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M – 00297 | Research Article

Monitoring of Water Quality with Trophic State Index (TSI) in the Chalan Beel Wetland Ecosystem of Bangladesh

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Abstract

This study was conducted to investigate the status of water quality for fisheries and aquatic environment in Chalan Beel, the largest wetland ecosystem in Bangladesh. Water samples were collected from five sampling stations over the period from February 2020 to January 2021 during the pre-monsoon, monsoon, and post-monsoon seasons, respectively. Surface water controlling parameters such as temperature, transparency, pH, DO, TDS, EC, total hardness, total alkalinity, Chlorophyll *a*, and TSI of Chalan Beel were monitored seasonally. The study revealed that temperature, transparency, pH, DO, TDS, EC, total alkalinity, total hardness, PO_4, and NO_3 exceeded the recommended level for fish culture. On the other hand, NH_3, SO_4, NO_2, Chlorophyll *a*, and trophic state index (TSI) were within the standard limits for aquaculture. Concentrations of Chlorophyll *a* and TSI (CHL) indicated no definite trend with seasons. In conclusion, the wetland is in mesotrophic condition as the TSI (CHL) was within 40, and apparently, there was a positive relationship between Chlorophyll *a* and TSI. To conserve a healthy environment of the beel ecosystem, it is necessary to promote knowledge about water quality issues and beel management through monitoring and research.

Keywords

Temporal variation; Water quality; Trophic state index; Chlorophyll *a*; Chalan Beel

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Introduction

Inland water bodies have been supporting rich and diversified fisheries and, thus, are critically important to the people of Bangladesh for their food security and livelihood (Hasan, 2004). However, due to sharp decline of natural fish production and consumption over the last years and created protein deficiency. The beel is a Bengali term used for relatively large surface, static water body that accumulates surface run-off water through an internal drainage channel (Banglapedia, 2004). This type of shallow and seasonal water body is common in low-lying floodplain areas throughout Bangladesh. The Chalan Beel is a large depression wetland in the northwest region of Bangladesh, which has a huge ecological and social importance. Chalan Beel is consisted of a series of depressions interconnected by many channels to form one continuous area of water bodies during rainy season (July to November), and it shields an area of about 375 km^2 (Hossain *et al.*, 2009). During the dry winter and summer, the water area decreases to 52 to 78 km^2 and looks like a cluster of Beels of different sizes (Shahnaz, 2005; Hossain *et al*., 2009), providing excellent alluvial cropland in the post-monsoon season. This beel is one of the most important sites for fishing, agriculture, aquaculture, livestock farming, integrated farming, and a site of recreation for the tourist. Nationally, this beel plays an important role in producing a huge number of different fish species and it supplies fish to local and national markets and provides a livelihood to around 0.1 million fishermen (Hossain *et al.*, 2009; Karim *et al*., 2020).

Water is the natural habitat of fishes and other aquatic animals, therefore, of great importance to study water quality while studying fish production (Kabir *et al*., 2020). Water provides the physical support in which aquatic organisms carry out their life functions such as breeding, nursing, feeding, swimming, digestion and excretion (Islam *et al*., 2021). Physicochemical water quality is pointed as an important factor to the success or failure of a fish culture operation. By assessing the physical, chemical and biological characteristics of water, one can conclude about its quality. Physicochemical water quality focuses on the various aspects of physicochemical parameters that detect the status of pollution and the suitability of a particular water body for various aquatic organisms (Islam *et al*., 2015). Nutrients in water play an important role in the lives of aquatic organisms including fish. Water nitrogen is found both as inorganic and organic species and in dissolved and particulate forms. Inorganic nitrogen exists both as oxidized species such as nitrate (NO_3^-) and nitrite (NO_2^-) and reduced species like ammonia (NH_4^++NH_3) and nitrogen gas (N_2). Dissolved phosphorus is readily available for plants and consists of inorganic orthophosphate such as $H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-} and organic phosphorus containing compounds (Rahaman *et al*., 2013a). All aquatic organisms including fish depend directly on nutrients for their survival, growth and reproduction. Some nutrient levels are related to the chlorophyll availability of the water body, which means the availability of phytoplankton in the water. Thus, nutrient availability is directly related to the productivity of the water body (Rahaman *et al*., 2013b). A shortage of nutrients causes the water body to be unproductive. An excess of nutrients causes eutrophication by algal blooms and makes the water toxic. So, nutrient concentration must be within an acceptable limit for a good aquatic environment and for better production of aquatic organisms including fish (Senthilkumar, Purvaja and Ramesh, 2008). Hence, the assessment of trophic status index (TSI) of water body and determining its limiting factors are key steps in pollution control and eutrophication management. Since algal flora play very important role in ecological context; the study of chlorophyll *a* concentration is of utmost importance (Nion *et al*., 2020). Chlorophyll *a* concentration may change the surrounding environment - physically, chemically, and biologically - in ways that favor or disfavor their continued persistence (Islam *et al*., 2021). The study of chlorophyll *a* concentration is considered useful for interpreting hydro-chemical variations in freshwater reservoir. So the temporal and spatial chlorophyll *a* concentration may act as an indicator of the water quality fluctuation in response to changing environment (Senthilkumar, Purvaja and Ramesh, 2008).

Presently, the Chalan Beel, like many other beels, is at the risk of partial or total degradation due to manifold reasons like agricultural encroachment including pesticide usage, siltation along with other

anthropogenic activities. Though a few works on physicochemical limnology of Chalan Beel are available (Rahman, 2012; Nahian *et al*., 2018), however, a detailed study on seasonal variation of the water quality (physical, chemical, biological and anionic) parameters and trophic state index (TSI) in Chalan Beel is evidently lacking. Therefore, the present study aimed to provide data on variations of water quality parameters and TSI of Chalan Beel over a period of one year to provide baseline information for assisting management decisions of the Beel ecosystem.

Materials and Methods

Study area

The Chalan Beel is situated between 24°31′12″ to 24°38′42″N latitude and 89°00′36″ to 89°35′36″E longitudes (Sayeed *et al.,* 2014). At present, the beel was compressed in the districts of Pabna, Sirajganj and Natore due to crisscross roads, embankments and expansion of other infrastructure (Sultana and Islam, 2016). The major parts of Chalan Beel cover an extensive area of Raiganj upazila of Sirajganj district and Chatmohar upazila of Pabna district and Singra upazila of Natore district with the north bank of the river Gumani. Therefore, the study was conducted in three representative cluster sites under Natore and Pabna districts. The study was conducted from February 2020 to January 2021, where February to May, June to September and October to January are considered as pre-monsoon, monsoon and post-monsoon seasons, respectively. The samples were collected from five sampling stations of three adjacent rivers (Atrai, Baral and Gumani) of Chalan Beel. The five sampling stations as St-1 (Atrai River, Natore), St-2 (Baral river, Pabna), St-3 (Gumani River, Pabna), St-4 (Baral River, Pabna) and St-5 (Baral river, Pabna) were selected according to the following aspects into consideration: i) the streams and drainage arms, ii) catchment area, and iii) water level of the river.

Table1: Location of sampling stations in Chalan Beel

Sampling stations	*Location*		*Latitude*	*Longitude*
	Upazila	*District*		
St-1 (Kachikata)	Gurudashpur	Natore	24°21'6.14"	89°18'33.12"
St-2 (Haripur)	Chatmohor	Pabna	24°15'4.43"	89°16'5.70"
St-3 (Austamanisha)	Bhangura	Pabna	24°15'37.50"	89°20'38.21"
St-4 (Baral bridge)	Bhangura	Pabna	24°13'0.51"	89°22'46.40"
St-5 (Thana para)	Faridpur	Pabna	24°9' 48.23"	89°26'38.20"

Sample collection

Surface water samples were collected from 5 fixed sampling stations of the Chalan Beel for seasonal monitoring of water quality control parameters such as transparency, temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), total alkalinity (TA), total hardness (TH), ammonia (NH_3), phosphate (PO_4), sulphate (SO_4), nitrate (NO_3), nitrite (NO_2), and chlorophyll *a*. To analyze the physicochemical quality, major nutrients and chlorophyll *a* concentration, 1,000 ml of water was collected in plastic bottles with double stoppers from each sampling point. Before sampling, the bottle was cleaned and washed with a detergent solution and treated with 5% nitric acid (HNO_3) over night. The bottles were finally rinsed with deionized water and dried. At each sampling station, the sampling bottles were rinsed at least three times before sampling was done. Pre-prepared sampling bottles were immersed about 10 cm below the surface water. After sampling, the bottles were screwed carefully and marked with the respective identification number. The samples were filtered with pre-combusted (4h, 450°C) Whatman GF/C filters. After filtration, the samples were kept frozen (-20°C) until analysis (within 48 hrs) to avoid further contamination until analysis (Islam *et al*., 2021).

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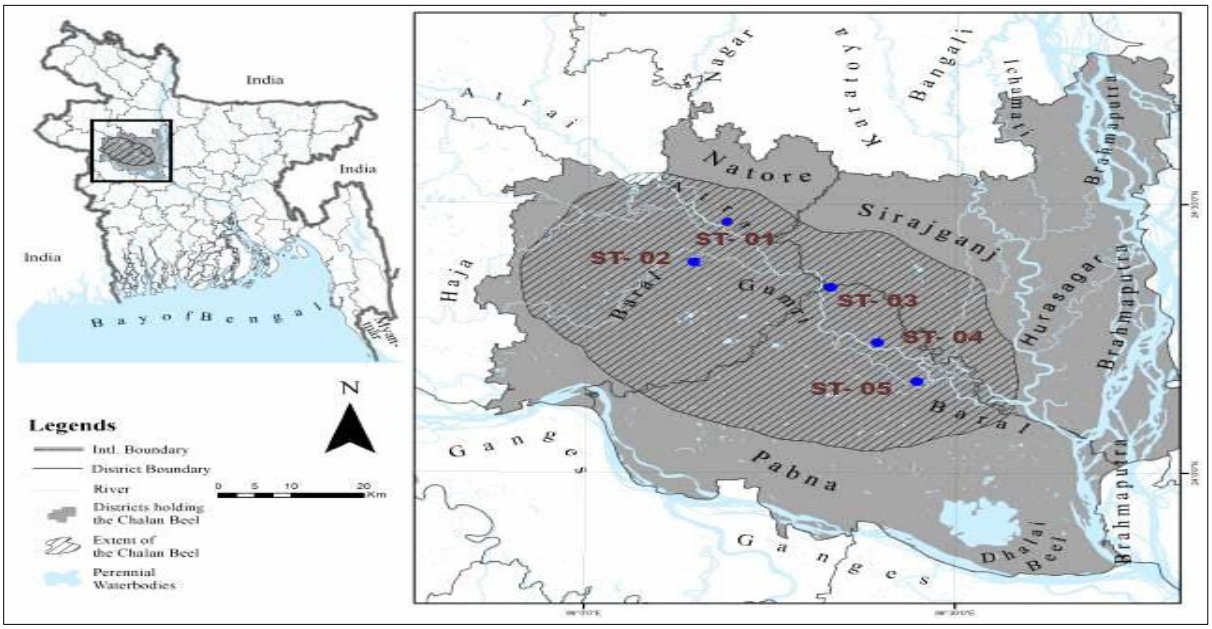

Figure 1: Map showing the study area of Chalan Beel (*Source:* Modified from Sayeed *et al.*, 2014).

