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## Evaluation of water quality for determining the pollution status of Dal lake in Kashmir Himalaya

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### Abstract

The Present study was aimed to estimate and investigate some physico-chemical parameters of Dal Lake of Kashmir, India. Physicochemical analysis of water samples was done on monthly basis from July to November. Ashai Bagh basin showed the highest level of pollution followed by Nehru Park basin. The concentration of pollutants mainly BOD, total hardness, chloride, nitrate nitrogen and phosphorus was found to be more at these two sites than Telbal basin. The results showed that highest concentration of BOD was found at Ashai Bagh 145.2 mg/L<sup>-1</sup> and lowest in the month of November 94.3 mg/L<sup>-1</sup>. In the case of total hardness, the highest value (143.3 mg/L<sup>-1</sup>) was observed at Nehru Park in the month of July, while the lower value (60.2 mg/L<sup>-1</sup>) was found at Telbal. The maximum mean nitrate-nitrogen (N-NO<sub>3</sub>) 425.2 µg/L was found at Nehru Park followed by 390.6 µg/L at Ashai Bagh and minimum (301.5 µg/L) was recorded at Telbal in summer. Similarly, the maximum mean phosphates (PO<sub>4</sub> -3) of 220.1 µg/L were found at Nehru Park followed by 216.5 µg/L at Ashai Bagh. Therefore the present study clearly indicates that Dal Lake is undergoing rapid eutrophication under the increasing anthropogenic impacts in its drainage basins. The rate of pollution varies from one basin to other. In general, the nutrient concentration was found highest at Ashai Bagh followed by Nehru Park and least at Telbal.

**Keywords:** Physico-chemical characteristics, Dal lake, Eutrophic, Anthropogenic pressure, Sewage

### 1. Introduction

The picturesque valley of Kashmir, located in the foothills of the Himalaya, experiencing a temperate-cum-Mediterranean climate. The high altitude valley abounds in a vast array of fresh water bodies. The rich aquatic resources, in the form of fresh rivers, lakes, springs etc., are of great importance. Dal Lake (Lat. 34° - 06' N, 74° - 45' E, alt. 1581 m) situated in the heart of Srinagar, the summer capital of Jammu and Kashmir State is under tremendous anthropogenic pressure for the last three decades. More than 50,000 people live within the lake itself in various hamlets besides living in houseboats. The lake is a goldmine for inhabitants, attracting the attention of national and international tourists for centuries, also provides livelihood to thousands of people who draw benefits from it through a series of trade activities ranging from fish production to farming. During recent years the rapid increase in population has resulted in establishment of new human settlements in the catchment area of the lake. Also the vast areas of forest were converted into agriculture and farmlands that resulted in opening up the terrestrial ecosystem, with heavy loads of nutrients leaching into the lake from the fertile top soil of the catchment area <sup>[1]</sup>. In addition to sewage and domestic effluents from the new and expanding human settlements the runoff from fertilized agricultural land and the residual insecticides and pesticides from the arable lands and orchards plantations also drain into the lake <sup>[2]</sup>. The increase in nutrient concentration results in hyper-eutrophication which disturbs the entire aquatic ecosystem. During the past few years, concern is being voiced by both public as well as state Govt. over the dying and deteriorating condition of Dal Lake <sup>[3]</sup>. The Lake ecosystem and its survival will be in danger if the present rate of pollution continues unabatedly.

### 1. Materials and Methods

#### 1.1. Study area

The present work was carried out in three sites/basins of Dal Lake Kashmir viz.

##### (1) Telbal basin (TB basin North side)

Telbal basin is situated in North side and shallow, open drainage lake is fed by Telbal inlet.

The complex land use pattern is reflected in this area, with fields of paddy, orchards and gardens in the lower slopes, and barren hills in upper side.

### (2) Ashai bagh basin (North West side)

This site is the outlet of west side of the Dal Lake through which the water flows out to the adjacent Nigin Lake. There are number of Houseboats resting in this location. Floating vegetable gardens are also located in this region. This region is also disturbed with sewage water pollution and anthropogenic activities.

### (3) Nehru Park basin (NP basin South side)

The Nehru park basin is the busiest tourist spot situated in the East side of lake. There are many hotels in the nearby side and people enjoy rides on shikaras, living in houseboats etc.

