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LIMNOLOGICAL ASSESSMENT OF TWO LAKES OF JAHANGIRNAGAR UNIVERSITY CAMPUS, SAVAR, BANGLADESH

CHANDRIMA DAS, MD ALMUJADDADE ALFASANE[1] AND SHAMIMA NASRIN JOLLY*

Department of Botany, Jahangirnagar University, Savar, Dhaka, Bangladesh

Keywords: Limnology, Principal Component Analysis (PCA), Phytoplankton Density

Abstract

The physicochemical and biological parameters of the water in two different lakes on the Jahangirnagar University campus were evaluated between December 2018 and August 2019. The chosen metrics were air and water temperature, Secchi depth, alkalinity, conductivity, pH, total dissolved solids (TDS), dissolved oxygen (DO), soluble reactive phosphate (SRP), soluble reactive silicate (SRS), nitrate-nitrogen (NO_3-N) and phytoplankton density (PD). The correlation between all the matrics was done. 37 orders of phytoplankton from lake-1 and 35 orders of phytoplankton from lake-2 were found under 8 classes (Cyanophyceae, Chlorophyceae, Bacillariophyceae, Synurophyceae, Euglenophyceae, Cryptophyceae, Dinophyceae, and Xanthophyceae). According to the principal component Analysis (PCA), 53.8% variation was found among the classes. In addition, *Monoraphidium*, *Oscillatoria, Cosmarium*, *Actinastrum*, *Trachlelomonas*, *Euglena*, *Pediastrum*, *Pinnularia*, and *Synedra* were found to be dominant species. The relationships between environmental factors and dominant phytoplankton species in two lakes were examined and it was found that the effects of the physicochemical parameters differ depending on the lake and dominant phytoplankton type. The study found negative correlations between various water quality parameters and phytoplankton taxa, suggesting an influence of environmental conditions on phytoplankton communities.

Introduction

Ecosystem productivity depends on water quality. Bangladesh faces a lack of natural lakes (Alfasane *et al.* 2012). Water with desirable physical, chemical, and biological properties is essential for the ecosystem. Chemical contaminants can stop algae from photosynthesizing and growing (Khan and Tisha 2020). Water temperature fluctuation usually depends on the season, geographic location, sampling time, and temperature of effluents entering the aquatic ecosystem (Rahman *et al.* 2016). Dissolved oxygen is necessary for the metabolism of all aquatic organisms with aerobic respiratory biochemistry (Goldman and Horne 1983). Physical and chemical qualities affect water quality, which affects fish and other aquatic species' distribution and productivity (Rahman *et al.* 2016). Pollution alters phytoplankton, food chains, and freshwater ecosystems (Chopra *et al.* 2013). Water qualities affect aquatic ecosystems (Li *et al.* 2009). Temperature, EC, and TDS affect water quality and phytoplankton growth (Tariquzzaman *et al.* 2016). The water quality is also affected by all physical factors (Kabir *et al.* 2002). Water chemistry affects phytoplankton development. Phytoplankton growth depends on environmental chemical composition (Alam *et al.* 2004, Alam and Hossain 2007). Water chemistry impacts freshwater reservoir phytoplankton diversity and dispersion (Flura *et al.* 2016). Blue-green algae bloom in the middle and lower water column when nitrogenous and phosphorus nutrients reach a limit. In low-nutrient water, blue-green algae fix nitrogen instead of photosynthesis (Bellinger and Sigee 2015, Khan and Tisha 2020). Diatoms are the best indicator of the quality and trophic status of the water (Dhumal and Sabale 2014). This research focused on the hydrobiology of the water in two different lakes of the Jahangirnagar University campus and the relationship among studied parameters.

*Author for correspondence: < jolly06_ju@yahoo.com>. [1]Department of Botany, University of Dhaka, Dhaka, Bangladesh.

Materials and Methods

The experiment was conducted in two lakes, designated as lake-1 (Jahanara Imam- Pritilota Hall Sorobor) and lake-2 (Community Mosque Lake) at Jahangirnagar University campus from December 2018 to August 2019. These lakes were chosen for their rich biodiversity (Fig. 1). Phytoplankton samples from lake-1 and lake-2 were separately placed in 1-liter plastic bottles, fixed with Lugol's iodine solution, and left undisturbed in darkness for 48 hrs to facilitate sedimentation. Phytoplankton cell counts were then conducted using a Hawksley microplankton counting chamber with improved Neubauer Ruling under a Nikon compound microscope at 400× magnification. Laboratory processing involved the filtration of water samples using a Sartorius-Membrane Filter Holder with a vacuum pump. Filtration was performed with Whatman GF/C circles, and the filtered samples were preserved in screw-capped Pyrex glass tubes. The filtrate was transferred to clean polystyrene bottles to analyze nitrate-nitrogen, soluble reactive phosphorus (SRP), and soluble reactive silicate (SRS).

Unfiltered samples were used for measurements of pH, alkalinity, conductivity, dissolved oxygen (DO), and total dissolved solids (TDS). All analyses were completed within 24 hrs. The following methods were employed for parameter analysis: AT and WT were determined using equipment from Gallenkamp, UK. Alkalinity was measured using the titration method (Mackereth *et al.* 1978). The pH was measured with a Griffin pH meter, conductivity with a meter (Golterman *et al.* 1978), and total dissolved solids (TDS) with a TDS meter. Dissolved oxygen (DO) was determined using Winkler's titration method (Wetzel and Linkens 1979), while soluble reactive phosphorus (SRP) and soluble reactive silicate (SRS) were analyzed spectrophotometrically, following the methods of Murphy and Riley (1962) and Wetzel and Linkens (1979), respectively. The Nitrate-nitrogen (NO_3-N) was measured using a spectrophotometric method outlined by Müller and Wiedemann (1955). R (v4.2.2) facilitated various analyses (e.g., PCA- principal component analysis) on physicochemical and biological parameters to uncover underlying patterns in the data. The PCA, specifically, helped to identify key drivers of phytoplankton abundance by condensing correlated variables into informative principal components (Jolliffe 2002). Excel and R programming languages (4.2.2) were used to represent data analysis.

