

Groundwater Arsenic Contamination and Health Implications among Urban Slum Communities along the Padma Riverbank, Rajshahi, Bangladesh

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Abstract: Groundwater is a major source of drinking water in Bangladesh, particularly among low-income and slum communities, but naturally occurring arsenic contamination poses a significant public health concern. This study assessed the physicochemical quality of groundwater and its potential health implications among residents of selected urban slum communities in Rajshahi City Corporation. A cross-sectional mixed-methods approach was employed, integrating household surveys, field observations, and laboratory analysis of 16 groundwater samples collected from nine wards (Wards 1, 4, 7, 22, 23, 24, 25, 28, and 29). Groundwater samples were analysed for arsenic, total dissolved solids (TDS), and salinity, while household questionnaires were used to document water-use practices, awareness, and self-reported health conditions. Arsenic concentrations showed substantial spatial variation, ranging from relatively low levels to a maximum of approximately 0.064 mg/L. Four samples (GW-10, GW-11, GW-12, and GW-13; 25%) exceeded the WHO guideline value of 0.01 mg/L, while GW-10 also exceeded the Bangladesh national permissible limit of 0.05 mg/L. Ward-level variation further demonstrated localised contamination hotspots. Elevated TDS and salinity were also observed in several samples, indicating variability in groundwater mineralisation and overall water quality. The household survey revealed considerable prevalence of reported water-related health conditions, including gastrointestinal disorders (84.21%), diarrhoea (82.11%), dysentery (62.11%), respiratory problems (54.74%), and several dermatological conditions, with fungal infections (28.42%) being the most frequently reported skin problem. Although these self-reported health outcomes cannot establish a causal relationship with arsenic exposure, their coexistence with contaminated groundwater indicates a potential public health concern. The findings demonstrate that groundwater quality in the urban slum communities of Rajshahi is spatially heterogeneous and that localised arsenic contamination remains a significant risk. Regular well-specific monitoring, arsenic screening, provision of safe alternative water sources, community awareness, and targeted mitigation measures are recommended to reduce long-term exposure and protect vulnerable urban populations.

Key Words: Arsenic contamination; Groundwater quality; Rajshahi City; Urban slums; Total dissolved solids; Salinity; Drinking water; Public health; Bangladesh.

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1. Introduction

Groundwater is one of the most vital freshwater resources globally, supplying drinking water to billions of people due to its widespread availability, relatively stable quality, and natural protection from microbial contamination. In Bangladesh, the adoption of tube wells since the 1970s has significantly reduced waterborne diseases associated with contaminated surface water [1, 2, 3]. However, naturally occurring arsenic contamination has emerged as one of the most pressing environmental health challenges worldwide. Arsenic, a toxic metalloid released into groundwater through hydrogeochemical processes such as the reductive dissolution of iron oxyhydroxides, has been linked to a wide range of chronic health effects, including arsenicosis, hyperkeratosis, melanosis, cardiovascular disease, diabetes mellitus, neurological disorders, respiratory illness, and cancers of the skin, bladder, liver, kidney, and lungs [4, 5, 6]. Bangladesh is among the most severely affected countries due to the geochemical characteristics of the Ganges–Brahmaputra–Meghna delta, where Holocene alluvial sediments are enriched with naturally occurring arsenic. Widespread contamination of shallow aquifers has exposed millions of people to chronic arsenic ingestion through drinking water [7, 8]. The World Health Organisation (WHO) recommends a guideline value of 0.01 mg/L for arsenic in drinking water, whereas the Bangladesh national standard is 0.05 mg/L. Although the national standard reflects practical implementation considerations, prolonged consumption of water containing arsenic concentrations between these thresholds may still pose significant health risks [9].

Groundwater quality is determined not only by arsenic concentration but also by physicochemical parameters such as total dissolved solids (TDS), salinity, pH, and electrical conductivity, which provide insights into groundwater mineralisation and hydrogeochemical evolution [10]. Rapid urbanisation in Bangladesh has intensified pressure on groundwater resources, particularly in informal settlements where municipal water services are inadequate. Urban slum dwellers often rely on untreated tube-well water while facing poverty, overcrowding, poor sanitation, and limited healthcare access, conditions that heighten vulnerability to environmental pollution and water-related diseases [11, 12, 13]. This heterogeneity underscores the need for site-specific assessments, as arsenic distribution varies significantly even within short geographical distances [7, 8].

The current study seeks to fill this gap in research by integrating groundwater quality evaluations with health information from communities living in urban slums in Rajshahi City. Previous studies focused on the chemical makeup of groundwater. This study takes an approach. It uses lab tests to look at arsenic, TDS and salinity. It also uses data from house visits about health problems people report themselves. This combined way of looking at things gives evidence that's important for the local area. This evidence can help with checking groundwater, assessing risks, and making plans to improve public health for people who live in cities and are in difficult situations.

1.1 Objectives

The specific objectives of this study were to:

- Check how much arsenic is in the water that people use for drinking in some areas of Rajshahi City.
- Look at the quality of the water by checking some physical and chemical features like total dissolved solids and salt content.
- See how the levels of arsenic found compare to the rules set by the World Health Organisation and the rules for drinking water in Bangladesh.
- Look at the health problems that people say they have because they use this water.
- Suggest ways to make the water better and stop people from getting sick because of arsenic.

2. Materials and Methods

The methodology was designed to assess arsenic contamination in drinking water and its health impacts among slum dwellers living along the Padma River in Rajshahi City Corporation.

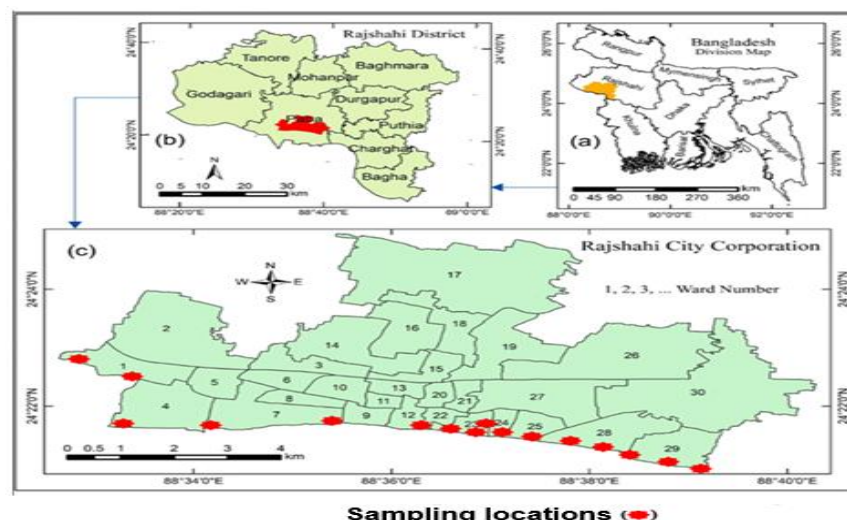


Figure 1: Areal map and locations of the study area

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2.1 Study Area

The study was conducted in selected wards of Rajshahi City Corporation, situated along the northern bank of the Padma River in north-western Bangladesh. The wards included Ward 1, Ward 4, Ward 7, Ward 22, Ward 23, Ward 24, Ward 25, Ward 28, and Ward 29. These areas were purposively chosen due to their dependence on groundwater sources for drinking and domestic purposes and their vulnerability to contamination. The selected wards consist largely of low-income communities and slum settlements characterized by rapid urbanisation, dense housing, limited sanitation facilities, and inadequate access to safe drinking water. Most households rely on shallow tube wells, deep tube wells, and a limited number of piped water supply systems, making the area suitable for investigating arsenic contamination and related public health concerns.

