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Physico-chemical Attributes Study from Different Sources of Freshwater Bodies in and around Barishal University Campus, Barishal, Bangladesh

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ABSTRACT: This study measured surface water temperature, water pH, TDS, EC, DO, nitrate, ammonium, sulphate and phosphate as water physico-chemical properties of four freshwater reservoirs in and around Barishal University campus. The surface water temperature was recorded highest (22.4 °C) in site 4 (BU Pond-2), and lowest (19.6 °C) in site 1 (Kirtankhola River). Water pH, nitrate, ammonium and sulphate showed almost same results among the four reservoirs. TDS and EC values range from 188 to 215 mg/l, and 195 to 225 µS/cm, respectively. DO level was almost similar in all the sites except Kirtankhola, which showed comparatively lowest amount (4.55 mg/l). Phosphate ranges from 3.20 to 4.15 mg/l. Among the four reservoirs, comparatively newly established BU pond-2 (site 4) showed poor results than the others in terms of the measured physico-chemical parameters.

Keywords: BU ponds, Kirtankhola River, Water pH, Barishal, Freshwater.

Nowadays, climate change related issues have been focused as an extensive research, because the changes might create many impacts on bio-diversity. Climate change in aquatic ecosystem itself represents a complex amalgam of different stressors including alterations in surface water temperature, pH, dissolved oxygen level, salinity and so on (1,2). As a part and parcel of aquatic ecosystem, freshwater bodies have been considered as more vulnerbable to climate changes impacts than the marine and terrestrial realms. They occupy less than 1% of the earth's surface, but they support 10% of all animals, one-third of all vertebrates, and 40% of all fish species (3-5). Moreover, the freshwater ecosystems are home to numerous living organisms and provide enormous support of wellbeing to billions people and associated organisms worldwide (6). Many living organisms within these ecosystems have very limited capacities to cope up with the environmental changes (7). That is the reason, why freshwater ecosystems are considered as the most heavily vulnerable ecosystems on the earth due to climate change, despite their tremendous importance for human being (8). Bangladesh is a land of water with numerous rivers, ponds, lakes and streams. Several rivers flow through Barishal division, located in south-central part of Bangladesh. Kirtankhola River is a notable and one of the major rivers flowing in Barishal district. Barishal University campus is located at the bank of the river.

Moreover, there are numerous ponds, lakes and other freshwater reservoirs are available in Barishal (9,10). This upazila recently touches the rapid economic development, thus there are the numbers of industries are increasing. Consequently, the freshwater reservoirs of this region has the possibility to face heavy pollution, due to direct discharge of oil and wastages from the water vehicles, agricultural runoffs, and dumping of industrial and municipal wastages (10). Then the polluted waters could severely affect the aquatic biota living within the reservoirs (12-14).

It is crucial to measure the water physico-chemical properties to evaluate the water quality in any concerning water bodies (15). Fluctuation in water physico-chemical properties can affect or influence the growth of certain living organisms and can cause degradation of surface water quality due to deoxygenation of the water (16). Assessing the water physico-chemical factors and supporting the interactions between the physical and chemical factors such as dissolved oxygen (DO), temperature, nitrogen, phosphorous, pH, electrical conductivity (EC) and total dissolved solids (TDS) are very complex to study (17). There are lacks of reports on water physico-chemical properties of freshwater reservoirs near to Barishal University Campus. Only, several works attempted to measure the water quality of Kirtankhola River among the numerous freshwater reserviors (9,14,18). Chakroborty et al studied several freshwater reservoirs from the Barishal City and they worked on phytoplankton species, one of the most important biological indicators of water quality (9). Moreover, newly established ponds in Barishal University Campus has no prior data on their water physico-chemical properties.

Therefore, the present study aimed to measure the water physico-chemical parameters along with the correlations among the parameters in and around Barishal University Campus. The findings would be helpful in details studies on water quality, pollution and impact on biodiversity of the area in future.

MATERIALS AND METHODS

Study site

The research was conducted at Barishal Sadar Upazilla under Barishal district, and the selected sites of freshwater bodies were located in and around the Barishal University campus. Surface water samples were collected from four freshwater bodies, as denoted by Site 1 (ST-1): Kirtankhola River, Site 2 (ST-2): Rupatali Lake, Site 3 (ST-3): BU Pond-1 and Site 4 (ST-4): BU Pond-2. The GPS coordination of the each sampling points was collected by Explorist (Model: 200), that was presented in Table 1, and location map of the sampling sites is shown in Figure 1.