Fig. 1. Photographs of the studied lakes (1, 2, and 3 were collection sites, marked by circles.)

Results and Discussion

During the studied period, the air temperatures ranged from 15 to 34°C and from 16 to 34°C for lake-1 and lake-2, respectively. The lowest temperature for lake-1 (15°C) and lake-2 (16°C) was recorded in December. The maximum temperature (34°C) was recorded in April and May for lake-1; and in May for lake-2 (Fig. 2). While the mean air temperatures over both lakes ranged from around 28 to 35°C and phytoplankton densities ranged from approximately 5 $\times 10^5$ to 11×10^5 ind/l, these values were highly variable. The present study, the water temperature was recorded from 14 to 32°C and from 15 to 33°C for lake-1 and lake-2, respectively.

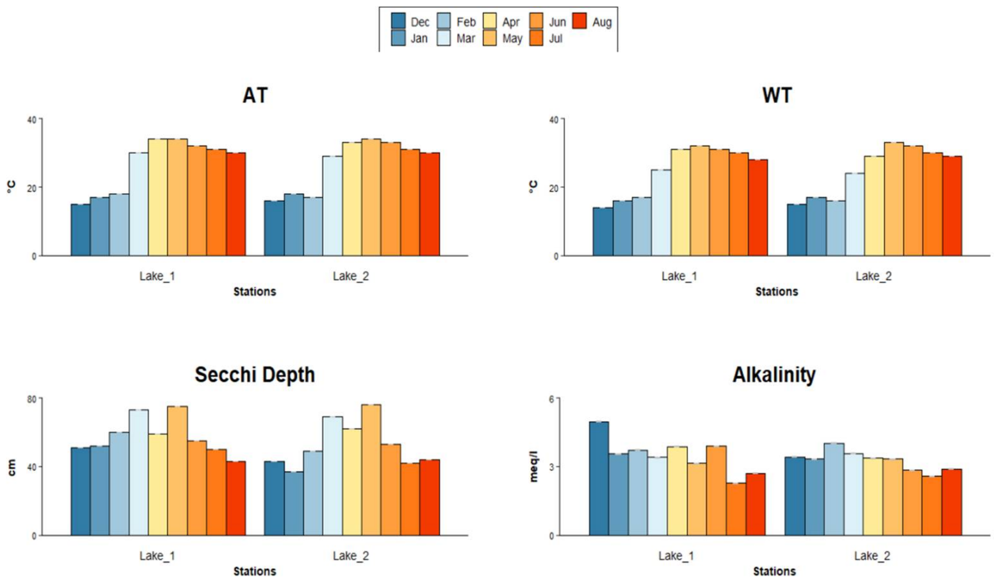


Fig. 2. Variation in monthly parameters for lakes 1 and 2 during the studied period.

This study showed similarities to the findings of the Trimohini beel in Rajshahi, Bangladesh, where the air temperature ranged from 19 to 33.5°C (annual mean value: 29.00 ± 5.88° C) for all research sites (Chowdhury 2013). Both lakes showed the highest water temperature (32°C) in the month of May. The lowest water temperature in lake-1 was 14°C, and in lake-2 was 15°C in December (Fig. 2). The mean values of water temperature for both lakes were 23 ± 4.13°C and 24 ± 4.24°C, respectively. It was stated that water temperature should be between 20 and 30℃ to support aquatic life (Jahan *et al.* 2017). In the limnological study of lake Ashura, Dinajpur, Bangladesh, the average air and water temperatures were found to be 31.5 ± 0.25ºC and 30.0 ± 0.45ºC, respectively (Alfasane *et al.* 2012). The mean water temperature (°C) was determined to be 24.05 ± 0.38 °C in the investigation of the influence of physicochemical parameters on the composition and abundance of phytoplankton in Ajiwa Reservoir, northwest Nigeria (Usman *et al.* 2017). In a north-south gradient investigation of nine Ethiopian lakes, average water temperatures ranged from 19 to 26°C (Vijverberg *et al.* 2012).

Secchi depths varied from 43 to 75 cm and 42 to 76 cm for lake-1 and lake-2, respectively. The lowest value for lake-1 (43cm) was in August, and for lake-2 (42cm) was in July. Both lakes showed their highest Secchi depths (75cm and 76cm, respectively) in May (Fig. 2). In the Trimohini beel of Rajshahi, Bangladesh, the average Secchi depth ranged from 60 to 320 cm (annual mean of 158.8 ± 94.6 cm). Also, transparency ranged from 20 to 110 cm (annual mean of 72.08 ± 29.9cm) (Chowdhury 2013). Regarding the effects of physico-chemical parameters on the composition and abundance of phytoplankton in Ajiwa Reservoir, Katsina State, northwestern Nigeria, the mean transparency (cm) value was 32.33 ± 1.07 (Usman *et al.* 2017).

