Effect of Seasonal Changes on Physicochemical Properties and Pollution Levels of the Dakatia River in Chandpur, Bangladesh

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Abstract

An essential body of water close to Chandpur, Bangladesh, the Dakatia River plays an essential role to the local ecosystem and socioeconomic life. Seasonal fluctuations are important water quality indicators, such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), and hardness, which are examined in this study. In accordance with the Environmental Conservation Rules (ECR, 2023), water samples were taken during the four seasons of winter, summer, rainy season, and pre-winter. Significant seasonal changes are indicated by the results. Winter water temperatures were 21.6°C, while rainy season temperatures were 28.7°C, all falling within the acceptable range of 20–30°C. During the wet season, the pH stayed within the permissible range of 6.5 to 8.5, ranging from 7.3 in the pre-winter to 8.2. The needed criterion (≥5 mg/L) was met by DO levels, which were highest in the summer (8.9 mg/L) and lowest in the pre-winter (5.9 mg/L). Moderate seasonal changes were observed in the EC and TDS readings, which remained well within acceptable bounds. BOD and COD readings remained below the statutory threshold, indicating mild organic contamination. Summer had the maximum hardness (67.6 mg/L), and pre-winter had the lowest (49.8 mg/L), indicating seasonal variations in mineral concentration. The Dakatia River's water quality is generally within safe limits; however, seasonal fluctuations show the impact of hydrological changes. To avoid possible deterioration and guarantee sustainable water quality for nearby communities and aquatic life, ongoing monitoring and management techniques are required.

Keywords: Dakatia River, Water Quality, Water Pollution, Seasonal Fluctuations, Environmental Monitoring

INTRODUCTION

Surface water is regarded as a vital natural resource for human existence and development-related

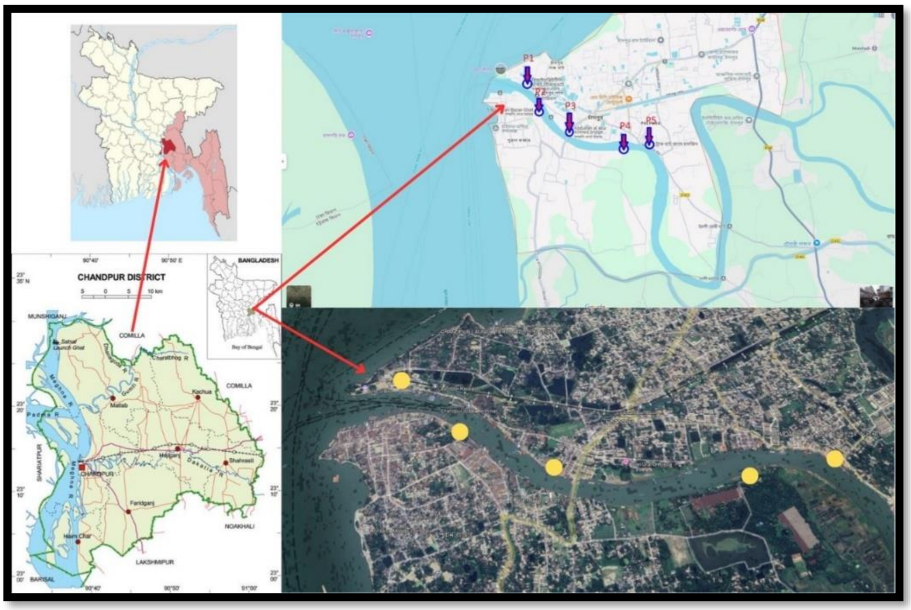
endeavors. Due to significant changes in the hydrological cycle brought about by climate change and human activity, water quality degradation has emerged as a critical global concern for humankind's sustainable development
[1,2]. Bangladesh relies on its river system, either directly or indirectly, for a number of uses, including forestry, drainage, sanitation, fisheries, agriculture, navigation, and salinity regulation[3].In several Study's, the diverse nature of pollution makes it a significant and complex issue in Bangladesh[4,5]. Surface water's physical, chemical, and biological makeup is influenced by a variety of natural (precipitation, watershed geology, climate, and geography) and man-made (domestic, industrial, and agricultural runoff) influences. Increasing surface water pollution endangers aquatic ecological balance, human health, social prosperity, and economic growth in addition to degrading water quality[6–8].Sometimes, seasonal or yearly fluctuations in freshwater availability can lead to deterioration in water quality[9]. Mixed industrialization is causing a constant deterioration in the quality of the water. A number of characteristics pertaining to the river's water quality have been examined by different researchers[10–14]. One of the top priorities in environmental protection policy is the monitoring of water quality[15]. Bangladesh's surface water is vulnerable to contamination by runoff from the chemical industry and agricultural areas, raw industrial and municipal effluent, and oil and lubricant spills from sea and river port operations[16,17].
Bangladesh is a river-rich country. There are over 230 rivers in Bangladesh[18]. India and Bangladesh share a river called the Dakatia. It is roughly 207 kilometers (129 miles) long. It travels from Tripura to Bangladesh. At Chandpur Boro Station molehead, it merges with the Meghna River after returning to India from Comilla District. There is industrial pollution in this river. The locals use this as a source of drinking water and irrigation as well[19]. The chemical composition of irrigation water can either directly or indirectly impact plant growth by causing toxicity or deficiencies or by changing the nutrients that plants can access[20]. The information provided by this study on the present state of the water quality in the Dakatia River is crucial. Since processes determine water quality, updated data is more beneficial for monitoring and water quality maintenance. After that, the study might be used to create a database of ongoing water quality data. To determine the present condition of the Dakatia River's quality, a comprehensive experimental investigation was required. Evaluating the seasonal fluctuation of the water's physio-chemical properties and the relationships between the several Dakatia River water quality measures were the objectives of the current study. The present water policy, water usage, management implementation plans, and antidegradation statement must all be followed in order to manage the Dakatia River's water quality.

