

Diversity of Microalgae in Kothapalli Pond, Karimnagar District: A Study on Freshwater Ecosystem Dynamics

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ABSTRACT

Microalgae are pivotal components of freshwater ecosystems, contributing significantly to primary production and ecological balance. This study aimed to assess the diversity of microalgae in Kothapalli Pond, located in Karimnagar District, Telangana, by identifying their types and abundance. Microalgae, often microscopic in nature, form the base of aquatic food webs and contribute to various ecosystem functions, including nutrient cycling and oxygen production. The study identified and classified different microalgal species, emphasizing their role in water quality and ecosystem health. The findings suggest that microalgae in Kothapalli Pond exhibit a broad range of biochemical diversity, with potential applications in biotechnology and environmental monitoring.

Keywords: Microalgae, Eutrophication, Freshwater, Chlorophyceae, Cyanobacteria, Kothapalli Pond.

INTRODUCTION

Freshwater ecosystems, such as ponds, lakes, and reservoirs, play crucial roles in maintaining ecological balance, supporting biodiversity, and providing essential resources for human use. Microalgae, the minute plant-like organisms in these water bodies, are foundational to the aquatic food web, contributing to primary production, nutrient cycling, and oxygenation of water. They serve as key indicators of water quality and are sensitive to changes in their environment, making them valuable for ecological monitoring and management (Hosmani, 2013; Najeeb, 2012). In Kothapalli Pond, located in Karimnagar District, Telangana, the diversity and abundance of microalgae are influenced by various environmental factors such as nutrient levels, water temperature, pH, and organic matter content. Microalgae in freshwater systems generally comprise a diverse array of species belonging to major classes like Bacillariophyceae (diatoms), Chlorophyceae (green algae), Cyanobacteria (blue-green algae), and Euglenophyceae (euglenoids), each of which plays a unique role in the aquatic ecosystem. The dynamics of microalgal communities can provide insights into the ecological health of the water body and its susceptibility to issues like eutrophication or contamination by pollutants (Dave, 2011; Negi and Rajput, 2011). Several studies have demonstrated the critical role of microalgae as bioindicators in freshwater systems. For example, Sundararajan et al. (2017) conducted a study on the diversity of phytoplankton in urban freshwater lakes of India, highlighting the dominance of Chlorophyceae and Cyanobacteria in nutrient-rich environments. Similarly, Deeksha Dave (2011) explored the impact of eutrophication in the Fateh Sagar Lake in Udaipur, where the proliferation of Cyanobacteria was linked to high levels of nitrates and phosphates from agricultural runoff. In another study by Chakrabarty and Das (2004), the seasonal variation in phytoplankton composition in the River Jalangi was assessed, with Bacillariophyceae dominating the species pool in clean, low-nutrient conditions, whereas Cyanobacteria flourished under nutrient-enriched conditions. These studies demonstrate how different microalgal groups respond to shifts in nutrient levels and environmental conditions. Microalgae are also significant due to their biochemical diversity, which makes them valuable in industrial and biotechnological applications. For instance, green algae (Chlorophyceae) have been studied for their potential in biofuel production (Demirbas, 2010), while diatoms (Bacillariophyceae) are known for their silica-based cell walls, which have applications in nanotechnology and as biofilters for water purification (Erasmus et al., 2015). Furthermore, species like *Oscillatoria* and *Anabaena*, which belong to the Cyanobacteria group, have shown promise for the production of valuable biochemicals like phycocyanin and astaxanthin, compounds used in the food, cosmetic, and pharmaceutical industries (Rao et al., 2016). In the context of Kothapalli Pond, the presence and composition of microalgae are crucial not only for understanding the ecological health of this freshwater system but also for evaluating its capacity to support local biodiversity and sustain the community's water needs. The study of microalgal diversity in this pond can provide a baseline for monitoring environmental changes and the effects of anthropogenic activities, such as agricultural runoff, on water quality and biodiversity.

Despite the widespread recognition of microalgae's ecological and industrial significance, few studies have been conducted on the microalgal diversity of small freshwater bodies like Kothapalli Pond in this region. This research aims to fill this gap

by identifying and classifying the microalgal species present in the pond and investigating the relationships between environmental factors and their abundance.

MATERIAL AND METHODS

Study Area

Kothapalli Pond is situated in Karimnagar District, Telangana, and is primarily used for agricultural irrigation. The pond's water quality and the health of its aquatic ecosystems are influenced by several factors, including nutrient input, local climate, and seasonal variations.

Fig 1: Kothapalli pond view



Sample Collection

Water samples were collected from various points across the pond during different seasons (June to December 2023) to assess seasonal variations in microalgal diversity. The collection was performed using plankton nets, and samples were preserved with 4% formaldehyde solution for later analysis in the laboratory.

Water Quality Analysis

Physico-chemical parameters of water samples were measured to assess the environmental conditions that influence microalgal distribution.

