

Assessment of Water Quality of Dal Lake, Srinagar

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ABSTRACT: The present study investigates the water quality of the Dal Lake. The samples were collected from four different locations to cover all the areas of lake. The sample sites include Nigeen, Boddal, Gagribal and Hazratbal areas. The pH, Alkalinity, TDS and Temp. were measured over a period of four months from July to October 2021. The secondary data on BOD, NO₃ and heavy metals was collected from the Jammu & Kashmir Lake Conservation and Management Authority (JKLCMA). Results inferred that the currently, the water quality of the Dal Lake deteriorated and observed significant pollution. The pH and TDS of the lake is quite high and measured in the range of 9.5 – 10. Among various basins the Gagribal basin recorded the higher TDS values varying from 221 mg/l to 269 mg/l whereas the Hazratbal basin recorded the lower values varying from 200 mg/l to 255 mg/l. TDS concentration in Boddal basin vary from 205 mg/l to 252 mg/l and in Nageen basin from 200 mg/l to 267 mg/l. The overall calcium and magnesium content of lake is high. Based on the

results, collected and measured, it was observed that the Dal Lake is undergoing rapid eutrophication (due to rapid anthropogenic disturbances) under increasing anthropogenic influences in the drainage basins. The rate of pollution varies from one site to other based on the creeping of the wastewater. The nitrogen and phosphorus compounds were found high and mainly their source is human wastes, detergents and agricultural practices. The pollutant load in the Dal has accelerated the unwanted plant growth which in turn has reduced the water quality of the lake. Correlation with available data shows continuous deterioration in water quality. Choking of lake has occurred due to closure of its natural drainage system called "Nalla Mar" which has been converted in to a macadamized road. Immediate remedial measures are needed to salvage the lake and long-term rehabilitative measures are needed to restore the original condition of the lake.

Index Terms: Dal Lake, TDS, Alkalinity, BOD, NO₃, Eutrophication, Phosphorus.

I. INTRODUCTION

Lakes are transitory waterbodies on the land surface generated by extreme geological processes such as volcanism, earthquakes, or glacial, and they make up a geological prospective. Only around 1% of the earth's continental area is covered by snow, and only 0.02 percent of the world's population lives there. Total hydrosphere water is the total amount of water in the atmosphere. Despite this low number, lakes are quite important function as a geological, geochemical, and geo-limnological reference point. Natural labs are places where physiochemical and biological features of not-for-profit organisations may be studied. Only the lacustrine environment has been refined, although new research in the discovery of deep, stratified lakes has resulted in a better knowledge of oceanic processes anoxic occurrences, as most of the processes in lakes are anoxic. The Kashmir valley is home to several freshwater

bodies (lakes, marshes, ponds, rivers, and streams) that are vital to the state's ecological, socioeconomic, cultural legacy and act as a key source of revenue for the local economy. Besides the Valley's 80 percent population is solely reliant on these water bodies, while most of the water is utilized for drinking, agriculture, and residential uses, for tourist interests, water bodies have been preserved and adorned.

Dal Lake is surrounded by mountains and located in the heart of Kashmir, Srinagar (34° 5' - 34° 6' N and 74° 8' - 74° 9' E). Dal Lake receives its water from the "Arrah" river, which runs in a northerly direction through Tel Bal, a dark and deep waterway. The entire water surface area of Dal Lake is 11.45 km², of which 4.1 km² is covered by floating gardens. The land area and marshy area, respectively, are 1.51 km² and 2.25 km².

Dal Lake is located in Srinagar, Jammu and

Kashmir, and it employs a large number of people in agriculture, fishery, tourism, and other industries. It brings together a large number of people through diverse activities and may be considered a source of cultural legacy, which is valuable in and of itself. However, the same activities that supply people with cash, job, housing, food, and pleasure also pose a threat to the lake. Water supplies are becoming increasingly contaminated as a result of increased industrialization, urbanization, and technological advancement in all industries. If the current pace of contamination continues unchecked, the lake's survival will be jeopardized. A vast range of inorganic, organic, and biological contaminants pollute natural streams. Biodegradable organic stuff in water, for example, is seldom hazardous, but the oxygen consumption during its decomposition prohibits the water from sustaining fish. To preserve Dal Lake from near-death, pH, BOD, COD, turbidity, and other physical chemical qualities must be kept within a range that is beneficial to the aquatic creatures involved

