






## Assessment of Drinking Water Quality: A Case Study in Dinajpur District, Bangladesh

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### Keywords

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Water quality,  
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Physicochemical parameter and  
bacteriological parameter.

### Abstract

Safe drinking water is essential for good health. But overgrowing population, geological formation, climatic change, soil erosion, pesticide & fertilizer application, and urbanization are responsible for the pollution of water and variation of the quality parameters of water. This study deals with the suitability of groundwater quality in four upazilas in the Dinajpur district, Bangladesh. In Dinajpur the major source of drinking water is provided by hand-pumping shallow tube wells. 32 water samples from those upazilas were collected (eight from each upazila) for laboratory testing. The important physicochemical parameters, such as temperature, pH, electrical conductivity, total dissolved solids, calcium, magnesium, hardness, bicarbonate, alkalinity, nitrate, and bacteriological parameters, such as total bacteria count, fecal coliform, and Escherichia coli were assessed. Then the testing data were in comparison with the World Health Organization (WHO) & Bangladesh Standards (BDS). The comparison showed that the water was suitable for daily use for the people according to standards. Physicochemical parameters were within the standard level except pH which was low in Dinajpur Sadar, hardness exceeded the limit according to WHO in Biral and Dinajpur sadar upazilas. In Biral, the concentration of magnesium exceeded the standard limits, and nitrate values were exceeded in all upazilas according to BDS. All the samples are free from microbial contamination. In addition, continuous monitoring of the chemical parameters of water is needed for its use in Dinajpur district, Bangladesh.

### 1. Introduction

Water is one of the important substances for human beings, without which life cannot be sustained for a longer period [1]. All living beings depend heavily on water to survive. The Earth's surface is covered by greater than 70% of its area with water. But only 2% of the water on earth is fresh that we can drink, and 98% is salt water. Groundwater is the main source of drinking water for the majority of the world's population [2-4]. Given its direct connection to public health, good-quality drinking water is a crucial concern for humanity and plays a vital role in human health and development [5-7]. Depending on body size, the human body contains somewhere between 55% and 78% water. The body needs eight glasses of water every day to function effectively. The quality of drinking water has long been a significant problem in many nations, especially developing countries like Bangladesh. Around a third of the world's population uses groundwater for various purposes, whether or not it has been treated. The majority of the people in Bangladesh believe that groundwater and water from tube wells are free from contamination. The primary source of pure drinking water in Bangladesh is hence hand-pump tube well water [8]. In developing countries, many people have insufficient pure drinking water and other problems such as inadequate facilities for sanitation and landfills near the water bodies [9, 10]. According to the United Nations, about 2.5 billion people in low- and middle-income countries do not have proper improved sanitation and quality drinking water, above 884 million [11]. Therefore, people are suffering from water-related diseases, around 2.3 billion overall in the world [12]. Waterborne disease may cause serious health hazards due to the absorption of pathogenic microorganisms in drinking water [13, 14]. Human health and environmental protection measures directly depended on the quality of drinking water [15].

Numerous physicochemical factors interact intricately to affect water quality, which is crucial for both human and environmental health. Both natural processes like erosion of soil, geology, and weather variation and anthropogenic activities like development of urban areas, agriculture, and operation of industrial work influence these variables [16-20]. Water may appear clean, yet it may contain invisible contaminants. Aquatic ecosystems are exposed to contaminants such as heavy metals, phosphates, fluoride, nitrites, nitrates, and micro plastics from smelting, mining, agricultural runoff, and insufficient treatment of wastewater [21-29]. Numerous health problems, from renal complications and hepatic diseases to certain carcinomas and neurological illnesses, have been connected to heavy metals like cadmium, nickel, arsenic, lead, and copper. Nonetheless, certain metals, like copper, are necessary trace elements whose toxicity varies depending on exposure duration and quantities [30, 31].

