

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(9): 547-556
www.biochemjournal.com
Received: 23-06-2024
Accepted: 26-07-2024

Vikas Gupta
Department of Fisheries Resource Management, Department of Fisheries Resource Management, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Dharambir Singh
Department of Zoology and Aquaculture, College of Basic science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Vipendra Singh
Department of Aquaculture Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Suneel Verma
Department of Fisheries Resource Management, Department of Fisheries Resource Management, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Vikas Kumar Tiwari
Department of Aquaculture, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Abhishek Singh
Department of Fisheries Resource Management, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Vijaypal Chaudhary
Department of Aquaculture, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Dharambir Singh
Department of Zoology and Aquaculture, College of Basic science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

Assessment and quantification of phytoplankton diversity of Tikkar Tal Lake of Morni Hills Haryana, India

Vikas Gupta, Dharambir Singh, Vipendra Singh, Suneel Verma, Vikas Kumar Tiwari, Abhishek Singh and Vijaypal Chaudhary

DOI: <https://doi.org/10.33545/26174693.2024.v8.i9Sg.2173>

Abstract

This study assessed plankton and aquatic weeds in Tikkar Tal Lake, Morni Hills, Haryana, over six months (March-August 2023). A total of 43 genera were recorded, including 29 phytoplankton, which were categorized into Bacillariophyceae (11 genera), Chlorophyceae (10 genera), Cyanophyceae (4 genera), Dinophyceae (2 genera), and Euglenophyceae (2 genera). Phytoplankton species distribution varied across sites, with the highest diversity observed at Site 3. The Shannon-Weaver diversity index for phytoplankton was highest at Site 3 (1.523) and lowest at Site 1 (0.647). The quantity of phytoplankton peaked in May (43,800 plankton/liter) and was lowest in August (14,800 plankton/liter). This study provides essential data for the conservation and management of Tikkar Tal Lake.

Keywords: Tikkar Tal Lake, phytoplankton, Shannon-weaver diversity index

Introduction

Lakes are vital inland aquatic systems, holding four times more water than rivers and comprising 50.01% of the Earth's surface water (Bhateria & Jain, 2016) [5]. These water bodies, which can be either freshwater or saltwater, serve numerous essential functions, including providing habitats for diverse flora and fauna, supplying water for irrigation and industrial use, supporting fisheries, recreation, and livelihoods, and aiding groundwater recharge. They also play a crucial role in regulating the microclimate in urban areas and contribute to environmental processes like the hydrological and biogeochemical cycles. Additionally, lakes are important for tourism and recreation globally, making them significant social and economic resources (Benjamin *et al*, 1996) [4].

The Tikkar Tal Lake is located in the Morni Hill range at latitude 30.657741°N and longitude 77.082265°E. Located in the Panchkula district of the Indian state of Haryana.

The intensity of human pressure, the loss of biodiversity, and the invasion of non-native species have made lentic freshwater one of the planet's most endangered ecosystems. The main source of food for the larvae of finfish and shellfish is fish food organisms, which are microscopic organisms that are naturally found in the aquatic environment (Bhatnagar & Singh, 2010) [6].

Phytoplankton are fundamental to the aquatic food chain, contributing significantly by transferring energy to higher trophic levels through herbivores, primarily zooplankton. Their populations are influenced by factors such as temperature, light, nutrients and grazing and they are sensitive indicators of water quality (Eva, 2001) [7]. Evaluating phytoplankton and zooplankton together can reveal important links between fish populations and their environment (Baykal *et al*, 2006) [3]. Freshwater ecosystems are particularly vulnerable to human impacts, with eutrophication affecting zooplankton structure and composition (Vandysch, 2004) [20].

Materials and Methods

Study Area: The Tikkar Tal Lake is situated about 41 km from Panchkula, Haryana. The Tikkar Tal Lake is situated between 30.6873° North latitude and 77.0877° East longitude. The average depth of the lake is 91 m.

Sampling site

During the present study, five fixed sampling sites were selected for the collection of fish food organisms and aquatic weed from 5 different directions (East, West, North, South, and center of the selected lake) of the Tikkar Tal Lake and named Sampling Site 1, Site 2, Site 3, Site 4 and Site 5.

Collection and preservation of samples

Plankton samples were collected by filtering 50L of water filtered through a plankton net of mesh size 50µm with a demarcating collecting tube allowed for the collection of plankton samples. These samples were collected in 100 ml plastic bottles and concentrated samples were then made up to a standard volume of 50 ml with distilled water. These samples were then preserved at 4% buffered formalin.

Identification and Quantification

Identification

The plankton level was identified and classified up to genus level, by using the methods from Ward and Whipple (1959) [21], Needham & Needham (1962) [13] & APHA (1998) [2].

Quantification

Organisms mL⁻¹ were used to measure plankton abundance. A Sedgwick rafter cell was used to count the organisms. A concentrated sample volume of 1.0 ml was added to the cell cavity. After allowing the plankton to settle, the L⁻¹ value was obtained by counting the number of plankton in 10 randomly chosen fields of the chamber.

Total phytoplankton (L⁻¹) = $Pp \times C \times 100/L$

Where,

Pp = The number of Phytoplankton counted in ten fields

C = Volume of final concentrate of the sample (ml)

L = The volume of water sample filtered

Species diversity index (d)

The species diversity index of phytoplankton and zooplankton was determined using the Shannon and Weaver Diversity Index method (Shannon and Weaver, 1963; Washington, 1984) [15, 22].

$$D = - \sum (ni/N) \log_2 ni/N$$

Where,

d = Species diversity

ni = Number of individuals of ith species.