Sample analysis

The physicochemical parameters of water were analyzed in the laboratory of the Department of Environmental Science and Resource Management of the Mawlana Bhashani Science and Technology University. Temperature and pH were determined by the thermometer and digital pH meter, respectively. Buffer solution containing pH 7.0 was used to calibrate the digital pH meter. The DO was determined by digital DO meter where sodium thiosulphate (0.025N) was used as a reagent. The EC and TDS were determined by EC and TDS meter, respectively. Total alkalinity (TA) and total hardness (TH) were determined by using titration technique. For the determination of dissolved nutrient concentrations, the water samples were prepared for ionic test followed by APHA (2005) using spectrophotometer (HACH DR 2800 Spectrophotometer) analysis in the Laboratory of the Bangladesh Fisheries Research Institute (BFRI), Mymensingh. After instrumental measurements, the values of ions including ammonia (NH_3), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4) and sulphate (SO_4) were calculated using computer-aided tools. The Chlorophyll *a* of water samples were analyzed by 90% acetone method in the Biochemistry and Molecular Biology Laboratory of the Mawlana Bhashani Science and Technology University.

Statistical analysis

The data was prepared and tabulated properly, and statistical analysis was performed on it. The data was presented and interpreted using Microsoft Office Excel and SPSS version 20.0 program. Pearson's correlation analysis was completed to illustrate the interrelationships between the water physicochemical parameters. The study's findings were presented in the form of graphs and tables.

Results and Discussion

Physiochemical Parameters

Temperature

The highest temperature 32.5°C was found at St-2 during monsoon and the lowest temperature 20.9°C was found at St-1 during post-monsoon (Figure 2). Typically, the highest mean temperature of 31.70°C was found in monsoon and the lowest temperature 21.34°C was found in post-monsoon (Table 2). The standard value for water temperature is 20 to 30ºC (EQS, 1997), hence the water temperature of the Chalan Beel was optimum for aquatic life. A mean water temperature of 27.68°C was recorded by Sayeed *et al.* (2015) in Chalan Beel, which is almost similar to the present study. The water temperature was found 28.7 to 3l.7°C during the wet season and 22.4 to 25.6°C during the dry season, respectively, in the Ashulia beel (Islam, Suravi and Meghla, 2010). The water temperature ranged from 25.6 to 28.7 ºC, 22.3 to 24.3 ºC and 24.1 to 25ºC during high tide, and 25.4 to 28.2 ºC, 23.8 to 24.3 ºC and 24 to 24.9ºC during low tide over pre-monsoon, monsoon and post-monsoon seasons, respectively, in the Sundarbans mangrove of Bangladesh (Nion *et al*., 2020). The highest mean temperature 31.1°C was found in monsoon and the lowest 21.12°C was found in post-monsoon in the Kaptai Lake water (Islam *et al*., 2021). This could be due to varied collection times and seasonal factors (Kabir *et al*., 2020).

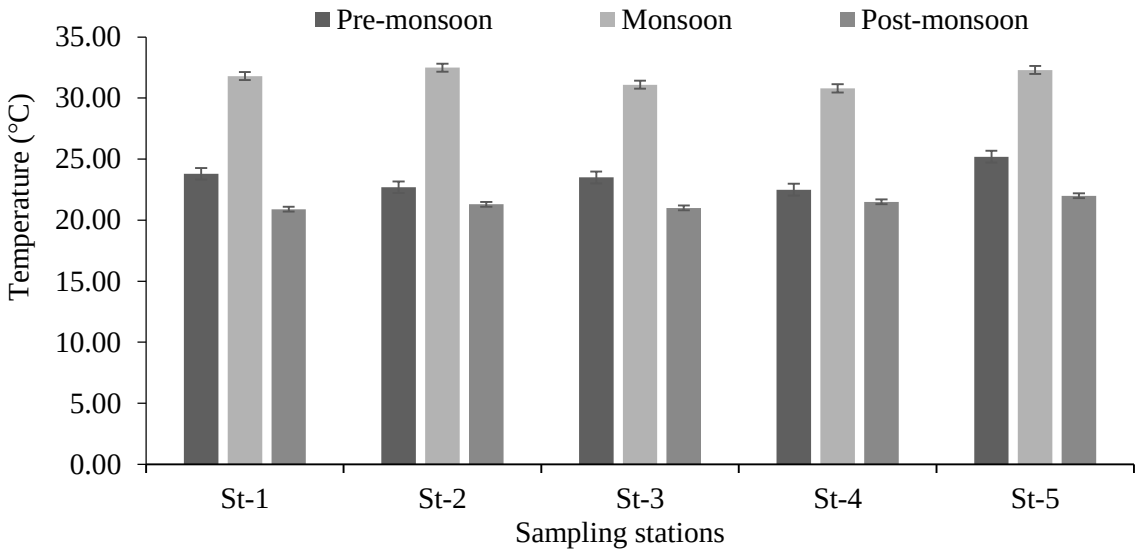

Figure 2: The temperature at various sampling stations during different seasons.

Transparency

The highest transparency level of 153.10 cm was found at St-2 during post-monsoon and the lowest transparency of 8.19 cm was found at St-5 during monsoon (Figure 3). On the other hand, the mean highest transparency of 54.30 cm was found in post-monsoon and the lowest transparency of 22.12 cm was found in monsoon season (Table 2). The transparency of productive water bodies should be no more than 40 cm (Rahman, 1992). It was indicated that the water of the studied beel was suitable for the aquatic organisms including fishes all through the three seasons, because of transparency within the desirable range. According to Sayeed *et al*. (2015), the highest Secchi depth was (278 cm) measured at the Baral site in October followed by the Gumani and the Katagang in October and August, respectively. The minimum transparency was 45 cm exhibited by the Baral site during March, which was closely followed

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by the Katagang and the Gumani site, respectively, in February (Sayeed *et al*., 2015). The transparency was found at 6.85 to 21.50 cm during wet and 5.25 to 13.75 cm during dry season in the Ashulia beel (Islam, Suravi and Meghla, 2010). The highest transparency of 303 cm was found in post-monsoon and the lowest transparency of 17 cm was found in monsoon season in the Kaptai Lake water (Islam *et al*., 2021).

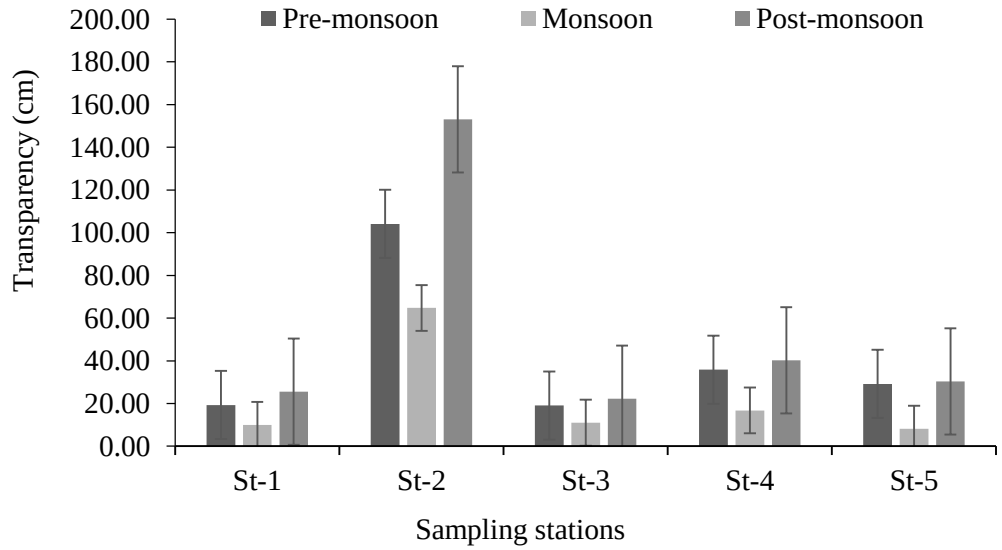

Figure 3: Transparency in different season at different sampling station

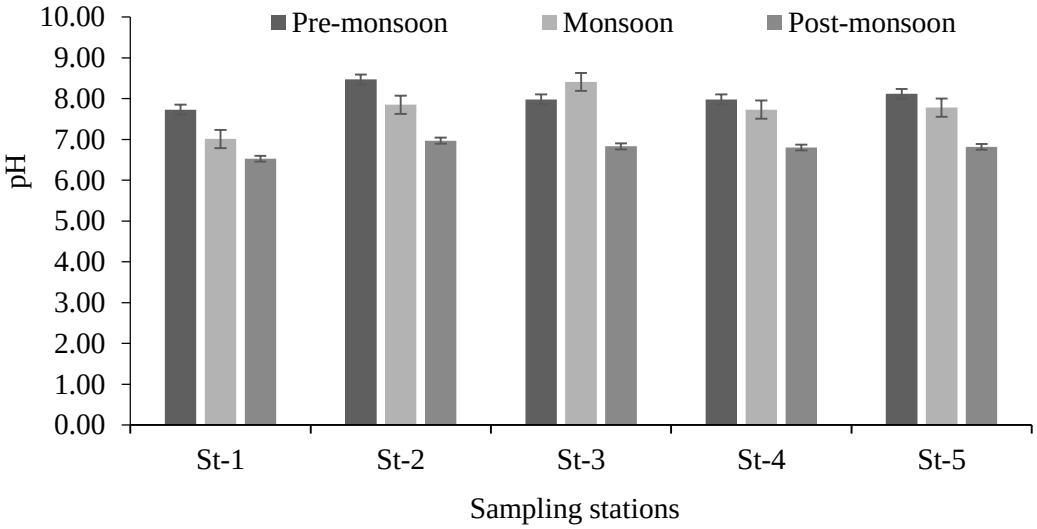

Figure 4: The pH in different season at different sampling station

pH

The highest pH level 8.47 was found at St-2 during pre-monsoon and lowest pH 6.53 was found at St-2 during post-monsoon (Figure 4). Generally, the mean highest pH was 8.06 found in pre-monsoon and the lowest 6.79 in post-monsoon season (Table 2). The standard limits of pH for inland surface water are 6.5

to 8.5 (EQS, 1997) and the study revealed that the pH values of all sampling stations were within the standard limit. Nahian *et al.* (2018) found that pH value was 8.14, 7.76 and 7.44 for pre-monsoon, monsoon and post-monsoon, respectively, in Gowain River. The average pH in wet and dry seasons was found 7.73 and 8.03, respectively, in the Tista River (Islam *et al.*, 2014), which is more or less parallel to the present study. The pH levels in Ashulia Beel were 7.1 to 7.8 in the wet season and 7.1 to 8.4 in the dry season, confirming the slightly alkaline quality of the beel water (Islam, Suravi and Meghla, 2010).

Total dissolved solid (TDS)

A constant level of minerals in the water is necessary for aquatic life; changes in the amounts of dissolved solids can be harmful because the density of total dissolved solids determines the flow of water in and out of an organism's cells. Concentrations that are too high or too low may limit the growth and may lead to the death of many fish or reefs (Weber-Scannell and Duffy, 2007). The highest and lowest TDS was found at St-2 (248 mg/L) and St-4 (56 mg/L) in pre-monsoon and post-monsoon season, respectively (Figure 5). Mean TDS contents were found 128.40, 103 and 85.39 mg/L in pre-monsoon, monsoon and post-monsoon season, respectively (Table 2). The standard level of TDS for aquatic environment or fisheries is 500 mg/L (EQS, 1997) and the results depict that river water had low TDS level. The mean values of total dissolved solids (TDS) at the different sites in the Chalan Beel were 158.64, 217.56 and 176.62 mg/L in the Gumani, Katagang and the Baral River, respectively (Sayeed *et al.* 2015). In the dry season, the TDS value ranged from 207 to 276 mg/L in the studied area which was higher than wet season and exceeded the standard limit in the Ashulia Beel (Islam, Suravi and Meghla, 2010). The mean highest TDS 80.5 mg/L was found in post-monsoon and the lowest TDS 44.5 mg/L was observed in monsoon season in the Kaptai Lake water (Islam *et al*., 2021).

