Article

Phytoplankton diversity is best food indicator forinsects and fishes from Kapileshwar Lake of Wardha District (Ms), India

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Abstract
As biological indicators of water quality, phytoplankton have long been recognized for their short life cycles and rapid responses to environmental changes. Their standing crop and species composition provide valuable insights into the ecological status of water bodies. The cornerstone of the nutrients cycle, phytoplankton are primary producers that are essential to preserving the balance between an ecosystem's biotic and abiotic elements. The phytoplankton diversity of Kapileshwar (Ashti) Lake, which is located in Wardha District, Maharashtra, close to Ashti Taluka, is the main subject of this study. This lake is a vital water source for the town of Ashti, supporting domestic use, irrigation, and fisheries. The surrounding landscape comprises agricultural fields and dense forests, contributing to the lake’s nutrient dynamics.A comprehensive investigation was conducted over 12 months, from February 2024 to January 2025, to assess the diversity and composition of phytoplankton in the lake. A total of 29 species belonging to four major groups - Chlorophyceae, Bacillariophyceae, Myxophyceae, and Euglenophyceae - were identified. These phytoplankton groups serve as essential food sources for aquatic insects and fish, indicating the lake's productivity and ecological balance. The findings highlight the significance of phytoplankton diversity in sustaining aquatic food webs and emphasize the need for continuous monitoring to ensure the lake's ecological health and water quality.

Keywords: phytoplankton; Kapileshwar Lake; species diversity; environmental indicators; chlorophyceae.

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1 Introduction

Derived from the Greek words "phyton" (meaning "plant") and "planktos" (meaning "migrant" or "drifter"), phytoplankton are minute photosynthetic organisms that are essential to watery environments. These microorganisms, primarily composed of diatoms, dinoflagellates, cyanobacteria, and green algae, exhibit a wide range of shapes, sizes, and functional adaptations. Their diversity is crucial for maintaining ecosystem balance, as different species contribute uniquely to nutrient cycling, oxygen production, and the regulation of carbon dioxide levels in aquatic environments.Phytoplankton are the main producers and the base of the aqua food chain. converting solar energy into organic material through photosynthesis. In addition to promoting the growth of higher levels of trophic structure, such fish and marine animals, and zooplankton, but also significantly contributes to global oxygen production, with estimates suggesting that nearly half of all the photosynthesis on Earth is attributed to phytoplankton (Field et al., 1998). This highlights their role in maintaining atmospheric oxygen levels and influencing climate regulation through carbon sequestration. Phytoplankton distribution is closely linked to oceanic and freshwater currents, particularly along the boundaries of eddies, where nutrient upwelling enhances their concentration. These physical processes create optimal conditions for phytoplankton blooms, which, in turn, sustain high productivity in marine and freshwater ecosystems (Levy et al., 2018). The interaction between phytoplankton and hydrodynamic features is essential in establishing the aquatic ecosystems' biological structure, influencing fishery yields and the overall health of marine biodiversity.

Environmental factors such as temperature, light availability, and nutrient concentrations greatly influence phytoplankton growth. During the summer months, increased sunlight and elevated temperatures create favorable conditions for phytoplankton proliferation. The process of tropholytic activity—where organic matter is broken down and recycled—further accelerates plankton multiplication, contributing to seasonal bloom events (Reid and Wood, 1976). However, excessive nutrient influx, often due to anthropogenic activities, can lead to harmful algal blooms (HABs), which deplete oxygen levels and release toxins detrimental to aquatic life (Anderson et al., 2012). They are of immense ecological and economic value, serving as the primary food source for a vast array of aquatic organisms, including fish and invertebrates. Additionally, plankton contribute significantly to the decomposition of organic matter and the bioremediation of water bodies by aiding in the natural purification of polluted waters and the breakdown of sewage. Their ability to assimilate and recycle nutrients is crucial in maintaining water quality and ensuring the sustainability of freshwater and marine ecosystems (Wetzel, 2001). Phytoplankton, in particular, are primary producers that drive aquatic food webs through photosynthesis, converting solar energy into organic matter. This biosynthesis of organic material supports higher trophic levels, from zooplankton to fish and even larger aquatic organisms such as amphibians and waterfowl (Falkowski & Raven, 2007). The diversity and abundance of phytoplankton influence not only energy transfer within aquatic ecosystems but also play a crucial role in global biogeochemical cycles, particularly in carbon and oxygen exchange processes (Field et al., 1998).

