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ORIGINAL ARTICLE **OPEN ACCESS**

A Seasonal Study on Phytoplankton Diversity and Distribution in Manasbal Lake of Kashmir Himalaya, India

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ABSTRACT
The present study was aimed to determine the seasonal variation in phytoplankton diversity of Manasbal Lake. The data was collected from 6 sampling sites during 4 seasons over a two-year study period. During the investigation, 101 phytoplankton species belonging to six groups were collected from the lake: Bacillariophyceae (49), Chlorophyceae (39), Cyanophyceae (07), Chrysophyceae (01), Dinophyceae (02), and Euglenophyceae (03). Bacillariophyceae accounted for the majority of phytoplankton, followed by Chlorophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, and Chrysophyceae indicating the diverse nature of phytoplankton in general and that of Manasbal lake in particular. The overall highest growth of different phytoplankton classes at different sites were shown by Bacillariophyceae at Site-S4, Site-S3 and S5 during summer followed by Chlorophyceae at the same sites. The overall highest mean density of phytoplankton was reported by Bacillariophyceae at Site-S4 followed by Site-S3 and S5 during summer and the seasonal trend in total phytoplankton density was reported as summer > spring > autumn > winter.
Keywords: *Phytoplankton, Seasonal variation, Bacillariophyceae, diversity*

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INTRODUCTION

Phytoplanktons are tiny, unattached plants that are found uniformly distributed throughout the water column. They live in the euphotic zone of freshwater lakes, ponds, and other bodies of water because they rely on light and nutrients. Phytoplanktonic species may be found in all bodies of standing water, as well as in the middle and lower sections of rivers [1-3]. These organisms are essential for primary production and biogenic oxygenation throughout the day in fresh water zones. Because of their short life cycle, phytoplanktonic communities respond very quickly to changes in the environment and so serve as bioindicators of pollution among the various aquatic groups.

MATERIAL AND METHODS

STUDY AREA

The high altitude Kashmir valley is home to a diverse range of freshwater bodies that provide a wide range of ecological services, including food, fodder, aquatic game, and tourist recreation, in addition to being a rich repository of flora and fauna. However, owing to perturbations in the catchment areas, the lake environment has altered dramatically in recent decades and entered an aggravated trend.

Manasbal lake (34° 14' 38'' N to 34° 15' 26'' N latitude and 74° 39' 07'' E to74°41' 20'' E longitude) is located at an of altitude of 1584 m above sea level in Ganderbal district of Jammu and Kashmir [17]. The area's climate is characterized by warm summers and cold winters [21]. The climate of Kashmir, according to Bagnoulus and Meher-Homji [4], may be divided into four seasons on the basis of mean temperature and precipitation (winter, spring, summer, and autumn). The area receives an average annual precipitation of roughly 650 mm, which is distributed unevenly around the district throughout the year. From January to May, western disturbances are mostly responsible for precipitation and snowfall, but the southwest monsoon is responsible for showers in July and August. From September to mid-November, the region has a brief spell of dryness with little or no precipitation.

