International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 5, Issue 2
April, 2018
Pages: 128-135

Comparative Physico-Chemical Limnology of Two Lakes of Kashmir Himalaya

H. Tanveer[*1]; R. Arnold[2]; R.M. Mishra[1]

[1] School of Environmental Biology, Awadesh Pratap Singh University, Rewa, M.P, India

[2] Govt. Girls P.G College, Awadesh Pratap Singh University, Rewa, M.P, India
Email: tanveer_evs@yahoo.co.in

http://dx.doi.org/10.18415/ijmmu.v5i2.111

Abstract

In the present paper an effort has been made to evaluate the trophic status of two lakes viz; Dal Lake and Manasbal Lake on the basis of physico-chemical parameters criterion. Four ecologically different habitats in each lake were selected for the present study i.e DL1-DL4 & MS1-MS4 in Dal and Manasbal Lake respectively. The rate of pollution in both the lakes varied from basin to basin as well as lake to lake. It has been observed that both lakes are subjected to anthropogenic stress in the form of nutrient enrichment which changes the overall trophic status of both the lakes. However, the stress is more pronounced in Dal Lake as compared to Manasbal Lake which shows higher pollution levels as depicted by physico-chemical parameters. While the rural lake (Manasbal) is marching towards high trophic nature as a result of heavy influx of nutrients from the catchment area, the urban valley lake (Dal) operating under tremendous anthropogenic pressures receives heavy load of pollutants leading to its rapid trophic evolution in the form of eutrophication.

Keywords: Trophic status; Anthropogenic; Catchment; Eutrophication

Introduction

In the Western Himalaya, the picturesque high altitude Valley of Kashmir being famous for its lakes, crystal clear tarns, mountains, snow and spring fed meadows and alpine forests. However, the most fascinating character that nature has gifted it, is its water resources. Kashmir valley is bestowed with innumerable freshwater bodies (lakes, wetlands, ponds, rivers, springs and streams) which are not only important for the ecological, socio-economic and cultural heritage of the state but also serve as primary source for the upliftment of local economy. Besides, 80% population of valley is entirely dependent on these water bodies for dinking, irrigation and domestic purposes while most of the water bodies have been maintained and decorated for tourist purposes and are the best health resorts of Kashmir valley.

The freshwater natural lakes of Kashmir Himalayas are mainly of three different types with respect to their origin, altitude and nature of biota they contain:

(i) The glacial upper mountain oligotrophic lakes (Alipather, Gangabal, Kounsernag, Kishanser, Vishnesar, Tarsar, Marsar, Sheshnag etc) situated on between an altitude of 3000-4000 m AMSL.

(ii) The lakes of tectonic origin being mesotrophic (pine forest lake-Nilnag) present in the lower fringes of Pir panjal range at an altitude of 2000-2800 m AMSL and

(iii) The eutrophic valley lakes, of fluviatile origin (Dal, Anchar, Manasbal, Wular, Trigam, Tilwan etc) are situated in the low lying areas at an altitude of 1560-1600 m AMSL. Mostly valley lakes occur all along the flood plains of the river Jhelum, the only recipient of the whole drainage of the valley through the alluvium of its deposition and covers a distance of 179 kms from Verinag spring to Baramulla.

For a long time, it was believed that the large volume of water contained in lakes would act as safeguard against serious damage to the ecosystem. But during recent times the rapidly increasing population has resulted in the establishment of new human settlements around the lakes which has resulted in the deterioration of water quality as well as aquatic life. The increasing intent in the circulation of nutrients in a water body is understandable in view of sewage and effluents which find their way into the water bodies and encircle them into wide range of substances such as nitrogen and phosphorus compounds.

Pollution and dwindling of the Kashmir Himalayan lakes is a very recent event, of the past 20-45 years, coinciding with a marked civilizational evolution in the lake drainage basins. As a result of heavy anthropogenic pressures, the lake ecosystems are not only shrinking in its surface area but are getting eutrophicated, posing health hazards to the people especially in the famous Dal Lake Kashmir. In spite of multifarious uses, unfortunately the water bodies are being used as receptacles for the sewage and industrial wastes. Due to unwise use, neglect and mismanagement, water, the elixir of life is becoming more and more unfit and dearer to the mankind. Proper management and enforcement of environmental laws only may save for us from this awful situation, provided basic information and data on the aquatic ecosystem, from the holistic point of view is generated in order to evolve effective and appropriate strategies for the management of natural and man-made water resources. This information may help us to fight with the natural calamities such as the floods and droughts and cultural calamities such as eutrophication and pollution.