Bangladesh, a country largely dependent on surface water and groundwater sources, faces significant challenges regarding water quality. The groundwater aquifer is contaminated by mixing higher amounts of arsenic and iron, bicarbonate content, and Total Dissolved Solids (TDS) [32]. A study included a total of twelve water samples collected from three different locations on the NSTU campus, Noakhali, for physical, chemical, and bacteriological parameter tests, and all the tested parameters were compared with national and international drinking water quality standards. It investigated that the water samples in almost all the locations were contaminated by microbial contamination, and the physical

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and chemical parameters also exceeded the permissible limit, which is not suitable for drinking purposes without any prior treatment [2]. The concentrations of most of the investigated parameters in the drinking water samples from the Rajshahi region were within the permissible limits of the World Health Organization and Bangladesh Standard Drinking Water Quality Guidelines. But in selected areas, the manganese level was above the standard level, which was unfit for drinking purposes without treatment [33]. The same research was carried out in the assessment of drinking water quality parameters at Sylhet Agricultural University campus and Kushtia district to analyze drinking water quality parameters. The results showed that the qualities of water were good in both places, but fecal and total coliform were found in some tube-well water from the Kushtia district [34, 35].

Bangladesh's environmental situation is not balanced. In some places, it is different. Generally, the quality of groundwater varies from location to location, sometimes based on seasonal variations in the types of soils, rocks, and surfaces through which it moves. An examination of the Dinajpur district's drinking water quality was the main emphasis of this study. Therefore, the study's objective was to determine the groundwater quality status of different biological, physical, and chemical parameters in the Dinajpur district of Bangladesh to assess whether it is suitable for drinking or not by Bangladeshi standards and World Health Organization (WHO) guidelines.

## 2. Materials and Methods

### 2.1. Study Area

Dinajpur District is located in between 88°23' and 89°18' east longitudes and in between 25°10' and 26°04' north latitudes, and it is situated at an elevation of 40 m from sea level. It covers an area of 3444.30 square km. The population density is 868/km<sup>2</sup>. The total population in this area was 2,990,128 according to the 2011 census. Dhepa, Punarbhaba, and Atrai are the main rivers of the district [36]. The study was conducted in the four upazilas of Dinajpur District. There are 13 upazilas in this district. Among these upazilas, the study was conducted in Dinajpur Sadar, Kaharole, Biral, and Birganj of Dinajpur District, which are marked by the red circle in Figure 1. The study locations' features are shown in Table 1.



Figure 1. Locations of sample collection

Table 1. Features of the Study Locations [36]

Upazila	Location	Total Area	Population Density
Dinajpur Sadar	Between 88°34' and 88°46' east longitudes and between 25°28' and 25°48' north latitudes	354.73 km <sup>2</sup>	1366/km <sup>2</sup>
Biral	Between 88°26' and 88°38' east longitudes and between 25°31' and 25°46' north latitudes	353.98 km <sup>2</sup>	729/km <sup>2</sup>
Birganj	Between 88°29' and 88°44' east longitudes and between 25°48' and 26°04' north latitudes and	413.11 km <sup>2</sup>	768/km <sup>2</sup>
Kaharole	Between 88°30' and 89°43' east longitudes and between 25°44' and 25°53' north latitudes	205.53 km <sup>2</sup>	751/km <sup>2</sup>

There were 32 groundwater samples (random sample collection frequency to cover whole areas was eight at each Upazila) collected in plastic bottles that were dry & clean from continuously used shallow hand-pumped tube wells which were around 20 to 40 m deep during June-July 2025. In the surrounding north-west region, screen able aquifers are often found between 15 and 24 meters and 33 and 46 meters in certain zones. These tube wells were around 8-12 m away from the latrines, and most of them were near the irrigation fields. The wells were selected randomly at eight parts of each upazila at the village level. Tube wells were pumped for two or three minutes to gain fresh water before collecting samples. The mouth of the tube well was sterilized by heating it with a blow lamp or a gas torch or by igniting a piece of cotton wool soaked with methylated spirits until any water in the tube well was gone. The bottles were also rinsed thoroughly with distilled water two or three times to make the bottles free from any contamination and impurities. To avoid bacteriological contamination, the bottles were sealed with airtight tapes. After collecting the sample, the bottles were well packed, and the time, date, and location were written with a permanent marker. The samples were brought into the laboratory for conducting tests within 4-5 hours after collection. The samples were stored at a 0-4°C temperature before testing.

