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PHYTODIVERSITY AND WATER QUALITY OF A SEMINATURAL MADHABPUR LAKE IN BANGLADESH

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Abstract

Seminatural lakes are important due to their natural diversity and various ecosystem services. Assessment of phytodiversity and water quality can add value in a limnological point of view. The present study was conducted on a Seminatural Madhabpur Lake in Bangladesh to estimate diversity and water quality. Samplings were carried out in May 2016 and April 2017. In the lake, phytoplankton belonged to 6 distinct divisions. Chrysophyta and Chlorophyta were the dominant groups in terms of density. A total of 70 phytoplankton taxa were documented, of which *Cryptomonas erosa* var. *reflexa, Cyclotella comta, Ankistrodesmus spiralis, Monoraphidium arcuatum, Cyclotella comensis* were dominant followed by *Ankistrodesmus falcatus, Trachelomonas compacta, Trachelomonas volvocina, Lepocinclis* sp. and *Mallomonas* sp. The mean chl *a* measured in this lake was 6.08 µg/l and 8.48 µg/l in 2016 and 2017, respectively. Among the macrophytes, *Potamogeton crispus, Monochoria hastata, Myriophyllum heterophyllum, Myriophyllum indicum, Nymphaea stellata, and Nymphoides cristatum* were the dominant species in the lake. The calculated water quality index (WQI) showed all sampling stations were "Excellent" in water quality status except for two stations in 2016. The WQI also showed that the values were less in 2017 than in 2016, which might be due to the addition of more parameters in the calculation. The limit of physicochemical parameters for drinking water was compared with the WHO and ECR guidelines and showed no concern for drinking. So, the lake water is considered as permissible for human consumption.

Introduction

Seminatural lakes are inland standing water bodies created or modified by human interference due to dams and embankments to streams, rivers or sea, which expand or reshape but retain many natural features. A small increase in water levels and less turbidity in the water column is a unique feature of such systems. Water flow in such seminatural systems is generally small and may be even negligeable in short sections connecting the reservoirs, which results in an increased sedimentation of seston and an abundant growth of aquatic vegetation (Cudowski *et al.* 2015). Despite their common origin, they are at varying stages of development. Their surface area are being gradually reduced, and they become shallower due to the lowering of the water level and accumulation of biogenic sediment. They have a permanently inundated basin. Seminatural lakes constitute an essential element of the natural environment of South-Asian subcontinents like Bangladesh. The habitat of the Seminatural lake is generally used by local people noting matters such as the source of drinking water, yield obtained from crops or fisheries.

Phytoplankton communities are sensitive to environmental changes; therefore, biomass and species composition can be utilised as water quality indicators (Brettum and Andersen 2005). The depletion of nutrients through climate hazards may cause leverage by phytoplankton species with

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small nutrient demands, high nutrient uptake efficiencies, and high flexibility to shunt excess energy toward nutrient acquisition. In all wetland ecosystems, phytoplankton is incredibly important. They are sensitive to changes in their environment, influencing various physicochemical properties and nutrient concentrations of water. Monitoring phytoplankton content and water quality parameters can prevent fish from dying and keep an uninterrupted water supply for domestic, agricultural, and recreational purposes (Imhoff and Alberrecht 1975). Under a specific physical setup, the quality and quantity of phytoplankton are governed by the concentration of essential nitrogen, phosphorus and silicious compounds (USEPA 2000).

Aquatic macrophytes are plants that are mechanised to live in aquatic systems. They are also called hydrophytes to separate from algae and other macrophytes. A macrophyte is a plant that grows in or near water and is either emergent, submerged, or floating. Submerged macrophytes influence nutrient concentrations and phytoplankton abundance in shallow-water ecosystems (Zimmer *et al.* 2003). The diversity in these algae and aquatic macrophytes is termed the “phytodiversity” of a lake, which is very important as the energy created by these primary producers is transferred to higher trophic levels via consumption. Besides this, they assist in recycling many biogeochemical cycles, and their diversity has immense ecological value.

Maintaining water quality is crucial for preserving aquatic ecosystems and safeguarding human health. Day by day, water quality issues are becoming a serious concern due to human extensification, urban growth and development. Thus, the assessment of surface water quality has become an essential issue. Water quality indices that describe water status are commonly used to assess freshwater health (Mentzafou *et al.* 2019). The water quality index (WQI) is a single number that can easily be calculated to describe the quality of water bodies used for different purposes (Tunc *et al*. 2013). The water quality status is known skillfully and scientifically through WQI, which helps choose a suitable water state to address contamination (Ewaid and Abed 2017).

