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SEASONALITY OF PHYTOPLANKTON AND THEIR RELATIONSHIP WITH SOME ENVIRONMENTAL FACTORS IN A POND OF OLD DHAKA

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Abstract

Results obtained in an investigation on Bangshal pond in old Dhaka, Bangladesh showed that highest and lowest air and water temperatures were recorded during summer (30.73 and 30.44ºC) and winter (24.5 and 23.5ºC), respectively. Seasonal variation of secchi depth exhibited the highest and the lowest value during monsoon (68.81cm) and summer (57.83 cm), respectively. During summer mean seasonal value of TDS (341.48 mg/l), conductivity (2019.88 µS/cm), alkalinity (7.6 meq/l) and SRP (0.16 µg/) were maximum while the value of pH (7.5), SRS (0.244 mg/l), SRP (0.14 µg/l) were minimum during winter. Highest values of pH (7.9), SRS (0.297 mg/l) and NO_3-N (0.26 mg/l) were found during monsoon while lowest values of conductivity (530.99 µS/cm) and NO_3-N (0.06 mg/l) were recorded during autumn. Concentration of Chl *a* remained highest during autumn (116.39 µg/l) and lowest value during winter (88.79 µg/l) and for phaeophytin the highest concentration was obtained during summer (42.73 µg/l) and the lowest during monsoon (18.37 µg/l). A total of 122 phytoplankton species were recorded in the present study and highest phytoplankton count was obtained during autumn followed by monsoon, summer and winter. Results of PCA and correlation matrix showed that three phytoplankton species, namely *Cryptomonas erosa*, *Arthrospira plantensis*, *Scenedesmus* mainly were influenced by pH during monsoon period.

Introduction

Bangladesh is essentially a delta with large number of lentic and lotic water bodies which may have inundation due to the influx of flood water and drainage congestion during the monsoon period. Ponds are manmade closed lentic aquatic system and in Bangladesh ponds distributed both in rural and urban areas were occupying about 1.13% of the total area of the country with a great potentiality of biological productivity (Khondker and Kabir 1995). In Bangladesh so far 100 limnological investigations were carried out on pond ecosystems (FAP-17 1993). Littoral and to some extent pelagic are the most important productive zones in pond ecosystems where interactions of different physico-chemical parameters with biological ones were observed. The vast pelagic zone is mainly occupied by plankton organisms and varies season to season. Seasonal plankton development is controlled by various physical, chemical and biological factors (Descy 1993, Acs and Kiss 1993). Due to changes of physical, chemical and biological variables of water, seasonal dynamics and succession of phytoplankton occur. Information regarding the seasonal variations of phytoplankton and environmental factors is quite insufficient in the Indian sub-continent and the data quality and methodology of previous studies were also not clearly defined (Cloern *et al*. 1985, Jewel *et al*. 2002, Hossain *et al*. 2007, Sultana and Khondker 2009). Therefore the present investigation was carried out in a pond ecosystem known as "Bangshal Pond" to find out the community characteristics and seasonality of phytoplankton and their relationships with some environmental factors.

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Materials and Methods

The study was conducted on Bangshal pond, one of the biggest (area 0.47 hector, maximum depth 7.2 meter) and oldest (excavated about 189 years ago) pond in old Dhaka city coordinated between 23°42'56.22"N and 90°24'26.25"E. The oval shaped pond surrounded by boundary wall, where over 3,000 peoples everyday take their bath and fish farming is carried out in every year. The stocked fishes are mainly composed of *Oreochromis niloticus* (Linnaeus 1758), *Labeo rohita* (Hamilton 1822), *Catla catla* (Hamilton 1822), *Heteropneustes fossilis* (Bloch 1794), *Channa punctatus* (Day 1878) and other common carps.

