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SEASONAL VARIATION OF WATER QUALITY OF DHARMA SAGAR OF COMILLA CITY

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Abstract

Dharma Sagar of Comilla, Bangladesh was limnologically investigated during dry to rainy period. Fluctuations of water temperature, water depth, Sechhi depth, pH, conductivity, total dissolved solids, dissolved oxygen, alkalinity, free CO_2, SRP, SRS and NO_3-N were studied in three different stations for six months. Water temperature, water depth and Secchi transparency ranged from 28.0 - 34.2ºC, 5.13 - 7.01 m, 0.39 - 0.80 m, respectively. The range of pH, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), alkalinity, free CO_2 , SRP, SRS and NO_3-N of water over dry to rainy period varied from 7.50 - 7.93, 422 - 650 µS/cm, 86 – 212 mg/l, 7.31 - 7.9 mg/l, 1.0 - 4.3 meq/l, 3.8 - 6.5 mg/l, 4.02 - 5.04 µg/l, 3.0 - 5.50 mg/l and 28.11 - 60.25 µg/l, respectively. A total of 20 genera of phytoplankton were recorded which belonged to six classes, namely Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Cryptophyceae and Dinophyceae. From Cryptophyceae, two genera were recorded namely, *Cryptomonas* and *Rhodomonas*. Among the members of Cyanophyceae *Lyngbya limnetica* Lemm. and *Raphidiopsis indica* Singh were dominated during the dry to rainy period. Dinophyceae was represented by *Peridinium cinctum* (Müller) Ehrenberg. Because of a higher pH and low nutrient concentration, the studied water body could be characterized as blue-green dominated, alkaline and meso-eutrophic type.

Introduction

Perennial pond-like water bodies of a large area and volume called *Sagar*, are the characteristic features of the aquatic ecosystems in many areas of Bangladesh. These water bodies were purposefully dug-out by the then Zaminders of British India for storing freshwater and to meet the needs of domestic water use by the local people (Islam *et al*. 2013). Since, these ecosystems are legendary through their history and sustains age old interesting biodiversity, their limnological study are also interesting. So far, limnological information are available for Nilsagar of Nilphamari district, Ramsagar of Dinajpur district and Joysagar of Sirajganj district (Aziz and Tanbir 2003, Nahar and Khondker 2009, Nahar *et al*. 2010, Khondker *et al*. 2012, Islam *et al*. 2013, Nahar *et al*. 2015).

Dharma Sagar of Comilla city is an attractive touristic water body and supplies freshwater for bathing, washing and for other domestic uses to the local people. Besides, this water body is also visited by thousands of migratory birds every year. So far, no limnological investigation has been carried out to assess the physical, chemical and biological water quality of this important aquatic ecosystem. But the deterioration of water quality through human intervention is a common occurrence in the area. The present investigation has therefore been undertaken to study the physical, chemical and biological water quality of Dharma Sagar.

Materials and Methods

Maharaja Dharma Manikya (1431-1462), King of Tripura ordered excavation of the basin of Dharma Sagar in 1458 to relieve the problem of water scarcity by the local inhabitants. In the early time of excavation, there was an island at the central point, which disappeared later on. The study

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area, the district head quarter of Comilla is situated in the eastern Bangladesh, located in the south of Gomati river and about 90 km south-east of Dhaka Metropolis, the capital of Bangladesh.

The area of Dharma Sagar is about 9.38 ha and is situated between 23º1″ and 24º11″ N and 90º34″ and 91º22″ E. For collecting samples, three permanent stations were set up in Dharma Sagar and the sampling was carried out monthly from May to October, 2011 between 09:00 and 10:00 a.m. Air and water temperature, water depth, Secchi depth, pH, conductivity and total dissolved solids (TDS) were measured *in situ* by using alcoholic thermometer, a graduated scale, a Secchi disc and by using various field meters (pH: Griffin pH meter, model- 50 UK; conductivity: Hanna, HI 9033, Singapore and TDS: Hanna, HI 9034, Singapore). Samples of dissolved oxygen were fixed by adding first two reagents of Winkler's Method in the sample *in situ* and later on their titration was carried out in the laboratory after transportation (Wetzel and Likens 1979). Analyses of alkalinity, soluble reactive phosphorus, soluble reactive silicate, nitrate, chlorophyll *a*, phaeopigment, and qualitative and quantitative aspects of phytoplankton were carried out from a composite 5-liter water sample collected from the water body manually by dipping a black canister from a depth of 50 cm below surface. The water was transported to the Department of Botany, University of Dhaka in an ice box on the same day of collection. Further processing of the collected samples including the determination of physical, chemical and biological parameters have been described elsewhere (Khondker *et al*. 2010).

