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Temporal Variation of Water Quality Parameters of the Dhanu River, Bangladesh

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Abstract

The study was conducted to assess the water quality of the Dhanu River during the wet season (June) and dry seasons (December). The concentration of water quality parameters in in dry and wet seasons were recorded for, pH: 6.8 and 6.1, EC: 82µS/cm and 50µS/cm, temperature: 28.8°C and 31.5°C; TDS: 53 and 32 ppm; DO: 5.7 and 6.6 ppm; BOD: 6.7 and 8.5 ppm; COD: 10.45 and 13.15 ppm; Hardness: 36.4 and 24.0 ppm; Alkalinity: 26.0 and 22.4 ppm and Chloride: 8.4 and 7.0 ppm, respectively. Moreover, the concentration of elements (Mg, Ca, Mn, Fe and Cu) and some of the toxic metals (As, Hg, Pb, Cd and Cr) were found within the safer level. The concentration of elements and trace metals showed no significant seasonal variation in the study area (p>0.05). pH, EC, temperature, TDS, hardness, alkalinity and turbidity showed significant seasonal variation (p<0.05) except DO, COD, BOD, chloride. River Pollution Index (RPI) demonstrates that the water of the Dhanu river is not in severe condition. In comparison with the other scientific findings, overall water quality of the Dhanu river is suitable for domestic uses and for aquatic life.

Keywords

Temporal variation; Water parameters; Trace metal; River Pollution Index (RPI); Dhanu river

Introduction

Dhanu river is an important river located eastern part of Bangladesh. It flows directly southwards from Sunamganj in Sylhet through the eastern thanas of Netrakona and Kishoreganj. River water quality is very important as it is used for many purposes like household needs, irrigation and aquatic life including fish and fisheries [1]. But the water quality of different sources is deteriorating day by day [2]. The prime responsible factors for the pollution of the river were haphazard industrialization, domestic sewage and agricultural inputs [3,4]. Discharged of untreated or partially treated industrial and domestic chemicals mixed wastewater [5] leaching of pesticides and residues of fertilizers and navigation are often factors that affect the quality of water. So the degradation of water quality has become an important issue in Bangladesh [6].

Now-a-days, the contamination of river water is a matter of great concern all over the world [7,8]. Industries are the major contributor of heavy metals produced from municipal and industrial wastewater [9-14]. Chemicals mixed water pollute the chemical quality of waste; thereby affect the aquatic life-disrupting the food web [15]. Besides aquatic life, polluted water creates 80% of all illnesses and ailments in the world [16].

Physical, chemical, and biological properties are used to assess water quality [17]. River Pollution Index (RPI) widely used in examines of water quality [4,5,18-23].

Dhanu River is navigable all the year-round. People of this basin depend on it for their household, industrial and other purposes. The water of the river is mainly used in agricultural purposes and plays a vital role in the economy of this region. It supports the habitat for aquatic organisms as well as fisheries and other aquatic vegetations in the bank of the river. So it is crucial to monitor and assess the water quality of the Dhanu River to ascertain whether the water quality is suitable for various uses or not. Therefore, the present study was carried out to assess the water quality of the river.

Materials and Methods

Study site

The study was conducted along the bank of the Dhanu River, Kishoreganj (24°36'56.58" N and 91°05'16.91" E) (Figure 1). Five locations (Dhonpur Ghat, Itna Ghat, Mithaimain Ghat, Betaga Ghat, Elanjuri Ghat) were selected for the present study.

