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Sumaiya Ahmed
Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh

Dulon Roy
Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh

Haraj Uddin
Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh

Shibananda Shil
University Grants Commission of Bangladesh, Agargaon, Dhaka-1207, Bangladesh

Md. Sagir Ahmed
Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh

Correspondence
Dulon Roy
Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh

Temporal analysis of phytoplankton diversity in relation to some physico-chemical parameters of the river Buriganga

Sumaiya Ahmed, Dulon Roy, Haraj Uddin, Shibananda Shil and Md. Sagir Ahmed

Abstract
Present study was conducted to compare phytoplankton diversity and their seasonal abundance in relation to some physico-chemical parameters from January to December 2001 in the river Buriganga. Among various chemical parameters dissolved oxygen content was found very low, range from 0.3-5.3 mg/l which is very alarming for aquatic lives in the river. In contrast, free CO_2 was high and ranged from 2.1-183.6 mg/l. The river water was alkaline and hard throughout the period of investigation (p^H 7.4 to 9.5, Hardness 145 to 380 mg/l and alkalinity 57 mg/l to 322 mg/l). About 59 species of algae belonging to 35 genera was identified during one year investigation. In the algal community the highest number of taxa belong to Chlorophyta (45.77%), followed by Cyanophyta (18.65%), Euglenophyta (18.65%) and Chrysophyta (16.95%). The dominant groups of algae like *Melosira* spp. (2779.16 indiv/l) were found throughout the year; other genus *Microcystis* spp. ($2.8x10^6$ cells/l) and *Oscillatoria* spp. (2520 indiv/l) were found dominant in July. The relationship between physico-chemical and biological parameter; temperature and phytoplankton were observed. Some species of phytoplankton have positive relationship with low oxygen content as well as nitrogen and some phytoplanktons have negative relationship. Diversity index of phytoplankton was carried out and ranged in between 0.279 to 1.296 and evenness index ranged from 0.1 to 0.9.The results indicated that the water of the river Buriganga was highly polluted and plankton diversity index was moderately rich and evenly distributed.

Keywords: Buriganga River, phytoplankton, species diversity, water quality parameters

1. Introduction
The phytoplankton population represents the biological wealth of a water body, constituting a vital link in the food chain. Phytoplankton is the major primary producers in many aquatic systems and is important food source for other organisms (Sukumaran *et al*, 2008). Phytoplanktons not only serve as food for aquatic animal, but also play an important role in maintaining the biological balance and quality of water (Pandey *et al*.). Phytoplankton species can be used as indicators of water quality for their sensitivity and dynamic responses to changes in the surrounding environment. The variability of phytoplankton with the seasonal changes in aquatic environment is very much necessary for the maintenance of water quality and sustainable aquaculture in Bangladesh.

Bangladesh is the land of rivers. The river Buriganga is situated at the south part of Dhaka city, Bangladesh. Day by day the river is being polluted by the discharging of huge volume of toxic waste or materials with the thousands of industrial unit of the Dhaka city (Alam, 2003) [1]. The interrelationship between the physico-chemical parameters and variability of plankton production of water body is great importance in an aquatic ecosystem. Fishes are dependent on physico-chemical parameters. Any change of these parameters may affect the growth, development and maturity of fish (Jhingran, 1985) [8]. The productivity of freshwater community that determines the fish growth is regulated by the dynamics of its physico-chemical and biotic environment (Wetzel, 1983). The pH, dissolved oxygen, alkalinity and the dissolved nutrients are important for the phytoplankton production (Bais and Agarwal, 1990) [3]. The present study deals with the phytoplankton diversity of the river Buriganga, especially the cyanobacteria, their seasonal abundance and relationship with physico-chemical parameters. At present the aquatic environment of the river Buringanga has been disrupted totally and many report stated that as a result of deoxygenating and toxic gases, the mortality of aquatic

organisms are common and it may longer not able to support life (Khan, 1998). The faunal survey of the plankton of a river is basic work for a developing country like Bangladesh.

