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Full Length Research Paper

Phytoplankton diversity at Watlab Ghat in Wular Lake, Kashmir

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The present study on Wular Lake, located at a distance of 34 km from Srinagar city of Kashmir valley, was undertaken from March, 2007 to February, 2008 to study various limnological parameters including plankton. A total of 64 phytoplankton spp. were identified. Bacillariophyceae was found to be the most dominant group at the selected site. The population density of bacillariophyceae varied from a minimum of 32 No./ml in the month of June, 2007 to a maximum of 417 No./ml in the month of January, 2008. The most abundant species in terms of population density were *Amphora spp., Cyclotella spp., Longissima elongatum, Navicula spp.* and *Nitzchia spp.* Chlorophyceae formed the second most dominant group of phytoplankton with *Chlorella spp.*, *Pediastrum spp., Spirogyra spp.* and *Volvox spp.* as the most abundant species. The number of chlorophyceae varied from minimum of 25 No./ml during December, 2007 and February 2008 to a maximum of 222 No./ml in May, 2007. Amongst myxophyceae (cyanophyceae), *Anabaena spp.* with population density of 93 No./ml was found to be the most dominant spp. at the selected site. Euglenophyceae formed the least represented group of phytoplankton which showed the peak population in spring. Chlorophyceae and cyanophyceae showed positive correlation with water temperature (r = 0.400 and 18. r = 0.744), respectively, at the selected site whereas bacillariophyceae and 19 euglenophyceae showed the negative correlation with water temperature, that is, r = -0.818 and r = -0.389), respectively.

Key words: Phytoplankton, Wular Lake, physico-chemical characteristics, eutrophication.

INTRODUCTION

Although, a voluminous literature is available on the plankton population of freshwater habitats of valley (Kant and Kachroo, 1977; Kaul et al., 1978; Zutshi et al., 1980, Kaul and Pandit, 1982; Mir and Kachroo, 1982; Yousuf et al., 1986; Wanganeo and Wanganeo, 1991; Pandit 1996; 1998;, Irfan and Sarwar, 1996; Wanganeo et al., 2004), scantly literature is available on the lake in question. It was, therefore, thought worthwhile to investigate the phytoplankton diversity of the selected site of the lake. The objective of the present work is to study various physico-chemical characteristics in relation to phytoplankton diversity which would help in assessing the trophic status of this lake. The data obtained would also help in antipollution conservation or conservation strategies in in addition to formulating the diversity of the lake.

Study area

The Wular Lake is the largest freshwater lake of India, situated at an altitude of 1580 m above mean Sea level. The lake extends from Bandipore to Sopore and is at a distance of 34 Kms from Srinagar city of Kashmir Valley Figure 1. In ancient times its surface area was 202 km^2, Stein (1961) but due to exceptionally high human interference in and around this mighty lake in the form of agriculture, industrialization and urbanization, the lake has shrunk today and its surface area is reduced to about 24 km^2. The lake is mono basined and is of an elliptical shape. The lake plays a significant role in hydrographic system of Kashmir valley by acting as a huge reservoir and absorbs high annual flood of River Jhelum.

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Figure 1. Map of Wular Lake showing sampling stations (Site III: Watlab Ghat).

The lake is undergoing rapid siltation and the water is contaminated with domestic and industrial wastes, originating mainly from the Srinagar city and entering the lake via river Jhelum thus, posing serious threat to the biological diversity of the lake.

METHODOLOGY

The sampling was carried on monthly basis from March, 2007 to February, 2008 at the selected site between 9 - 10 am. The water samples were collected from surface and stored in plastic bottles. The bottles were thoroughly cleansed and rinsed with distilled water before collection. The different physico-chemical characteristics were analyzed following the works of Theroux et al. (1943); Trivedy and Goel (1984); APHA (1998). For phytoplankton analysis, monthly samples (500 ml) were collected from the site in wide mouth plastic bottle. To the sample, 5 ml of Lugol's iodine solution was added. After keeping it for 24 h, the supernatant was discarded and 20 ml concentrate was obtained. Quantitative analysis of phytoplankton was done by putting one drop of fixed sample (0.02 ml) on the glass slide and studying it under inverted microscope (Metzer). The results were obtained by recording the number of organisms per ml following Welch (1952). For qualitative analysis, the information given in Dippel (1904); Edmondson (1959); Needham and Needham (1962) were used.

