

Physico-chemical Parameters and Diversity of Phytoplankton in Kirtankhola River, Bangladesh

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Abstract

The river Kirtankhola has great importance in southern part of Bangladesh due to its necessity in transportations, municipal and agricultural purposes. But the ecological status and impacts of water quality on phytoplankton diversity were undiscovered. To cover the maximum area of the river, water samples were collected from the 6 locations (ST) covering about 13 km. Some parameters were measured immediately after sampling by portable devices and others done in laboratory following standard methods. The overall quality of the water was found good according to water quality guidelines of World Health Organization, although the water of port area showed comparatively high SO_4^{2-} and CO_3^{2-} values which attracts attention for future monitoring. ST 6 showed comparatively more alkaline water (pH 8.45) along with highest EC, TDS, NO_3^- , NH_4^+ and DIP values. Besides, 53 phytoplankton taxa belonging to Cyanophyceae (6), Chlorophyceae (10), Euglenophyceae (12) and Bacillariophyceae (25) were identified from the river. *Scenedesmus acuminatus* was found commonly in five stations except ST 1, whereas *Euglena chlamydophora* (ST 1), *Gomphonema olivaceum* (ST 3) and *Cymbella parva* (ST 5) found rarely. Highest diversity was counted in ST 6. Moreover, Chlorophyceae and Bacillariophyceae have positive correlation with several physical parameters, whereas Cyanophyceae negatively correlated. Euglenophyceae has both negative and positive correlations with some physico-chemical parameters. However, this was the first attempt to measure diversity of primary producers and their correlations with water quality of Kirtankhola River.



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Introduction

Bangladesh is a land of water, crisscrossed with almost 700 rivers. Numerous rivers flow through

Barishal (administrative division), located in south-central part of Bangladesh and, Kirtankhola river is a notable and one of the major rivers in Barishal

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division. The total length of the river is about 160 km, but the 21 km of the river flowing through Barishal and Jhalokathi district under the Barishal division is actively known as Kirtankhola (Mahbub,¹). The river Kirtankhola with the second largest river port in Bangladesh plays vital roles in lives and livelihoods of people living in the vicinity of the river, and also in the socio-economy of the region. The river is the significant gateway to this division as well as agricultural practices, industrial progresses and human settlements are very common in nearby lands. Thereby, the river would expose to heavy pollution due to direct discharge of oil and wastages from the water vehicles, agricultural runoffs, and dumping of industrial and municipal wastages. Consequently, its water quality is changing which severely would affect the aquatic biota of the river especially phytoplankton (Kumar and Dua,²).

To assess water quality, it is crucial to measure the physical and chemical factors found in the concerning water bodies. Physico-chemical factors have direct effects on the growth of phytoplankton, the primary producers on which other life forms are directly or indirectly dependent in the aquatic ecosystem (Partensky,³). Numerous studies showed that the phytoplankton communities are sensitive to changes in their environment, thereby, can be used as an effective bio-indicator for assessing water quality along with assessing the physico-chemical properties (Reynolds,⁴; Brettum and Andersen,⁵). However, understanding the diversity or ecological status like species abundance, richness and evenness of phytoplankton in aquatic ecosystem is highly complex and ecologists use different indices to measure the status of any area (Maguran,⁶; Purvis and Hector,⁷). According to various studies, species richness and evenness of species can be measured by most widely used diversity indices i.e. Margalef index and Simpson index respectively, whereas Shannon diversity index is for knowing combined status of species abundance or richness and evenness (Shannon and Weiner,⁸; Spellerberg and Peter,⁹; Simpson,¹⁰).

In aquatic ecosystem, quantitative and qualitative abundance of the phytoplankton, and phytoplankton diversity which plays crucial role in increasing productivity, has been reported directly correlated with existing water quality conditions of the water body (Newall,¹¹; Vallina,¹²). However, fluctuation

in water physico-chemical properties can trigger luxurious growth of certain groups of phytoplankton which can cause degradation of surface water quality resulting into deoxygenation of the water leading to death of other organisms (Whitton and Patts,¹³). Therefore, the growth and development of phytoplankton communities in relation to the water physico-chemical factors, influencing the water quality has been researched over the last few decades (Akbar,¹⁴; Peerapornpisal,¹⁵; Elliott,¹⁶). Assessing the water physico-chemical factors supporting the phytoplankton growth, and interactions between the physical and chemical factors such as dissolved oxygen (DO), temperature, nitrogen, phosphorous, pH, electric conductivity (EC) and salinity (TDS) are very complex (Goldman and Horne,¹⁷).