2.2 Study Design

A cross-sectional mixed-methods design was employed, integrating household questionnaire surveys, field observations, and laboratory analysis of groundwater samples. This design allowed for the simultaneous assessment of groundwater quality and community-level health outcomes. Household surveys were conducted to collect socio-demographic information, water source characteristics, awareness of arsenic contamination, and self-reported water-related health conditions. Field observations documented environmental and sanitary conditions in the study area. This flowchart outlines the sequential framework adopted for assessing groundwater quality and its associated health impacts in Rajshahi City, Bangladesh. The study commenced with site selection and sampling, where sixteen groundwater samples (GW-1 to GW-16) were collected across selected wards. Subsequently, laboratory analysis was performed to determine arsenic concentrations using atomic absorption spectrophotometry (AAS), alongside measurements of total dissolved solids (TDS) and salinity. A household survey was then conducted to gather socio-demographic information, water-use practices, and self-reported health symptoms. Finally, the stage of data integration and analysis combined laboratory findings with survey responses to perform risk assessment, evaluate health impacts, and generate spatial mapping of contamination patterns (Figure 2).

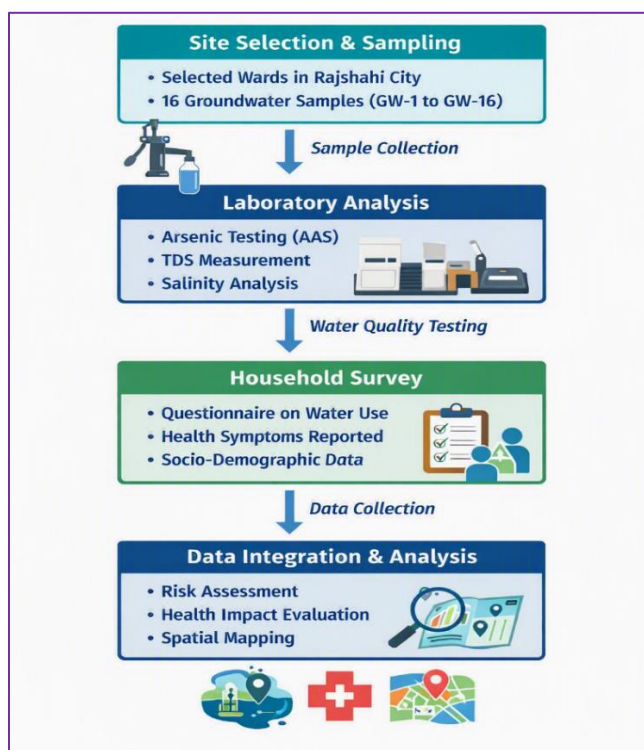


Figure 2: Flowchart of the Study Design

3.3 Groundwater Sampling

There are sixteen groundwater samples were collected from tube wells of the area. The sampling sites, which are called GW-1 to GW-16, to cover areas like where people live, schools, roads and poor neighbourhoods. However, three samples from each Ward of 23 and 29, two samples from each Ward of 01, 07, and 28 and one sample from each Ward of 04, 22, 24 and 25 of the selected locations of the area (Table 1).

Sl. No.	Sample Code	Location	Ward
1	GW-1	Shahazipara, Kasiadanga	Ward-01
2	GW-2	Hatubhanga More, Kanthalbaria	Ward-01
3	GW-3	Keshobpur Dakshinpara	Ward-04
4	GW-4	Sreerampur (Islampur Jame Masjid)	Ward-07

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5	GW-5	Opp. DC Bangloue	Ward-07
6	GW-6	Kumarpara (Ghoshpara)	Ward-22
7	GW-7	Moholdarpara	Ward-23
8	GW-8	Backside Shahmukhdome College	Ward-23
9	GW-9	Panchaboti Madrasha Field	Ward-23
10	GW-10	Raninagar Khademul School	Ward-24
11	GW-11	Talaimari Shohid Minar	Ward-25
12	GW-12	Badurtola Balur Ghat	Ward-28
13	GW-13	Talaimari East Part	Ward-28
14	GW-14	Dasmari School More	Ward-29
15	GW-15	Charsatbaria	Ward-29
16	GW-16	Backside Mizaner More	Ward-29

Table 1: List of Groundwater Sampling Locations in the study Area

Table 1 presents the 16 groundwater sampling locations (GW-1 to GW-16) selected across Wards 01, 04, 07, 22, 23, 24, 25, 28, and 29 of Rajshahi City Corporation, which include the locations of Shahazipara–Kasiadanga, Hatubhanga More–Kanthalbaria, Keshobpur Dakshinpara, Sreerampur, Kumarpara, Moholdarpara, Raninagar, Talaimari, Badurtola, Dasmari, and Charsatbaria. The sites cover residential, institutional, roadside, and other representative areas, providing spatial coverage of groundwater conditions across the city. The sampling network provides a geographically distributed representation of groundwater sources, forming the basis for subsequent physicochemical and hydrochemical assessment of groundwater quality. Groundwater samples were collected in pre-cleaned polyethene bottles, flushed thoroughly with well water before sampling. Each sample was labelled with its code (GW-1 to GW-16), ward number, and location. Samples were transported to the laboratory under controlled conditions to minimise contamination.

3.4 Laboratory Analysis

Groundwater samples were tested for levels, total dissolved solids and salinity using standard laboratory methods.

- Arsenic levels were checked using Atomic Absorption Spectrophotometry with a hydride generation method according to WHO and Bangladesh Department of Environment guidelines.
- Total dissolved solids were found using a conductivity meter, and the results were given in milligrams per litre.
- Salinity was figured out by measuring conductivity and then changing the numbers into salinity values using standard factors.

Quality control steps involved checking instruments, with solutions doing extra tests twice and using blank samples to make sure the results were right and accurate.

3.5 Household Survey

Household surveys were conducted among slum residents in the selected wards. A structured questionnaire was administered to collect data on:

- Socio-demographic characteristics (age, gender, education, occupation).
- Drinking-water sources and usage patterns.
- Awareness of arsenic contamination and safe water practices.
- Self-reported water-related health conditions, including diarrhoea, dysentery, gastrointestinal disorders, dermatitis, fungal infections, scabies, and skin discolouration.

Respondents were selected purposively to represent households dependent on groundwater sources. Informed consent was obtained before participation, and confidentiality was maintained throughout the survey.

3.6 Data Analysis

The lab results were checked against the World Health Organisation standard, which is 0.01 mg/L and also against the Bangladesh national standard for drinking water, which is 0.05 mg/L. The groundwater samples were put into categories like moderate risk or unsafe depending on whether they met these standards. Data from the survey about people's background and their health were analysed with statistics to find out where people are more at risk and how often they get sick from water. The way arsenic contamination spreads in areas was studied ward by ward to find out where the problem is most serious.

