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Studies on Physico-Chemical Parameters of Water and Sediments of Dal Lake

Syed Eshrat*, S Jeelani and S.A.Shah

Department of Chemistry, National Institute of Technology, Srinagar -190006, India.

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ABSTRACT

The present investigation was carried to monitor simultaneously the physico-chemical characteristics of water and sediments of Dal Lake over a period of one year from March 2014-Feb.2015. In all 17 parameters from surface water and 13 parameters from sediments were analysed. The parameters analysed during the study were pH, conductivity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), dissolved oxygen (DO), ammonical nitrogen, phosphate, sulphate, total hardness (TH), chloride (Cl⁻), and metals (Na, K, Fe, Ca, Mg). The results of both water and sediment samples revealed an overall increase in the concentration of the parameters than the permissible limits due to pollution.

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Introduction

Despite the number of restoration and conservation plans prepared by national and international agencies and implemented by the state authorities, there is no significant progress to retain the glory of this lake and the lake conditions as a whole continue to deteriorate at an alarming rate.

The urbanization, industrialization, modernization and modern agricultural activities have put tremendous pressure on the water bodies causing eutrophication and pollution of these water bodies. The Dal Lake of the valley has also been subjected to such pressures in recent times and also in advance of tourist inflow and establishment of locality in the Dal Lake. Dal Lake is situated at the foot of the Zabarwan hills, the run-off has also disturbed the sediment composition. In addition, the agricultural runoff from the feeding channels, the lake has got tremendous algal bloom which has resulted in the eutrophication of the lake. About 50,000 people live within the lake in various hamlets. Besides living in houseboats, people use this lake for personal purposes generating huge business out of it and producing numerous pollutant substances for it in the form of floating gardens and using fertilizers at large in nearby paddy fields thus, the lake is deteriorated by these activities in diverse ways.

Chemistry of lake water and sediment is a cumulative reflection of catchment geology, weathering and erosional processes as well as anthropogenic inputs. The concentration and abundance of chemical constituents in lake Sediment reflect the occurrence and abundance of these metals in rocks of the catchment areas and anthropogenic sources. Being an urban lake, the municipal and domestic effluents have altered the water composition of Dal lake leading to increased eutrophication and the results indicate that the direct discharge of sewage from houseboats, human encroachments, increase in population within the catchment area etc have resulted in the deterioration of water quality, prolific growth of aquatic macrophytes and siltation[1].

In recent decades, the nutrient inputs have been increased several folds than the level of their natural occurrence due to population growth, agricultural practices, urbanization and sewage run-off from urban areas, resulting in accelerated eutrophication and pollution [2]. Excessive sedimentation rates enhanced by extensive soil erosion due to deforestation and an encroachment by surrounding population have dramatically reduced the lake volume [3].

Materials and Methods

After a thorough survey of the lake, four sites were selected for the collection of water and sediment samples. The sampling was carried on fort-night basis over a period of one year in all seasons. Separate samples were collected from the pre-selected sites. The water sampling was carried with routine type sampler while the sediment samples were carried with the help of an Ekman-Birge dredger from deeper sites.

The water samples were collected in plastic container which were previously sterilised with 70% alcohol and rinsed with distilled water. For dissolved oxygen, samples were collected in separated glass bottles and fixed at the sampling site in accordance with the Winkler's method [4]. The sediment samples were also collected from the same sites, dried in oven at 160°C and grinded in wooden pestle and mortar and then passed through the 2mm sieve. The sieved samples were stored in air tight polythene bags for analysis.

The methods of APHA (2005) [4] and Vogel's (2009) [5] were followed for the estimation of different physico-chemical characteristics of water while the sediment samples were analysed using standard methods. The micronutrients analysis was carried by AAS method.

Results and Discussion

The results of various water quality parameters of the four different sites i.e., Hazratbal, Bod-Dal, Gagribal, and Nageen of Dal Lake are given in the Table-1.

The value of pH obtained depicts the alkalinity of water and considerable fluctuation in pH can be observed in natural

Table 1. Physico-Chemical characteristics of Surface Water.

Parameters	Hazratbal	Bod-dal	Gagribal	Nageen
pH	7.92	8.16	7.66	8.55
Conductivity	190.1	145.6	125.9	214.0
TDS	260	345	255	234
DO	13.49	12.35	13.33	14.90
BOD	3.22	0.83	0.68	0.89
COD	5.05	1.25	0.985	1.37
TH	138	90	189	118
Na	6.3	4.9	5.1	6.9
K	3.9	2.8	2.8	2.4
Ca	33.05	24.00	28.08	27.75
Mg	13.15	6.8	27.77	10.72
Fe	4.7	3.7	4.2	3.6
Cl ⁻	17.00	15.35	16.90	11.36
HCO ₃ ⁻	240	140	180	190
SO ₄ ²⁻	12	10	30	35.4
P-PO ₄	0.4	2	2.1	0.1
NH ₃	4.9	4.3	10.4	3

*All the values are in mg/L except EC and pH in (μS/cm)

water due to exposure to air and different biological activities within the lake. The pH ranges between 7.66 - 8.55 indicates the productive nature of water body [6] and falls well within the limits of WHO.