N = Total number of individuals in the sample

Results

Phytoplankton

Phytoplankton, the most basic form of aquatic life, are autotrophic organisms crucial for generating oxygen in the atmosphere. Diatoms, green algae, and cyanobacteria are very different from phytoplankton. The Six major families of phytoplankton are Euglenophyceae, Bacillariophyceae, Cyanophyceae, Chlorophyceae, and Dinophyceae.

Plankton samples were collected from five different site within Tikkar Tal Lake during the research period. The qualitative analysis of these 5 samples revealed that there are 29 genera of phytoplankton in total, belonging to five major groups i.e. Bacillariophyceae (11 genera) represented by *Aulacoseria*, *Cyclotella*, *Cymbella*, *Denticula*, *Diplonies*, *Fragilaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia*, *Synedra*. Chlorophyceae (10 genera) represented by *Actinastrum*, *Coelastrum*, *Crucigenia*, *Eudorina*, *Monactinus*, *Monoraphidium*, *Pedistrum*, *Scenedesmus*, *Tetrastrum*, *Tetraedron*. Cyanophyceae (4 genera) are represented by *Spirulina*, *Merismopedia*, *Oscillatoria*, and *Phormidium*. Dinophyceae (2 genera) represented by *Ceratium*. and *Pyrodinium*, and Euglenophyceae (2 genera) represented by *Euglena*, and *Phacus*.