Bangladesh belongs to a deltaic region where rivers and lakes serve a significant portion of the wetlands. Several studies were conducted on natural and artificial lakes in Bangladesh (Khondker *et al.* 2010, 2012; Alfasane *et al.* 2012, 2013; Islam *et al.* 2013). However, the term 'Seminatural lake’ is entirely unfamiliar in Bangladesh. So far a litlltle hydrobiological research has been conducted on Seminatural lakes in Bangladesh (Alfasane *et al*. 2019), although they are critical water sources for drinking and domestic purposes and have good aesthetic value. The use of Madhabpur Lake is multipurpose, *i.e.* for drinking and industrial purposes. People from home and abroad use Madhabpur Lake as a tourist place because its sparkling and clear water, lofty hills, and the cerulean sky make an enthralling environment. The lake is a sketched fascinating scene by nature (Sharmin 2023). Therefore, the present research was carried out to study the water quality in relation to phytodiversity of the Madhabpur seminatural Lake in Bangladesh.

Materials and Methods

Madhabpur Lake is a scenic view of nature and is the most attractive to tourists, increasing the aesthetic beauty of the visiting spots. In addition, it provides ecosystem services in the adjacent area. The lake belongs to Madhabpur Tea-Estate, owned by the National Tea Company in the Madhabpur Union under Kamalganj Upazila of Moulvibazar District, in the northeast corner of Bangladesh. Geographically, the lake stands at an altitude of nearly 46 m above the mean sea level.

Formerly, several streams flowed from the hills of the tea estate. At the begining, the tea estate authority built some embankments among the hills to reserve water for drinking and other purposes, as water does not stay for longer time due to the sloping lands of the hills. Only three hills initially surrounded the lake, but now it has been expanded naturally by small streams coming from the hills surrounding it. Since its origin, it has been strictly maintained by the tea estate authority and only used for drinking; even boating and fishing are restricted there (Madhabpur Lake 2023).

The field survey was conducted in two phases (May 2016 and April 2017), emphasising phytoplankton diversity and water quality. In May 2016 and April 2017, samplings were carried out at three sampling stations (N1, N2, and N3) from the northeast part and three sampling stations (S1, S2, and S3) from the southeast part of the lake. In May 2016, one additional sample was taken from the entrance of the lake, denoted as O (Table 1).

Table 1. Geographic locations of the sampling stations of Madhabpur Lake in Bangladesh.

Sampling site	Latitude	Longitude
O	24º 16' 55.27" N	91º 49' 17.01" E
N1	24º 16' 56.32" N	91º 49' 5.65" E
N2	24º 16' 56.78" N	91º 49' 7.85" E
N3	24º 16' 56.96" N	91º 49' 11.59" E
S1	24º 16' 54.14" N	91º 49' 13.72" E
S2	24º 16' 52.21" N	91º 49' 10.98" E
S3	24º 16' 51.15" N	91º 49' 9.28" E

All the samples were collected from 10:00 am to 01:00 pm. As there is no boating facility, samples were collected only from the lakeshore (littoral zone) with the help of a mug attached to a long stick. For this reason, measuring the Secchi depth of any part of the lake was impossible. During every sampling, 100 litres of water were passed through the plankton net having mesh width >20 µm by holding a second plankton net (pore diameter 20 µm) just below it. So, the released water from the first plankton net passes through the second one. The samples were stored in 50 ml capacity plastic screw-capped bottles containing Lugol's iodine solution for the quantitative and qualitative analysis of phytoplankton. Water temperature, pH, TDS, conductivity, and DO of water were measured in *situ* at each sampling site using portable meters. To further measure various physicochemical and biological parameters, surface water samples were filled in plastic bottles (500 ml) and kept in the cool sampling box. After taking the water samples to the laboratory, a 100 ml water sample was used to determine alkalinity following the procedure of Mackereth *et al.* (1978). Then 250 ml of the water sample was filtered for chl *a* and phaeopigment estimation, and the filtered water was used for the chemical analysis. Chl *a*, SRS and SRP were determined in the National Professor AKM Nurul Islam Laboratory, Department of Botany, University of Dhaka, as described by Gani *et al.* (2011) following the methods of Marker *et al*. (1980), Wetzel and Lickens (1979) and Murphy and Rilley (1962), respectively. Other anions (F^-, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}) and cations (Ca^{2+}, Mg^{2+}, Mn^{2+}, Fe^{2+}, K^+, Na^+, NH^{4+}) were measured in the laboratory of Bangladesh Council for Scientific and Industrial Research.

