Summer Limnology of a high mountain Lake ‘Kailash Lake’ Bhaderwah, Jammu and Kashmir
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ABSTRACT

The knowledge of high altitude lakes and their regional limnology is yet uneven and insufficient, as well as their ecological status and sensitivity to human activity impacts. This work describes the major limnological characteristics and functioning of high mountain lakes in mountain bound area in Bhaderwah Jammu and Kashmir and their relationships with regional environmental variables. The composition of plankton communities and various physicochemical parameters were analyzed and discussed in this paper.

Keywords: Kailash Lake, limnobiology, Plankton.

1. Introduction

High altitude lakes of Himalaya located above timber line represent a relatively common ecosystem in mountain ranges in general; however, they remain less intensely studied than lowland lakes, mainly because of their remoteness and the short summer open-water period (Bhat, et al. 2011). Nevertheless, high altitude lakes are sensitive reference systems of global climatic change and other human impacts (Schmidt and Psenner, 1992). In fact, although remote high altitude lakes are in general protected from direct human impacts, in the last few decades they have been increasingly affected by airborne contaminants, such as acids and nutrients (Marchetto et al., 1995; Rogora et al., 2006), organic pollutants and heavy metals (Carrera et al., 2002). Due to the extreme environmental conditions (low temperature, strong radiations, mostly low buffering capacity and low nutrient level) these ecosystems have a relatively simple food web and react more rapidly and more sensitively to environmental changes than other lakes (Psenner, 2002). Even minor impacts are able to significantly affect the physical and chemical properties of soft water high altitude lakes, to induce changes in species composition and abundance of the biota and to cause accumulation of trace substances in higher trophic organisms (Hofer et al., 2001). In spite of the socio-economic and ecological importance of high mountain lakes, better knowledge of several ecological aspects (especially regarding species distribution patterns and biogeography, diversity and functional interaction among the different components of the food web) is needed for better understanding of their relationships with the environmental variables. These lakes have received little attention so far in terms of their limnology, diversity, conservation and water management, but they are becoming increasingly important due to the possible consequences of the global climate change.

The Valley of Bhaderwah holds a beautiful township of the same name cradled in the midst of magnificent Himalayas. Affording beautiful landscaped vistas, with mesmerizing natural beauty, Bhaderwah, a veritable paradise, is also aptly known as “Chota Kashmir”. Towards the south-western side and at an elevation of 4923m above sea level and geographical co-
ordinates of 32° 52’ 34” N and 75° 40’ 56” E is situated most important Hindu pilgrimage lake of north India commonly known as Kailash Kund which is the ice-cold, crystal clear watered and glacial fed high altitude Himalayan lentic system. Kailash Lake, which has more religious significance according to Hindu belief, is considered as an abode of mythological serpent God, Vasukining. This enchanted creator lake which remains frozen for maximum part of the year has its legend that the lake was also visited by Lord Shiva who described it to Mata Parvati as the most important pilgrimage of the north India in the ‘Vasuki Puran’. The yatries while taking the Holy dip also worship the lake (Lord Shiva and Sh. Vasukinag). Lake is believed to be as holy as the sacred Mansarover Lake in China. A dip in the ice-cold water of Kailash Kund is believed to wash away the sins of the yatries and make their wishes come true. Many papers dealing with various limnological aspects of high altitude lakes have demonstrated increased interest in such water bodies in the Himalayan state of Jammu and Kashmir (Kaul and Vass, 1970; Kant and Kachroo, 1971; Zutshi and Vass, 1982; Wanganeo, 1984). But our study on high altitude Lake of Jammu has been brief. Earlier Hutchinson (1973) has reported about some limnological observations of high mountain lakes of Indo-Tibet boarder, now in China.