Table 2: Water quality parameters along with Trophic State Index (TSI) in Chalan Beel

Parameters	*Seasons (mean ± SD)*		
	Pre-monsoon	*Monsoon*	*Post-monsoon*
Temperature (ºC)	23.54±1.07	31.70±0.74	21.34±0.44
Transparency (cm)	41.50±35.72	22.15±24.04	54.30±55.64
TDS (mg/L)	128.40±67.43	103.00±7.81	85.39±21.84
pH	8.06±0.27	7.76±0.49	6.79±0.16
DO (mg/L)	6.04±1.18	7.06±0.24	6.34±0.49
EC (µS/cm)	173.40±21.51	187.40±11.61	134.80±14.49
Alkalinity (mg/L)	105.20±45.41	100.00±28.48	122.01±22.93
Hardness (mg/L)	66.60±15.01	73.20±5.59	76.00±12.81
NH_3 (mg/L)	0.02±0.01	0.02±0.01	0.02±0.01
NO_3 (mg/L)	21.40±5.25	13.98±5.25	18.08±11.15
NO_2 (mg/L)	0.12±0.05	0.15±0.07	21.34±0.44
PO_4 (mg/L)	2.62±1.46	3.58±2.19	54.30±55.64
SO_4 (mg/L)	24.00±12.02	28.40±8.02	85.39±21.84
Chlorophyll *a* (µg/L)	1.36±0.34	1.31±0.49	0.99±0.17
TSI (SD)	75.91±10.01	86.60±11.98	73.09±11.21
TSI (CHL)	33.40±2.35	32.81±3.30	30.35±1.84

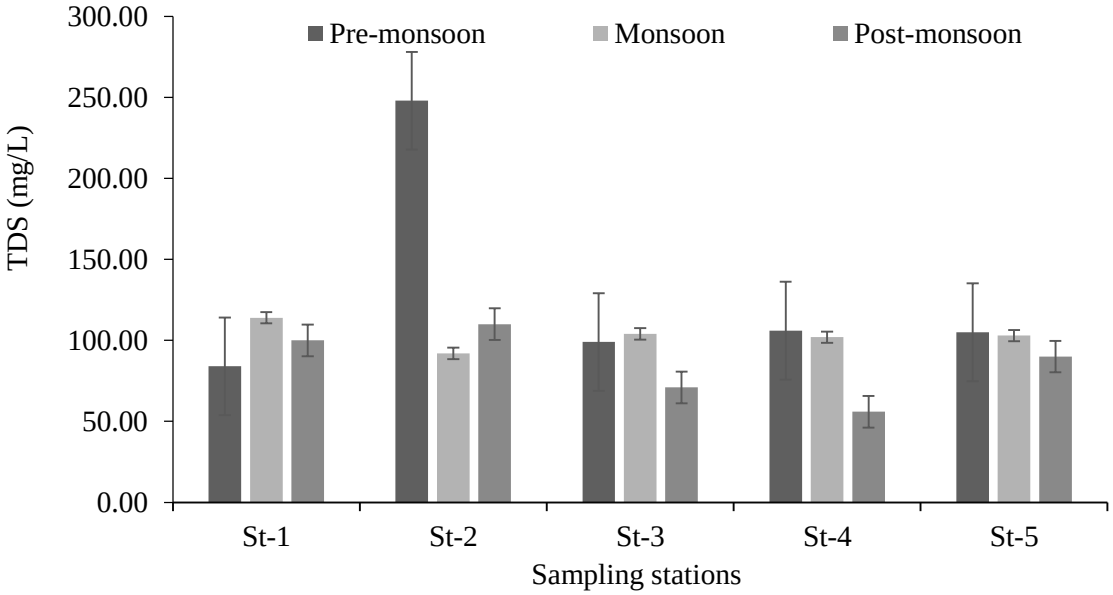

Figure 5: The TDS concentrations at various sampling stations during different seasons

Dissolved oxygen (DO)

The lowest DO (4.0 mg/L) was found at St-1 during pre-monsoon and the highest DO (7.40 mg/L) was found at St-1 during monsoon season (Figure 6). Usually, the highest DO (7.06 mg/L) was found in monsoon and the lowest DO (6.04 mg/L) was observed in pre-monsoon season (Table 2). When dissolved oxygen becomes too low, fish and other aquatic organisms cannot survive (Islam *et al*., 2017). Nahian *et al.* (2018) found their study in Gowain River the mean concentration of DO was 4.86, 5.18 and 4.42 mg/L in pre-monsoon, monsoon and post-monsoon season, respectively. Adequate DO is needed to maintain good water quality, aquatic organism endurance, and microorganism putrefaction of waste (Islam, Suravi and Meghla, 2010; Rahman *et al.*, 2012). For fisheries, the optimal DO concentrations ranged from 4 to 6 mg/L (Boyd, 1998), below which most aquatic species will perish. In Dhaleswari River, the lowest value of DO was observed 4.9 mg/L in monsoon and 4.1 mg/L in post-monsoon season, suggesting that the concentration of DO was higher in monsoon than in post-monsoon and pre-monsoon seasons (Islam *et al.*, 2012). However, the present investigation disclosed that the obtained results of DO were within the permissible limit (5 mg/L) for aquatic environment established by ECR (1997). The range of investigated DO was 1.1 to 2.1 mg/1 during the wet and 0.5 to 2.0 mg/1 during the dry season indicated that observed DO content was much lower than the desired limit and the Ashulia Beel water quality was not suitable for fisheries and aquatic organisms (Islam, Suravi and Meghla, 2010). During the study period, the averages DO of the different stations all through the seasons ranged from 6.35 to 7.21 mg/L in the Kaptai Lake water (Islam *et al*., 2021).

Electrical conductivity (EC)

The lowest EC value 109 µS/cm was found at St-3 during post-monsoon and the highest EC 199.0 µS/cm was found at St-4 during pre-monsoon (Figure 7). On an average, the mean highest EC 187.40 µS/cm was found in monsoon and the lowest EC 134.80 µS/cm was observed in post-monsoon (Table 2). For inland surface water EC contents 800 to 1000 µS/cm is suitable for aquatic environment (ECR, 1997) and the EC contents of Chalan Beel was very lower than the standard. The EC contents of Turag River water ranged from 691 to 822 µS/cm, 618 to 1334 µS/cm and 155 to 276 µS/cm in post monsoon, pre-monsoon and monsoon season, respectively, and in the monsoon season, the flow of the river increases that may cause

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the dilution of the salinity of the water, while in dry season, the flow of the river decreases resulting into an increase of EC (Meghla *et al.*, 2013). The higher values of conductivity were obtained during low rainfall months and low conductivity values were obtained during the high rainfall months (Kabir *et al*., 2020). In wet season the range of EC was 130 to 310 µS/cm, and in dry season the range of EC was 341 to 442 µS/cm in the Ashulia Beel water (Islam, Suravi and Meghla, 2010). Usually, the highest EC of 141.24 µS/cm was found in post-monsoon and the lowest of EC 82.50 µS/cm was observed in monsoon season in the Kaptai Lake water (Islam *et al*., 2021).

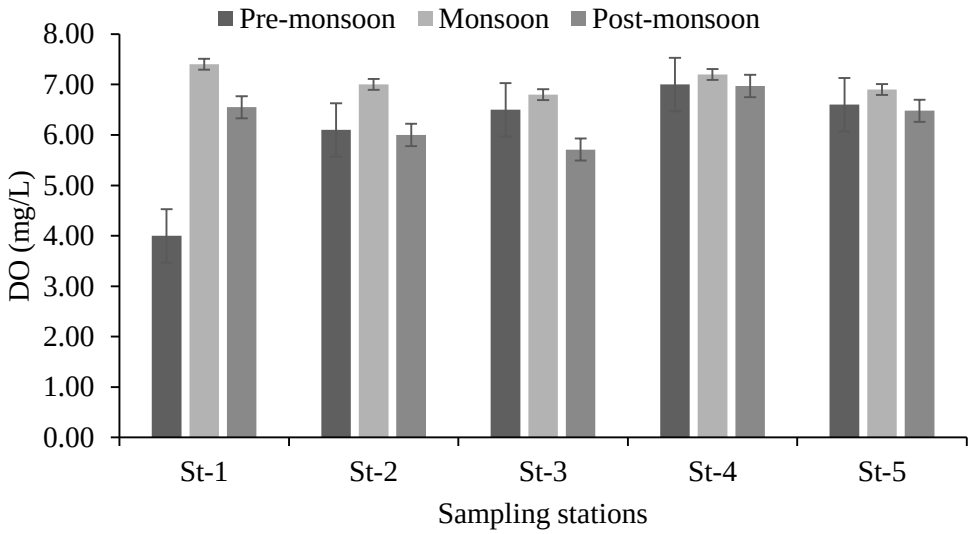

Figure 6: The DO contents in different season at different sampling station

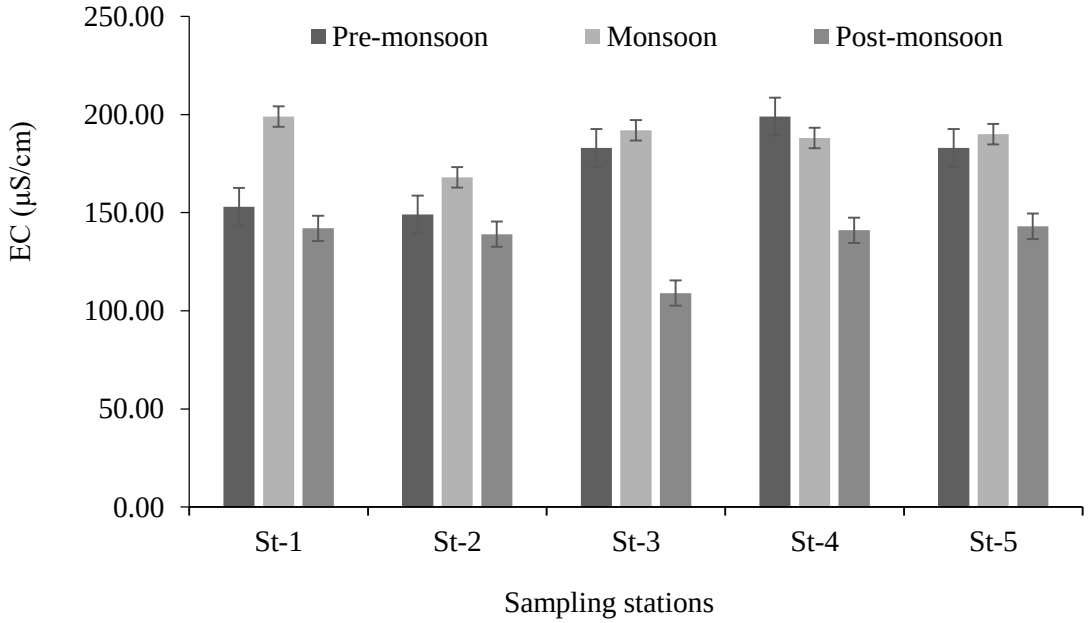

Figure 7: The EC contents in different season at different sampling station

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Total alkalinity

The lowest alkalinity 55 mg/L was found at St-1 during post-monsoon and highest alkalinity 156 mg/L was found at St-3 during pre-monsoon season (Figure 8). On an average, the highest alkalinity of 122.01 mg/L was found in post-monsoon and the lowest alkalinity of 100.0 mg/L was observed in monsoon season (Table 2). According to Nahian *et al.* (2018), the mean alkalinity was 279.30, 163.95 and 188.16 mg/L in pre-monsoon, monsoon and post-monsoon season, respectively. According to Rahman (1992), standard value of alkalinity is >100 mg/L for fresh water and most of the water samples. Mobin *et al.* (2014) determined the minimum alkalinity 109.98 mg/L at Ashulia Beel in monsoon season and maximum 411.10 mg/L at Abdullapur in pre-monsoon season of the Turag River. In monsoon, post-monsoon, and pre-monsoon seasons, the concentration of alkalinity in Dhaleshwari River was found to vary from 126 to 200, 150 to 595 and 450 to 640 mg/L, respectively (Islam *et al.*, 2012). The highest alkalinity 137.5 mg/L was found in post-monsoon and the lowest alkalinity 62.5 mg/L was observed in monsoon season in the Kaptai Lake water (Islam *et al*., 2021). The concentration of alkalinity was found 30 to 63 mg/L in wet and from 90 to 115 mg/L in dry season in the Ashulia Beel water (Islam, Suravi and Meghla, 2010).