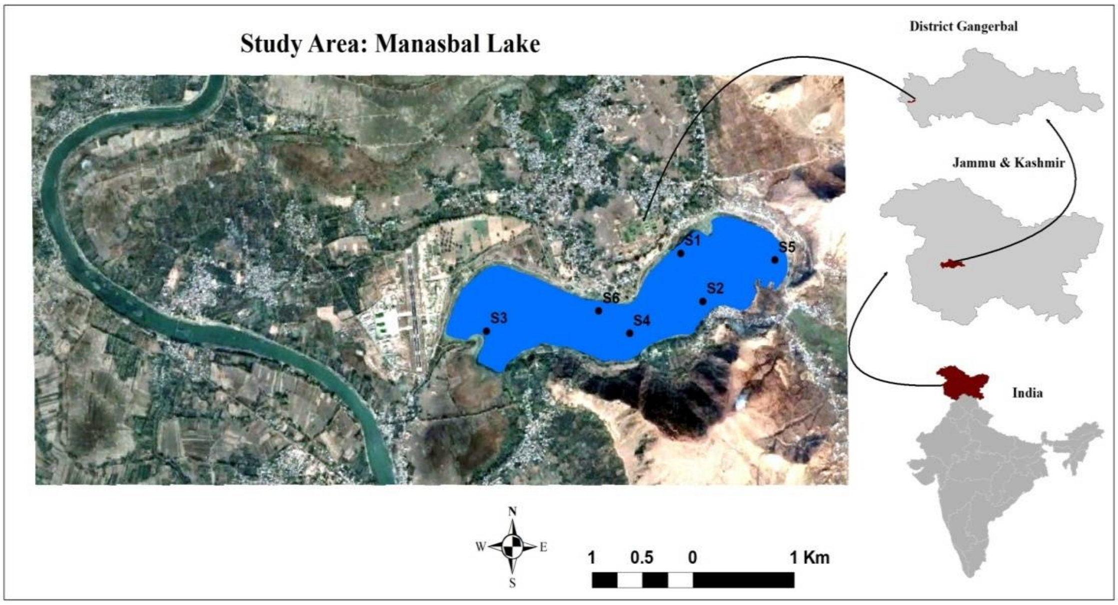

Figure 1: Six samplin g locations in Manasbal lake

COLLECTION AND ANALYSIS OF SAMPLES

Water samples were collected monthly from six different locations throughout a two-year study period (2019 – 2020). Phytoplanktons were obtained by filtering 50 litres of water through plankton net with a mesh size of 70mm. The filtrate was transferred to glass vials and preserved in 5% formalin. Adoni (1985) methodologies were employed for their qualitative analysis. The drop count method was used for quantitative examination, and the number of plankton (phytoplankton) per litre of concentrate was determined.

RESULTS AND DISCUSSION

During the current investigation, 101 phytoplankton species from six families were collected from the Manasbal lake: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Chrysophyceae, Dinophyceae, and Euglenophyceae. Bacillariophyceae accounted for the majority of phytoplankton, followed by Chlorophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, and Chrysophyceae. Out of the total of 101 phytoplankton species recorded in the lake, 49 belonging to the Bacillariophyceae, 39 to the Chlorophyceae, 07 to the Cyanophyceae, 03 to the Euglenophyceae, 02 to the Dinophyceae, and 01 to the Chrysophyceae, indicating the diverse nature of phytoplankton in general and that of Manasbal lake in particular (Table 1, Figure 2).

Sr.no	Classes					Sites		Total taxa
		S1	S2	S3	S4	S5	S6	
1	Bacillariophyceae	27	28	40	39	37	29	49
2	Chlorophyceae	24	23	29	22	35	25	39
3	Cyanophyceae	5	3	6	5	4	5	07
4	Euglenophyceae	2	2	3	3	3	2	03
5	Dinophyceae	2	2	-	1	1	2	02
6	Chrysophyceae	-	1	1	1	1	1	01
	Total	**60**	**59**	**79**	**71**	**81**	**64**	**101**

Table 1: Taxonomic distribution of phytoplankton at various study sites in Manasbal lake

In an earlier study by Abubakr *et al.,* [1], a total of 125 phytoplankton species were reported from the Manasbal lake and still in other studies carried out by Akhter *et al.,* [2], a total of 56 phytoplankton species were reported from four sites of Manasbal lake. Thus, the present study on Manasbal lake presents a better species diversity as compared to earlier studies.