Results and Discussion

In the present investigation, data on 19 variables related to the physical, chemical and biological aspects of Dharma Sagar were collected and analyzed for six months. Figs 1 and 2 are showing their flux during the period of investigation. The air and water temperature both showed a similar pattern of fluctuation during the period of study (Fig. 1). With a few exceptions, water temperature was found to be closed to the air temperature as expected. This observation is similar to the previous reports (Durve and Bal 1961, Oppenheimer *et al*. 1978, Chowdhury and Mazumder 1981, Bhuiyan *et al*. 2010a). Trend of increase in water temperature over surrounding air temperature in the summer seems to be due to thermal properties of water and air (Haroon 1986). From the Fig. 1, it is evident that temperature was lower in June and July. Similar observation was also made by Islam *et al*. (1994). The mean air temperature and water temperature were 32.58ºC and 31.78ºC, respectively.

The mean water and Secchi depth recorded were 6.05 m and 0.48 m, respectively. Water depth increased in July and dropped in May. Observation of highest depth of water bodies in July is in agreement with the results presented by Khan *et al.* (1994). From the Fig. 1, it is evident that water level of 'Dharma Sagar' was more or less low in the months of May and June. These results are also similar to the observation made by Islam *et al*. (1994). But Secchi depth did not change significantly because of the excessive human influences. Since, the water of 'Dharma Sagar' is used by the local inhabitants, the water remain slightly turbid all through the year. In the study sites when water depths were in lower range, then total phytoplankton count was higher. This seems to be due to concentration of nutrients resulting rapid multiplication of phytoplankton. In May, August and October the SRP was closer to 5 µg/l (Fig. 2).

Phytoplankton is not directly related to the transparency of the water. Such type of relation was also reported by Khondker and Parveen (1992) and Khondker and Kabir (1995).

The pH is a good indicator of water quality which determines whether the nutrients remain in dissolved state (Hasan and Bhuiyan 2013). Venkateswarlu (1969) stated that pH more or less controls the amount of ions in water. Compared to other studied water bodies the mean pH (7.67) of Dharma Sagar was found slightly alkaline in nature. The difference of pH between lowest and

highest is 0.17 among all the samples. However, the mean values are very close to some of the ponds of Bangladesh (Oppenheimer *et al*. 1978, Ameen *et al.* 1986. Nahar *et al*. (2010) recorded a mean pH of 7.40 for Jaysagar of Sirajganj.

