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Assessment on the Effect of Rapid Urbanization on Groundwater Quality of Mirpur Area, Dhaka City, Bangladesh

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Abstract

Dhaka's population is increasing day by day as more people are migrating towards Dhaka city for improving their level of living and for availing the cities amenities. Hence, this is creating pressure on the overall water quality of Dhaka city. The work intended to assess the groundwater standard in Mirpur area of Dhaka City, Bangladesh by analyzing eight (08) different physicochemical water quality parameters. In December 2023, six (06) separate water samples were taken throughout the dry season from six (06) sites across the area. The results showed that all sites had pH levels between 7.18 to 7.50, which is within acceptable ranges for drinking water quality and indicates neutral to slightly alkaline conditions. Total dissolved solids (TDS) continued to be far below safety limits (210–250 ppm), indicating that the water's mineral content was quite low. Electrical conductivity (EC) measurements fell within acceptable ranges (290-350 µS/cm), indicating suitable groundwater quality. Dissolved oxygen (DO) levels varied (3.7-9.3 mg/L), with some sites exhibiting satisfactory oxygenation while others raised concerns about potential water quality issues. Total hardness (TH) levels (330-900 mg/L) exceeded recommended limits (200-500 mg/L) at all sites, suggesting potential issues with water quality. However, chemical oxygen demand (COD) levels were minimal or zero (0-3 mg/L), indicating minimal organic pollution. Iron concentrations were generally low (0-0.05 mg/L). Total chlorine (TC) concentrations varied (0-0.03 mg/L) across sites. In summary, the study emphasizes how crucial it is to continuously monitor and regulate the quality of groundwater in order to guarantee the sustainability and safety of water resources in the Mirpur region.

Keywords

Groundwater, Water quality, Mirpur area

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Introduction

Dhaka's population is increasing every day as more and more people move there from all across the country to use the city's amenities and raise their standard of living. Apart from the current population of about 17 million, a recent poll indicated that a minimum of 1,418 new inhabitants are relocating to Dhaka city every day. As groundwater is better than surface water, it is preferred by city dwellers. They are dependent on groundwater for their day-to-day purpose. Only 20% of Dhaka's daily water needs are satisfied by surface water from five treatment facilities. The Mirpur Zone, located northwest of Dhaka City, is home to 1.68 million people overall and is constantly expanding day by day. The demand for groundwater is rising due to growing population and urbanization, which ultimately affecting the water quality of groundwater. The total daily water supply available to the Mirpur zone is now only around 30 million liters, but demand is higher than that (Darling et al., 2002). Furthermore, pumps' capacity to collect water is declining even while the population of the capital is expanding and water consumption is rising by 5% annually. About 78% water are extracted from underground sources, with the remaining 22% generating from surface water. As to the findings of a report released by the Dhaka Water Supply and Sewerage Authority (DWASA), over 2.4 billion liters of water, or 78% of the city's supply, were drawn per day from 644 deep wells and it is transported by a 3750 km water pipe network (Khan et al., 2019; Mamoon et al., 2020). The metropolis of Dhaka, home to more than 18 million people, mainly depends on groundwater for its supply of clean water. Overpopulation and indiscriminate development have made Mirpur's water problem a serious issue in recent times. The water table is dropping dangerously as a result of extensive groundwater extracting. Excessive development influenced to encroach the huge water bodies (rivers, canals, lakes, etc.) all over the Dhaka city that forced people to prefer groundwater over surface water. Thus, from the standpoint of public health as well as improved water resource management, groundwater quality monitoring is an arduous necessity. The quality of Dhaka's ground water has previously been the subject of numerous studies (Moshfika et al., 2022). Given these conditions, the goal of this study was to ascertain the physicochemical characteristics of the groundwater quality in the Mirpur region.

Method and Materials

Study area

The study area, Mirpur is located northeast of Dhaka City in the latitudes of 23°46.0′-23°49.5′N and the longitudes of 90°21.3′-90°23.2′E. It has a total area of 88.38 km^2 (Figure 1). With a growing population, fast urbanization, and industrialization, this area serves as one of the primary residential and commercial districts of Dhaka city. The only area left with any vegetation is the National Botanical Garden of Bangladesh (Shetu et al., 2018).

