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Phytoplankton diversity and its ecological implications: A Study in Bandipur area, North 24-Parganas, West Bengal

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ABSTRACT

The vast diversity of microalgae in freshwater ecosystems is of the essence as they serve as the principal producers in the food chain. Research on the diversity of microalgae was carried out in selected ponds located in the Bandipur region of North 24-Parganas. A grand total of 26 different phytoplankton taxa have been documented. The value of Shannon-Wiener diversity index (2.463-2.97) was utilized to assess the diversity of phytoplankton and indicated a moderate pollution level in the water ecosystems. The other diversity indices (Dominance_D, Simpson_1-D, Evenness_e^H/S, Brillouin and Berger-Parker) contemplated the investigation to establish the facts. Necessary measures should be considered to maintain its biological and aesthetic properties.

Keywords: Phytoplankton diversity, Ecology, Bandipur, West Bengal

INTRODUCTION

Phytoplankton diversity plays a pivotal role in the aquatic ecosystem. Phytoplankton itself acts as the primary producer in the aquatic food chain for various organisms (Graham et al 2009; Sarker and Wiltstire, 2017). Phytoplankton involves to create biological community that helps to regulate the food web (Field *et al.,* 1998). Phytoplankton diversity especially in aquatic ecosystem is dependent or influenced by different physio-chemical factors (Sin *et al.,* 1999) like water body temperature, sunlight exposure time, water pH, photosynthetic rate of phytoplankton etc. (Veereshakumar and Homani, 2006). Phytoplanktons are very essential in aquatic ecosystems, accounting for major part of the worldwide photosynthetic mechanisms and producing almost half of Earth's atmospheric oxygen (Falkowski, 2012). Due to their fast growth rates and brief life spans, they serve as sensitive indicators of environmental alterations, allowing scientists to study water quality and ecosystem health. For example, changes in phytoplankton community composition frequently indicate nutrient over-enrichment (eutrophication), resulting in harmful algal blooms (HABs) that decrease oxygen levels, interfere with food webs, and generate toxins harmful to aquatic organisms and human health (Heisler *et al.,* 2008). The preponderance of toxic cyanobacteria, like species of *Microcystis*, in nutrient-abundant waters describes the various adverse effects of anthropogenic burden (Paerl *et al.,* 2016). The ecological importance of phytoplankton diversity describes much more than the primary production. Higher biodiversity increases ecosystem resilience through the act of functional redundancy, a specific situation where multiple species accomplish comparable roles, offering support against environmental stress (Loreau *et al.,* 2001). For instance, diatoms deposit silica in their cell walls that effectively capture carbon and manage silicon cycling, whereas coccolithophores assist in carbonate generation, affecting ocean alkalinity (Rost & Riebesell, 2004). Reduced diversity may initiate trophic cascades, endangering fisheries and carbon sequestration potentialities (Boyce, Lewis, & Worm, 2010; Nico Salmaso *et al.,* 2015. The diversity of phytoplankton is regulated by a complex interaction of abiotic and biotic factors. The combination of light availability, temperature, nutrient levels (such as nitrogen and phosphorus), and hydrodynamic conditions collectively shapes community composition (Reynolds, 2006). Alterations influenced by climatic conditions like stratified water layers and varied mixing patterns, additionally strike these interactions, typically benefiting cyanobacteria in warmer, stratified lakes (Huisman *et al.,* 2018). Examining phytoplankton diversity is crucial for understanding the organization and operation of

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aquatic ecosystems. Due to their essential function in primary production, nutrient cycling, and climate regulation, phytoplankton established themselves as crucial elements of the biosphere.

Several recent studies have significantly advanced our understanding of phytoplankton diversity across different aquatic ecosystems in India. Krishnan *et al.* (2024) conducted a pioneering study on epiphytic algae in the riparian lentic habitats of the Achankovil River, Kerala, documenting 61 taxa dominated by Bacillariophyceae and Charophyceae, and highlighting the sensitivity of these communities to flooding and pollution Similarly, Krishnan *et al.* (2020) reported 30 phytoplankton taxa from the upstream region of the same river, with Chlorophyceae as the most dominant group. In West Bengal, Pore *et al.* (2020) used phytoplankton-based biomonitoring to assess pollution levels in a lentic freshwater body, showing seasonal variations where eutrophic conditions were linked to nitrate enrichment and algal blooms of *Botryococcus braunii*. Ghosh (2021) studied seasonal phytoplankton dynamics in the Altara waterbody of Hooghly, identifying bloom-forming species such as *Nitzschia palea* and *Euglena viridis* as indicators of moderate pollution. Additionally, Barinova *et al.* (2012) examined Santragachi Lake and revealed a complex seasonal pattern influenced by nutrient fluctuations, demonstrating moderate pollution through bio-indicator species and diversity indices These studies collectively underscore the role of phytoplankton as sensitive bioindicators for monitoring aquatic ecosystem health in different regions of India. Comprehending the elements that affect their diversity and distribution is crucial for safeguarding aquatic ecosystems and reducing the impacts of worldwide environmental changes. Ongoing studies on phytoplankton diversity will generate the insights necessary to create successful conservation and management approaches, escorting the health and sustainability of aquatic ecosystems for future generations.