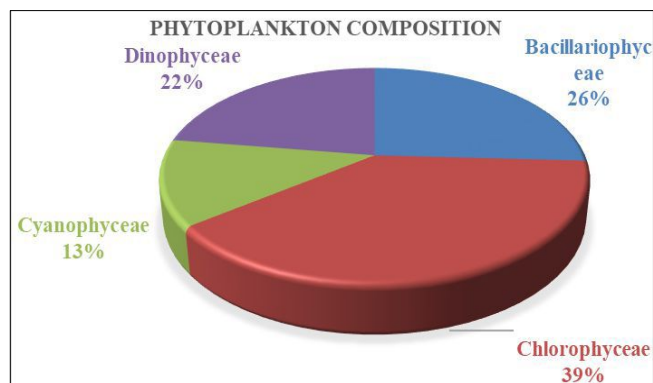


Fig 1: Percentage of various phytoplankton groups at site 1

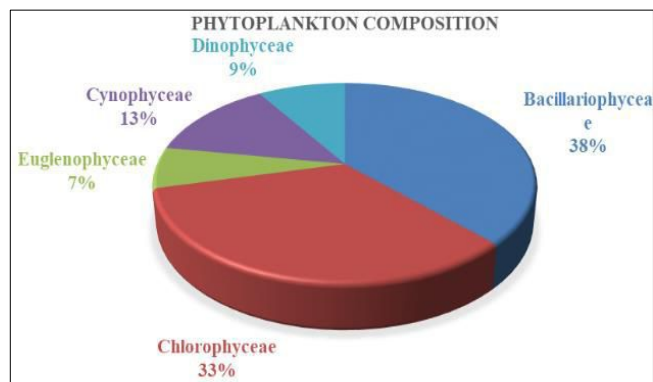


Fig 2: Percentage of various phytoplankton groups at site 2

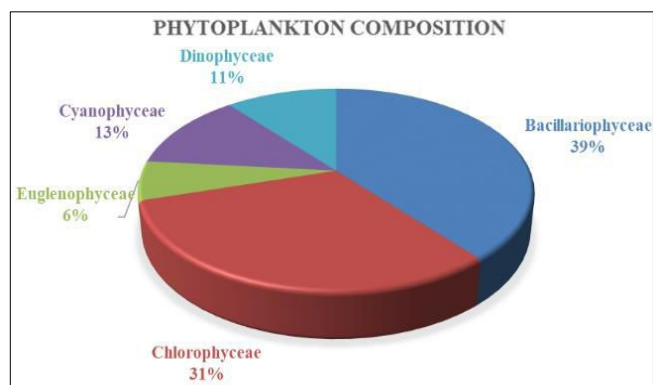


Fig 3: Percentage of various phytoplankton groups at site 3

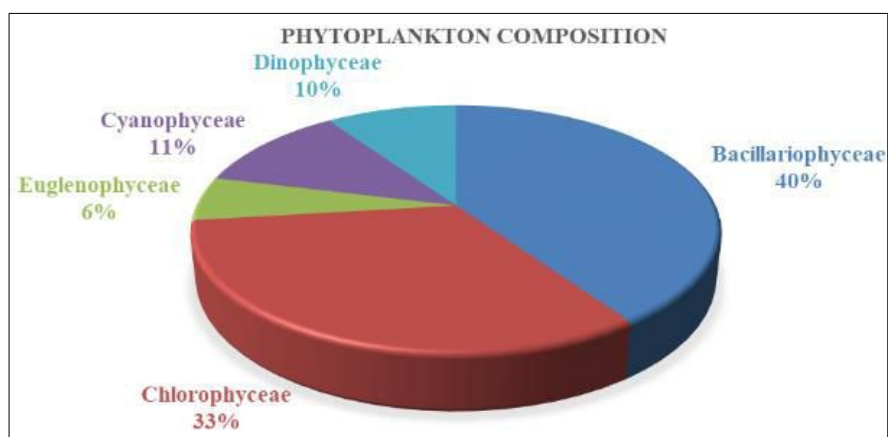


Fig 4: Percentage of various phytoplankton groups at site 4

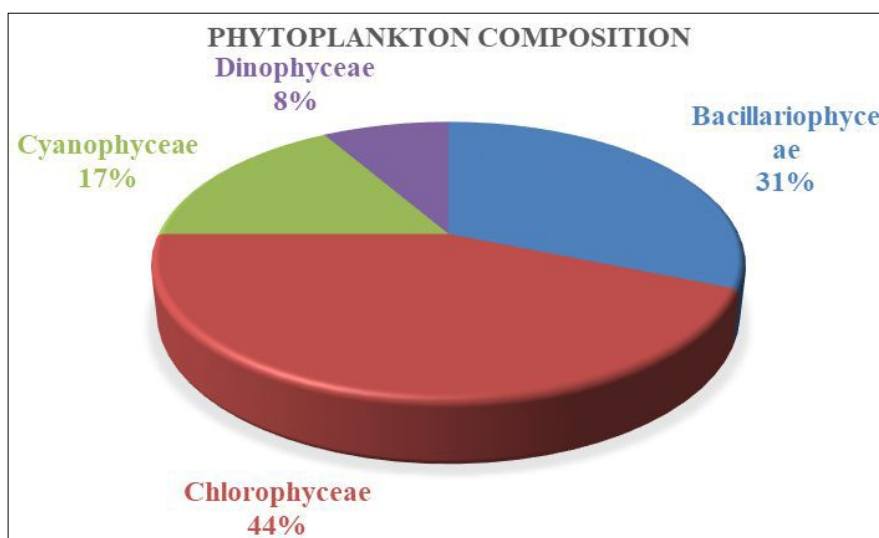


Fig 5 Percentage of various phytoplankton groups at site 5

Quantitative analysis of total phytoplankton during different months: The highest count, 39400, 40600, 43800, 38600, 36000, and 31000 recorded during March, April, May, June, July, August at site No. 3. Respectively whereas

the lowest 16000, 18000, 17600, 15200, 24000, and 14800 was recorded at Site No. 1, 2, 1, 1, 5 and 1 respectively during same months. Overall Site 3 had the highest phytoplankton count while Site 1 generally had the lowest.

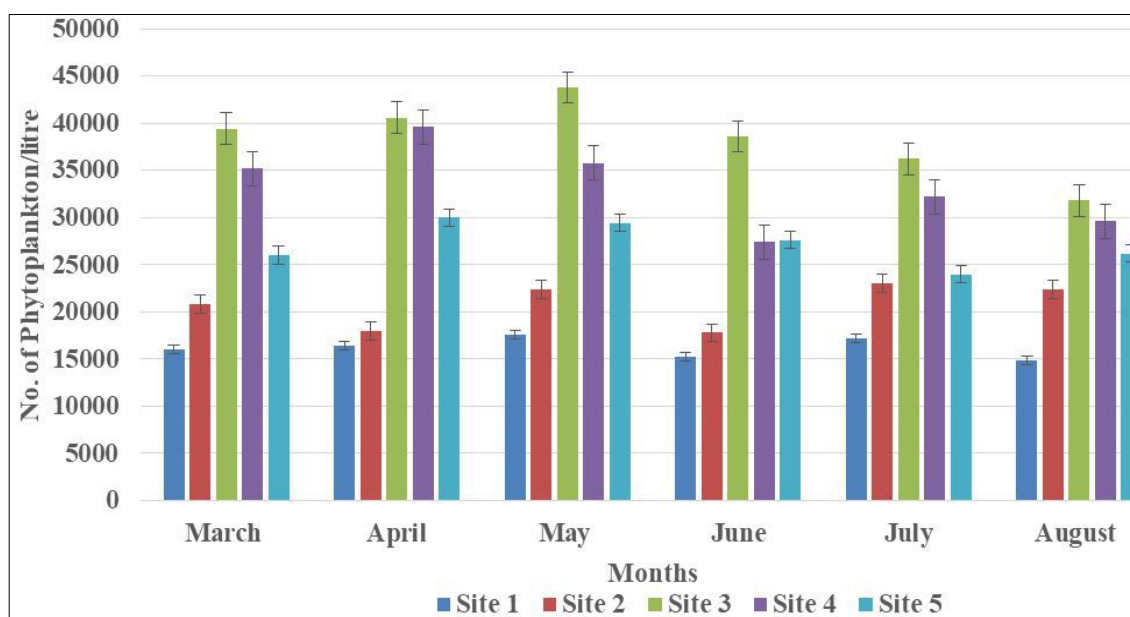


Fig 6: Phytoplankton population at different months

Species diversity indices (d)

A measure of biological variations at the species level of biological organization, species diversity occurs at various spatial scales. It is common practice to use species diversity as a measure for assessing ecological change (Spellerberg, 2008) ^[17].

Shannon and Weaver Diversity Index

The Shannon and Weaver index is a diversity measure that, like other indices, considers evenness or equitability, reflecting how evenly different species are represented in a sample (Spellerberg, 2008) ^[17].

