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Original Article

Analysis of groundwater quality: A case study in the Manikganj District, Bangladesh

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ABSTRACT

Groundwater is one of the most important sources of drinking and domestic water in rural Bangladesh, but its quality may be affected by natural processes and human activities. This study assessed the groundwater quality of selected tube-wells in Deuly village, Singair Upazila, Manikganj District, Bangladesh. A total of ten groundwater samples were collected randomly from different tube-wells and analyzed in the laboratory of the Department of Civil Engineering, European University of Bangladesh. The selected physicochemical parameters included pH, turbidity, dissolved oxygen (DO), arsenic, total dissolved solids (TDS), and total suspended solids (TSS). The results were compared with the World Health Organization (WHO) and Bangladesh Drinking Water Standards (BDWS) to evaluate the suitability of groundwater for drinking purposes. The pH values ranged from 6.98 to 7.04, indicating nearly neutral water and remaining within the permissible range. Turbidity values varied from 1.14 to 19.40 NTU, where several samples exceeded WHO and BDWS limits, suggesting the presence of suspended impurities. DO concentrations ranged from 4.3 to 19.4 mg/L, with three samples below the BDWS recommended value. Arsenic was not detected in any sample. TDS values ranged from 249 to 1293 mg/L, with only one sample exceeding the BDWS limit, whereas TSS values ranged from 3.8 to 42 mg/L, with one sample exceeding the standard. Overall, the groundwater quality was mostly acceptable, although some samples required treatment before drinking.

Keywords: Bangladesh drinking water standards, drinking water standards, groundwater quality, Manikganj district, physicochemical parameters

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INTRODUCTION

Groundwater is one of the most important sources of drinking and domestic water in rural Bangladesh because tube-wells are widely used where a piped water supply is limited. Although groundwater is often considered safer than untreated surface water, its quality can be affected by natural hydrogeochemical processes, agricultural activities, sanitation conditions, and local land-use practices. Therefore, regular groundwater-quality assessment is essential for protecting public health and ensuring a safe drinking-water supply.[1] The World Health Organization (WHO) emphasizes that drinking-water quality management should be based on health protection, routine monitoring, and comparison with guideline values, whereas Bangladesh applies national drinking-water standards under the Environment Conservation Rules, 1997.[2]

In Bangladesh, groundwater plays a major role in domestic water supply, but its quality has become a significant public health concern. The shift from surface water to tube-well water reduced exposure to many waterborne pathogens, yet it also revealed serious chemical contamination problems, especially arsenic in shallow aquifers. The British Geological Survey and Department of Public Health Engineering reported widespread arsenic contamination in Bangladesh groundwater, and later studies confirmed that many districts contain arsenic concentrations above both the WHO guideline value and the Bangladesh national standard.[3] Arsenic exposure through drinking water is associated with long-term health and economic burdens, making it one of the most important parameters in groundwater-quality studies in Bangladesh.[4] Besides arsenic, physicochemical parameters such as pH, turbidity, dissolved oxygen (DO), total dissolved solids (TDS), total suspended solids (TSS), iron, manganese, chloride,

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nitrate, and hardness are commonly used to evaluate drinking-water suitability. The Bangladesh Environment Conservation Rules list drinking-water standards for several key parameters, including arsenic at 0.05 mg/L, pH at 6.5–8.5, DO at 6 mg/L, suspended particulate matter at 10 mg/L, and TDS at 1000 mg/L. WHO guidelines also highlight the importance of turbidity because high turbidity can protect microorganisms from disinfection, increase chlorine demand, and affect the acceptability of drinking water.[5] Therefore, pH, turbidity, DO, arsenic, TDS, and TSS are useful indicators for preliminary assessment of groundwater quality.