The management strategies evolved by the developed countries cannot be adopted as such because our metrological, geologic, socio-economic and environmental conditions are quite different, so it requires systematic and appropriate scientific understanding of the water body and water quality. In this context an attempt has been made to determine the current trophic status of two different lake ecosystems of Kashmir valley viz, Dal lake and Manasbal lake enjoying different ecological conditions.

Study Area

Dal Lake

The Dal Lake is the second largest lake of Kashmir covering an area of about 11.56 sq. km. The lake is surrounded by Zabarwan hills on three sides. Dal Lake is an urban lake situated toward the North-east of Srinagar. It is tectonic in origin (Jeelani and Shah., 2006) at an altitude of about 1584 m (A.M.S.L). It is situated between $34^{o}5'$ – $34^{o}6'$ N latitude and $74^{o}8'$ – $74^{o}9'$E longitude. Lying in the Eastern side of Srinagar, at the foot of the Zabarwan mountain, with Shankar Acharya (Takhtai-Sulaiman) in its south and Hazratbal (Dargah) in its west is the lake par-excellence-the Dal Lake. It is a shallow open drainage type water body divided into five basins- the Hazratbal basin, the Gagribal, the Nishat, the Nigeen and the Brarinambal basin, which are interconnected. The main sources of water for the lake are

Telbal Nallah, a perennial stream which brings water from a high altitude lake, Marsar draining Dachigam in the east of the lake from its northern end and Botkol, draining water mainly from the northern and north western catchments.

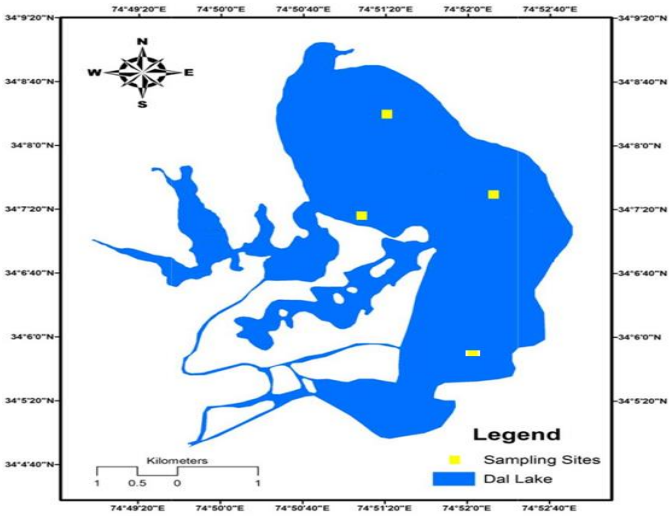

Fig. 1 Map of Dal Lake

Manasbal Lake

Manasbal Lake is the deepest fresh water Valley Lake of Kashmir situated 32 km northwest of the Srinagar city, at an altitude of about 1585 m (A.M.S.L.) within the geographical co-ordinates of $34^0 14' – 34^0 15'$ N and $74^0 39' – 74^0 41'$ E. The lake is flanked predominantly by rural areas with three villages Kondabal, Gratabal and Jarokabagh overlooking the lake. The lake is oblong in outline covering an area of 2.80 km^2 with the maximum depth of 12.5m (Yousuf., 1979). The oblong outline of Manasbal Lake extends in a Northeast-Southwest direction with a maximum length and breadth of 3.5 and 1.5 km, respectively. The volume of water has been estimated as 12.8×10^6 m3 (Yousuf., 1992). The lake is fed seasonally by an irrigational stream; Larkul, on the eastern side, which is operational only during summer season. It drains into the river Jhelum through a 1.6 km Nunnyar Nalla near Sumbal village. It has predominantly rural surroundings with three villages, Kondabal, Jarokbal and Gratbal. It is the deepest (~12m deep) of all the freshwater lakes fed by groundwater in Kashmir Valley (Lawrence., 1895; Raina., 1971).