II. METHODS and MATERIALS

2.1. Study Area

Dal Lake is tectonic in origin and lies between 34°5'N and 34°9'N latitude and 74°50'E and 74°54'E longitude, spanning an area of about 11.50 km². It is located to the north-east of Srinagar, Kashmir, India, at a height of about 1,584 m above mean sea level. The lake is primarily fed by a large perennial inflow stream, Telbalnala, which drains the largest sub-catchment area of about 145 km² and contributes around 80% of the overall inflow into the lake, as well as a number of small waterways located along the shoreline, such as Peshpawana, Shalimarnala, Merakshanalala, and Harshikul. Hazratbal, Boddal, Nigeen, and Gagribal are the four basins that make up the lake (fig. 3.1). The Nigeen basin is the deepest (highest depth of approximately 6 m), while the Gagribal basin is the shallowest (maximum depth of about 3 m) (maximum depth 2.5 m). At Hazratbal basin, the stream Telbalnala joins several smaller streams to reach the lake.

2.2. Analytical Procedure

The experimental analysis was carried out according to the standard methods of examination of water and wastewater (APHA, 2017). Water temperature was determined by portable digital Thermometer and pH was measured with the help of digital pH meter. The pH meter was standardized before use with buffer solution having pH values of 9.2 and 4.0. Dissolved oxygen and conductivity of lake water were also determined with the help of portable digital oxygen meter and conductivity meter; both the

instruments were standardized before use with standard sodium sulphide (5%) and potassium chloride (0.01M) solutions respectively. The concentration of Ca²⁺, Mg²⁺, Cr and HCO³⁻ were determined by volumetric methods. The estimation of Ca²⁺ and Mg²⁺ was done by EDTA titration using Eichrome black T and murexide as indicators, whereas in Cl⁻ estimation water samples were titrated against AgNO³ using potassium chromate as an indicator and for HCO³⁻ titration was done against H₂SO₄ and methyl orange was used as an indicator. Na⁺ and K⁺ concentration was determined by means of flame emission photometry. The standards were prepared from dried fresh NaCl and KCl. In this method water samples were atomized and sprayed into a burner and the intensity of light emitted by a particular spectral line was measured by a photoelectric cell and a galvanometer. Sulphate was estimated by gravimetric method. Spectrophotometer was used for the estimation of NO³⁻. In this type of photometry light is passed through an absorbing column of colored solution and directed upon the photosensitive device, which converts the radiant energy into electrical energy. Thus, the current produced is measured by a sensitive voltmeter.

III. RESULTS AND DISCUSSIONS

Variation of various physical and chemical parameters of the Dal Lake are tabulated and graphically shown below.

Table 3.1 variation of Temperature & pH

S. No.	Parameters	Site 1	Site 2	Site 3	Site 4
01	Temperature (°C)	27.0	28	27	23
02	pH	9.5	9.5	7.5	8.5

Table 3.2 Variation of Total Dissolved Solids

S.No.	Location	TDS (mg/l)
1.0	Hazratbal Basin	1690
2.0	Boddal Basin	1000
3.0	Gagribal Basin	1520
4.0	Nageen Basin	1670

Figure 3.1 Temporal Variation of Ammonical Nitrogen

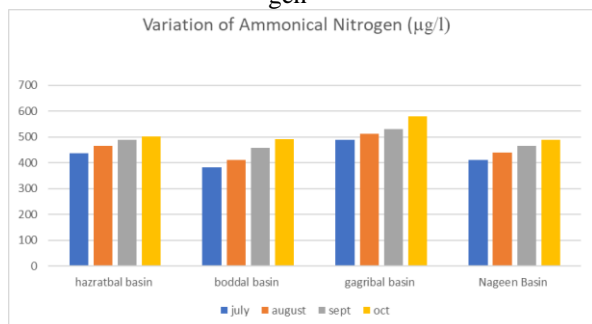


Figure 3.2 Temporal Variation of Nitrate

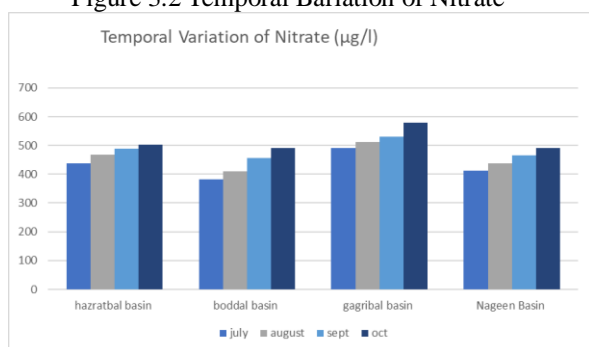


Table 3.3 Variation of Biochemical Parameters

Site	Site 1	Site 2	Site 3	Site 4
BOD₅ (mg/l)	17	18	10	19
COD	75	76	79	78
Facial Coliform (MPN/100 ml)	10	8	18	15