4. Results and Discussion

4.1 Socio-demographic Characteristics of the Respondents

The traits of individuals and their living situations are crucial for determining whether a household is consuming contaminated water. This is due to the fact that these traits influence the type of water individuals opt to drink, their awareness of potential hazards in their surroundings, their ability to seek assistance when necessary, and their capacity to take measures to avoid illness. This research focused on the residents of the slums close to the Padma River within the Rajshahi City Corporation to understand their demographic characteristics.

Variable	Categories	Age (%)
Gender	Male	51.58
	Female	48.42
Age	18–30	17.89
	31–45	30.53
	46–60	46.32
	>60	5.26
Occupation	Govt. Employee	3.16
	Non-Govt. Employee	11.58
	Housewife	44.21
	Businessman	26.32
	Shopkeeper	7.37
	Others	7.37
Education	Non-educated	34.74
	Primary	43.16
	SSC	11.58
	HSC	7.37
	Higher Education	3.16

Table 2: Demographic Profile of the Respondents in the Study Area

Table 2 shows the characteristics of the people who took part in the study. The people who answered the questions were mostly men and women with 51.58 % being men and 48.42 % being women. This means that the men and women were almost equal in number. The people who took part in the study were mostly between 46 and 60 years old, which is 46.32 %. Then there were people between 31 and 45 years old which's 30.53 %. Some people were between 18 and 30 years old, which is 17.89%, and a few people were over 60 years old, which is 5.26 %. When we look at what the people who took part in the study do, we see that most of them are housewives, which's 44.21 %. Then there are people who have their businesses, which is 26.32%, and people who work for others, which is 11.58 %. When we look at how much the people who took part in the study have learned, we see that 43.16 % of them finished school. Some people, which is 34.74 % did not go to school at all. A few people, which is 3.16 % went to college or university.

4.2 Types and Depth of Drinking Water Source in the Study Area

Figure 3 shows the types and depths of drinking-water sources at 16 locations (GW-1 to GW-16). Three main sources were found: shallow tubewells, deep tubewells and piped water supply. Shallow tubewells were at GW-1, GW-4, GW-10 GW-12 GW-13 and GW-14. These had depths from 60 to 120 feet. Deep tubewells were at GW-2, GW-3, GW-6, GW-7, GW-9, GW-11 GW-15 and GW-16. These went from 120 to 160 feet. Piped water supply was at GW-5 and GW-8. These sources were 300 feet deep.

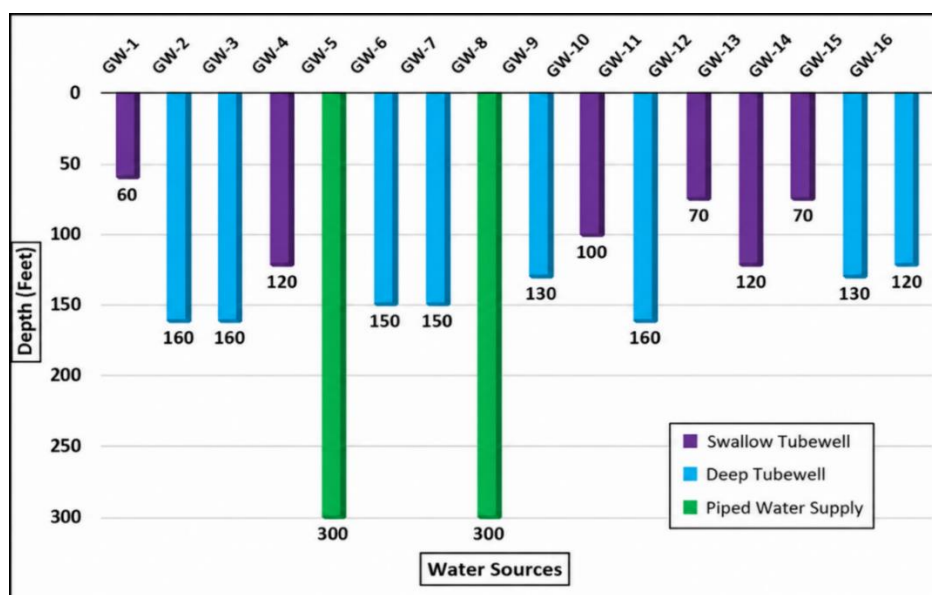


Figure 3: Types and Depth of Drinking Water Source in the Study Area

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The results show that groundwater is the source of drinking water in the study area. Tubewells are more common than piped-water systems. Relying much on groundwater is important because shallow aquifers in Bangladesh can have problems with arsenic contamination and other water quality issues. Deep tubewells are often better because deeper aquifers might have less arsenic. Depth alone does not always mean safe water. Arsenic levels can change depending on rocks and water movement [14, 15]. So the differences in source type and depth show the need to check groundwater quality regularly. This includes checking for levels and looking at well depth. Improving piped water supplies and encouraging rainwater harvesting can help reduce using groundwater that might be polluted. This also helps reduce health risks from arsenic, over time [16].

4.3 Quality of Supply Waters

The research investigated the primary sources and quality of groundwater used for drinking by residents in the examined region. Results indicated that groundwater from tube wells and various local sources acts as the main source of drinking water for the majority of households. Nonetheless, respondents reported worries about water quality, such as potential contamination and unsafe drinking conditions.

4.3.1 Physical Characteristics of Ground Water

Figure 4 presents the observed physical and sensory characteristics of groundwater samples from the study area. Among the samples, 54% appeared clear, 70% had no noticeable odour, and 95% had a normal taste. However, approximately 40% showed slight yellow colouration, while 5% appeared reddish or brownish. A metallic odour was detected in 25% of the samples, and approximately 4–5% had a bitter taste. These variations in appearance, odour, and taste may be associated with differences in groundwater geochemistry and the presence of dissolved minerals, particularly iron and manganese, which have previously been reported in groundwater from the Rajshahi region.

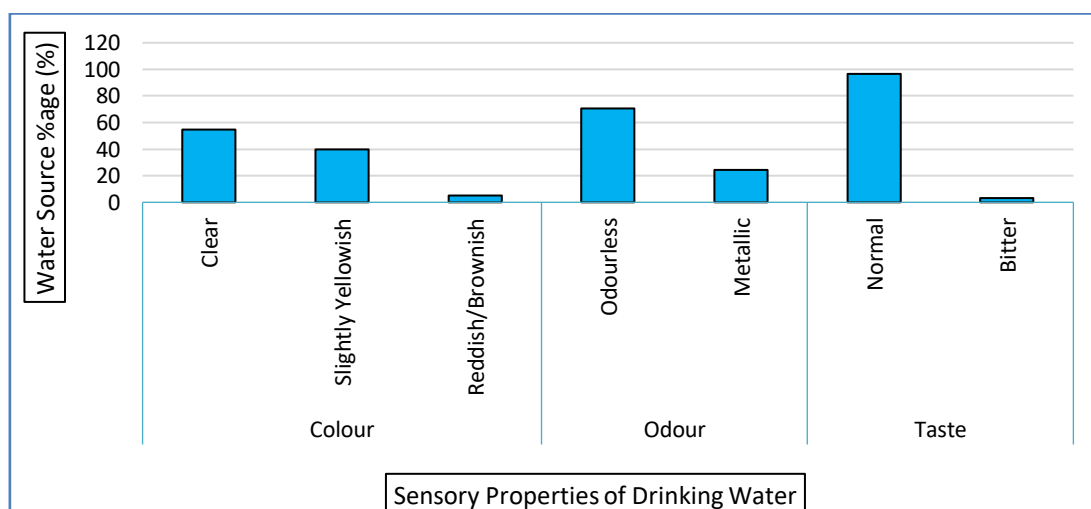


Figure 4: Physical Characteristics of Drinking Water in the Study Area.