Shannon and Weaver diversity index for Phytoplankton

During the study period of all selected sites of Tikkar Tal

Lake (Site1, site2, site3, site 4, and site 5), the range of the Shannon and Weaver Diversity Index of sampling site 1, ranged from 0.647 to 1.369, the maximum value of diversity index was recorded in May and the minimum in July month. The index of sampling site 2, ranged from 1.065 to 1.494, the maximum diversity index was recorded in March and the minimum in August. The diversity index of site 3, ranged from 0.950 to 1.523, the maximum diversity index was recorded in April and the minimum in August. The diversity index of site 4, ranged from 1.004 to 1.498, the maximum diversity index was recorded in June and the minimum in March. The diversity index of site 5, ranged from 1.030 to 1.352, the maximum diversity index was recorded in March and the minimum in April.

Table 1: Monthly distribution of different phytoplankton species/groups at sampling site 1

Group/Class	Species	March	April	May	June	July	August
Bacillariophyceae	<i>Aulacoseria</i> sp.	+	+	+	—	—	+
	<i>Cyclotella</i> sp.	—	—	+	+	+	—
	<i>Cymbella</i> sp.	—	+	+	+	—	+
	<i>Denticula</i> sp.	+	—	—	+	+	+
	<i>Diplonies</i> sp.	+	+	+	+	—	—
	<i>Fragilaria</i> sp.	+	+	+	+	—	+
	<i>Gomphonema</i> sp.	—	—	+	+	+	—
	<i>Melosira</i> sp.	+	+	+	+	—	+
	<i>Navicula</i> sp.	—	+	+	—	—	+
	<i>Nitzschia</i> sp.	—	+	+	+	—	+
	<i>Synedra</i> sp.	+	—	+	+	—	+
Clorophyceae	<i>Actinastrum</i> sp.	+	—	—	+	+	+
	<i>Coelastrum</i> sp.	—	+	+	+	—	+
	<i>Crucigenia</i> sp.	+	+	+	+	—	—
	<i>Eudorina</i> sp.	+	—	—	—	+	+
	<i>Monactinus</i> sp.	+	+	+	+	+	+
	<i>Monoraphidium</i> sp.	+	—	—	—	+	+
	<i>Pedistrum</i> sp.	+	+	+	+	+	—
	<i>Scenedesmus</i> sp.	+	+	+	+	+	+
	<i>Tetrastrum</i> sp.	+	—	+	—	+	—
	<i>Tetraedron</i> sp.	—	+	+	+	—	—
	<i>Spirulina</i> sp.	—	+	+	+	+	—
Cyanophyceae	<i>Merismopedia</i> sp.	+	+	+	+	—	—
	<i>Oscillatoria</i> sp.	—	+	+	+	—	—
	<i>Phormidium</i> sp.	—	—	+	+	—	+
	<i>Ceratium</i> sp.	—	+	+	+	+	—
Dinophyceae	<i>Pyrodinium</i> sp.	+	—	—	+	+	+

Table 2: Monthly distribution of different phytoplankton species/groups at sampling site 2

Group/Class	Species	March	April	May	June	July	August
Bacillariophyceae	<i>Aulacoseria</i> sp.	+	+	+	—	—	+
	<i>Cyclotella</i> sp.	—	—	+	+	+	—
	<i>Cymbella</i> sp.	—	+	+	+	—	+
	<i>Denticula</i> sp.	+	—	—	+	+	+
	<i>Diplonies</i> sp.	+	+	+	+	—	—
	<i>Fragilaria</i> sp.	+	+	+	+	—	+
	<i>Gomphonema</i> sp.	—	—	+	+	+	—
	<i>Melosira</i> sp.	+	+	+	+	—	+
	<i>Navicula</i> sp.	—	+	+	—	—	+
	<i>Nitzschia</i> sp.	—	+	+	+	—	+
	<i>Synedra</i> sp.	+	—	+	+	—	+
Clorophyceae	<i>Actinastrum</i> sp.	+	—	—	+	+	+
	<i>Coelastrum</i> sp.	—	+	+	+	—	+
	<i>Crucigenia</i> sp.	+	+	+	+	—	—
	<i>Eudorina</i> sp.	+	—	—	—	+	+
	<i>Monactinus</i> sp.	+	+	+	+	+	+
	<i>Monoraphidium</i> sp.	+	—	—	—	+	+
	<i>Pedistrum</i> sp.	+	+	+	+	+	—
	<i>Scenedesmus</i> sp.	+	+	+	+	+	+
	<i>Tetrastrum</i> sp.	+	—	+	—	+	—
	<i>Tetraedron</i> sp.	—	+	+	+	—	—
Cyanophyceae	<i>Spirulina</i> sp.	—	+	+	+	+	—
	<i>Merismopedia</i> sp.	+	+	+	+	—	—
	<i>Oscillatoria</i> sp.	—	+	+	+	—	—
	<i>Phormidium</i> sp.	—	—	+	+	—	+
Dinophyceae	<i>Ceratium</i> sp.	—	+	+	+	+	—
	<i>Pyrodinium</i> sp.	+	—	—	+	+	+
Euglenophyceae	<i>Euglena</i> sp.	+	+	+	+	—	+
	<i>Phacus</i> sp.	—	+	+	+	+	—

Table 3: Monthly distribution of different phytoplankton species/groups at sampling site 3