There are several reports available on phytoplankton communities from Barishal region (Islam and Alfasane,¹⁸; Khondker,¹⁹; Chakraborty,²⁰) and Rajonee,²¹ reported the water physico-chemical parameters of Kirtankhola River, but no investigation has been done on phytoplankton diversity in relation to the water physico-chemical parameters of this river yet. Therefore, the present study aimed to measure the water physico-chemical parameters along with phytoplankton diversity to assess the correlations among the parameters and different phytoplankton groups in this river. Results of the study would be helpful in details studies on water quality, pollution and impact on biodiversity of the river in future.

Materials and Methods

Study Site

The research was conducted in Kirtankhola River at six sampling locations. Each of the locations (stations) located at approximately 2.5 km distance covering in total 13 km of the river and the average width of the site is 500 m. Details of the site is represented in Figure 1.

Water Sampling

Water samples were collected from the surface to 40cm depth of water by Ruttner sampler and other sampling bottles during July 2020 to September 2020. Collections were completed between 7 to 10 am with the help of an engine boat. The water temperature, pH, TDS (Total dissolved solid), EC (Electrical conductivity) and DO (Dissolve oxygen)

were measured using portable devices (Digital thermometer, HI98108 pHep+, HI98302 DiST2 and HI98304 DiST4) during the sampling time immediately after collections. To measure the rest of the physico-chemical parameters, water samples were taken in plastic containers and sealed with

aluminum foil. Moreover, 1 L of sample water was transferred to graduated cylinders adding with few drops of Lugol's solution and 4% neutral formalin for measuring phytoplankton diversity. Air temperature was in between 29 to 26.5°C during the studied time.