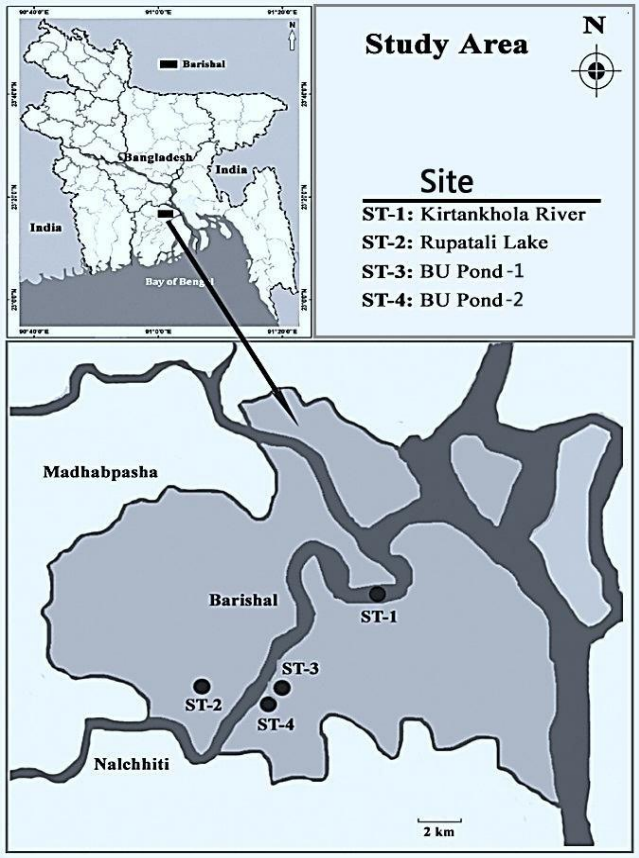

Figure 1: Art work of studied area showing all sampling sites.

Table 1. Geographical coordinates of each sampling sites.

SS	Area	Water Source	Latitude (N)	Longitude (E)
ST-1	Around BU campus area	SW	22.647	90.347
ST-2	Around BU campus area	SW	22.675	90.347
ST-3	In BU campus area	SW	22.660	90.361
ST-4	In BU campus area	SW	22.658	90.361

Note: Here, SS, BU and SW indicated Study Site, University of Barishal and Surface Water, respectively.

Water sampling and analytical methods

Water sampling was carried from December 2018 to February 2019 during the winter season. From each sampling sites, water samples were collected in

triplicate. Water samples were collected from 15-30 cm below the water surface and collected in 500 ml polypropylene bottles which were cleaned with conc. HNO_3 and rinsed three times with distilled water and collections were completed between 7 to 10 am. Before the sample collection, sample bottles were rinsed three times also with the water of respective sampling stations. The surface water temperature (SWT), pH and DO (Dissolve oxygen) were measured using a calibrated portable multi-parameter meter (HACH, Model: HQ 30d). TDS (Total dissolved solid) and EC (Electrical conductivity) were performed using portable TDS meter (HANNA, Model: HI98301 DiST 1), and digital EC meter (HANNA, Model: HI98303 DiST 3). All these measurements were done at the sampling time immediately after collections. The rest of the chemical parameters (NO_3^-, NH_4^+, SO_4^{2-} and PO_4^{3-}) were measured through standard protocols as described in APHA (19). The sealed samples were preserved until the analysis was completed.

Statistical analysis

All data were processed in MS Excel 10 version to calculate average value. To evaluate the relationships among the water quality parameters, Pearson's correlation matrix was calculated by SPSS (version 25) with $p < 0.5$ level of significance. All these water quality parameters were compared with EQS (Environmental Quality Standard) set in the Environmental Conservation Rules, 1997 (20).