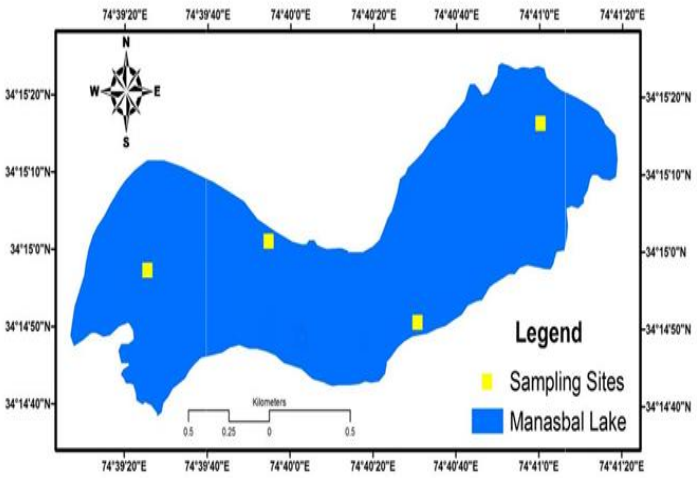

Fig. 2 Map of Manasbal Lake

Material and Methodology

The physico-chemical characteristics of water were monitored on monthly basis. The water samples were collected from each of the sampling sites in one litre polythene bottles for the laboratory investigations. The parameters including depth, transparency, temperature, pH and conductivity were determined on spot while the rest of the parameters were determined in the laboratory within 24 hours of sampling. The analysis was done by adopting standard methods of APHA (1998).

Results and Discussion

A perusal of data in Table 1 reveals that the surface water temperature of all sites in two lakes follows closely that of the air temperature. The temperature variation recorded during the study period was optimal for normal growth and survival of aquatic organisms (Boyd., 1979). The variation in the temperature of the present study is in broad agreement with the findings of Rao *et al.* (1980) for Nainital lake and Billore and Vyas (1982) for Pichhola lake.

From the biological point of view, transparency governs the depth to which photosynthesis could take place. The lowest mean depth is an indication of an evolutionary process coinciding with higher trophic status of the lake Rawson (1953, 55) and Hayes (1957). During the study period, the Secchi disc transparency remains higher in Manasbal Lake through the study period as compared to Dal lake. Transparency fluctuated from one lake to another and among the two lakes under study, Dal Lake was found to be on lower side in transparency.

All chemical and biological reactions are directly dependent upon pH of the water system (Srinivasan., 1967). According to Whitmore (1989) alkaline pH (>7.5) is mainly exhibited by eutrophic and mesotrophic lakes. The lakes remained alkaline throughout the study period within a range of 7.0 – 9.9. Values above 9 have been attributed to extreme divergence from the equilibrium because of high photosynthetic activities (Hutchinson., 1967). pH recorded in the present study was in alkaline range suggesting that the lakes were well buffered throughout the study period.

Conductivity value is an index of total nutrient level of a water body (Kaul., 1977). The average conductivity of four study sites in Dal Lake was recorded to be 256.7 µS/cm while as in Manasbal Lake

the average value was 377.6 µS/cm. This is clearly related with the ever-increasing pollution level in the lake. Shastree *et al.,* (1991) also reported that high level of conductivity reflects the pollution status as well as trophic level of the lake.

Table 1 Evaluation of different parameters in two lakes

Parameter	Dal Lake	Manasbal Lake
Water temperature (˚C)	15.24	14.58
Transparency (m)	1.30	1.78
pH Scale (1-14)	8.3	8.0
Conductivity (µS/cm)	256.7	377.6
Dissolved Oxygen (mg/l)	7.5	9.6
Total Alkalinity (mg/l)	122.9	144.2
Chloride (mg/l)	20.7	18.7
Ammonical-Nitrogen (µg/l)	229.2	46.1
Nitrate-Nitrogen (µg/l)	439.4	203.3
Total Phosphorus (µg/l)	584.2	169.0

Dissolved oxygen is one of the critical factors for aquatic life and the pattern of its spatial and temporal distribution in the lakes and determines the occurrence and the abundance of the aquatic organisms (Wetzel., 1999). The source of oxygen in water is phytoplanktonic photosynthesis and atmospheric oxygen. In Dal Lake, the average value was 7.5 mg/l while as in Manasbal Lake it was recorded as 9.6 mg/l. Oxygen level is depleted in water bodies due to decomposition of organic wastes (Mustapha., 2003).