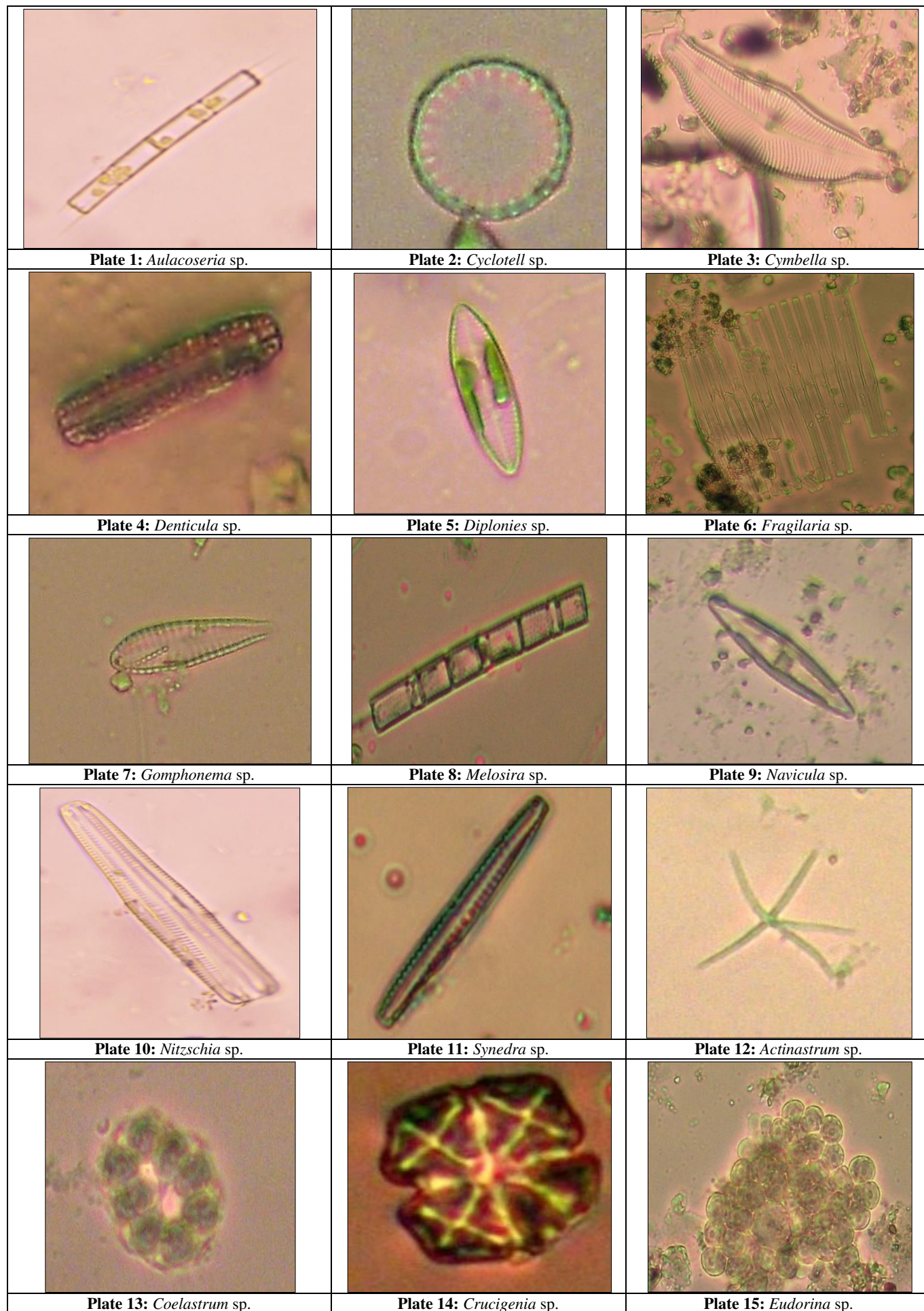
Group/Class	Species	March	April	May	June	July	August
Bacillariophyceae	<i>Aulacoseria</i> sp.	+	+	+	—	—	+
	<i>Cyclotella</i> sp.	—	—	+	+	—	+
	<i>Cymbella</i> sp.	—	—	+	+	—	+
	<i>Denticula</i> sp.	+	+	—	—	+	+
	<i>Diplonies</i> sp.	+	+	+	+	+	—
	<i>Fragilaria</i> sp.	+	—	+	+	—	+
	<i>Gomphonema</i> sp.	+	+	+	+	—	+
	<i>Melosira</i> sp.	+	+	—	+	—	+
	<i>Navicula</i> sp.	+	+	+	—	—	+
	<i>Nitzschia</i> sp.	+	—	+	+	—	+
	<i>Synedra</i> sp.	+	—	+	+	—	+
Clorophyceae	<i>Actinastrum</i> sp.	+	—	—	+	+	+
	<i>Coelastrum</i> sp.	—	+	+	+	—	+
	<i>Crucigenia</i> sp.	+	+	+	+	—	—
	<i>Eudorina</i> sp.	+	—	—	+	+	+
	<i>Monactinus</i> sp.	+	+	+	+	+	+
	<i>Monoraphidium</i> sp.	+	—	—	—	+	+
	<i>Pedistrum</i> sp.	+	+	+	+	+	—
	<i>Scenedesmus</i> sp.	+	+	+	+	+	+
	<i>Tetrastrum</i> sp.	+	+	+	—	+	—
	<i>Tetraedron</i> sp.	—	+	+	+	—	—
Cyanophyceae	<i>Spirulina</i> sp.	—	+	+	+	+	+
	<i>Merismopedia</i> sp.	+	+	+	+	—	—
	<i>Oscillatoria</i> sp.	+	—	+	+	—	+
	<i>Phormidium</i> sp.	—	—	+	+	—	+
Dinophyceae	<i>Ceratium</i> sp.	—	+	+	+	+	—
	<i>Pyrodinium</i> sp.	+	—	+	+	+	+
Euglenophyceae	<i>Euglena</i> sp.	—	+	+	+	+	+
	<i>Phacus</i> sp.	+	—	+	+	+	—