Materials and Methods

Study Area

A research was conducted on one of the contaminated rivers, the Dakatia River. Five sampling stations were established inside the study area, designated point-A (BIWTC Ghat, Chandpur) and point-B (five no Puran Bazar Ghat, Chandpur). Locations of points C, D, and E are Pal Bazar Bridge, Miyazi Bari Ghat, Truck Ghat Jame Masjid, and Chandpur, respectively. The research region, as seen in [Figure 1], spans 5 km along the Dakatia River from BIWTC Ghat to Truck Ghat Jame Masjid. The selection of these sites was influenced by the pollution from various waste sources, including emissions from residences, companies, and industry. These sampling locations are portrayed in Figure 1.

Figure 1: Map shows the Dakatia River study area in Chandpur, Bangladesh



Sample Collection and Examination of water parameters

Between January 2024 and October 2024, water samples were collected from five sampling stations for physicochemical analysis. Winter (January), Summer (April), Rainy Season (July), and pre-winter (October) were the four distinct seasons selected for the sampling period. Each sampling station provided samples, which were stored in 1000 ml plastic bottles. In all, 20 water samples were gathered for the pre-winter, summer, rainy season, and winter seasons. Prior to being treated with 5% nitric acid (HNO3) overnight, the bottles were cleaned and rinsed with a detergent solution. Once the bottles were sampled, they were screwed and labeled with the proper identification number. All water samples were gathered, kept, and analyzed by the environmental lab at the Institute of Water Modelling (IWM) in Dhaka, Bangladesh, using protocols authorized by the EPA. The water's temperature was measured in the field using a thermometer with a Celsius scale (manufactured in Germany and reading 100°C). The pH was measured using a pH meter, an electronic digital equipment. Electrical conductivity was evaluated using standard methods, and total dissolved solids (TDS) was determined using the gravimetric method. A few examples of chemical parameters include the Winkler titration method for measuring dissolved oxygen (DO), the dilution method for measuring biological oxygen demand (BOD), the Closed Reflux Colorimetric method for determining COD, and the EDTA titrimetric method for measuring hardness. After being collected, the data was correctly organized and subjected to statistical analysis. The collected data was displayed and analyzed using Microsoft Office Excel. The results of the investigation were displayed using charts and tabular formats.

Results and Discussion

Water quality monitoring is essential to managing the river ecology. In the current investigation of the Dakatia River's water quality, eight (8) parameters were looked at, and the findings are as follows.

Temperature

An important factor in controlling water quality is temperature. All changes in the physicochemical characteristics of water are due to it. Chemical processes are typically accelerated by higher temperatures.