Beyond their role in the food web, phytoplankton are among the most sensitive indicators of environmental change. As they rapidly respond to variations in nutrient availability, temperature fluctuations, and changes in light conditions, their presence, composition, and abundance can serve as a bio-indicator of water quality. Different species of phytoplankton thrive under specific ecological conditions, making them valuable for monitoring pollution levels and detecting anthropogenic disturbances such as eutrophication, chemical contamination, and climate-induced shifts in water parameters (Reynolds, 2006). The dominance of certain phytoplankton groups, such as cyanobacteria, can indicate nutrient overloading and poor water quality, whereas a balanced phytoplankton community suggests a stable and healthy ecosystem (Anderson et al., 2012).The presence of phytoplankton in freshwater bodies is not just a reflection of ecological conditions but also a determinant of food availability for aquatic organisms. In reservoir systems, phytoplankton serve as a primary food source for aquatic insects, which, in turn, are essential prey for fish and other higher organisms. The interdependence of phytoplankton and aquatic insects ensures a balanced energy flow in freshwater ecosystems, contributing to the productivity and stability of these habitats (Thorp & Covich, 2010). The abundance and diversity of phytoplankton can directly influence fishery yields, making them a crucial factor in reservoir and lake management strategies.

2 Material and Methodology

2.1 Study area

Kapileshwar Lake, located just 1 km from Ashti Tahsil in Wardha District, Maharashtra, is a significant water body known for its historical and ecological importance. Named after the revered Kapileshwar Mandir, which stands at its base, the lake holds cultural and spiritual significance for the local community. Constructed in 1960 as an irrigation project by the Government of Maharashtra, the lake plays a vital role in supporting agriculture, fisheries, and local water needs.Beyond its functional purpose, Kapileshwar Lake is also a well-known tourist attraction, drawing visitors with its scenic beauty and tranquil surroundings. The lake has a catchment area of 6.68 sq. km and a substantial water storage capacity of 1.720 million cubic meters, making it a crucial freshwater resource in the region. Its surrounding landscape, consisting of agricultural fields and patches of dense forest, contributes to its rich biodiversity. The lake supports a variety of aquatic life, including diverse phytoplankton populations, which are essential for maintaining ecological balance.

2.2 Collection, preservation and identification of planktons

Plankton samples were systematically collected by filtering 40 liters of water through a plankton net constructed from silk bolting cloth No. 25, featuring a mesh size of 56 microns. To preserve the integrity of the collected plankton, 4% formalin was added to the sample before transporting it to the laboratory for further analysis. For enumeration, the samples underwent centrifugation to concentrate the planktonic organisms. A 1 ml aliquot of the concentrated sample was then transferred into a Sedgwick-Rafter counting cell for microscopic examination. The study was conducted over a 12-month period, from February 2024 to January 2025, allowing for a thorough seasonal evaluation of phytoplankton diversity and population dynamics.

Phytoplankton species were identified using standard taxonomic keys and authoritative references, including those by Smith (1950), Prescott (1973), Edmondson (1959), Agarkar (1998), and Adoni (1985). The enumeration of phytoplankton was carried out using a standardized counting formula to ensure precise and consistent data analysis, providing valuable insights into the ecological status of the water body.

$$n = \frac{(a\ x\ 1000)\ x\ C}{I}$$

where

n = Number of plankton/liters of water,

a = Average of plankton in one small chamber,

C = ml. of plankton concentration, and

I = Volume of original water filtered in liter.