RESULTS AND DISCUSSION

The monthly variations in various physico-chemical parameters of the lake at the selected sites are shown in Table 1. Water temperature varied from a minimum of 6°C in the month of January, 2008 to a maximum of 27°C in the month of July, 2007. Depth of site showed great fluctuation from a minimum of 1.35 m in October, 2007 to a maximum of 2.60 m in March, 2007. Transparency varied from a minimum of 20 cm in March, 2007 to a maximum of 120 cm in January, 2008. Transparency remained high during winter season. Conductivity values fluctuated from a minimum of 105 μScm^{-1} in the month of May, 2007 to a maximum of 295 μScm^{-1} in the month of November, 2007. TDS varied from a minimum of 39 (mg/l) in the month of March, 2007 to a maximum of 162 (mg/l) in February, 2008. Dissolved oxygen ranged from a minimum of 4.40 (mg/l) in July, 2007 to a maximum of 12.0 (mg/l) in January, 2008. Carbon dioxide fluctuated from a minimum of 4.0 (mg/l) in the month of January, 2008 to a maximum of 16.0 (mg/l) in July, 2007. The pH remained on alkaline side throughout the period of investigations and varied from a minimum of 7.7 in February, 2008 to a maximum of 8.9 in June, 2007.

Table 1. Monthly variation in various physico-chemical characteristics at Watlab Ghat in Wular Lake, Kashmir from March 2007 to February 2008.

Month	Temperature (^{O}C)		Depth(m)	Transparency (cm)	TDS(mg/l)	Dissolved Oxygen (mg/l)	CO$_2$ (mg/l)	pH	Conductivity (µS/cm)	Alkalinity (mg/l)			Hardness (mg/ll)	Calcium (mg/l)	Magnesium (mg/l)	Chloride (mg/l)
	^{o}Air(C)	^{o}Water(C)								Bicarbonate	Carbonate	hydroxides				
March 2007	21	17	2.60	20	78	8.40	7.0	8.0	127	120.0	–	–	90.0	27.0	8.50	13.50
April	23	20	2.40	27	62	9.00	9.0	8.2	135	132.0	–	–	135.0	25.0	10.0	14.0
May	25	22	2.50	32	39	10.40	10.0	8.2	105	125.0	–	–	146.0	21.0	9.50	16.0
June	27	25	2.02	95	46	6.0	12.0	7.8	145	105.0	–	–	140.0	22.50	11.50	20.50
July	30	27	1.85	97	51	4.40	16.0	7.5	140	86.0	–	–	100.0	24.0	12.0	28.0
August	28	24	1.64	100	42	7.0	14.0	7.8	180	92.0	–	–	154.0	25.50	9.0	46.0
September	25	22	1.50	80	80	6.40	12.0	8.1	205	145.0	–	–	175.0	31.0	12.0	30.0
October	23	20	1.35	65	92	8.0	11.0	7.7	276	115.0	–	–	190.0	35.0	15.0	18.50
November	16	13	1.37	40	84	9.40	9.0	8.2	295	162.0	–	–	150.0	44.0	13.0	14.0
December	11	9	1.50	50	79	10.40	8.0	8.0	150	156.0	–	–	138.0	46.0	16.0	19.0
January 2008	8	6	1.80	120	135	12.0	4.0	8.8	210	190.0	–	–	130.0	39.0	20.0	15.50
February	12	9	1.95	115	162	10.0	6.0	8.6	148	182.0	–	–	115.0	42.0	22.50	12.0

Alkalinity was of bicarbonate type and varied from a minimum of 86.0 (mg/l) in the month of July, 2007 to a maximum of 190.0 (mg/l) in the month of January, 2008. High values of total hardness were recorded throughout the study period. The values of hardness varied from a minimum of 90.0 (mg/l) in the month of March, 2007 to a maximum of 190.0 (mg/l) in October, 2007. Calcium was recorded to be the most dominant cation of the lake at the selected site. The values of calcium fluctuated from a minimum of 21.0 (mg/l) in the month of May, 2007 to a maximum of 46.0 (mg/l) in December, 2007. Magnesium fluctuated from a minimum of 8.50 (mg/l) in the month of March, 2007 to a maximum of 22.50 (mg/l) in the month of February, 2008. Chloride values varied from a minimum of 12.0 (mg/l) in February, 2008 to a maximum of 46.0 (mg/l) in the month of August, 2008. High chloride values during the present study are indicative of organic pollution of animal origin.