Water temperatures at five sampling locations ranged from 21.3 to 21.9 ºC, 25.9 to 26.2 ºC, 28.1 to 29.0 ºC, and 25.0 to 26.0 ºC in the winter, summer, rainy season, and pre-winter correspondingly. During the Rainy season, Point-D recorded the highest temperature of 28.9 ºC, while Point-B and Point-D recorded the lowest temperature of 21.6 ºC during winter season (Figure 2). Readings of the temperature of river water show that it varies with the season. The average water temperature throughout the winter, summer, rainy, and pre-winter seasons was 21.60 ± 0.217, 26.1 ± 0.13, 28.7 ± 0.351, and 25.4 ± 0.377, respectively [Table 1].

pH

At all sampling locations, the pH values varied from 7.82 to 8.28, 7.19 to 8.13, 7.98 to 8.45, and 7.00 to 7.64 during the pre-winter, winter, summer, and rainy season, respectively. In the pre-winter period depicted in Figure 2, Point-B recorded the lowest pH of 7.00, whereas Point-C recorded the greatest pH of 8.45 during the rainy season. Seasons affect the pH of river water, according to readings. The average pH of the water was 8.10 ± 0.172 during the winter, 7.80 ± 0.376 during the rainy season, 8.2 ± 0.184 during the rainy season, and 7.3 ± 0.28 during the pre-winter season [Table1].

Dissolved Oxygen (DO)

For water to be considered healthy, it must have a significant amount of dissolved oxygen. Without oxygen, all life cannot exist. For natural stream cleaning mechanisms to sustain aerobic living forms, oxygen levels must be sufficient. Pre-winter, winter, summer, and rainy season DO levels ranged from 5.41 to 9.01 mg/L, 8.46 to 9.20 mg/L, 7.77 to 8.55 mg/L, and 5.10 to 6.54 mg/L, respectively, at all sampling sites. As shown in Figure 2, Point-A recorded the lowest DO of 5.10 mg/L during the pre-winter period and the highest DO of 8.85 mg/L during the summer. Table 1 shows that the average DO values of water were 7.9 ± 1.440 in the winter, 8.9 ± 0.313 in the summer, 8.0 ± 0.349, and 5.90 ± 0.619 in the rainy and pre-winter seasons, on average.

Electrical conductivity (EC)

The EC measures how many ions are present in water. Ion concentration is influenced by water sources, flow, and the surrounding environment. EC levels throughout the pre-winter, winter, summer, and rainy seasons varied from 250.0 to 269.0 µS/cm, 204.60 to 228.0 µS/cm, 247.0 to 257.0 µS/cm, and 221.0 to 257.0 µS/cm, respectively, among the five monitoring locations. During the pre-winter season, point A recorded the greatest EC value (232 µS/cm), while point B recorded the lowest EC value (204.60 µS/cm) during winter season (Figure 2). In the rainy and pre-winter seasons, the average EC values of water were 258.5 ± 8.289, 247.4 ± 14.92, 252.8 ± 4.207 during summer, and 218.5 ± 8.616 in the winter, according to Table 1.

Total Dissolved Solid (TDS)

The quantity of particle materials in solution is measured by total dissolved solids, or TDS. This shows that different land use practices are linked to nonpoint source pollution issues. The TDS values at all sampling sites ranged from (116.8 to 103.40) mg/L during the winter season, (120.0 to 114.5) mg/L during Summer Season, (113.9 to 97.1) mg/L during rainy season and from 82.80 mg/L to 86.70 mg/L during the wet season. Station 1 indicated the highest TDS value (130.60 mg/L) during pre- winter season, while Point A recorded the highest TDS value (127.8 mg/L) during the pre-winter season (Figure 2). According to Table 2, the average TDS values for the winter, summer, rainy season and pre-winter seasons were 111.8 ± 4.998, 118.0 ± 2.287, 109.6 ± 7.056 and 117.2 ± 8.377 respectively.

Biological oxygen demand (BOD)

The Biochemical Oxygen Demand (BOD) is a crucial metric for evaluating the water quality of rivers, such as Bangladesh's Dakatia River. Because BOD measures the amount of oxygen bacteria need to break down organic molecules in water, greater BOD values correspond to higher pollution levels. The BOD levels at each sampling location in our study varied from 3.5 to 2.6 mg/L, 3.9 to 1.8 mg/L, 3.5 to 2.7 mg/L, and 3.40 to 2.00 mg/L in the winter, summer, wet, and pre-winter seasons, respectively. According to Figure 2, station A recorded the greatest BOD value (1.80 mg/L) during the summer, while point C showed the highest BOD value (3.90 mg/L) during the winter. Table 1 shows that the seasonal average BOD values were 2.9 ± 0.365, 2.7 ± 0.798, 3.0 ± 0.311, and 2.8 ± 0.552 for the winter, summer, rainy season, and pre-winter seasons, respectively.