Qualitative and quantitative analysis of phytoplankton was carried out in the Research Laboratory, Department of Botany, Jagannath University and National Professor AKM Nurul Islam Laboratory, Department of Botany, University of Dhaka , by observing the water samples under a light microscope using a counting chamber, and photomicrographs were taken for further identification. Almost all individuals were photographed and placed under a Nikon (Optiphot, UFX-11A) microscope fitted with a camera (Nikon FX-35 WA, Japan) and another camera, Axio Lab A1, Germany. The field of the glass slide was scanned under a magnification ranging from 10 × 40 to 10 × 100. Different monographs and books have been consulted for identification, algal literature, and publications available for Bangladesh (Islam and Begum 1970, Islam and Khondker 1981, Prescott 1982).

The samples of littoral macrophytic vegetation were collected from the selected stations from the lake. After transporting to the laboratory, the samples of macrophytes were washed with tap water, cleaned, and screened. The taxa were identified with the help of Khan and Halim (1987), Khondker *et al.* (2010), and Alfasane *et al.* (2010). After prior knowledge of macrophytes present in the water body, the abundance of macrophyte taxa was recorded *in situ.*.

Phytoplankton density and the percentage composition of each class were calculated as species richness, dominance, diversity, and evenness.

Species richness index (SR)

Species richness (SR) was calculated as proposed by Gleason (1922), shown below-

$$SR = \frac{S-1}{log_e N}$$

Where S = the number of species representing a particular sample.

N = the natural logarithm of the total number of individuals of all the species within the sample.

Dominance index (D)

The dominance index (D) value was determined using the McNaughton formula (1967), as described by Ignatiader and Mimicos (1977).

$$D = 100\frac{(n_1 + n_2)}{N}$$

D = dominance index, proportional to the percentage of total standing crop contributed by the two most prominent species n1 and n2 = percentage of total population contributed by the two most abundant species in the sample.

N = average value of total phytoplankton standing crop concentration in the same series of samples.

Shannon’s diversity index (H´)

The Shannon’s species diversity index (H´) indicates the diversity as the relative abundance of species dependence function, and the unit, i.e. a particular numerical value. Phytoplankton density and the percentage composition of each class were calculated as species diversity using Shannon’s formula by Odum (1969), as shown below-

$$H' = \sum_{i=1}^{s} \frac{n}{N} log_2 \frac{n}{N}$$

Where N = Total number of individuals per litre., s = is the species number, n_i= is the number of individuals of each species, H'= species diversity in bits of information per individual.

Simpson's Diversity Index (Δ)

Simpson's Diversity Index (Δ) is one approach to quantifying biodiversity calculated from species proportions (Simpson 1949). The Δ considers the number of species and the population size of each species. The Simpson formula, shown below, represents the irreplaceable samplings. With n items in groups of n_i......n_k identical items, the probability of two different items is

$$\Delta = 1 - \sum_{i=1}^{k} \frac{n_i(n_i - 1)}{n(n-1)}$$

Pielou evenness index (J)

Pielou's evenness index measures diversity along with species richness (Pielou 1967). While species richness is the number of species in a given area, evenness is the count of individuals of each species. A calculated value of Pielou's evenness ranges from 0 (no evenness) to 1 (complete evenness). Species evenness, i.e.

$$J = H' / In(S)$$

Where *H'* is Shannon Weiner diversity, and S is the total number of species in a sample.