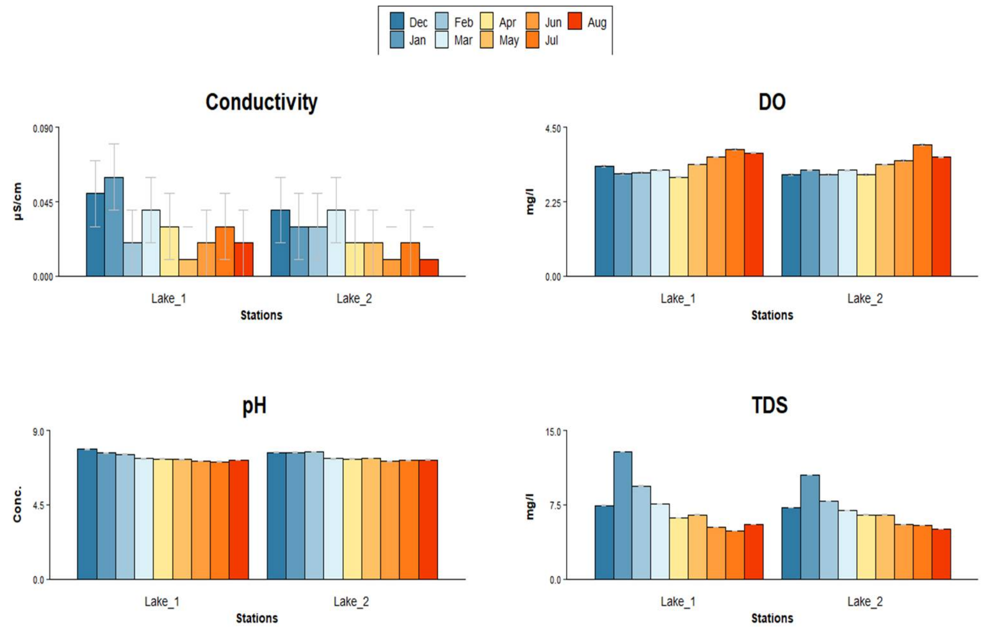


Fig. 3. Variation in monthly parameters for lakes 1 and 2 during the studied period.

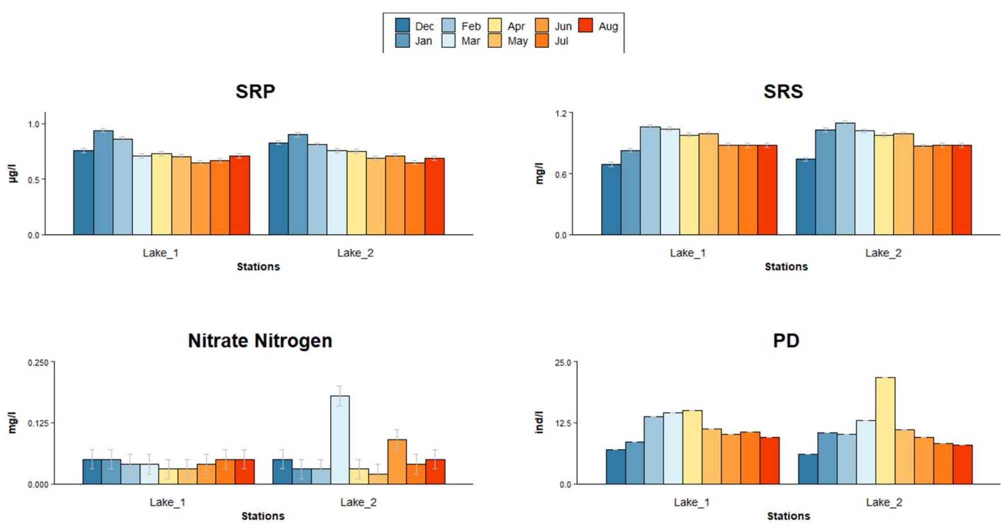


Fig. 4. Variation in monthly parameters for lakes 1 and 2 during the studied period.

The ranges of alkalinity were 2.27-4.97meq/l for lake-1 and 2.57-4.03meq/l for lake-2. Lake-1 showed the highest monthly average alkalinity in December and the lowest in August, whereas lake-2 showed the highest in February and the lowest in July (Fig. 2). The median alkalinity of lake-1 was 3.55. Similar results were reported in lake Ashura, Dinajpur, Bangladesh (2.96 ± 0.58

meq/l), as well as in the central and southern parts of Europe (2.18 ± 2.05 meq/l) in the study of phytoplankton species in European lakes (Alfasane *et al.* 2012, Maileht *et al.* 2013).

From December to August, lake-1 showed a mean conductivity of 0.01 to 0.06 μS/cm, and lake-2 showed 0.01 to 0.05 μS/cm. Lake-1 seemed to have the highest monthly mean conductivity in January and the lowest in May. Lake-2 showed the highest conductivity in December and the lowest in June. In lake-1, the median conductivity value was found to be 0.035, while in lake-2, it was 0.03 (Fig. 3). Analyses of the physicochemical properties of the Hebbal, Shivpure, and Elemallappa Shetty lakes in Bengaluru, India, showed comparable outcomes (0.6 to 2.3 μS/cm) (Aratrika and Ganesh 2020). The electric conductivity (EC) ranged from 50 to 120 µS/cm in the research of phytoplankton assemblage in connection to the water quality of the wetland at Bangladesh's national monument. Furthermore, during the study, the average EC varied between 64.5, 88.5 and 74.25 µS/cm (Alam 2017). According to the study on the physical and chemical limnology of a shallow, hypertrophic artificial lake, the conductivity peaked in August and February at 600 and 750 µS/cm, respectively, and then fell to 499 µS/cm in July and 350 µS/cm in September (Khondker and Parveen 1992).