MATERIAL AND METHODS

Phytoplankton samples were gathered from the Bandipur region (Figure.1) situated in the Barrackpore subdivision of the North 24-Parganas district in West Bengal, India (22.7357°N, 88.3957°E). We gathered phytoplankton samples between a specific time frame of 9 am and 10 am in an amber colour container with 500 ml capacity and preserved them using Lugol’s iodine solution at a particular ration of 100:1. The supernatant was extracted using a pipette, and the sample was concentrated to 5 ml for examination. The drop count technique (Trivedy and Goel, 1984) was employed for the numerical depiction of phytoplankton. The concentrated phytoplankton sample was mixed thoroughly for homogeneous distribution of the planktonic organisms. Then collected the water sample with a pipette and three drops were analyzed using an Olympus compound microscope on a clean glass slide and their average values were recorded for further analysis. Algal materials were recognized using reference literature (Desikachary, 1959; Prescott, 1962; Komárek and Anagnostidis, 2005; Smith, 1950; Turner, 1892; Wehr *et al.,* 2015). Specific parameters such as water temperature and pH were measured with the PCS Multiparameter Tester 35 Series device.

The community structure was examined using various alpha diversity indices through PAST (Paleontological Statistical software: Hammer, *et al.,* 2001). The status of these water bodies in terms of pollution was defined using the relationship established by Wilhm and Dorris (1968).

RESULTS AND DISCUSSION

A total of 26 genera of phytoplankton of 5 distinct classes, Chlorophyceae (5), Cyanophyceae (9), Bacillariophyceae (5), Euglenophyceae (3) and Zygnematophyceae (4) recorded from seven different ponds of Bandipur area (Table 1). Diversity analysis quantitatively expresses the variations of species present there by using various diversity indices. These indices (Table 2) are characterized by their preferences towards richness or evenness or dominance. Alpha diversity is believed as the most widely utilized way to measure species diversity which describes the total number of species present in a specific condition in a local community.

The pond 1 described the maximum richness value and established it as the most varied phytoplankton community. Pond 6

Table 1: Phytoplankton Data Sheet expressing Species Abundance Score and selected limnological qualities

Genus	Class	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7
		Temp:21º	Temp:24º	Temp:25º	Temp:24º	Temp:23º	Temp:24º	Temp:25º
		pH: 6	pH: 5	pH: 6	pH: 5.5	pH: 6	pH: 6.6	pH: 6
Scenedesmus sp.	Chlorophyceae	19	0	6	0	3	0	6
Oscillatoria sp.	Cyanophyceae	25	6	9	3	12	9	2
Lyngbya sp.	Cyanophyceae	6	0	0	2	0	0	0
Nitzschia sp.	Bacillariophyceae	11	31	22	10	12	0	9
Phormidium sp.	Cyanophyceae	16	19	0	9	6	9	0
Navicula sp.	Bacillariophyceae	21	0	5	4	0	15	0
Euglena sp.	Euglenophyceae	26	0	17	0	0	2	0
Phacus sp.	Euglenophyceae	0	8	0	0	3	2	2
Navicula sp.	Bacillariophyceae	25	16	19	12	19	11	0
Fragilaria sp.	Bacillariophyceae	0	9	0	2	3	0	0
Coleochaete sp.	Chlorophyceae	3	0	0	0	0	0	0
Desmidium sp.	Zygnematophyceae	11	0	12	9	6	0	9
Closterium sp.	Zygnematophyceae	13	3	0	2	0	6	0
Gomphonema sp.	Bacillariophyceae	26	21	0	16	0	11	19
Anabaena sp.	Cyanophyceae	3	0	5	0	0	0	2
Chroococcus sp.	Cyanophyceae	5	9	6	0	3	6	6
Euglena sp.	Euglenophyceae	0	17	0	3	0	9	18
Pseudoanabaena sp.	Cyanophyceae	14	0	9	3	9	0	6
Cosmarium sp.	Zygnematophyceae	9	0	3	11	6	0	9
Desmidium 2 sp.	Zygnematophyceae	0	3	6	0	3	11	0
Microcystis sp.	Cyanophyceae	9	16	13	0	0	0	5
Ulothrix sp.	Chlorophyceae	6	0	0	0	0	0	2
Pediastrum sp.	Chlorophyceae	17	0	5	9	7	6	6
Spirogyra sp.	Chlorophyceae	9	0	3	0	9	0	0
Merismopedia sp.	Cyanophyceae	13	7	0	2	4	0	0
Nostoc sp.	Cyanophyceae	7	6	0	0	0	2	0
Total no. of Individuals		294	171	140	97	105	99	101