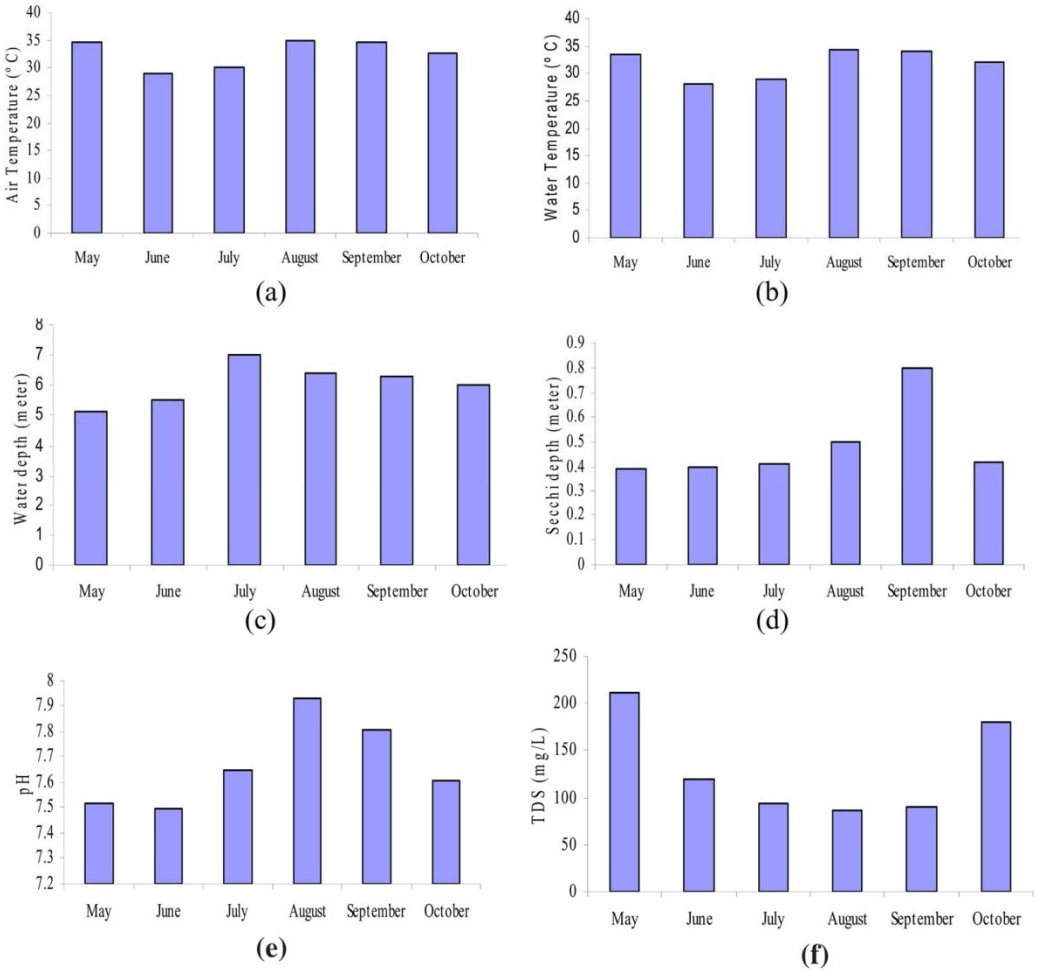

Fig. 1. Seasonal fluctuations of (a) air temperature, (b) water temperature, (c) water depth, (d) Secchi depth (e) pH and (f) TDS at the pace of investigation.

The range of conductivity recorded was 422 - 650 µS/cm which is higher than those reported for Nilsagar, Ramsagar and Joysagar (Islam *et al*. 2012). In Dharma Sagar, conductivity was higher in May, but dropped to lower in following months because of the rainfall (Fig. 2).

Mean TDS recorded in Dharma Sagar is 130.44 mg/l, which is nearly double than the values reported for Nilsagar and Jaysagar (Islam *et al*. 2012). Increase in the amount of TDS in May seems to be due to the runoff of surface chemicals from adjacent area. Record of higher values of TDS in the months of May might be associated with the predominance of phytoplankton (Table 1).