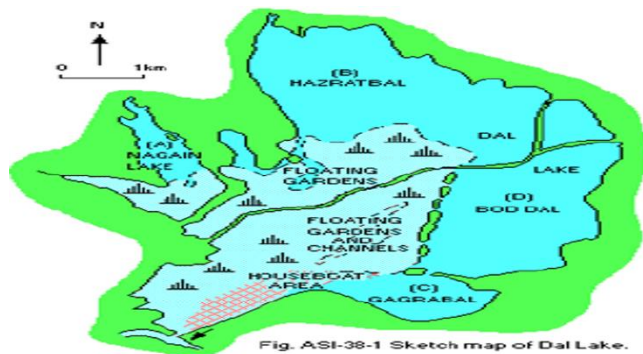


Fig 1: Sketch map of Dal Lake

## 2.2. Sample collection

Water samples were collected monthly from 3 sites of Dal lakes and were kept in polyethylene plastic bottles that were prior cleaned with metal-free soap, rinsed repeatedly with distilled water, then soaked in 10% nitric acid for 24 h and finally rinsed with distilled water. All water samples were properly stored and taken on the same day to laboratory and stored at 4°C until processing and analysis. The parameters like pH, temperature and dissolved oxygen were checked on spot while the parameters like free carbon dioxide, BOD, total hardness, chloride, phosphorus and alkalinity values were determined by [4].

## 3. Results

A perusal of data clearly showed considerable variation in pH in different months at all the selected sites. pH displayed great variations during the study period and the pH remained alkaline and ranges from 7.0 to 8.9. The results

show that there is a decreasing trend of pH from summer to autumn at all three sites. Maximum pH (8.6) was observed in the month of July at Nehru park basin (Table 3) and minimum pH 7.0 was observed in month of November at Ashai Bagh (Table 1). Both Ashai Bagh and Nehru Park showed minimum quantity of dissolved oxygen 6.8 mg/L<sup>-1</sup> and 7.0 mg/L<sup>-1</sup> respectively in the month of July while Telbal showed 7.5 mg/L<sup>-1</sup> (Table 2) in the month of July. The maximum quantity of dissolved oxygen was observed in the month of November at all three sites with highest concentration 9.3 mg/L<sup>-1</sup> at Telbal (Table 2). The results clearly show that there is a decreasing trend of dissolved oxygen from July to November at all three sites. The BOD was highest in the summer season and lowest in autumn season. The highest mean concentration of BOD was found at Ashai Bagh 145.2 mg/L<sup>-1</sup> and lowest in the month of November 94.3 mg/L<sup>-1</sup> (Table 1). The free CO<sub>2</sub> depicted well marked fluctuations at all the sites, registering a minimum mean value (3.4 mg/L<sup>-1</sup> at Ashai Bagh) and maximum in winter (10.1 mg/L<sup>-1</sup> at Telbal). Significant variation was found in total alkalinity concentration at all the sites in different months showing decreasing trend from summer to winter. The highest values of total alkalinity concentration was recorded at Nehru Park exhibiting value of 96.9 mg/L<sup>-1</sup> and 95.3 mg/L<sup>-1</sup> (Table 3) in the month of July and August, respectively; whereas water samples of Telbal recorded lowest concentration with a value of 71.5 mg/L<sup>-1</sup> (Table 2) in the month of November. Total hardness showed a same trend highest in summer months and decreases during *Senescense Phase*. In the case of total hardness, the highest value (143.3 mg/L<sup>-1</sup>) was observed at Nehru Park in the month of July, while the lower value (60.2 mg/L<sup>-1</sup>) was found at Telebal (Table 2) in November. Maximum concentration of chloride was observed at Ashai bagh which is 42.2 mg/L<sup>-1</sup> (Table 1) followed by 42.0 mg/L<sup>-1</sup> Nehru Park (Table 3) and minimum (35.9 mg/L<sup>-1</sup>) was recorded at Telbal during Peak Growth Phase. The maximum mean nitrate-nitrogen (N-NO<sub>3</sub>) 425.2 µg/L was found at Nehru Park followed by 390.6 µg/L at Ashai Bagh and minimum (301.5 µg/L) was recorded at Telbal in summer. The maximum mean phosphates (PO<sub>4</sub> -3) of 220.1 µg/L were found at Nehru Park followed by 216.5 µg/L at Ashai Bagh and minimum (212.6 µg/L) was recorded at Telebal in summer months. Both nitrate-nitrogen and phosphorus showed decreasing trend highest in Peak Growth Phase and lowest in *Senescense Phase*.