### 2.3. Laboratory Testing

The sample study was carried out according to the American Public Health Association's (APHA) [38] and Bangladesh Environment Conservation Rules, 1997 (BECR) generally agreed-upon basic protocols for drinking water assessment, including specific quality control and quality assurance. Physical parameters were tested in the Biotechnology and Molecular Biology Laboratory of the Department of Bio-Chemistry at Hajee Mohammad Danesh Science & Technology University, Dinajpur. The chemical parameters were also measured in this laboratory. The bacteriological parameters such as total bacteria count, fecal coliform, and *Escherichia coli* were tested in the microbiology laboratory of the Department of Microbiology at Hajee Mohammad Danesh Science & Technology University, Dinajpur. Temperature were measured using thermometer, pH, electrical conductivity, TDS were measured using multi-parameter analyzer, chemical parameter were determined using titration and bacteriological parameter using membrane filter method. For total bacteria count, the samples were taken in petri dishes with plate count agar added to them. The biosafety cabinet was switched on to maintain a suitable temperature of 35-37°C for bacterial incubation for 24 hours. After 24 hours the sample was taken out from the incubator, and the total bacteria were counted. For fecal coliform, at first the petri dish was opened, and a pad was placed in it. Culture medium of m-FC agar was added to saturate the pad. Then the test samples passed the membrane filter with the help of a vacuum. The filtration took the unit apart and used the forceps, placing the membrane filter in the Petri dish on the pad with the grid side up. It was ensured that no air bubbles were trapped between the pad and the filter. Then the petri dish was inverted for incubation. At last incubated at 44.5°C for 24 hours with 100% humidity. After 24 hours the colonies of the fecal coliform were observed. At last, for *Escherichia coli*, samples were passed through a filter, placed on selective growth media like eosin methylene blue (EMB), and incubated for 24 hours at a temperature of 35-37°C. After 24 hours the sample was taken out from the incubator, and the *Escherichia coli* was observed.

### 3. Results and Discussion

In this experimental analysis, the quality of drinking water of four Upazilas of Dinajpur district was contrasted with Bangladesh Standards and World Health Organization (WHO) guidelines in the experimental study which are tabulated as follows in Table 2. The values of mean and standard deviation were given in Table 3.

Table 2. Drinking water quality standards [37-41]

S. N.	Parameters	Bangladesh Standards	WHO	Determination Methods/Apparatus
1	Temperature	20-30°C		Thermometer
2	pH	6.5-8.5	6.5-8.5	Multi-parameter analyzer (DZB-718)
3	Electrical Conductivity	600-1200 $\mu$ S/cm	1200 $\mu$ S/cm	Multi-parameter analyzer (DZB-718)
4	Hardness	200-500 mg/L	200 mg/L	Titrimetric Analysis
5	Alkalinity	20-200 mg/L	80-120 mg/L	Titrimetric Analysis
6	Total Dissolved Solid	1000 mg/L	1000 mg/L	Multimeter
7	Calcium	75 mg/L		Titrimetric Analysis
8	Magnesium	30-35 mg/L		Titrimetric Analysis
9	Chloride	150-600 mg/L	250 mg/L	Titrimetric Analysis
10	Nitrates	10 mg/L	50 as N	Titrimetric Analysis
11	Bicarbonates	10 meq/L	1.5-7.5 meq/L	Titrimetric Analysis
12	<i>Escherichia coli</i>	0/100 ml	0/100 ml	Membrane Filter
13	Total Bacteria Count	30-300	30-300	Membrane Filter
14	Fecal Coliform	no	no	Membrane Filter

