International Journal of Social Science and Education Research

ISSN Print: 2664-9845
ISSN Online: 2664-9853
Impact Factor: RJIF 8.00
IJSSER 2023; 5(1): 49-51
www.socialsciencejournals.net
Received: 13-01-2023
Accepted: 19-02-2023

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Arsenic contamination in seawater: A case study of West Bengal

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DOI: https://doi.org/10.33545/26649845.2023.v5.i1a.103

Abstract
Arsenic contamination in water is a significant environmental and public health concern, particularly in regions with high industrial activity. This study focuses on the detection and analysis of arsenic levels in sea water near industrial areas in West Bengal, India. Using advanced analytical techniques, the study aims to quantify the concentration of arsenic, identify potential sources of contamination, and assess the implications for environmental and human health.

Keywords: Arsenic, human health, sea water, water pollution, environment

Introduction
Arsenic is a toxic metalloid that can have severe health effects, including cancer, cardiovascular diseases, and neurological disorders (Jomova *et al*., 2011) [3]. Industrial activities, such as mining, chemical manufacturing, and metal processing, can release arsenic into nearby water bodies (Rahman and Singh, 2019) [5]. West Bengal, known for its dense industrial regions, is at risk of arsenic contamination in its coastal waters (Rahaman *et al*., 2013) [4].
Long-term consumption of arsenic-contaminated food and water can result in skin sores and cancer. Diabetes and cardiovascular disease have also been linked to it. Exposure during pregnancy and early infancy has been associated with poor effects on cognitive development as well as an increase in young adult fatalities (Dakeishi *et al*., 2006) [2]. Throughout the Earth's crust, arsenic is a semimetallic element that occurs naturally (Binkowski, 2019) [1]. Arsenic is a chemical that is present in soil, water, and air at varying concentrations depending on the location (Smedley and Kinniburgh, 2002) [6].

Aims and Objectives
This research aims to determine the concentration of arsenic in sea water near industrial areas in West Bengal, identify potential contamination sources, and discuss the implications for public health and the environment.

Justification
Haldia and Digha, one of the major industrial centers in West Bengal, hosts a range of industries, including petrochemicals, refineries, and manufacturing plants. These industries often discharge effluents containing heavy metals, including arsenic, into nearby water bodies. The proximity of Haldia to the coastline increases the risk of arsenic entering the seawater through industrial runoff and effluent discharge.

Materials and Methods
Study Area
The study was conducted in coastal regions near industrial hubs in West Bengal, including Haldia and Digha. These areas were chosen due to their proximity to industries known to discharge arsenic and other heavy metals.

Sample Collection
- **Sampling Locations:** Water samples were collected from various points along the coast, both near industrial discharge sites and at control sites further away from industrial activity.

- **Sampling Procedure:** Samples were collected using clean, acid-washed polyethylene bottles. Each sample was preserved with nitric acid to maintain the integrity of the arsenic present.

Analytical Methods

1. **Sample Preparation**
- Water samples were filtered using 0.45 µm membrane filters to remove particulate matter.
- Samples were then digested with a mixture of nitric and hydrochloric acids.

2. **Arsenic Detection**
- **Inductively Coupled Plasma Mass Spectrometry (ICP-MS):** Used for the precise quantification of arsenic in water samples.
- **Hydride Generation Atomic Absorption Spectrometry (HGAAS):** Used as a complementary method to verify results obtained from ICP-MS.

3. **Quality Control**
- Calibration standards and blank samples were run alongside water samples to ensure accuracy and precision.
- Duplicate samples and spiked samples were analyzed to assess the recovery rate and reliability of the methods.

Results

Arsenic Concentration

The concentration of arsenic in sea water samples varied significantly between different sampling points. The average arsenic concentrations were as follows

Near Industrial Discharge Sites

Area	Unit (µg/L)
Control	5
Haldia	20
Digha	14

Table 1: *ANOVA* of Arsenic Concentration of different area

ANOVA table	SS	DF	MS	F (DFn, DFd)	P value
Treatment (between columns)	342.0	2	171.0	F (2, 6) = 171.0	*p*<0.0001
Residual (within columns)	6.000	6	1.000		
Total	348.0	8			

Table 2: Significance difference of Arsenic Concentration of different area

ANOVA summary	
F	171.0
P value	<0.0001
P value summary	****
Significant diff. among means (*p*< 0.05)?	Yes
R square	0.9828