RESULTS AND DISCUSSION

Physico-chemical parameters of water

Temperature gives the measure of heat intensity stored in a volume of water. It is highly correlated with atmospheric temperature as well as the morphometric features. Surface water temperature affects aquatic life largely (21). From the present study, average surface water temperature from the four sampling sites ranges from 19.60 to 22.40 °C (Table 2). Minimum temperature of 19.60 °C was observed at ST-1 (Kirtankhola River), and maximum of 22.40 °C was at ST-4 (BU Pond 2). The standard limit of water temperature for Bangladesh is 20-30 ^{0}C according to EQS, 1997. The average values showed that except ST-1 (Kirtankhola River) and ST-3 (BU Pond-1), all the temperature was within the permissible limit. In general, water temperature depends on geographical location and other meteorological conditions (22). In case of freshwater reservoirs, temperature fluctuation can cause adverse effects on aquatic organisms (7).

The pH of the sampling locations was ranged from 7.95 to 8.15 on average (Table 2). The maximum value of pH was recorded at ST-2 (Rupatali Lake) and minimum value was recorded at ST-3 (BU Pond-1). Sewages or terrestrial run-off from nearby houses containing carbonates and bicarbonates may be the reasons for the highest values of pH in sampling sites. Overall, the pH values of all the samples were within the pH range assigned by ECR (1997) as the standard for aesthetic purposes (6.5-8.5). It is reported that lowered pH is responsible for aquatic organisms' growth and cell morphology (14). However, slightly alkaline pH is very helpful for freshwater organisms. Besides, other factors like waste dilution in fresh water, salinity and temperature reduction as well as organic matter decomposition are responsible for pH fluctuation (23).

In aquatic environment, total dissolved solids mainly signify the inorganic pollution load of water system, while the electrical conductivity measures the concentration of ions in water (24). The soluble ions in the surface water originate primarily from solution of rock materials (25). In the study area, the highest amount of TDS (215 mg/l) and EC (225 µS/cm) were recorded at ST-1 (Kirtankhola River) and the lowest value of TDS (188 mg/l) and EC (195 µS/cm) were found at ST-4 (BU Pond-2) (Table 2). The measured TDS and EC values for all four sampling sites were within permissible limit, suggested by EQS (1997). That meant the total dissolved solids and electric conductivity of the area in and around Barishal University campus still is in good quality.

DO values reflect the physical and biological processes preventing in the water. It also indicates the degree of pollution in water bodies. The lowest level of DO was measured at newly established BU Pond-2 (4.55 mg/l). At other three reservoirs, DO value was within the standard limit as prescribed by ECR (1997) (26). May be for increased anthropogenic activities and temperature, the DO level was minimum at the BU Pond-2 than the other sites. Consequently, the pond is not perfect for fish culture. Authors suggested before making any approach for fish or other aquatic organism maintaining in this pond, it is mandatory to maintain the standard DO level first.

Nitrate (NO_3^-) and ammonium (NH_4^+) are the available forms of nitrogen in water. The NO_3^- concentrations in four sites varied from 0.55 to 0.68 mg/l, which were within the limit of inland water bodies (Table 2). According to ECR (1997), the standard value of NO_3^- for inland water bodies is 10.0 mg/l. Considering the limit, our collected samples were safe for the domestic purposes. Variation in nitrate concentration was mostly due to geographical positions and variation of water sources. The concentration of NH_4^+ represents the presence of fecal matter from latrine (25). In present study NH_4^+ concentration of sample water ranges from 0.45 to 0.65 mg/l. Except ST-1 (Kirtankhola River), for other three stations NH_4^+ concentration was high in respect to standard value (Table 2). High concentration of ammonium might be due to municipal waste disposal as well as use of several agrochemicals. The BU Pond-2 showed highest amount of ammonium (0.65 mg/l) that means the agrochemicals from nearby, at the bank of the pond, tree plantation mix with the water along with surface water run off during rainy season.

The range of SO_4^{2-} and PO_4^{3-} concentrations of the collected water samples varied from 1.35 to 1.80 mg/l, and 3.20 to 4.15 mg/l respectively (Table 2). The ECR set 400.0 mg/l and 6.0 mg/l, as the standard limit of SO_4^{2-} and PO_4^{3-} for Bangladesh, respectively (ECR, 1997). The measured values for both sulphate and phosphate indicate that the values of the samples were within the standard level of inland water bodies. In Bangladesh, both surface and groundwater sources contained an insignificant amount of SO_4^{2-}, which is strongly supported by our result (27). The highest value of phosphate was found in BU Pond-1 and the highest value of sulphate was measured in Kirtankhola River. BU Pond-2 gave the lowest amount of phosphate.