DO ranged from 3.00mg/l to 3.83mg/l and from 4.10mg/l to 8.80mg/l in lake-1 and lake-2, respectively. Lake-1 showed the highest monthly mean DO in August and the lowest in April. On the other hand, lake-2 showed the highest mean DO in July and the lowest in December. Lake-1 seemed to have a median of 3.33, while lake-2 reported a median of 3.20 (Fig. 3). A lake of Maharashtra (India) (6.69 to 7.9 mg/l) (Dhumal and Sabale 2014); and migratory birds visiting and non-visiting wetlands in Savar, Bangladesh (5.54 to 6.5 mg/l) (Momtaz *et al*. 2010) showed very identical results at similar range. The dissolved oxygen (DO) level of the water ranged between 6.35 to 8.83 mg/l in the study of phytoplankton assemblage in connection to the water quality of the wetland at Bangladesh's national monument (Alam 2017). It was found in the investigation on the physical and chemical limnology of a shallow, hypertrophic artificial lake that the DO ranged from 4.19 to 10.39 mg/l at the surface (Khondker and Parveen 1992).

During the studied period, the pH range was 7.11-7.87 and 7.14-7.69 for lake-1 and lake-2, respectively. The highest monthly mean pH for lake-1 was in December, and the lowest was in July. In lake-2, the highest pH was in February, and the lowest was in June. Both lakes showed higher pH values in the rainy season and less in winter. Lake-1 and lake-2 showed median pH values of 7.29 and 7.31, respectively (Fig. 3). Comparable ranges were found in the two fishponds in Khulna (7.1 to 9.1) as well as the water of Hakaluki Haor in Sylhet, Bangladesh (6.5 to 8.0) (Islam *et al.* 2014). Regarding the water quality of the wetland at Bangladesh's national monument, in the phytoplankton assemblage, the pH of the water was 6.35 to 7.61. In addition, all stations' water pH was raised during the study period (6.75 to 7.61) compared to earlier study periods (Alam 2017). TDS of lake-1 varied from 4.87 to 12.87 mg/l and 5.07 to 10.52 mg/l for lake-2. The highest monthly mean TDS for both lakes was found in the month of January, the lowest for lake-1 was in July, and for lake-2, that was in August. TDS showed a median value of 6.50 in lake-1 and 6.49 in lake-2, respectively (Fig. 3). The TDS levels were relatively low in comparison to those of the Hakaluki Haor in Sylhet, Bangladesh (18.2 to 159.5 mg/l, Islam *et al.* 2014). The mean value of TDS was 70.68 ± 2.71 mg/l in investigating the impacts of physico-chemical variables on phytoplankton composition and abundance in Katsina State, northwest Nigeria (Usman *et al.* 2017).

During the present study period, lake-1 showed a range of SRP 0.65 to 0.94 μg/l, while lake-2 showed 0.65 to 0.9 μg/l. In January, both lakes had the highest monthly average SRP, while June and July showed the lowest. SRP median values in lake-1 and lake-2 were 0.71 and 0.75, respectively (Fig. 4). Compared to the limnology of Lake Ashura, the SRP values were much lower (11.60 ± 1.60 µg/l, Alfasane *et al.* 2012). The dissolved phosphorus levels at different stations in the wetland at Bangladesh's national monument ranged from 42 to 95 mg/l during the investigation of phytoplankton assemblage about water quality. Comparable ranges were found in the study of the effects of physico-chemical parameters on the composition and abundance of phytoplankton in Ajiwa reservoir Katsina State, northwestern Nigeria, where the mean value for phosphorus content was 0.53 ± 0.03 μg/l (Usman *et al.* 2017). Also, the SRP ranged from 0.53 to 1.44 mg/l, according to a study on the physical and chemical limnology of a shallow, hypertrophic artificial lake. The values were highest in March and lowest in July (Khondker and Parveen 1992). The SRS median values in lake-1 and lake-2 were 0.87 and 0.88 mg/l, respectively (Fig. 4). NO_3-N ranged from 0.3-0.06 mg/l in lake-1 and 0.2-0.18 mg/l in lake-2 from December 2018 to August 2019. Lake-1 and lake-2 showed the greatest monthly mean NO_3-N in February and March, respectively, and the lowest in July (Fig. 4). However, similar values (0.03 - 0.04 mg/l) were observed in a comparative limnology of three ponds on the Jahangirnagar University campus (Zaman *et al.* 1993). However, the nitrate-N content of the water varied in the examined wetland from 1.4 to 5.6 mg/l and 2.8 to 8.4 mg/l, respectively, in the investigation of phytoplankton assemblage in connection to water quality (Alam 2017).

