Diatom Flora of Lake Manasbal during Summer

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The Manasbal lake (34°15'N and 74° 40' E), situated about 32 km north-east of Srinagar at an altitude of 1584m (a.s.l.), is the deepest of all valley lakes, having the maximum depth of 12.5m. The lake derives water chiefly from springs spread over its basin. Excess water from the lake flows out through a short natural stream, the Nunniyor Nalla, into the river Jhelum. The lake has, over the years, been greatly influenced by the human activities in its immediate catchment and signs of eutrophication of this beautiful water body have been documented (Pandit and Yousuf, 2002, 03).

A number of ecological studies on the plankton associations of the Manasbal lake during the past forty years or so (Zutshi and Vass, 1977; Yousuf, 1979; Wanganeo, 1980; Wanganeo and Zutshi, 1984; Zutshi & Wanganeo, 1984) are available. In the present communication an attempt is made to identify and enumerate the summer diatom flora of the water body under the present limnological set up so as to point out changes that have taken place in its composition and population density over the time. The lake was sampled during summer (June – August 2005) at five sampling sites – S1 in the inlet area, S2 within dense growth of C*eratophyllum demersum*, S3 and S4 in deeper macrophyte-free limnetic zone and S5 in the outlet area. Water samples were collected and analysed for different parameters as per the standard methods given in CSIR (1974), APHA (1998) and Wetzel and Likens (2000). Plankton samples were collected and studied with the help of standard taxonomic works (Edmondson, 1959; Heureck, 1896; Cox, 1996; Plaskitt, 1997; APHA, 1998).

Mean values of the various physical and chemical parameters of the lake are summarized in Table 1. The temperature of surface water varied between 23^0C and 26^0C with no significant differences among sites. The transparency was higher in the limnetic zone as the littoral areas were covered by thick macrophytic growth. Specific conductivity fluctuated in the range of 314 – 400µS. The water was fairly alkaline and the pH (8.09 – 9.45) seemed to be directly related with the photosynthetic activity (Goldman and Horne 1984; Wani *et al.*, 1990). Bicarbonate was the dominant anion and ranged from 86 mgl^{-1} to139 mgl^{-1}, while carbonate was low, 4.6 mgl^{-1} – 20 mgl^{-1}, in the lake. The lake has been all through a 'hard water' type (Vass, 1973 and Yousuf, 1979) with the total hardness values ranging from 145 mgl^{-1} to 186 mgl^{-1}. Calcium (26 mgl^{-1} to 38 mgl^{-1}) was the most dominant cation in the lake. Vass (1973) and Yousuf (1979) also reported calcium to be the main cation contributing to the total hardness.

Dissolved oxygen values were high at S1 (11.4 mgl^{-1}) and S2 (11.1mgl^{-1}) sites, which are characterized by thick growth of macrophytes. The limnetic zone (S3 and S4) recorded relatively less concentration of dissolved oxygen, whereas the least values (5mgl^{-1}) were observed at S5, which is very shallow but with scant macrophyte population. Organic decomposition was high at S5, which is substantiated by the fact that free carbon dioxide was recorded only at this site. The CO_2 released during the decomposition resulted in lowering of the pH. Chloride content in the lake ranged from 17.6 mgl^{-1} to 23.2 mgl^{-1}. Silicates ranged from 2.1 mgl^{-1} to 5.3 mgl^{-1}. Nitrate, the most common form of combined nitrogen in lakes and streams (Cole, 1975) ranged from 171μgl^{-1} to 249μgl^{-1}. The concentration of orthophosphate phosphorus in the lake (39μgl^{-1} to 53μgl^{-1}) was low as compared to total phosphorus, which ranged from 137μgl^{-1} to 201 μgl^{-1} in the lake. There seems to have been appreciable increase in the phosphorus content in the lake during the past few decades (Yousuf, 1979; Pandit and Yousuf, 2003).

Bacillariophyceae outnumbered the other groups of phytoplankton in the lake. A total of 34 diatom taxa belonging to 16 genera were recorded from the lake. The most commonly found genera included *Navicula* (7 species), *Cymbella* (5 species), *Amphora* (4 species), *Nitzschia* (3 species). A comparison of the present data with the earlier reports indicated that no significant changes have occurred in the species composition over the last thirty years or so (Wanganeo, 1980; Zutshi and Wanganeo, 1984). Most of the diatoms recorded are known to prefer nutrient rich environments (Patrick and Reimer, 1975; Abuzer, 2006).

Diatoms are usually abundant in alkaline waters having pH >8 (Kamat, 1965) and as per Round (1981) *Nitzschia* can be dominant in the plankton when water is rich in organic nutrients. Association of *Nitzschia accicularis* and *Navicula* sp. has been shown to indicate extreme alkaline condition of water (Kamat, 1981). *N. accicularis* was the most dominant diatom throughout the lake. *Navicula*, another dominant genus, included 7 species; two of them, *N. radiosa* and *Navicula* sp., were common throughout the lake, whereas *N. atomus, N. denticulata, N. fusiformis* and *N. johnsonii* were present only in the limnetic areas. Cox (1996) states that *N. radiosa* is common and widely distributed species. Potapova and Charles (2003) stated *Cymbella* as 'calcium loving' organism found in water with high conductivity. In the present study *Cymbella* included 5 species with only *Cymbella* sp. occurring at all sites. All others were restricted to the littoral zone only. *Amphora* was represented by three taxa in the study. *Amphora ovalis* was the most dominant form.