Table 1: Physico-chemical parameters of the water in Ashai Bagh of Dal Lake

Parameter	July	August	September	October	Nov 1 <sup>st</sup> Week	Nov 4 <sup>th</sup> Week
	<i>Peak Growth Phase</i>			<i>Senescense Phase</i>		
Temperature (°C)	26.0±0.35	26.0±0.79	19.0±0.79	18.0±1.00	5.0±0.50	4.0±0.18
pH	7.7±0.15	7.5±0.17	7.4±0.28	7.2±0.24	7.2±0.24	7.0±0.15
DO (mg/L)	6.8±0.41	6.9±0.15	7.4±0.15	8.7±0.36	8.8±0.36	9.1±0.12
BOD (mg/L)	145.2±6.20	139.2±7.50	111.4±3.09	98.5±1.67	95.6±4.60	94.3±3.50
CO <sub>2</sub> (mg/L)	4.4±0.80	3.4±2.00	4.6±1.14	7.1±1.10	9.4±0.70	9.7±0.80
Total Alkalinity (mg/L)	91.8±2.40	90.3±3.10	90.2±3.00	88.2±3.50	79.1±3.80	74.5±2.70
Total Hardness (mg/L)	135.2±3.40	137.3±3.20	133.1±2.50	82.2±4.30	64.6±3.80	64.1±4.50
Chloride (mg/L)	42.2±1.60	41.8±2.30	40.2±2.80	39.6±1.10	39.1±1.10	38.4±2.90
Nitrate Nitrogen (µg/L)	390.6±8.01	242.4±9.91	228.2±10.20	216.2±12.09	118.5±9.15	112.5±3.04
Total Phosphorus (µg/L)	216.5±12.60	216.2±12.09	212.1±14.70	207.4±13.03	204.5±10.30	204.2±10.30

**Table 2:** Physico-chemical parameters of the water in Telbal of Dal Lake

Parameter	July	August	September	October	Nov 1 <sup>st</sup> Week	Nov 4 <sup>th</sup> Week
	<i>Peak Growth Phase</i>			<i>Senescense Phase</i>		
Temperature (°C)	27.0±0.79	26.0±0.61	19.0±0.35	18.0±0.71	5.0±0.71	4.0±0.18
pH	8.2±0.15	8.1±0.16	8.0±0.16	7.5±0.15	7.4±0.3	7.4±0.3
DO (mg/L)	7.5±0.15	7.7±0.30	8.9±0.15	9.0±0.5	9.1±0.22	9.3±0.61
BOD (mg/L)	133.4±6.70	124.1±5.11	113.2±3.30	111.6±4.30	106.6±4.00	99.7±3.90
CO <sub>2</sub> (mg/L)	4.2±1.50	4.6±0.90	4.5±0.50	5.1±0.60	9.4±0.60	10.1±0.60
Total Alkalinity (mg/L)	84.2±3.20	86.1±2.10	89.6±2.70	88.4±3.40	73.1±3.50	71.5±2.00
Total Hardness (mg/L)	125.1±3.50	125.8±4.60	120.2±4.10	70.4±3.60	61.6±4.60	60.2±4.10
Chloride (mg/L)	34.4±3.00	35.9±3.20	30.4±2.90	30.8±2.30	26.2±1.40	25.8±2.30
Nitrate Nitrogen (µg/L)	301.5±8.90	292.1±12.40	289.4±15.80	244.5±7.70	211.1±8.90	203.5±10.90
Total Phosphorus (µg/L)	212.6±13.90	210.4±13.00	211.3±10.80	202.9±15.00	199.7±11.10	198.2±11.10