Samples and sampling sites

Six (6) water samples were collected from six different locations in the Mirpur region (Sectors 1, 2, 6, 10, 11, and 12) and placed in 250 ml HDPE sample collecting bottles. The bottles were dried and thoroughly cleaned with a detergent solution before collecting the water samples. After that, deionized water was used to rinse them. Following sample collection, bottles were quickly sealed and prominently labeled with a unique identification number (Parveen et al., 2022; Pasha et al., 2023; Rezwan et al., 2022). Important information was recorded in a notebook, including the collection date, place, and time. The samples were taken at least two kilometers apart from each location, starting at the Dhaka WASA pump station. The process of testing, carried out under the direction of Daffodil International University's (DIU) Department of Environmental Science and Disaster Management (ESDM).

Sample analysis and instrumental techniques

The HANNA Multiparameter (HI9814) was used to detect pH and total dissolved solids (TDS). The DiST®4 EC Tester, the HANNA Pocket Conductivity Meter (HI98304), and the Lutron 5509 Dissolved Oxygen Meter were used to measure the electrical conductivity (EC) and dissolved oxygen (DO), respectively. Using a standard 0.01N EDTA solution and a titration technique, total hardness was evaluated. Water samples were digested in the HANNA COD Reactor (HI839800) to determine the chemical oxygen demand (COD). Finally, HANNA COD and Multiparameter Photometer (HI83099) was used to measure COD, total chlorine, and iron.