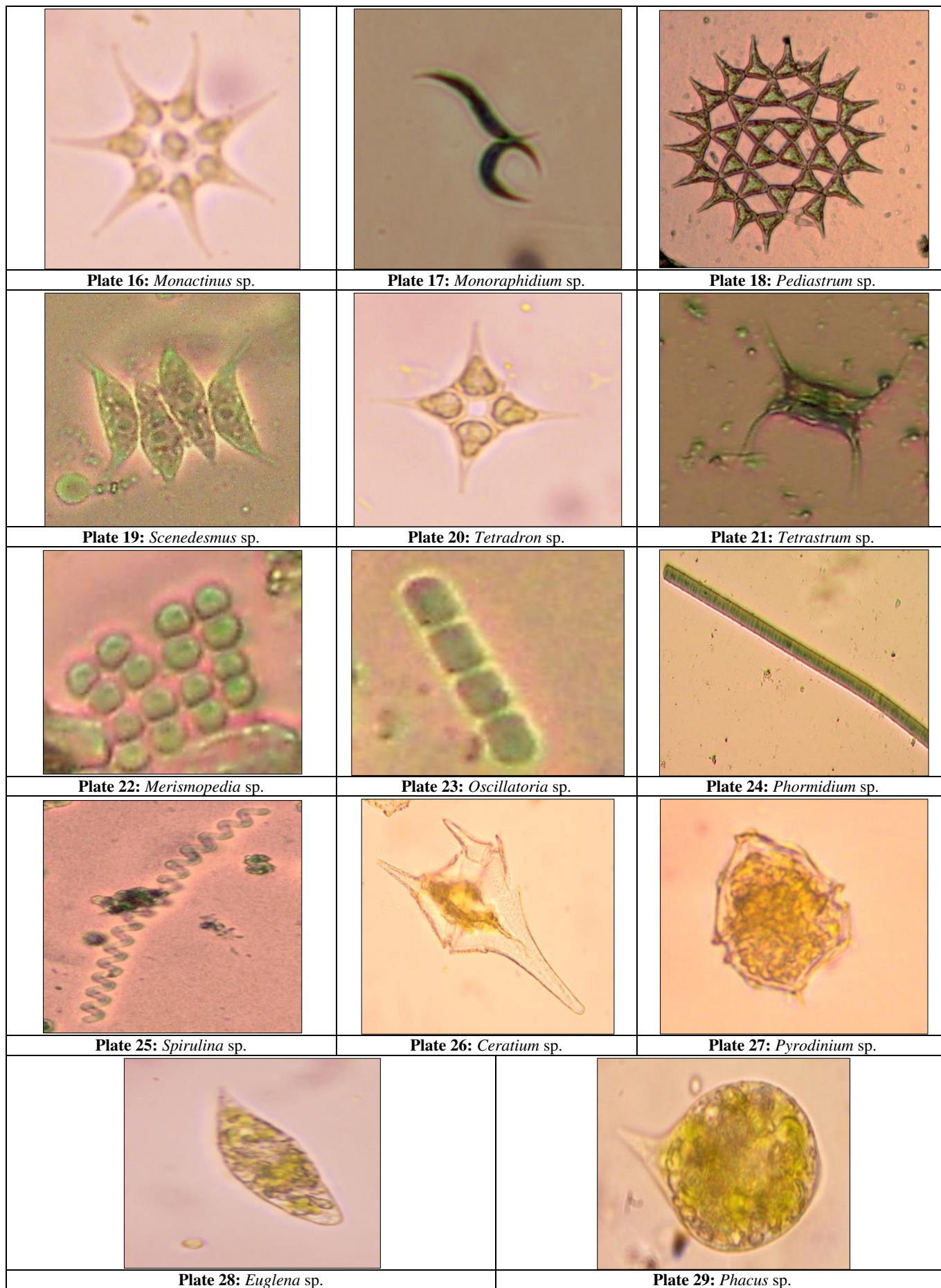
Table 4: Monthly distribution of different phytoplankton species/groups at sampling site 4

Group/Class	Species	March	April	May	June	July	August
Bacillariophyceae	<i>Aulacoseria</i> sp.	+	+	+	—	—	+
	<i>Cyclotella</i> sp.	—	—	+	—	+	—
	<i>Cymbella</i> sp.	—	+	+	+	—	+
	<i>Denticula</i> sp.	+	—	—	+	+	+
	<i>Diplonies</i> sp.	+	+	+	+	—	—
	<i>Fragilaria</i> sp.	—	—	+	+	—	+
	<i>Gomphonema</i> sp.	—	—	+	+	+	—
	<i>Melosira</i> sp.	+	—	+	—	—	+
	<i>Navicula</i> sp.	—	+	+	—	—	+
	<i>Nitzschia</i> sp.	—	+	+	+	—	+
Clorophyceae	<i>Synedra</i> sp.	+	—	+	+	—	+
	<i>Actinastrum</i> sp.	+	—	—	+	+	+
	<i>Coelastrum</i> sp.	—	+	—	+	—	+
	<i>Crucigenia</i> sp.	+	—	+	+	—	—
	<i>Eudorina</i> sp.	+	—	—	—	+	+
	<i>Monactinus</i> sp.	+	—	+	+	+	+
	<i>Monoraphidium</i> sp.	+	—	—	—	+	+
	<i>Pedistrum</i> sp.	+	+	—	+	+	—
	<i>Scenedesmus</i> sp.	+	—	+	+	+	+
	<i>Tetrastrum</i> sp.	+	—	+	—	+	—
Cyanophyceae	<i>Tetraedron</i> sp.	—	+	—	+	—	—
	<i>Spirulina</i> sp.	+	+	+	+	+	—
	<i>Merismopedia</i> sp.	+	+	+	+	—	—
	<i>Oscillatoria</i> sp.	—	+	+	+	—	—
Dinophyceae	<i>Phormidium</i> sp.	—	—	+	—	—	+
	<i>Ceratium</i> sp.	—	+	+	+	+	—
	<i>Pyrodinium</i> sp.	+	—	—	+	+	+