Chemical Oxygen Demand (COD)

One of the most important indicators of water quality is the Chemical Oxygen Demand (COD), which calculates how much oxygen is needed to oxidize the organic and inorganic substances in water. Significant pollution, which can harm aquatic ecosystems, might be indicated by elevated COD levels. It has been demonstrated that COD levels in the Dakatia River vary depending on the study and location. During the winter, summer, rainy, and pre-winter seasons, the COD levels at each sampling location ranged from 21.00 to 15.00 mg/L, 16.0 to 10.0 mg/L, 19.00 to 12.00 mg/L, and 16.00 to 10.00 mg/L, respectively. Figure 2 shows that during the pre-winter and winter seasons, points B and C recorded the lowest COD values (10.0 mg/L), whereas during the winter season, point B recorded the highest COD value (22.00 mg/L). Table 1 shows the average COD values for the winter, summer, rainy season, and pre-winter respectively: 19.2 ± 2.775, 13.2 ± 2.387, 15.0 ± 2.550, and 13.2 ± 2.387.

Hardness

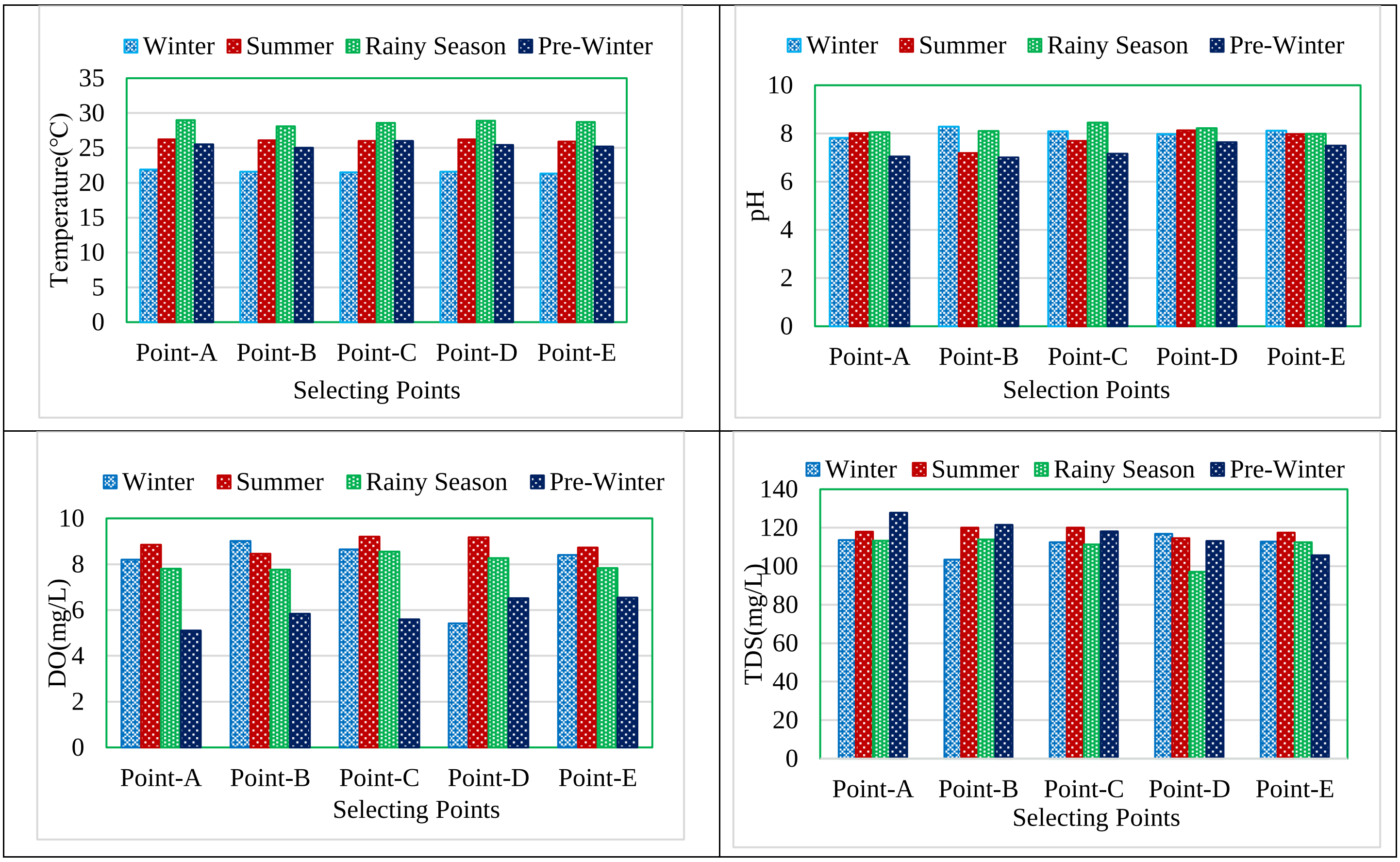
In the winter, summer, rainy season, and pre-winter seasons, the hardness levels at each sampling location varied from 23.40 to 22.70 mg/L, 78.00 to 54.00 mg/L, 61.00 to 42.00 mg/L, and 55.00 to 47.00 mg/L, respectively. Figure 2 illustrates that Point B had the highest hardness value (78 mg/L) in the summer and the lowest (42 mg/L) in the rainy season. Table 1 shows that the average hardness values were 54.8 ± 2.387, 67.6 ± 8.961, 50.6 ± 8.355, and 56.8 ± 7.59 for the winter, summer, rainy season, and pre-winter seasons, respectively.

