at the wavelength of 520 nm according to APHA. The assemblage of the arsine generator is shown (Fig. 2). Later on, the analyses of Type B samples are done within 15 days of the collection with the help of Flow Injection Hydride Generation Atomic Absorption Spectrometry (FI-HG-AAS) accessible at SOES, Jadavpur University, Kolkata, India.

**RESULTS AND DISCUSSION**

Samples are collected from four zones of the district; each zone comprises six sites as representative. Data and GPS locations of sites are presented in Table 2.

**Table 2 : The available data of analysis done by Ag-DDTC and FI-HG-AAS methods**

(BDL = below detection limit. For a generation of statistical graphs BDL= <3 value taken as 0)

<table>
<thead>
<tr>
<th>Geographical zone</th>
<th>Samples</th>
<th>Analysis of sample (Type A) by Ag-DDTC</th>
<th>Analysis of sample (Type B) by FI-HG-AAS</th>
<th>Depth(m)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Arsenic in 2016 (µg/L)</td>
<td>Average arsenic in 2016 (µg/L)</td>
<td>Arsenic in 2016 (µg/L)</td>
<td>Average arsenic in 2016 (µg/L)</td>
</tr>
<tr>
<td>Z 1</td>
<td>S 1</td>
<td>0</td>
<td>1.45 (L)</td>
<td>&lt;3</td>
<td>&lt;3 (L)</td>
</tr>
<tr>
<td></td>
<td>S 2</td>
<td>0</td>
<td></td>
<td>&lt;3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S 3</td>
<td>0</td>
<td></td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td></td>
<td>S 4</td>
<td>3.4</td>
<td></td>
<td>&lt;3</td>
<td>&gt;3</td>
</tr>
<tr>
<td></td>
<td>S 5</td>
<td>3.2</td>
<td></td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td></td>
<td>S 6</td>
<td>2.1</td>
<td></td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td></td>
<td>S 7</td>
<td>22.28</td>
<td>43.69</td>
<td>28</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>S 8</td>
<td>14</td>
<td></td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
In the upper Longai Valley (Z 1), sampling has been done from Kathaltali Bazar to Baithakhal Tea Estate via Lowairpoa (S1-S6) is found to be neutral to slightly alkaline (pH 7.1 - 8.3). Applying Ag-DDTC method, arsenic is individually spotted in the ambit of (0 - 3.4) which is rationalized by an FI-HG-AAS method where arsenic contamination is found to be <3 µg/L (unnoticeable) (Fig. 3). In the middle Longai Valley (Z 2), groundwater samples are collected from Patharkandi to Suprakandi (S7-S12), arsenic in individual sites ranges from 14 - 73 compared to 17 - 91 by FI-HG-AAS (Fig. 4) which is higher than the WHO guideline value of 10µg/L. In the lower Longai Valley (Z 3), groundwater samples (S13-S18) are collected from around the proximal and distal locations of Karimganj town. Here arsenic concentration discretely rolls in the spectrum of 50 - 62 µg/L measured in Ag-DDTC method against (54 – 98) in FI-HG-AAS method (Fig. 5). In lower Longai Valley pH is acidic and ranges in 5.9 - 6.9.
Fig. 4: Variation of arsenic in Central Longai valley (Z 2)

Fig. 5: Variation of arsenic in North Longai valley (Z 3)

Water samples (S19-S24) are collected from Badarpur Town to Duttapur, South Mahakal situated on the southern bank of upper stretch of the R. Kushiara near Bhanga (Z 4). In this zone pH of some samples is slightly acidic (6.3-6.6) while others are neutral (7.1-7.2). Measurement by FI-HG-AAS shows that arsenic comes in the range of 3 – 113 µg/L. One discrete site at South Mahakal (S 22) attains the highest value 113 µg/L (Fig. 6). However, measurement in Ag-DDTC method shows variation is in the range of 0-85 µg/L.

Fig. 6: Variation of arsenic in South bank of Upper Kushiara valley (Z 4)

As regards the depth of the aquifer, people used to draw water with the help of Tara-pump from 15-20m depth in Z 1. Here groundwater arsenic is rarely noticeable. This area belongs to Tea Estates and anticline in nature. In this locality, borewells are seldom found. While doing boring
for groundwater they often envisage hard subsurface layer at ~20m depth which is difficult to penetrate, so the vast majority of the community go for hand-dug wells in getting drinking water. So here hand dug wells are abundant. In Z 2, Z 3, and Z 4 water is being lifted from 25-30m depth with an exception at Karimganj district town, where a larger number of people get their additional water from 50-60m depth with the help of deep tube well. Both the aquifer strata (25-30m & 50-60m) are laced with arsenic and the soil is alluvium in nature. The sample sites which contain higher than 10 µg/L arsenic in groundwater are shown by red solid circle while sites having less are shown by a blue solid circle. It may be worth mentioning here that in Karimganj town arsenic concentration falls with the depth of aquifer. Analyses show that no noticeable arsenic is seen in borewells having higher than 80m depth (not shown in the table) wherein the sand deposit colour is found to be bright yellowish-orange to dark reddish.

Comparison of four geographical zones in terms of average arsenic (Fig.7) shows that Lower Longai Valley (Z 3) is blended with a higher level of average arsenic. Here the arsenic concentration attains zenith 55.68 and 75 µg/L measured by two respective methods, which renders it unfit for safe drinking. However, in the Lower Longai Valley (Z 1), the contamination is found to be less than WHO provisional guideline value and is safe to use for domestic purposes. The assessment by Ag-DDTC method is found in conformity with the FI-HG-AAS when contamination stands below 10µg/L however for a higher level of arsenic, a deviation occurs.

Most of the samples analysed have the desirable range of pH in the safe limit of 6.5-8.5, the standard set by the WHO (2004). pH is not found to be a limiting factor for the use of groundwater for drinking purposes in the study area. However, there are a number of outliers such as a pH of 5.5 at South Mahakal (S 22) and 8.3 at Kathaltali Bazar (S 1) respectively.

The subsurface water arrangements show irregular fluctuations in arsenic concentration whenever there is a variation of phreatic pH (Fig.8) which establishes the fact that the geologic...
environment is pH dependent. We observe a sharp rise in arsenic concentration at the lowest pH. Individually it shows the highest value of 85 and 113 µg/L in both the methods at lowest pH 5.5. The gradual decrease in arsenic concentration occurs with a shift of pH from acidic to alkalinity. It is obvious that the release of arsenic into groundwater from arsenic-bearing sediments takes place at pH<7. Physiographically, this type of groundwater with a high level of arsenic contamination is located in the riparian areas characterized by freshwater swamp type of soil. However, the trend refuses to move higher at pH greater than 7.2 and takes turnaround to touch bottom.

CONCLUSION

The results of our study show that the magnitude of arsenic contamination is severe in some alluvium pockets of Karimganj district of Assam. These pockets are found in flood-affected, low-lying and riparian areas. The severity is reflected by the recent works of several researchers. The National Research Council of U.S. observed that the exposure to 50 µg/L level of arsenic contamination could easily result in a combined cancer risk of 1 in 100. It is found that the emerging threat of arsenic contamination in groundwater is a major constraint on the use of drinking, domestic as well as agricultural purposes. Keeping in mind the above situation, the author tries to locate the arsenic-rich phreatic environment and in this direction identify some surficial pockets of floodplains corresponding to Z 2, Z 3, and Z 4. I do hope this work will generate a massive awareness among the populace of this otherwise isolated Valley for their well being and help them to explore the alternative sources.

Abbreviations


REFERENCES