Table 5: Monthly distribution of different phytoplankton species/groups at sampling site 5

Group/Class	Species	March	April	May	June	July	August
Bacillariophyceae	<i>Aulacoseria</i> sp.	+	+	+	—	—	+
	<i>Cyclotella</i> sp.	—	—	+	+	+	—
	<i>Cymbella</i> sp.	—	+	+	+	—	+
	<i>Denticula</i> sp.	+	—	—	+	—	+
	<i>Diplonies</i> sp.	+	+	+	+	—	—
	<i>Fragilaria</i> sp.	+	+	+	+	—	+
	<i>Gomphonema</i> sp.	—	—	+	+	+	—
	<i>Melosira</i> sp.	+	+	—	+	—	+
	<i>Navicula</i> sp.	—	+	+	—	—	+
	<i>Nitzschia</i> sp.	—	+	+	+	+	+
Clorophyceae	<i>Synedra</i> sp.	+	—	+	+	—	+
	<i>Actinastrum</i> sp.	+	—	—	+	+	+
	<i>Coelastrum</i> sp.	—	+	+	+	—	+
	<i>Crucigenia</i> sp.	+	—	—	+	—	—
	<i>Eudorina</i> sp.	+	—	—	—	+	—
	<i>Monactinus</i> sp.	+	+	—	—	+	+
	<i>Monoraphidium</i> sp.	+	—	—	—	+	+
	<i>Pedistrum</i> sp.	+	+	+	—	+	—
	<i>Scenedesmus</i> sp.	+	+	—	+	—	+
	<i>Tetrastrum</i> sp.	+	—	+	—	+	—
Cyanophyceae	<i>Tetraedron</i> sp.	—	+	+	+	—	—
	<i>Spirulina</i> sp.	—	+	+	+	+	—
	<i>Merismopedia</i> sp.	+	+	+	+	—	—
	<i>Oscillatoria</i> sp.	—	+	+	+	—	—
Dinophyceae	<i>Phormidium</i> sp.	—	—	+	+	—	+
	<i>Ceratium</i> sp.	—	+	+	+	+	—
	<i>Pyrodinium</i> sp.	+	+	—	+	+	+



**Plate 1-29:** Phytoplankton reported in study sites of Tikkar Tal Lake

Discussion

Phytoplankton

Phytoplankton play a crucial role in aquatic ecosystems, serving as the primary producers and driving productivity within these environments. Their diversity serves as a key indicator for monitoring the water bodies, reflecting their essential position in the aquatic flora (Sunder & Khatri, 2018) ^[18]. The total 29 genera of phytoplankton were found during the study period in Tikkar Tal Lake which belongs to 5 major groups: Bacillariophyceae (11 genera), Chlorophyceae (10 genera), Cyanophyceae (4 genera), Dinophyceae (2 genera), and Euglenophyceae (2 genera). Similarly, Negi *et al.* (2015) ^[12] also observed consistent in Nainital Lake between 2007 and 2009 when 25 genera of phytoplankton from the three classes Bacillariophyceae (13 genera), Chlorophyceae (8 genera), and Cynophyceae (4 genera) were identified. Singh *et al.* (2024) ^[16] observed thirty-one genera distributed among four groups: Bacillariophyceae (9 genera), Chlorophyceae (15 genera), Cyanophyceae (6 genera), and Euglenophyceae (1 genus). Gianello *et al.* (2019) ^[8] reported a phytoplankton richness value of 48, categorized into Bacillariophyceae (19), Chlorophyceae (12), Cyanophyceae (7), Euglenophyceae (5), Conjugatophyceae (Zygnematophyceae) (3), and Dinophyceae (1).

Quantification of Phytoplankton

During present study in Tikkar Tal Lake at Site 1, Site 2, Site 3, Site 4, and Site 5, respectively, 17600 phytoplankton/liter, 22400 phytoplankton/liter, 43800 phytoplankton/liter, 39600 phytoplankton/liter, and 30000 phytoplankton/liter were recorded. Similarly, Ahmed *et al.* (2003) ^[1] found a maximum load of phytoplankton in summer (11, 300–51, 850 No/L) and recorded the highest count of phytoplankton (51,850) in and around the estuarine environment. Matta *et al.* (2018) ^[10] also found the total number of plankton (Average 893.8 No/L of phytoplankton and 293.31 No/L of zooplankton). Sunder & Khatri (2018) ^[18] observed that the total phytoplankton population ranges from 1190 to 3930 units × 3930 units/liter.