2. Materials and Methods

The river Buriganga is surrounded by south-western periphery of the Dhaka city. It is considered as one of the most populated urban river in the country, Bangladesh. It lies between latitude 23^0 37′42″N and longitude 90^0 26′30″E. The three study areas were selected such Kamrangirchar (S_1), Babubazar (S_2) and Sadarghatat (S_3) of the river and sampling time was 9am to 12pm from January 2001 to December 2001**.**

The physico-chemical and biological parameter were recorded by HACH kit (model FF-2 cat, No. 2430-01) and electrical microscope {OLYMPUS (CH30) EA40 (0.65160/0.17)} respectively. Phytoplankton was analyzed qualitatively and quantitatively by using taxonomic keys (Wards and Whipple, 1959). A part of unfiltered sample water was used to determine the ionic concentration such as: p^H, conductivity, phosphate, salinity, were measured by digital p^H meter (HI-98107), digital conductivity meter (HACH-CO 150), colorimeter (HACH Model FF-2), salinity meter (HACH-cal150) respectively. Dissolved Oxygen (DO) measured by DO meter (Do-5509 AF.01214) and the rest of the chemical compound acidity, alkalinity, hardness, ammonia, nitrite etc. were measured by HACH kit.

Phytoplankton samples were collected using plankton net (20 micron mesh size) and preserved in dark sterile plastic bottles with 5% formalin on site. Identification of the phytoplankton species was conducted in laboratory of Fisheries and Marine Science department under a phase contrast light microscope at 16x40 and 16x10 magnification (Model No: XSZ21-05DN, Made in China) with bright field and phase contrast illumination. Quantitative analysis of phytoplankton was done on Sedgewick-Rafter counting chamber (S-R cell). Analysis involved transfer of 1 ml sub-sample from each of the samples to the Sedgewick- Rafter counter and counting of cells within 10 squares of the cells, chosen randomly.

The cell counts were used for computing the cell density using the formula:

$N= (A\times C\times X) \div (L\times Y)$

Here,

N= Number of phytoplankton per liter of original water.

A= Average number of phytoplankton observed in 10 sub cell of the S-R cell.

C= Volume of the concentrated sample in ml.

X= Number of the total cells in the S-R cell.

L= Volume of the original water expressed in liter.

Y= Number of counted cells of the S-R cell.

The phytoplankton were then identified up to the genus level and enumerated by APHA, 1992 and Bellinger. The mean number of phytoplankton was recorded and expressed numerically per liter of water of the river.

2.1 Diversity indices

To determine the diversity indices the following formula was used: (Shannon, 1948)

$$H' = -\sum_{i=1}^{s}\left[\left(\frac{ni}{n}\right) \ln\left(\frac{ni}{n}\right)\right]$$

Here,

H′= the amount of observed diversity in a community.

S= the number of species (species richness).

ni= the relative abundance of the species.

n =the total number of individuals in the samples.

3. Results and Discussion

3.1 Water quality parameters

Physico-chemical parameters have an effect on the quality and quantity of phytoplankton population. During this study period, physicochemical parameters of river water such as temperature, ammonia, alkalinity, hardness, dissolved oxygen (DO), free CO_2 and pH were measured and found variable during the study period (Table 1).The observed variations in water temperature might be related to the weather conditions. However, temperature is found within the optimal ranges (25-30 °C). The highest value of dissolved oxygen (DO) is 5.28 mg/l in the month of November. The range of dissolved oxygen is 0.3-5.3 mg/l. Carbon dioxide (CO_2) level fluctuated from 2.1mg/l to 183.6 mg/l at different sampling stations during the study period. From January to March ammonia is highly concentrated and it is above 2 mg/l but from April to December ammonia concentration is decreased. Hydrogen ion concentration (p^H) is fluctuated from 7.4 to 9.5 during the study period. The monthly variation of hardness of water ranged 145 to 380 mg/l, P^H and hardness is showed a positive relationship among them**.** Alkalinity was expressed as phenolphthalein alkalinity or total alkalinity including carbonate, bicarbonate and hydroxide alkalinity. The alkalinity concentration range is 57-322 mg/l in different stations during study period**.** Alkalinity and p^H was positively related.