Sample collection and preservation

The water samples were collected in the wet (June)/2016 and dry seasons

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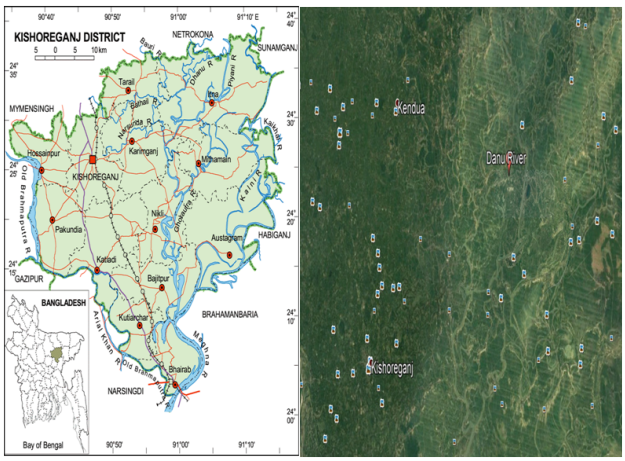

Figure 1: Map showing the sampling site

(December)/2016 from five different sites. The locations were marked as site 1 (Dhonpur Ghat), site 2 (Itna Ghat), site 3 (Mithaimain Ghat), site 4 (Betaga Ghat) and site 5 (Elanjuri Ghat). The 1000 ml plastic bottles were washed well and rinsed with 5-6 ml analytical grade HCl. The bottles were rinsed again with sample water. The samples were collected securely and sealed with proper levelling. Aeration during sampling was avoided as far as possible. Immediately after collection, water samples were transferred to the laboratory of Bangladesh Council of Scientific and Industrial Research (BCSIR), Chittagong.

Sample analysis

pH, Temperature, Conductivity, TDS and DO were measured by pH meter (Hanna pH meter), thermometer, TDS meter and DO meter (Hanna DO meter, HI-9146) respectively from studied sites. The rest of the parameters were tested by the approved method stated in APHA [24]. Chloride, Alkalinity, Hardness, Biochemical Oxygen Demand (BOD_5), and Chemical Oxygen Demand (COD) were measured by Volhard Method, Titrimetric, Complexiметric titration Method, Modified Winkler Method and Dichromate Reflux Method respectively.

The concentration of trace metals (Mg, Ca, Mn, Fe, & Cu) and others trace metals (As, Hg, Pb, Cd, & Cr) were determined using Atomic Absorption Spectrophotometer (Model-iCE 3300, Thermo Scientific, Designed in the UK, Made by China) using the standard analytical method.

Statistical analysis

One Way Analysis of Variance (ANOVA) (Posthoc LSD test) was executed to find out the seasonal variation of physicochemical parameters, elements and metals in the study sites (SPSS v.22).

River Pollution Index (RPI)

Each water quality parameter used to determine RPI is changed to one of four index scores (S_i = 1, 3, 6, or 10) [3]. Particularly, RPI refers to the arithmetic average of these index scores with respect to the water quality [22].

The River Pollution Index (RPI) is calculated using the following equation [25]

$$RPI = 1/4 \sum_{i=1}^{4} Si$$

Where, S_i signifies the index scores and the RPI value ranges from 1 to 10(Table 1).

Results and Discussion

Seasonal variation of physicochemical parameters

The concentration of pH, EC, temperature, TDS, hardness, alkalinity and turbidity varied significantly in different season (p<0.05) except DO, COD, BOD, chloride.

pH

pH is widely known as the regulatory factor in water as many properties, processes and reaction are pH dependent [5]. The permissible limit of pH for irrigation is 6.0–8.4 [26], 6.0-9.0 [27]. The highest amount of pH 6.9 was found at site 3 during the dry season. In the wet season, pH value was found 6.1 in all sites except site 1 (Figure 2). This result indicate the slightly alkaline nature of the river water. Bhuyan et al. [3]recorded pH concentration between 7.1-7.8 in the water of the Old Brahmaputra River. The value of pH was found 6.3-7.3 in the water of the Halda River [22]. Sikder et al. [28] recorded pH (7.5-7.9) in the water of the Turag River.