The observed sensory characteristics are broadly consistent with previous findings on groundwater quality in Rajshahi and north-western Bangladesh, where elevated concentrations of arsenic, iron, and manganese have been reported [6, 8, 15]. The yellowish, reddish-brown colouration and metallic odour observed in some samples may therefore indicate the presence of dissolved or oxidised mineral constituents. However, sensory characteristics alone cannot determine the safety of drinking water, particularly with respect to arsenic contamination. Arsenic is generally colourless, odourless, and tasteless, meaning that water may appear clear and acceptable while still containing potentially harmful concentrations of arsenic. Long-term exposure to arsenic-contaminated water is associated with significant health risks in Bangladesh [16, 17, 18]. Therefore, the physical observations presented in Figure 4 should be considered as a preliminary assessment of groundwater quality and interpreted alongside laboratory measurements of physicochemical parameters and arsenic concentration. This combined approach is essential for accurately evaluating the suitability and safety of groundwater for drinking purposes.

4.3.2 Arsenic Concentration in Groundwater

Figure 5 illustrates substantial spatial variation in arsenic concentrations among the 16 drinking-water sources. Most samples contained relatively low arsenic concentrations; however, four samples (GW-10, GW-11, GW-12, and GW-13; 25%) exceeded the WHO guideline value for drinking water. GW-10 recorded the highest concentration (0.064 mg/L), exceeding both the WHO guideline value and the Bangladesh Department of Environment standard of 0.05 mg/L. The concentrations in GW-11, GW-12, and GW-13 were 0.038, 0.024, and 0.025 mg/L, respectively, indicating potential health concerns associated with long-term consumption.

The observed spatial variability is consistent with the heterogeneous distribution of arsenic in groundwater across Rajshahi and north-western Bangladesh. Previous studies have similarly reported considerable differences in groundwater arsenic

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concentrations between locations and water sources, particularly among shallow tubewells [6, 8, 15]. Such variability reflects the influence of local hydrogeological and geochemical conditions on arsenic mobilisation and distribution.

Although most of the investigated sources were within the recommended limit, the detection of elevated arsenic in four sources indicates that localised contamination remains an important concern. Chronic exposure to arsenic-contaminated drinking water has been associated with various adverse health effects and increased risks of chronic disease [16, 18]. Therefore, the affected sources, particularly GW-10, GW-11, GW-12, and GW-13, require regular monitoring and appropriate mitigation measures, including access to verified arsenic-safe drinking-water sources. Overall, the findings emphasise that groundwater safety should be evaluated on a source-specific basis rather than assuming that all wells within the study area have similar arsenic conditions.

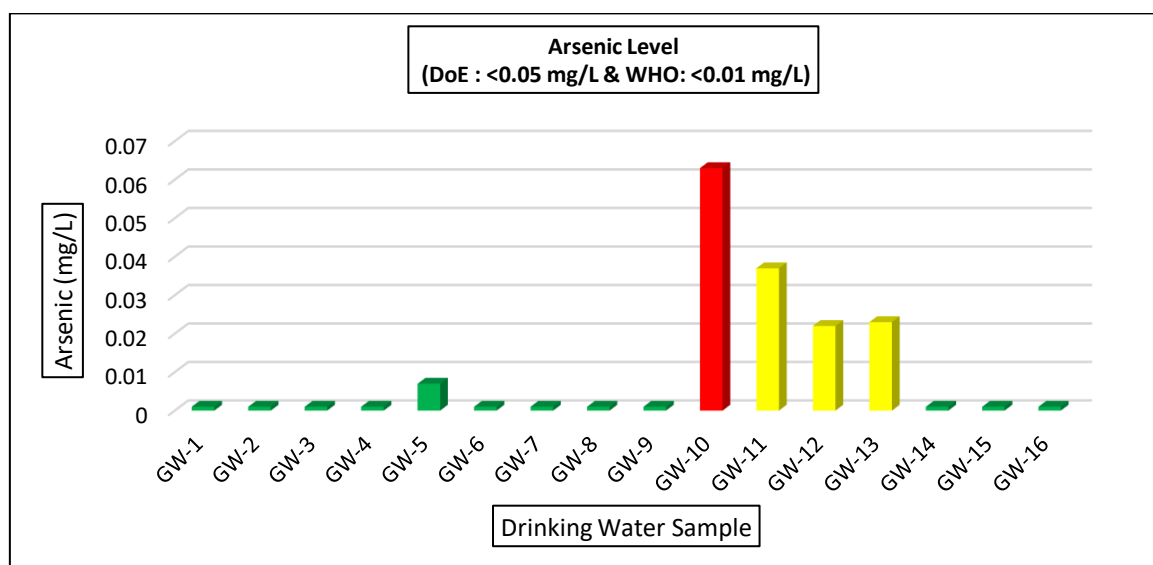


Figure 5: Arsenic Concentration in Drinking Water Sources of the Study Area

Figure 6 demonstrates considerable ward-wise variation in the average arsenic concentration of drinking-water sources in Rajshahi City Corporation (RCC). Ward 24 recorded the highest average concentration (0.063 mg/L), exceeding both the WHO guideline value of 0.01 mg/L and the Bangladesh drinking-water standard of 0.05 mg/L. Wards 25 and 28 also showed elevated concentrations above the WHO guideline, although their average levels remained below the Bangladesh standard. In contrast, the remaining six wards recorded average arsenic concentrations below the WHO guideline. The observed spatial variability is consistent with previous studies conducted in Rajshahi and north-western Bangladesh, which have reported substantial differences in groundwater arsenic concentrations among locations and individual wells [6, 15]. Such variation may reflect differences in local hydrogeological and geochemical conditions that influence arsenic mobilisation and distribution in groundwater. The results also highlight an important distinction between national and international drinking-water standards: water sources in Wards 25 and 28 may comply with the Bangladesh standard but still exceed the more stringent WHO guideline.