2.3 Sedgwick-Rafter cell method

The Sedgwick-Rafter counting cell, named after its inventor, is a specialized rectangular cavity slide measuring 50 x 20 x 1 mm, designed to hold an exact volume of 1 ml (1000 mm^3) of a water sample. Before analysis, the sample is thoroughly mixed to ensure uniform distribution of planktonic organisms. Using a graduated pipette, 1 ml of the homogenized sample is carefully transferred into the cavity of the counting cell. A cover slip is then placed precisely to minimize air bubbles, ensuring an unobstructed view for microscopic examination. The prepared slide is observed under a binocular microscope, allowing for detailed analysis and enumeration of planktonic organisms.

3 Results and Discussion

Reid and Wood (1976) emphasized that phytoplankton serve as fundamental components of aquatic ecosystems, playing a crucial role in maintaining ecological balance. Any fluctuations in phytoplankton populations are directly correlated with changes in water quality, making them reliable indicators of environmental conditions. Global studies on phytoplankton communities in various water bodies have revealed significant variations in species composition, often influenced by differing pollution levels. These findings have led researchers to widely utilize algal diversity and abundance as bio-indicators of water pollution (Rawson, 1956; Hutchinson, 1967; Palmer, 1969). The presence or dominance of specific phytoplankton taxa can provide valuable insights into nutrient availability, organic pollution, and overall aquatic health, underscoring their importance in ecological monitoring and water quality assessment.

3.1 Data analysis

In the present study, a total of 29 phytoplankton species (Table and Fig. 1) were identified, classified into four major groups: Chlorophyceae, Bacillariophyceae, Myxophyceae, and Euglenophyceae. Among these, Chlorophyceae exhibited the highest dominance across all sampling sites, followed by Bacillariophyceae and Myxophyceae. The least represented group was Euglenophyceae, which was limited to the occurrence of *Phacus* spp. and *Euglena* spp., showing minimal presence in the lake. Comparative studies have reported variations in phytoplankton diversity across different water bodies. Veerendra et al. (2006) identified 34 phytoplankton species belonging to four major classes in Mani Reservoir, Karnataka, with Bacillariophyceae being the most abundant, followed by Chlorophyceae, Cyanophyceae, and Euglenophyceae. Telkhade et al. (2008) recorded 12 phytoplankton species from Masala Lake in Chandrapur, Maharashtra. Similarly, Shirsat et al. (2004) documented 24 phytoplankton species from a freshwater pond in Beed district, highlighting regional variations in phytoplankton composition. Additionally, Ghosh et al. (2012) studied phytoplankton diversity and its seasonal fluctuations in Santragachi Lake, West Bengal, further emphasizing the role of environmental factors in shaping phytoplankton communities. These studies reinforce the significance of phytoplankton diversity in understanding aquatic ecosystem health and water quality.