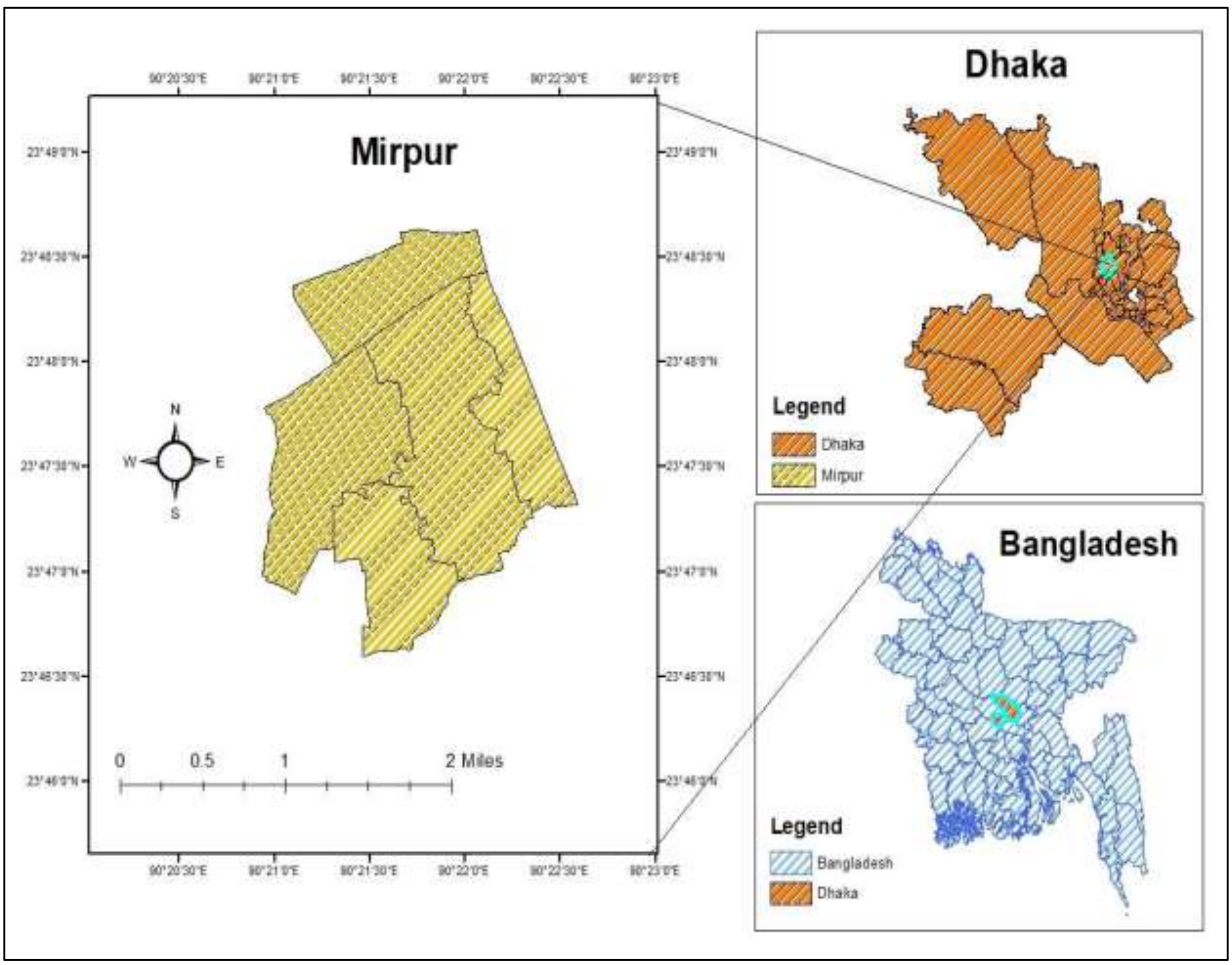


Figure 1. The study area, Mirpur, Dhaka, Bangladesh.

Statistical analysis

Every experimental outcome is displayed as the mean ± standard deviation (n = 3). At the 0.01 and 0.05 significant levels of evaluation, the mean difference was assessed. The water quality metrics were correlated using Pearson's correlation calculation. The data gathered was analyzed using Microsoft Excel 2016 and IBM SPSS (Version 23). The results of this investigation were presented using tabular representations and bar charts.

Results and Discussion

Figure 2 shows the current physio-chemical characteristics of the six water samples used in this investigation. pH is an important parameter among the others (Hasan et al., 2009). The samples' pH values fall between 7.18 to 7.5 (Table 1). The investigation found that the samples of Mirpur 6 (M 6) had the greatest pH value, while the samples of Mirpur 2 (M 2) had the lowest pH value (Figure 2 A), indicating that the samples' water quality is satisfactory. The pH standard range is 6.5–8.5. The number of solids present in a water sample is known as total dissolved solids, or TDS (Uddin et al., 2016). TDS concentrations in the region vary from 210 to 250 ppm (Table 1). The samples of Mirpur 10 and 11 (M 10 and M11) had the greatest TDS value, whereas the samples of Mirpur 1 and 2 (M 1 and M2) had the lowest TDS value, according to the study (Figure 2 B). TDS typically has a limit of 1000 ppm (WHO, 2008).

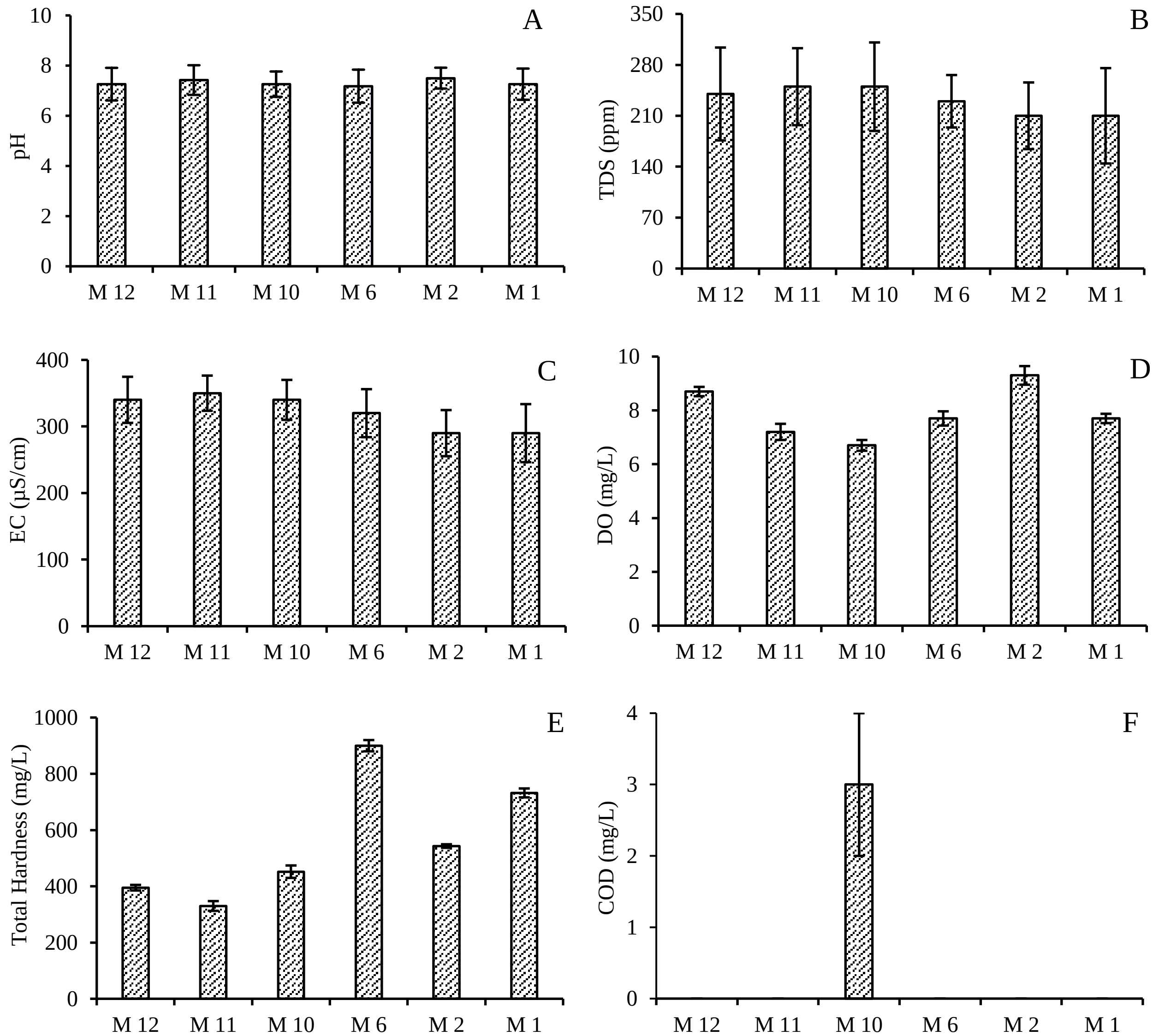
Table 1. Status and summary statistics of different water quality parameters.