The pH of Dal Lake water is also on alkaline side and varies from 7.5 to 9.5. At both Hazratbal and Nageen basin pH vary between 8.0 to 9.5 whereas at the Boddal and Gagribal basins it varies from 8.0 to 9.5 and 7.5 to 9.5. Lower pH values at sites within Gagribal basin are close to the sewage disposal and houseboats. The current lake's low nitrite-nitrogen content indicated a slow pace of denitrification. The nitrite-nitrogen concentrations fluctuated irregularly over time. Higher nitrate-nitrogen readings at Site V might be attributed to surface runoff of nitro-phosphate fertilizers from surrounding floating gardens, as well as household waste from neighboring house boats. The lower nitrate-nitrogen concentrations of sites I and IV may be connected to the lower D.O concentrations at the bottom, which is corroborated by the rise in ammonium-nitrogen, indicating that there was insufficient oxygen to convert ammonia to nitrate. Every year, BOD increases at a rapid rate. The lake environment is being harmed by azolla weeds that have nearly completely covered the water surface. Increased nitrate and phosphate levels in the lake create siltation, affecting the lake's depth year after year. The city's 15 major drains are the primary source of pollution in the dal lake. The coliform is positive for MPN, indicating that the lake is heavily polluted with organic materials or sewage. So, according to the current study, nutrient loading and maximal weed cover throughout the whole lake have exceeded eutrophic conditions, resulting in hyper eutrophic conditions.

3.1. Variation of major & minor ions

Figure 3.2. Variation of Ca & Mg

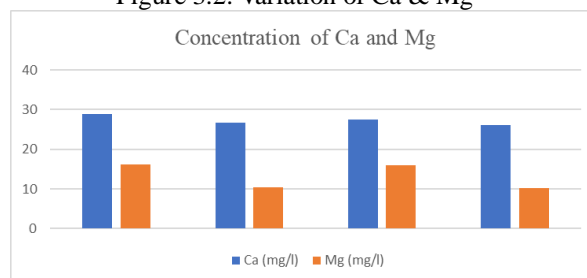


Figure 3.4 Variation of Na & K

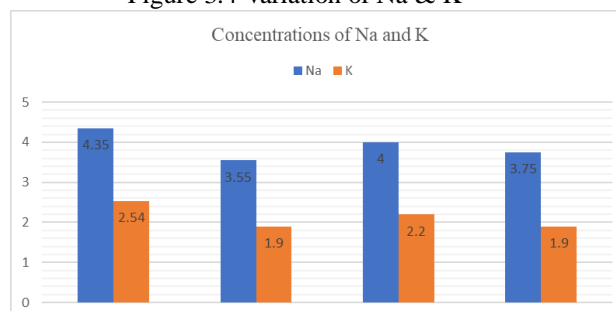


Figure 3.5 Variation of Bicarbonates & Chlorides.