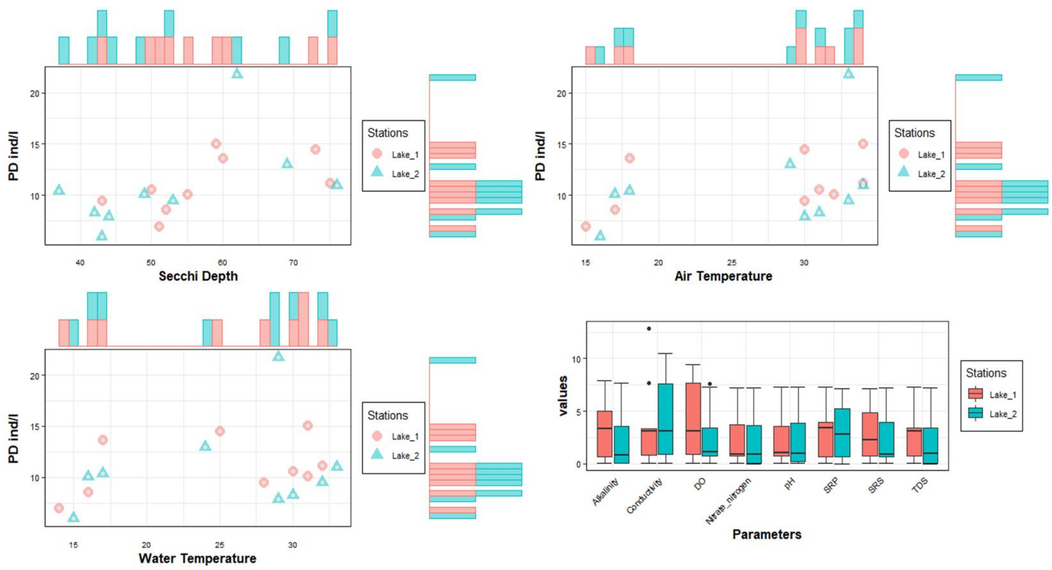


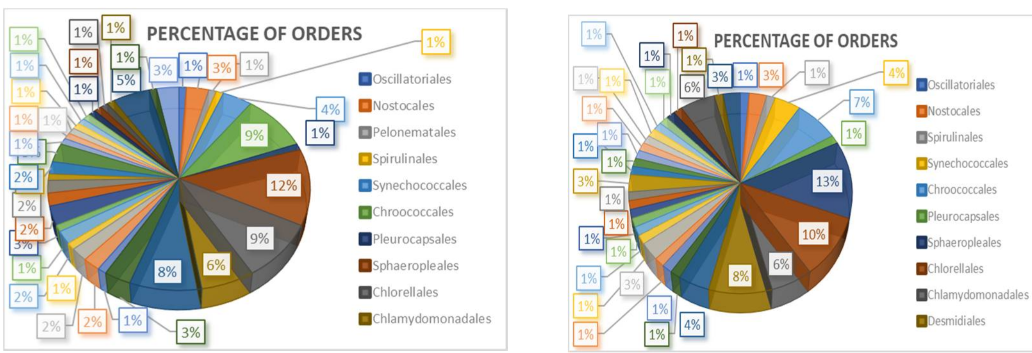
Fig. 5. Phytoplankton dispersion patterns concerning different water factors (all pair and box plots in RStudio 4.2.2).

Lake-1 and lake-2 showed monthly average phytoplankton densities of 7×10^5 to 14.5×10^5 ind/l and 6×10^5 to 21.73×10^5, respectively, from December to August. The highest monthly phytoplankton density for lake-1 was 15.06×10^5 ind/l in April, and the lowest was 7.00×10^5 ind/l in December. PD in lake-1 showed a median value of, ranging from a low of 7.00 to a high of 15.06. Meanwhile, in lake-2, the lowest and highest numbers of the median were 6.00 and 21.73, respectively (Fig. 5). The PD median values in lake-1 and lake-2 were 10.60 and 10.10, respectively (Fig. 4). The values were relatively high in a comparative study of phytoplankton diversity to the water quality of migratory birds visiting and non-visiting wetlands of Savar (Momtaz *et al.* 2010).

The majority of cells were found in both lakes at depths between 41 and 55 cm on the Secchi depth scale and between 43 and 61 ind/l on the density scale, as shown in Fig. 5. Data revealed that the two lakes had different characteristics and water quality, which might affect their ecological health and management. For instance, increased alkalinity and dissolved oxygen in lake-1 might enable increased biodiversity and productivity, but increased soluble reactive phosphorus in lake-2 might encourage the development of hazardous algal blooms. Sufficient carbonates in the water caused it to be alkaline (Sharma *et al*. 2016) (Fig. 5).

Composition of phytoplankton

Lake-1 showed 37 orders, while lake-2 showed 35 orders; Pelonematales and Trebouxiales were unique to lake-1. For lake-1, Sphaeropleales accounted for the most significant percentage (12%), followed by Chroococcales, Chlorellales, and Desmidiales. Moreover, the Sphaeropleales constituted the largest group in lake-2 (13%), followed by the Chroococcales, Chlorellales, and Desmidiales. Sphaeropleales were found in certain investigations to be more tolerant than other algae to high light intensities, high temperatures, and low nitrogen levels (Přibyl and Cepák 2019) (Fig. 6).



Lake-1 Lake-2

Fig. 6. Percentage of orders obtained during the studied period in two lakes.

PCA cells

The first two PCs of the dataset represented the most variation in standard deviation. Additionally, from cumulative proportion, the first two PCs expressed 53.8% of the total variation in the sample. Positively contributing to PC1 were alkalinity, conductivity, pH, TDS, SRP, and Chlorophyceae, while other parameters contributed adversely. Furthermore, conductivity, DO, pH, Cryptophyceae, and Dinophyceae negatively contributed to PC2 but positively contributed to other parameters. The items were shown as either row names or points. A series of arrows represented the variables. The scores were expressed as data points or sample identifiers. Each variable's score was expressed as a deviation from its average. The variable vectors were shown as arrows (Fig. 7A, 7B, and 7C). During the studied period, 1–9 corresponded to lake-1 and 10–18 corresponded to lake-2 (Fig. 7). The PC1 and PC2 revealed 59% of the total variation in the study of contemporary limnology of the fast-changing glacierized watershed of the world's largest High Arctic lake (St Pierre *et al*. 2019).

