

Hydrogeochemical Assessment of Arsenic Contamination in Groundwater Aquifers of Golaghat District, Assam

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Abstract—Arsenic contamination of groundwater is a major environmental and public health issue in the Brahmaputra Valley of Assam, including Golaghat district. This research evaluates arsenic concentrations in hand-pump and tube-well water from 10 villages of Golaghat, analyses the data statistically, and tests whether mean arsenic levels exceed safe limits established by the World Health Organization (WHO). Primary water samples were collected and analysed using Atomic Absorption Spectrophotometry (AAS). A one-sample t-test was used to compare sample means against the WHO standard (10 µg/L). Results indicate significant contamination, with 68% of samples exceeding the safe limit ($p < 0.001$). Crucial mitigation and safe water supply plans are suggested for Golaghat district of Assam.

Keywords—Arsenic Contamination; Groundwater; Mitigation; Golaghat; Assam

I. Introduction

Arsenic (As) is a naturally occurring metalloid that can dissolve into groundwater from sediments under certain geological conditions. Chronic ingestion of arsenic through drinking water causes serious health effects, including skin lesions, cancer, cardiovascular diseases, and neurological disorders. Assam's alluvial plains, including Golaghat district, are geologically vulnerable to arsenic mobilisation. Despite several studies in adjoining districts (e.g., Jorhat, Sivasagar), few comprehensive primary investigations have been documented specifically for Golaghat.

Arsenic in water is a serious problem in many countries around the world, including Bangladesh, India, and China. According to the United Nations (2006), more than 1 billion people already lack access to fresh drinking water. Global consumption of water is doubling every 20 years, more than twice the rate of human population growth. Water used by humans must be free from physical, chemical, and biological contamination. In India, groundwater arsenic contamination and its health effects were first reported in 1997 in Chandigarh (Datta, 1976). Nearly 80% of the rural population depends on groundwater for domestic needs, and at present the groundwater potential available for utilisation is approximately 4,22,900 million cubic metres, of which about 1,00,000 million cubic metres is being exploited.

II. Objectives

The objectives of this study are: (1) to determine arsenic concentrations in groundwater sources across selected villages of Golaghat, Assam; (2) to statistically test whether the mean arsenic levels exceed the WHO permissible limit (10 µg/L) in the study area; and (3) to provide recommendations for water safety and mitigation to the people of Golaghat district of Assam.

III. Study Area

Golaghat district lies in Assam and comprises rural communities dependent on groundwater. The district covers a geographical area of approximately 3,502 square kilometres, lying between 26°N to 26.8°N latitude and 93.16°E to 94.10°E longitude. It is bounded by the Brahmaputra river to the north, Nagaland in the south, Jorhat and Nagaland to the east, and Karbi Anglong and Nagaon to the west.