Parameters	Mean	SD	Min.	Max.	Standards		
					DOE 1997	WHO 2008	ECR 1997
pH	7.3	0.1	7.18	7.5	6.5-8.5	6.5-8.5	6.5-8.5
TDS (ppm)	231.7	18.3	210	250	< 1000	< 1000	1000
EC (µS/cm)	321.7	26.4	290	350	< 3000	-	-
DO (mg/L)	7.9	1.0	6.7	9.3	> 6	-	> 6
TH (mg/L)	558.7	217.8	330	900	200-500	500	500
COD (mg/L)	0.5	1.2	0	3	4	-	10
Iron (mg/L)	0.0	0.0	0	0.05	0.3-1.0	0.3	0.3-1.0
TC (mg/L)	0.0	0.0	0	0.03	0.2	0.2	0.2

* SD = Standard Deviation

A crucial indicator of water quality is electrical conductivity (EC), which shows how well water can conduct electricity (Parveen et al., 2022; Pasha et al., 2023). The current EC status in the range of 290–350 µS/cm (Table 1). The samples of Mirpur 11 (M 11) had the highest EC value, whereas the samples of Mirpur 1 and 2 (M 1 and M 2) had the lowest EC value, according to the study (Figure 2 C). There was no EC concentration in the area that was higher than what was allowed. Dissolved oxygen (DO) is a critical measure that indicates the proper water quality (Pasha et al., 2022; Rezwan et al., 2022). The range of DO concentrations in the water samples is 6.7-9.3 mg/L. The samples of Mirpur 2 (M 2) had the highest DO in the current investigation, while the samples of Mirpur 10 (M 10) had the lowest (Figure 2 D). A healthy aquatic ecosystem requires a DO value of 5 mg/L, under the Environmental Conservation Rules (Uddin et al., 2016). The presence of minerals (calcium and magnesium) in the water is what causes it to be hard. Significant amounts of dissolved minerals are present in hard water, whereas less minerals are dissolved in soft water. Total hardness (TH) values in the region range from 348 to 452 mg/L (Table 1). The samples of Mirpur 6 (M 6) had the highest overall hardness, whereas the samples of Mirpur 11 (M 11) had the lowest (Figure 2 E). Total hardness concentrations are typically 200–500 mg/L (WHO, 2008). Figure 2(F) indicates that just one sample, Mirpur 10 (M 10), had the chemical oxygen demand (COD) in that region. The region's iron concentration falls between 0 and 0.05 mg/L

(Table 1). Only the samples of Mirpur 6 and 10 (M 6 and M 10) contained iron. As shown in Figure 2 G, the values were 0.05 for M 6 and 0.04 for M 10. Total chlorine (TC) concentrations in the region vary from 0.0 to 0.03 mg/L (Table 1), with a benchmark value of 0.2 mg/L (DOE 1997, ECR 1997, WHO 2008). The samples of Mirpur 1, 2, and 10 (M 1, M 2, and M 10) had the highest total chlorine (TC), whereas the samples of Mirpur 12 (M 12) had the lowest (Figure 2 H).