A total of 24 samples was collected early in the morning (between 7.30 a.m. to 9.30 a.m.) at fortnightly intervals over a period of one year from June 2010 to May 2011. Air temperature, water temperature, secchi depth, pH, total dissolved solids (TDS) and conductivity were measured *in situ* using portable devices. The water samples for chemical analysis were collected from 0.5 meter depth of water. After collection, the water samples were brought to the National Professor A.K.M Nurul Islam laboratory, Department of Botany, University of Dhaka for further analysis. Alkalinity was determined after Mackereth *et al*. (1978) and dissolved oxygen (DO) and soluble reactive silicate (SRS) after Wetzel and Likens (1979), soluble reactive phosphorus (SRP) and nitrate nitrogen (NO_3-N) after Murphy and Rilley (1962) and Müller and Wiedemann (1955). Chl *a* and phaeophytin were determined after Marker *et al*. (1980). Samples of phytoplankton were collected by sedimentation technique with Lugol's solution and quantification of plankton was done with the help of a HBCC (Helber bacterial counting chamber, having a fixed volume 1.005 µl) under compound microscope, Nikon (Optiphot, UFX-11A) fitted with a camera (Nikon FX-35 WA, Japan).

In the present study four distinct seasons that prevail in Bangladesh were considered according to Rashid (1991). These are: winter (late November to February), summer (March to May), monsoon (June to early October) and autumn (late October to November).

To find out the relationship between different seasons and physico-chemical parameters Principal Component Analysis (PCA) (Primer 6: Clarke and Gorley 2006) was applied. PCA is a useful tool to specify the reduced set of variables explaining a percentage of the variability in the ordination of samples in space. Later on to correlate the phytoplankton characteristics with seasonality correlation matrix analysis (Statistica 6) was used with PC1 and PC2 scores and abundance of different phytoplankton species, concentrations of Chl *a*, phaeophytin and phytoplankton density. Prior to PCA analysis water temperature and pH were standardized while rest of the environmental variables were log(x+1) transformed. Abundance of different phytoplankton species, concentrations of Chl *a* and phaeophytin and phytoplankton density were also transformed log(x+1) during application of correlation matrix.

Results and Discussion

During the present study period (June, 2010 to May, 2011), monthly mean air temperatures varied from 17 to 35.5ºC while water temperatures ranged between 19 and 33ºC. Mean seasonal air and water temperature showed that highest and lowest temperatures were recorded during summer (30.73 and 30.44ºC) and winter (24.5 and 23.5ºC), respectively. Air temperature was found higher than water temperature during winter and summer but in monsoon and autumn changes occurred inversely. The variations were further aggravated by heavy precipitation during the monsoon (Fig. 1) when most of the dominant phytoplankton was counted but the highest abundance was obtained during autumn (Table 1). The effects of water temperature on phytoplankton have been directly examined in many aquatic ecosystems and it was found that water temperature strongly regulates the seasonal variations of phytoplankton (Richardson *et al*. 2000). However, the observed

temperature variations in the current study were within the optimal ranges (18.3 - 37.8°C) for the production of plankton in tropical ponds (Alfasane *et al*. 2003, Hossain *et al*. 2007).