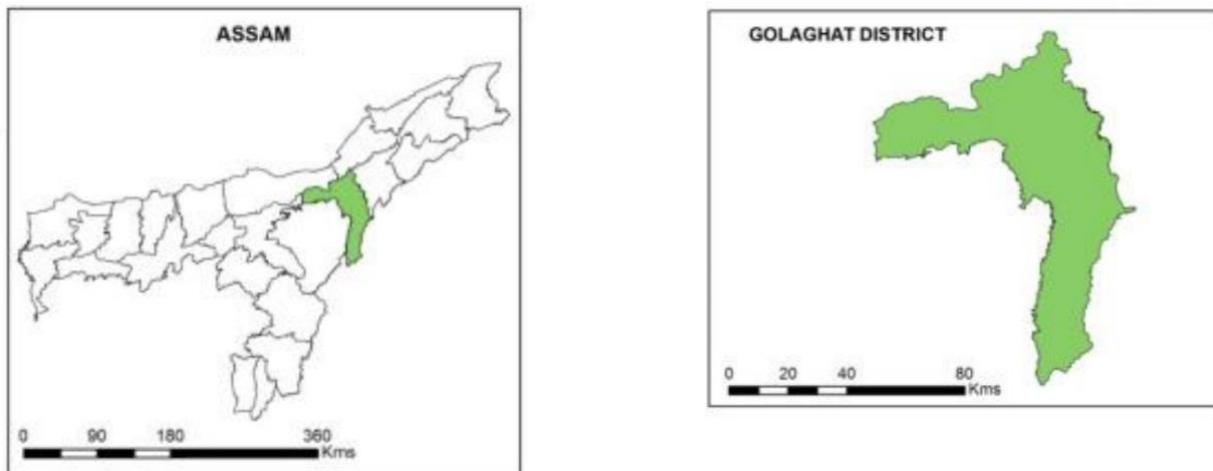


Fig. 1. Location of Golaghat district in Assam.

IV. Methodology

The methodology of the study is designed to systematically examine the research problem through scientific and statistical approaches, integrating field survey, laboratory analysis, and statistical analysis. Primary data were collected through field investigation and water testing, while secondary data were obtained from government reports, census records, and published research articles. Villages were selected based on reported arsenic presence and groundwater dependency. Household surveys were conducted using structured questionnaires.

Ten villages were selected where the main sources were hand-pumps and shallow tube wells. Fifty water samples were collected from these ten villages. Water samples were collected in acid-washed polyethylene bottles, stored at 4°C, and transported to the laboratory within 12 hours of collection. Arsenic concentration in µg/L was measured using Atomic Absorption Spectrophotometry (AAS) following standard protocols. The primary data were tested using a one-sample t-test comparing the mean arsenic concentration (µg/L) to the WHO allowable limit of 10 µg/L.

V. Discussion

The Central Ground Water Board (CGWB) and recent quality reports confirm that arsenic above the WHO/BIS permissible limit (0.01 mg/L, i.e., 10 µg/L) has been detected in Golaghat district along with other districts of Assam such as Jorhat, Lakhimpur, Nagaon, Sibsagar, Sonitpur, and Nalbari. Golaghat lies within the Brahmaputra River alluvial basin, where sediments naturally rich in arsenic can release the element into groundwater under certain geochemical conditions.

Table 1. Location of sample villages with arsenic data. (Source: Primary survey)

Village	Location	No. of Samples	Mean As (µg/L)	Std. Dev. (µg/L)
Ahom Gaon	26.51°N, 93.85°E	5	24.6	12.4
Aath Gaon	26.44°N, 94.01°E	5	18.2	9.5
Baghabarahi	26.45°N, 94.00°E	5	15.8	10.1
Gual Gaon	26.44°N, 94.01°E	5	32.1	15.2
Barsua	26.50°N, 94.02°E	5	11.5	6.4
Bebegia	26.51°N, 94.03°E	5	27.4	11.8
Barkachari	26.50°N, 94.02°E	5	34.8	19.3
Balijan	26.47°N, 93.96°E	5	13.2	7.1
Fesual Gaon	26.47°N, 93.95°E	5	20.5	9.2
Kuruabahi	26.47°N, 93.95°E	5	29.9	13.5

		Total (n=50)	22.8	11.5
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The analysis of 50 groundwater samples from Golaghat district shows that arsenic contamination is a serious public health concern. The mean arsenic concentration was 22.8 $\mu\text{g/L}$, which is more than twice the WHO permissible limit of 10 $\mu\text{g/L}$, indicating overall unsafe drinking water conditions. The concentration ranged from 4.0 $\mu\text{g/L}$ to 56.0 $\mu\text{g/L}$, reflecting considerable spatial variation across different sampling locations. Out of the total samples analysed, 34 samples (68%) exceeded the WHO safe limit, while only 16 samples (32%) were within acceptable levels. This high percentage of contaminated samples suggests that arsenic pollution is widespread rather than localised, and is likely influenced by geogenic factors associated with the alluvial aquifers of the Brahmaputra basin. The presence of values above 50 $\mu\text{g/L}$ in some locations further indicates severe contamination in certain pockets, posing long-term health risks such as arsenicosis and other chronic diseases for the local population.