Water temperature

Temperature is an important parameter for river water as it affects dissolved oxygen (DO) [29]. The ranges of temperature are 30.7°C to 27.6°C during the dry season and 32.°C to 30.7°C in the wet season. The highest lowest temperature 27.6°C was recorded at site 2 during the dry season (Figure 2). Sharif et al. [5] reported 29°C during monsoon season and 22°C during the dry season in the lower Meghna river. According to Environment Conversion Rules, the permissible value of temperature for inland temperature 32.1°C was recorded at site 1 during wet season whereas the water is 40°C [27].

Electrical conductivity (EC)

The value of EC ranged from 87 µS/cm to 78 µS/cm during the dry season and 62 µS/cm to 37 µS/cm during the wet season. The highest concentration of EC 87 µS/cm was found at site 3 during the dry season and the lowest EC 37 µS/cm was documented at site 5 during the wet season (Figure 2). The amount of EC was reported between 185-1080 µS/cm in the Old Brahmaputra River [23]. Bhuyan and Bakar [2] recorded 119 µS/cm EC during the dry season and 356 µS/cm EC during the wet season in the Halda river. Bhuyan and Bakar (2017)22 reported that the amount of EC in the water of the Halda river ranged between 110-524 µS/cm. According to Environment Conversion Rules, the allowable value of EC for inland water is 1200 µS/cm [27]. EC demonstrates the total concentration of ionized constituents of water [30], higher conductivity in water reflects higher water pollution [31]. De [32] reported typical EC value is 300 µS/cm for river water.

Turbidity

The concentration of turbidity in the Dhanu river water varied from 16 NTU to 22 NTU during the dry season and 34 NTU to 48 NTU during the wet season. The highest amount of turbidity was recorded at site 1 during the wet season and the lowest value of turbidity was found at site 2 during the dry season (Figure 2).

Total dissolved solids (TDS)

TDS indicates the amount of inorganic and organic substance contained in a liquid in molecular, ionized or micro-granular suspended form. TDS varied from 50 ppm to 56 ppm during the dry season and 24 ppm to 40 ppm during the wet season. In the present study, the highest TDS was recorded at site 3 during the dry season and the lowest TDS was recorded at site 5 during the wet season (Figure 2). According to Environment Conservation Rules, the admissible limit of TDS is up to 2100 ppm for river water [27].

Dissolved Oxygen (DO)

Dissolved Oxygen is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. The amount of DO ranged from 3.8 ppm to 5.5 ppm during the dry season and 4.8 ppm to 6.0 ppm during the wet season. The highest amount of DO 6.4 ppm was recorded at site 4 during the wet season and the lowest DO 3.8 ppm was recorded at site 2 during the dry season (Figure 2). Bhuyan et al. [23] found 0.66-2.9 ppm DO in the Old Brahmaputra River. Bhuyan and Bakar [2] reported 0.98 ppm during the wet season and 5.0 ppm during the dry season in the Halda River. According to the Environmental Conservation Rules, the

Parameters	Sampling sites	Dry season		Wet season	
		Value (ppm)	Mean (ppm)	Value (ppm)	Mean (ppm)
Pb	1	ND (<0.01)	ND(< 0.01)	ND (<0.01)	ND (<0.01)
	2	ND (<0.01)		ND (<0.01)	
	3	ND (<0.01)		ND (<0.01)	
	4	ND (<0.01)		ND (<0.01)	
	5	ND (<0.01)		ND (<0.01)	
Cd	1	ND (<0.003)	ND(<0.003)	ND (<0.003)	ND(<0.003)
	2	ND (<0.003)		ND (<0.003)	
	3	ND (<0.003)		ND (<0.003)	
	4	ND (<0.003)		ND (<0.003)	
	5	ND (<0.003)		ND (<0.003)	
Cr	1	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)
	2	ND (<0.05)		ND (<0.05)	
	3	ND (<0.05)		ND (<0.05)	
	4	ND (<0.05)		ND (<0.05)	
	5	ND (<0.05)		ND (<0.05)	
Hg	1	ND (<0.006)	ND (<0.006)	ND (<0.006)	ND(<0.006)
	2	ND (<0.006)		ND (<0.006)	
	3	ND (<0.006)		ND (<0.006)	
	4	ND (<0.006)		ND (<0.006)	
	5	ND (<0.006)		ND (<0.006)	
As	1	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)
	2	ND (<0.05)		ND (<0.05)	
	3	ND (<0.05)		ND (<0.05)	
	4	ND (<0.05)		ND (<0.05)	
	5	ND (<0.05)		ND (<0.05)	