Complete round the year investigation of these mountain lakes was not possible as the lakes are often inaccessible for the majority of the year. Moreover, the season when lakes are free from ice is very short and ice cover may last for six to nine months. Investigations of mountain lakes of other regions have also been much more thorough and some of the workers contributed in this field were Baldi et. al. (1953), Findenegg (1953), Pennak (1955). Other notable contributions on high mountain lakes are of Loffler (1969), James and Hubbick (1969), Hickel (1973). Present work attempts to give an insight on some of the limnological features of glacial fed water body. Various physico-chemical characteristics viz. a viz. plankton population of the water bodies is analyzed and described.

2. Materials and materials

The surface water samples were collected in one litre polyethylene bottles after at all sites during the period of investigation. Temperature, pH and conductivity were recorded on the spot using Hg thermometer, digital pH meter and portable conductivity meter respectively. Water samples were collected in 250 ml glass bottles for estimation of dissolved oxygen following the titration methods (APHA, 1998). Collected water samples were brought to the laboratory for immediate estimation of total hardness, total alkalinity, chloride, calcium, magnesium, phosphate, nitrate and nitrate following methods in APHA, 1998. For the quantitative and qualitative estimation of phytoplankton and zooplankton 20 L of the lake water was sieved through a plankton net made of nylon bolt (mesh size 64 μm) and the filtered samples were then preserved in 4% formalin solution. Enumeration of the samples was done by taking 1 ml of the sub-sample in Sedgwick rafter chamber in triplicate and counting its entire contents under microscope to obtain the statistical accuracy after their identification with the help of standard taxonomical works (Edmondson, 1959; Heurek, 1896; Randhawa, 1959; Pal et al., 1962; Penak, 1978; Michael and Sharma, 1988). The results have been expressed as units per liter for phytoplankton, individuals per liter for zooplankton (Wanganeo and Wanganeo, 1991). Species diversity index was calculated by using the Shannon diversity index (1963):

$$H' = - \sum p_i \log_2 p_i$$

Where $H'$ = Shannon diversity index; $p_i =$ the importance of probability of each species ($n_i/N$), $N =$ total no. of individuals in “S” species and $n_i =$ number of individuals in ith species.
3. Results and discussion

No seasonal behavior has been possible to assess. The only summer spectrum of the lake has been investigated here. The physico-chemical features of the lake are given in Table 1. In the Lake, air temperature and water temperature were found close to one another with average values of 10.67 °C and 9.67 °C due to the standing feature of the water. Such phenomenon has been recorded under temperate climatic conditions, (Qadri and Yousef 1980, Wanganeo 1980) and also under tropical condition (Bhatia et. al.1970). Dissolved oxygen in the lake was present with average value of 4.93 mg/l. Low dissolved oxygen values may be attributed to the non mixing and low biological population in the lake. Average pH value of 7.3 was observed during the study period. pH may be associated with increase photosynthesis as has been emphasized by Sreenivasan (1967 a,b), Unni (1972), Otsuki and Wetzel (1974). Goldman and Horne (1983) also discussed the fact that changes in pH in lentic water body are generally governed by CO$_2$, CO$_3^-$, HCO$_3^-$, complex operation. Total alkalinity, which is taken as temporary hardness of CaCO$_3$ mg/L in the lake on the average was 16 mg/l. According to Hutchinson (1967) carbonates appear in water only when pH exceeds 8.34 and with increase in the concentration of carbonates, pH value also shows an increasing trend. This seems to be true for the present lake. Carbon dioxide concentration was recorded in the range of 10 to 12mg/l with average of 10.67 mg/l. Electrical Conductivity varied in the range of 20µS to 70 µS during summer 2008-09 with average of 46.67 µS. The higher conductivity values of the lake (70 µS) may be due to tourist and angling pressure and the results were supported by findings of Vass et al., (1989). Zutshi et al. (1980) reported that the conductivity of a water body decreases with the increase in altitude and the present lake represents such phenomenon. It has also been observed that the geological character of rocks and subsoils not only in the catchment area but that of the lake basin (Hutchinson, 1937, 1967) as well influences the conductivity of the lake water. Total hardness and TDS in the lake were found with an average value of 12.67 and 23.33 mg/l.