3.2 Algal biodiversity

The group Chlorophyceae was represented by 15 species (Table 1 and Fig. 1) in the present study, exhibiting dominance during the winter season, followed by summer. Similar findings were reported by Sakhare and Joshi (2002), who identified 14 species of Chlorophyceae from Yeldari Reservoir in Maharashtra. Kumavat and Jawale (2003) observed a peak in algal abundance during February (winter) and a decline in August in a fish pond at Anjale, Jalgaon district. Srivastava (1985) noted Ceratium spp. as the most dominant among phytoplankton, alongside other commonly observed forms such as *Peridinium spp., Staurastrum spp., Synedra spp., Botryococcus spp., Aphanocapsa spp., Pediastrum spp., Microcystis spp.,* and*Chrysamoeba spp.,* along with some algal filaments.Nirmal Kumar et al. (2005) also recorded the dominance of Chlorophyceae under low temperatures and high dissolved oxygen levels in the Ratheshwar wetland of Central Gujarat. Pawar et al. (2006) documented 23 species of Chlorophyceae from Pethwadaj Dam in Kandhar, Nanded, further highlighting the seasonal variation in Chlorophyceae abundance. Bacillariophyceae formed a significant component of both freshwater and marine plankton. In the present investigation, this group was represented by five species, showing maximum density during winter. Diatoms emerged as the second largest phytoplankton group in the reservoir. Sree Latha and Rajalakshmi (2006) observed peak diatom abundance in September and October.Myxophyceae, represented by seven species, exhibited peak density during the summer and a decline in winter. Fritsch (1907) emphasized the role of bright sunlight rather than temperature in promoting bluegreen algae growth, while Hutchinson (1967) observed a minimum density of Myxophyceae in winter and a maximum in warmer months.Euglenophyceae, comprising two identified species, showed higher density during winter and summer, with the lowest occurrence during monsoon. Kumar (1990) reported a similar seasonal trend, where Euglenophyceae peaked in winter. Palmer (1969) highlighted the significance of Euglenophyceae as biological indicators of organic pollution, underscoring their importance in assessing water quality.

Observations on plankton density suggest that the aquatic ecosystem is capable of supporting Indian major carps and other fish species. The major carps exhibited a preference for both phytoplankton and zooplankton as primary food sources. Additionally, the presence of abundant natural food resources indicates that exotic species such as common carp can also be successfully stocked in the water body. Srinivas et al. (2003) reported that Hussainsagar Lake has experienced varying degrees of pollution and eutrophication, which have influenced its ecological balance. Despite these environmental changes, the lake continues to support a stable food web, demonstrating the resilience of plankton communities in sustaining aquatic biodiversity. The availability of diverse plankton species plays a crucial role in maintaining trophic interactions, ensuring a sustainable food supply for fish populations.

Tabel 1 Phytoplankton Biodiversity of Kapileshwar Lake from Ashti, Wardha District.

Sr. No.	Class	Identified phytoplanktonic spp.
1	**Chlorophyceae**	*Pediastrum spp., Cosmorium spp., Microspora spp., Cladophora spp., Coelastrum spp., Zygnema spp., Chlamydomonas spp., Chlorella spp., Volvox spp., Ulothrix spp.,Closterium spp., Oedogonium spp., Nitella spp., Voucherena spp.,* and *Chara spp.*
2	**Bacillariophyceae**	*Pinnularia spp., Mostogioea spp., Naviculla spp., Diatoma spp.,* and *Fragilaria spp.*
3	**Euglenophyceae**	*Phacus spp.,* and *Euglena spp.*
4	**Myxophyceae-**	*Nostoc spp., Oscillatoria spp., Anabaena spp., Rivularia spp., Stigonema spp., Microcystis spp.,* and *Spirulina spp.*