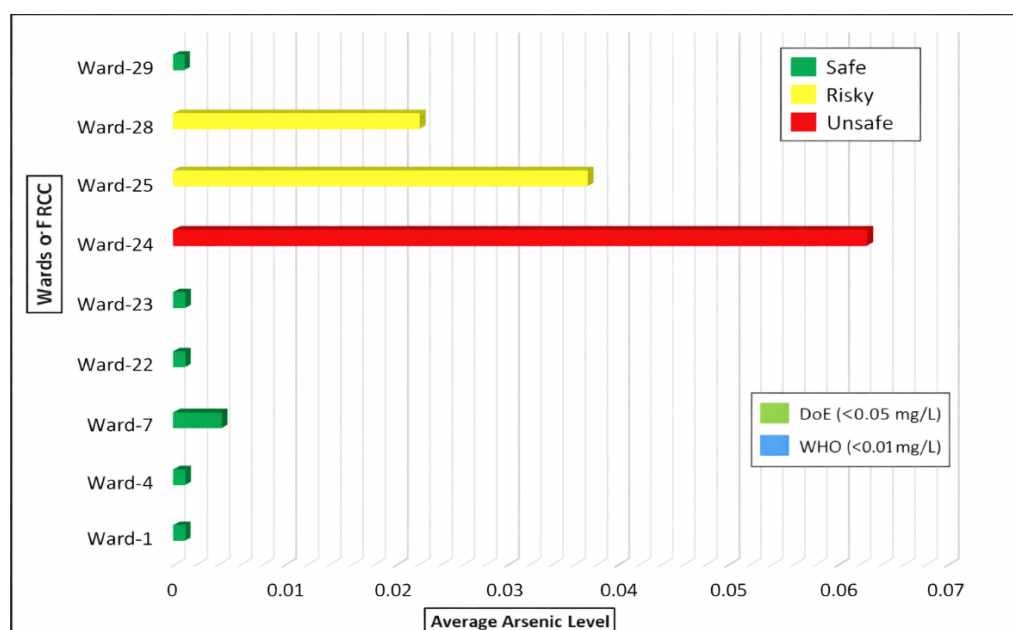


Figure 6: Average Arsenic Levels in Drinking Water across Wards of RCC

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Given the health risks associated with prolonged exposure to arsenic-contaminated drinking water, ward- and source-specific monitoring is essential, particularly in Wards 24, 25, and 28. Regular testing and switching to verified low-arsenic water sources can effectively reduce exposure, as demonstrated by well-switching approaches in Bangladesh [17]. Therefore, the spatial distribution shown in Figure 6 emphasises the need for targeted arsenic monitoring, safe-water interventions, and continued assessment of groundwater quality in areas with elevated concentrations.

4.3.3 Relationship of Arsenic, TDS and Salinity in Groundwater

Figure 7 illustrates the relationship between total dissolved solids (TDS), salinity, and arsenic concentration in drinking-water samples from Rajshahi City. The results indicate a clear increasing trend between TDS and salinity, suggesting that samples with higher dissolved-solids content generally had greater salinity. Several samples exceeded the reported salinity threshold of 1 ppt, indicating increased mineralisation of the groundwater. Arsenic concentrations also varied considerably among the samples, with some exceeding the applicable drinking-water guideline values, indicating localised arsenic contamination.

The combined occurrence of elevated TDS, salinity, and arsenic suggests variability in the groundwater's physicochemical characteristics and reflects differences in local hydrogeochemical conditions. Similar groundwater-quality concerns, including elevated dissolved solids and arsenic contamination, have been reported in Rajshahi and other parts of Bangladesh [16, 18]. Importantly, TDS and salinity should not be considered direct indicators of arsenic contamination, as their relationship with arsenic may vary according to local geological and hydrochemical processes.

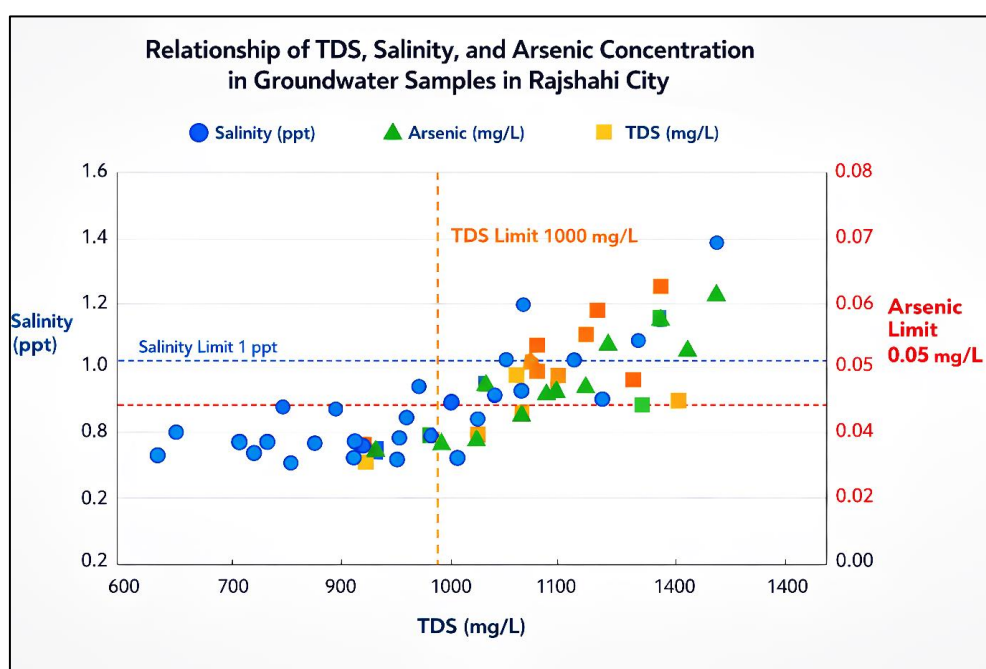


Figure 7: Relationship of TDS, Salinity and Arsenic Concentration in the Drinking Water

The findings are also consistent with broader evidence that chronic exposure to arsenic-contaminated groundwater can pose significant risks to human health, including skin, respiratory, and other chronic health effects [6, 15]. Therefore, the observed variation in TDS, salinity, and arsenic emphasises the need for regular monitoring of groundwater quality and source-specific assessment, particularly in areas where multiple water-quality parameters exceed recommended levels. Such monitoring can support the identification of unsafe drinking-water sources and guide appropriate mitigation and safe-water management strategies.

4.3.4 Measure of Water Quality

Figure 8 compares the measured arsenic, total dissolved solids (TDS), and salinity in groundwater samples GW-1 to GW-16 with the relevant drinking-water standards of the World Health Organisation (WHO) and Bangladesh Department of Environment (DoE). Arsenic concentrations varied considerably among the sampling locations, with several sources exceeding the WHO guideline value of 0.01 mg/L, while some also exceeded the Bangladesh standard of 0.05 mg/L. This indicates localised arsenic contamination and highlights the potential risk of prolonged exposure through drinking water.

TDS concentrations also showed variation among the samples, with some sources exceeding 1000 mg/L, indicating relatively high levels of dissolved substances and comparatively poorer water quality. Salinity remained relatively stable in most samples but exceeded the reported 1 ppt threshold at some locations, suggesting localised increases in groundwater mineralisation. However, these parameters should be interpreted individually because elevated TDS or salinity does not necessarily indicate the presence of arsenic.