Previous studies in Bangladesh have shown that groundwater quality varies spatially due to geology, aquifer depth, land use, and local contamination sources. Ahsan *et al*. evaluated groundwater quality around Dhaka using standard water-quality parameters and compared the results with Bangladesh drinking-water standards.[6] Rahman *et al*. assessed drinking-water quality using index-based methods and included parameters such as pH, TDS, electrical conductivity, turbidity, hardness, major ions, and heavy metals, demonstrating the usefulness of combined parameter analysis for determining overall drinking-water suitability.[7] Similarly, the APHA standard methods are widely used for laboratory analysis of water and wastewater parameters, ensuring that water-quality data are generated through recognized analytical procedures.[8]

Studies specifically conducted in Manikganj and Singair Upazila further justify the importance of groundwater-quality investigation in this area assessed groundwater arsenic at Singair Upazila and collected 99 tube-well water samples to examine arsenic and its relationship with other metals and ions.[6] Their study reported that arsenic was correlated with iron, suggesting geochemical interaction within the aquifer system. Tasneem *et al*. also investigated arsenic and iron in Singair Upazila and found arsenic concentrations ranging from 0.0011 to 0.0858 mg/L, indicating that some groundwater sources exceeded the WHO and Bangladesh permissible limits.[9] Another local study on Manikganj groundwater quality used Water Quality Index and Principal Component Analysis, measuring parameters such as pH, TDS, electrical conductivity, hardness, alkalinity, iron, manganese, sulfate, chloride, and turbidity.[10] These studies indicate that groundwater quality in Manikganj is not uniform and requires site-specific investigation.

National water-quality reports also show that safe water access in Bangladesh cannot be assessed only by the presence of an improved water source. UNICEF reported that only about half of households collected water meeting Bangladesh standards for both arsenic and *Escherichia coli*, indicating that chemical and microbial contamination remain important concerns for drinking-water safety.[11] Although the present study focuses mainly on physicochemical parameters, microbial parameters such as total coliform, fecal coliform, and *E. coli* should be included in future studies for a more complete assessment.

The present study was conducted in Singair Upazila, Manikganj District, Bangladesh. Ten groundwater samples were collected from different tube-wells and analyzed for pH, turbidity, DO, arsenic, TDS, TSS, and total solid (TS) in the Civil Engineering laboratory of European University of Bangladesh (EUB). The measured values were compared with WHO guidelines and Bangladesh Drinking Water Standards (BDWS) to determine whether the groundwater quality exceeded permissible limits. This study is important because it provides localized evidence on groundwater quality in a rural area of Manikganj and helps identify whether tube-well water requires treatment, filtration, or regular monitoring before drinking.

METHODOLOGY

Study Area

Singair is an Upazila (subdistrict) located in the northern part of Manikganj District, within the Dhaka Division of Bangladesh. Covering an area of approximately 221.45 km^2 and hosting a population of around 328,125 people, it represents a moderately populated rural region of central Bangladesh (CityPopulation.de, 2022). The Upazila is predominantly agricultural, with rice, jute, vegetables, and various fruits forming the backbone of local livelihoods. The topography consists of flat alluvial plains intersected by small rivers and canals, which are crucial for irrigation but also subject the area to seasonal flooding. The climate is subtropical with distinct wet and dry seasons, influencing both water availability and groundwater recharge patterns, making it an important region for hydrological studies.

Given its reliance on agriculture and proximity to natural water bodies, Singair Upazila serves as a representative study area for groundwater quality analysis, providing insights into rural water resource management and potential anthropogenic impacts on water quality.

Data Collection and Sampling Points

Samples were collected randomly from different tube wells in Deuly Village, Singair Upazila, Manikganj District. The collected samples were stored in clean, dry plastic bottles containing 1 L that were washed with distilled water before use. Most of the samples were collected during the day, and the remaining in the evening, only after it had been pumped for a minimum of 15 min to obtain a composite sample. The bottles were tightly sealed after collection. All the samples collected were found to be odorless. However, some groundwater samples were not clear, which might be due to the presence of turbidity. The water collected from the study area is shown in Figure 1.

Laboratory Analysis

All groundwater samples were analyzed in the laboratory of the Department of Civil Engineering, EUB, to determine selected physicochemical water quality parameters, including turbidity, pH, DO, arsenic, TDS, TSS, and TS. The analysis was carried out using standard laboratory equipment such as filter paper, pH meter, turbidimeter, DO meter, arsenic testing jar, reagent strips, beakers, conical flasks, electrical balance, burette, burner, oven, and other necessary apparatus. All reagents used in the analysis were of analytical grade, and all solutions were prepared using distilled water to ensure accuracy and reliability of the results. The measured concentrations of the analyzed parameters were compared with the Canadian Council of Ministers of the Environment guidelines and the BDWS, 1997, to assess whether the groundwater quality exceeded the permissible limits.