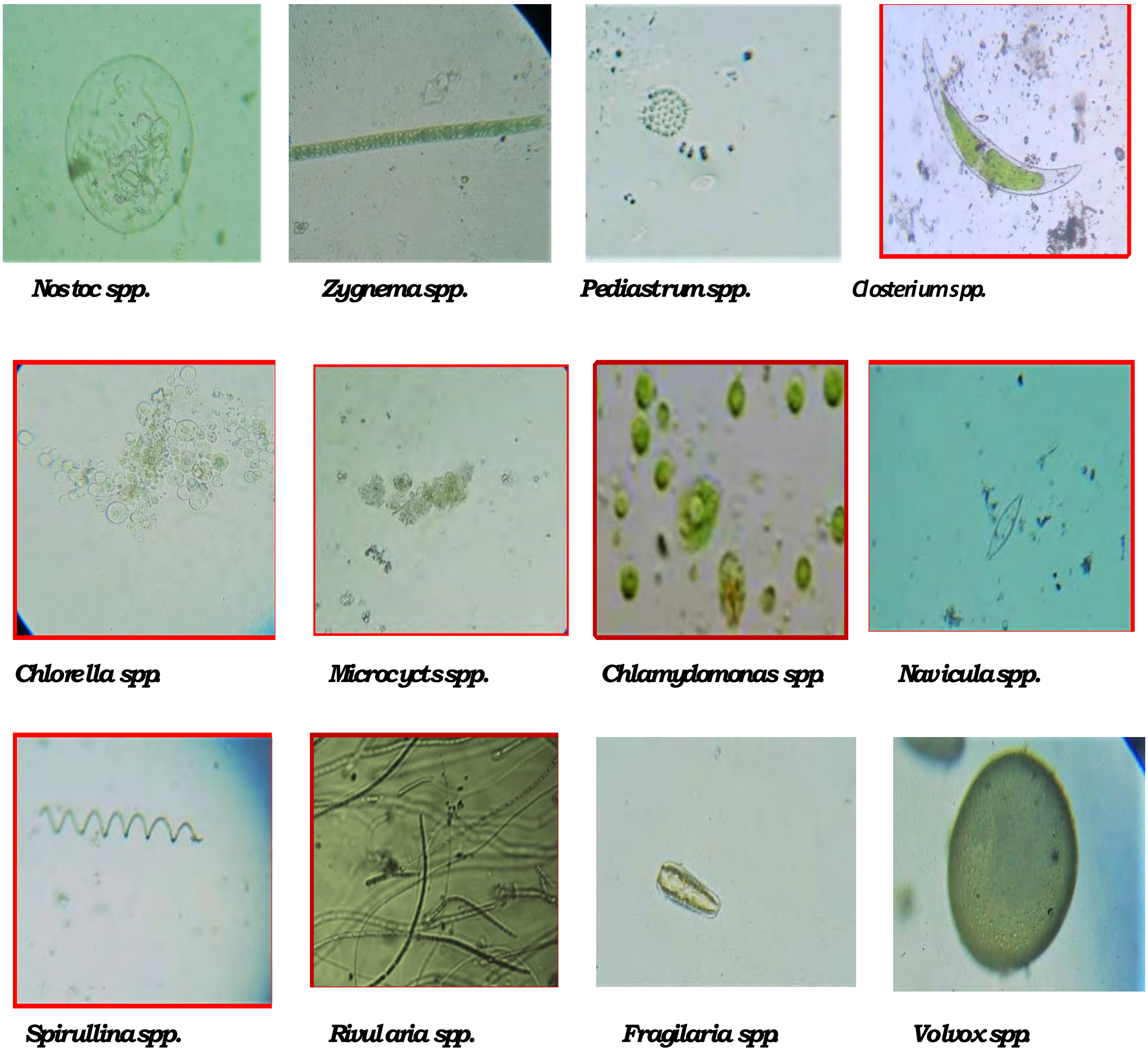

Fig. 2 Phytoplanktonic biodiversity of Kapileshwar Lake from Ashti, Wardha District (MS), India.

4 Conclusion

In the present investigation, total 29 phytoplankton species were identified, phytoplankton were studied under four groups viz. Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglenophyceae. Chlorophyceae is represented by 15 species. Chlorophyceae showed its dominance, followed by Bacillariophyceae and Myxophyceae.Group Myxophyceae represented by 07 species and showed maximum density during summer season and minimum during winter. In the present investigation Bacillariophyceae was represented by 05 species and showed maximum density during winter season, Diatoms occupied as second largest group of the phytoplankton in the lake. Euglenophyceae represented by only *Phacus spp.* and *Euglena spp.*Phytoplankton diversity is a pivotal indicator of food availability and ecological health in freshwater ecosystems like Kapileshwar Lake. It underpins the productivity of aquatic food webs, supports diverse fish and insect populations, and reflects the overall water quality. Understanding and preserving this diversity are essential for the sustainable management of the lake's natural resources and for maintaining the ecological balance that supports both biodiversity and human livelihoods.

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