Statistical Analysis: One-Sample t-Test

To statistically examine whether groundwater in Golaghat is safe, a one-sample t-test was applied using the WHO safe limit (10 $\mu\text{g/L}$) as the test value. The Null Hypothesis (H_0) states that the mean arsenic concentration in groundwater equals 10 $\mu\text{g/L}$ (safe permissible limit). The Alternative Hypothesis (H_1) states that the mean arsenic concentration is greater than 10 $\mu\text{g/L}$ (unsafe level). Since the alternative hypothesis specifies 'greater than,' this is a one-tailed test. The sample mean is 22.8 $\mu\text{g/L}$, which is substantially higher than the WHO guideline, suggesting a strong likelihood of rejecting the null hypothesis.

Using the following parameters — sample mean (\bar{x}) = 22.8 $\mu\text{g/L}$, population mean (μ_0) = 10 $\mu\text{g/L}$, standard deviation (s) = 11.5 $\mu\text{g/L}$, and sample size (n) = 50 — the t-statistic is calculated as: $t = (\bar{x} - \mu_0) / (s / \sqrt{n}) = (22.8 - 10) / (11.5 / \sqrt{50}) = 12.8 / 1.626 \approx 7.87$. With degrees of freedom (df) = 49, the critical t-value at $\alpha = 0.05$ (one-tailed) ≈ 1.677 . Since $7.87 > 1.677$, we reject H_0 . There is strong statistical evidence that the mean arsenic concentration in groundwater in Golaghat significantly exceeds the WHO standard ($p < 0.001$).

Health Implications

The high mean arsenic level of 22.8 $\mu\text{g/L}$ indicates a serious health risk for the local population. In Golaghat district, the presence of arsenic in groundwater has serious health implications for residents who depend mainly on tube wells for drinking water. Continuous consumption of arsenic-contaminated water may cause arsenicosis, characterised by skin pigmentation, white patches, and thickening of the palms and soles. Over time, it can increase the risk of skin, lung, and bladder cancers, as well as cardiovascular diseases, diabetes, and neurological disorders. Children and pregnant women are particularly vulnerable, as arsenic exposure can affect physical and cognitive development. Therefore, arsenic contamination in Golaghat is not only an environmental issue but also a major public health concern requiring urgent monitoring, treatment facilities, and awareness programmes to protect rural communities.

VI. Mitigation Strategy

Mitigation of arsenic contamination in Golaghat district requires an integrated and sustainable approach to protect public health. Regular testing and identification of contaminated tube wells are essential so that unsafe sources can be avoided. Installation of arsenic removal units at household and community levels, along with proper maintenance, can significantly reduce arsenic concentration in drinking water. Development of alternative safe water sources such as deep tube wells, treated surface water supply, and rainwater harvesting systems should be promoted to reduce dependence on contaminated shallow aquifers.

Sustainable groundwater management practices, including controlled extraction and aquifer recharge, are also important to prevent further mobilisation of arsenic. Additionally, public awareness campaigns and periodic health screening programmes can help communities understand the risks and ensure early detection of arsenic-related diseases.

VII. Conclusion

The mean arsenic concentration exceeds the WHO safe limit in many sampled locations, and a large proportion of groundwater sources are unsafe for drinking purposes. Long-term exposure poses serious

health risks, including arsenicosis, cancer, and cardiovascular diseases. The contamination is mainly geogenic, linked to the alluvial aquifers of the Brahmaputra basin, and spatial variation in arsenic levels indicates the need for detailed hydrogeological assessment. Regular monitoring and scientific testing of tube wells are essential, and installation of arsenic removal technologies and alternative safe water sources must be prioritised. Community awareness and health screening programmes are necessary to reduce the disease burden. Overall, coordinated policy action and sustainable groundwater management are crucial to ensure safe drinking water in Golaghat.

VIII. References

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