Table 3. Means and Standard deviations of all parameters at study locations

Parameter Name	Dinajpur Sadar		Biral		Birgonj		Kaharole	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Temperature	21.28	0.09	21.39	0.15	21.30	0.29	21.36	0.21
pH	6.41	0.12	6.60	0.12	6.64	0.25	6.52	0.19
Electrical Conductivity	404.00	120.41	487.25	184.55	338.25	82.42	302.38	93.53
TDS	206.00	94.22	192.50	116.86	123.63	51.49	128.75	33.03
Calcium	31.99	20.63	41.34	15.29	35.59	14.81	30.48	17.03
Magnesium	21.27	12.64	30.58	19.29	22.24	9.08	16.93	5.07
Bicarbonate	2.58	1.38	3.03	1.03	2.04	0.61	2.22	0.73
Hardness	209.61	131.75	278.15	95.64	158.18	74.62	107.37	32.48
Chloride	70.32	24.95	74.73	22.81	53.77	7.30	52.47	6.44
Nitrate	15.91	4.60	13.03	5.28	12.58	5.42	11.76	3.61
Alkalinity	2.58	1.38	2.99	1.05	2.04	0.61	2.18	0.73
TBC	281.25	9.33	125.00	57.69	71.25	22.87	61.25	19.51

### 3.1. Physiochemical Parameter

#### 3.1.1. Temperature

Temperature is the most significant factor that influences the chemical, physical, and biological characteristics of water. The standard range of temperature lies between 20 and 30°C, according to the Bangladesh Standards. The temperature range of all the four upazilas water samples was found to be between 21 and 22 °C shown in Figure 2, which was within the standard limit.

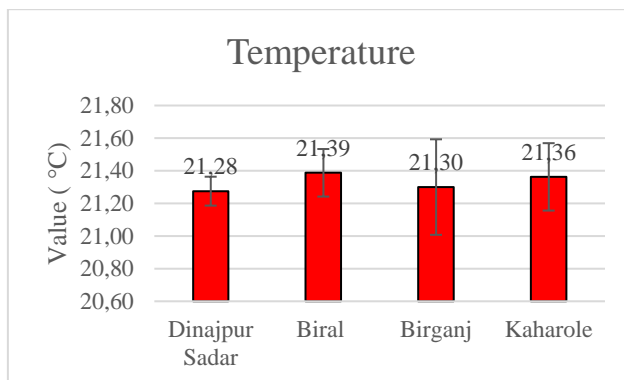


Figure 2. Variation of temperature values at study locations.

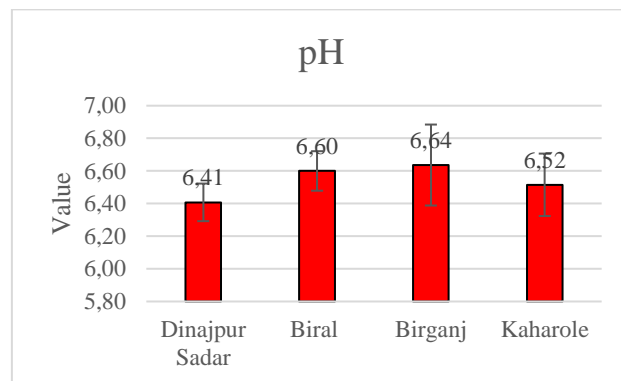


Figure 3. Variation of pH values at study locations

**3.1.2. pH**

The safe drinking water pH range is 6.5 to 8.5 according to the Bangladesh Standards and WHO. All tested water samples pH were found in between the range shown in Figure 3 but, Dinajpur sadar upazila value was lower than the standard. The water in this location was found acidic in nature; hence, proper treatment is necessary. The pH values of all upazilas were around 6.5.