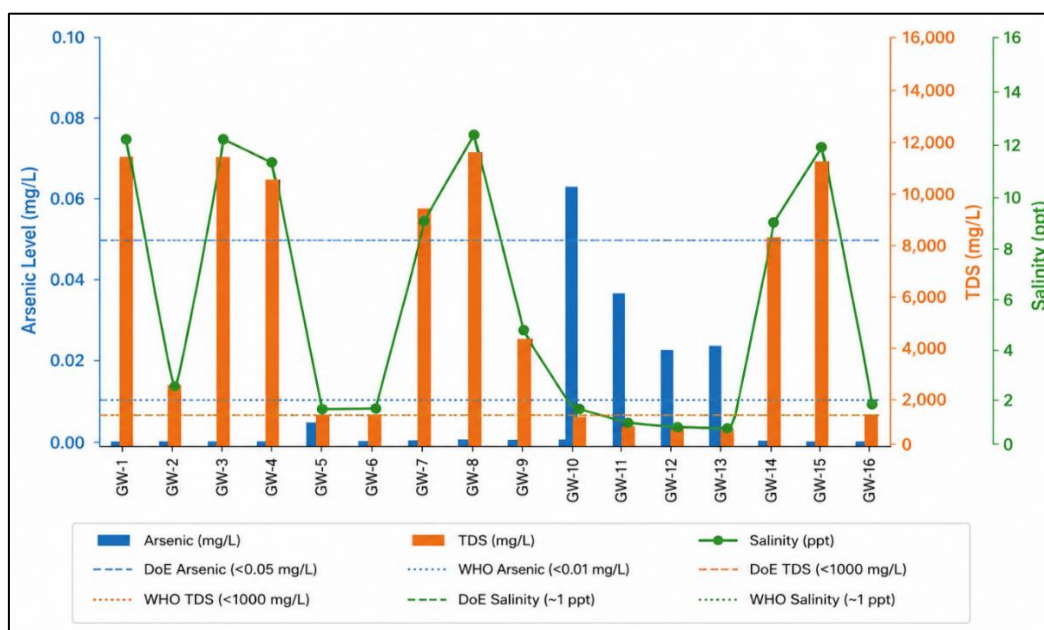


Figure 8: Measure of Drinking water Quality based on WHO and DoE

Overall, the combined assessment indicates that groundwater quality varies substantially among the studied sources, with arsenic representing the most important health-related concern. These findings are consistent with previous studies reporting widespread and spatially variable groundwater arsenic contamination in Rajshahi and north-western Bangladesh^[20]. Long-term exposure to arsenic-contaminated water has been associated with serious health consequences, emphasizing the need for continuous monitoring and appropriate mitigation measures^[21]. Therefore, source-specific water-quality testing, identification of contaminated wells, and access to verified safe-water sources are essential for sustainable drinking-water management in Rajshahi City.

4.4 Health Implications of Drinking Water Pollution in the area

The study area had some effects on people's health. People who drank water from the ground in that area got sick with water-borne diseases and skin problems. The water had arsenic in it. That is very bad for people who live in that area. If people drink water with arsenic in it for a time, they can get very sick with skin diseases, stomach problems and other long-term illnesses. We need to make sure people have water to drink, and we need to do something to help people who are getting sick from the bad water with arsenic in it. The people who drank groundwater in the study area were the ones who got sick. Arsenic in drinking water is a problem for people who live in the area. Arsenic can cause skin diseases and other health problems like stomach problems. The study area needs drinking water, and people need help to stay healthy. Arsenic contamination is an issue, and we need to do something about it to help the people in the study area.

4.4.1 Water-borne Diseases in the Study Area

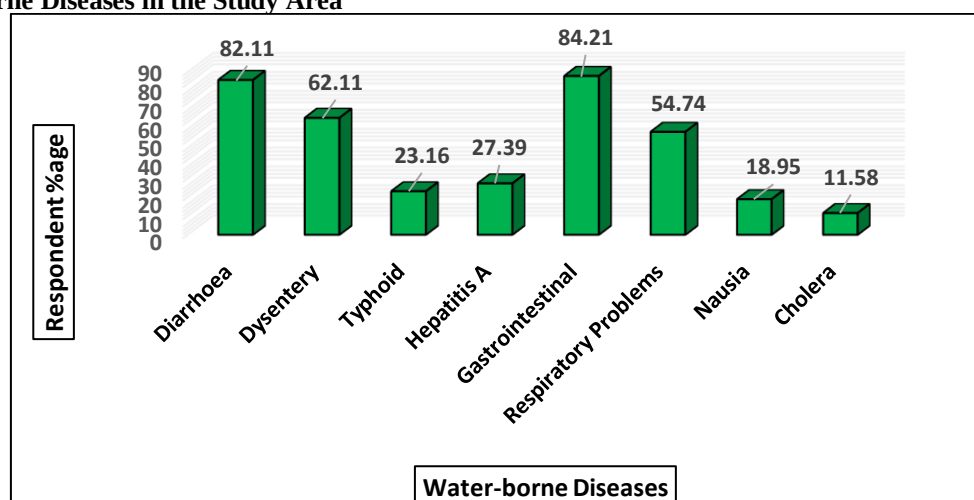


Figure 9: Water-borne Diseases in the Study Area

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Figure 9 presents the prevalence of reported water-borne and water-related diseases among the study population. Gastrointestinal disorders (84.2%) and diarrhoea (82.11%) were the most frequently reported conditions, followed by dysentery (62.11%) and respiratory problems (54.74%). Hepatitis A and typhoid were reported by 27.39% and 23.16% of respondents, respectively, while nausea (18.95%) and cholera (11.58%) were comparatively less prevalent. The high occurrence of gastrointestinal illnesses, particularly diarrhoea and dysentery, indicates substantial public-health concerns related to drinking-water quality and possible exposure to microbial or chemical contaminants.

The observed disease burden is broadly consistent with previous evidence from arsenic-affected areas of Bangladesh, where contaminated groundwater has been associated with adverse health outcomes ^[19]. Studies in Rajshahi have also reported health effects associated with prolonged exposure to contaminated groundwater, including respiratory and psychosocial health problems ^[22]. However, the present findings should be interpreted cautiously because the reported diseases may result from multiple environmental, microbial, chemical, and socioeconomic factors, and the observed prevalence cannot by itself establish a direct causal relationship with arsenic contamination. Overall, the high prevalence of gastrointestinal and other reported illnesses highlights the importance of safe drinking-water supplies, regular water-quality monitoring, improved sanitation, and targeted health interventions in the study area. Particular attention should be given to communities relying on groundwater sources with documented contamination, where reducing exposure to unsafe water could contribute to improved public health.

4.4.2 Skin Diseases in the Area

Figure 10 presents the prevalence of reported skin-related diseases among respondents. Fungal infections were the most common condition (28.42%), followed by rough patches (23.16%) and scabies (17.89%). Dermatitis (13.68%) and eczema (12.63%) were reported at moderate frequencies, while discolouration was the least prevalent condition (11.58%). The findings indicate a considerable burden of dermatological problems among the study population.