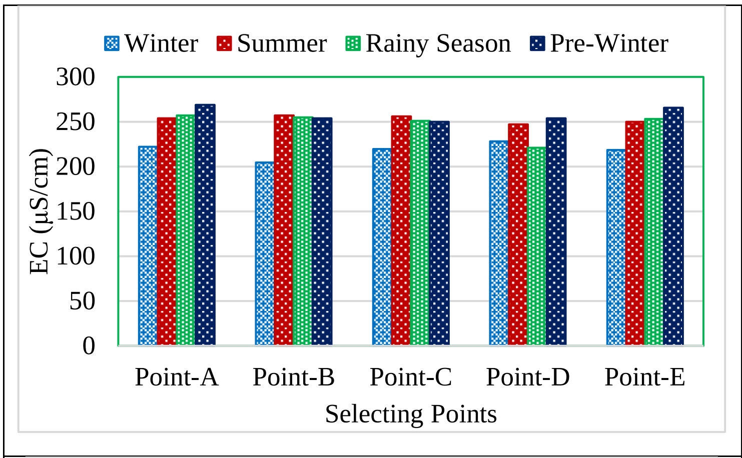
Table 1: Information about the physico-chemical water quality of the Dakatia River (parameter ranges are in brackets)

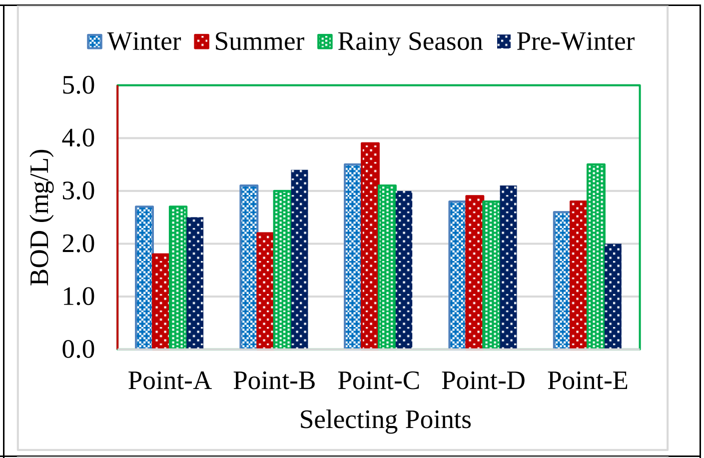
Parameter	Season (Mean ± SD)				Standard
	Winter	Summer	Rainy season	Pre-Winter	ECR,2023
TEMP. (°C)	21.60 ± 0.217	26.1 ± 0.13	28.7 ± 0.351	25.4 ± 0.377	20.0 to 30.0
	(21.90 to 21.30)	(26.20 to25.90)	(29.0 to 28.1)	(26.0 to 25.2)	
pH	8.10 ± 0.172	7.80 ± 0.376	8.2 ± 0.184	7.3 ± 0.28	6.50 to 8.50
	(8.28 to 7.82)	(8.13 to 7.19)	(8.45 to 7.98)	(7.64 to 7.00)	
DO (mg/L)	7.9 ± 1.44	8.9 ± 0.313	8.0 ± 0.349	5.90± 0.619	≥ 5 mg/L
	(8.65 to 5.41)	(9.20 to 8.46)	(8.55 to 7.77)	(6.54 to 5.10)	
EC (µS/cm)	218.5 ± 8.616	252.8 ± 4.207	247.4 ± 14.92	258.5 ± 8.289	≤1200 µS/cm
	(228.0 to 204.60)	(257.0 to 247.0)	(257.0 to 221.60)	(269.0 to 250.0)	
TDS (mg/L)	111.8 ± 4.998	118.0 ± 2.287	109.6 ± 7.056	117.2 ± 8.377	