RESULTS AND DISCUSSION

The results of the laboratory analysis of groundwater samples collected from Deuly village, Singair Upazila, Manikganj District, are presented and discussed in this section. The analyzed parameters include pH, turbidity, DO, arsenic, TDS, and TSS. These parameters were selected to evaluate the physicochemical quality of groundwater and to determine its suitability for drinking purposes. The obtained values were compared with the WHO guidelines and BDWS to identify whether the measured concentrations were within the permissible limits.

pH

Table 1 presents the pH values of 10 collected groundwater samples from the study area in Manikganj District, Bangladesh. The measured pH values ranged from 6.98 to 7.04, indicating that the groundwater samples were nearly neutral in nature. Among the samples, the lowest pH value was recorded in sample 2 (6.98), whereas the highest pH values were found in sample 8 and sample 9 (7.04). The average pH value of the samples was approximately 7.02, which suggests that the groundwater is neither strongly acidic nor alkaline. According to both WHO and BDWS, the acceptable pH range for drinking water is 6.5–8.5. Therefore, all analyzed groundwater samples were within the permissible standard limits, indicating that the groundwater quality of the study area is acceptable in terms of pH.

Figure 1: Collected water sample

Turbidity

Table 2 shows the turbidity concentrations of 10 groundwater samples collected from Manikganj District, Bangladesh. The turbidity values ranged from 1.14 NTU to 19.40 NTU, with an average value of approximately 8.01 NTU. The lowest turbidity was observed in Sample 2 (1.14 NTU), whereas the highest turbidity was recorded in sample 7 (19.40 NTU). According to the table, the permissible turbidity limit is 5 NTU according to WHO and 10 NTU according to BDWS. Among

Table 1: The value of pH of the collected water sample

Number	pH	Standard value according to WHO	Standard value according to BDWS
Sample 1	7.02	WH	
Sample 2	6.98		
Sample 3	7.02		
Sample 4	7.01		
Sample 5	7.03	6.5-8.5	6.5-8.5
Sample 6	7.01		
Sample 7	7.03		
Sample 8	7.04		
Sample 9	7.04		
Sample 10	7.01		

WHO: World Health Organization, BDWS: Bangladesh Drinking Water Standards

Table 2: The concentration of turbidity of the collected water samples

Number	Turbidity (NTU)	Standard value according to WHO	Standard value according to BDWS
Sample 1	11.9	5 NTU	10 NTU
Sample 2	1.14		
Sample 3	2.31		
Sample 4	11.17		
Sample 5	8.97		
Sample 6	7.61		
Sample 7	19.4		
Sample 8	5.63		
Sample 9	10.27		
Sample 10	1.71		

WHO: World Health Organization, BDWS: Bangladesh Drinking Water Standards

the ten samples, seven samples exceeded the WHO standard, whereas four samples exceeded the BDWS standard. Samples 1, 4, 7, and 9 were above the Bangladesh standard, indicating comparatively higher suspended particles or impurities in these groundwater sources. On the other hand, samples 2, 3, and 10 were within both the WHO and BDWS permissible limits. Therefore, the turbidity results suggest that although some groundwater samples are acceptable, several samples require proper filtration or treatment before being considered suitable for drinking purposes.

DO and Arsenic

Table 3 presents the DO and arsenic concentrations of ten groundwater samples collected from the study area in Manikganj District, Bangladesh. The DO values ranged from 4.3 mg/L to 19.4 mg/L, with an average concentration of approximately 10.32 mg/L. The lowest DO concentration was recorded in samples 6 and 9 (4.3 mg/L), whereas the highest value was observed in sample 7 (19.4 mg/L). According to the BDWS, the recommended DO value is 6 mg/L. Among the ten samples, seven samples were above the BDWS standard, indicating acceptable DO levels, whereas samples 1, 6, and 9 were below the standard limit. Lower DO values may indicate reduced oxygen availability and comparatively poorer water quality conditions in those samples.