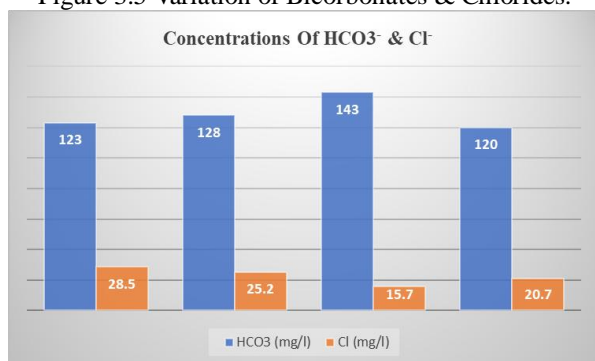


Figure 3.6 Variation of Sulphates & Nitrates

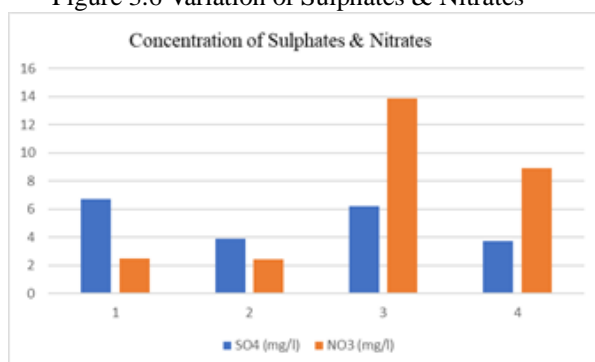


Figure 3.7 Variation of Iron & Zinc

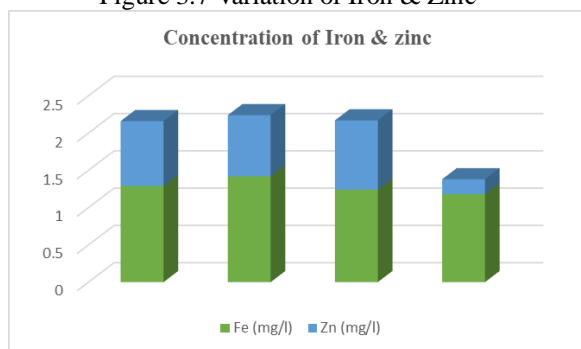
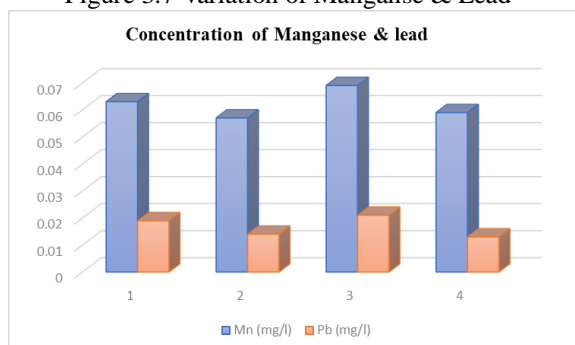


Figure 3.7 Variation of Manganese & Lead



In the present study area, the annual amplitude of calcium concentration in surface water sam-

ples show varied, fluctuation from 10.1 mg/l to 45.7 mg/l. A comparison of various basins reveal that Hazratbal basin recorded highest concentration of 12.2 mg/l to 45.7 mg/l, higher being close to the inflow channel sites and the Nageen basin recorded lowest concentration of 10.1 mg/l to 26.2 mg/l, the lowest being towards deeper site. Comparison of various basins reveal that in Hazratbal basin magnesium concentration vary from 5.2 mg/l to 16.2 mg/l, in Boddal from 4.2 mg/l to 10.5 mg/l, in Gagribal from 4.4mg/l to 15.9 mg/l and in Nageen from 3.7 mg/l to 10.3 mg/l. Sodium concentration in Dal Lake surface water ranges from 1.5 mg/l to 6.5 mg/l. Its concentration in Boddal and Nageen varies from 1.5 mg/l to 5.6 mg/l and 1.8 mg/l to 5.3 mg/l. While at Hazratbal it varies from 2.2 mg/l to 6.5 mg/l and at Gagribal from 1.6 mg/l to 6.4 mg/l. Potassium concentration in surface water of Dal Lake ranges from 1.1 mg/l to 3.8 mg/l. Basin wise investigation reveals that all the four basins recorded minimum potassium concentration of 1.1 mg/l and a maximum value of 3.8 mg/l at Hazratbal, 3.3 mg/l at Gagribal and 2.7 mg/l at both Boddal and Nageen basins. The bicarbonate concentration in Dal Lake surface water shows a wider range, varying from a low of 34 mg/l to a high of 201 mg/l. Basin wise variations show Hazratbal ranking high (45 mg/l to 201 mg/l) and Nageen ranking low (37 mg/l to 120 mg/l) i.e., it is positively correlated with calcium and magnesium. The higher values are recorded at sites close to the inflow channels. At Boddal it varies from 34 mg/l to 128 mg/l and at Gagribal from 37mg/l to 198 mg/l.

IV. CONCLUSIONS

The relative concentration of major elements in Dal Lake sediments shows that the Ca, Mg, Fe and K constitute >70% of the total elemental composition of the sediments. The expected normal trend of the major elements Ca, Mg, Na, K and Fe is attributed to the weathering and dissolution of rocks of the catchment area of about 317 km². Relative concentration of the heavy metals shows that Zn is dominant heavy metal followed by Cu, Pb, Co and Ni. In general, the concentration of these heavy metals increases away from inflow channel being lower at inflow channel / Hazratbal basin and higher in Gagribal basin / Nageen basin. The higher values recorded at different sites are close to sewer drains, house boats, restaurants, etc., reflecting their source from anthropogenic activities.