McIntosh evenness index

The McIntosh index is used for assessing diversity and considers the number of different types of members within a community (McIntosh 1967). The McIntosh evenness index (Mc E) has the following structure.

$$Mc\ E = \left[N - \sqrt{\sum ni2}\right] / [N - \left(\frac{N}{\sqrt{S}}\right)]$$

Where, n_i= Number of individuals belonging to i species, S =Total number of species, N= Total number of individuals

Water Quality Index (WQI) is a rating reflecting the composite influence of different water quality parameters on the overall water quality. The main objective of computing the WQI is to turn complex water quality data into easily understandable and usable information. The WQI was calculated using the Weighted Arithmetic Index method (Brown *et al*. 1970, Hasan *et al.* 2023) .

$$WQI = \sum WiQi / Wi$$

The quality rating scale for each parameter Qi was calculated by using this expression:

Quality rating, $Qi = 100[\frac{Vn - Vi}{Vs - Vi}]$

Where, *Vn* = the actual amount of the nth parameter, *Vi* = the ideal value of this parameter *Vi* = 0, except for pH and DO. Vi = 7.0 for pH; Vi = 14.6 mg/l for DO, *Vs*= recommended ECR or WHO standard of the corresponding parameter, Relative weight (*Wi*) was calculated by a value inversely proportional to the recommended standard (*Vs*) of the corresponding parameter, $Wi = 1/Vs$

Generally, WQI is discussed for a specific and intended use of water. This study considers the WQI for human consumption, and the permissible WQI for drinking water was taken as 100.

Table 2. Classification of water quality status based on the Arithmetic WQI method (Brown *et al*. 1972).

Water quality index	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
Above 100	Unsuitable for drinking and propagation of fish culture

Results and Discussion

The fluctuations in different physicochemical parameters and nutrients showed considerable variations between the two sampling periods. In 2017, the highest water temperature was recorded in S1, whereas the lowest was in N1, and in 2016, the highest and the lowest were recorded in N1 and S2, respectively. The average pH range in the two sampling periods was between 7 and 7.6. So, there was a slight variation in pH. Dissolved oxygen (DO) was observed to be up to 13 mg/l in the lake; the range was between 10 and 12 mg/l. During the study period, the TDS varied from 12-24 mg/l, and EC varied from 20-64 µS/cm. The highest mean EC was recorded in station O in 2016, whereas the lowest was obtained in station N3 in 2017 (Fig 1a).

Regarding nutrient concentrations, the two study periods showed variation among sampling stations. In the case of SRP, variations were observed between the sampling periods for all the stations except S3. The SRS showed resonable dissimilarities in N1, N3 and S3, whereas, in the case of NO_3^- differences were observed in N1, N3, S2 and S3 (Fig. 1b).

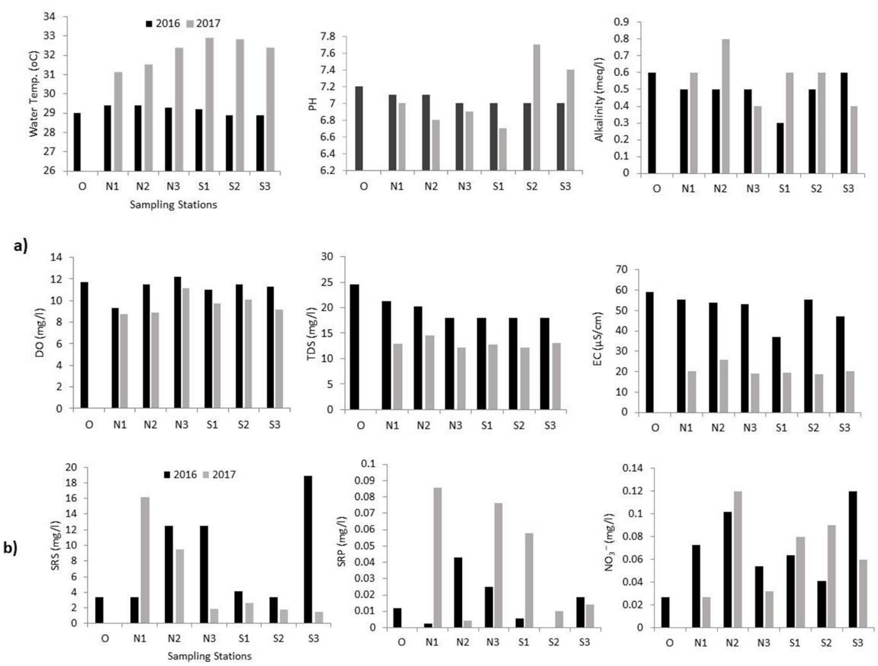

Fig. 1. Fluctuation of physicochemical factors (a) and nutrients (b) from 2016 to 2017 in the Madhabpur Lake, Bangladesh. a) Water temperature, pH, alkalinity, DO, TDS, EC; b) SRS, SRP and NO_3^-.