Recently six months (January 2014 to June 2014) survey was conducted in the river Buriganga from Kamrangirchar to Sadarghat whereas pH found 7.2-7.6, alkalinity 67-398 mg/l, ammonia 1.6-3 mg/l, hardness 56-223mg/l, nitrite-nitrogen 0, phosphate phosphorus 0.3-0.9 mg/l and dissolved oxygen 1.2-7.2 mg/l.

3.2 Qualitative Status of Phytoplankton Community: Four groups of phytoplankton viz.; Chlorophyceae, Cyanophyceae, Euglenophyceae and Chrysophyceae consisting of 35 genera were identified in the different sampling station of the river Buriganga. Among the identified genera, 27 Genera belonged to Chlorophyceae, 11 to Cyanophyceae, 11 to Euglenophyceae, and 10 to Chrysophyceae (Table 3). Among the identified genera, *Euglena*, *Microcystis* and *Melosira* were found dominant. The highest number of taxa belongs to Chlorophyta (45.77%), Cyanophyta (18.65), Euglenophyta (18.65%) and Chrysophyta (16.95%). A total number of 35 genera and 59 species of algal have been recorded (Table 3). Islam *et al*. (1974) [7], conducted an investigation from April 1973 to March 1974 on Buriganga River. The investigation was recorded 72 genera including 194 species of algae. Among them the maximum number of the genera was 38 under the class Chlorophyceae (52.77%) and the minimum number was 1 belongs to the phylum Chrysophyceae (1.39%) and other number were 18, 9, 2, 2, 2 belongs to the class Bacillariophyceae (25%), Cyanophyceae (12.5%), Kanthophyceae (2.78%), Euglenophyceae (2.78%) and Rhodophyceae (2.78%) respectively. Recent finding (2014) stated that 14 genera of phytoplankton have been recorded under three class Cyanophyceae (28.57%), Euglenophyceae (35.71%) and Bacillariophyceae (35.71%). Three data showed gradual decreased of phytoplankton diversity. So we can predict that if this situation is continued in following 30 years the plankton diversity may be extinct and this river will be declared as a dead river very soon.

Table 1: Monthly variation in physico-chemical parameters at different sampling station of the river Buriganga from January to December 2001

Months	Station A								Station B								Station C							
	Temperature (°C)	Alkalinity (mg/l)	Ammonia (mg/l)	Free CO_2 (mg/l)	Nitrogen (mg/l)	DO (mg/l)	P^H	Hardness (mg/l)	Temperature (°C)	Alkalinity (mg/l)	Ammonia (mg/l)	Free CO_2 (mg/l)	Nitrogen (mg/l)	DO (mg/l)	P^H	Hardness (mg/l)	Temperature (°C)	Alkalinity (mg/l)	Ammonia (mg/l)	Free CO_2 (mg/l)	Nitrogen (mg/l)	DO (mg/l)	P^H	Hardness (mg/l)
January	23.5	300	2.03	17.0	0.16	2.4	8.5	224	23.6	308	2.03	10	0.0	2.3	10	180	22.2	310	2.03	5.0	0.0	0.8	9.5	235
February	26.2	315	2.03	45.2	0.0	1.5	8.5	260	26.1	350	2.03	20.2	0.05	1.5	9.0	250	26.6	322	2.03	17.0	0.4	1.7	8.7	380
March	28.3	300	2.03	19.0	0.0	0.8	7.8	232	31.6	440	2.03	163.8	0.0	1.3	8.8	269	32.7	300	2.03	183.6	0.0	0.3	9.3	279
April	37.7	308	2.03	50.0	0.05	2.9	9.4	235	32.2	230	2.03	49.6	0.02	2.7	9.3	270	36.5	150	2.03	32	0.7	2.6	8.6	250
May	35.5	160	2.8	38.8	0.05	2.1	9.8	64	36.0	121	2.8	54.2	0.05	1.4	7.5	39	36.8	159	2.9	68.6	0.05	0.8	9.4	160
June	35.0	148	1.2	30.2	0.06	3.0	8.9	52	36.5	108	1.2	53.2	0.05	1.4	7.9	30	35.5	130	1.9	62.6	0.08	1.3	9.1	155
July	34.5	133	1.4	15.8	0.01	2.8	9.8	59	32.5	193	1.2	16.0	0.04	1.5	9.8	45	33.8	190	1.4	15	0.03	1.3	8.3	163
August	31.3	280	2.0	20.0	0.03	4.1	7.7	65	32.0	177	1.1	19.0	0.02	3.9	9.3	40	31.8	67	1.15	18.2	0.03	4.3	8.9	155
September	27.0	110	1.4	24.0	0.0	3.0	6.7	175	26.5	100	0.6	10.0	0.0	3.9	6.2	155	26.0	110	0.8	19.2	0.01	4.0	8.6	145
October	23.0	110	2.5	8.0	0.2	3.9	7.6	170	23.6	69	1.1	8.8	0.01	4.0	8.3	190	22.7	57	1.1	2.8	0.03	3.8	8.1	165
November	14.4	78	2.03	7.2	0.0	4.1	8.6	178	14.4	72	2.2	6.2	0.0	3.9	8.6	185	14.4	68	2.3	2.1	0.0	5.3	8.8	170
December	21.6	250	2.03	34	0.01	2.1	7.5	160	21.6	290	2.03	32	0.05	1.0	7.5	200	18.6	300	2.03	32.5	0.5	0.5	7.4	217
Mean	28.1	207.6	1.96	25.7	0.05	2.7	8.4	156.1	28.0	204.8	1.7	36.9	0.02	2.4	8.5	154.4	28.1	180.2	1.81	38.22	0.15	2.23	8.73	206.1
SD (±)	6.93	91.9	0.45	13.9	0.07	1.02	0.9	77.1	6.56	120.3	0.63	43.77	0.02	1.2	1.1	92.6	7.49	102.3	0.59	50.58	0.24	1.71	0.60	70.30