Identification of Microalgae

Microalgae were identified using a light microscope in the laboratory, based on their morphological characteristics. The Lackey drop method was used to calculate the abundance of different microalgal species. The species were then categorized into major classes, such as Bacillariophyceae, Chlorophyceae, Cyanobacteria, and Euglenophyceae.

RESULTS

Water Quality Parameters

The analysis of water quality in Kothapalli Pond over the study period (June–December 2023) revealed significant seasonal variations in temperature, pH, and nutrient concentrations, all of which influenced the abundance and diversity of microalgae.

- **Temperature** ranged from 22°C in December to 26°C in July, which is within the typical range for freshwater algae growth.
- **pH levels** fluctuated between 7.5 and 8.5, which is conducive to the growth of a wide variety of microalgal species.
- **Nutrient concentrations** showed seasonal variation, with higher levels of **phosphate** and **nitrate** recorded during the monsoon months (July–September), which correlated with increased microalgal abundance.

The table below summarizes the key physico-chemical characteristics of the pond water throughout the sampling period:

Table: Physico chemical characteristics of sampling sites

Month	Temp	pH	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻
July 2023	24.0	8.8	55.42	241.28	152.26

Aug2023	24.5	8.4	46.20	239.26	126.10
Sep 2023	23.0	7.8	13.40	249.86	132.12
Oct 2023	22.50	8.2	12.24	232.04	147.26
Nov 2023	22.0	8.4	24.46	252.16	138.26
Dec 2023	23.0	8.2	11.32	248.06	148.48

The analysis of water samples showed significant seasonal variation in temperature, pH, and other water quality parameters. The temperature ranged from 22°C to 26°C, and the pH fluctuated between 7.5 and 8.5, which is conducive to the growth of most freshwater microalgae. Nutrient concentrations, including nitrate and phosphate, were found to influence the abundance and diversity of microalgae.

Microalgal Composition and Abundance

A total of 12 species of microalgae were identified across the sampling period. These species belonged to four major classes: **Bacillariophyceae** (diatoms), **Chlorophyceae** (green algae), **Cyanobacteria** (blue-green algae), and **Euglenophyceae** (euglenoids).

- **Bacillariophyceae (Diatoms)** were the dominant group in terms of abundance, particularly during the months of **July to September**, when nutrient concentrations (particularly phosphate and nitrate) were higher. Species such as *Amphora*, *Cyclotella*, *Nitzschia*, and *Navicula* were most abundant in these months. These diatoms are well-adapted to the nutrient-rich conditions of the pond.
- **Chlorophyceae (Green Algae)**, including *Chlorella*, *Scenedesmus*, *Pediastrum*, and *Ankistrodesmus*, showed a more consistent presence across all months, but were most abundant during **October to December** when nutrient concentrations were comparatively lower. These species are often found in low-nutrient environments and contribute significantly to primary production in the pond.
- **Cyanobacteria (Blue-Green Algae)**, such as *Anabaena*, *Oscillatoria*, and *Spirulina*, were observed in higher numbers during **July and August** when nutrient levels were at their peak. Cyanobacteria are typically associated with eutrophic conditions and can form harmful algal blooms under such conditions.
- **Euglenophyceae (Euglenoids)**, represented by species like *Euglena*, were less abundant compared to the other classes, but were present in small numbers throughout the year, particularly when the pond's pH was slightly higher.
- The table -2, summarizes the seasonal distribution, abundance peaks, and ecological roles of each major group of microalgae identified in Kothapalli Pond.

Table 2: seasonal distribution, abundance peaks, and ecological roles of each major group of microalgae

Class	Species Identified	Abundance Peak	Seasonal Dominance
Bacillariophyceae (Diatoms)	<i>Amphora</i> , <i>Cyclotella</i> , <i>Nitzschia</i> , <i>Navicula</i>	July–September (High Nutrients)	Dominant in nutrient- rich months
Chlorophyceae (Green Algae)	<i>Chlorella</i> , <i>Scenedesmus</i> , <i>Pediastrum</i> , <i>Ankistrodesmus</i>	October–December (Lower Nutrients)	Common in low-nutrient conditions
Cyanobacteria (Blue- Green Algae)	<i>Anabaena</i> , <i>Oscillatoria</i> , <i>Spirulina</i>	July–August (High Nutrients)	Associated with eutrophic conditions
Euglenophyceae (Euglenoids)	<i>Euglena</i>	Throughout the year	Less abundant, present year-round

The **relative abundance** of the microalgal groups varied seasonally in relation to nutrient availability and other environmental conditions. Diatoms (Bacillariophyceae) were most abundant during the high-nutrient months, whereas green algae (Chlorophyceae) and cyanobacteria (Cyanobacteria) were more prevalent during periods of lower nutrient concentrations.