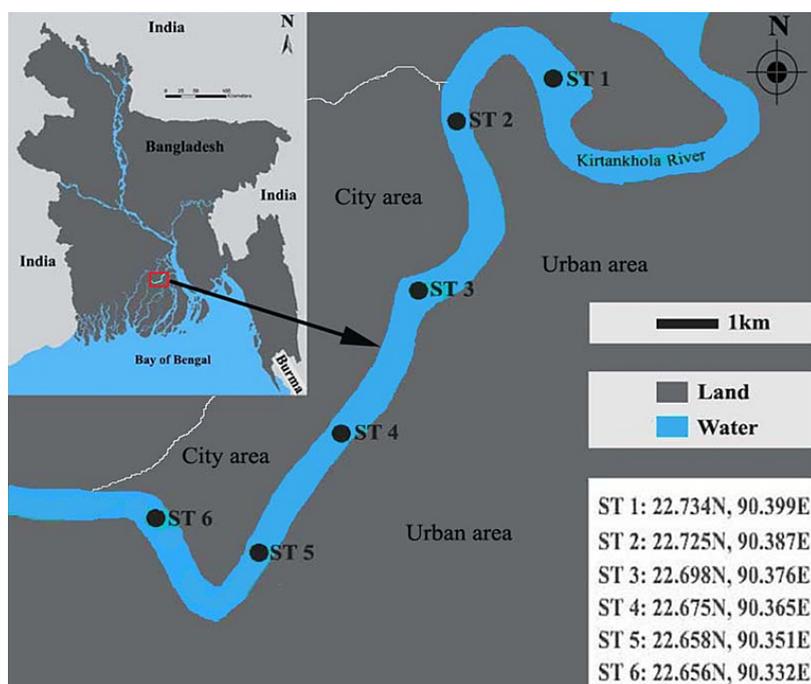


Fig. 1: Location of Kirtankhola River in Bangladesh with all sampling stations

Laboratory Analysis

NO_3^- , NH_3 , SO_4^{2-} and CO_3^{2-} were measured following standard methods (APHA,²²). After 48 hours, 100 ml concentrated sediment was taken from the graduated cylinders to identify and count phytoplankton species using light microscope and hemacytometer. For identification confirmation, Bellinger and Sigeo,²³ Ahmed *et al.*,²⁴ Islam and Moniruzzaman,²⁵ and Smith,²⁶ were consulted. The presented taxonomic arrangements were prepared following Komárek & Fott,²⁷ and Bold & Wynne.²⁸ MS excel was used to calculate the average and mean value of all the collected data. Then program PAST was applied to calculate the three diversity indices (Shannon, Simpson and Margalef index) where phytoplankton were expressed as organisms per ml. Another software program JMP was used to determine the correlations among the physico-chemical parameters and phytoplankton groups significant at 95% confidence level ($P \leq 0.05$).

Results and Discussion

Physico-Chemical Parameters

From the investigated physico-chemical parameters average temperature was from 17.7 to 18.6°C respectively in all stations. ST 6 looked different by most of the measured parameters, for example it gave the highest value in pH (8.45), EC (260 $\mu\text{S}/\text{cm}$), TDS (355 mg/l), NO_3^- (1.15 mg/l), NH_3 (1.05 mg/l), DIP (4.10 mg/l) and lowest in CO_3^{2-} (Table 1). These values concluded that the water of the station was comparatively more contaminated and it may due to the effluents from factories near by bank of the station. On the other hand, ST 5 showed least amount in 5 parameters (DO, EC, TDS, NO_3^- and SO_4^{2-}), that indicated the less contamination probably due to fewer anthropogenic impacts in this station area. ST 3 located next to the river port and provided highest concentration of DO, SO_4^{2-} and CO_3^{2-} and lowest pH, which meant water of this station is being acidic compared to the

water samples from at other stations. Most probably, movements of water vehicles were the reasons for more dissolved oxygen and the wastage or oil discharge may be the reason for increase in SO_4^{2-} and CO_3^{2-} level. However, ST 1, 2 and 4 showed comparatively moderate values for maximum parameters that indicated similar environmental surroundings and less anthropogenic activities

than ST 3 and 6. However, water of Kirtankhola was not polluted during the study time according to World Health Organization water quality guidelines (WHO, ²⁹). But water of the area of ST 3 and ST 6 should get further attention for future monitoring due to their surrounding anthropogenic activities to improve water quality as supported by earlier study (Rajonee,²¹).

Table 1: Average value of water physico-chemical parameters in six stations of Kirtankhola River

Parameter (Unit)	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
SWT (°C)	18.1	17.7	18.6	18.0	18.6	17.7
pH	8.15	8.10	7.75	8.05	7.80	8.45
DO (mg/l)	5.22	6.55	7.40	6.65	4.20	4.80
EC (µS/cm)	208	185	195	225	175	260
TDS (mg/l)	220	185	195	325	185	355
NO_3^- (mg/l)	0.95	0.80	0.85	0.75	0.60	1.15
NH_4^+ (mg/l)	0.35	0.55	0.75	0.88	0.70	1.05
SO_4^{2-} (mg/l)	2.5	1.75	3.10	2.15	1.55	2.65
DIP (mg/l)	3.25	2.75	3.78	3.70	3.65	4.10
CO_3^{2-} (mg/l)	15.22	16.90	22.25	17.70	21.12	14.15

Note: SWT means surface water temperature

Table 2: List of phytoplankton and their occurrence (Cell/ml) in the studied area