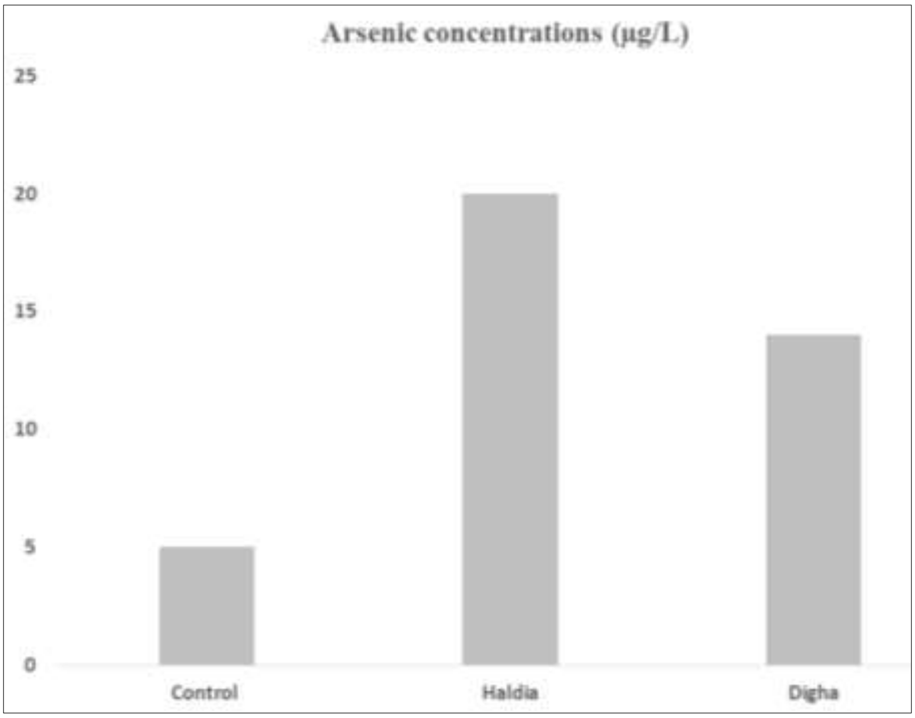

Fig 1: Graphical representation of arsenic concentrations of different areas.

The table presents the concentration of a specific heavy metal in water samples from three different areas: Control, Haldia, and Digha, measured in micrograms per liter (µg/L). The concentrations recorded are 5 µg/L for the Control area, 20 µg/L for Haldia, and 14 µg/L for Digha.

Interpretation of Results

1. **Control Area:** The Control area has the lowest concentration of the heavy metal, at 5 µg/L. This value serves as a baseline for comparison against the other areas. It is indicative of an environment with minimal

anthropogenic impact on heavy metal levels, possibly representing natural background levels of the contaminant.

2. **Haldia:** Haldia exhibits the highest concentration of the heavy metal, at 20 µg/L, which is four times higher than the Control. This significant elevation suggests a high level of contamination, likely due to industrial activities. Haldia is known for its industrial and port activities, which could be major sources of heavy metal pollution. The presence of refineries, chemical industries, and heavy traffic from port activities might contribute to this elevated level.
3. **Digha:** Digha shows a heavy metal concentration of 14 µg/L, which is nearly three times higher than the Control but lower than Haldia. Digha is a coastal area known for tourism and some localized fishing industries. The elevated levels here might be due to runoff from urban areas, improper waste disposal, or the influence of maritime activities. While not as heavily industrialized as Haldia, the human activities in Digha still contribute significantly to the contamination levels.

Potential Sources of Contamination

- **Industrial Activities:** In Haldia, the predominant source of heavy metals is likely industrial discharge. Heavy industries, including chemical manufacturing and refineries, often release heavy metals as byproducts.
- **Urban Runoff and Tourism:** In Digha, tourism and urban runoff could be major contributors. Waste from tourism activities, combined with inadequate waste management infrastructure, often leads to higher concentrations of pollutants.
- **Natural Processes:** While the Control area's data suggest minimal contamination, natural weathering of rocks and soil can still contribute minor amounts of heavy metals to the water system.

Environmental and Health Implications

- **Ecological Impact:** Elevated levels of heavy metals can be toxic to aquatic life, affecting species diversity and ecosystem health. Bioaccumulation in the food chain can lead to long-term ecological damage.
- **Human Health:** For humans, consumption of water with high levels of heavy metals can lead to various health issues, including neurological disorders, kidney damage, and cancers. The significant difference between the Control and contaminated areas highlights potential health risks for local populations, particularly in Haldia.

Recommendations for Future Action

1. **Regular Monitoring:** Establish regular monitoring programs in these areas to track changes in heavy metal concentrations over time.
2. **Pollution Control Measures:** Implement stricter regulations and pollution control measures for industries in Haldia. Encourage the adoption of cleaner technologies and proper waste disposal practices.
3. **Public Awareness:** Raise awareness among local populations about the potential health risks associated with contaminated water and promote the use of filtration systems or alternative water sources.
4. **Further Research**: Conduct comprehensive studies to identify specific sources of contamination and evaluate the effectiveness of implemented control measures.

Conclusion

This study highlights the significant levels of arsenic contamination in sea water near industrial areas in West Bengal. The findings underscore the urgent need for regulatory actions, effective remediation strategies, and continuous monitoring to protect environmental and public health. Future research should focus on comprehensive assessments of arsenic sources and long-term monitoring to mitigate the adverse effects of arsenic pollution.

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