*ND denotes not detected

Table 1: Concentrations of trace metals in water of the Dhanu river

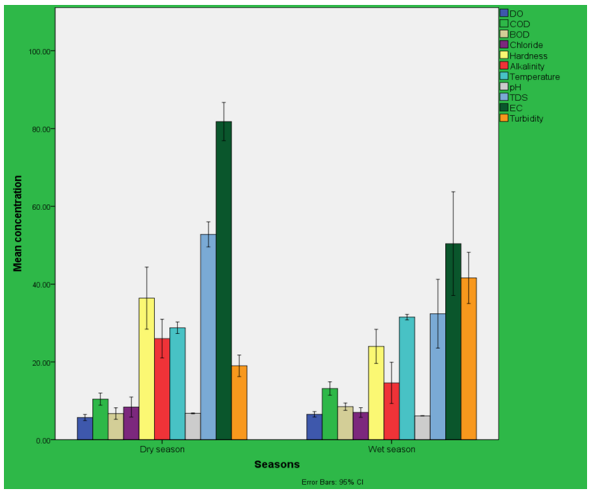

Figure 2: Graph showing mean concentrations of physicochemical parameters in water during two seasons

prescribed DO for river water is 4.5 ppm to 8.0 ppm [27].

Biochemical oxygen demand (BOD_5)

Biochemical Oxygen Demand is a measure of the quantity of oxygen used by microorganisms in the oxidation of organic matter. River water having BOD more than 10 mg/l is considered to be moderately polluted water and more than 20 mg/l as to be highly polluted water [33]. The value of BOD found between 5.2 ppm to 8.2 ppm during the dry season and 7.4 ppm to 9.3 ppm during the wet season. The highest amount of BOD 9.3 ppm was recorded at site 1 during the wet season and the lowest BOD 5.2 ppm was recorded at site 2 during the dry season (Figure 2). The concentration of BOD was recorded 21-138 ppm in the Old Brahmaputra River [23]. 30-545 ppm BOD was found in the water of the Halda River in different seasons [2]. Sikder et al. [28] recorded 22 ppm BOD in the Turag River. According to Environment Conservation Rules, the highest permissible value of BOD is 50 ppm for river water.

Chemical oxygen demand (COD)

COD is regarded as the important factor to assess pollution level in water while higher COD is detrimental to aquatic living organisms [34]. COD varied between 11.9 ppm to 8.8 ppm in the dry season and 11.3 ppm to 14.8 ppm during the wet season. The maximum amount of COD 14.8 ppm was found at site 1 during the dry season. While the minimum amount was found at site 2 during the dry season. From the study, the average COD of water was found 10.45 ppm and 13.15 ppm during dry and wet season respectively (Figure 2). Bhuyan et al. [23] found 45-250 ppm COD in the Old Brahmaputra River. Bhuyan and Bakar [2] found maximum 983 ppm COD during monsoon season while the minimum 43 ppm was recorded during pre-monsoon season in the Halda River. Bhuyan et al. [22] documented 8.4 ppm during the rainy season and 4.1 ppm during the winter season in the Meghna River. The maximum permissible value of COD for river water is 200 ppm [27].