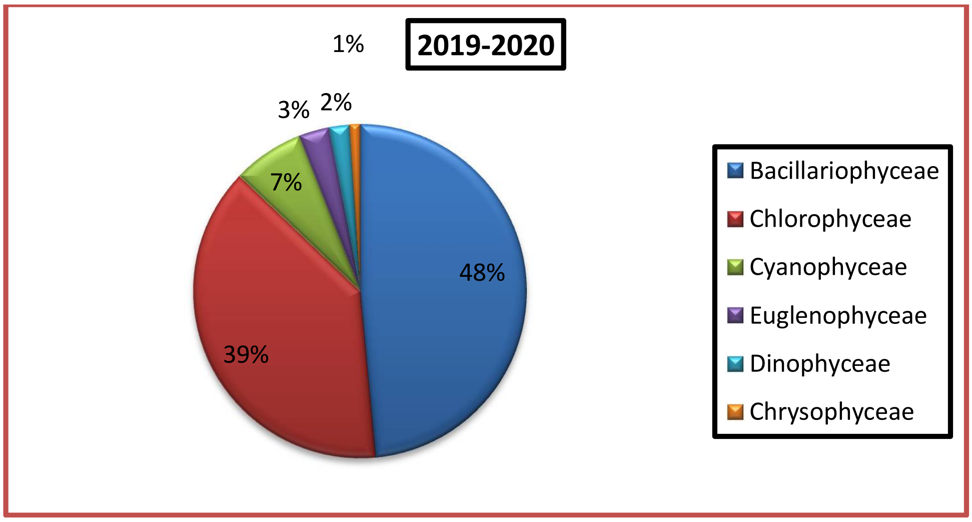

Figure 2: Percent contributions of various phytoplanktonic classes in Manasbal lake

Bacillariophyceae was the most dominant group in terms of diversity and density and showed its peak growth in summer and spring at most of the sites. In general, the highest population diversity of phytoplankton was observed during warm months extending from spring to summer ((Table 2, Figure 3)). The findings are in full agreement with the findings of Lund [15] and Munawar [16].

Sites	Phytoplankton Classes	Winter	Spring	Summer	Autumn
S1	Bacillariophyceae	243.4813	344.7708	407.293	283.7708
	Chlorophyceae	217.5854	294.2181	334.1667	250.2292
	Cyanophycea	45.25	61.70834	71.91666	51.54167
	Dinophyceae	10.27083	16.33333	20.77083	13.4375
	Euglenophyce	13.9375	19	23	16.54167
S2	Bacillariophyceae	244	341.2292	407.1428	289.4375
	Chlorophyceae	187.5208	257.6125	309.9163	218.1458
	Cyanophycea	32.77083	54.27083	61.33928	46.125
	Dinophyceae	14.125	16.33333	20.10714	13.4375
	Euglenophyce	7	19	22.5	16.54167
	Chrysophyceae	22.25	26.54166	28.28571	23.64584
S3	Bacillariophyceae	469.9583	698.5625	789.7708	564.875
	Chlorophyceae	299.4583	481.75	564.7708	395.6042
	Cyanophyceae	83.6875	128.5	157	109.1042
	Euglenophyceae	25.875	46.66666	58.58334	36.85416
	Chrysophyceae	15.35416	22.10416	25.77084	17.95834
S4	Bacillariophyceae	511.8125	828.3333	988.0834	671.0833
	Chlorophyceae	246.9375	419.6042	506.8334	319.3958
	Cyanophyceae	76.35416	112.5208	141.0625	95.08334
	Dinophyceae	15.85416	21.70834	28.0625	21.3125
	Euglenophyceae	33.20833	58.22916	83.12501	53.97916
	Chrysophyceae	15.75	21.75	28.25	21.375
S5	Bacillariophyceae	407.5625	622.3959	758.3542	494.0417
	Chlorophyceae	320.7083	543.6667	674.0208	430.2917
	Cyanophyceae	59.625	90.83335	106.625	74.93751
	Dinophyceae	9.145834	15.45834	18.60416	11.8125
	Euglenophyceae	28.95833	57.75	56.125	142.8333
	Chrysophyceae	9.75	15.6875	18.875	12.27083
S6	Bacillariophyceae	262.6463	373.9188	446.435	307.7063
	Chlorophyceae	230.6463	301.1763	357.0825	257.4175
	Cyanophyceae	67.5	88.25	100.6875	75.1875
	Dinophyceae	10.27125	16.3325	20.77125	13.4375
	Euglenophyceae	13.9375	19	23	16.54125
	Chrysophyceae	22.25	26.54125	28.77125	23.64625

Table 2: Seasonally population density in different taxa of Phytoplankton (ind./L) at different sites