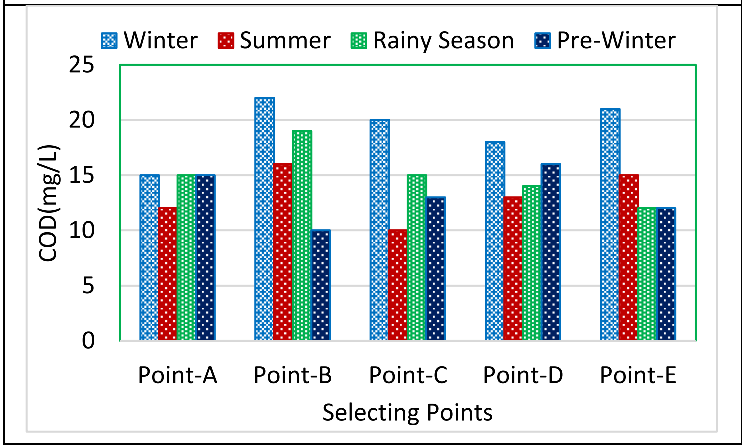
	(116.8 to 103.40)	(120.0 to 114.5)	(113.9 to 97.1)	(127.8 to 105.7)	≤ 1000 mg/L
BOD (mg/L)	2.9 ± 0.365	2.7 ± 0.798	3.0 ± 0.311	2.8 ± 0.552	≤ 6 mg/L
	(3.5 to 2.6)	(3.9 to 1.8)	(3.5 to 2.7)	(3.40 to 2.00)	
COD (mg/L)	19.2 ± 2.775	13.2 ± 2.387	15.0 ± 2.550	13.2 ± 2.387	≤ 200 mg/L
	(21.00 to 15.00)	(16.0 to 10.0)	(19.00 to 12.00)	(16.00 to 10.00)	
Hardness (mg/L)	54.8 ± 2.387	67.6 ± 8.961	50.6 ± 8.355	49.8 ± 3.962	≤ 10 NTU
	(23.40 to 22.70)	(78.00 to 54.00)	(61.00 to 42.00)	(55.00 to 47.00)	

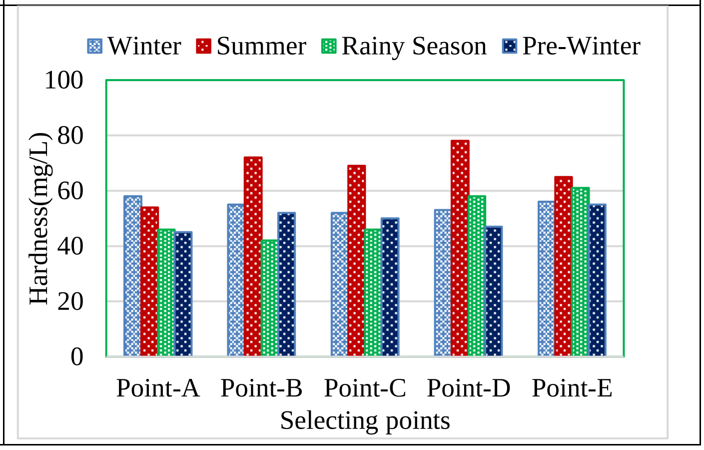
Figure 2: Seasonal fluctuations in the Dakatia River's water quality parameters at various locations











Correlation matrix

Water samples from the Dakatia River's winter, summer, rainy season, and pre-winter seasons shown substantial correlation with one another, according to a correlation matrix used to ascertain the relationship between the physicochemical parameters (Table 2-5). For Winter season (Table-2) The correlation between pH and COD (0.9756) is very strong. Higher pH levels are strongly associated with higher COD (Chemical Oxygen Demand). It would appear that the pH balance may be impacted by organic pollutants. TDS as well as EC (0.9926) a very strong positive connection. The more Total Dissolved Solids (TDS) there are, the higher the electrical conductivity (EC). This makes sense because conductivity is influenced by dissolved ions. Both DO and TDS (-0.7015) There is a strong negative association between rising TDS and falling dissolved oxygen (DO). Aquatic organisms may have less access to oxygen if there are high dissolved sediments. Hardness (-0.7063) and BOD high degree of negative correlation. Water hardness reduces with an increase in Biological Oxygen Demand (BOD). suggests that water's mineral content is impacted by organic contaminants.