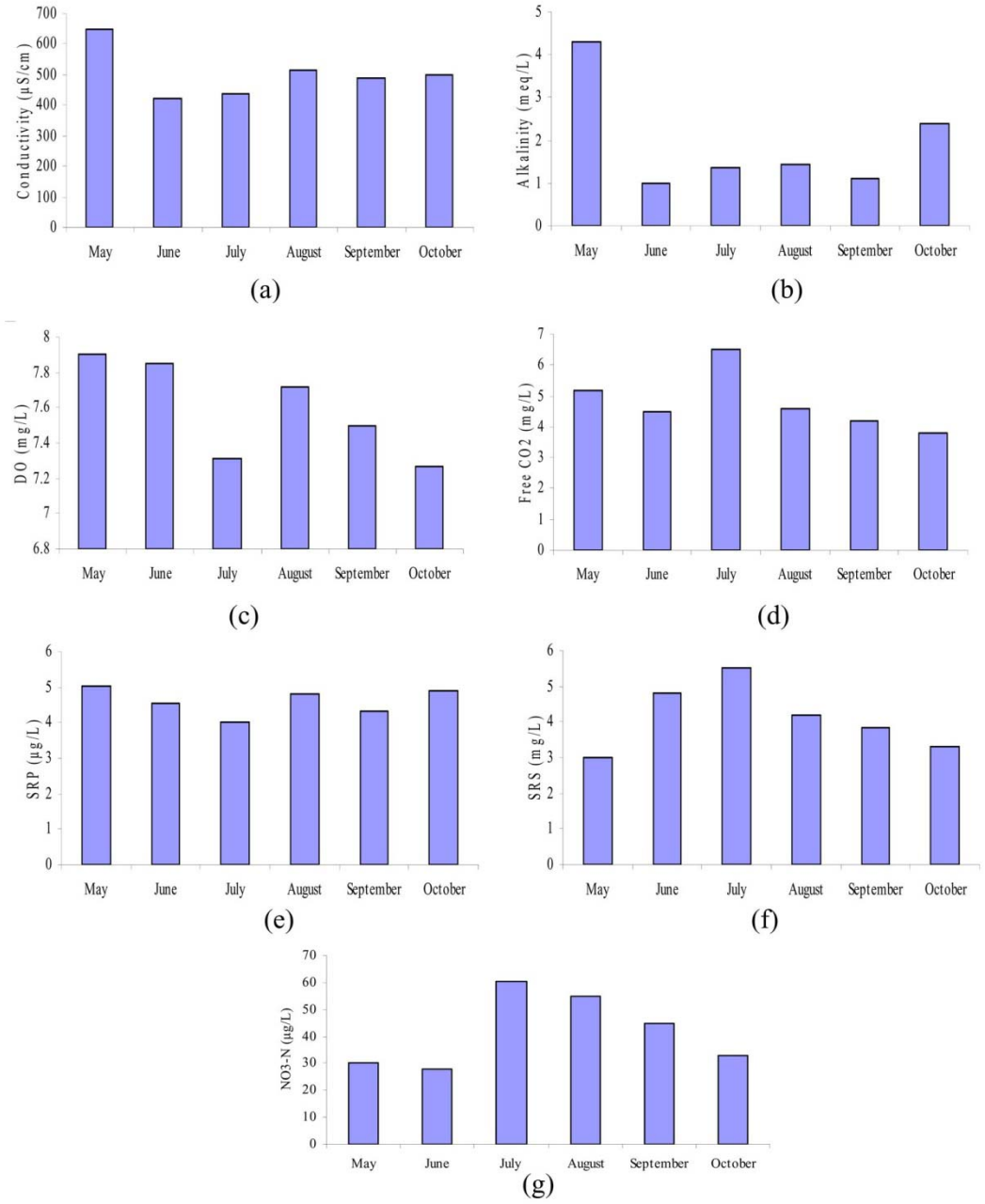

Fig. 2. Variation of (a) conductivity, (b) alkalinity, (c) dissolved oxygen, (d) free CO_2, (e) SRP, (f) SRS and (g) NO_3-N in different months of samplings at the study sites.

Table 1. Qualitative and quantitative (×10^6 ind/l) aspect of phytoplankton in Dharma Sagar, Comilla during the study period of 2011.

Species	May	June	July	August	Sept.	October
Cyanophyceae						
Lyngbya limnetica Lemm.	10.71	9.50	11.08	10.25	9.50	9.30
L. contorta Lemm.	1.40	1.75	1.25	1.75	1.00	0.90
Raphidiopsis indica Singh	10.08	9.25	9.80	9.60	8.50	7.00
Spirulina subtilissima Kütz. *ex* Gomont	8.80	7.90	8.00	7.25	8.0	7.00
Anabaena ballyganglii J. C. Banerji	2.75	1.40	2.00	1.50	0.85	0.80
Anabaenopsis arnoldii Aptekarj	2.22	1.25	2.10	1.75	1.00	0.75
Coelosphaerium minutissimum Lemm.	0.75	1.40	1.50	0.65	0.78	0.75
C. kuetzinzinigianum Näg	0.50	1.10	1.30	0.60	0.22	0.25
Cylindrospermum michailovskoense Elenkin	1.22	0.90	1.0	0.80	0.50	0.20
Microcystis incerta Lemm.	6.00	4.90	5.92	4.10	3.25	4.20
Merismopedia punctata Meyen	6.25	6.50	6.0	5.75	5.0	4.82
Synechocystis aquatilis Sauv.	1.25	0.25	0.90	0.50	0.21	0.20
Sub total	**51.78**	**47.85**	**52.85**	**45.50**	**39.6**	**36.22**
Chlorophyceae	4 Genera					
Crucigenia quadrata Morren	7.00	6.00	6.80	5.50	3.00	2.75
Scenedesmus dimorphus (Turp.) Kütz.	4.95	4.27	4.42	3.13	1.75	1.50
Scenedesmus regularis Swir.	2.25	2.00	2.50	1.75	1.25	1.45
Hyaliella polytomoides Pascher	1.12	0.25	1.00	0.75	0.50	0.25
Sphaerocystis schroeteri Chod.	1.10	2.00	2.90	1.50	1.00	0.25
Sub total	**16.57**	**12.77**	**15.62**	**11.63**	**6.71**	**6.15**
Euglenophyceae	4 Genera					
Euglena rostrifera Johnson	2.10	2.00	1.75	2.15	2.00	1.40
E. oxyuris var. *minor* Prescott	1.08	1.10	1.10	1.00	1.00	1.10
E. mainxii Defl.	1.05	1.25	0.75	0.85	1.00	0.50
E. gojdicsae Prescott	1.05	0.75	0.90	0.75	0.55	0.40
E. ehrenbergii Klebs	1.00	0.40	0.75	0.50	0.45	0.85
Phacus brevicaudatus (Klebs) Lemm.	3.15	2.62	3.55	3.00	1.95	1.70
P. ephippion Pochm.	2.10	2.00	1.50	1.75	1.25	1.10
Trachelomonas oblonga Lemm.	1.20	1.00	1.25	0.50	0.60	0.35
T. raciborskii Wolosz.	1.10	0.75	0.75	0.40	0.25	0.10
T. volvocina Ehrenberg	1.08	0.50	0.25	0.10	0.15	0.05
Lepocinclis ovum var. *major (*Huber-Pestalozzi)	1.10	0.75	1.00	0.79	0.50	0.22
L. ovum var. *globula* (Perty) Lemm.						
Sub total	**16.01**	**13.12**	**13.55**	**11.79**	**9.70**	**7.77**
Bacillariophyceae	2 Genera					
Melosira granulata var. *angustissima* Müll.	2.50	1.25	2.0	0.58	0.50	0.45
Navicula gracilis Ehrenberg	1.25	0.92	0.90	0.60	0.52	0.50
Sub total	**3.75**	**2.17**	**2.90**	**1.18**	**1.02**	**0.95**
Cryptophyceae	2 Genera					
Cryptomonas erosa Ehrenberg	8.01	7.78	7.79	6.40	5.67	6.23
Rhodomonas minuta Skuja	5.25	5.25	5.34	5.00	4.90	5.20
Sub total	**13.26**	**13.03**	**13.13**	**11.40**	**10.57**	**11.43**
Dinophyceae	1 Genus					
Peridinium cinctum (Müller) Ehrenberg	**7.50**	**7.25**	**6.90**	**6.82**	**7.12**	**6.34**
Grand Total	**108.87**	**96.19**	**104.95**	**88.32**	**74.72**	**68.86**