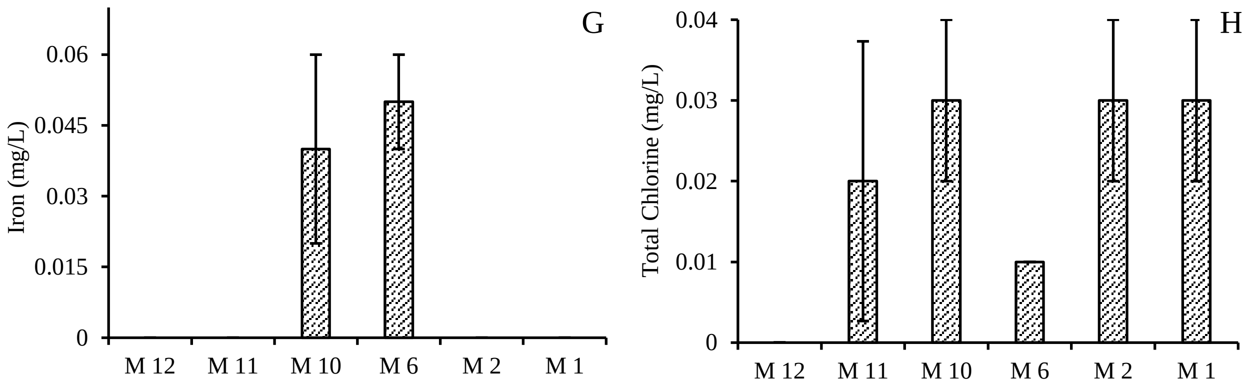


Figure 2. Status of water quality parameters in Mirpur area, (A) pH; (B) Total dissolved solids (TDS); (C) Electrical conductivity (EC); (D) Dissolved oxygen (DO); (E) Total hardness (TH); (F) Chemical oxygen demand (COD); (G) Iron; (H) Total chlorine (TC).

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Table 2. Cross-correlation matrix between the water quality parameters.

Parameters	**pH**	**TDS**	**EC**	**DO**	**TH**	**COD**	**Iron**	**TC**
pH	1.00							
TDS	-0.19	1.00						
EC	-0.18	0.98	1.00					
DO	0.42	-0.61	-0.51	1.00				
TH	-0.52	-0.58	-0.59	0.03	1.00			

COD	-0.22	0.49	0.34	-0.60	-0.24	1.00		
Iron	-0.62	0.30	0.21	-0.50	0.50	0.52	1.00	
TC	0.42	-0.34	-0.48	-0.23	0.03	0.39	-0.07	1.00

The correlation between the water quality metrics in Table 2 is displayed via the correlation matrix. The link between DO and COD shows that when COD decreases, DO's value increases. As seen in Figure 3 A, the association is negative, with r = -0.604 indicating a moderately unfavorable relationship. The sample waters' relationship between DO and TDS showed that DO values increased as TDS values decreased. Additionally, the association is negative, with a moderately negative relationship of r = -0.611 (Figure 3 B). According to the link between EC and TDS, EC value increases as TDS increases. With r = 0.984 (strong positive association), it is a positive relationship (Figure 3 C). The link between the pH and iron levels in the sample waters showed that as pH increased, iron levels decreased. Additionally, the association is negative, with a moderately negative relationship of r = -0.624 (Figure 3 D).