Class	Taxa	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
Cyanophyceae	<i>Anabaena constricta</i> (Szafer) Geit.	2	1	-	-	1	-
	<i>Microcystis aeruginosa</i> Kütz.	-	1	-	1	-	1
	<i>Merismopedia punctata</i> Meyen	-	-	1	1	-	-
	<i>Oscillatoria limnetica</i> Lemm.	1	-	2	-	1	-
	<i>Oscillatoria sancta</i> (Kütz.) Gom.	-	1	-	-	-	1
	<i>Oscillatoria subbrevis</i> Schmidle	1	-	-	1	1	1
Chlorophyceae	<i>Actinastrum hantzchii</i> Lagerh.	1	1	-	2	-	1
	<i>Chlamydomonas gloeogama</i> Kors.	2	1	1	-	-	1
	<i>Chlorella vulgaris</i> Beyernick	-	-	2	1	-	-
	<i>Eudorina elegans</i> Ehr.	-	-	-	-	1	2
	<i>Pandorina morum</i> (Müll.) Bory	-	-	3	-	2	-
	<i>Planktosphaeria gelatinosa</i> Smith	1	-	1	-	-	3
	<i>Scenedesmus acuminatus</i> Chodat	-	1	2	1	1	4
	<i>Scenedesmus brasiliensis</i> Bohlin	1	-	-	2	-	1
	<i>Scenedesmus quadricauda</i> (Tur.) Bréb.	-	-	-	-	1	1
	<i>Scenedesmus regularis</i> Svirenko	2	2	1	-	-	-
Euglenophyceae	<i>Euglena acus</i> (Müll.) Ehr.	1	-	1	-	-	-
	<i>Euglena chlamydotheca</i> Mainx	1	-	-	-	-	1
	<i>Euglena clara</i> Skuja	-	1	2	1	-	1

	<i>Euglena proxima</i> Dangeard	-	-	-	-	1	3
	<i>Euglena variabilis</i> Klebs	-	-	1	-	1	-
	<i>Euglenocapsa pisciformis</i> Klebs	-	2	-	-	-	1
	<i>Phacus caudatus</i> Hubn.	2	-	1	3	-	-
	<i>Phacus curvicauda</i> Swirenko	1	1	-	-	1	2
	<i>Lepocinclis acus</i> (Müll.) Mar. & Melk.	-	-	-	-	1	1
	<i>Trachelomonas armata</i> (Ehr.) Stein	-	-	-	1	1	-
	<i>Trachelomonas hispida</i> Lemm.	-	1	1	-	-	-
	<i>Trachelomonas oblonga</i> Lemm.	1	1	-	-	-	2
Bacillariophyceae	<i>Cymbella cistula</i> (Ehr.) Kirch.	2	1	2	-	-	1
	<i>Cymbella parva</i> (W. Smith) Kirch.	-	-	-	-	1	-
	<i>Cyclotella bodanica</i> Eulen. ex Grun.	-	-	-	-	1	2
	<i>Cyclotella comta</i> (Ehr.) Kütz.	1	-	2	1	-	1
	<i>Fragilaria brevistriata</i> Grun.	3	-	1	-	-	-
	<i>Fragilaria crotonensis</i> Kitton	-	-	-	1	-	1
	<i>Fragilaria capucina</i> Desm.	-	1	-	-	-	1
	<i>Fragilaria virescens</i> Ralfs	-	1	3	-	-	2
	<i>Gomphonema fanensis</i> Maillard	1	-	-	2	1	-
	<i>Gomphonema lanceolatum</i> (Ehr.) Hust.	1	1	-	-	1	2
	<i>Gomphonema olivaceum</i> (Horn.) Kütz.	-	-	2	-	-	-
	<i>Melosira distans</i> (Ehr.) Kütz.	-	1	-	2	-	2
	<i>Melosira granulata</i> (Ehr.) Ralfs	1	3	-	2	-	-
	<i>Melosira undulata</i> (Ehr.) Kütz.	-	-	2	1	-	1
	<i>Navicula cuspidata</i> Kütz.	1	1	-	-	-	2
	<i>Navicula decussis</i> Oestrup	-	-	1	-	-	3
	<i>Navicula placentula</i> (Ehr.) Grun.	2	-	-	1	1	1
	<i>Nitzschia acicularis</i> W. Smith	-	2	1	-	-	-
	<i>Nitzschia clausii</i> Hantz.	-	-	2	-	-	2
	<i>Nitzschia gracilis</i> Hantz.	1	-	-	1	-	1
	<i>Nitzschia subrostrata</i> Hustedt	-	1	2	-	1	-
	<i>Nitzschia subtubicola</i> Germain	2	-	-	-	1	1
	<i>Surirella robusta</i> Ehr.	-	-	1	2	-	1
	<i>Synedra tabulata</i> (Ag.) Kütz.	1	-	3	-	-	-
	<i>Synedra ulna</i> (Nitzsch) Ehr.	-	-	1	1	-	2

