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RESEARCH ARTICLE

Diversity of phytoplankton in relation to different environmental variables in Bhimtal lake of Kumaon Himalaya of Uttarakhand State India

R.K. Negi and Vishal Rajput

Department of Zoology & Environmental Sciences, Gurukula Kangri University, Haridwar UK India.

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Abstract

This investigation was carried out to examine the diversity of phytoplankton in Bhimtal lake of Uttarakhand state, India. Various water parameters were correlated with phytoplankton diversity. Sampling was carried out during May 2007 to April 2009. A total 19 genera of phytoplankton belonging to three groups viz. bacillariophyceae (8 genera), chlorophyceae (8 genera) and cyanophyceae (3 genera) were reported from the all study sites. Bacillariophyceae and chlorophyceae were found to be dominant at all the sites during monsoon and winter months, while cyanophyceae were just reported abundant in winter months. As far as correlation relationship among the different biotic variables is concerned bacillariophyceae was positively correlated with GPP (0.632**, 0.592**, 0.588**) and with chlorophyceae (0.869**, 0.905**, 0.847**) at sites I, II and III respectively. Bacillariophyceae was found negatively correlated with total dissolved solids (-0.589**, -0.604**) at sites I and II, with nitrate (-0.597**, -0.589**) at sites I and III and with zooplankton (-0.594**, -0.520**, -0.633**) at sites I, II and III.

Introduction

Phytoplankton form a highly diverse group of prokaryotic and eukaryotic micro-organisms, and have served as one of the paradigm systems for studies on the maintenance of species diversity ("Paradox of the plankton"; Hutchinson, 1961; Huisman and Weissing, 1999, Stomp *et al.*, 2004). Several factors are known to affect phytoplankton species coexistence at a local scale, such as productivity (Leibold, 1996), nutrient supply ratios (Tilman, 1982; Sommer, 1993) and underwater light climate (Huisman *et al.*, 2004, Stomp *et al*., 2007). Phytoplankton and zooplankton are the initial biological component from which the energy is transferred to higher organisms through food chain ((Boyd, 1982, Rajesh *et al*., 2002) and their abundance and composition in an aquatic ecosystem are regulated by various abiotic or physicochemical factors such as pH, light, temperature, salinity, turbidity and nutrients (Buzzi, 1999, Veereshakumar and Hosmani, 2006). Phytoplankton forms the vital source of energy as primary producers and serves as a direct source of food to the other aquatic plants and animals.

A large number of natural lakes in India are picturesque and most of them are utilized for drinking and irrigation purpose. For example, Nainital, Bhimtal, Dal, Sagar and Bhopal lakes supply drinking water to cities of their respective location. However, increasing anthropogenic activities in the past few decades have greatly affected the hydrological regime of the lakes in the country. Consequently, inflow of eroded materials and other contamination from the lake catchments has accelerated the rate of sedimentation and eutrophication process (Gopal and Zutshi, 1998).

Bhimtal lake is a lake in the town of Bhimtal which lies in District Nainital, Uttarakhand, India. It is the largest lake and the only real lake of district Nainital (Das and Upadhyay, 1979). It is a perennial lake which not only supports a large variety of aquatic life but is a winter stopover for Trans Himalayan birds. In India, many such lakes and reservoirs have been studied for the water quality, but still there are many such aquatic ecosystems that

remain unexplored. The Bhimtal lake is one among them which has not received due attention. Ecological studies in these lakes may contribute greatly to both the scientific and conservation interests. This study provides fundamental information on the phytoplankton species diversity and abundance and the influence of physico-chemical parameters of water on phytoplankton population, species composition and community organization in the Bhimtal lake.

Study area

Bhimtal: Bhimtal Lake is a lake in the town of Bhimtal which lies in District Nainital, Uttarakhand, India. The lake, which is larger than Naini lake, is approximately 22 km from Nainital at Bhimtal lake is situated in Bhimtal town, (**Fig. 1**) at 1331 m altitude, 29°20'N latitude and 79°29'E.