Hardness

Hardness is caused by compounds of calcium and magnesium, and by a variety of other metals. The concentration of hardness recorded between 29 ppm to 42 ppm during the dry season and 20 ppm to 29 ppm during the wet season. The maximum amount of hardness 42 ppm was recorded at site 2 and site 4 during the dry season. The minimum amount of hardness 20 ppm was recorded at

site 1 during the wet season (Figure 2). The value of hardness in the dry season is always greater than the wet season in the Dhanu river water. Bhuyan et al. [23] recorded 84-148 ppm hardness in the water of the Old Brahmaputra River. The highest hardness (121 ppm) was reported during monsoon season whereas the lowest (38 ppm) was found during post-monsoon in the Halda River [2].

Total alkalinity (TA)

TA is very important for fish and aquatic life because it protects or buffers against rapid pH changes. The alkalinity ranges from 21 ppm to 31 ppm during the dry season and 19 ppm to 27 ppm during the wet season. The highest amount of alkalinity was recorded at site 5 during dry season whereas the lowest amount was recorded at site 3 during the wet season (Figure 2). The value of alkalinity in the water of the Old Brahmaputra River varied between 85-197 ppm [23]. Bhuyan and Bakar [2] recorded maximum value of alkalinity 67 ppm both in monsoon and post-monsoon season in the Halda River. Islam et al. [4] recorded 166 ppm during the wet season and 176.5 ppm during winter in the Halda river water. The amount of alkalinity was found in 50.4 ppm during monsoon season and 146.5 ppm was recorded during winter seasons in the Bansi River [35].

Chloride (Cl^-)

Chlorides are not injurious to public health but elevated levels of Cl^- in inland water is usually regarded as an index of pollution [31]. Cl^- value was recorded between 6.0 ppm to 11.0 ppm during the dry season and 6 ppm to 8 ppm during the wet season. The highest amount of Cl^- was detected at site 4 and the lowest amount at site 1 and site 4 (Figure 2). Bhuyan et al.[23] recorded the chloride value between 10-98 ppm in the Old Brahmaputra River. The highest concentration (56 ppm) of chloride was found during monsoon season and the lowest 12 ppm was documented during pre-monsoon season in the Halda River [2].

Seasonal variation of trace metals and elements

A total of five elements (Mg, Ca, Mn, Fe and Cu) and five toxic metals (As, Hg, Pb, Cd and Cr) were measured during the study. The concentrations of all the elements and metals were recorded within the permissible limit. No significant seasonal variation was found in the concentration of elements and trace metals ($p>0.05$).

Calcium (Ca)

Calcium is naturally present in water. Calcium is largely responsible for water hardness, and may negatively influence the toxicity of other compounds. Calcium has an important role in the biological processes of fish. Fish can absorb calcium for these needs directly from the water or food [36]. In the present study, the range of Ca found between 13.1 ppm to 8.7 ppm during the dry season and 1.8 ppm to 4.4 ppm during the wet season. The maximum amount of Ca was recorded at site 5 during dry season whereas the minimum amount was recorded at site 4 during the wet season.

Magnesium (Mg)

Magnesium (Mg) ranges from 1.5 ppm to 2.1 ppm in the dry season and 0.5 ppm to 1 ppm during the wet season. The highest amount of Mg was recorded at site 1 during dry season whereas the lowest amount was recorded at site 3 during the wet season. The amount of Mg is almost uniform over a season. But the change of Mg with the change of season at site 1 is very significant.

Manganese (Mn)

The concentration of Manganese (Mn) in the Dhanu river water found between 0.01 ppm to 0.06 ppm in the dry season and 0.01 ppm to 0.05 ppm during the wet season. The highest amount of Mn was recorded at site 2 during the dry season and the lowest amount was recorded at site 3 during the wet season and at site 4 during the dry season. These findings were recorded within the allowable limit set by EU [37]. The present results are lower than the findings of Mokaddes et al. [38].