Total alkalinity varied greatly between the sampling sites among the two lakes. Minimum and maximum values of alkalinity were recorded in Manasbal Lake. The overall low value was recorded in Dal Lake. The higher value of Manasbal indicated that the lake was well buffered as compared to Dal Lake. Both the lakes were found to be on alkaline side throughout the year. The alkaline nature of Kashmir lakes in general is attributed to the presence of calcium-rich rocks in the catchment area (Zutshi *et al.,* 1980).

Chloride content in water is regarded as an indication of organic load of animal origin from the catchment area (Kumar *et al.,* 2004). The chloride concentration during the present study was lowest in Manasbal during summer and highest in Dal Lake during winter. A comparison of present study with data of Yousuf and Qadri (1981) reveals that the chloride concentration has significantly increased over past few decades in Kashmir valley lakes and has contributed to pollution.

The presence of nitrate in any aquatic ecosystem depends on the activity of nitrifying bacteria. Nitrate is the common form of inorganic nitrogen entering freshwater from the draining basin, ground water and precipitation but mostly occurs in low concentration under natural conditions (Wetzel., 1983). The higher value of nitrate was recorded in Dal Lake during autumn and lowest in Manasbal Lake. The higher value of nitrate in Dal Lake is attributed to nitrogen fertilizer used in catchment area which enters the lake through agricultural run-off.

Vollenweider (1972) has pointed out that phosphorus plays a central role in eutrophication of water bodies. Phosphate enters the lakes through domestic wastewater, accounting for the accelerated eutrophication (Vyas et al., 2006). Total phosphorous concentration indicated that both the lakes are eutrophic in nature, Dal Lake being more eutrophic than Manasbal Lake. Increased concentration of phosphate and nitrate nitrogen in lakes resulted in enhanced productivity (Pandit and Yousuf., 2002).

Conclusion

Considering various ecological parameters, taken into account for determining lake typology, it is concluded that both lakes are subjected to anthropogenic stress in the form of nutrient enrichment which changes the overall trophic status of both the lakes. However, the stress is more pronounced in Dal Lake as compared to Manasbal Lake which shows higher pollution levels as depicted by water quality parameters. Extensive and rapid growth of planktonic algae, caused by an increased input of nutrients is a common problem in lakes. Among the two lakes, Dal Lake showed higher value for Nitrogen and phosphorous- main agents responsible for the eutrophication.

In the valley lakes the problem of pollution is mainly due to addition of major plant nutrients particularly nitrogen and phosphorus, derived from human wastes, detergents, fertilizers, agricultural activities etc. at an accelerated rate. The nutrients have been chiefly responsible for an increase in organic production particularly in the form of dense macrophytic growth and the overall deterioration of water quality. The deterioration of water quality and other associated problems as a result of racing eutrophication have reduced the recreational and aesthetic appeal of the lakes, besides other economic benefits. Kaul and Handoo (1987) are of the view that eutrophication of aquatic ecosystems has a regional aspect in as much as it is dependent upon the regional nutrient contributing factors viz., precipitation, natural drainage, morphology of the basin and many others, as well as their metabolism is influenced by the complex interrelationship of climatic, hydro-geographical and civilization / cultural features. In view of the variability of these nutrient contributing and metabolism related factors, Kaul (1977) opined that the valley lakes experiencing higher trophic evolution and enjoying various degrees of eutrophication need conservatory measures to be adopted for arresting the degradation of these lake ecosystems.

Suggestions

Lakes are not only just mirror of the society living around them but also reflect the understanding of their managers. At present, both the lakes are being polluted, catchment being denuded, drainage channels being obstructed and subject to encroachments. In the present scenario, for checking any further advancement in the trophic level of these lakes, some measures need to be taken up immediately.

- Reduction in eutrophication of water body by reducing the nutrient input and by improving sanitation and waste disposal system.
- Agriculture land use in the catchment area and excessive use of fertilizers in the floating gardens should be checked.

- De-weeding programme needs to be taken up on scientific lines where the weeds should be uprooted and not trimmed superficially.
- Re-arrangement of mooring areas of houseboats along with the provision of sewage system
- Fencing of the catchment area and ban on construction of floating gardens.
- Afforestation in the upper reaches and keeping a check on cattle grazing needs to be taken up on priority basis so as to reduce degree of soil erosion.
- Improvement in water circulation at the places where dissolved oxygen levels are very low.
- Environmental education and strict implementation of the laws
- All the dwellers must be rehabilitated properly.
- Last but not the least, there should be complete co-ordination between various government agencies for success of any conservation plan for these lakes.

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