Fig.1. Satellite view of Bhimtal lake

Material and methods

The monthly water samples were collected from three selected sites i.e. I, II and III. Physico-chemical parameters such as dissolved oxygen, pH, total alkalinity, TDS, Free carbon dioxide, total hardness, turbidity, chloride, nitrates, phosohate, GPP,NPP and transparency were analyzed by standard methods (APHA,1998). Phytoplankton samples were done by using plankton net (30µm) on the surface at a minimum speed of a boat. Plankton samples were fixed in 4% formalin and preserved in 100 ml bottle. Qualitative and quantitative evaluation of phytoplankton from each site was carried out with the help of "Sedgwick Rafter" counting cell and identified using standard literature (APHA 1998). The community structure was analyzed using the Shannon-Wiener index of diversity. The Pearson correlation coefficient was used to examine the relationship among the different abiotic variable between phytoplankton. Analysis was performed using SPSS version 10.

Results

In Bhimtal lake, total 19 genera of phytoplankton belonging to three groups viz. bacillariophyceae (8 genera), chlorophyceae (8 genera) and cyanophyceae (3 genera) were reported, out of which chlorophyceae was found dominant with percentage occurrence varying from 52.13% - 54.2% **(Table-1**). Among bacillariophyceae, *Diatoma* and *Nevicula* were found dominant at all the sites, followed by *Amphora, Denticula, Fragillaria, and Pinnularia*. The maximum number of bacillariophyceae was recorded during September, 2008 and minimum during the month of May, 2007. Among chlorophyceae, *Volvox* was found to be dominant followed by *Chlorella, Closterium, Cladophora, Ulohtrix, Vaucheria* and *Spirogyra*. The maximum number of chlorophyceae was observed in the month of September, 2008 and minimum in May, 2007. Among cyanophyceae, *Nostoc* was found dominant followed by *Anabeana* and *Microcystis.* The maximum number of cyanophyceae was recorded in October, 2007 and minimum in May, 2008.

Seasonal Variation As far as seasonal variation in phytoplankton in Bhimtal lake is concerned, members of bacillariophyceae and chlorophyceae were found to be dominant at all the sites during monsoon and winter months while cyanophyceae were just reported while they were found to be abundant in winter months at site-III.

Genus wise diversity of phytoplankton (Table-1, Fig.1) documented the dominance of *Volvox* sp. (percentage occurrence, 21.39-22.60%) belonging to chlorophyceae followed by *Diatoma* sp. (percentage occurrence, 11.72-12.87%) in bacillariophyceae group and *Spirogyra* with percentage occurrence of 7.69-8.41% belonging to chlorophyceae. Maximum percentage occurrence of phytoplankton was observed during the winter season while minimum during the summer season at all the selected sites.

In Bhimtal lake, diversity index of phytoplankton was recorded ('H' 2.3752) at site I, ('H' 2.3292) at site II and ('H' 2.3479) in table 3. The maximum diversity index was reported at site I and minimum at site II.

Correlation coefficient between physico-chemical and phytoplankton were given in table 4. Bacillariophyceae was positively correlated with GPP (0.632**, 0.592**, 0.588**) and with chlorophyceae (0.869**, 0.905**, 0.847**) at sites I, II and III respectively. Bacillariophyceae was found negatively correlated with total dissolved solids (-0.589**, -0.604**) at sites I and II, with nitrate (-0.597**, -0.589**) at sites I and III and with zooplankton (-0.594**, -0.520**, -0.633**) at sites I, II and III.

Chlorophyceae: Chlorophyceae were found to be positively correlated with GPP (0.683**, 0.669**, 0.659**) and with bacillariophyceae (0.869**, 0.905**, 0.847**) at sites I, II and III respectively while negatively correlated with total dissolved solids (-0.559**, -0.528**) at sites I and II, with nitrate (-0.654**, -0.574**, -0.592**) and with zooplankton (-0.525**, -0.531**, -0.632**) at sites I, II and III.