Table 2: coefficient of correlation between winter season physicochemical water quality measurements of the Dakatia River

	Temp. (°C)	pH	DO (mg/L)	TDS (mg/L)	EC (µS/cm)	BOD (mg/L)	COD (mg/L)	Hardness (mg/L)
Temp. (°C)	1							
pH	-0.62571	1						

DO (mg/L)	-0.10517	0.452398	1					
TDS (mg/L)	0.03229	-0.76272	-0.7015	1				
EC (µS/cm)	0.126351	-0.79553	-0.74837	0.992571	1			
BOD (mg/L)	-0.08221	0.405412	0.334538	-0.32914	-0.3006	1		
COD (mg/L)	-0.78127	0.975607	0.39559	-0.61823	-0.67072	0.36068	1	
Hardness (mg/L)	0.425046	-0.34918	0.302168	-0.12569	-0.1429	-0.70634	-0.40755	1

Table 3: coefficient of correlation between summer season physicochemical water quality measurements of the Dakatia River

	Temp. (°C)	pH	DO (mg/L)	TDS (mg/L)	EC (µS/cm)	BOD (mg/L)	COD (mg/L)	Hardness (mg/L)
Temp. (°C)	1							
pH	0.156985	1						
DO (mg/L)	0.15555	0.611795	1					
TDS (mg/L)	-0.39406	-0.78808	-0.39803	1				
EC (µS/cm)	-0.10027	-0.79801	-0.3978	0.953605	1			
BOD (mg/L)	-0.4997	0.055954	0.665892	0.117793	-0.05807	1		
COD (mg/L)	-0.14456	-0.38078	-0.8341	-0.05495	-0.09458	-0.52742	1	
Hardness (mg/L)	0.012838	-0.20053	0.224367	-0.26838	-0.30769	0.473294	0.203327	1

For summer season (Table 3), EC and TDS (0.9536) Extremely High Positive Association Higher Electrical Conductivity (EC) is correlated with higher Total Dissolved Solids (TDS). This is to be expected as dissolved salts and minerals make water more conductive. The COD and DO (-0.8341)

Strongly Negative Association. Lower dissolved oxygen (DO) results from higher chemical oxygen demand (COD). As a result of higher COD using more oxygen, DO levels are lowered, indicating organic contamination. Both TDS and pH (-0.7881) Negative correlation that is strong. High dissolved solids can make the water more acidic since TDS causes the pH to drop. Both BOD and COD (-0.5274) the correlation is moderately negative. Normally, there is a positive correlation between BOD and COD, so this is unusual. A negative correlation can mean that they are being affected differently by different sources of pollution.

Table 4: coefficient of correlation between rainy season physicochemical water quality measurements of the Dakatia Rive

	Temp. (°C)	pH	DO (mg/L)	TDS (mg/L)	EC (µS/cm)	BOD (mg/L)	COD (mg/L)	Hardness (mg/L)
Temp. (°C)	1							
pH	-0.05416	1						
DO (mg/L)	0.17519	0.940911	1					
TDS (mg/L)	-0.41823	-0.2742	-0.4714	1				
EC (µS/cm)	-0.34958	-0.27815	-0.46862	0.996921	1			
BOD (mg/L)	-0.31127	-0.17426	-0.0653	0.336725	0.299	1		
COD (mg/L)	-0.72695	0.127725	-0.191	0.296	0.262776	-0.4093	1	
Hardness (mg/L)	0.48804	-0.28258	0.051256	-0.53094	-0.52764	0.445804	-0.8568	1

For rainy season (Table 4), DO (0.9409) and pH a strong positive correlation. Higher dissolved oxygen (DO) levels are strongly correlated with higher pH levels (less acidity). This is common in clean water systems where alkaline conditions maintain stable oxygen levels. TDS and EC (0.9969) extremely Positive Correlation. There is a nearly perfect correlation between electrical conductivity (EC) and total dissolved solids (TDS). This is to be expected since conductivity is increased by dissolved ions (salts, minerals). Hardness and COD (-0.8568) incredibly high negative correlation. Lower water hardness is linked to higher COD (pollution) levels. This implies that softer water is typically found in places with higher levels of organic contamination. COD (-0.4093) and BOD moderate correlation that is negative and COD often have a positive correlation, however in this case, the association is negative. This could indicate that BOD and COD are impacted differentially by various pollution sources, such as organic and industrial waste.