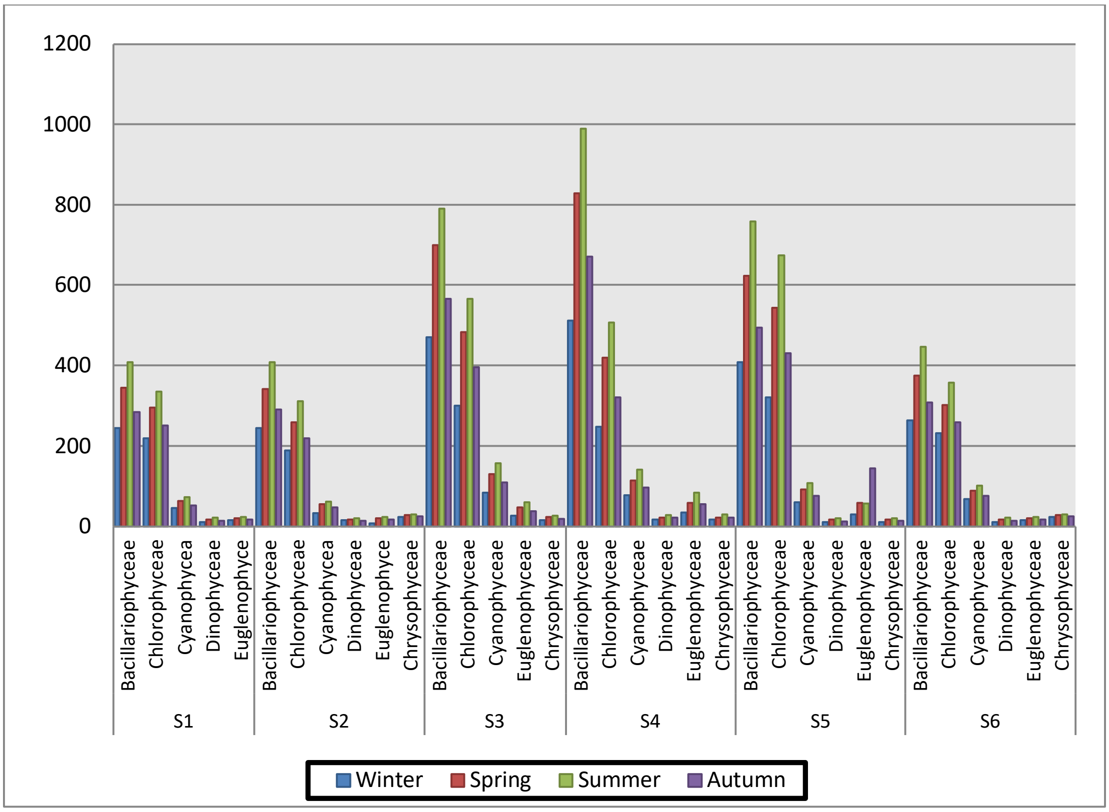

Figure 3: Seasonally population density in different taxa of Phytoplankton (ind./L) at different sites during Jan. 2019- Dec. 2020.

The Chlorophyceae was the second dominant group of phytoplankton after Bacillariophyceae. The total Chlorophyceae species recorded from the lake was 39, out of which 13 taxa were recorded from all the sites which include *Ankistrodesmus falcatus, Closterium sp., Closterium setaceum, Closterium subalatum, Coelastram cambricum, C. sphaericum, C. minimum, C. reniforma, Oocystis sp., Scenedesmus armatus, Scenedesmus quadricauda, Selenastrum pilosum,* and *T. minimum.* On seasonal basis, Chlorophyceae revealed its peak growth in summer and spring (Table 2, Figure 3). The spring bloom of Chlorophyceae was also recorded by Sommer [25]. Khan [13] also reported spring and summer peak of Chlorophyceae in his study on two Kashmir valley lakes viz., Naranbagh and Trigam. Spring peak of Chlorophyceae can be attributed to absence of macrophytic bloom due to which chlorophyceans are able to absorb the nutrients well from the increased phosphorus and nitrate pool and may be also due to the increasing temperature. The abundance of Chlorophyceae during summer may be due to the favorable environmental conditions viz. light temperature and nutrients, as it is generally believed that Chlorophyceae have a rather lower limit optimum for phosphorous [23]. Swingle [27] has also reported that inorganic fertilization results in large generation of Chlorophyceae. Abundance of Chlorophyceae encountered within the present study during summer may also be due to use of detergents and fertilizers in the immediate surroundings of the lake which often reach into the lake. The class, however, showed restricted growth during the cold water period extending from December to February.