Cyanophyceae: Cyanophyceae were positively correlated with free CO_2 (0.527**) at site I. It was negatively correlated with water temperature (-0.538**) and with pH (-0.629**) at site III.

Discussion

Algal species composition and diversity is known to change seasonally in response to changes in physical, chemical and biological conditions of the lake (Reynolds, 1984), the most important parameters being light and nutrients. Increase in nutrients especially is largely linked to terrestrial run-off (Talling and Talling, 1965). Rainfall may be one of the reasons that caused the increase of nutrients, leading to increase in the numerical abundance of phytoplankton. This is in accordance to our findings where abundance was reported maximum during post-monsoon season and positively correlated with GPP which was also documented by Parker and Hutcher, 1974; Venu and Seshvatharam, 1984; Sukuman, 1980; Schffer, 1998; Hubble and Harper, 2002; Senthlkumar and Sivakumar (2008). The dominant groups of phytoplankton were reported to be negatively correlated with TDS as various types of anthropogenic activities results in increase in TDS values which altered the quality of water as indicated by Senthlkumar and Sivakumar (2008). Physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton. In aquatic habitat, the penetration of light, temperature, salinity, pH, hardness, phosphates and nitrates are the important factors for growth and density of phytoplankton, on which zooplankton and high consumer depend for their existence (Mahar *et al*., 2000). Al-Tayyar *et al*. (2008) studied some environmental features of phytoplankton in Mosul Dam lake and reported that the lake is undergoing cultural eutrophication on the basis of algal abundance with bacillariophyta having maximum number of 1400 cells/ml and chlorophyta with 550 cells/ml. Rouf *et al.* (2008) have studied the temporal changes in the algal communities in drowned tropical forest reservoir and lake in Malaysia and reported the bacillariophyceae as the dominant group. Similar observations were made during the present study with bacillariophyceae as a dominant group in the lake under investigation.

From the present investigation, it can be documented that the phytoplankton population of a reservoir is closely related with seasonal variations in hydrography and geographical variation in phytoplankton diversity is not governed by a single factor but by a relatively complex network of multiple environmental variables.

Table 1. Group wise occuence percent in the phytoplankton in the Bhimtal lake during 2007-2009.

	Total Species	Total Individuals			Occurrence percent		
		Site I	Site II	Site III	Site I	Site II	Site III
Bacillariophyceaes	8	2009	2343	2221	36.4213198	36.5865084	36.5296053
Chlorophyceae	8	2990	3339	3193	54.20594634	52.1392879	52.5164474
Cyanophyceae	3	517	722	666	9.372733865	11.2742036	10.9539474

Table 2. Genus wise diversity of the phytoplankton in the Bhimtal lake during 2007-2009

Species	Species occurrence percent		
	Site I	Site II	Site III
Amphora	3.15	2.93	2.64
Diatoma	12.87	11.92	11.72
Cymbella	1.16	3.02	3.19
Denticula	4.58	4.29	4.09
Pinnularia	4.20	4.05	4.14
Nevicula	6.96	6.43	6.33
Fragillaria	2.82	2.51	2.63
Synedra	0.65	1.38	1.75
Volvox	22.60	21.63	21.39
Chlorella	5.71	5.19	5.32
Closterium	2.04	2.07	1.84
Cladophora	4.16	3.80	3.78
Vaucheria	4.80	4.43	4.62
Microspora	1.03	2.43	3.05
Spirogyra	8.41	7.69	7.71
Ulothrix	5.42	4.83	4.76
Anabaena	4.27	4.82	4.34
Microcystis	1.05	2.21	2.10
Nostoc	4.04	4.23	4.50