Table 1: Mean Physico-chemical features of Manasbal Lake during summer 2005

PARAMETERS	S 1	S 2	S 3	S 4	S 5
Water temperature ^{0}C	25.6 ±6.1	26 ±5.8	23 ±4.4	23.6 ±4.0	25 ±4.0
Transparency (m)	1 ±0.4	1 ±.16	3.8 ±.84	4.2 ±1.1	0.5 ±0.04
pH	9.18 ±0.21	9.45 ±0.45	8.53 ±0.34	8.51 ±0.24	8.09 ±0.91
Conductivity(μScm^{-1})	317 ±14.3	314 ±10.8	345 ±23.1	350 ±19	400 ±78.4
Dissolved oxygen (mgl^{-1})	11.4 ±1	11.1 ±1.2	7.46 ±1.5	7.46 ±1.6	5.0 ±1.8
Carbon dioxide (mgl^{-1})	A	A	A	A	6.6 ±4.9
Carbonates (mgl^{-1})	18 ±8.6	20 ±4.3	16 ±5.6	12 ±5.2	4.6 ±6.5
Bicarbonates (mgl^{-1})	96 ±69	86 ±61	128 ±71	139 ±64	93 ±23
Chloride (mgl^{-1})	17.6 ±6.5	23.2 ±5.4	20.9 ±2.1	20.2 ±3.2	19.5 ±1.24
Calcium (mgl^{-1})	29 ±6	26 ±2	30 ±2	31 ±3	38 ±12
Calcium Hardness(mgl^{-1})	73 ±15	66 ±7	75 ±5	78 ±9	96 ±31
Magnesium (mgl^{-1})	17 ±3	19 ±2	24 ±.9	19 ±2	22 ±6
Total Hardness (mgl^{-1})	147 ±30	145 ±15	193 ±6	157 ±14	186 ±54
Silicates (mgl^{-1})	2.1 ±.2	2.4 ±1	2.6 ±1.4	5.3 ±3.5	3.5 ±1.5
Nitrate(μgl^{-1})	171 ±61	209 ±93	212 ±83	249 ±82	187 ±52
Ammonical Nitrogen(μgl^{-1})	151 ±59.5	130 ±41.3	76 ±38.8	101 ±42.7	108 ±32.1
Orthophosphorus (μgl^{-1})	39 ±10.4	53 ±20.4	46 ±0	44 ±21	50 ±10
TP (μgl^{-1})	144 ±10	201 ±40	137 ±14	158 ±53	187 ±30

Eunotia sp. was present at all the sites with maximum number in shallow region with scanty macrophyte population. *Fragilaria crotonensis*, which has been considered to be a eutrophic species (Hutchinson,1967; Vollenweider, 1970), also occurred in good numbers in the lake. *Synedra*, typical of eutrophic waters (Lowe,1972) was also distributed throughout the lake.

The total population density of diatoms during summer season fluctuated from 1,76,000 ind/m^3 at S3 to 4,57,000 ind/m^3 at S2. The sequence of dominance with regard to the population density at various sites was S2 >S1 > S5 > S4 > S3 (Table 2). It was found that macrophyte-infested sites (S1 and S2) supported a higher population density of diatoms than the other sites (Fig. 2). It is attributable to the fact that most of the diatom taxa found in the lake are basically epiphytic on the higher plants and they contribute to

the plankton only when they get detached from the macrophytes (Zutshi and Wanganeo, 1984; Sarwar and Zutshi, 1987; Ticku and Zutshi, 1994*)*. Both *Myriophyllium* and *Ceratophylum,* which are dominant macrophytes in the lake, have been reported to support rich and varied epiphytic flora both in terms of number of taxa and population density (Sarwar and Zutshi, 1987). On the whole when the present data on the ecological features of Bacillariophyceae in the lake are compared with the earlier reports (Wanganeo, 1980; Pandit and Yousuf, 2003), it becomes apparent that although the lake is undergoing eutrophication process, the process is fortunately very slow as compared to the other nearby water bodies of the valley and if appropriate measures are taken at the right earnest further trophic progression in the lake can be controlled to a great extent.

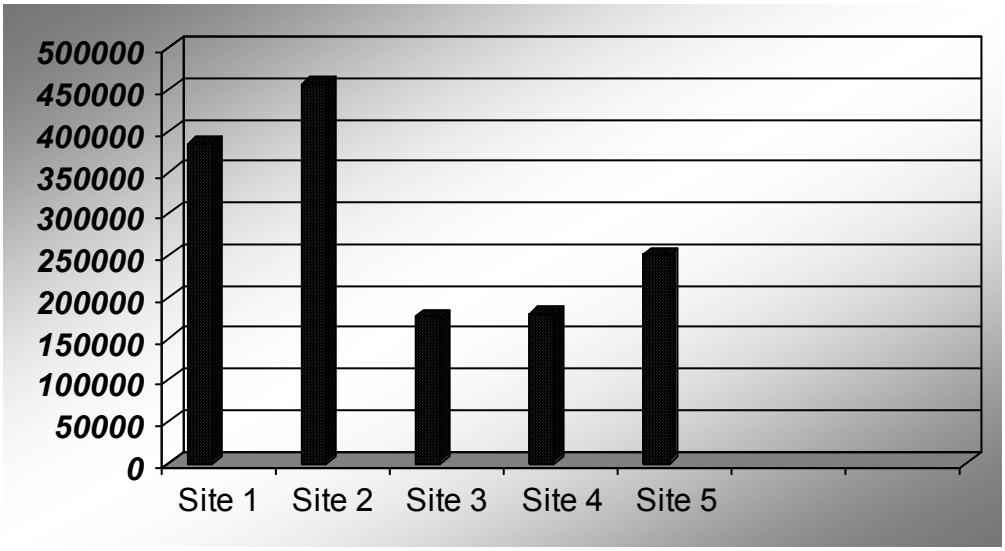

Fig. 2. Total population density (ind/m^3) of diatoms at different sites

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