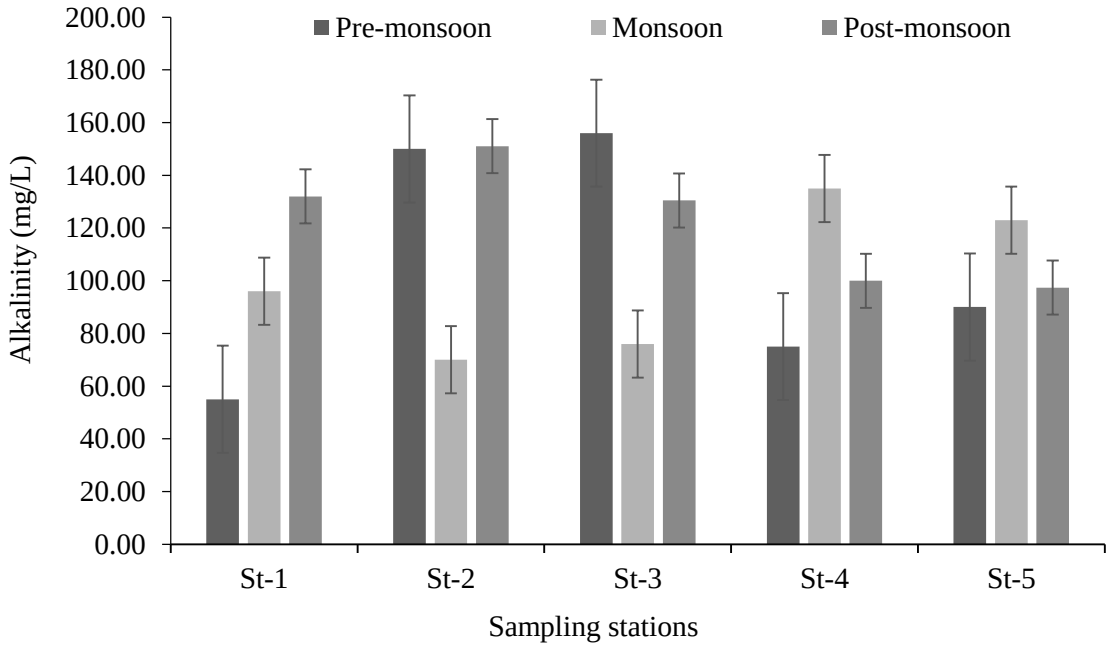

Figure 8: The total alkalinity contents in different season at different station

Total hardness

The most important impact of hardness on fish and other aquatic life seems to be the effect the presence of these ions has on the other more toxic metals such as lead, cadmium, chromium and zinc. Generally, harder the water, lower the toxicity of other metals to aquatic life (Islam *et al.*, 2015). The lowest hardness 43 mg/L was found at St-1 during pre-monsoon and highest hardness 95 mg/L was found at St-1 during post-monsoon (Figure 9). The average highest hardness 76.01 mg/L was found in post-monsoon and the lowest hardness 66.60 mg/L was found in monsoon season (Table 2). Hardness of water is due to the presence of chloride, sulfate, carbonate and bicarbonate (Rahman *et al.*, 2012). Accordingly, the water of the Chalan Beel may be regarded as slightly hard (Rahman, Rahman and Asaduzzaman, 2010). The optimum hardness for aquatic organism is 123 mg/L (Huq and Alam, 2008), and this study revealed that

hardness contents were more or less suitable for fisheries. The average hardness in Tista river water of wet and dry seasons was found 98.48 and 102.46 mg/L, respectively (Islam *et al.,* 2015), which is closely analogous to the present investigation. The value of hardness was found to vary from 30.0 to 91.3 mg/L in wet and from 115 to 127 mg/L in dry season in the Ashulia Beel water (Islam, Suravi and Meghla, 2010). The average highest hardness 71.25 mg/L was found in pre-monsoon and the lowest hardness 43 mg/L was found in monsoon season in the Kaptai Lake water (Islam *et al*., 2021).

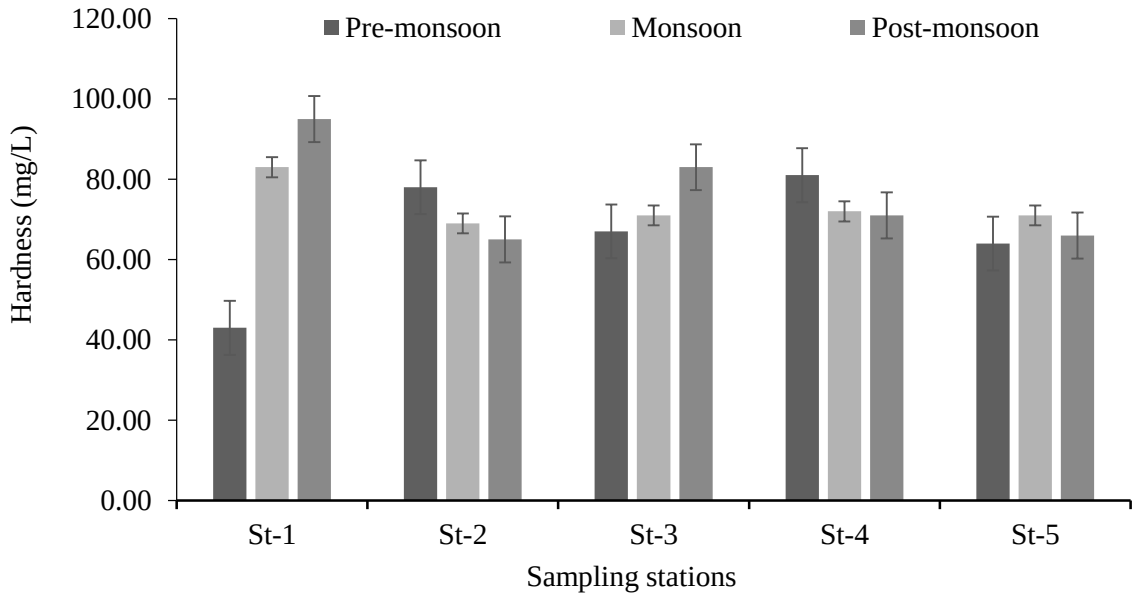

Figure 9: The total hardness contents in different season at different station

Dissolved Nutrients

Ammonia (NH_3)

The lowest concentration 0.01 mg/L was found at St-1 along with several stations during pre-monsoon, monsoon and post-monsoon and highest concentration 0.04 mg/L was found at St-5 during post-monsoon (Figure 10). In Kaptai Lake, the lowest concentration (0.01 mg/L) of NH_3 was found at St-1 along with St-4 during pre-monsoon and highest concentration (0.5 mg/L) was found at St-4 during monsoon season (Islam *et al.,* 2021). Rahman (1992) stated that high concentration of ammonia (12 mg/L or more) in water could be due to organic pollution, gas work pollution, and high decomposition that may be lethal to fish and other aquatic organisms. In Sundarbans, the NH_3-N concentrations were 0.035, 0.037 and 0.07 mg/L during high tide in pre-monsoon, monsoon and post-monsoon, respectively; and the NH_3-N concentrations were 0.078, 0.034 and 0.052 mg/L during low tide in pre-monsoon, monsoon and post-monsoon season, respectively (Nion *et al*., 2020).

Nitrate (NO_3)

The lowest NO_3 concentration (4.10mg/L) was found at St-4 during post-monsoon and highest concentration (35.20 mg/L) was found at St-4 during post-monsoon season (Figure 11). The mean highest concentration of NO_3 (21.4 mg/L) was recorded during pre-monsoon while the lowest concentration (13.98 mg/L) was found during monsoon season (Table 3). Islam *et al.* (2021) reported that the mean

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highest concentration of NO_3 (1.625 mg/L) was recorded during post-monsoon while the lowest concentration (1.25 mg/L) was found during pre-monsoon season in Kaptai Lake water. According to Kamal *et al.* (2007) in Mouri River showed the maximum NO_3 concentration as 1.85 mg/L in St-2, and varied from 0.57 to 1.85 mg/L.

Table 3: Dissolved nutrient concentrations in water of Chalan Beel

DN	*Pre-monsoon*					*Monsoon*					*Post-monsoon*				
(mg/L)	*St-1*	*St-2*	*St-3*	*St-4*	*St-5*	*St-1*	*St-2*	*St-3*	*St-4*	*St-5*	*St-1*	*St-2*	*St-3*	*St-4*	*St-5*
NH_3	0.01	0.02	0.01	0.03	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.01	0.02	0.03	0.04
NO_3	20.40	15.20	18.10	25.10	28.20	10.3	8.20	18.10	5.10	28.20	17.80	15.20	18.10	4.10	35.20
NO_2	0.07	0.15	0.09	0.10	0.18	0.11	0.20	0.11	0.08	0.25	0.10	0.09	0.21	0.20	0.28
PO_4	5.20	1.80	2.10	2.30	1.70	7.20	4.10	2.50	2.20	1.90	4.20	1.50	2.15	2.20	1.80
SO_4	12	40	15	20	33	25	40	24	20	33	22	10	13	25	40

Note: DN = Dissolve Nutrients.