Table 3. Site wise species diversity Shannon-Weiner index

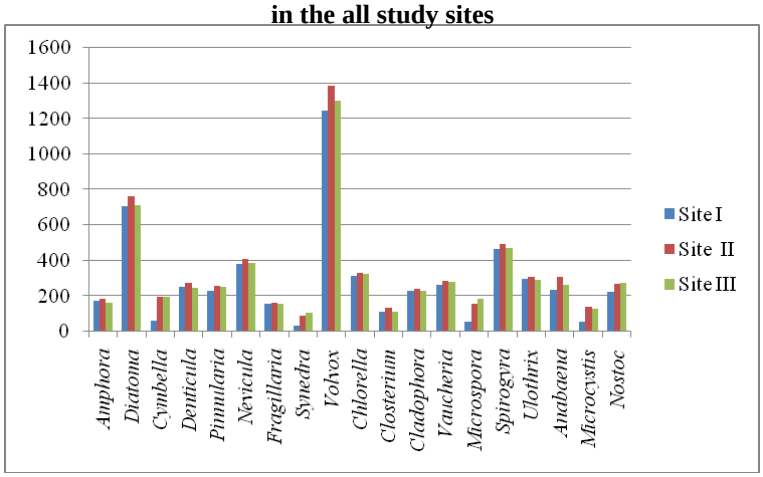
Sampling Site	Total number of individuals of all species	Diversity Index
Site I	5293	2.3752
Site II	6133	2.3292
Site III	5806	2.3471

Table 4. Correlation coefficient (r) of different group of phytoplankton (A) Bacillariophyceaes (B) Chlorophyceae (C) Cyanophyceae with different abiotic parameters

	Site I			Site II			Site III		
Abiotic variables	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Water (°C)	-0.043	-120	-0.383	0.019	0.014	-.460*	0.013	0.092	-.538**
Air (°C)	-0.085	-0.095	-0.37	-0.019	0.003	-.443*	-0.015	0.071	-.499*
Turbidity (JTU)	-0.048	-0.039	0.159	-0.309	-0.322	0.323	0.132	0.219	0.086
pH	0.08	-0.022	-0.229	-0.025	-0.006	-.410*	-0.061	0.058	-.629**
Alkalinity (mg/l)	-0.286	-0.249	0.15	-0.342	-0.321	0.179	-0.288	-0.384	0.371
DO (mg/l)	-0.078	-0.05	0.19	-0.157	-0.185	0.298	-0.114	-0.252	.415*
Free CO_2 (mg/l)	0.338	0.258	.527**	0.191	0.197	0.063	-0.057	-0.088	0.072
TDS (mg/l)	-.589**	-.559**	-0.003	-.604**	-.528**	-0.021	-.497*	-.412*	-0.076
Hardness (mg/l)	-0.246	-0.141	0.276	-0.256	-0.203	0.175	-0.255	-0.376	0.26
Nitrate (mg/l)	-.597**	-.654**	-0.074	-.510*	-.574**	-0.03	-.589**	-.592**	-0.204
Phosphate mg/l)	-0.205	-0.228	-0.182	-.456*	-.466*	-0.385	-.404*	-0.381	-0.323
Chloride (mg/l)	-.443*	-.430*	-0.302	-0.374	-0.381	-.438*	-0.356	-0.345	-0.286
Trans. (m.)	0.33	0.378	0.261	0.301	0.233	0.387	0.174	0.097	0.282
GPP	.632**	.683**	0.198	.592**	.669**	0.142	.588**	.659**	0.252
NPP	0.138	0.142	0.081	0.139	0.135	0.194	0.168	0.035	.425*
Bacillariophyceae	1	.869**	0.159	1.00	.905**	0.119	1.00	.847**	0.205
Chlorophyceae	.869**	1	0.24	.905**	1.00	0.084	.847**	1.00	0.136
Cyanophyceae	0.159	0.24	1	0.119	0.084	1	0.205	0.136	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Fig. 2. Species wise comoposition of in the species in the all study sites



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