Inter relationship profile among various physico-chemical parameters have been computed. Transparency showed positive but non-significant correlation with total dissolved solids (r = 0.397). Very high significant positive correlation have been found between water temperature and dissolved oxygen (r = 0.814), dissolved oxygen and pH (r = 0.814), pH and alkalinity (r= 0.899). In present study, the following groups of planktonic algae were reported in the order of abundance. Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophycea. T (^{O}C) he monthly variations in phytoplankton population density (No./ml) is shown in Table 2. Bacillariophyceae constitute most important group of algae even though most species are sessile and associated with littoral substrate Wetzel (1983). Diatoms preferred food that are used by many grazers and organisms in the upper trophic level and thus, form the basis of productive fisheries, Ryther (1969). In present study, bacillariophyceae constituted the most dominant group of phytoplankton which was represented by 33 species. The monthly percent contribution of bacillariophyceae amongst phytoplankton in terms of population density is shown in Figure 2. The population density of bacillariophyceae at the selected site varied from a minimum of 32 No./ml in the month of June to a maximum of 417 No./ml in January, 2008. The most abundant species of bacillariphyceae in terms of population density were *Fragilaria spp.* (87 No./ml), *Epithemia spp.* (114 No./ml), *Gomphonema spp.* (114 No./ml), *Longissima elongatum* (107 No./ml), *Navicula spp.* (174 No/ml) and *Nitzchia spp.* (82 No./ml) with *Navicula spp.* as the most dominant species.

The dominance of bacillariophyceae amongst phytoplankton substantiates the findings of Zutshi (1991) who recorded maximum number of diatom species from the high altitude lakes of the Himalayan region. On seasonal basis, highest population density of diatoms were observed in winter which could be attributed to their ability to grow under the conditions of weak light and low temperature which are less suitable for other algae. The findings are in full agreement with the findings of Lund (1965); Munawar (1974). The present water body showed factors. Chlorophyceae formed the second most dominant group of phytoplankton which was represented

Table 2. Monthly variations in population density (No./ml) of Phytoplankton at Watlab Ghat in Wular Lake, Kashmir from March 2007 to February 2008.