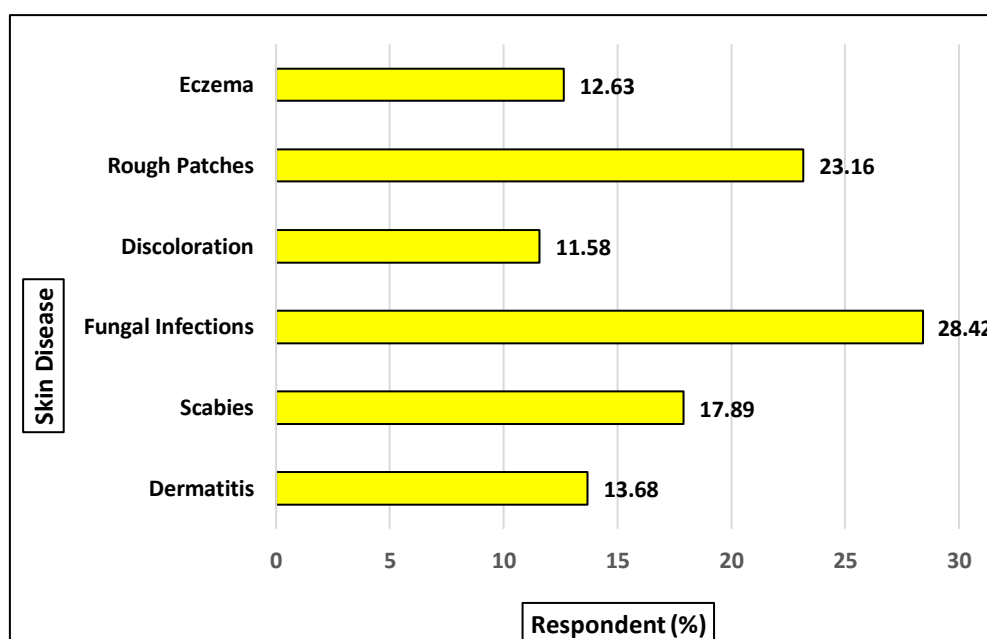


Figure 10: Skin-Related diseases in the Study Area

The observed occurrence of skin manifestations is consistent with previous research on health effects associated with arsenic exposure in Bangladesh. Arsenic exposure has been widely associated with characteristic skin changes, including pigmentation abnormalities, hyperkeratosis, and other dermatological manifestations ^[23, 24]. Studies conducted in Rajshahi and north-western Bangladesh have also documented health problems associated with arsenic-contaminated groundwater, while recent assessments have identified the region as vulnerable to groundwater arsenic contamination ^[25, 26]. However, the skin conditions reported in Figure 10 should not be attributed exclusively to arsenic contamination, as fungal infections, scabies, dermatitis, and eczema can also result from hygiene conditions, microbial exposure, environmental factors, and other causes. Therefore, the observed prevalence should be interpreted as an indicator of dermatological health burden rather than direct evidence of arsenic-induced disease. Nevertheless, given the documented presence of arsenic in some drinking-water sources in the study area, continued water-quality monitoring, clinical assessment, and improved access to safe drinking water are important for reducing potential exposure and associated health risks.

5. Conclusion

This study demonstrates that groundwater quality among urban slum communities along the Padma Riverbank in Rajshahi City is spatially heterogeneous, with localised arsenic contamination posing an important public-health concern. Laboratory analysis of 16 groundwater samples showed that arsenic concentrations varied substantially among sampling locations. Four

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samples (GW-10, GW-11, GW-12 and GW-13), representing 25% of the tested sources, exceeded the WHO guideline of 0.01 mg/L. GW-10 recorded the highest concentration at approximately 0.064 mg/L, exceeding both the WHO guideline and the Bangladesh national permissible limit of 0.05 mg/L. At the ward level, Ward 24 had the highest average arsenic concentration (0.063 mg/L), while Wards 25 and 28 also exceeded the WHO guideline. These findings demonstrate that groundwater safety cannot be assumed uniformly across the study area and that well-specific assessment is essential. The assessment of other water-quality parameters further indicates variability in groundwater conditions. Elevated TDS and salinity were observed at some sampling points, suggesting differences in groundwater mineralisation. However, these parameters should not be interpreted as direct indicators of arsenic contamination because their relationship with arsenic depends on local hydrogeochemical conditions. The findings therefore support the need for an integrated approach in which arsenic, TDS, salinity and other relevant water-quality parameters are assessed independently and regularly.

The household survey also identified a substantial burden of self-reported health problems. Gastrointestinal disorders (84.21%) and diarrhoea (82.11%) were the most frequently reported conditions, followed by dysentery (62.11%) and respiratory problems (54.74%). Among dermatological conditions, fungal infections (28.42%), rough patches (23.16%) and scabies (17.89%) were most frequently reported. However, because the study employed a cross-sectional design and relied on self-reported health information, these findings cannot establish a direct causal relationship between arsenic exposure and the reported illnesses. The health conditions may also reflect microbial, environmental, sanitary and socioeconomic factors. Taken together, the coexistence of measured arsenic contamination and a high prevalence of reported water-related health problems indicates a significant environmental-health concern for vulnerable urban slum communities. The results highlight the importance of regular well-specific arsenic monitoring, identification and marking of contaminated sources, provision of verified arsenic-safe drinking water, improved sanitation, community awareness, and targeted health interventions, particularly in higher-risk areas such as Wards 002024, 25 and 28.

Future research should expand the number of sampling locations and households, incorporate seasonal groundwater monitoring, detailed hydrochemical and GIS-based spatial analysis, and longitudinal assessment of exposure and clinically confirmed health outcomes. Further investigation of the effectiveness, affordability and community acceptance of arsenic-removal technologies and alternative safe-water options would also strengthen evidence for sustainable intervention in the study area.