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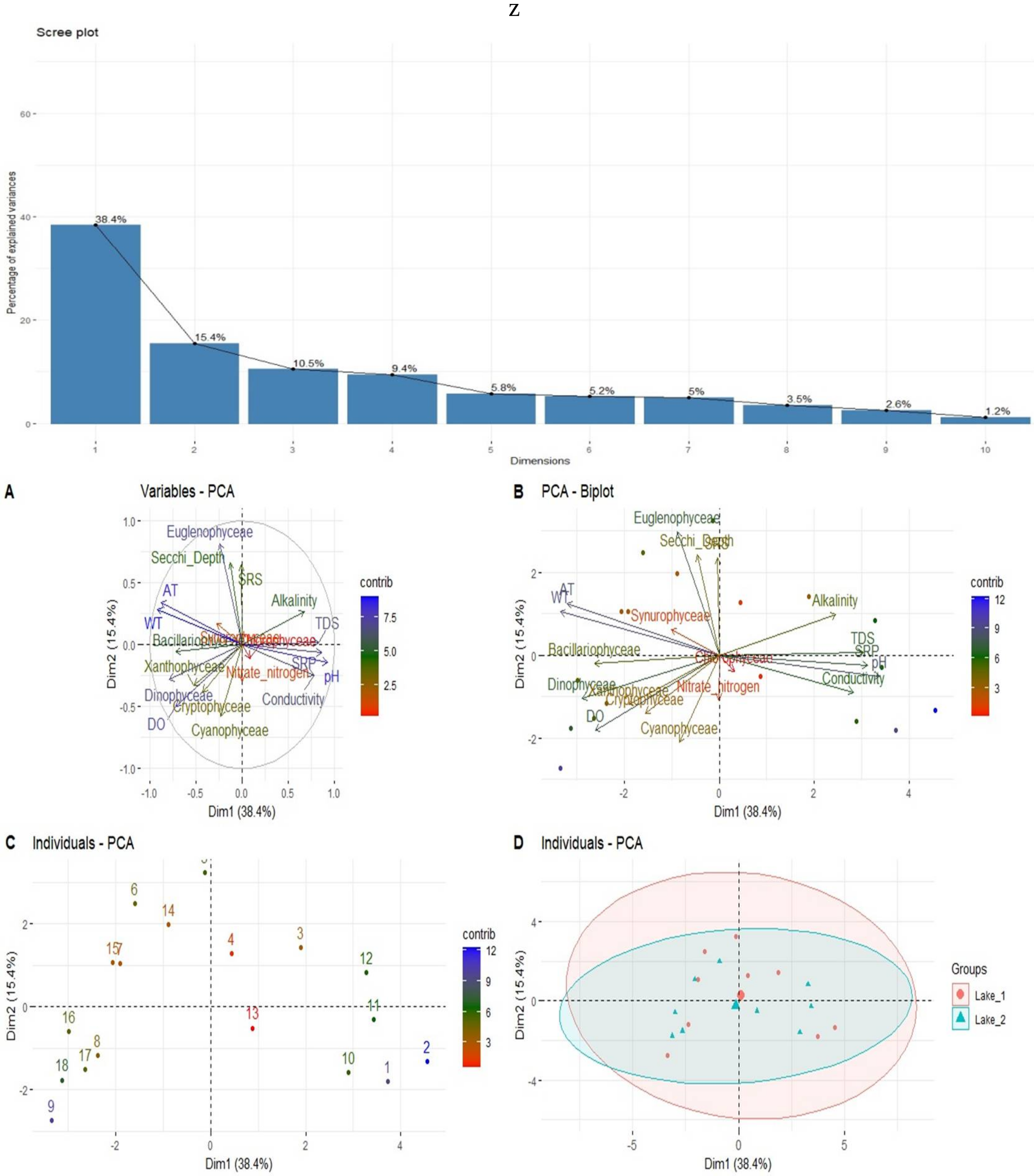

Fig. 7. Principal component analysis (PCA) of monthly phytoplankton cell densities observed in the investigated waterbodies during the studied period. (The scree plot, along with Figures A, B, C, and D, depicted the variance among parameters and their contributions, revealing that the first two principal components (PCs) accounted for 53.8% of the variation in phytoplankton cell densities.)

Cyanophyceae negatively correlated with Secchi depth, alkalinity, pH, TDS, SRP, SRS, Chlorophyceae, and Euglenophyceae. Chlorophyceae negatively correlated with WT, SRP, SRS, Cyanophyceae, Bacillariophyceae, Dinophyceae, and Synurophyceae. Bacillariophyceae showed negative correlations with Secchi depth, alkalinity conductivity, pH, TDS, SRP, SRS, Nitrate-nitrogen, and Chlorophyceae. Euglenophyceae negatively correlated with conductivity, DO, pH, TDS, SRP, Nitrate-nitrogen, Cyanophyceae, Chlorophyceae, Dinophyceae, Synurophyceae, and Xanthophyceae. Cryptophyceae negatively correlated with Secchi depth, alkalinity, conductivity, pH, TDS, SRP, SRS, Nitrate-nitrogen, Dinophyceae, and Synurophyceae. Dinophyceae negatively correlated with Secchi depth, alkalinity, conductivity, pH, TDS, SRP, SRS, Nitrate-nitrogen, Chlorophyceae, and Euglenophyceae. Synurophyceae negatively correlated with alkalinity, conductivity, pH, TDS, SRP, Nitrate-nitrogen, Chlorophyceae, Euglenophyceae, Cryptophyceae, and Xanthophyceae. Xanthophyceae negatively correlated with Secchi depth, alkalinity, conductivity, pH, TDS, SRP, SRS, and Synurophyceae.