Months / Genera	Mar 07	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 08	Feb
Bacillariophyceae												
Achananthes lanceolata	5	–	–	–	–	–	–	2	–	6	11	9
Amphora spp.	3	8	–	–	9	–	11	–	12	17	12	15
Amphora ovalis	2	5	6	–	–	–	–	–	–	8	10	7
Asterionella formosa	–	–	–	–	–	–	–	–	–	6	8	11
Ceratoneis arcus	–	10	2	–	–	–	–	–	–	9	10	–
Cyclotella spp.	2	7	4	–	6	–	–	9	6	15	13	19
Cymbella cistula	7	6	6	–	5	–	7	–	5	–	12	16
Closteriopsis longissima	10	8	7	–	–	9	10	8	–	12	17	15
Cocconeis placentula	–	–	–	–	–	–	–	–	–	3	2	–
Diatoma spp.	9	5	9	7	–	8	–	–	–	9	15	8
Diatoma vulgare	–	–	–	–	–	–	–	–	–	3	3	–
Epithemia spp.	12	17	7	–	11	9	–	12	7	15	12	12
Eunotia spp.	–	–	9	–	–	–	–	–	–	–	24	18
Frustulia spp.	–	5	8	–	–	–	–	–	–	8	15	9
Fragilaria spp.	–	–	15	–	–	–	–	–	7	14	21	30
Fragilaria capucina	–	–	3	–	–	–	–	–	–	3	6	5
Gomphonema spp.	9	15	16	11	–	–	–	7	8	12	21	15
Gomphonema gracile	–	–	–	–	–	–	–	–	–	5	4	5
Gomphonema germinatum	5	–	–	–	–	–	–	–	–	–	5	6
Longissima elongatum	–	12	15	14	9	–	5	–	–	19	15	18
Melosira spp.	–	–	9	–	–	–	–	–	–	–	12	15
Meridion circulare	–	9	6	–	–	–	–	–	–	5	9	6
Meridion spp.	7	7	5	–	–	–	–	–	–	12	22	15
Navicula spp.	13	18	14	–	12	16	11	–	–	30	36	24
Navicula americana	10	–	–	–	–	–	–	–	–	9	11	–
Nitzchia spp.	7	9	10	–	–	–	6	11	–	–	24	15
Nitzchia vermicularis	3	–	–	–	–	–	–	–	–	9	5	10
Stauroneis spp.	12	8	12	–	–	–	3	–	–	12	19	16
Surirella spp.	16	9	–	–	–	–	–	–	–	15	9	14
Synedra ascus	–	–	6	–	–	–	–	–	–	7	–	–
Synedra radiana	–	–	3	–	–	–	–	–	–	6	13	11
Synedra ulna	2	4	5	–	–	–	–	–	–	12	9	–
Tabellaria spp.	8	9	11	–	–	–	–	–	–	–	12	17
Total	142	171	188	32	52	42	53	49	45	281	417	361
Chlorophyceae												
Actinastrum Spp.	9	10	–	–	14	–	–	–	–	–	2	–
Ankistrodesmus spp.	12	15	–	–	8	–	–	–	–	–	7	7
Ankistrodesmus falcatus	–	–	6	–	–	5	–	–	3	2	–	–
Chlorella spp.	9	12	18	–	18	15	–	–	–	–	6	–
Coelastrium sphaericum	8	1021	–	7	12	–	8	–	–	–	–	
Chlamydomonas	12	9	–	–	–	–	9	–	–	–	4	–
Cosmarium spp.	7	8	15	–	6	–	12	9	–	–	–	–
Closterium spp.	12	16	–a	–	–	–	–	6	7	–	7	5
Closterium setaceum	8	9	–	7	9	–	–	12	–	3	–	–
Eudorina spp.	9	12	10	–	–	–	8	–	–	–	–	–
Oedogonium spp.	–	14	18	9	–	–	–	–	6	–	–	–

Table 2. Contd.

Pediastrum spp.	12	24	30	16	12	–	8	7	2	–	–	–
Scenedesmus spp.	9	12	22	–	15	7	–	–	–	–	–	–
Selenastrum spp.	16	15	27	–	–	–	6	9	8	4	–	–
Selenastrum gracile	3	–	–	–	–	–	5	–	–	–	–	–
Spirogyra spp.	15	18	–	9	8	–	–	–	3	6	10	5
Tetraspora spp.	–	9	6	–	7	–	5	3	–	–	–	–
Ulothrix zonata	5	7	12	–	–	10	–	–	4	2	–	–
Volvox spp.	9	8	10	–	–	–	11	18	8	6	–	5
Zygnena spp.	18	14	–	–	7	6	–	–	–	–	5	3
Total	173	222	195	41	114	60	64	72	37	25	43	25
Cyanophyceae												
Anabaena spp.	6	–	–	12	24	16	30	–	–	5	–	–
Lyngbya spp.	–	–	–	9	18	20	5	–	–	4	–	–
Microcystis spp.	8	–	–	16	15	–	–	5	–	–	–	2
Merismopedia spp.	–	–	–	10	11	9	–	–	–	–	–	3
Nostoc spp.	–	–	–	–	8	8	–	–	–	3	–	–
Oscillatoria spp.	6	7	12	14	21	12	–	–	9	7	–	–
Phormedium spp.	–	3	8	–	8	9	–	7	6	–	–	4
Rivularia spp.	3	–	–	7	10	8	–	9	2	–	–	–
Total	23	10	20	68	115	82	35	21	17	19	–	9
Euglenophyceae												
Euglena ascus	19	12	11	–	–	–	–	–	–	9	8	12
Phacus spp.	16	21	14	–	–	–	–	–	–	4	14	10
Total	35	33	25	–	–	–	–	–	–	13	22	22
Grand total	373	436	428	141	281	184	152	142	99	338	482	417

by 21 species. In present study, the number of chlorophyceae varied from a minimum of 25 No./ml during December, 2007 and February, 2008 to a maximum of 222 No./ml in April, 2007. The most abundant species in ter- ms of population density were *Pediastrum spp.* (111 No./ml) , *Selenastrum spp.* (85 No./ml), *Chlorella spp.* (78 No./ml) and *Spirogyra spp.* (74 No./ml) with *Pediastrum spp.* as the most abundant species at the selected site.