The arsenic concentration in all collected groundwater samples was recorded as 0 mg/L, which is well below the BDWS permissible limit of 0.05 mg/L. This indicates that arsenic contamination was not detected in the analyzed samples. Therefore, based on arsenic concentration, the groundwater samples were found to be safe.

TDS and TSS

Table 4 presents the concentrations of TDS and TSS in ten groundwater samples collected from the study area in Manikganj District, Bangladesh. The TDS values ranged from 249 mg/L to 1293 mg/L, with the lowest value recorded in sample 10 (249 mg/L) and the highest value recorded in sample 6 (1293 mg/L). According to the BDWS, the permissible limit

Table 3: The concentration of dissolved oxygen and arsenic of the collected water sample

Number	Dissolved oxygen (mg/L)	Standard value according to BDWS	Arsenic (mg/L)	Standard value according to BDWS
Sample 1	5.6	6 mg/L	0	0.05 mg/L
Sample 2	15.2		0	
Sample 3	12.3		0	
Sample 4	6.4		0	
Sample 5	8.97		0	
Sample 6	4.3		0	
Sample 7	19.4		0	
Sample 8	14.4		0	
Sample 9	4.3		0	
Sample 10	12.4		0	

BDWS: Bangladesh Drinking Water Standards

Table 4: The concentration of TDS and TSS of the collected water sample

Number	TDS (mg/L)	Standard value according to BDWS	TSS (mg/L)	Standard value according to BDWS
Sample 1	573	1000 mg/L	4.5	10 mg/L
Sample 2	733		5.7	
Sample 3	429		4.2	
Sample 4	473		7.5	
Sample 5	948		3.9	
Sample 6	1293		9.9	
Sample 7	463		4.1	
Sample 8	649		7.4	
Sample 9	428		3.8	
Sample 10	249		42	

BDWS: Bangladesh Drinking Water Standards, TDS: Total dissolved solids, TSS: Total suspended solids

for TDS is 1000 mg/L. Among the ten samples, nine samples were within the acceptable limit, whereas sample 6 exceeded the BDWS standard, indicating a comparatively higher amount of dissolved solids in that water sample.

The TSS values ranged from 3.8 mg/L to 42 mg/L. The lowest TSS value was found in sample 9 (3.8 mg/L), whereas the highest value was observed in sample 10 (42 mg/L). The BDWS standard value for TSS is 10 mg/L. Most of the samples were within the permissible limit, but sample 10 exceeded the standard limit, suggesting the presence of a higher amount of suspended particles in that sample. Therefore, based on the TDS and TSS results, most groundwater samples were acceptable; however, sample 6 for TDS and sample 10 for TSS may require further monitoring or treatment before being considered fully suitable for drinking purposes.

CONCLUSION

The study evaluated the groundwater quality of 10 tube-well samples collected from Singair Upazila, Manikganj District, Bangladesh. The results showed that the pH values ranged from 6.98 to 7.04, with an average value of approximately 7.02, indicating that all samples were nearly neutral and within the WHO and BDWS permissible range of 6.5–8.5. Turbidity values ranged from 1.14 to 19.40 NTU, with an average of about 8.01 NTU. Among the samples, 70% exceeded the WHO limit of 5 NTU, whereas 40% exceeded the BDWS limit of 10 NTU, indicating turbidity as a major concern. DO concentrations ranged from 4.3 to 19.4 mg/L, with an average of about 10.32 mg/L; however, 30% of samples were below the BDWS recommended value of 6 mg/L. Arsenic was recorded as 0 mg/L in all samples, which was below the BDWS limit of 0.05 mg/L. TDS ranged from 249 to 1293 mg/L, with 90% of samples within the BDWS limit of 1000 mg/L. TSS ranged from 3.8 to 42 mg/L, and 90% of samples were within the standard limit of 10 mg/L. Overall, the groundwater quality was mostly acceptable, but elevated turbidity, low DO in some samples, and higher TDS/TSS in selected samples indicate the need for filtration, treatment, and regular monitoring.

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