However, in a comparative study of phytoplankton diversity concerning the water quality of migratory birds visiting and non-visiting wetlands of Savar, Cyanophyceae showed negative correlations with electric conductivity, TDS, DO, nitrogen, and sulfur. The correlations between Chlorophyceae and electric conductivity, TDS, pH, total N, and total S were negative. Electric conductivity, pH, DO, and total S showed negative correlations with Bacillariophyceae. In terms of electric conductivity, TDS, DO, nitrogen, and sulfur, Euglenophyceae showed negative correlations (Momtaz *et al.* 2010). However, in the study of phytoplankton assemblage concerning the water quality of the wetland at the national monument of Bangladesh, Cyanophyceae showed a negative correlation with dissolved-P. Chlorophyceae showed negative correlations with EC, pH, BOD, and dissolved-P. Bacillariophyceae negatively correlated with TDS, pH, DO, Nitrate-N, and Ammonium-N. Euglenophyceae showed negative correlations with TDS and Nitrate-N (Alam 2017). However, in Dianchi Lake, axis-1 was positively correlated with SRP, DO and negatively correlated with NO_3^-. Cyanophyta dominated the right side of axis-1. SRP greatly influenced the Cyanophyta community organization (Zhang *et al*. 2020).

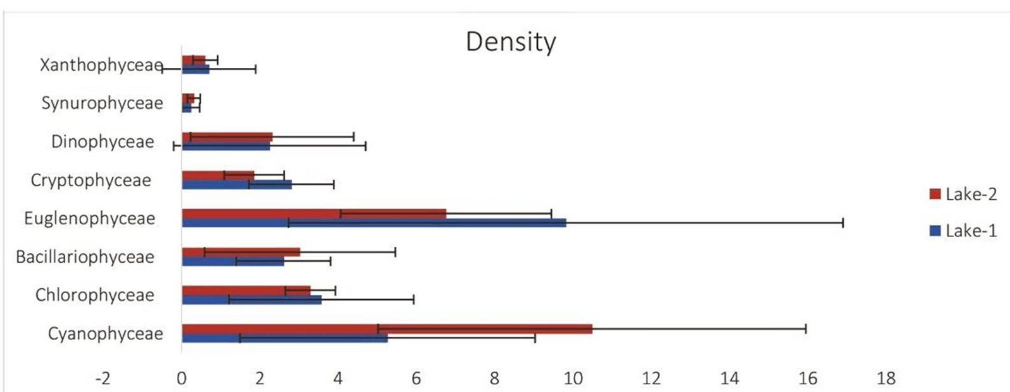

Fig. 8: A comparison of mean densities of different phytoplankton classes in lake-1 and lake-2.

In the present study, at lake-2, the Cyanophyceae group's mean value outweighed that of the other groups (Fig. 8). Similarities were most noticeable in the most abundant group of phytoplankton, the Cyanophyceae (Dimitrova *et al.* 2014). At Santa Olalla, cyanobacteria were the dominant phytoplankton. Although the dominant cyanobacterial community was diversified, the species composition shifted with time. In addition, the proportion of cells from various species to total cyanobacteria varied substantially (López-Archilla *et al.* 2004). In contrast, Euglenophyceae predominated in lake-1 (Fig. 8). Similarly, it was found that euglenoid algae predominated in the phytoplankton flora of lake Ashura (Alfasane *et al.* 2012). Most Euglenophyceae were found in April and May in terms of quantity and variety (Chowdhury and Mamun 1970). The findings seemed to be consistent with the results of the present investigation. Following monthly collections from December 2018 through August 2019, four prominent phytoplankton genera were selected for further study.

Table 1. Density of dominant phytoplankton in different months in Lake-1.

Months	Dominant 1	Dominant 2	Dominant 3	Dominant 4
December	*Monoraphidium* 8.5	*Carteria* 7	*Closterium* 6.075	*Scenedesmus* 5.8
January	*Oscillatoria* 9	*Carteria* 8	*Monoraphidium* 6.1	*Trachlelomonas* 5.65
February	*Cosmarium* 9.1	*Carteria* 8.7	*Monoraphidium* 7.9	*Euglena* 7.67
March	*Actinastrum* 70.5	*Scenedesmus* 11.9	*Monoraphidium* 9.55	*Trachlelomonas* 8.57
April	*Trachlelomonas* 57.5	*Scenedesmus* 12.9	*Actinastrum* 10.5	*Phacus* 7.75
May	*Trachlelomonas* 37.5	*Monoraphidium* 12.5	*Actinastrum* 11.5	*Scenedesmus* 11
June	*Euglena* 29.78	*Actinastrum* 23.5	*Scenedesmus* 11.9	*Trachlelomonas* 10.5
July	*Oscillatoria* 12.5	*Trachlelomonas* 11.25	*Pediastrum* 9.35	*Monoraphidium* 8.55
August	*Monoraphidium* 9.55	*Trachlelomonas* 8.95	*Peridinium* 7.67	*Oscillatoria* 7.5

Table 2. Density of dominant phytoplankton in different months in Lake-2.