Total hardness in the lake may not only be due to the calcium and magnesium but other salts may have contributed substantially to it. Calcium content in the lake was less in concentration as compared to magnesium and the mean value of calcium in the lake was 5.01 mg/l and that of magnesium as 6.16 mg/l respectively. Low values of calcium can be attributed to the precipitation process. Magnesium salts, on the other hand, being more soluble in water, get concentrated in the water column due to the evaporation of water from the lake surface (Hutchinson, 1933; Mianping, 1997). Chloride values in the lake recorded with average of 13.99 mg/l. Nitrate, nitrite ammonia, phosphate and sulphate concentration in the lake were recorded with an average concentration of 6.57, 0.34, 0.39, 0.09 and 2 mg/l respectively. Vass (1980) and Zutshi et al. (1980) reported the distribution of the main plant nutrients like nitrate, ammonia and phosphate to be governed by physical factors such as input source to the lake (catchment characteristics), changes in mixing depth during stratification and complete mixing during isothermal conditions and by biological processes such as algal photosynthesis. The nitrogenous compounds in the water bodies are derived to an appreciable degree from the atmosphere, whereas ammonia is the chief product of decomposition of plant and animal proteins (Sharma, 2000). As the decomposition of plant and animal proteins is negligible in the lake, catchment characteristics (geological features) and atmosphere and closed nature of the lake seem to be responsible for their higher concentration. Total iron concentration in the lake was found in the average value of 0.16 mg/l. Biological measurements provide direct information on the condition of groups of biota resident in the water resources and also on the conditions of the resource. They address management issues, more directly and can provide a...
more sensitive time-integrated assessment of a water body than physical or chemical variables directly (Bhat et al. 2011). The phytoplankton population in these lakes was mainly represented by Bacillariophyceae, Chlorophyceae and Cyanophyceae. Total of 14 species were recorded from the lake, of which bacillariophyceae contributed maximum number of 7 species (50%) to the total phytoplankton, chlorophyceae contributed 5 species (35.71%) and 1 specie (7.14%) each was contributed by cyanophyceae and dyanophyceae towards the total phytoplankton, Figure 1 (a). As far as the dominance of various species at different sites is concerned Fragillaria sp., Cyclotella sp., Navicula sp., Ankistrodesmus sp., and Pediastrum sp. were most dominating species during the study period. Average population density of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Dyanophyceae was recorded contributing 55%, 30%, 10% and 5% respectively, Figure 2 (a). Among zooplankton Total of 5 species of were recorded during the investigation in which 3 species belonging to copepoda contributing maximum 60% to the total zooplankton, 1specie belonging to cladocera and rotifera each contributing 20% each to the total zooplankton. Figure 1 (b). Average population density of copepod, Cladocera and Rotifera with respect to the total zooplankton was recorded as 45%, 33% and 22% respectively, Figure 2 (b). The abundance of bacillariophyceae in cold regions is due to the fact that they are able to grow in conditions of wea- k light and low temperature which are less suitable for other algae Loffler (1969), in Mt. Everest Lakes, James and Hubbick (1969) in Hindu Kush lakes recorded low phytoplankton densities.

Table 1: Physico-chemical characteristics of Kailash Lake during summer 2008 & 09