Table 2: Monthly variation in the abundance (individual/l) of different groups of phytoplankton in the river Buriganga

Groups	Months												Average
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
S1	560	3450	4020	2550	9260	3730	7930	26200	930	104	1870	1780	5198.67
S2	300	1480	4520	1610	6030	1320	1200	9520	200	530	450	420	2298.33
S3	270	1080	2660	300	1840	6550	660	6260	224	910	190	540	1790.33
Total	1130	6010	11200	4460	17130	11600	9790	41980	1354	1544	2510	2740	9287.33

Table 3: Showing the percent composition of different groups of algae in the river Buriganga

Division	Class/Order	No. of genera	No of species	Total No of species in the division	Present composition of the division
Chlorophyta	Volvocales	5	5	27	27
	Chlorococcales	9	16		
	Zygnemataceae	2	6		
Cyanophyta	Cyanophyceae	7	11	11	18.64
Euglenophyta	Euglenophyceae	4	11	11	18.64
Chrysophyta	Bacillariophyceae	7	9	10	16.95
	Dinophyceae	1	1		
Total		35	59	59	100

Table 4: Diversity indices of phytoplankton community of the river Buriganga

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Station A												
TS	300	1480	4520	1610	6030	1320	1190	9520	200	530	450	420
R_1	2.02	1.58	1.92	2.81	3.97	2.88	2.60	2.26	1.74	4.77	3.77	2.67
H′	0.48	0.37	0.52	0.81	0.66	0.43	0.31	0.11	0.44	0.78	0.90	0.75
H'_{mas}	0.78	0.78	0.90	1	1.294	1	0.95	1	0.70	1.15	1.04	0.90
E	0.62	0.48	0.57	0.81	0.55	0.43	0.32	0.11	0.63	0.68	0.86	0.83
Station B												
TS	560	3450	4020	2550	9260	3730	7920	26200	930	104	1870	1780
R_1	1.09	2.54	2.50	4.40	4.54	3.64	2.82	2.26	2.02	2.98	3.06	3.38
H′	0.51	0.77	0.63	1.18	0.58	0.29	0.35	0.28	0.55	0.60	0.83	4.91
H'_{mas}	0.60	1	1	1.20	1.28	1.15	1.078	1.04	0.85	0.85	1.04	1.08
E	0.84	0.77	0.63	0.98	0.45	0.25	0.33	0.27	0.65	0.71	0.81	0.84
Station C												
TS	540	560	2300	860	8840	4700	21290	10040	580	1380	470	1660
R_1	3.29	1.09	3.27	5.11	3.54	4.08	3.23	2.49	2.53	3.82	4.12	4.97
H′	0.71	0.56	0.81	0.07	0.70	0.05	0.10	0.59	0.61	1.30	0.97	0.93
H'_{mas}	1	0.60	1.07	1.20	1.18	1.20	1.18	1.04	0.90	1.11	1.08	1.23
E	0.71	0.93	0.92	0.68	0.06	0.44	0.82	0.56	0.67	1.17	0.90	0.76