The electrical conductivity ranges between 125.9-214.0 μS/cm. The higher value of electrolytic conductivity attributes to the higher levels of various charged chemical species (anions and cations). Generally the E.C. is higher during summer season and gradually falls in winter months. The EC is attributed to high salinity and high mineral content and also corresponds to the highest concentration of dominant ions, which are the result of ion exchange and solubilization in the aquifer [7]. The Gagribal basin shows low value of E.C. and the Nageen basin shows high value of E.C.

The TDS value ranges from 234-345 mg/L. The high concentration of TDS decreases the palatability and may cause gastrointestinal irritation in humans and may have laxative effects reported by WHO-1996.

The DO levels in aquatic systems probably reveal more about their metabolism than any other single measurement. The concentration of DO ranges from 12.35-14.90 mg/L. The measurement of the dissolved oxygen is primary parameter in water pollution studies as it indicates aerobic or anaerobic nature of biological activities in water bodies. The dissolved oxygen concentration depends on the physical, chemical, and biological activities in the water body. The lower concentration of DO could be due to increase in water temperature and higher rate of decomposition of organic matter [8-9]. The basin Nageen shows the higher values of DO (14.90 mg/L) depicts the low disturbance w.r.t other basins of the lake.

The BOD (biochemical oxygen demand) indicates the presence of biodegradable waste present in the water. More the biodegradable waste less is the oxygen concentration in the water body. The BOD ranges from 0.68-3.22 mg/L. The Hazratbal basin shows elevated value for BOD.

The results of COD obtained ranges from 0.985-5.05 mg/L. The COD (chemical oxygen demand) is the amount of oxygen consumed by organic matter from boiling acid potassium dichromate solution. It provides a measure of the organic matter in a water sample that is susceptible to oxidation under the conditions of the test. COD is an imperative parameter, indicates both biodegradable and non-biodegradable waste present in the water.

During the present study, the average value of hardness across four basins of lake ranges from 90-189 mg/L. Calcium and Magnesium are the major cations that contribute towards

hardness of water. No doubt, other polyvalent ions of some other metals like strontium, iron, aluminium, zinc and manganese etc. The hardness of water body depends on geology of Lake and also nature of drainage inputs. The results 24.00-33.05mg/L shows that calcium content in the lake is high, and Dal Lake would fall within the category of calcium-rich waters. Also, the Magnesium in the range of 6.8- 27.77 mg/L is the common constituent of natural water and is because of contact of water with magnesium-rich limestone or dolomite[10].

Sodium is an abundant element and present in most of the natural waters though the concentration in fresh waters is negligible w.r.t. seawater and brackish water. Sodium imparts salty taste and ranges between 4.9-6.9 mg/L.

Although potassium is a relatively abundant element, its concentration in natural fresh waters is usually less than 20 mg/L. The basin Hazratbal shows higher value of 3.9 mg/L while the basin Nageen shows low value of 2.4 mg/L.

Iron is also found in natural waters though in trace quantities. The form and solubility of iron in natural waters are strongly depending upon the pH and the oxidation-reduction potential of the water. In the pH range of 6-9 surface water rarely carry more than 1 mg of dissolved iron per litre. The value ranges from 3.6-4.7 mg/L and the Hazratbal basin shows high value of iron.

In the present study, the chloride concentration ranges between 15.35-17.00 mg/L. Chloride is generally present in natural waters and the main sources of chloride are sewage and industrial wastes.

Alkalinity of water sample is its quantitative capacity to neutralize a strong acid to a designated pH. The alkalinity of many surface waters is primarily a function of carbonate, bicarbonate and hydroxide content. In the pH range of 7-9, bicarbonates are of great importance. In present investigation the value of alkalinity ranges between 140-240 mg/L, of which maximum value of 240 mg/L was observed at Hazratbal basin and minimum of 140 mg/L at Bod-Dal. Also, the water bodies with alkalinity less than 100 mg/L are desirable for domestic use.

Sulphate in lake water is due to presence of sulphate containing rocks and also because of industrial wastes, detergents and mine drainage. The value of sulphate ranges from 10- 35.4 mg/L. The Nageen basin shows higher value of 35.4 mg/L and the Bod-Dal basin shows lower value of 10 mg/L during the course of study.

Phosphorus is generally considered as key nutrient in the algal productivity of lake and enhances the eutrophication processes. The agricultural-runoff and sewage from the surrounding areas of Dal Lake are the major sources of phosphorus in it. The Nageen basin shows low concentration of inorganic phosphorus 0.1 mg/L while the Gagribal basin shows higher values of 2.1 mg/L depicts the level of contamination.