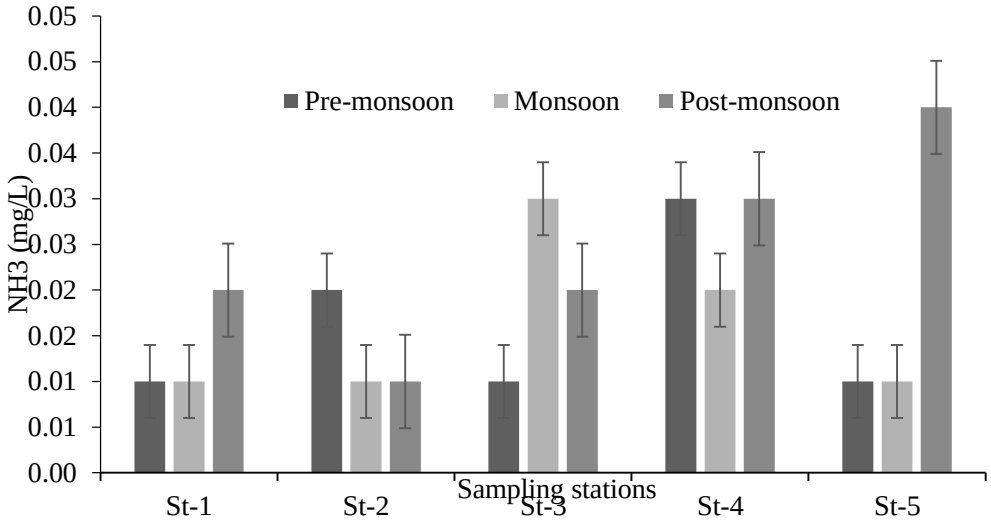

Figure 10: Concentration of NH3 in different season at different station

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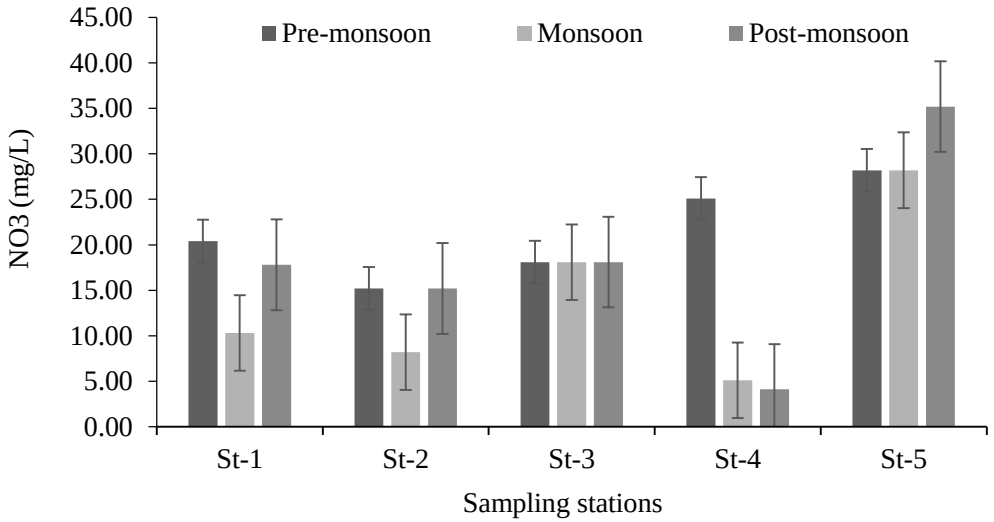

Figure 11: Concentration of NO_3 in different season at different station.

Nitrite (NO_2)

The concentrations of NO_2 at four stations were within the range of 0.07 (at St-1 along the study period during pre-monsoon) to 0.28 mg/L (at St-5 during monsoon) (Figure 12). However, the mean highest concentration of NO_2 (0.18 mg/L) was recorded during post-monsoon while the lowest concentration of NO_2 (0.12 mg/L) was found during pre-monsoon (Table 3). Islam *et al.* (2021) found that the mean highest concentration of NO_2 (0.025 mg/L) was recorded during monsoon while the lowest concentration of NO_2 (0.02 mg/L) was found during pre-monsoon and post-monsoon season in Kaptai Lake. The mean highest concentration of NO_2 (0.025 mg/L) was recorded during monsoon while the lowest concentration of NO_2 (0.02 mg/L) was found during pre-monsoon and post-monsoon season in Sundarbans mangrove water (Nion *et al*., 2020).

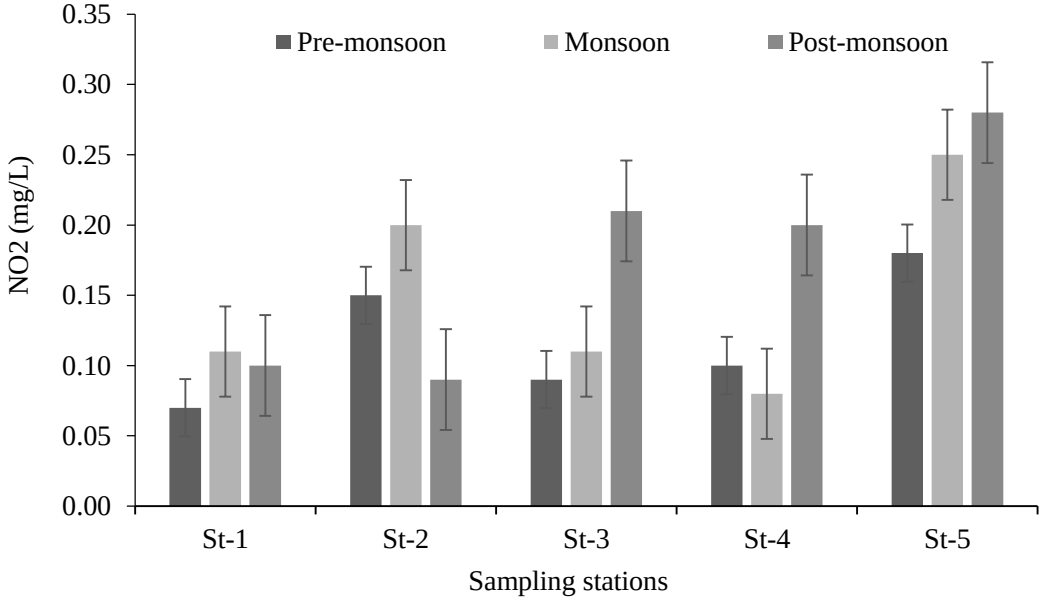

Figure 12: Concentration of NO_2 in different season at different station

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Phosphate (PO_4)

The lowest concentration 1.50 mg/L was found at St-2 during post-monsoon and highest concentration 5.20 mg/L was found at St-1 during pre-monsoon (Figure 13). On average the highest concentration of PO_4 (3.58 mg/L) was recorded during monsoon while the lowest concentration of PO_4 (2.37 mg/L) was found during post-monsoon (Table 3). Phosphate is one of the limiting nutrients for floral growth in freshwater bodies that regulate phytoplankton production (Pal and Chakraborty, 2014). In a study the phosphate level was recorded in the winter season 0.225 mg/L and 0.825 mg/L in the summer season (Sarwade and Kamble, 2014). Manohar (2018) found the mean monthly lowest and highest amount of total phosphorus 329.21 and 1246.38 mg/L, respectively, at two different sampling stations, whereas the average value of phosphorus was 796.66 mg/L. The highest concentration of PO_4 (1.81 mg/L) was recorded during monsoon, while the lowest concentration (1.13 mg/L) was found during post-monsoon season in the Kaptai Lake water (Islam *et al.*, 2021).

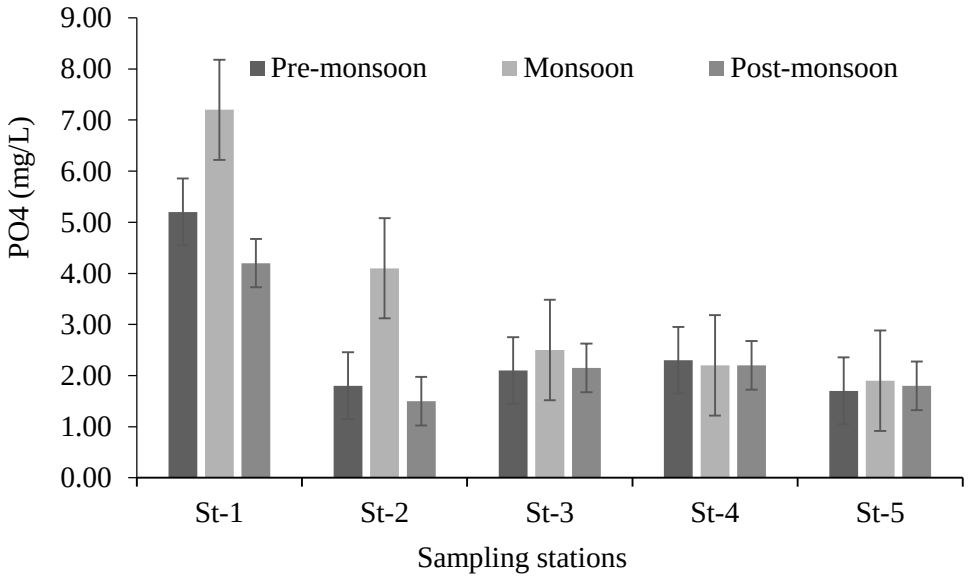

Figure 13: Concentration of PO_4 in different season at different station

Sulphate (SO_4)

The lowest concentration 10 mg/L was found at St-2 during post-monsoon and highest concentration 40 mg/L was found at St-2 during pre-monsoon and monsoon and at St-5 during post-monsoon, respectively (Figure 14). On average the highest concentration of SO_4 was 28.40 mg/L recorded during monsoon while the lowest concentration of SO_4 was found 22 mg/L during post-monsoon (Table 3). Concentration of SO_4 at Rangamati points varied from 0.76 to 1.64 mg/L in rainy season and 2.91 to 3.50 mg/L in dry season. The safe limits for SO_4 concentration for aquaculture ranged from 5 to 100 mg/L (Boyd, 1998) and values in both the seasons were much below this range, except at Subolong in dry season (Karmakar *et al.*, 2011). The highest concentration of SO_4 (69.75 mg/L) was recorded during post-monsoon while the lowest concentration of SO_4 (57 mg/L) was found during monsoon season in the Kaptai Lake water (Islam *et al.*, 2021).

Biological Parameter

Chlorophyll a

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The highest Chlorophyll *a* was found 2.12 µg/L at St-4 during monsoon and the lowest 0.70 µg/L was found at St-1 during post-monsoon season (Figure 15). The mean highest Chlorophyll *a* of 1.63 µg/L was found in monsoon and the lowest 0.99 µg/L was in post-monsoon season. The mean highest Chlorophyll *a* (1.60 µg/L) was found in monsoon and the lowest (0.98 µg/L) was found in post-monsoon season in the Kaptai Lake water (Islam *et al.*, 2021). The concentrations of chlorophyll a ranged from 0.611 to 0.840, 0.217 to 1.168 and 0.180 to 1.75 mg/L during high tide, and 0.638 to 0.883, 0.218 to 1.189 and 0.69 to 1.88 mg/L during low tide over pre-monsoon, monsoon and post-monsoon season, respectively in the Sundarbans mangrove water (Nion *et al*., 2020).