Dissolved oxygen is one of the primary factors in natural water as a regulator of metabolic process. Therefore, its concentration is an indicator of organic pollution (Hasan and Bhuiyan 2013). As the surface water becomes loaded with organic matter or/and with wastewater its DO content is affected. Among the samples carried out from Dharma Sagar, the mean DO concentration was 7.59 mg/l. This result is in agreement with that recorded in Nilsagar (Islam *et al*. 2013). Talukder and Khondker (1995) showed a range of DO concentration 9.0-12.0 mg/l from some ponds of greater Noakhali district. DO concentration in some rural ponds of greater Comilla district, ranged from 8.5 - 14.0 mg/l (Khondker and Talukder 1995).

Mean alkalinity of 'Dharma Sagar' was 0.19 meq/l, where as higher alkalinity 0.60, 0.50 and 0.66 meq/l was recorded in Nilsagar, Ramsagar and Joysagar, respectively (Islam *et al*. 2012). Mean free CO_2 recorded for Dharma Sagar was 0.50 mg/l.

The importance of soil phosphorous in ponds for increasing primary productivity is recognized by Banerjee (1967). In the present investigation, mean soluble reactive phosphorous was 4.61 µg/l. Almost identical concentration was recorded for Nilsagar and Ramsagar which were 6.80 and 3.16, respectively (Islam *et al*. 2012).

Table 2. Comparison of mean values of different limnological parameters of four Sagars of Bangladesh.

Parameter	Dharma Sagar (Present investigation)	Nilsagar (Islam *et al*. 2012)	Ramsagar (Khondker *et al*. 2012)	Joysagar (Nahar *et al*. 2010 and pers. comm.)
Zs (cm)	48	53	75	14.10
Air temp. (°C)	32.58	19.27	20.48	29.90
Wat. Temp. (°C)	31.78	20.20	22.50	27.4
TDS (mg/l)	130.44	32.00	10.66	-
Cond. (µS/cm)	502.50	126.33	73.66	109.20
pH	7.67	6.96	6.73	7.40
Alkal. (meq/l)	0.19	0.60	0.50	0.66
DO (mg/l)	7.59	11.64	7.99	-
PO_4-P (µg/l)	4.61	6.80	3.16	79.87
NO_3-N (µg /l)	41.95	0.19	0.007	97.50
SRS (mg/l)	4.10	0.67	0.77	11.43
Chl *a* (µg/l)	-	12.47	5.92	174.10
Phaeopig (µg/l)	-	5.65	3.65	47.5
Phytopl. $\times 10^4$ (ind/l)	8999	25078	164	19680
Total genera	20	15	15	13
Dominat group	Cyanophyta	Cyanophyta	Chlorophyta	Cyanophyta
Dominant species	*Lyngbya limnetica* Lemm.	*Lyngbya limnetica* Lemm.	*Staurastrum coarctatum* Bréb. var. *subcurtum* Nordst.	*Raphidiopsis mediterraneana* Skuja