The group Cyanophyceae ranked third after Bacillariophyceae and Chlorophyceae in order of number of species and population density (Table 2, Figure 3). A total of 07 taxa were recorded from the lake including *Anabaena globosa, Aphanocapsa sp., Merismopedia elegans, M. punctata, Microcystis aeruginosa, Spirulina sp.,* and *Oscillitoria sp*. Cyanophyceae in the present study depicted its peak growth during summer at most of the sites, whereas low densities were recorded during cold water periods. Blooms of some Cyanophyceans like *Merismopedia elegans, Microcystisa aeroginosa* were noticed in summer. The dominance of this group during summer months indicates the influence of temperature on this group. George [7] has suggested that high temperatures act as a principal factor causing blooms of Cyanophyceae, in agreement with Pandey and Tripathi [28], who also observed a maximum number of blue-greens during the summer and a minimum number in the winter.

Only 03 taxa of Euglenophyceae, *Euglena acus*, *Phacuscerantus* and *P. makii* have been recorded from the lake. Euglenophyceae in the present study showed its peak growth in spring except at some sites, where the peak growth was observed in summer (Table 2, Figure 3). Kant and Kachroo [11] recorded maximum occurrence in spring and autumn in their study on Dallake, while as Nygaard [18] observed that Euglenophyceae attained their maximum growth in spring and summer.

Dinophyceae formed the least represented group in the phytoplankton community, being represented by ***Ceratium hirundinalla*** and ***Peridium purillium,*** which were recorded in the lake. Rawson [22] classified *Ceratium* as a mesotrophic algal form. According to Findenegg [6] some of the Australian lakes which get rapidly polluted due to human influence enter into a phase of dense population of *Ceratium* which is followed by *Oscillatoria* bloom. The presence of *Ceratium* in fairly good numbers is an indication that the lake under discussion has higher trophic evolution due to discharge of waste water.

Chrysophyceae, the least represented group in the phytoplankton community, being represented by lone taxa of ***Dinobryon sp.,*** assumes a lesser importance as far as population size is concerned (Table 2, Figure 3). According to Hunter [8], the presence of Chrysophytes in combination with one or two other algal groups, indicates oligotrophic or mesotrophic conditions. However, Hutchinson [9] stated that ***Dinobryon sp.*** may appear in productive lakes when nutrients are largely exhausted by other biotic components. This is probably the reason for the low density of ***Dinobryon sp.*** in the present study.

In the present study, the total phytoplankton depicted high diversity and density during summer followed by spring. The peak proliferation of phytoplankton during these two seasons may be caused by moderate water temperature conditions, regeneration, and mineral availability [5], which is caused by breakdown of organic materials in sediments during these two peak times. The current findings are also in line with those of previous researchers who studied phytoplankton in several freshwater bodies in India [19, 26].

CONCLUSION

It is evident from the present study that Bacillariophyceae was the dominant class in the Manasbal lake followed by Chlorophyceae, with just a little contribution from Cyanophyceae and Euglenophyceae, as has been the case in the majority of Valley lakes. Bacillariophyceae and Chlorophyceae were found to be about similar in terms of species composition, although Cyanophyceae and Euglenophyceae contributed fewer phytoplanktons to the Manasbal lake over the research period. The thick mats of algae were observed in several locations, possibly as a result of excessive enrichment from sewage of adjacent residential hamlets and houseboats. During the sample visits at these sites, signs of floating human waste, bad odors presumably caused by hydrogen sulphide, decomposition of organic materials in the form of macrophytes but dominated by algal mats, and anoxic conditions in the water were quite obvious. Because there are several elements influencing phytoplankton growth and multiplication, the species dynamics must be thoroughly analyzed and monitored in order to achieve any meaningful findings.

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