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Range</th>
<th>Average ± SD</th>
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<th>Range</th>
<th>Average ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temp. (°C)</td>
<td>9-13</td>
<td>10.67 ± 2.08</td>
<td>Calcium (mg/l)</td>
<td>4.2-5.8</td>
<td>5.01 ± 0.80</td>
</tr>
<tr>
<td>Water Temp. (°C)</td>
<td>9-11</td>
<td>9.67 ± 1.15</td>
<td>Magnesium (mg/l)</td>
<td>1.4-12.12</td>
<td>6.16 ± 5.46</td>
</tr>
<tr>
<td>D O₂ (mg/l)</td>
<td>3.6-7.2</td>
<td>4.93 ± 1.97</td>
<td>Chloride (mg/l)</td>
<td>9.99-16.99</td>
<td>13.99 ± 3.61</td>
</tr>
<tr>
<td>pH</td>
<td>7.2-7.4</td>
<td>7.33 ± 0.12</td>
<td>Nitrate (mg/l)</td>
<td>5.1-8.8</td>
<td>6.57 ± 1.97</td>
</tr>
<tr>
<td>Total alkalinity (mg/l)</td>
<td>4-24</td>
<td>16.00 ± 10.58</td>
<td>Nitrite (mg/l)</td>
<td>0.005-0.016</td>
<td>0.34 ± 0.58</td>
</tr>
<tr>
<td>CO₂ (mg/l)</td>
<td>10-12</td>
<td>10.67 ± 1.15</td>
<td>Ammonia (mg/l)</td>
<td>0.26-0.5</td>
<td>0.39 ± 0.12</td>
</tr>
<tr>
<td>Conductivity (μS)</td>
<td>20-70</td>
<td>46.67 ± 25.17</td>
<td>Phosphate (mg/l)</td>
<td>0.02-0.15</td>
<td>0.09 ± 0.07</td>
</tr>
<tr>
<td>Total hardness (mg/l)</td>
<td>10-18</td>
<td>12.67 ± 4.62</td>
<td>Sulphate (mg/l)</td>
<td>1-3</td>
<td>2.00 ± 1.00</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>10-40</td>
<td>23.33 ± 15.28</td>
<td>Total iron (mg/l)</td>
<td>0.04-0.38</td>
<td>0.16 ± 0.19</td>
</tr>
</tbody>
</table>

The dominant group in Kashmir Himalayan lakes was bacillariophyceae followed by significant population of chlorophyceae in some lakes (Wanganeo and Wanganeo, 1991). The chlorophyceae dominance followed by bacillariophyceae in the lake is an indication of the oligotrophic nature of the waterbody. Rawson (1956) related dominance of the chlorophyceae with the clarity of lake water. The zooplankton population also showed significant variation in density Arctodiaptomus, Limnocalanus and Daphnia sp. are typical in lake. It is significant that red pigmented Arctodiaptomus does not exist in water bodies situated at less than 3,000m in altitudes, Vass et al., (1989). In Kashmir Himalayas the Arctodiaptomus sp. was recorded
in lakes situated >3000 meter altitude. Daphnia sp. has been reported in the Kailash Kund Lake, Hutchinson (1937) reported same species in Panggong Tso Lake.

Fig 1: Percentage contribution of Phytoplankton and Zooplankton species

Fig 2: Average Phytoplankton and Zooplankton density contribution

Overall the biodiversity in this lake was found low as compared to other high mountain lakes of Jammu and Kashmir. The low biodiversity in the lake may be considered due to harsh...
environmental conditions prevailing in the lake as the lake remains frozen for about more than three months. The biotic life during the frozen period is expected to have decreased further as it is only during the warmer period the phytoplankton are being reported to be dominant in such water bodies. Khan (2003) and Bhat (2009) reported that physico–chemical parameters like light, temperature and nutrient concentration, lake currents, and grazing by zooplankton control the phytoplankton growth and reproduction.

4. Conclusion

The ecological characteristics of the high mountain lakes make them extraordinary sensors for natural or human induced environmental change. The chemical composition of their waters, their thermal and hydrological dynamics, as well as their biological communities respond with high sensitivity to changes in climate variables such as temperature or precipitation. However, their self-recovery capacity once the pressure or the origin of the impact is eliminated is also extraordinary, due, mainly, to their high water turnover rates. One of the main contributions of this work is the utilization of information as support for management and restoration of the lake ecosystems and their watersheds. This work contributes indirectly by stressing the importance of communication and of cooperation between scientists and managers, in order to achieve a greater efficiency in environmental conservation and to technically back up management measures.

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References


organochlorine compounds to remote high mountain lakes of Europe. Environ. Sci. Technol., 36, pp 2581-2588.