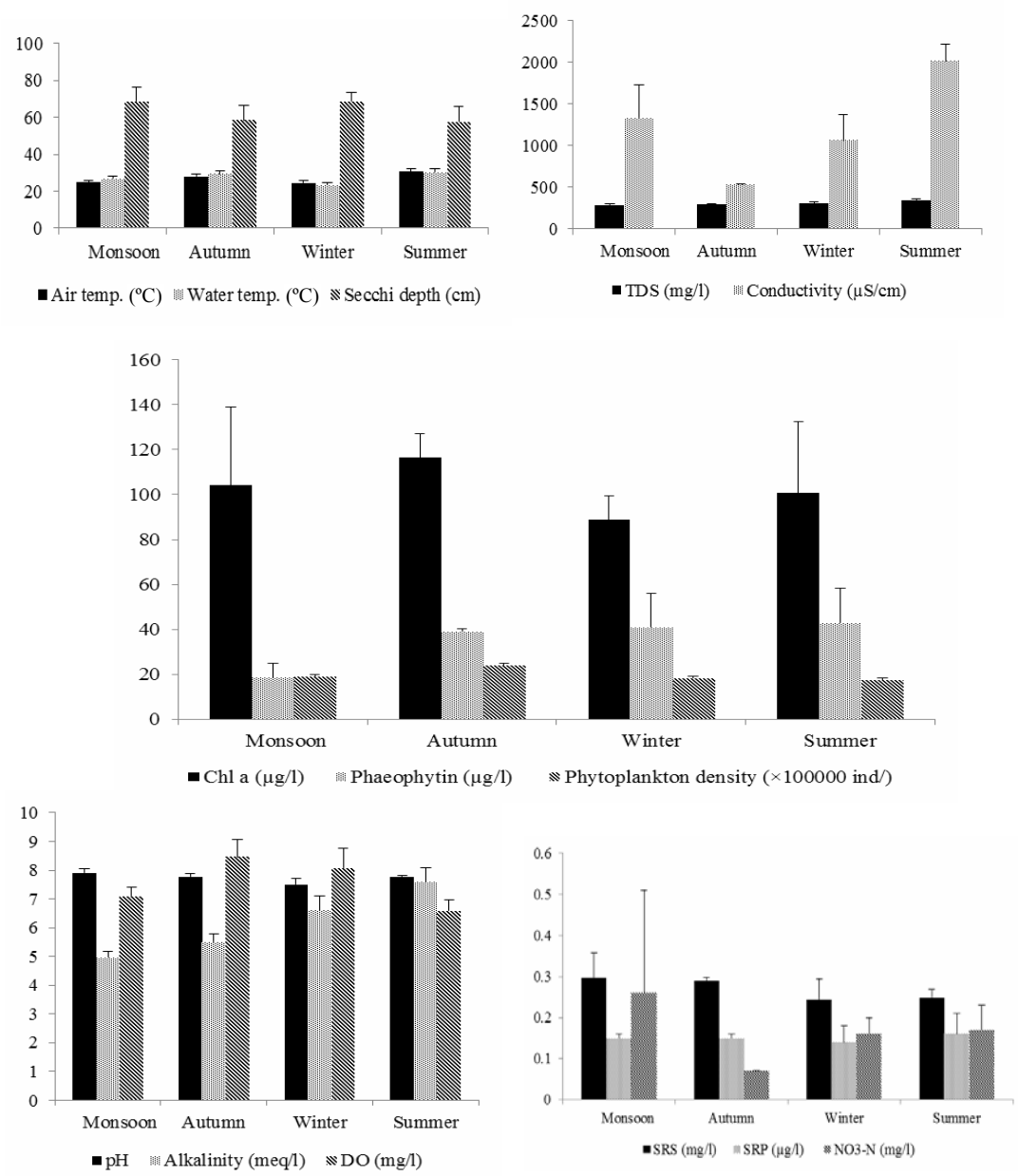

Fig. 1. Seasonal variations of different physico-chemical parameters (Air temp., water temp. secchi depth, TDS, conductivity, pH, alkalinity, DO, SRS, SRP and NO_3-N), Chl *a*, phaeophytin and phytoplankton density in the Bangshal pond (mean value with standard deviation).

Light is a major resource for phytoplankton and has a complex pattern of spatial and temporal variability (Litchman 2000, Çetin and Şen 2004). During the study period secchi depth as a water transparency varied from 50 to 81 cm. Several researchers recorded a significant correlation between the growth of phytoplankton and transparency in different aquatic ecosystems (Çetin and Şen 2004, Hossain *et al*. 2007, Begum *et al*. 2007). Seasonal variation of secchi depth showed that the highest value was during monsoon (68.81cm) and the lowest was in summer (57.83 cm). It was observed that phytoplankton diversity was the maximum during monsoon (Fig. 1, Table1).

During the course of investigation other chemical parameters such as monthly mean pH fluctuated from 7.14 to 8.25 while alkalinity ranged from 4.5 to7.95 meq/l. More or less similar variation in pH was reported by Khondker and Talukder (2005) from different pond ecosystems of Comilla but the range of alkalinity was much lower than the present study. Conductivity ranged from 516 to 2266 µS/cm which was comparable to result from four polluted ponds of Dhaka studied by Khondker *et al.* (1990). Dissolved oxygen concentration varied from 3.45 - 10.97 mg/l which was much similar to the result of Temple ponds in Assam (Banita 2013). Other limnological variables showed wide range of variation like the previous studies that carried out different times by different researchers (Zaman *et al*. 1993, Khondker and Talukder 1995, Talukder and Khondker 1995, Sultana and Khondker 2009). In the present study TDS ranged from 264.66 to 358.6 mg/l, SRS ranged from 0.173 - 0.426 mg/l, NO_3-N varied from 0.07 - 0.980 mg/l, SRP ranged 0.069 - 0.217 µg/l, chl *a* varied from 29.02 - 138.13 µg/l and phaeophytin varied from 10.68 - 72.34 µg/l. Seasonally of pH showed lowest value obtained in winter (7.5) among the four seasons which was an indication that the study pond alkaline in nature. Polluted nature of water was observed by exhibiting higher conductivity during summer (2019.88 µS/cm) and less polluted condition prevailed during autumn when the value was lower (530.99 µS/cm). Alkalinity