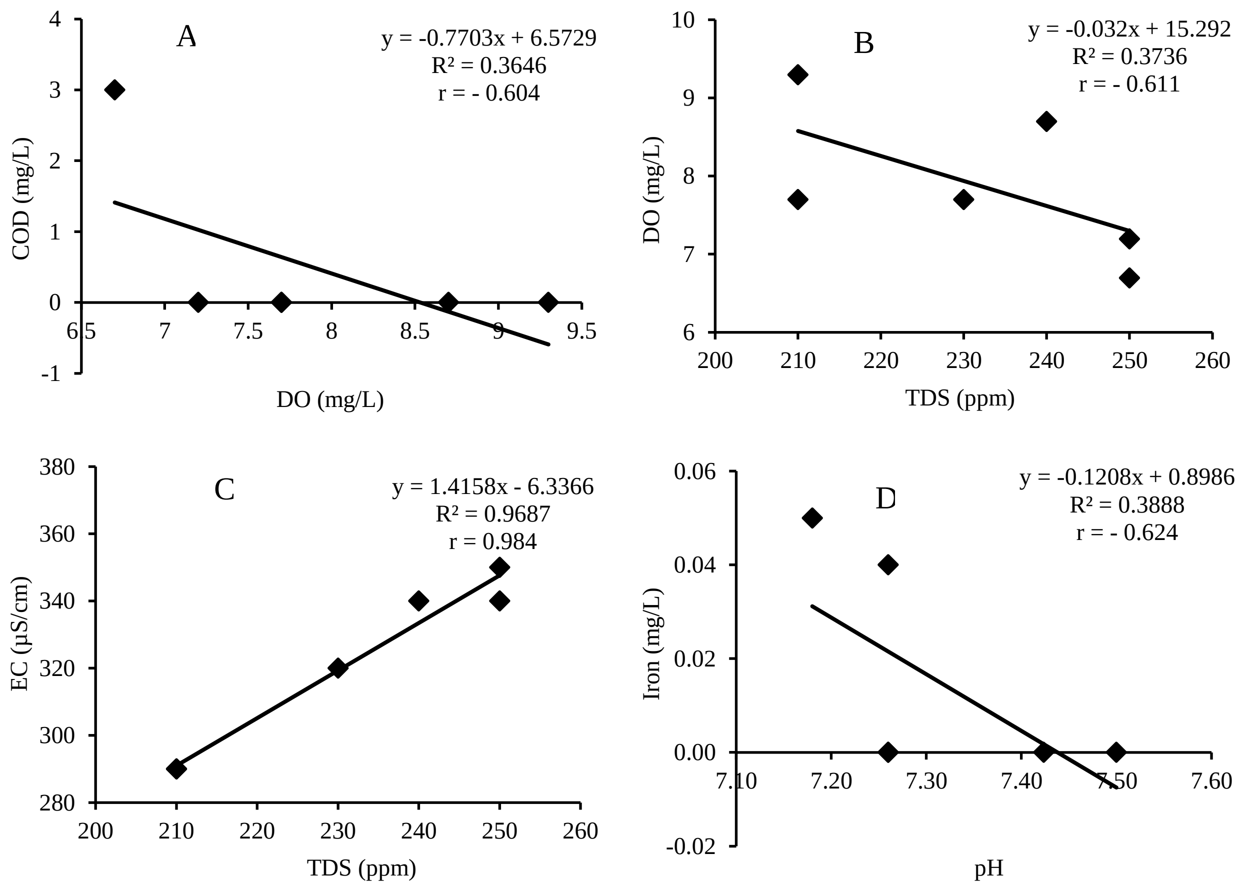

Figure 3. Correlation between, (A) DO v. COD; (B) DO v. TDS; (C) EC v. TDS; (D) Iron v. pH.

Groundwater quality in the Mirpur region of Bangladesh was investigated, and the results showed generally good conditions across important physicochemical criteria. The pH range of the water, which was well within permissible bounds for drinking, was neutral to slightly alkaline. While dissolved oxygen (DO) levels were adequate to exceptional, Mirpur 10 indicated lower levels that needed care, total dissolved solids (TDS) remained below recommended criteria, indicating minor contamination. Measurements of electrical conductivity (EC) likewise fell within acceptable bounds. However, at Mirpur 6 and Mirpur 1, Total Hardness was higher than the legal limit of 500 mg/L, indicating possible problems with the quality of the water that need to be looked into further. Low levels of COD suggest low amounts of organic pollution. Mirpur 10 and Mirpur 6 both had elevated iron contents; the former was found to be higher above the national average.

Conclusion

While the investigation into groundwater quality in the Mirpur area of Bangladesh revealed generally favorable conditions across various physicochemical parameters, the broader context of Dhaka's heavy reliance on groundwater presents significant challenges. In terms of the surrounding environment, the Mirpur area's determined water quality metrics (pH, TDS, EC, DO, TH, COD, Iron, TC) are in quite decent shape. The whole Dhaka, including Mirpur, heavily dependent on the groundwater for nearly 70% of its water supply. So, the DWASA should be careful and responsible enough to maintain that status of the water quality as a huge population lives there and all in all dependent on that water source.

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