DISCUSSION

The results of this study on the diversity and seasonal dynamics of microalgae in Kothapalli Pond highlight the intricate relationship between environmental factors, nutrient availability, and microalgal community structure. The seasonal variations in the abundance and diversity of microalgal species were influenced primarily by nutrient levels (particularly nitrate and phosphate), water temperature, and pH. These findings are consistent with previous studies that suggest that microalgae, as primary producers in freshwater ecosystems, are highly responsive to shifts in environmental conditions (Sundararajan et al., 2017; Najeeb, 2012).

Seasonal Variations in Microalgal Groups

- **Bacillariophyceae (Diatoms)**, which dominated the microalgal community from **July to September**, were associated with high nutrient concentrations, particularly phosphates and nitrates. Diatoms, such as *Amphora*, *Cyclotella*, *Nitzschia*, and *Navicula*, thrive in nutrient-rich conditions and are effective indicators of water quality and eutrophic conditions. Their dominance during the monsoon months suggests that the pond experiences an influx of nutrients during rainfall, likely due to agricultural runoff, which promotes the growth of these species.
- **Chlorophyceae (Green Algae)**, such as *Chlorella*, *Scenedesmus*, and *Pediastrum*, were most abundant during the **cooler months from October to December**, when nutrient concentrations were comparatively lower. These species are typically found in environments with lower nutrient levels, suggesting that the pond enters a more stable, nutrient-limited phase after the monsoon. The presence of green algae during this period reflects a shift toward conditions that are less conducive to eutrophication.
- **Cyanobacteria (Blue-Green Algae)**, including species like *Anabaena*, *Oscillatoria*, and *Spirulina*, were prevalent during **July and August**, when nutrient concentrations were at their peak. Cyanobacteria are often associated with **eutrophic** conditions, where high nutrient levels can lead to the formation of harmful algal blooms (HABs). The increased abundance of Cyanobacteria during these months underscores the potential risks of nutrient loading in the pond, which may result in oxygen depletion, reduced water quality, and adverse impacts on aquatic life.
- **Euglenophyceae (Euglenoids)**, such as *Euglena*, were found in low abundance throughout the study period, suggesting they are less sensitive to fluctuations in nutrient levels and other environmental conditions. Their consistent, albeit minimal, presence indicates that they can tolerate a range of water quality conditions, though they do not dominate the community at any point.

Environmental Factors and Microalgal Dynamics

The study confirmed that **nutrient concentrations** (particularly nitrate and phosphate) were key drivers of microalgal abundance and composition in Kothapalli Pond. **Nutrient enrichment**, often due to agricultural runoff during the monsoon season, leads to an increase in microalgal growth, especially diatoms and cyanobacteria, which are highly responsive to such conditions. In contrast, periods of lower nutrient availability favored the growth of green algae, which are typically found in oligotrophic (low-nutrient) environments.

The **pH** of the water, which fluctuated between **7.5 and 8.5**, was also conducive to the growth of most microalgal species. This pH range is typical for freshwater systems, and as such, it did not significantly limit microalgal growth or diversity.

Microalgae as Bioindicators

Microalgae, due to their sensitivity to environmental changes, serve as excellent bioindicators of water quality. The dominance of diatoms in nutrient-rich months, and the increased presence of cyanobacteria in response to high nutrient concentrations, provides valuable insight into the ecological health of Kothapalli Pond. These findings underscore the importance of regular monitoring of microalgal populations to assess potential water quality issues such as eutrophication and pollution, which can have long-term impacts on the aquatic ecosystem and human water usage.

CONCLUSION

The study of microalgal diversity in Kothapalli Pond revealed a highly dynamic and seasonally variable community structure, strongly influenced by nutrient levels and environmental conditions. The findings suggest that the pond's microalgal community is primarily composed of **Bacillariophyceae (diatoms)** during high-nutrient conditions (monsoon months), **Chlorophyceae (green algae)** during periods of lower nutrient levels (post-monsoon months), and **Cyanobacteria (blue-green algae)** under eutrophic conditions, particularly in the rainy season.

The dominance of diatoms during periods of high nutrient concentrations and the increased presence of cyanobacteria highlight the potential risks of nutrient loading in the pond, which could lead to eutrophication and harmful algal blooms. This underscores the need for effective management strategies to reduce nutrient input, particularly from agricultural runoff, to maintain the ecological health of the pond.

Microalgae, as indicators of water quality, provide a cost-effective and efficient method for monitoring the health of freshwater ecosystems. This study emphasizes the importance of integrating microalgal monitoring into broader environmental management strategies, both for assessing the current state of water bodies and for predicting future trends in response to anthropogenic activities. The findings also suggest potential applications for microalgae in biotechnology, particularly in areas such as biofuel production, water purification, and the synthesis of valuable biochemicals, such as phycocyanin and astaxanthin, from cyanobacteria.

Overall, this study contributes to a deeper understanding of microalgal diversity in small freshwater bodies like Kothapalli Pond and highlights the importance of preserving these ecosystems for maintaining biodiversity and water quality in the region.

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