Table 1. List of dominant phytoplankton with densities (×10^4 ind/l) recorded during four seasons in the Bagshal pond.

Phytoplankton species	Monsoon	Autumn	Winter	Summer
Arthrospira platensis Gomont	2.67	-	-	-
Crucigenia	4.98	40.65	7.39	5.03
Microcystis	-	6.10	-	-
Pelonema aphane Skuja	-	-	-	4.53
Chorella vulgaris Beyerinck	20.33	21.20	-	-
Cosmarium	6.80	5.75	5.34	-
Scenedesmus	1.07	-	-	-
Euglena	1.90	9.70	-	-
Cyclotella	24.58	-	9.24	26.75
Peridinium	13.12	-	10.88	3.2
Cryptomonas erosa Ehrenberg	1.80	-	-	-
Rhodomonas	10.44	22.0	18.22	23.67

and TDS showed same pattern of fluctuation where both of these remained higher during summer (7.6 meq/l and 341.48 mg/l) and lower during monsoon (4.97 meq/l and 283.42 mg/l). In case of alkalinity, Begum and Alam (1987) reported maximum and minimum value in summer and rainy season, respectively from two ponds in Majdee court. SRP was found to be higher during summer (0.16 µg/l) and lower in winter (0.14 µg/l). Concentration of Chl *a* remained highest during autumn (116.39 µg/l) and lowest value was found during winter (88.79 µg/l) and for phaeophytin

the highest concentration was obtained during summer (42.73 µg/l) and the lowest during monsoon (18.37 µg/l) (Fig. 1).

Density of phytoplankton population varied from 5.11×10^5 - 34.90×10^5 ind/l in the present investigation. A total of 40 genera was represented in the phytoplankton communities comprising of 122 species during the study period. Class wise distribution of those species was Chlorophyceae 34.42%, Euglenophyceae 31.96%, Cyanophyceae 15.57%, Bacillariophyceae 13.11%, Cryptophyceae 4.09% and Dinophyceae 0.85%. From two urban ponds of Dhaka Sultana *et al*. (1999) also reported five groups phytoplankton of which Chlorophyceae was the most abundant class. Dominance of Chlorophyceae was also observed in different ponds of Bangladesh (Zaman 1993, Chowdhury and Mamun 2006) as mentioned earlier in case of phytoplankton the highest density was recorded during autumn and the lowest during summer (Fig. 1). Phytoplankton diversity as number of species remained highest in monsoon and lowest in summer in the studied pond. During monsoon dilution of water occurred by heavy precipitation and mixing of nutrients may be pervasive that's why phytoplankton showed rich in diversity although maximum density counted during autumn. In the autumn season the dominant groups of algae were *Crucigenia, Chlorella vulgaris, Cosmerium*, *Euglena*, *Rhodomonas* (Table 1). These variations in phytoplankton growth are complicated due to interactions between ecological factors and regeneration rate of nutrients (El-Gindy and Dorgham 1992). Seasonal variation showed that highest phytoplankton count in autumn was due to lower concentration of phosphate and nitrate and least value of conductivity was observed at that period (Fig 1).