Phytoplankton Diversity

Species diversity is a reliable tool to assess the quality of an ecosystem based on relations between the number of taxa and the number of individuals. This research recorded a total of 53 phytoplankton species belongs to four classes, where Bacillariophyceae was dominant group following Euglenophyceae, Chlorophyceae and Cyanophyceae. The occurrence of Cyanophyceae was almost similar in all stations. ST 6 showed highest number of individuals (53), while minimum (20) was found in ST 5 (Table 2). *Fragilaria brevistriata*, *Melosira granulata*, *Phacus caudatus*, *Pandorina morum* and *Scenedesmus acuminatus* was found abundantly

(cell/ml) in ST 1, 2, 4, 5 and 6. *Scenedesmus acuminatus* was found commonly in five stations except at ST 1, whereas *Euglena chlamydotheca*, *Gomphonema olivaceum* and *Cymbella parva* found only in ST 1, 3 and 5. As single genus *Euglena* and *Nitzschia* possess highest number of taxa in this studied river. However, Margalef index indicated that ST 6 had highest species richness, while ST 4 had lowest (Figure 2 a). In case of species evenness by Simpson index, ST 2, 4 and 5 had few species that were dominant over the other species, but phytoplankton were evenly distributed in ST 1, 3 and 6 (Figure 2b). The Shannon Weiner index indicated the higher diversity in ST 3 and 6, while

ST 4 and 5 had least diversity in species distribution (Figure 2 c). However, the three-diversity indices showed that diversity of phytoplankton in ST 6 was far better than the other stations.

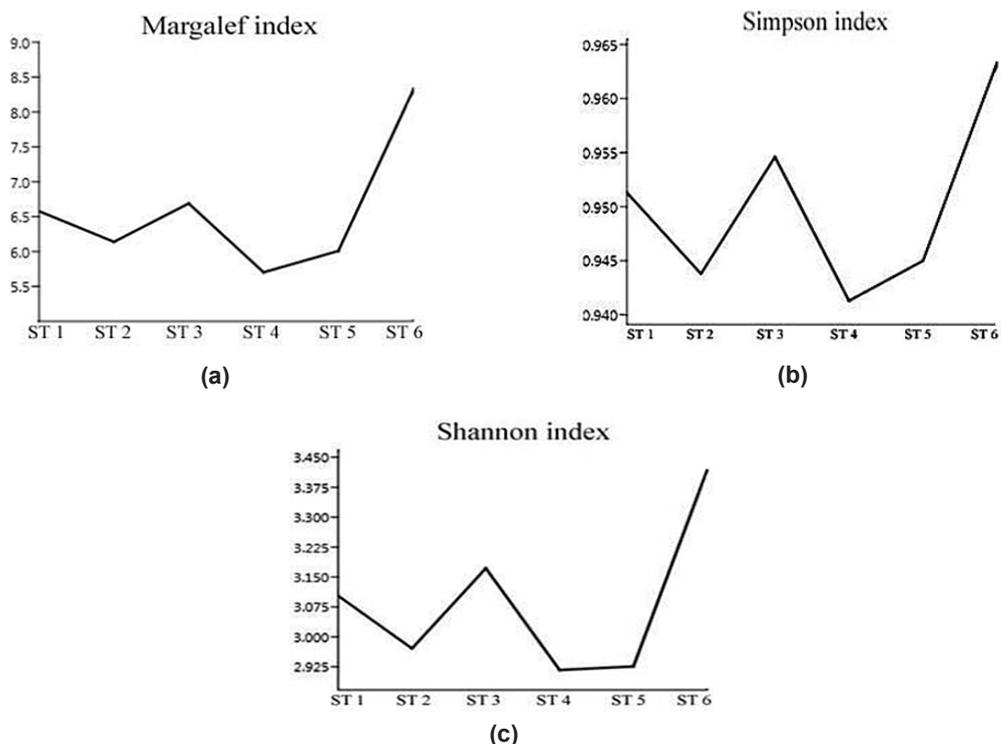


Fig. 2: The graphs show three diversity indices in all stations. Here, (a) Representative of Margalef index, (b) Simpson index and (c) Shannon index