showed least richness value. The value of individuals actually reveals the sample size. In this case pond 1 has the largest sample size and pond 4 indicates smallest sample size. It has been established that more even communities can be explained by lower values of "Dominance_D". Here pond 1 indicates lowest dominance value (0.05616) and pond 7 with highest value (0.1002). This supports the diverse nature of the pond and least diverse in case of pond 7. 'Simpson_1-D' index is the complement of the dominance index. Its higher values indicate higher diversity unlike Simpsons basic dominance index (D). Here highest value for 'Simpson_1-D' was recorded in pond 1 as 0.9438 and lowest in pond 7 as 0.8998. The "Shannon_H' index which encounters both abundance and evenness qualities recorded highest in pond 1 (2.97) and lowest in pond 7 (2.463). The 'Evenness_e^H/S' values describe in which way the individuals are allotted among species, found highest in pond 6 as 0.9177 and lowest in pond 7 as 0.8383. Pond 6 indicates a very prominent even species distribution and pond 7 is lowest in evenness, where few specific species dominate. Brillouin index accounts the sample as the entire population. Its higher value indicates more diversity. In this case it recorded its maximum value (2.788) in pond 1 and lowest (2.182) in pond 7 like the Shannon diversity. Berger-Parker index pinpoints the dominance value through the highest abundant species. It inversely correlates with Shannon diversity. Pond 1 recorded lowest dominance (0.08844), hence highest diversity and pond 7 with highest dominance (0.1881), thus lowest diversity features. After considering all the above facts it has been said that pond 1 is most diverse and the diversity value of pond 7 is to the lowest degree.

The percentage composition of the phytoplankton class showed that members of Bacillariophyceae and Cyanophyceae were dominant among the collected seven ponds. The members of Euglenophyceae and Chlorophyceae interpreted lowest percentage composition.It has been noted that members of Cyanophycean and Bacillariophyceae can

Table 2: Various Alpha Diversity values

	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7
Taxa_S	22	14	15	15	15	13	14
Individuals	294	171	140	97	105	99	101
Dominance_D	0.05616	0.09487	0.08582	0.0887	0.08462	0.08782	0.1002
Simpson_1-D	0.9438	0.9051	0.9142	0.9113	0.9154	0.9122	0.8998
Shannon_H	2.97	2.483	2.579	2.545	2.597	2.479	2.463
Evenness_e^H/S	0.8861	0.8556	0.8787	0.8495	0.8945	0.9177	0.8383
Brillouin	2.788	2.296	2.343	2.237	2.301	2.207	2.182
Berger-Parker	0.08844	0.1813	0.1571	0.1649	0.181	0.1515	0.1881

endure environmental temperatures and conditions due to their heat stress tolerance, reaching their peak limits, while other members are unable to thrive as well in those situations.Their physiological and biochemical characteristics affirm their ecological triumph in diversified environments (Hamm *et al.,* 2003; Rossi & De Philippis, 2015). Wilhm and Dorris (1968) have put forward a kinship between species diversity and pollution condition of a water body. He expressed various conditions and its related consequences. When species diversity value > 3, it indicates clean; 1-3 = as moderately polluted and < 1 designates as heavily polluted and these seven ponds show a moderate level of pollution. So, by this study we can highlight the detailed changes in phytoplankton composition of selected seven different ponds and also, and we can correlate these studies in depicting the pollution status of a water body.

CONCLUSION

The current study on the phytoplankton diversity in seven distinct water bodies reflects phytoplankton fluctuation. This research highlights the diversity status and also illustrates the pollution level of the water body by utilizing these tiny organisms as an instrument for biomonitoring study. In this research, the overall Shannon diversity values (2.463-2.97) indicate a moderate degree of pollution in the examined aquatic ecosystems. Given that local residents use these water bodies for different purposes, this is important because effective conservational strategies and balanced usage can help to safeguard them from further decline. It is essential for the sustainable utilization of our ecosystem. It should be mentioned that these water bodies play a crucial role for the surrounding population of each segment of the ecosystem. Therefore, protective measures should be taken with utmost seriousness to understate the condition.

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