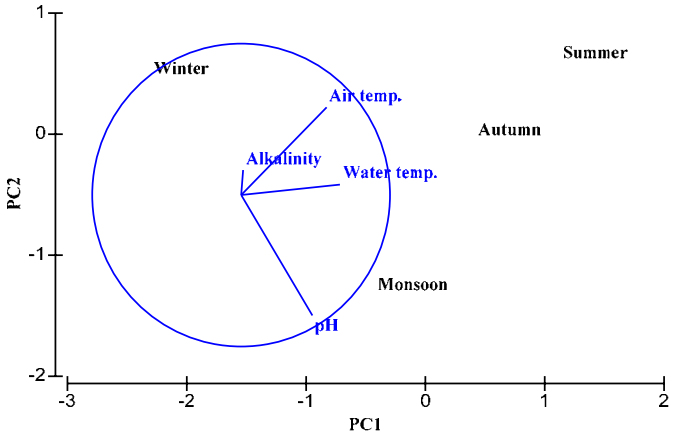

Fig. 2. Principal Component Analysis (PCA) plot of the first two PC axes on the transformed environmental data (Air temp. = Air temperature, Water temp. = Water). The length of the vectors in this plot reflects the significance of each variable contribution to each axis. If the vector reaches the circle, then none of that variable's coefficients differ from 0.

PCA analysis showed that out of 11 physico-chemical parameters only 4 are correlated with seasonality and found statistically significant with principal components (PCs). The first two PCs explained 99.5% of the total variance (Fig. 2). PC1 correlated positively only with water temperature (r = 0.664) while PC2 correlated positively with air temperature (r = –0.680) and alkalinity (r = – 0.201) and negatively correlated with pH (r = –0.795). Autumn and summer season ordinated positive sides of both the axes while monsoon placed negative side of both PCs. Winter season ordinated negative side on PC1 and positive side of PC2 (Fig. 2). Correlation

matrix between PC1, PC2 and phytoplankton species abundance, Chl *a*, paheophytin and phytoplankton density showed that *Cryptomonas erosa*, *Arthrospira platensis*, *Scenedesmus* and phaeophytin concentration were correlated with PC2 score and PC2 correlated with pH, air temperature and alkalinity (Table 2). It was found that during monsoon seasonal value of pH

Table 2. Correlations between the principal component score (PC1 and PC2) and dominant phytoplankton species, chl *a*, phaeophytin and phytoplankton density. The means and standard deviation (Std. Dev.) obtained from the four seasons. Marked (*) correlations are significant at p < 0.05000 N = 4 (Casewise deletion of missing data).

	PC1		PC2	
PC1	r = 1.0000	p = ---	r = 0.0006	p =.999
PC2	r = 0.0006	p = 0.999	r = 1.0000	p = ---
Chlorella vulgaris	r = 0.2365	p = 0.764	r = –0.7997	p = 0.200
Cosmarium	r = –0.6288	p = 0.371	r = – 0.5276	p = 0.472
Cyclotella	r = –0.2470	p = 0.753	r = –0.0539	p = 0.946
Cryptomonas erosa	r = –0.0454	p = 0.955	r = –0.9595*	p = 0.041
Peridinium	r = –0.3951	p = 0.605	r = –0.0953	p = 0.905
Arthrospira platensis	r = –0.0454	p =.0955	r = –0.9595*	p = 0.041
Scenedesmus	r = –0.0454	p = 0.955	r = –0.9595*	p = 0.041
Euglena	r = 0.2585	p = 0.742	r = –0.7325	p = 0.267
Rhodomonas	r = 0.3402	p = 0.660	r = 0.9002	p = 0.100
Crucigenia	r = 0.1575	p = 0.842	r = 0.1096	p = 0.890
Microcystis	r = 0.3179	p = 0.682	r = 0.0237	p = 0.976
Palonema aphane	r = 0.6362	p = 0.364	r = 0.5118	p = 0.488
Chl *a*	r = 0.7119	p = 0.288	r = –0.3642	p = 0.636
Phaeophytin	r = 0.0619	p = 0.938	r = 0.9726*	p = 0.027
Phytoplankton density	r = 0.1763	p = 0.824	r = –0.1709	p = 0.829

was the maximum and alkalinity was the minimum (Fig. 1) and above mentioned phytoplankton species only counted during monsoon (Table 1). So, significant positive impact of pH and negative impact of alkalinity was found during monsoon in case of *Cryptomonas erosa*, *Arthrospira plantensis*, *Scenedesmus* and phaeophytin concentration of phytoplankton. Impact of air temperature was significant only on phaeophytin concentration of phytoplankton but other than monsoon period.

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