Relative variation of major ions in Dal Lake water depicts the predominance of Ca and HCO₃ over the other ions and therefore the usual ionic progression is HCO₃⁻ > Ca²⁺ > Cl⁻ > Mg²⁺ > Na⁺ > K⁺ brings it close to the well-known sequence for global fresh waters. The order of cations is Ca²⁺ >

Cl⁻ > Mg²⁺ > Na⁺ > K⁺ and the order of anions is HCO₃⁻ > Cl⁻ > SO₄²⁻. The higher concentration of Ca²⁺ and HCO₃⁻ indicate that water has retained the chemical character of meteoric waters with some increasing concentration as Ca²⁺ and HCO₃⁻ are higher in rain water /snow melt. The higher SO₄²⁻ concentration may be due to the association of gypsum/ anhydrite with the lacustrine deposits (Karewas) and some part of SO₄²⁻ may come from agricultural sources as ZnS is widely used as fertilizer in paddy fields and floating gardens etc. NO₃ concentration shows reverse correlation with all the major ions as its highest concentration is recorded in Gagribal basin instead of Hazratbal basin. The higher values of NO₃⁻ at Gagribal and Nageen basin are a warning and an alarming signal of water pollution as the values approach up to 13.9 mg/l. Temp-spatial variation of trace elements already given in hydrochemistry does not show marked differences. Relative concentration of trace elements shows slightly higher concentration of Fe > Zn > Mn > Pb in a decreasing order. In general, lower concentration of trace elements in water samples may be attributed to the high pH, organic matter and dissolved oxygen the very low or negligible concentration of trace elements in water is perhaps also as a result of their lockup in the lake sediments. Direct discharge of untreated human wastes from houseboats and human settlements adjoining the lake has further aggravated the nature and extent of pollution. Human encroachments and siltation have combined with natural processes to reduce the overall area of the lake. Drastic changes have taken place in the water chemistry of Dal Lake over the past few decades. Correlation with available data shows continuous deterioration in water quality. Choking of lake has occurred due to closure of its natural drainage system called "Nalla Mar" which has been converted in to a macadamized road. Immediate remedial measures are needed to salvage the lake and long-term rehabilitative measures are needed to restore the original condition of the lake.

V. FUTURE SCOPE

The higher concentration of calcium and bicarbonate indicates the intense chemical weathering of denuded catchment area, as the catchment area of the Dal Lake comprises mainly of carbonate and volcanic rocks. Similarly, the chemical weathering of minerals like dolomite, pyroxene and olivine may release magnesium ions but it occurs in lower concentration compared to calcium, this low concentration may be due its low geochemical abundance. It was observed that following main types of pollutants enter in Dal Lake on daily basis. Sewage and Sullage, Agriculture runoff, Detergents and soaps,

Animal waste, Solid wastes (plastics, paper, polythene, rusted metal), Wastes from houseboats, hotels and business establishments around Dal and Soil erosion from catchment areas. In order to minimize these pollutants, following measures should be adopted.

- Centralized treatment plant for all houseboat, so that all waste generated doesn't directly be discharged into dal lake.
- Rehabilitation of house boat/hotel owners and people live in and around Dal at a suitable place.
- Removal of excess weeds from Dal Lake on continuous basis.
- Construction of STPs at all inflow channels.
- Restoration of a natural outflow channel (drainage i.e., "Nalla Mar") that will suck and drain extra pollutants from Dal Lake. It is pertinent to mention here that "Nalla Mar" was a long natural out flow drainage channel which was closed back in 1960s. and turned in to a macadamized road.
- Construction of sanitation latrines for the villagers living in the catchment area of Dal Lake in order to minimize the direct disposal of sewage into the Lake.
- Protection of water quality by reducing use of chemical pesticides by farmers. They should be encouraged to use biological pest controls instead of chemical pesticides.
- Farmers may avoid using commercial fertilizers (nitrogen and phosphorus) and animal dung in their farmlands in the catchment area. They should be encouraged to develop and implement nutrient management plans to reduce excess application of fertilizers.
- Afforestation of the catchment area and
- Control of grazing animals in the catchment area.

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