Months	Dominant 1	Dominant 2	Dominant 3	Dominant 4
December	*Oscillatoria* 8.3	*Cosmarium* 6.7	*Trachlelomonas* 6.23	*Chlorella* 5.9
January	*Euglena* 8.15	*Cosmarium* 7.7	*Carteria* 6.6	*Trachlelomonas* 5.3
February	*Trachlelomonas* 7.73	*Oscillatoria* 6	*Euglena* 5.15	*Chlorella* 4.19
March	*Pediastrum* 21.55	*Oscillatoria* 20.55	*Monoraphidium* 9.55	*Euglena* 8.78
April	*Trachlelomonas* 17.5	*Euglena* 9.78	*Actinastrum* 9.5	*Pinnularia* 6.5
May	*Euglena* 14.8	*Oscillatoria* 13.5	*Scenedesmus* 11	*Monoraphidium* 10.5
June	*Pinnularia* 25.29	*Oscillatoria* 12.5	*Trachlelomonas* 11.5	*Staurastrum* 9.35
July	*Oscillatoria* 12.5	*Trachlelomonas* 11.5	*Staurastrum* 9.41	*Pediastrum* 9.35
August	*Synedra* 23.55	*Oscillatoria* 14.5	*Trachlelomonas* 11.5	*Pediatrum* 9.61

According to specific months of study, the dominating phytoplankton groups were categorized as dominant 1, dominant 2, dominant 3, and dominant 4, respectively. Tables 1 and 2 included the names of each dominant phytoplankton genus. *Actinastrum* (70.5×10^5ind/l) showed the highest dominant-1 value in lake-1 in March, whereas *Pinnularia* (25.29×10^5ind/l) did so in June for lake-2. *Actinastrum* (23.5×10^5ind/l) was highest during June for dominant-2 in lake-1; however, *Oscillatoria* (20.55×10^5ind/l) was highest in March for lake-2. *Scenedesmus* (11.9×10^5ind/l) was most abundant in lake-1 in June, while *Trachlelomonas* was most abundant in lake-2 in June and August for dominant-3. Both *Scenedesmus* (11×10^5ind/l) and *Monoraphidium* (10.5×10^5ind/l) showed the highest Dominant-4 value for lake-1 and lake-2 in May (Tables 1 and 2). Almost relative kinds of species were also found in the study of lake Ashura (Alfasane *et al.* 2012). Comparing phytoplankton diversity and water quality of migratory birds visiting and not visiting Savar wetlands, *Chlorella, Chlamydomonas, Pinnularia, Synedra, Oscillatoria, and*

Euglena were also found to be dominating species (Momtaz *et al*. 2010). The study of the comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds indicated that the plankton diversity was impacted by the overflow of nutrients and dissolved matter in water bodies. *Closterium* and *Scenedesmus* were detected in mesotrophic water bodies, while *Navicula*, *Scenedesmus*, *Pediastrium*, *Microcystis*, *Oscillatoria*, and *Closterium* were reported to be dominant in the Chinnapperkovil Pond (Rajagopal and Archunan 2010). In the study of alkalinity and hardness in production ponds, alkalinity also showed indirect impacts on "primary productivity" or phytoplankton growth (Wurts 2002).

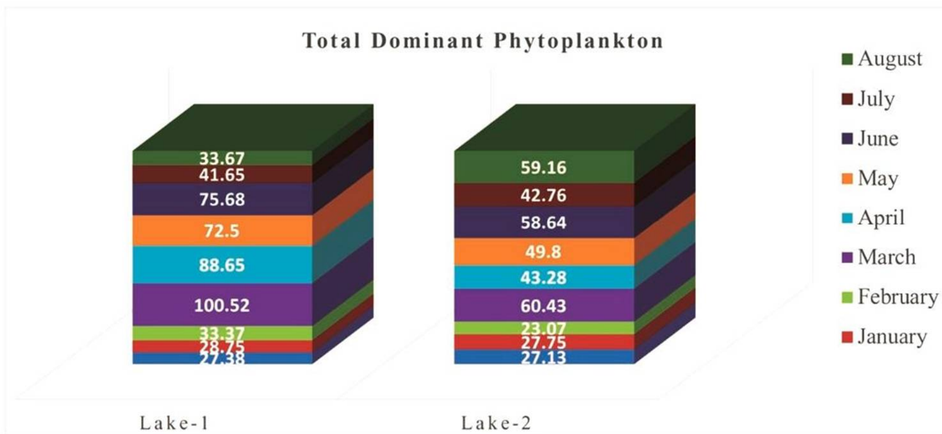

Fig. 9. Graph showing the comparative values of total dominant phytoplankton in the studied lakes.

According to the data (Fig. 9), the total dominating phytoplankton concentrations in both lakes changed monthly. In lake-1, the highest concentrations occurred in March and April, whereas in lake-2, they peaked in March and August. 502.17×10^5 ind/l of total dominant phytoplankton were found in lake-1, whereas 392.02×10^5 ind/l were found in Lake 2. With the exception of March, lake-1 appeared to have higher phytoplankton concentrations than lake-2. It could be due to several factors, including differences in nutrient availability, water temperature, and the presence of organisms competing with phytoplankton for resources. Similar results showed that the dominating phytoplankton and their seasonality varied in different water bodies depending on their nutritional status, age, morphometric, and other locational characteristics in Ajiwa reservoir Katsina state, northwestern Nigeria (Usman *et al.* 2017).

In conclusion, the dynamics of dominant phytoplankton species in lakes are influenced by a complex interplay of environmental factors such as air and water temperature, alkalinity, conductivity, dissolved oxygen, pH, TDS, nitrate-nitrogen, SRP, and others. The study reveals significant relationships between environmental factors and dominant phytoplankton species in lakes. The relationships between these factors and phytoplankton vary between lakes, indicating the importance of considering local conditions and characteristics. While some lakes show strong correlations between specific parameters and phytoplankton abundance, others exhibit more nuanced or even contradictory associations. Understanding these relationships is crucial for managing and conserving freshwater ecosystems, as phytoplankton play a vital role in nutrient cycling and overall ecosystem health.

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