3.3 Quantitative analysis of phytoplankton

The quantitative observation was made at one-month interval on the phytoplankton community of the 4 selected stations in the river Buriganga. Abundance and diversity of phytoplanktons of the selected stations were moderately different. From the accumulated data in a year, the total monthly average of phytoplankton was 5198.67indiv/l (S1), 2298.33 indiv/l (S2), 1790.33 indiv/l (S3)**.** The recorded major group of phytoplankton is ranked based on the dominance by average number**.** Various algae like *Microcystis aeruginosa* and other members of the Chlorococeales (*Coelastrum sp., Scenedesmus opoliensis., S. quadricauda, Pediastrum simplex, P. duplex)* was found well in low oxygen content. The diatoms like *Gomphonema parvulum, Eunotia arcus, E. pectinalis, Nitzchia hantzschiana* etc. were found in high amount of dissolved oxygen (Islam 1975). The bloom forming species like *Microcystis* spp. was found dominant in May and July and *Oscillatoria* spp. was found in May. After heavy rainfall surface run off increase nutrient contents which stimulate excessive growth or bloom of Cyanobacteria. The summer season is the most favorable period for the growth and multiplication of algae. Because of increasing the light intensity and phytoplankton growth is considerable. But pollution level of Buriganga River is so high that summer season is not suitable for the algal growth.

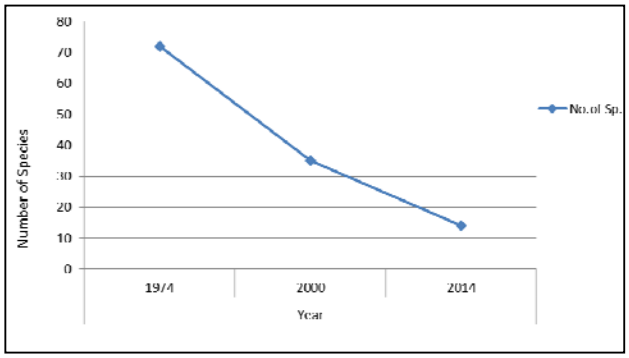

Fig 1: Showing that how the phytoplankton diversity gradually decreased (1974 to 2014)

3.4 Diversity Index

Shanon's diversity index varied between 0. 1 to 0.9. Extremely low diversity (0.1) of phytoplankton occurred in July to August whereas the highest diversity (0.9) occurred in May. Actually diversity drops with increasing pollution. The evenness index ranges from 0.1 to 0.9 Closer to 1 is the more equaled abundant are the species in the study community. Therefore, the measurements of similarity were calculated using Sorensen index of taxonomic similarity was found in between 86-96%.

4. Conclusion

The water of the river Buriganga is highly polluted and contain very low amount of dissolved oxygen (0.25mg/l), which is threatened for fish and other aquatic lives. From the present study it was revealed that the river was moderately rich in phytoplankton diversity which is low compared with the previous study. However, Cyanobacteria appeared high in number during the study period. The highly toxic *Microsystis* spp. was found very high ($2.8x10^4$cell/l) in number and forms bloom during winter season. In this paper we showed that phytoplankton diversity has declined alarmingly. If this situation continued it would be Dead River in near future. So, immediate action should be taken by the government to recover this river which is the heart of Dhaka city.

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