Chlorophyceae depicted unimodal spring peak. Kant and Kachroo (1977) also reported a single chlorophycean peak in summer in Dal Lake of Kashmir. Spring peak in present investigation can be attributed to the increasing temperature in addition to the increased phosphorus and nitrate concentration. Cyanophyceae have worldwide distribution and majority of species are cosmopolitan. They are good photosynthesizers and replenish the water with oxygen. Certain species of this group in freshwater fix atmospheric nitrogen to supplement with nitrogen requirement viz. *Anabaena* and *Nostoc*, and thus, have potential value as bio-fertilizer Kapoor and Arora, (2000). Cyanophyceae (myxophyceae) formed the third most dominant group of phytoplankton at the selected site. The most abundant species in terms of population density were *Oscillatoria spp.* (88 No./ml), *Anabaena spp.* (93 No./ml) and *Lyngbya spp.* (56 No./ml). The population density of cyanophyceae varied from a minimum of 9 No./ml in the month of February, 2008 to a maximum of 115 No./ml in July, 2007.

The monthly percent contribution of cyanophyceae in terms of population density amongst different groups of phytoplankton is shown in Figure 2. Cyanophyceae in present study depicted unimodal summer peak thereby indicating an influence of temperature on this group. However, increased phosphate concentration during summer due to intensified agricultural activities and addition of waste-water containing phosphates can also be related to dominant summer peak. The presence of *Oscillatoria* and *Merismopedia* at the selected site indicate the eutrophication of the lake. Euglenoids are almost unicellular, lack a distinct cell wall and possess one, two or three flagella Wetzel (1983). They are generally abundant in water rich in organic matter. The monthly the dominance of bacillariophyceae, which is the characteristic feature of eutrophic waters, Naumann (1919). However, the seasonal changes in the pattern of species composition are on account of changing environmental contribution of euglenophyceae in terms of population density amongst different phytoplankton groups is shown in Figure 2.