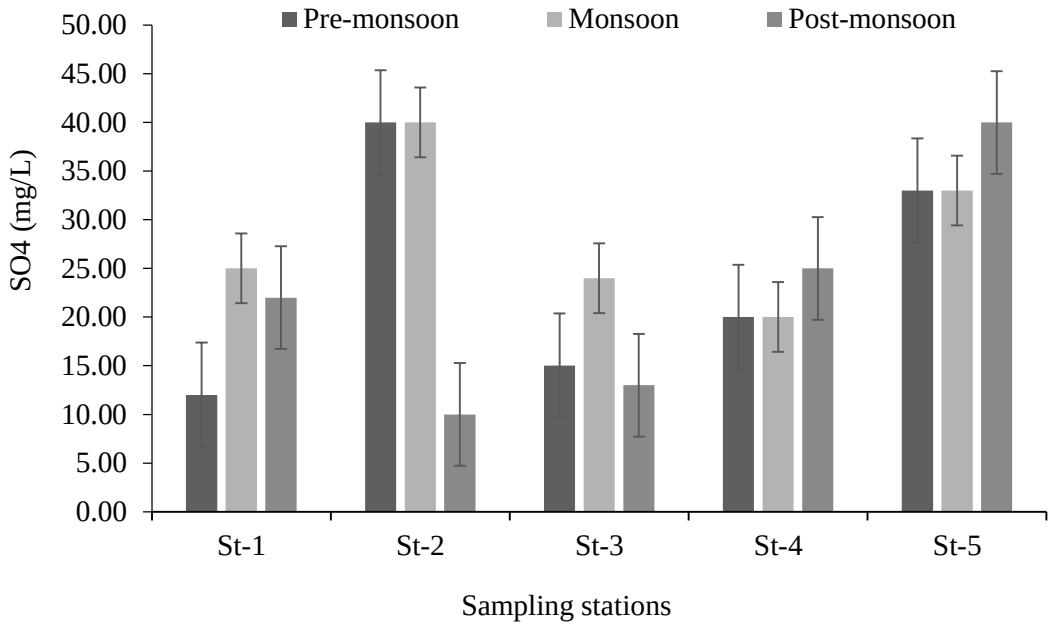

Figure 14: Concentration of SO_4 in different season at different station

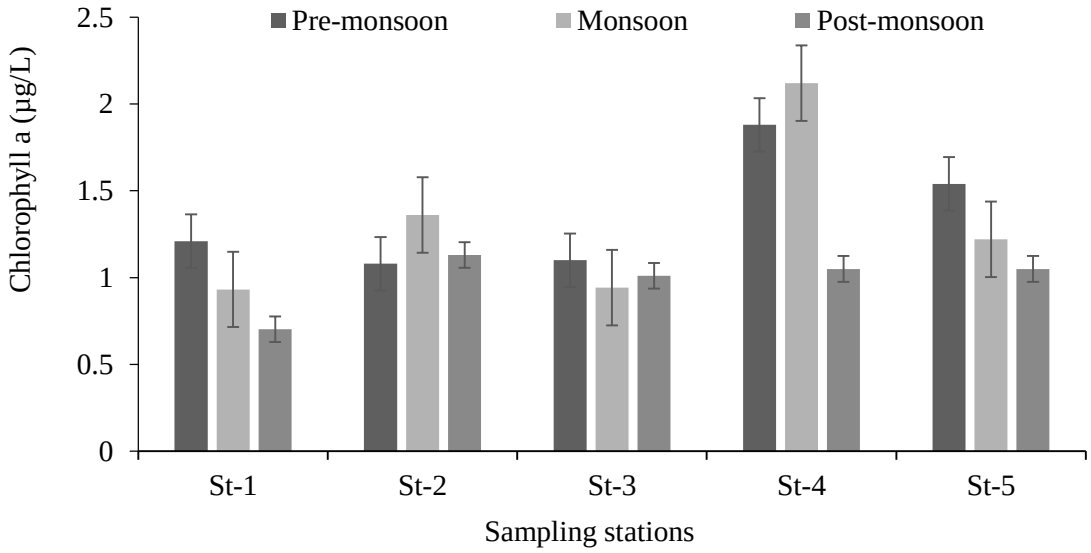

Figure 15: The context of Chlorophyll *a* in different season at different station

Estimation of Trophic State Index (TSI)

Chlorophyll a TSI

The highest Chlorophyll *a* TSI 37.97 was found at St-4 during monsoon and the lowest Chlorophyll *a* TSI 27.14 was found at St-1 during post-monsoon season (Figure 16). However, on average the highest Chlorophyll *a* TSI 33.40 was found in pre-monsoon and the lowest Chlorophyll *a* TSI 30.35 was found in post-monsoon season. Khondker *et al.* (2010) recorded Chlorophyll *a* TSI 41.24 in Bogakain Lake of Bandarban, Bangladesh. According to Yang *et al.* (2012), on the basis of Chlorophyll *a* TSI, the *Beel* is oligo-mesotrophic (30<TSI≤40). The highest Chlorophyll *a* TSI (34.56) was found in pre-monsoon and the lowest Chlorophyll *a* TSI (29.71) was found in post-monsoon season in the Kaptai Lake water (Islam *et al.*, 2021).

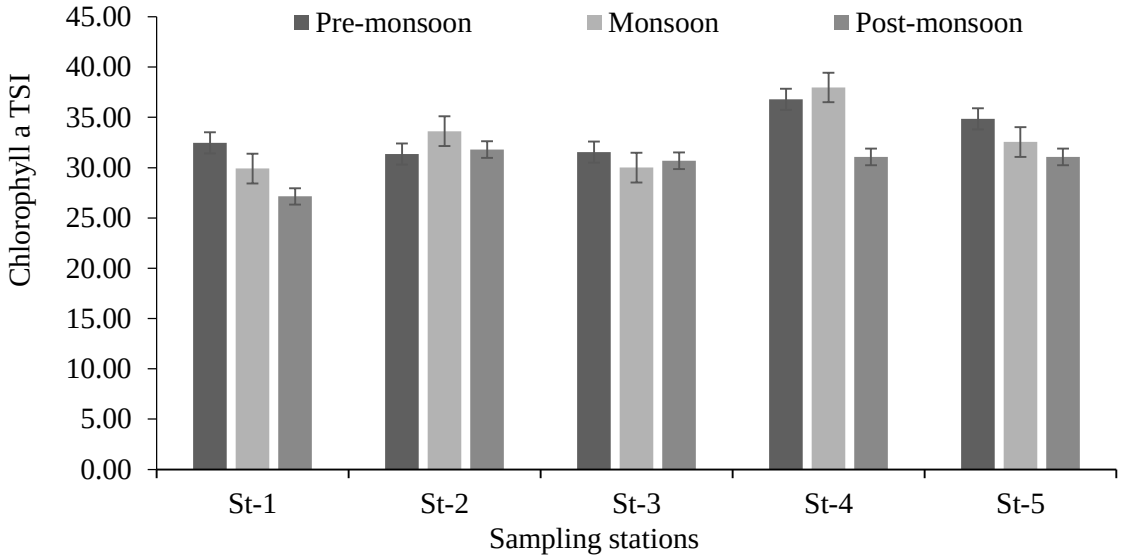

Figure 16: The status of Chlorophyll *a* TSI in different season at different sampling station

Secchi disc TSI

The highest Secchi disc TSI (96.05) was found at St-5 during monsoon and the lowest Secchi disc TSI (53.86) was found at St-2 during post-monsoon season (Figure 17). On average the highest Secchi disc TSI (86.60) was found in monsoon and the lowest Secchi disc TSI (73.09) was found in post-monsoon season. The Secchi disc TSI of Kaptai Lake recorded 48.19 in pre-monsoon and 53.00 in post-monsoon season (Rahman *et al.*, 2014). The average TSI (SD) was found 89.80, 107.83 and 100.73 in pre-monsoon, monsoon and post-monsoon season, respectively, in Kaptai Lake (Islam *et al.*, 2021). Results of the study found that according to Yang *et al.* (2012) on basis of Secchi disc TSI the *Beel* has middle eutrophic (60<TSI≤70) condition.

Source analysis of water quality parameters and Chlorophyll a

Pearson's correlation analysis is a useful statistical method for demonstrating the degree to which one variable is dependent on the others (Kabir *et al.*, 2020). Actually, correlation coefficient is used to measure the interrelation and extent of associations among the variables. Correlation coefficient value +1

indicates a perfect relationship between the variables, and −1 indicates perfect relationship, but the variables vary inversely, and a zero value means no relationship between the variables (Shil, Singh and Mehta, 2019). For statistical analysis, the real values of the variables (temperature, transparency, pH, EC, TDS, DO, alkalinity, hardness, ammonia, nitrate, nitrite, phosphate, sulphate and chlorophyll a) were used (Table 4). The correlation matrix (Table 4) showed the actual Pearson's correlation coefficient values. Significant positive correlations exist between Trans.-TDS, Trans.-pH, TDS-pH, pH-SO_4 and NO_2-SO_4 during the pre-monsoon season. The analysis showed a significant positive association between EC-TDS and Temp.-NO_2 during the monsoon season (Table 4). This indicates that the variables are changing in a direct proportional relationship. However, strong positive correlation between PO_4-Hardness, SO_4-NH_3 and pH-Chlorophyll *a* were also observed throughout the post-monsoon seasons (Table 4). A reasonable and considerable negative correlation was also identified for pH-DO, showing that they change in an inverse proportionate manner.

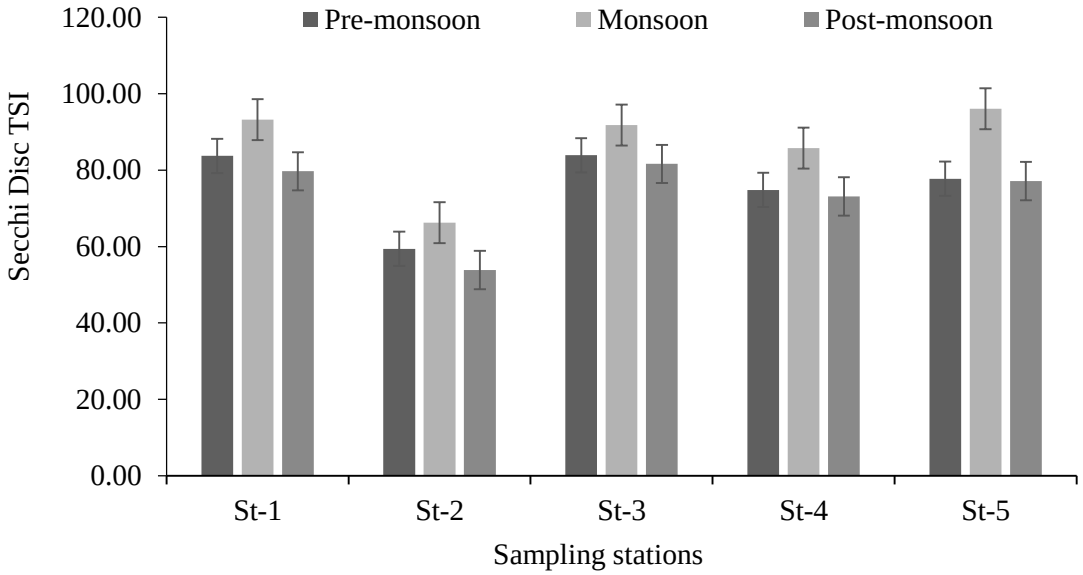

Figure 17: The status of Secchi disc TSI in different season at different sampling station

Table 4. Pearson correlation coefficients (r) among physicochemical parameters, dissolved nutrients and Chlorophyll *a* in Chalan Beel water

Para-meter	*Temp.*	*Trans.*	*TDS*	*pH*	*DO*	*EC*	*Alkal.*	*Hard.*	*NH_3*	*NO_3*	*NO_2*	*PO_4*	*SO_4*	*Chlor. a*
Pre monsoon														
Temp.	1													
Trans.	-.469	1												
TDS	-.436	.991**	1											
pH	-.210	.892*	.909*	1										
DO	-.131	.156	.155	.482	1									
EC	.045	-.506	-.533	-.237	.731	1								
Alkal.	-.239	.484	.582	.658	.423	-.128	1							
Hard.	-.543	.550	.528	.684	.863	.426	.484	1						
NH_3	-.760	.401	.310	.270	.467	.348	-.096	.749	1					
NO_3	.555	-.529	-.595	-.323	.302	.664	-.640	-.041	.064	1				