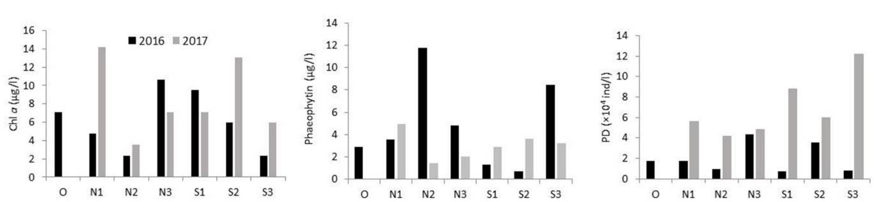

Fig. 2. Variation of chl *a*, phaeophytin and phytoplankton density (PD) from 2016 to 2017 in the Madhabpur Lake, Bangladesh.

The mean phytoplankton density (PD) in 2016 and 2017 were 1.9 $\times 10^4$ and 6.9 $\times 10^4$ ind/l, respectively. The phytoplankton biomass as chl *a* concentration ranged from 0.74-12.22 µg/l. The average chl *a* concentrations in this lake were 6.08 and 8.48 µg/l during 2016 and 2017, respectively.

In the present study, the algal density follows the spatial variations of chl a concentration in most sampling sites. Increase in chl *a* concentration were related to the density of Chrysophyta and Euglenophyta. Phytoplankton recorded from the water samples of seven stations of Madhabpur Lake belonged to 6 distinct divisions. Chrysophyta and Chlorophyta were the dominant groups in terms of density. In 2016, Chrysophyta occupied about 45% of the total phytoplankton density. Chlorophyceae was the second dominant group, occupying about 41% of total density, followed by Cryptophyta (6%), Dinophyta (4%), and Euglenophyta (3%). The distribution of phytoplankton assemblage was found lower in terms of density during 2017 when Chrysophyta (27%) was found dominant, followed by Chlorophyta (25%), Cryotophyta (18%), Euglenophyta (17%), Dinophyta (13%).

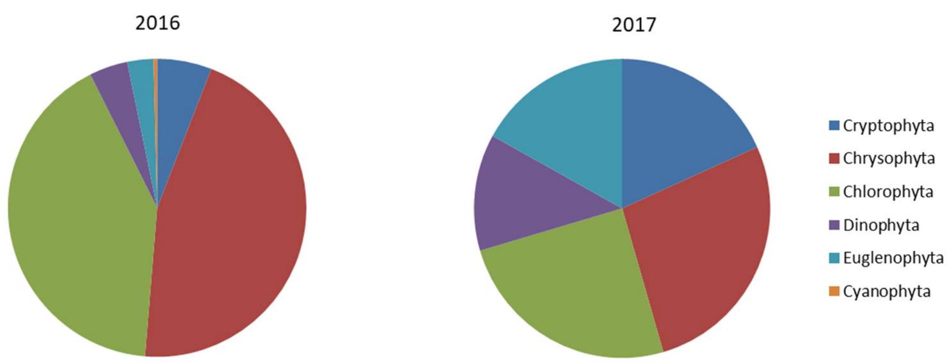

Fig. 3.Groupwise distribution of phytoplankton communities of Madhabpur Lake during May 2016 and April 2017.

During 2016, the species richness index (SR) varied between 8 and 21, whereas the range was 19 to 28 in 2017. The minimum value was calculated in Station N2, and the maximum was calculated in station N3 (highest number of species). The lowest dominance index (δ) value (0.14) was observed in station N3 during 2017, and the highest value (0.59) was in station O during 2017.

Table 4. Phytoplankton species richness (S) and dominance index (Y) of Madhabpur Lake.

	2016			2017		
St	Species	SR	δ	Species	SR	δ
O	*Monoraphidium arcuatum*	9	0.59	-	-	-
N1	*Cyclotella comta*	13	0.4	*Mallomonas* sp.	24	0.2
N2	*Cyclotella comensis*	8	0.28	*Cyclotella comta*	26	0.45
N3	*Microcystis* sp.	16	0.3	*Rhodomonas* sp.	28	0.14
S1	*Ankistrodesmus spiralis*	9	0.27	*Euglena acus*	19	0.17
S2	*Trachelomonas crevia*	21	0.029	*Euglena* sp.	26	0.22
S3	*Peridinium* sp.	10	0.21	*Peridinium* sp.	23	0.32

The species richness index (SR) varied between 8 and 28; the minimum value was calculated during May 2016 and April 2017 (the highest number of species). The lowest dominance index (δ) value calculated (0.14) was observed in April at station N3, and the highest value (0.59) was in May 2016 at station O (Table 4).