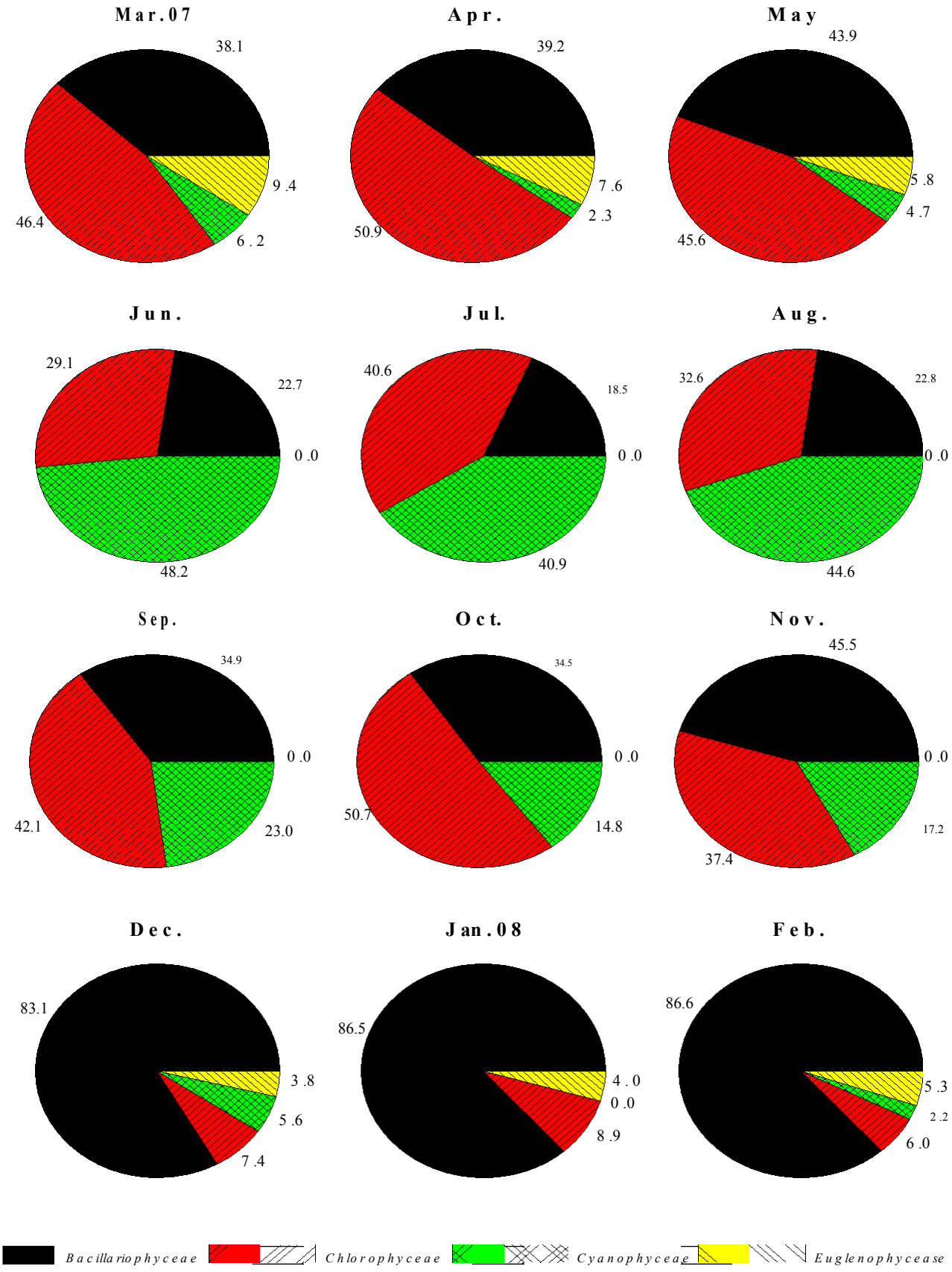

Figure 2. Showing monthly percent contribution of different phytoplankton groups at Watlab Ghat in Wular Lake, Kashmir.

In present study, euglenophyceae formed the least represented group of phytoplankton. The No. of euglenophyceae varied from a minimum of 13 No./ml in December, 2007 to a maximum of 35 No./ml in April, 2007. Euglenophyceae in present study showed the peak development in spring which can be attributed to the increasing temperature in addition to the level of organic matter. Intra relation profile among various chemical and phytoplankton have been computed. Water temperature showed significant negative correlation with bacillariophyceae (r = -0.818), positive correlation with chlorophyceae (r = 0.400), positive significant correlation with cyanophyceae (r = 0.744) and positive significant correlation with euglenophyceae (r = 0.717). With carbon dioxide, phytoplankton showed negative and significant correlation (r = -0.606) whereas, it was found to be negative and non- significant with pH (r = 0.348). Phytoplankton in present study showed negative and highly non-significant correlation with PO_4-P (r = -0.55) and negative and significant correlation with NO_3-N (r = -0.751). In general, phytoplankton in present study depicted bimodal peak spring and winter). The findings are in full agreement with the findings of Raina (1981) who recorded bimodal peak of phytoplankton one in winter and another in summer in Bod-Sar Lake of Kashmir.

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REFERENCES

APHA (1998). Standard Methods for examination of water and wastewater.20th Edition. American Public Health Association, Washington DC (U.S.A.), pp. 1-1193.

Dippel L (1904). Diatomeen Der Rhein – Mainebene Braunschweig. Druk und Verlag Friendrich Vieweg und Sohn, pp. 1-170.

Edmondson WT (1959). Ward and Whipple's Freshwater Biology. 2nd Ed. Johan Wiley and Sons Inc., New York, pp. 1-1248.

Irfan – ul, Majid, Sarwar SG (1996). Diatoms as pollution indicators of Wular Lake, Kashmir. J. Nat. Biosphere 2: 14-22.