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Parameter	*Temp.*	*Trans.*	*TDS*	*pH*	*DO*	*EC*	*Alkal.*	*Hard.*	*NH_3*	*NO_3*	*NO_2*	*PO_4*	*SO_4*	*Chlor. a*
NO_2	.427	.467	.467	.738	.484	.016	.245	.390	-.025	.311	1			
PO_4	.030	-.401	-.428	-.742	-.920*	-.434	-.636	-.828	-.279	-.105	-.702	1		
SO_4	.056	.805	.799	.929*	.395	-.240	.387	.528	.186	-.044	.901*	-.660	1	
Chlor. *a*	-.024	-.276	-.379	-.202	.473	.760	-.588	.352	.614	.817	.117	-.176	-.048	1
Monsoon														
Temp.	1													
Trans.	.363	1												
TDS	-.197	-.810	1											
pH	-.288	.117	-.550	1										
DO	-.097	-.100	.532	-.909*	1									
EC	-.333	-.948*	.951*	-.321	.320	1								
Alkal.	-.247	-.538	.255	-.280	.288	.382	1							
Hard	-.003	-.440	.877	-.823	.807	.688	.074	1						
NH_3	-.806	-.321	.036	.719	-.441	.236	-.128	-.280	1					
NO_3	.437	-.446	.124	.295	-.614	.278	.100	-.200	-.019	1				
NO_2	.879*	.296	-.428	.088	-.463	-.420	-.065	-.405	-.584	.652	1			
PO_4	.257	.100	.502	-.768	.736	.213	-.364	.837	-.451	-.398	-.233	1		
SO_4	.863	.734	-.643	.067	-.339	-.746	-.456	-.404	-.600	.226	.843	.033	1	
Chlor. *a*	-.443	.165	-.388	.024	.196	-.301	.634	-.357	.034	-.492	-.239	-.448	-.239	1
Post monsoon														
Temp.	1													
Trans.	.016	1												
TDS	-.109	.570	1											
pH	.409	.649	-.007	1										
DO	.379	-.289	-.327	-.413	1									
EC	.465	.232	.343	-.198	.748	1								
Alkal.	-.697	.632	.639	.135	-.667	-.264	1							
Hard.	-.787	-.543	.006	-.852	-.049	-.273	.241	1						
NH_3	.759	-.633	-.449	-.151	.554	.278	-.962**	-.240	1					
NO_3	.475	-.197	.426	-.010	-.250	.060	-.196	-.131	.455	1				
NO_2	.694	-.573	-.562	.175	.136	-.169	-.827	-.346	.870	.480	1			
PO_4	-.589	-.489	.117	-.970**	.302	.154	.093	.907*	-.091	-.114	-.397	1		
SO_4	.766	-.521	-.165	-.258	.608	.508	-.859	-.208	.947*	.571	.705	.033	1	
Chlor. *a*	.561	.521	-.174	.972**	-.227	-.118	-.095	-.915*	.057	-.018	.342	-.990**	-.077	1

Conclusions

The study concluded that physiochemical parameters of Chalan Beel such as transparency, pH, EC, total hardness, total alkalinity, NH_3, SO_4 and NO_2 concentrations were in favor of fisheries. The mean concentration of PO_4, NO_3, DO, TDS and temperature exceeded the recommended value for fisheries throughout the study period. Presence of excessive amount of TDS in the reservoir is at most alarming condition. Results of the study revealed that wetland was in mesotrophic condition and positive relationships exist between Chlorophyll *a* and trophic state index (TSI). Despite receiving trash from various anthropogenic sources, the water quality of Chalan Beel is still good. The current study is a baseline investigation of the Chalan Beel's seasonal variation of physicochemical characteristics, which will provide useful information for wetland ecosystem management and conservation.

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References

APHA (American Public Health Association) (2005). Standard methods for the examination of water and wastewater. 21st ed. Washington, DC: American Public Health Association. Available online at: http://www.ncbi.nlm.nih.gov/pubmed/17489283 [Accessed on 11 March 2022].

Banglapedia (2004). National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, 1st edn. February 2004. Dhaka, Bangladesh. Available online at: https://www.banglapedia.org [Accessed on 17 April 2022]

Boyd, C.E. (1998). Water quality for pond aquaculture. Alabama: International Center for Aquaculture and Aquatic Environments, Auburn University, pp. 37.

ECR (Environment Conservation Rules) (1997). Environment conservation rules. Bangladesh: Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, pp. 22-24.

EQS (Environmental Quality Standards) (1997). Environmental quality standard. Bangladesh: Bangladesh Gazette, Registered. Department of Environment, Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, pp. 205-208.

Haque, M.A., Nabi, M.R.U., Billah, M.M., Asif, A.A., Rezowan, M., Mondal, M.A.I., Siddiqui, A.A.M., Mahmud, S.S. and Khan, M.R. (2018). Effect of water parameters on temporal distribution and abundance of zooplankton at Kaptai Lake reservoir, Rangamati, Bangladesh. *Asian Journal of Medical and Biological Research*, 4(4): 389-399. DOI: https://doi.org/10.3329/ajmbr.v4i4.40112

Hasan, M.R. (2004). Oxbow lakes and floodplain fisheries sustainable livelihoods: A lesson from the wetland country, Bangladesh, Book of abstracts. In: *Seventh INTECOL Interventional Wetlands Conference, Utrecht, The Netherlands* (Vol. 122).

Hossain, M.A., Nahiduzzaman, M., Sayeed, M.A., Azim, M.E., Wahab, M.A. and Olin, P.G. (2009). The Chalan *Beel* in Bangladesh: habitat and biodiversity degradation, and implications for future management. *Lakes and Reservoirs Research and Management*, 14(1): 3-19. DOI: https://doi.org/10.1111/j.1440-1770.2009.00387.x

Hossain, M.B., Shanta, T.B., Ahmed, A.S., Hossain, M.K. and Semme, S.A. (2019). Baseline study of heavy metal contamination in the Sangu River estuary, Chattogram, Bangladesh. *Marine Pollution Bulletin*, 140: 255-261. DOI: https://doi.org/10.1016/j.marpolbul.2019.01.058

Huq, S.M.I. and Alam, M.D. (2008). A handbook on analysis of soil, plant and water. BACERDU, University of Dhaka, Bangladesh, pp. 246.

Iqbal, I. (2006). The railway in colonial India: between ideas and impacts. In: R. Srinivasan, M. Tiwari and S. Silas (eds.), *Our Indian Railway: Themes in Indian Railway History*, New Delhi, India: Foundation Books Pvt. Ltd., pp. 173-186.

Islam, M.S., Ali, Y., Kabir, M.H., Zubaer, R.M., Meghla, N.T., Rehnuma, M. and Hoque, M.M.M. (2021). Assessment of temporal variation of water quality parameters and the trophic state index in a subtropical water reservoir of Bangladesh. *Grassroots Journal of Natural Resources*, 4(3): 164-184. DOI: https://doi.org/10.33002/nr2581.6853.040313

Islam, M.S., Islam, M.A., Islam, M.J., Kabir, M.H. and Meghla, N.T. (2014). Status of water quality in the Tista River at Kaunia point and its impact on aquatic environment. *Journal of Environmental Science and Natural Resources*, 8(1): 29-33. DOI: https://doi.org/10.3329/jesnr.v8i1.24660

Islam, M.S., Meghla, N.T., Suravi and Sultana, N. (2012). Status of water quality in the Dhaleshwari River and its effect on aquatic organism. *Journal of Environmental Science and Water Resources*, 1(8): 192-201. Available online at: https

://journaldatabase.info/articles/status_water_quality_dhaleshwari_river.html [Accessed on 14 April 2022]

Islam, M.S., Rehnuma, M., Tithi, S.S., Kabir, M.H. and Sarkar, L. (2015). Investigation of water quality parameters from Ramna, Crescent and Hatirjheel Lakes in Dhaka City. *Journal of Environmental Science and Natural Resources*, 8(1): 1-5. DOI: https://doi.org/10.3329/jesnr.v8i1.24620

Islam, M.S., Shil, S.C., Kabir, M.H. and Hoq, M.E. (2017). Investigation of heavy metal contamination in fishes from Passur River near the Sundarbans mangroves of Bangladesh. *Journal of Environmental Science and Natural Resources*, 10(1): 21-24. DOI: https://doi.org/10.3329/jesnr.v10i1.34689

Islam, M.S., Suravi and Meghla, N.T. (2010). Investigation on water quality in the Ashulia Beel, Dhaka. *Bangladesh Journal of Fisheries Research*, 14(1-2): 55-64. DOI: http://hdl.handle.net/1834/34274

Kabir, M.H., Tusher, T.R., Hossain, M.S., Islam, M.S., Shammi, R.S., Kormoker, T. and Islam, M. (2020). Evaluation of spatiotemporal variations in water quality and suitability of an ecologically critical urban river employing water quality index and multivariate statistical approaches: a study on Shitalakhya River, Bangladesh. *Human and Ecological Risk Assessment: An International Journal*, 27(5): 1388-1415. DOI: https://doi.org/10.1080/10807039.2020.1848415

Kamal, D., Khan, A.N., Rahman, M.A. and Ahamed, F. (2007). Study on the physicochemical properties of water of Mouri River, Khulna, Bangladesh. *Pakistan Journal of Biological Sciences*, 10(5): 710-717. DOI: 10.3923/pjbs.2007.710.717

Karim, S.M.R., Halim, K.M.A., Uddin, M.A., Yeasmin M.F. and Hasanuzzaman K.M. (2020). Investigation on species composition in Chalan *Beel* of Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 6: 88-91. DOI: https://doi.org/10.22271/fish.2020.v8.i6b.2364

Karmakar, S., Haque, S.S., Hossain, M.M. and Shafiq, M. (2011). Water quality of Kaptai Reservoir in Chittagong hill tracts of Bangladesh. *Journal of Forestry Research*, 22(1): 87-92. DOI: https://doi.org/10.1007/s11676-011-0131-6

Khan, M.A.G., Chowdhury, S.H. and Paul, J.C. (1996). Community structure and ecology of microbenthic invertebrate fauna of Lake Kaptai, Bangladesh. *Tropical Ecology*, 37(2): 229-245.

Khondker, M., Alfasane, M.A., Islam, M.S., Bhuiyan, M.A.H. and Gani, M.A. (2010). Limnology of Lake Bogakain, Bandarban, Bangladesh. *Bangladesh Journal of Botany*, 39(2): 153-159. DOI: https://doi.org/10.3329/bjb.v39i2.7301

Manohar, S. (2018). Physicochemical parameters and planktonic species as indicators to assess water quality of River basin and Winam (Nyanza) Gulf of Lake Victoria catchment, Kisumu County, Kenya (East Africa). *Journal of Environmental and Analytical Toxicology*, 8(2): 1-9. DOI: https://doi.org/10.4172/2161-0525.1000560

Meghla, N.T., Islam, M.S., Ali, M.A., Suravi and Sultana, N. (2013). Investigation of physicochemical properties of water from the Turag River in Dhaka city, Bangladesh. *International Journal of Current Microbiology and Applied Science*, 2(5): 110-167.