Shannon-Wiener index of diversity (*H*) was found to be the highest (2.82) in 2016 in the station N3. In 2017, the *H* value was almost similar to 2016. However, in station O, the diversity index was lower. The *H* value increases with an increasing number of individual species. The minimum evenness index value calculated was in 2016 at station O (0.52), and the maximum value (1.01) was documented in 2017 at station S3 (Table 5).

Table 5. The phytoplankton diversity and evenness index of Madhabpur Lake during the study periods of 2016 and 2017.

Station	Shannon diversity index		Simpson diversity index		Pileu evenness index		McIntosh evenness index	
	2016	2017	2016	2017	2016	2017	2016	2017
O	1.15	-	0.6	-	0.52	-	0.55	-
N1	2.56	1.73	0.9	0.79	0.8	0.67	0.86	0.75
N2	1.87	2.05	0.75	0.76	0.57	0.98	0.63	0.79
N3	2.82	2.3	0.93	0.8	0.84	0.83	0.91	0.74
S1	2.65	2.11	0.89	0.79	0.9	0.96	0.87	0.81
S2	2.32	2.45	0.88	0.93	0.71	0.8	0.82	0.94
S3	2.52	1.83	0.83	0.9	0.8	0.79	0.75	1.01

Different types of aquatic macrophytes dominated Madhabpur Lake during the study period (Table 6). Among these macrophytes, *Myriophyllum aquaticum* (Vell.) Verdc. (Family-Haloragaceae) was found to be a new record for Bangladesh (Alfasane *et al*. 2019).

The WQI for human consumption was considered permissible because water quality data information is easily understandable. Among the classified five types, all sampling stations were “Excellent” in water quality status except station O.

Madhabpur Lake bears a predominant aquatic flora and fauna, which is characteristic of the area and is utilised as a shelter and breeding ground for migratory birds. Its freshwater reserve is a good source for nurturing plants and animals on an emergency basis. The measurement of evenness refers to the distribution of area among categories of individuals where larger values imply greater diversity, independently of richness. Evenness equals zero when one individual is present, i.e., the area distribution among different categories is uneven and dominated by one category. Evenness equals 1 when the observed diversity equals perfect evenness, i.e., a proportional abundance of each category. Higher values in diversity indices represent high diversity (Lopes *et al.* 2023). Table 5 represents the actual diversity measurement among all sampling stations in phytoplankton. Higher values have been seen in stations N1 and S1, i.e., these stations are highly diversified in the case of phytoplankton. In station O, the richness of *Monoraphidium arcuatum* was higher, *i.e.*, this species was dominant. So, the evenness value was lower.

The physicochemical parameters of the Madhabpur Lake can be comparable with other high-altitude studied natural and artificial lakes in Bangladesh. The mean value of pH, DO, TDS, and EC of Madhabpur Lake was found in the range of Kaptai Lake and Foy’s Lake (Chowdhury and Mazumder 1981, Rubel *et al*. 2019). Comparatively higher DO values and less TDS than the other urban lakes in the country indicated its less polluted and less disturbed natural environment (Islam and Saha 1975, Islam and Mendes 1976, Khondker and Parveen 1992).

Table 6. Composition and Abundance of macrophytes of Madhabpur Lake.

Macrophyte Species	Abundance
Nymphaea nouchali	++
N. stellata	+++
Nymphoides cristatum	+++
N. indicum	++
Nelumbo nucifera	++
Myriophyllum heterophyllum	+++
M. aquaticum	+
M. indicum	+++
Monochoria hastata	+++
Vallisneria spiralis	+
Aponogeton sp.	+
Ceratophyllum demersum	++
Cyperus platystylis	++
Utricularia sp.	++
Enhydra fluctuans	++
Hygroryza aristata	++
Ludwigia sp.	+
Oryza rufipogon	++
Limnophila heterophylla	++
Polygonum glabrum	++
Pistia stratiotes	+
Potamogeton crispus	+++
Schoenoplectus articulates	+

+++ = Dominant, ++ = Sub-dominant, + = Few in number

Table 7. WQI of Madhabpur Lake during May 2016 and April 2017.