Iron (Fe)

Iron (Fe) value recorded between 0.15 ppm to 0.30 ppm during the dry season and 0.15 ppm to 0.45 ppm during the wet season. The maximum amount of Fe was found at site 1 during the wet season and the minimum amount was recorded at site 5. The results are far below the findings recoded by Myllynen et al. [39] in Perhonjoki River, Ozturk et al. [40] in Avsar Dam Lake, Balkis et al. [41] in Gokova Bay and Bhuyan et al. [22] in Meghna River.

Copper (Cu)

Copper (Cu) is an essential trace nutrient that is required in small amounts (5-20 ppm) by humans, other mammals, fish and shellfish for carbohydrate metabolism and the functioning of more than 30 enzymes. However, copper concentrations that exceed 20 ppm can be toxic [42]. The concentration of Cu varied between 0.10 ppm to 0.25 ppm during the dry season and 0.10 ppm to 0.20 ppm during the wet season. The highest amount Cu 0.25 ppm was found at site 5 during the dry season and the lowest amount Cu 0.1 ppm were found at site 1 and site 4. The present findings are far below the permissible limit set by WHO [43], and EPA [44]. Ahmad et al. [45] and Rao et al. [46] reported higher amount of Cu while Mokaddes et al. [38] found lower concentration of Cu in the Buriganga River, Turag river, Balu river, Meghna river amd Shitalakshiya river.

Zinc (Zn)

Zinc (Zn) concentration was found in the Dhanu river between 0.01 ppm to 0.05 ppm and 0.03 ppm to 0.10 ppm during dry and wet seasons respectively. The maximum amount of Zn was found at site 2 the wet season and minimum amount was found at site 4 the dry season. The present result recorded below the acceptable limit (3 mg/kg) set by WHO [47], Balkis et al. [41] reported the higher amount (4.9 mg/kg) of Zn from Gokova Bay, Turkey.

Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg), and Arsenic (As)

Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg), and Arsenic (As) are considered as the most concerned heavy metals. These metals have a severe impact on human health, aquatic life and the environment. The mentioned toxic metals were recorded below the detection limit (Table 1). It is very pleasant that the Dhanu River water is safe from the effect of toxic metals.

River pollution index (RPI)

RPI was used by a different organization like Taiwan EPA to determine water quality [2]. According to RPI, DO value shows that the water of the Dhanu River negligibly polluted (Table 1). So it is clear that the average DO level of the Dhanu river water is perfect for aquatic lives. BOD_5 value ranges from 5 ppm to 15 ppm is moderately polluted (Table 2) [18,25]. This indicates that the organic pollutants of this are not severe for the existence of aquatic life.

Items/ranks	Good	Less polluted	Moderately polluted	Highly polluted
DO (mg/L)	>6.5	4.6-6.5	2.0-4.5	<2.0
BOD_5 (mg/L)	<3.5	3.0-4.9	5.0-15	>15
SS (mg/L)	<2.0	20-49	50-100	>100
NH_3-N (mg/L)	<0.5	0.5-0.9	91.0-3.0	>3.0
Index scores (Si)	1	3	6	10
Sub-index	<2	2.0-3.0	3.1-6.0	>6.0

Table 2. River Pollution Index (RPI) Chart

Conclusion

From the findings of the present study, it can be concluded

that the variation of water quality parameters in different seasons is significant. All the water quality parameters indicate the overall water quality of the Dhanu River is suitable for uses. The abundant DO, lower value of BOD_5 and COD shows that the river water is suitable for aquatic life. This river water holds sufficient amount of essential elements which are used as micronutrient of aquatic life. As the amount of toxic metal is very insignificant so the water is safe for irrigation and household need. Local Authority or the Environment Agency should pay special attention to maintain the health of the Dhanu River and to protect from pollution (both natural and anthropogenic).

This research is a preliminary study on the water quality of the Dhanu River. The findings of the research will be important resources for the researchers, academicians and policymakers to protect the Dhanu River from pollution that other researchers were not able to discover.

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