In natural fresh waters nitrogen is found in several combined forms such as nitrates, ammonia compounds and nitrites. Commercial fertilizers and manures are the major sources of nitrogen in the water bodies. Also, ammonia is produced when nitrogenous organic matter is decomposed by microbiological activities, and thus found in most of the water bodies. The concentration of ammonical nitrogen is found between 3-10.4 mg/L. The Gagribal basin shows higher value of NH₃-N while the low concentration is found at Nageen basin.

Sediment analysis

The sediment quality is an important environmental concern, hence should be assessed in order to define the lake ecosystem. The sedimentation rates in the Kashmir valley, being tectonically active, should be higher than other zones.

For the quantification of the dissolved load entering the lake, it is important to quantify the chemical weathering rates and erosional processes of catchment area.

From the Table-2, the 13 parameters of sediments were analysed in the present investigation from four different sampling sites. The conductivity ranges between 185-275 $\mu\text{S}/\text{cm}$. The pH values fluctuating between 7.2-8.1, depicts the alkaline conditions of the lake sediments. However, sediments are rich in mineral nutrients and the high concentration of Ca^{2+} and HCO_3^- derived from carbonates and silicates indicates the intense chemical weathering of the surrounding area.

Table 2. Geo-Chemical characteristics of Bed Sediments of Dal Lake.

Parameters	Hazratbal	Bod-dal	Gagribal	Nageen
Conductivity	267	270	185	275
pH	7.2	7.8	8.1	7.5
% OM	89.3	87.11	92.07	96.4
Ca	29.7	40.08	56.11	30.64
Mg	35.78	19.49	19.49	38.98
CaCO_3	5	6	12	18
HCO_3^-	17.35	24.4	30.5	61
Cl^-	7.5	2.68	5.84	4.26
Na	250	210	180	250
K	0.8	0.8	0.5	0.4
$\text{NH}_3\text{-N}$	5.8	5.4	6.1	6.4
SO_4^{2-}	38	10	22.44	14
P- PO_4^-	10.5	12.5	1.4	1.6

*All the values are in mg/L except EC and pH in ($\mu\text{S}/\text{cm}$)

The percentage organic matter (OM) in the bed sediment ranges between 87.11-96.4 mg/L. the high organic matter might be due to deterioration, eutrophication as well sewage disposal into the lake [11].

The concentration of Na^+ ranges in between 180-250 mg/L in the course of study. The dissolution of evaporates can be an important source of sodium. Also, the K^+ concentration value ranges from 0.4- 0.8 mg/L with a slight variation. The chloride concentration ranges between 2.68-7.5 mg/L, shows higher value in Hazratbal basin and low in Bod-Dal basin.

The ammonical nitrogen concentration shows higher value at the Nageen basin of 6.4 mg/L and the agricultural and anthropogenic inputs are the extra sources of $\text{NH}_3\text{-N}$, in addition to atmospheric nitrogen. The sulphate varies between 10- 38 mg/L of which Hazratbal basin shows higher value of SO_4^{2-} concentration and minimum at Bod-Dal basin. Also, the concentration for available phosphorus is high at Hazratbal basin.

Remedial measures

The condition of Dal Lake has reached a critical stage from the hydrological and ecological point of view, and if proper conservative measures are not taken, the lake is likely to further deteriorate as it is evident that anthropogenic activities are affecting the water quality and causing sediment pollution. The degradation is due to encroachments, eutrophication (from domestic and industrial effluents) and silt [12]. Thus, the human population settlements and public effluent are chief factors for the degradation of lake particularly the urban lake.

The Da lake is facing problems such as excessive weed growth, deterioration in water quality, discharge of sewage and nutrients into the lake and deposition of silt. The following remedial measures can be suggested for stopping the further deterioration of lake;

- The management of the sewage from the houseboats and hotels should be first stage to investigate the problem.
- The encroachment of the lake area should be totally stopped.
- The construction of new houseboats, boats and restaurants within the Lake should be banned.
- The expansion of Srinagar city should be planned according to the capacity of land.

- The future tourism development including the number of tourists should be based on capacity of land. The provision of amenities, services and energy supplies rather than the mere promotion of tourism for economic gains.

- Reforestation in the nearby area in practice and effective means of reducing soil erosion.

- The proper dredging and cleansing action of lake can also be helpful to reduce the sedimentation of lake.

- The ecology of the lake should be monitored on regular basis and area wise.

Conclusion

In the present investigation the detailed survey of water and sediments of Dal Lake were carried out indicates that the lake has reached a critical condition from the environment point of view. The geochemical characteristics of the lake water are mostly influenced by the lithology of the lake and weathering of carbonate and silicate rocks. Anthropogenic activities show an impact on both water and sediment chemistry of lake particularly in portions proximate to habitation/hotels/houseboats/sewage drains. Also, it reveals that the main cause of degradation of the lake is the discharge of agricultural wastes, deforestation and municipal sewage inputs. The results drawn from the data reveals that it is possible to formulate viable strategies which could help to reduce the pollution load of the Dal lake.

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