Table 2. Average physico-chemical properties of water quality in the four sites. Here, BSV means Bangladesh Standard Value.

Parameter (Unit)	**ST-1**	**ST-2**	**ST-3**	**ST-4**	**BSV**	**Ref.**
SWT (^oC)	19.6	20.3	19.8	22.4	20.0-30.0	(26)
pH	8.05	8.15	7.95	8.01	6.5-8.5	(26)
TDS (mg/l)	215	195	205	188	500	(20)
EC (µS/cm)	225	208	215	195	700	(20)
DO (mg/l)	6.30	6.80	6.78	4.55	5.0-8.0	(26)
NO_3^- (mg/l)	0.65	0.55	0.55	0.68	10.0	(26)
NH_4^+ (mg/l)	0.45	0.56	0.58	0.65	0.50	(26)
SO_4^{2-} (mg/l)	1.80	1.48	1.35	1.55	400	(26)
PO_4^{2-} (mg/l)	3.78	3.70	4.15	3.20	6.0	(26)

Table 3: Calculated correlations among the physico-chemical parameters in Kirtankhola River.

Par.	**SWT**	**pH**	**TDS**	**EC**	**DO**	**NO_3^-**	**NH_4^+**	**SO_4^{2}**	**PO_4^{2-}**
SWT	1								
pH	-0.625*	1							
TDS	0.142	0.885*	1						
EC	-0.651*	0.787*	0.911*	1					
DO	0.005	-0.222	0.155	0.231	1				
NO_3^-	-0.211	0.878*	-0.008	0.877*	0.006	1			
NH_4^+	-0.115	-0.021	0.789*	0.779*	-0.023	-0.301	1		
SO_4^{2-}	-0.211	-0.855*	-0.020	0.147	-0.274	0.888*	-0.089	1	
PO_4^{2-}	0.101	-0.010	0.080	0.002	0.087	0.040	-0.781*	0.060	1

Table 4: Calculated correlations among the physico-chemical parameters in Rupatali Lake.

Par.	**SWT**	**pH**	**TDS**	**EC**	**DO**	**NO_3^-**	**NH_4^+**	**SO_4^{2}**	**PO_4^{2-}**
SWT	1								
pH	-0.154	1							
TDS	0.175	-0.001	1						
EC	-0.825*	-0.054	0.672*	1					
DO	-0.626*	0.180	-0.021	-0.019	1				
NO_3^-	0.017	-0.766*	0.594*	0.575*	0.121	1			
NH_4^+	0.084	0.062	-0.012	0.526*	0.027	0.556*	1		
SO_4^{2-}	-0.113	-0.925*	0.108	-0.048	-0.003	0.079	-0.077	1	
PO_4^{2-}	0.001	0.045	-0.201	-0.071	-0.082	0.021	-0.043	0.074	1

Table 5: Calculated correlations among the physico-chemical parameters in BU Pond-1.

Par.	SWT	pH	TDS	EC	DO	NO_3^-	NH_4^+	SO_4^{2}	PO_4^{2-}
SWT	1								
pH	0.021	1							
TDS	0.032	0.087	1						
EC	-0.785*	0.118	0.547*	1					
DO	-0.814*	0.202	0.161	-0.085	1				
NO_3^-	-0.055	-0.111	0.036	0.545*	-0.148	1			
NH_4^+	-0.054	-0.011	-0.170	0.684*	-0.237	0.138	1		
SO_4^{2-}	-0.755*	-0.862*	-0.018	-0.002	0.092	0.174	-0.008	1	
PO_4^{2-}	0.021	0.199	0.028	-0.301	-0.068	0.024	-0.050	0.078	1

Table 6: Calculated correlations among the physico-chemical parameters in BU Pond-2.