Shannon and Weaver diversity index for Phytoplankton

During the present investigation, the range of Shannon and Weaver diversity index for Phytoplankton of different sampling sites of Tikkar Tal Lake (site 1, site 2, site 3, site 4, and site 5) the variation was observed in their values. Species diversity index value (H) was maximum at site 4 (1.523) followed by site 2 and site 3 (1.494), (1.923), site 1 (1.369), and site 5 (1.352). Similarly, Pandey *et al.* (2014) ^[14] also measured the variety index during the monsoon (H= 1.297), winter (H= 1.289), and summer (H= 1.222). Matta *et al.* (2020) ^[11] recorded the Shannon and Weaver index (1.58). Hossain *et al.* (2017) ^[9] recorded Shannon and Weaver Index (H) for phytoplankton as highest in Axx (0.6829) and lowest in CV (0.5387). Suneel *et al.* (2024) ^[19] recorded the Shannon and Weaver diversity index for phytoplankton at several sample sites, showing levels in descending order from Blue Bird Lake as follows: site 4 (2.06), site 1 (1.95), site 2 (1.91), and site 3 (1.89).

Conclusion

Phytoplankton diversity is crucial in aquatic ecosystems, reflecting the health and productivity of water bodies. The presence of 29 genera across five major groups in Tikkar

Tal Lake highlights the richness and complexity of these communities. This diversity is essential for maintaining ecological balance and supporting the overall stability of the ecosystem. The variation in genus composition also indicates the dynamic nature of these aquatic environments.

Reference

1. Ahmed KKKU, Ahamed SU, Hossain MRA, Ahmed T, Barman S. Quantitative and qualitative assessment of plankton: Some ecological aspects and water quality parameters of the river Meghna, Bangladesh. Bangladesh J Fish Res. 2003;7(2):131-40.
2. American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF). Standard methods for the examination of water and wastewater. 20th ed. New York: American Public Health Association; c1998.
3. Baykal T, Salman S, Acikgoz I. The relationship between seasonal variation in phytoplankton and zooplankton densities in Hirfan IY dam lake, Turkey. Turk J Biol. 2006;30:217-26.
4. Benjamin R, Chakrapani BK, Devashish K, Nagarathna AV, Ramachandra TV. Fish mortality in Bangalore lakes, India. Electron Green J. 1996;1:6.
5. Bhateria R, Jain D. Water quality assessment of lake water: A review. Sustain Water Resour Manag; c2016.
6. Bhatnagar SC, Singh N. Assessing the impact of e-government: A study of projects in India. Inf Technol Int Dev. 2010;6(2):109-21.
7. Eva W. Phytoplankton and water quality characterization: Experiences from the Swedish large lakes Mälaren, Hjälmaren, Vättern, and Vänern. Ambio. 2001;30(8):529-37.
8. Gianello D, Ávila-Hernández E, Aguer I, Crettaz-Minaglia MCC. Water quality assessment of a temperate urban lagoon using physico-chemical and biological indicators. SN Appl Sci. 2019;1:1-13.
9. Hossain MRA, Pramanik MMH, Hasan MM. Diversity indices of plankton communities in the River Meghna of Bangladesh. Int J Fish Aquat Stud. 2017;5(3):330-4.
10. Matta G, Gijli L, Kumar A, Machel J. Hydrochemical characteristics and planktonic composition assessment of River Henwal in the Himalayan Region of Uttarakhand using CPI, Simpson's, and Shannon-Weaver Index. J Chem Pharm Sci. 2018;11(1):122-30.
11. Matta G, Kumar A, Nayak A, Kumar P, Kumar A, Tiwari AK. Water quality and planktonic composition of River Henwal (India) using comprehensive pollution index and biotic indices. Trans Indian Natl Acad Eng. 2020;5:541-53.
12. Nagi RK, Rajput V. Assessment of phytoplankton diversity in relation to abiotic factors of Nainital Lake of Kumaon Himalayas of Uttarakhand State, India. Asian J Sci Inform. 2015;8(2):157-64.
13. Needham JG, Needham PR. A guide to the study of fresh-water biology. 1962.
14. Pandey BN, Siddhartha R, Tanti KD. Phytoplanktonic diversity and their relationships with certain physico-chemical properties of swamp of Purnia, Bihar (India). Ann Exp Biol. 2014;2(1):17-27.
15. Shannon CE, Weaver W. The mathematical theory of communication. Urbana: University of Illinois Press; c1963.

16. Singh A, Verma S, Mehta P, Jatav SK, Yadav S. Study of hydrobiological parameters and their effect on plankton diversity in Yamuna River at Okhla Barrage. *J Exp Zool India*. 2024;27(1):435-41.
17. Spellerberg IF. Shannon-Wiener index. In: *Encyclopedia of Ecology*. Elsevier; c2008. p. 3249-52.
18. Sunder S, AK K. Studies of phytoplankton diversity in Ottu Reservoir, Sirsa (Haryana), India. *Res J Recent Sci*. 2018;6(1):1295-6.
19. Verma S, Singh G, Singh A, Ravikant, Mehta P, Maurya M, *et al*. Assessment of plankton diversity of Blue Bird Lake at Hisar, Haryana, India. *Int J Adv Biochem Res*. 2024;8(1):77-86.
20. Vandysh OI. Zooplankton as an indicator of the state of lake ecosystems polluted with mining wastewater in the Kola Peninsula. *Russ J Ecol*. 2004;35:110-116.
21. Ward HB, Whipple GC. *Freshwater biology*. New York: John Wiley & Sons; c1959.
22. Washington HG. Diversity, biotic and similarity indices: A review with special relevance to aquatic ecosystems. *Water Res*. 1984;18(6):653-694.