Sampling site	2016		2017	
	WQI	Status	WQI	Status
O	27.67	Good	-	-
N1	27.28	Good	19.42	Excellent
N2	20.04	Excellent	21.29	Excellent
N3	19.82	Excellent	7.26	Excellent
S1	17.35	Excellent	12.21	Excellent
S2	20.92	Excellent	13.22	Excellent
S3	23.64	Excellent	11.68	Excellent

The primary productivity of Madhabpur Lake is directly correlated with the density of phytoplankton. The authority provides no artificial food, so phytoplankton populations constitute a vital link in the food chain. The value of the dominance index was always higher when the community was dominated by fewer species (Whittaker 1965). Biological communities vary in the number of species they contain (richness) and the relative abundance of these species (evenness). According to the above statement, the phytoplankton community of station N1 was more dissimilar, whereas, in station S1, phytoplankton diversity was lower. Species richness, as a measure on its own, does not consider the number of individuals of each species present. It gives equal weight to those species with few individuals as it does to a species with many individuals (Ghosh *et al.* 2012). The diversity measuring quantities follow the mentioned information.

The ecosystem of Madhabpur Lake was dominated by the members of Chrysophyta. In the lake *Microcystis* sp., *Mallomonas* sp., *Rhodomonas* sp., *Cyclotella comta*, *Euglena acus* were the dominant phytoplankton species whereas, in Lake Rainkhyongkain, the phytoplankton population was dominated by *Cyclotella comensis* followed by *Protoperidinium conicum*, *Coelosphaerium kuetzingianum*, *Euglena* sp. and *Mallomonas paxillata* (Alfasane *et al.* 2013). Of these, *Cyclotella comensis* was found to be common with Lake Bogakain (Khondker *et al.* 2010). Islam (1969) reported only some submerged and attached algae from Lake Rainkhyongkain. Phytoplankton belongs to Chrysophyta, and Chlorophyta was the dominant group in terms of density in Madhabpur Lake, whereas Chlorophyta was dominant in Gulshan Lake and Dhanmondi Lake. Data showed highly significant differences among Cyanophyceae, Chlorophyceae, and Bacillariophyceae groups between Gulshan and Dhanmondi Lake (Rahman 2019), such as lower dominance and higher species diversity. However, Simpson's diversity index increases as the diversity and species richness of the habitat increase (Shetty *et al.* 2022). Results of the present study correlate well with these findings.

Over the entire sampling period, the physicochemical and nutrients of the water were found to be different compared with lakes in Bangladesh. The Guidelines for Drinking Water Quality (GDWQ) is an international reference point for establishing national or regional regulations and standards for water safety of the World Health Organization (WHO 2018). A Comparison of water quality parameters of Madhabpur Lake with environmental conservation rules (ECR 2023) and World Health Organization (WHO 2018) in Bangladesh is shown in Table 8 measurement among all sampling stations in phytoplankton. Higher values have been seen in stations N1 and S1, i.e., these stations are highly diversified in the case of phytoplankton. In station O, the richness of *Monoraphidium arcuatum* was higher, *i.e.*, this species was dominant. So, the evenness value was lower.

Table 8. Comparison of important water quality parameters of Madhabpur Lake with recommended guideline values for drinking water by ECR (2023) and WHO (2018).

Parameter	Unit	Mean values for Madhabpur Lake		Limit values by ECR	Guideline values by the WHO
		2016	2017		
pH	-	7.05	7.08	6.5-8.5	6.5-9.2
DO	mg/l	11.21	9.62	6	4-6
TDS	mg/l	19.67	12.93	1000	500
EC	µs/cm	51.55	20.68	1200	-
SRS	mg/l	8.29	5.56	250	100
Mn	mg/l		0.001	0.4	0.1-0.5
Fe	mg/l		0.1	0.3-1.0	0.3
Chloride	mg/l		239	150-600	250
NO_2-N	mg/l		0.14	1.0	-
NO_3-N	mg/l		0.69	45	10

The comparison of physicochemical data of the lake with guideline values by ECR and WHO helps to assess the health risks of drinking water for local people. The values of all represented parametersin the present study were within the range of WHO and ECR standards, which does not pose a health risk (Table 8). So, the concentration of DO, TDS, ECR, Mn, Fe, and Chloride is satisfactory, *i.e.* the water is suitable for drinking. The results of physicochemical and biological data should be necessary to evaluate the water quality of freshwater resources of the unexplored natural lakes of Bangladesh.

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