**3.1.3. Electrical Conductivity (EC)**

Electrical conductivity amounts are generally used to see the concentration of salts in water. The groundwater environment, source, and movement are affected by the concentration of salts. According to Bangladesh standards, the standard value of EC lies within 600-1200  $\mu\text{S}/\text{cm}$  and 1200  $\mu\text{S}/\text{cm}$  according to WHO. The range of EC was found in all upazillas were below 600  $\mu\text{S}/\text{cm}$  shown in Figure 4, indicating the groundwater contains less than the permissible limit. The EC in Biral upazila water was higher than others. Kaharol & Birganj water had low EC, among others.

**3.1.4. Total Dissolved Solid**

Total Dissolved Solid (TDS) is one of the essential chemical water quality parameters. The presence of different kinds of minerals such as nitrate, ammonia, phosphate, sulfates, alkalies, certain acids, etc., which are comprised of both colloidal and dissolved solids in water, is indicated as TDS. The standard range of TDS is <1000 mg/l according to the WHO and Bangladesh standards. According to Figure 5, All the testing samples in all locations were within the safe limit and suitable for drinking purposes. Number of solids were higher in Dinajpur Sadar and Biral upazilas.

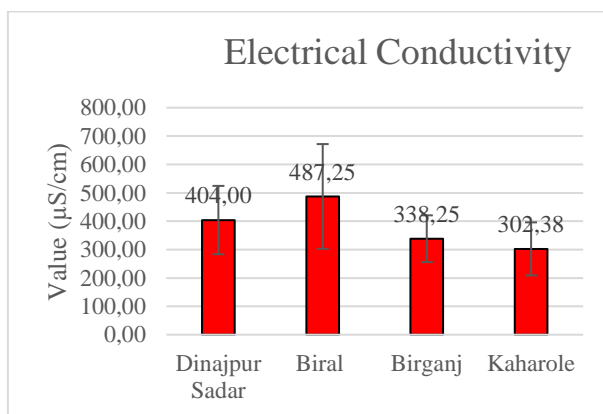


Figure 4. Variation of electrical conductivity values at study locations

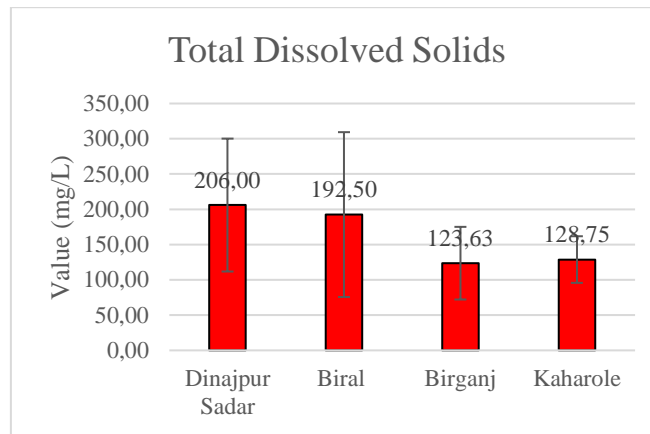


Figure 5. Variation of Total Dissolved Solid values at study locations

**3.1.5. Calcium**

The calcium in the safe drinking water range is 75 mg/l according to Bangladesh Standards. The calcium values were found below the range in all locations shown in Figure 6. Highest mean value was found in Biral and lowest in Kaharol.

**3.1.6. Magnesium**

The Magnesium in the safe drinking water range is 30-35 mg/l according to the Bangladesh Standards. According to Figure 7, the magnesium value was found below the standard limit in Dinajpur Sadar, Birganj and Kaharol, but in Biral upazila, it was found within the standard limit. The maximum value 30.58 mg/L was found in Biral upazila. A lower concentration 16.93 mg/L was found in Kaharole.