References

1. Rasul, M.T. & Jahan, M.S. (2010). Quality of Ground and Surface Water of Rajshahi City Area for Sustainable Drinking Water Source. *Journal of Scientific Research*. 2 (3):577-584. <https://www.banglajol.info/index.php/JSR/article/view/4093/4666>
2. Argos M., Kalra T., Rathouz P.J., Chen Y., Pierce B., Parvez F., Islam T., Ahmed A., Rakibuz-Zaman M., Hasan R., Sarwar G., Slavkovich V., Geen A.V., Graziano J. & Ahsan H. (2010). Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study. *The Lancet*. 376, (9737): 252-258. [https://doi.org/10.1016/S0140-6736\(10\)60481-3](https://doi.org/10.1016/S0140-6736(10)60481-3)
3. Haque, K.E. & Farhana, T. (2011). Arsenic contamination in groundwater and its sufferings, Manigram, Rajshahi, Bangladesh: A case study. *International Journal of Earth Sciences and Engineering*. 4(3):382-394. https://www.researchgate.net/publication/288615852_Arsenic_contamination_in_groundwater_and_its_sufferings_Manigram_Rajshahi_Bangladesh_A_case_study
4. McArthur J.M., Ravenscroft P., Safiulla S. & Thirlwall M.F. (2001). Arsenic in groundwater: Testing pollution mechanisms for sedimentary aquifers in Bangladesh. *Water Resources Research*. 37(1):109-117. <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2000WR900270>
5. Alam, S.M.M., Farha, M.N. & Zaman, A.K.B. (2015). An Appraisal of Arsenic and Pesticide Toxicity for Economically Terminal People: a Snap Shot of North-Western Part of Bangladesh. *Journal of Scientific Research*, 7(3):159-165. <https://doi.org/10.3329/jsr.v7i3.23540>
6. Smith A.H., Lingas E.O. & Rahman M. (2000). Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. *Bull World Health Organ*. 78(9):1093-103. PMID: 11019458; PMCID: PMC2560840. <https://pubmed.ncbi.nlm.nih.gov/11019458/>
7. Habib M.A., Reza A.H.M.S., Hasan M.I., Ahsan M.A., Moniruzzaman M., Hasan A.B., Shofi S.I. & Hridoy K.M. (2024). Evaluating arsenic contamination in northwestern Bangladesh: A GIS-Based assessment of groundwater vulnerability and human health impacts. *Heliyon*. 10(6). ISSN 2405-8440. <https://doi.org/10.1016/j.heliyon.2024.e27917>
8. Saha, K.C. (2003). Diagnosis of Arsenicosis. *Journal of Environmental Science and Health*. 38:255 - 272. <https://www.semanticscholar.org/paper/Diagnosis-of-Arsenicosis-Saha/1647896488345f57ccfcde6c5dd44250340c325d>
9. BWDB (2004). Water Level and Discharge Data of the River Padma (Bangladesh Water Development Board, Rajshahi, Bangladesh).
10. Jiang, J.Q., Ashekuzzaman, S.M., Jiang, A., Sharifuzzaman, S.M. & Chowdhury, S.R. (2012). Arsenic contaminated groundwater and its treatment options in Bangladesh. *Int J Environ Res Public Health*. 10(1):18-46. <https://doi.org/10.3390/ijerph10010018>
11. Bhuiyan, M.F.K., Rana, M. & Alam, M.F. (2023). Depression among chronic arsenic exposure patients in Shampur Upazila, Rajshahi, Bangladesh. *Int. J. Biosci*. 22(4):55-63. <http://dx.doi.org/10.12692/ijb/22.4.55-63>
12. Ali M.A. (2006). Arsenic Contamination of Groundwater in Bangladesh. *International Review for Environmental Strategies*. 6(2):329 - 360. https://www.iges.or.jp/en/publication_documents/pub/peer/en/1204/IRES_Vol.6-2_329.pdf
13. Islam, M.N., Das, B.K. & Huque, M.E. (2018). Risk Assessment for Bangladeshis due to Arsenic Exposure from Consumption of Vegetables Grown with Natural Arsenic Contaminated Groundwater. *Indian Journal of Science and Technology*. 11(6):1-11. <https://doi.org/10.17485/ijst/2018/v11i6/120996>
14. Parvez F., Chen Y., Brandt-Rauf P.W., Slavkovich V., Islam T., Ahmed A., Argos M., Hassan R., Yunus M., Haque S.E., Balac O., Graziano J.H. & Ahsan H. (2010). A prospective study of respiratory symptoms associated with chronic arsenic exposure in Bangladesh: findings from the Health Effects of Arsenic Longitudinal Study (HEALS). *Thorax*. 65(6):528-33. <https://doi.org/10.1136/thx.2009.119347>

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15. Hanchett, S. (2007). Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP): Final Evaluation Study (ICR). https://www.academia.edu/14967162/Bangladesh_Arsenic_Mitigation_Water_Supply_Project_BAMWSP_Final_Evaluation_Study_ICR
16. Chowdhury U.K., Biswas B.K., Chowdhury T.R., Samanta G., Mandal B.K., Basu G.C., Chanda C.R., Lodh D., Saha K.C., Mukherjee S.K., Roy S., Kabir S., Quamruzzaman Q. & Chakraborti D. (2000). Groundwater arsenic contamination in Bangladesh and West Bengal, India. *Environ Health Perspect.* 108(5):393-7. <https://doi.org/10.1289/ehp.00108393>
17. Rahaman M.S., Mise N. & Ichihara S. (2022). Arsenic contamination in food chain in Bangladesh: A review on health hazards, socioeconomic impacts and implications, *Hygiene and Environmental Health Advances*, Volume 2, 2022, 100004, ISSN 2773-0492. <https://doi.org/10.1016/j.heha.2022.100004>
18. Das N.K. & Sengupta S.R. (2008). Arsenicosis: Diagnosis and treatment. *Indian J Dermatol Venereol Leprol.* 74:571-581. <https://ijdv.com/arsenicosis-diagnosis-and-treatment/#:~:text=doi%3A%2010.4103/0378%2D6323.45098>
19. Mou, S.I., Paul, R., Haque, F. & Swarnokar, S.C. (2025). Water Supply and Sanitation Crisis in Joragata Railway Slum, Khulna: A Study on Groundwater Quality, Hygiene Practices, and Health Risks. *American Journal of Environmental Protection.* 14(5):181-196. <https://doi.org/10.11648/j.ajep.20251405.13>
20. Ahmad S.A., Khan M.H. & Haque M. (2018). Arsenic contamination in groundwater in Bangladesh: implications and challenges for healthcare policy. *Risk Manag Healthc Policy.* 11:251-261. <https://doi.org/10.2147/RMHP.S153188>. PMID: 30584381; PMCID: PMC6281155.
21. Safiuddin, M. (2011). Arsenic contamination of groundwater in Bangladesh: A review. *International Journal of the Physical Sciences.* 6. 10.5897/IJPS11.1300.
22. Mostafa, M.G., Uddin, S.M.H. & Haque, A.B.M.H. (2017). Assessment of hydro-geochemistry and groundwater quality of Rajshahi City in Bangladesh. *Appl Water Sci.* 7:4663–4671. <https://doi.org/10.1007/s13201-017-0629-y>
23. Jameel Y., Mozumder M.R.H., van Geen A. & Harvey C.F. (2021). Well-Switching to Reduce Arsenic Exposure in Bangladesh: Making the Most of Inaccurate Field Kit Measurements. *Geohealth.* 5(12):e2021GH000464. <https://doi.org/10.1029/2021GH000464>. PMID: 34938930; PMCID: PMC8670558.
24. Ahmed, F.T., Khan, A., Khan, R., Saha, S.K., Alam, M.F., Dafader, N.C., Sultana, S., Elius, I.B. & Mamun, S.A. (2021). Characterization of arsenic contaminated groundwater from central Bangladesh: Irrigation feasibility and preliminary health risks assessment. *Environmental Nanotechnology, Monitoring and Management*, 15, 100433.
25. Rasul M.T. & Jahan M.S.S. (2006). Arsenic Situation in Rajshahi City Area and its Mitigation. Rajshahi: Institute of Environmental Science, University of Rajshahi.
26. Alam M.G., Allinson G., Stagnitti F., Tanaka A. & Westbrooke M. (2002). Arsenic contamination in Bangladesh groundwater: a major environmental and social disaster. *Int J Environ Health Res.* 12(3):235-53. <https://doi.org/10.1080/0960312021000000998>. PMID: 12396524.