Table 3: Correlation coefficient between physico-chemical parameters and different phytoplankton groups at 5% probability level

	Temp (°C)	pH	DO (mg/l)	EC (mS/cm)	TDS (mg/l)	NO ₃ ⁻ (mg/l)	NH ₄ ⁺ (mg/l)	SO ₄ ²⁻ (mg/l)	DIP (mg/l)	CO ₃ ²⁻ (mg/l)
Temp	1									
pH	-0.8765	1								
DO	0.0058	-0.3154	1							
EC	-0.5767	0.8059	-0.1184	1						
TDS	-0.5366	0.7075	-0.1195	0.9446	1					
NO ₃ ⁻	-0.5766	0.8001	-0.0629	0.7987	0.5630	1				
NH ₄ ⁺	-0.1487	0.2638	-0.0174	0.6337	0.7319	0.2527	1			
SO ₄ ²⁻	0.1062	0.1023	0.4096	0.4708	0.2653	0.6389	0.2085	1		
DIP	0.2611	0.0931	-0.2176	0.3918	0.6155	0.2879	0.3874	0.4779	1	
CO ₃ ²⁻	0.3730	-0.9589	0.3099	0.6809	0.3841	-0.7128	-0.0107	0.0172	0.1098	1
CYN	-0.0201	0.1921	-0.2297	0.0000	0.1559	0.2579	-0.7247	0.1800	-0.2988	-0.4073
CHL	-0.1636	0.4649	-0.0182	0.7426	0.5535	0.8266	0.5887	0.3830	0.6980	-0.2653
EUG	-0.6058	0.8066	-0.1302	0.8141	0.6205	0.9434	0.4813	0.5133	0.3858	-0.6477
BAC	-0.2195	0.4534	0.1879	0.7324	0.5288	0.8539	0.5038	0.3717	0.5852	-0.2821

CYN= Cyanophyceae, CHL= Chlorophyceae, EUG= Euglenophyceae, BAC= Bacillariophyceae.

■ Significant and ■ Highly Significant

Note: Here, correlations among the phytoplankton groups were discarded.

Correlation Studies

The study attempted to make correlations among the measured physico-chemical parameters, also with the four groups of phytoplankton. There were significant and highly significant correlations among the measured parameters, and with the phytoplankton groups. However, there were no significant correlations in case of dissolve oxygen and dissolve inorganic phosphorus with other parameters except TDS. These two are important to measure impacts of water quality on aquatic biota. However, EC and TDS were significantly correlated with maximum parameters in physico-chemical aspects in Kirtankhola River (Table 3). Increases of EC was linked with the increases of pH, TDS, NO_3^- , CO_3^{2-} and NH_4^+ , and the decreases in temperature could increase the EC, TDS and pH values in the water. Moreover, NO_3^- negatively correlated with CO_3^{2-} ($r=-0.7128$) but positively with SO_4^{2-} ($r= 0.6389$). In case of phytoplankton group, the water quality had no impact on Cyanophyceae except NH_4^+ ($r= -0.7247$). That meant, presence of NH_4^+ is responsible for low occurrence of Cyanobacteria. On the other hand, EC, TDS, NO_3^- , NH_4^+ and DIP were responsible for presence of Chlorophyceae. Temperature and CO_3^{2-} was sensitive for the occurrence of Euglenophyceae, although increasing pH, EC, TDS, NO_3^- , and SO_4^{2-} favored their abundance, while Bacillariophyceae positively correlated with EC, TDS, NO_3^- , NH_4^+ and DIP.

Conclusion

This study indicates that the water of Kirtankhola River is in good quality, although some locations (ST 3 and 6) are being contaminated due to discharges from industries, water vehicles and other anthropogenic activities. In total 53 phytoplankton taxa were recorded under four classes and Bacillariophyceae is dominant over the other groups and the water of ST 6 showed good biodiversity indices comparatively than others. However, this is the first report on phytoplankton diversity and correlation among water physico-chemical parameters with phytoplankton groups in this river. The water quality has mostly positive impacts on Chlorophyceae and Bacillariophyceae.

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Conflict of Interest

Authors did not have any conflict of interest.

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