Par.	SWT	pH	TDS	EC	DO	NO_3^-	NH_4^+	SO_4^{2}	PO_4^{2-}
SWT	1								
pH	0.020	1							
TDS	-0.103	0.014	1						
EC	-0.489*	0.074	0.654*	1					
DO	-0.514*	-0.024	-0.133	0.011	1				
NO_3^-	0.001	-0.019	-0.233	0.554*	0.321	1			
NH_4^+	0.087	-0.202	0.108	0.655*	-0.213	0.119	1		
SO_4^{2-}	-0107	0.612	0.248	0.564*	-0.107	0.058	-0.624*	1	
DIP	-0.121	0.217	0.212	-0.009	-0.298	0.033	-0.317	0.014	1

Table 7: Correlations among the parameters from the four freshwater reservoirs.

Para.	SWT	pH	TDS	EC	DO	NO_3^-	NH_4^+	SO_4^{2-}	PO_4^{2-}
SWT	1								
pH	-0.077	1							
TDS	-0.256	-0.165	1						
EC	-0.930*	-0.022	0.982*	1					
DO	-0.913	0.240	0.571	0.002	1				
NO_3^-	0.581	-0.170	-0.097	-0.244	-0.150	1			
NH_4^+	0.302	-0.268	-0.298	-0.925*	-0.059	0.042	1		
SO_4^{2-}	-0.186	-0.677*	0.060	0.233	-0.228	0.283	-0.115	1	
PO_4^{2-}	-0.188	-0.250	0.182	0.139	0.079	-0.741	-0.261	-0.051	1

Note: * Correlation is significant at the 0.05 level (2-tailed).

Correlation studies

As we know, positive correlation indicated the positive influence of presence of the parameters where negative correlation indicated the negative trend of the availability of the parameters in the water. Kirtankhola river water shows significant correlation within its several parameters. For example, pH positively correlated with TDS, EC and NO_3^-, while it was negatively correlated with SWT and SO_4^{2-} (Table 3). TDS of the water positively correlated with NH_4^+ and EC. Only DO have no correlation with any of the parameters in the water that is similar of the findings of Hossen et al. (2021) (11). NO_3^- showed only positive correlation, and NH_4^+ and SWT showed only negative correlations.

In case of Rupatali Lake, surface water temperature was the causes of lower EC (r= -0.65) and DO (r= -0.62) values. Similarly, NO_3^- and SO_4^{2-} can reduce the pH values. TDS has positive correlation with EC (r= 0.67) and NO_3^- (r= 0.59), while EC positively correlated with NO_3^- (r= 0.57) and NH_4^+ (r= 0.52). NO_3^- and NH_4^+ also positively correlated each other (r=0.55), that means the presence of NH_4^+ linked with availability of NO_3^- in Rupatali lake (Table 4).

BU Pond-1 and BU Pond-2 showed same correlation patterns among temperature with EC and DO (Negative correlation), while TDS with EC; EC with NO_3^- and NH_4^+ (positive correlation). Only presence of SO_4^{2-} in BU Pond-1 responsible for reduction in pH value (Table 5). SO_4^{2-} showed another correlation with NH_4^+ (r= -0.62) in BU Pond-2 (Table 6). BU ponds showed maximum correlations with ions present in its water that indicate the newly established pond correlation is actually based on its

soil structure. Its low level of DO may be responsible for low level of primary producer (phytoplankton). The river Kirtankhola showed the highest correlations with its parameters, because the long river may have the connections of same sources from where the parameters are mixed up with the waters.

The combined correlations of the four reservoirs showed only positive correlation between TDS and EC (r= 0.982), which means the presence of TDS influences the presence of EC. On the other hand, EC of the study area negatively correlated with SWT and NH_4^+ (r= -0.930 and-0.925), and another significant negative correlation found between pH and SO_4^{2-} (r= -0.677) (Table 7). That indicated the aquatic organisms have correlations with the present trace elements, environmental factors, and physico-chemical parameters and with other organisms within the water bodies (28-30).

CONCLUSION

The four freshwater reservoirs in and around Barishal University Campus showed significant variations in its some measured parameters, and the BU Pond-2 found as unsuitable for fish culture due to lack of considerable DO amount.

CONFLICT OF INTEREST

The authors declared no any interest with other individual, institute or organization.

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Author's contributions
AN planned and designed the experiment. KB performed the experiment and both authors are equally contributed during data analysis. Finally, manuscript was prepared by AN.

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