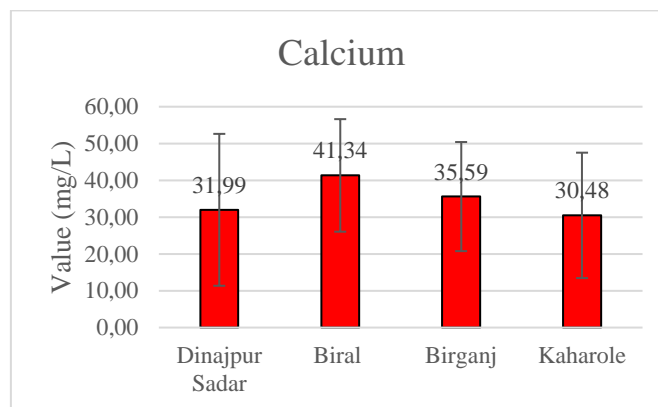


Figure 6. Variation of calcium values at study locations

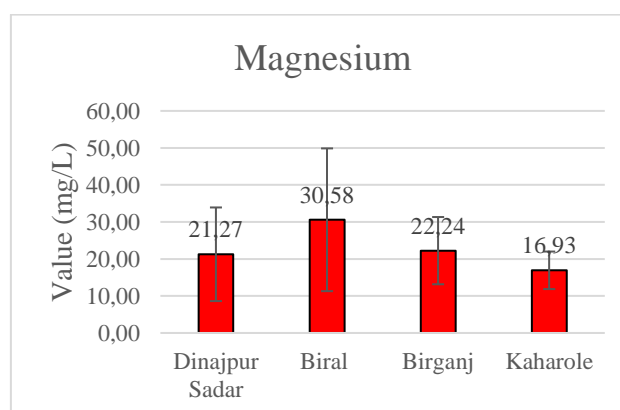


Figure 7. Variation of magnesium values at study locations

**3.1.7. Hardness**

The amount of calcium and magnesium ions dissolved in water is called "hardness". The hardness in the safe drinking water range is 200-500 mg/L according to the Bangladesh Standards and 200 mg/L according to the WHO. All upazillas value shown in Figure 8 were within the limit of Bangladesh Standards but in Biral and Dinajpur Sadar the value exceeded the limit according to WHO. The lower amount of hardness was 107.37 mg/L, found in Kaharole upazila.

**3.1.8. Bicarbonate**

According to Bangladesh standards the acceptable value of bicarbonate in the safe drinking water is 10 meq/L and the WHO is 1.5-7.5 meq/L. The bicarbonate range was within the range shown in Figure 9 of all the study locations. Concentrations of bicarbonate in all upazilas were within the range of 2-3 meq/L.