**Table 3:** Physico-chemical parameters of the water in Nehru park of the Dal Lake

Parameter	July	August	September	October	Nov 1 <sup>st</sup> Week	Nov 4 <sup>th</sup> Week
	<i>Peak Growth Phase</i>			<i>Senescense Phase</i>		
Temperature (°C)	26.0±0.94	26.0±1.22	18.0±0.71	18.0±0.94	4.0±0.35	3.0±0.18
pH	8.9±0.16	8.8±0.48	8.4±0.21	7.5±0.18	7.4±0.12	7.4±0.12
DO (mg/L)	7.0±0.38	7.2±0.32	7.7±0.14	8.3±0.9	8.4±0.15	9.1±0.38
BOD (mg/L)	141.1±4.6	138.5±6.6	131±5.8	111.2±4.74	106.2±2.9	102.9±2.26
CO <sub>2</sub> (mg/L)	4.6±1.13	4.8±1.30	4.4±1.00	5.2±1.30	8.6±2.00	9.4±1.12
Total Alkalinity (mg/L)	96.9±3.40	95.3±4.00	95.2±3.70	93.1±3.30	86.8±3.20	76.9±3.10
Total Hardness (mg/L)	143.3±2.70	132.3±4.40	128.4±2.90	94.1±3.60	84.9±4.30	82.5±3.30
Chloride (mg/L)	41.9±3.10	42.0±2.60	41.1±3.50	40.3±2.10	35.3±1.70	34.7±1.50
Nitrate Nitrogen (µg/L)	425.2±11.18	394.3±11.70	380.1±15.80	264.1±6.20	232.1±9.40	230.3±7.90
Total Phosphorus (µg/L)	220.1±15.81	218.6±13.99	214.3±10.38	211.6±12.66	207.1±13.00	206.9±12.45

#### 4. Discussion

The lake is characterized by highly alkaline pH during summer as well as in the winter season. pH range between 7.0 to 8.9 indicates productive nature of water body [5]. Also there was a decreasing trend of pH at all three sites which could be due to efficient utilization of phosphorus by macrophytic vegetation in the lake [6]. The lower values of dissolved oxygen observed during Peak Growth Phase could be due to cumulative effect of human activities like dumping of organic wastes from floating gardens where oxygen is used in decomposing these organic wastes. Oxygen level is depleted in water bodies due to decomposition of organic wastes [7] [8]. The high temperature and low DO during pre-monsoon (summer) create favorable conditions for development of blue-green algae [9]. Bio-Chemical oxygen demand is a parameter to assess the organic load in a water body. Many researchers have recorded higher BOD values in polluted water. The test result gives the indication that dal lake water is having higher value of BOD which directly hinders the aquatic life. The high concentration of free CO<sub>2</sub> during November may be attributed to the decomposition of organic matter while low concentration of free CO<sub>2</sub> during months of higher temperature season could be due to high photosynthetic activity [10]. Total hardness was found to be more during Peak Growth Phase. The higher concentration of both Ca<sup>2+</sup> and Mg<sup>2+</sup> in Dal Lake can be attributed to their leaching from agricultural soils [11]. The chloride concentration was observed higher in Peak Growth Phase (summer) than in *Senescense Phase* (winter). During summer months the concentration of chloride concentration is more than winter [12] [13]. Highest concentration of NO<sub>3</sub>-N was found in summer and least was in autumn. The high nitrate concentration in water bodies could be due to leaching and surface run off of nitro-phosphate fertilizers from nearby farm fields into Lake as well as from domestic run-off and organic load in summer and least concentration in Autumn

[14, 15, 16]. The highest concentration of PO<sub>4</sub><sup>-3</sup> in lake was observed in summer and least concentration in autumn. The significant increase in total phosphorus during summer is due to excess runoff from floating gardens as well as from agriculture catchment areas. Phosphate enters the Lakes through domestic wastewater, accounting for the accelerated eutrophication [17]. Besides this, weathering of parent bedrocks along the tributary water channel of Dal Lake, soil erosion in the catchment area could be the possible conformity of high concentration of PO<sub>4</sub><sup>-3</sup> in summers. PO<sub>4</sub><sup>-3</sup> enters surface water by ways of anthropogenic activities; wastewaters, land run off, domestic waste and fertilizers [18] [19].

#### 5. Conclusion

The present comparative study and results pertaining to the different basins of Dal Lake concludes that the increasing disturbances from the various anthropogenic sources are cause of deterioration of the water quality to great extent. Lake has been significantly polluted from last few years as a result of direct drainage of sewage, run-off and disposal of solid wastes. Ashai Bagh and Nehru Park basin in particular were observed to be more affected by the pollution sources arising from tourism and sewage disposal. For preventing and controlling the destruction of the Lake, various Basins should be instructed not to discharge their waste in the water as it results to further deterioration of the lake.

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