Table 5: coefficient of correlation between pre-winter season physicochemical water quality measurements of the Dakatia Rive

	Temp. (°C)	pH	DO (mg/L)	TDS (mg/L)	EC (µS/cm)	BOD (mg/L)	COD (mg/L)	Hardness (mg/L)
Temp. (°C)	1							

pH	-0.05594	1						
DO (mg/L)	-0.39385	0.857309	1					
TDS (mg/L)	0.172327	-0.80762	-0.91402	1				
EC (µS/cm)	-0.29566	-0.02571	-0.17706	0.071797	1			
BOD (mg/L)	0.012013	-0.29349	-0.1389	0.407978	-0.80061	1		
COD (mg/L)	0.439052	0.468182	-0.03145	0.093248	0.173827	-0.13272	1	
Hardness (mg/L)	-0.38175	0.122496	0.531477	-0.67453	-0.09104	-0.25134	-0.78753	1

For pre-winter season (Table-5), DO (0.8573) and pH strong positive correlation. Higher dissolved oxygen (DO) is associated with alkaline water (pH). This is to be expected in clean, less contaminated water because acidic environments tend to make oxygen less available. TDS and DO have a substantial negative correlation (-0.9140). Lower dissolved oxygen (DO) results from higher total dissolved solids (TDS). This implies that a high concentration of minerals or pollutants lowers oxygen, which can be detrimental to aquatic life. Both pH and TDS (-0.8076) high Negative correlation. Water with higher TDS has a lower pH and is more acidic. This can be the result of industrial contamination or dissolved contaminants. pH and COD (0.4681) moderate a positive correlation. Greater pH is typically linked to greater COD (chemical pollution) levels. This implies that certain industrial pollutants may have an alkaline composition. Hardness and COD (-0.7875) strong correlation that is negative. Lower hardness is associated with higher COD levels. This implies that pollution may lower the amount of minerals in water, perhaps as a result of dilution effects.

Conclusion

The data provided in our study shows seasonal fluctuations in various water quality measures and their adherence to the 2023 Environmental Conservation Rules (ECR) criteria. The rainy season has the highest temperatures, most likely as a result of warmer air and more sunlight. Naturally, winter has the lowest temperatures. There is neither excessively acidic nor alkaline pollution, as the pH stays within the normal range of 6.5 to 8.5. Pre-Winter's lowest pH may be caused by alkalinity being impacted by organic decomposition. Because of increased aeration and photosynthetic activity by aquatic plants, the DO is at its maximum during the summer. Pre-Winter's lowest DO (5.9 mg/L) raises the possibility that oxygen levels may be impacted by the breakdown of organic materials. EC is lowest in winter, indicating dilution effects from seasonal changes. It is highest in pre-winter, perhaps because of more dissolved salts from decreased water flow. The rainy season has the lowest TDS because of rainfall-induced dilution. TDS is slightly higher in the summer, perhaps as a result of more evaporation that concentrates dissolved minerals.

Increased organic contamination from surface runoff is suggested by the maximum BOD during the rainy season. The winter season COD increases indicate the presence of more organic or chemical pollutants that need more oxygen to break down. Seasonal contamination, perhaps from urban or agricultural runoff, is suggested by higher BOD and COD throughout the winter and rainy seasons. The water quality of the Dakatia River is usually satisfactory, since all metrics are within the ECR 2023 requirements. In order to avoid excessive organic pollution, BOD and COD levels should be regularly monitored during the winter and rainy seasons. During the rainy season, stop agricultural runoff to keep BOD and COD levels low. The study's conclusions give researchers, managers of water resources, and environmentalists important knowledge to help them put suitable plans for enhancing water quality management programs into action. Our study's findings highlight the importance of identifying and minimizing specific pollution sources, which could improve the allocation of funds for commercial, residential, and agricultural waste management strategies along the river. Such findings may further promote the adoption of stricter pollution control rules.

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