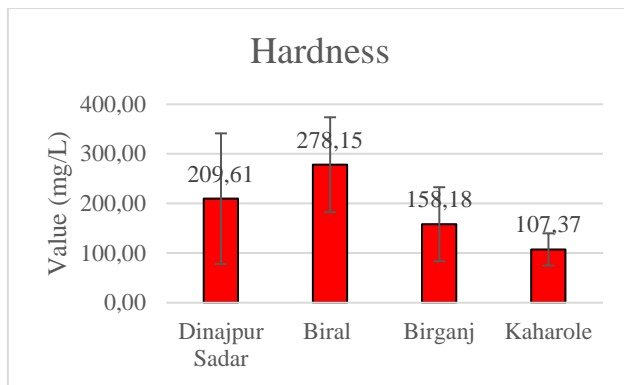


Figure 8. Variation of hardness values at study locations

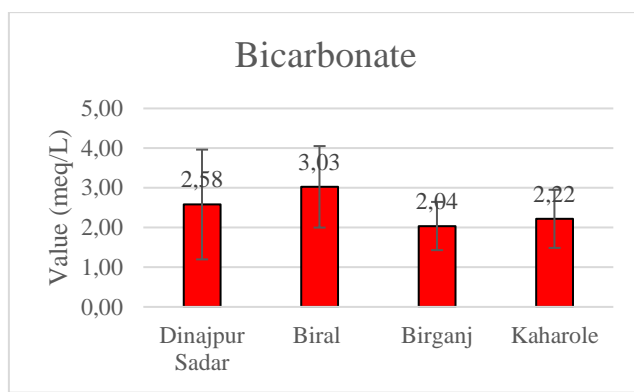


Figure 9. Variation of Bicarbonate values at study locations

**3.1.9. Chloride**

The test results of chloride for study locations were found to be very low in all Upazilas. The chloride in safe drinking water is an allowable limit of 250 mg/l according to WHO guidelines and 150-250 mg/l according to Bangladesh standards. The lower value of chloride indicates in Figure 10 that there were no salty tastes in the four Upazilas water. Dinajpur Sadar & Biral had slightly greater values of chloride in water than Birganj & Kaharole.

**3.1.10. Alkalinity**

According to Bangladesh standards the acceptable value of alkalinity is 20-200 mg/L and the WHO 80-120 mg/L for drinking water. The alkalinity value was found in the range of 2-3 mg/L shown in Figure 11, out of which all water samples were below the standard limit. Alkalinity values of all upazilas were around 2-3 mg/L. Among them, Biral had a higher value of 2.99 mg/L.

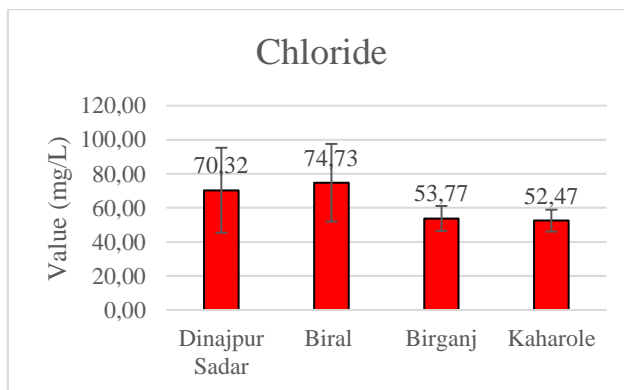


Figure 10. Variation of chloride values at study locations

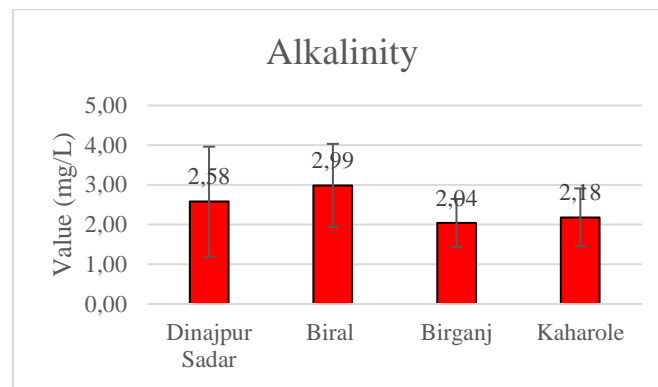


Figure 11. Variation of alkalinity values at study locations

### 3.1.11. Nitrate

According to Bangladesh standards and WHO, the acceptable value of nitrate is less than 10 mg/L and 50 mg/L respectively for drinking water. The value of nitrate in all locations within the standard limit shown in Figure 12 according to the WHO and higher than the standards according to BDS. The concentration of nitrate, 15.91 mg/L was higher among all upazilas.