Mean soluble reactive silicate content of Dharma Sagar (4.10 mg/l) was found to be little lower compared to some other ponds of greater Noakhali and Comilla districts, which varied from 8.8 - 19.6 mg/l and 5.6 - 10 mg/l, respectively (Khondker and Talukder 1995, Talukder and Khondker 1995). Silicate concentration in a mesotrophic pond in Dhaka city ranged between 8.44 and 14.20 mg/l. In some polluted waters silicate concentration was recorded as high as 50.0 mg/l (Khondker and Rahim 1991).

Mean nitrate nitrogen (41.95 µg/l) was found to be nearly one half of the concentration compared to Joysagar (Table 2). However, the value is almost similar to the lower range of some pond ecosystems of Bangladesh (Zaman *et al*. 1993, Khondker and Kabir 1995).

Data on phytoplankton count and the quality of the population has been summarized in Table 1. Among phytoplankton 20 genera were recorded, which belonged to six classes, namely Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Cryptophyceae and Dinophyceae (Bhuiyan *et al*. 2010b). Highest number of genera was recorded from Cyanophyceae being the *Lyngbya limnetica* as dominant phytoplankton. The density of cyanophycean population occurred 52.85×10^6 ind/l in July. Chlorophyceae constituted the second highest number i.e. 16.57×10^6 ind/l (Table 1). In the population dynamics of phytoplankton during the period of study it was seen that *L. limnetica* constituted the highest number 11.08×10^6 ind/l. The second dominant phytopnakotn was *Raphidiopsis* (10.08×10^6 ind/l), while the third dominant group was *Cryptomonas* sp. (8.01×10^6 ind/l) and *Peridinium cinctum* (7.50×10^6 ind/l).

Monthly density of phytoplankton did not vary much but comparatively the highest density was found in the month of May and the lowest density occurred in October (Table 1). Number of genera of phytoplankton recorded for Dharma Sagar are nearly same to that of other three Sagar ecosystems of Bangladesh (Table 2). As compared to the total standing crop of phytoplankton, Joysagar found to be relatively higher productive followed by Nilsagar, Dharmo Sagar and Ramsagar. The concentration of phosphate phosphorus in pelagic water showed as a key governing factor for this (Table 2). Out of the four Sagar ecosystems as compared in Table 2, 3 were dominated by Cyanophytes and one by desmids. For phytoplankton composition pH could be a governing factor. Ramsagar was dominated by *Staurastrum coarctatum* Bréb. var. *subcurtum* Nordst., a desmid and had a pH of 6.73 (Table 2). On the other hand, all the three other Sagar ecosystems namely, Dharma Sagar, Nilsagar and Jaysagar showed a pH of 7.67, 6.97 and 7.40, respectively (Table 2). Blue green usually dominates within a pH of alkaline range and it has been seen that a mean pH >7 of Dharma Sagar might influence the blue-green dominance.

The present study reveals the phytoplankton quality, quantity and concentrations of some water quality parameters of a historically, age old and attractive aquatic ecosystem situated in the district head quarter of Comilla, Bangladesh. With reference to the data presented in Table 2, the depth of visibility (Zs 48 cm), alkalinity (0.19 meq/l), PO_4-P concentration (4.61 µg/l) and the total phytoplankton standing crop (8999×10^4 ind/l) shown for Dharma Sagar states that the water body has been passing a mesotrophic stage gradually advancing towards eutrophic condition. If the daily load of organic pollutants via excessive bathing activities, soap and detergent based washings and leading connections of residential drainage run offs keep continue, the overall water quality will deteriorate imparting a negative impact on the town dwellers. So, the present study revealed that the presently studied historic, recreational and useful water body of Dharma Sagar will remain under threat, if sound and planned management is not undertaken and implemented.

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