Mobin, M.N., Islam, M.S., Mia, M.Y. and Bakali, B. (2014). Analysis of physicochemical properties of the Turag River water, Tongi, Gazipur in Bangladesh. *Journal of Environmental Science and Natural Resources*, 7(1): 27-33. DOI: https://doi.org/10.3329/jesnr.v7i1.22140

Nahian, M., Islam, M.S., Kabir, M.H., Tusher, T.R. and Sultana, N. (2018). Seasonal variation of water quality in Gowain River near Ratargul swamp forest, Sylhet, Bangladesh. *Grassroots Journal of Natural Resources*, 1(1): 26-36. DOI: https://doi.org/10.33002/nr2581.6853.01013

Nion, M.S.H., Islam, M.S., Hoq, M.E., Kabir, M.H. and Hoque, M.M.M. (2020). Seasonal and tidal dynamics of nutrients and Chlorophyll *a* concentration in water at the Sundarbans mangrove ecosystems of Bangladesh. *Grassroots Journal of Natural Resources*, 3(1): 50-67. DOI: https://doi.org/10.33002/nr2581.6853.03015

Pal, P., and Chakraborty, K. (2014). Importance of some physical and chemical characteristics of water bodies in relation to the incidence of zooplanktons: a review. *Indian Journal of Social and Natural Sciences*, 3: 102-116. Available online at:

https://www.researchgate.net/publication/305601143_Importance_of_some_physical_and_chemical_characteristics_of_water_bodies_in_relation_to_the_incidence_of_zooplanktons_A_review [Accessed on 07 May 2022]

Rahaman, S.M.B., Golder, J., Rahaman, M.S., Hasanuzzaman, A.F.M., Huq, K.A., Begum, S., Islam, S.S. and Bir, J. (2013b). Spatial and temporal variations in phytoplankton abundance and species diversity in the Sundarbans mangrove forest of Bangladesh. *Journal of Marine Science Research and Development*, 3(2): 1-9. DOI: https://doi.org/10.4172/2155-9910.1000126

Rahaman, S.M.B., Sarder, L., Rahaman, M.S., Ghosh, A.K., Biswas, S.K., Siraj, S.M.S., Huq, K.A., Hasanuzzaman, A.F.M. and Islam, S.S. (2013a). Nutrient dynamics in the Sundarbans mangrove estuarine system of Bangladesh under different weather and tidal cycles. *Ecological Processes*, 2(29): 1-13. DOI: https://doi.org/10.1186/2192-1709-2-29.

Rahman, A. (2012). Economic incentives for wetland biodiversity and fisheries conservation: the case of Chalan Beel (Wetland). IIFET 2012 Tanzania Proceedings. Available online at: https://ir.library.oregonstate.edu/downloads/gq67jw92c [Accessed on 22 January 2022]

Rahman, M., Rahman, M., and Asaduzzaman, M. (2010). The aggression of human activities on Chalan beel a threat on wetland environment: study on Natore - Rajshahi region of Bangladesh. *Journal of Science Foundation*, 8(1-2): 151-159. DOI: https://doi.org/10.3329/jsf.v8i1-2.14638

Rahman, A.K.M.L., Islam, M., Hossain, M.Z. and Ahsan, M.A. (2012). Study of the seasonal variations in Turag River water quality parameters. *African Journal of Pure and Applied Chemistry*, 6(10): 144-148. DOI: https://doi.org10.5897/AJPAC12.023

Rahman, M.M., Bashar, M.A., Farhana, Z. and Hossain, M.Y. (2014). Temporal variation of physicochemical parameters in Kaptai Lake, Bangladesh. *World Journal of Fish and Marine Sciences*, 6(5): 475-478. DOI: https://doi.org/10.5829/idosi.wjfms.2014.06.05.8696

Rahman, M.S. (1992). *Water quality management in Aquaculture*. Dhaka, Bangladesh: BRAC Prokashana, p.84.

Saifullah, A.S.M., Kabir, M.H., Khatun, A., Roy, S. and Sheikh, M.S. (2012). Investigation of some water quality parameters of the Buriganga River. *Journal of Environmental Science and Natural Resources*, 5(2): 47-52. DOI: https://doi.org/10.3329/jesnr.v5i2.14600

Sarker, M.N.I. (2016). Knowledge, adoption and constraint analysis of chili technology in Char area of Bangladesh. *International Journal of Ecology and Development Research*, 1(1): 16-18. Available online at: https://www.researchgate.net/publication/305279648_Knowledge_Adoption_and_Constraint_analysis_of_Chilli_Technology_in_Char_Area_of_Bangladesh [Accessed on 30 May 2022]

Sayeed, M.A., Hashem, S., Salam, M.A., Hossain, M.A.R. and Wahab, M.A. (2014). Efficiency of fishing gears and their effects on fish biodiversity and production in the Chalan *Beel* of Bangladesh. *European Scientific Journal*, 10(30): 294-309. DOI: https://doi.org/10.19044/esj.2014.v10n30p%p

Sayeed, M.A., Hossain, M.A.R., Wahab, M.A., Hasan, M.T., Simon, K.D. and Mazumder, S.K. (2015). Water and sediment quality parameters in the Chalan *Beel*, the largest wetland of Bangladesh. *Chinese Journal of Oceanology and Limnology*, 33(4): 895-904. DOI: https://doi.org/10.1007/s00343-015-4176-9

Sarwade, A.B. and Kamble, N.A. (2014). Evaluation of physicochemical parameters of river Krishna, Sangli, Maharashtra. *Octa Journal of Environmental Research*, 2(4): 329-337. Available online at: http://www.sciencebeingjournal.com/sites/default/files/09-0204_Asha.pdf [Accessed on 21 May 2022]

Senthilkumar, B., Purvaja, R. and Ramesh, R. (2008). Seasonal and tidal dynamics of nutrients and Chlorophyll *a* in a tropical mangrove estuary, southeast coast of India. *Indian Journal of Marine Science*, 37(2):132-140. Available online at: http://www.iomenvis.in/rramesh/publications/2008-6.pdf [Accessed on 20 April 2022]

Shahnaz, K. (2005). *Drastic fall in Chalan Beel fish production*. Holiday-internet Edition.

Shrivastava, S. and Kanungo, V.K. (2013). Physicochemical analysis of pond water of Surguja district, Chhattisgarh, India. *International Journal of Herbal Medicine*, 1(4): 35-43. Available online at: https://www.florajournal.com/vol1issue4/nov2013/5.1.pdf [Accessed on 29 April 2022]

Sultana, N. and Islam, M. (2016). Fish production and livelihood of fish farmers of Chalan Beel area. *Bangladesh Journal of Agricultural and Veterinary Science*, 9: 51-56. DOI: https://doi.org/10.9790/2380-0911025156

Suravi, Islam, M.S., Ali, M.A., Meghla, N.T. and Sultana, N. (2013). Seasonal variations of water quality parameters from the Pungli River in Tangail region. *International Journal of Current Microbiology and Applied Sciences*, 2(5): 155-167.

Shil, S., Singh, U.K. and Mehta, P. (2019). Water quality assessment of a tropical river using water quality index (WQI), multivariate statistical techniques and GIS. *Applied Water Science*, 9(7): 1-21. DOI: https://doi.org/10.1007/s13201-019-1045-2

Weber-Scannell, P.K. and Duffy, L.K. (2007). Effects of total dissolved solids on aquatic organisms: A review of literature and recommendation for Salmonid species. *American Journal of Environmental Sciences*, 3(1): 1-6. Available online at: https://www.researchgate.net/publication/26449048_Effects_of_Total_Dissolved_Solids_on_Aquatic_Organisms_A_Review_of_Literature_and_Recommendation_for_Salmonid_Species [Accessed on 19 February 2022]

Yang, J., Yu, X., Liu, L., Zhang, W. and Guo, P. (2012). Algae community and trophic state of subtropical reservoirs in southeast Fujian, China. *Environmental Science and Pollution Research*, 19(5): 1432-1442. DOI: https://doi.org/10.1007/s11356-011-0683-1.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5	Author 6	Author 7
Conceived and designed the research or analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Collected the data	Yes	Yes	Yes	Yes	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes	No	Yes
Critical revision of the article/paper	Yes	Yes	Yes	Yes	No	Yes	Yes
Editing of the article/paper	Yes	No	Yes	Yes	No	Yes	Yes
Supervision	Yes	No	Yes	Yes	No	Yes	Yes
Project Administration	Yes	No	Yes	Yes	No	Yes	Yes
Funding Acquisition	Yes	No	Yes	Yes	No	No	Yes
Overall Contribution Proportion (%)	25	20	15	10	10	10	10

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Research involving human bodies (Helsinki Declaration)
Has this research used human subjects for experimentation? No

Research involving animals (ARRIVE Checklist)
Has this research involved animal subjects for experimentation? Yes (checklist attached)

Research involving Plants
During the research, the authors followed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora. Yes

Research on Indigenous Peoples and/or Traditional Knowledge
Has this research involved Indigenous Peoples as participants or respondents? No

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
Have authors complied with PRISMA standards? No

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Authors have no competing financial, professional, or personal interests from other parties or in publishing this manuscript.

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The ARRIVE guidelines 2.0: author checklist

The ARRIVE Essential 10

These items are the basic minimum to include in a manuscript. Without this information, readers and reviewers cannot assess the reliability of the findings.

Item		Recommendation	Section/line number, or reason for not reporting
Study design	1	For each experiment, provide brief details of study design including: a. The groups being compared, including control groups. If no control group has been used, the rationale should be stated. b. The experimental unit (e.g. a single animal, litter, or cage of animals).	There was no animals or related experiments. Experimental unit is not applicable for this study.
Sample size	2	a. Specify the exact number of experimental units allocated to each group, and the total number in each experiment. Also indicate the total number of animals used. b. Explain how the sample size was decided. Provide details of any *a priori* sample size calculation, if done.	No animal was used in our study. Not applicable for our study.
Inclusion and exclusion criteria	3	a. Describe any criteria used for including and excluding animals (or experimental units) during the experiment, and data points during the analysis. Specify if these criteria were established *a priori.* If no criteria were set, state this explicitly. b. For each experimental group, report any animals, experimental units or data points not included in the analysis and explain why. If there were no exclusions, state so. c. For each analysis, report the exact value of *n* in each experimental group.	This item does not correspond to our study. This item does not correspond to our study. This item does not correspond to our study.
Randomisation	4	a. State whether randomisation was used to allocate experimental units to control and treatment groups. If done, provide the method used to generate the randomisation sequence. b. Describe the strategy used to minimise potential confounders such as the order of treatments and measurements, or animal/cage location. If confounders were not controlled, state this explicitly.	This item does not correspond to our study. This item does not correspond to our study.
Blinding	5	Describe who was aware of the group allocation at the different stages of the experiment (during the allocation, the conduct of the experiment, the outcome assessment, and the data analysis).	This item does not correspond to our study.
Outcome measures	6	a. Clearly define all outcome measures assessed (e.g. cell death, molecular markers, or behavioural changes). b. For hypothesis-testing studies, specify the primary outcome measure, i.e. the outcome measure that was used to determine the sample size.	This item does not correspond to our study. This item does not correspond to our study.
Statistical methods	7	a. Provide details of the statistical methods used for each analysis, including software used. b. Describe any methods used to assess whether the data met the assumptions of the statistical approach, and what was done if the assumptions were not met.	This item does not correspond to our study. This item does not correspond to our study.
Experimental animals	8	a. Provide species-appropriate details of the animals used, including species, strain and substrain, sex, age or developmental stage, and, if relevant, weight. b. Provide further relevant information on the provenance of animals, health/immune status, genetic modification status, genotype, and any previous procedures.	This item does not correspond to our study. This item does not correspond to our study.
Experimental procedures	9	For each experimental group, including controls, describe the procedures in enough detail to allow others to replicate them, including: a. What was done, how it was done and what was used. b. When and how often. c. Where (including detail of any acclimatisation periods). d. Why (provide rationale for procedures).	This item does not correspond to our study. This item does not correspond to our study. This item does not correspond to our study. This item does not correspond to our study.
Results	10	For each experiment conducted, including independent replications, report: a. Summary/descriptive statistics for each experimental group, with a measure of variability where applicable (e.g. mean and SD, or median and range). b. If applicable, the effect size with a confidence interval.	This item does not correspond to our study. This item does not correspond to our study.

Prof. Dr. Md. Sirajul Islam