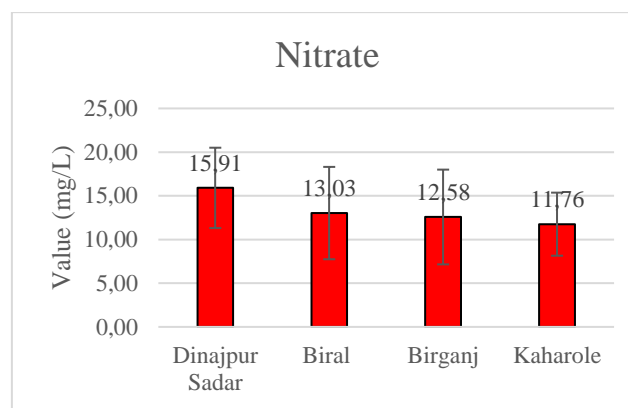


Figure 12. Variation of nitrate values at study locations

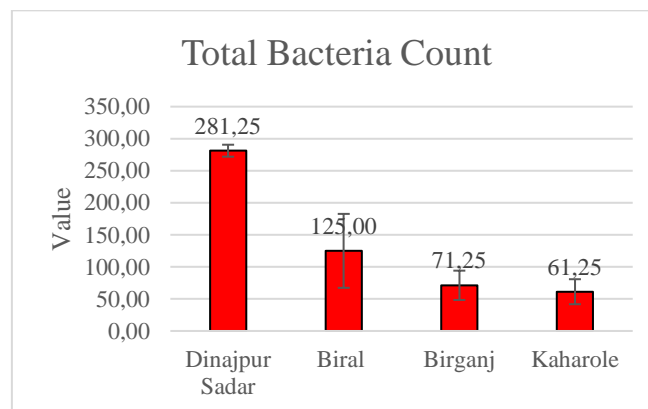


Figure 13. Variation of total bacteria count values at study locations

## 3.2. Bacteriological Parameter

### 3.2.1. Total Bacteria Count

According to the WHO guideline, the value of the total bacteria count should remain within 30-300 cfu/ml. The total bacteria count for four upazilas was found within the standard limit shown in Figure 13, which was safe for drinking purposes. There were no pathogenic organisms in all water samples. Therefore, the water quality was free from contamination and had no adverse effects on health. The concentration of bacteria was higher in Dinajpur Sadar than other upazilas and lower in Kaharol.

### 3.2.2. Fecal Coliform

There was an absence of fecal coliform in all water samples of four upazilas in the Dinajpur district. In these regions, all water samples were free from pathogenic organisms, which is suitable for drinking purposes. Fecal coliform presence in water is unusual, and its use could bring serious health risks to people.

### 3.2.3. Escherichia coli

There was an absence of Escherichia coli in all water samples of four upazilas. The samples are free from Escherichia coli organisms. The water is suitable for drinking purposes.

## 4. Conclusions

The study was an overall representation of the four upazilas in the Dinajpur district's groundwater quality that explored to explain whether the water was fit for drinking or not. After analyzing and comparing the test results, it was assessed that most of the water quality parameters (physical, chemical, and bacteriological) satisfied conditions from different locations in the Dinajpur district compared with both World Health Organization (WHO) and Bangladesh standards (BDS). In general, the study result indicated that almost all the water samples were safe for drinking and domestic purposes posed no adverse health risks to the public without prior treatment of water based on the collected samples. However, the physical parameter pH of Dinajpur Sadar upazila were below the lower limit that the water in these areas were acidic in nature. Electrical conductivity values were also low, which indicates a lower concentration of salts in the water. Chemical parameters of calcium, magnesium was found to be lower in Dinajpur Sadar and Kaharol upazila than in others. In Biral, the concentration of magnesium exceeded the standard limits. Hardness values exceeded the limit according to WHO in Biral and Dinajpur Sadar, Alkalinity was very low in all upazilas, and nitrate values were exceeded in all upazilas according to BDS. Therefore, this location has need of awareness. Bacteriological parameters were within the limit according to the drinking quality standards by both the World Health Organization (WHO) and Bangladesh standards (BDS). No Fecal coliforms and Escherichia coli were found in drinking water tested in the laboratory. For a more extensive study, more samples can be collected from groundwater in each upazila, and continuous monitoring is required to know the overall groundwater quality parameters of the greater Dinajpur district, Bangladesh. Also, the samples were collected during the monsoon period, June-July; for seasonal fluctuations, some results might be interpreted. So, samples should be tested in another period to check the result.

## Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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