Kant S, Kachroo P (1977). Limnological studies on Kashmir lakes I. Hydrological features, composition and periodicity of phytoplankton in Dal and Nagin lakes. Phykos. 16: 77-97.

Kapoor K, Arora L (2000). Influence of some pesticides on cyanobacteria *in vitro* conditions. Indian J. Environ. Ecoplan. 3(2): 219-226 .

Kaul V, Pandit AK (1982). Biotic Factors and Food Chain Structure in Some Typical Wetlands of Kashmir. J. Poll. Res. I(1-2): 49-54.

Kaul V, Fotedar DN, Pandit AK, Trisal CL (1978). A Comparative Study of Plankton Population of some Typical freshwater water bodies of Jammu and Kashmir State. *In*: Environmental Physiology and Ecology of Plants (D.N. Sen, Bansal RP, eds). Singh B, Pal Singh M, Dehra Dun, India, pp. 249-269.

Lund JWG (1965). The Ecology of Freshwater Phytoplankton. J. Biol. Rev. 40: 231-293.

Mir AM, Kachroo P (1982). Limnology of Kashmir Lakes vii. The Ecology of Bacillariophyceae in Two Lakes of Srinagar. Proceedings Of the Indian National. Acad. 48(2): 378-390.

Munawar M (1974). Limnological Studies on freshwater ponds of Hyderabad, India. 4. The Biocene periodicity and species composition of unicellular and colonial plankton in polluted and unpolluted environments. J. Hydrobiol. 45: 1-32 .

Naumann E (1919). Nagra Synpunkter Angaenda Limno Plankton Oskologie, Svensk. Bot. Ticlskr. 13: 129-161 .

Needham JG, Needham PR (1962). A guide to study freshwater biology. Holden – Dey, Inc., Francisco. pp. 1-108.

Pandit AK (1996). Lakes in Kashmir Himalaya, *In*: Ecology, Environment and Energy. Khan AH, Ashok K, Pandit. (eds). The University of Kashmir, Srinagar – 190006, J&K, India.

Pandit AK (1998). Plankton Dynamics in Freshwater wetlands of Kashmir. *In*: Ecology of polluted waters and toxicology. Mishra KD (ed), Technoscience publication, Jaipur, India.

Raina R (1981). Plankon Dynamics and Hydrobiology of Bod-Sar lake of Kashmir. Ph.D. thesis, Kashmir University.

Ryther JH (1969). photosynthesis and fish production in seas: the production of organic matter and its conversion to higher form of life. J. Sci. 166: 72-76.

Stein MA (1961). A Chronicle of the Kings of Kashmir, Kalhana's Rajtarangi. Vol. II. M/SA Constable and Co., Ltd., London.

Theroux FR, Eldrige EF, Mallmann WL (1943). Laboratory manual for Chemical and Bacterial Analysis of Water and Sewage. McGraw hill Book Co. Inc., New York pp. 1-267.

Trivedy RK, Goel PK (1984). Chemical and Biological methods for water pollution studies. Environmental publications, Karad, India, pp. 1-215.

Wanganeo A, Wanganeo R (1991). Algal Population in valley lakes of Kashmir Himalaya. J. Archiv, Hydrobiol. 121: 219-233.

Wanganeo A, Gagroo S, Yousuf AR, Wanganeo R (2004). Latitudinal variation in phytoplankton assemblage. *In*: Biodiversity Scenario, (Khanna DR, Chopra AR, Prasad G) Discovery Publishing House, New Delhi.

Wetzel RG (1975). Primary production. *In*: River Ecology. (Ed. B.A. Whitton). Blackwell Scientific Publication, Oxford. pp. 230-247.

Wetzel RG (1983). Limnology. 2nd Ed. Sounders college publishing co., New York, pp. 1-767.

Yousuf AR, Balki MH, Qadri MY (1986). Limnological Features of a forest lake of Kashmir. J. Zool. Soc. India. 38(1/2): 29-42.

Zutshi DP (1991). Limnology of high altitude Lakes of Himalayan region. Verh. Internat. Verein. 24: 1077-1080 .

Zutshi DP, Subla BA, Khan MA, Wanganeo A (1980). Comparative Limnology of nine lakes of Jammu and Kashmir Himalayas.Hydrobiol. 72: 101-112.