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Ecological monitoring of Dal Lake, Kashmir

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Abstract
In addition to natural siltation, the rapidly expanding human populations and rapid urbanization have threatened the Dal lake water ecosystem as well as the natural resources present in it. The present research investigated the levels of various physico-chemical parameters in three seasons, i.e. in winter, summer and autumn. Samples were obtained in each season from the four sites of selection. As strong denudation of the catchment area and agricultural activities with other activities affect the lake water and lake bed, water quality has been found to be unfit for domestic use. As the lake is located in the river's low lying field and flood plain, it receives material that flows into it and the consistency of the water begins to improve over a period of time. As a consequence, in a short period of time, large-scale improvements are seen in the Dal Lake, which are visible from the physico-chemical parameters examined in the work conducted compared to the earlier studies**.**

Keywords: Dal Lake, water quality, STP, waste, point source, contamination

1. Introduction
Water is the most plentiful and essential element in nature and occupies nearly 3⁄4th of the surface of the earth, but several variables have led to its constraint being so plentiful. The desirable water properties differ with the use of the effort. The disproportionate desires of human beings linked to water for their own usage, which may include multiple applications, such as economic, agricultural or leisure perspectives. For drinking purposes, treasured water is used, which must be practically
Pure, free from turbidity, bacteria, foul odour and colour [1]. Contact contaminants from different forms of sources, such as point sources (particularly wastewater discharges), non-point sources and diffuse sources, and even from atmospheric deposition, into waterways. It has also impacted lakes and wetlands, as most of the lakes in major cities have been poisoned. Because of its effect on economic activities, water contamination has raised a significant problem. In the background of a developing world such as India, the issue of water contamination holds greater significance. Although the problem's severity is immense and widespread, the losses due to its influence are very gigantic because of its direct and direct effects on human health and wellbeing. As a consequence of population growth, droughts and industrialization, the never-ending need and the scarce supply of safe and pure water is a challenge. The union territory of Jammu and Kashmir is the northern most part of Indian Territory. Located between the Himalayas with latitude of 32^0 17'N to 36^0 58'N and longitude 73^0 26'E to 80^0 30'E. It is famous for its health resorts and beautiful lakes. Very famous lake among these lakes is Dal Lake, which is on the verge of dying. The lake is 11.45 km^2 with floating gardens, including 4.1 km2 with 1.51 km2 of surface area and land and marsh are 2.25 km2 respectively [2].

In the summertime snow in deeper catchments melts, leading to full season flush into the Dal lake inlet Dachigam and Dara. A permanent stream named Telbal inlet enters from the lake, north and supply 80% of the lake named high-altitude water Lake of Marsar [3]. The key contributors to the depletion of the physico-chemical properties of the water quality of Dal Lake are land encroachments, urbanization, the use of pesticides, insecticides and fertilizers for farming activities, soil erosion, hotels situated nearby or on the banks which dump waste i.e, organic as well as inorganic effluents into the water body. The increase in the accumulation of nutrients results in high strung-eutrophication that disrupts the whole fresh water ecosystem. In the last few years, doubts have been raised; both the public and the state government voiced it over the dying and deteriorating state of Dal Lake [4]. The mind striking concerns and worries about the water quality deterioration of the Dal Lake which is the economical backbone to many communities, led us to carry out an investigation on the level of pollution in the lake.

2. Study Area (selection sites)
The four selection sites selected from the sample collection are as follows:

1. SITE-I also called as the lokut Dal, it is situated near the char chinar with an elevation of 1581 meters. This site has least human interference which means lesser pollution.
2. SITE-II is located in Dalgate and receives all the wastes of houseboats and other encroachments on it.
3. SITE-III is located on the eastern side of lake near LAAM STP.

4. SITE-IV is located on the western side of the lake and near Naseem bagh. This site receives the treated water of STP Habak.

3. Methodology

All the samples of water were collected from the surface from all the four sites. The samples were collected in 2 liter polyethylene bottles and for BOD in separate bottles. The BOD bottles were immediately covered with dark cover to prevent sunlight penetration. All the samples were immediately taken to the lab for analysis. All these samples were collected during the day in year 2019 in three seasons viz; summer season, autumn season, and winter season.

4. Result and Discussion

A total of 11 parameters were evaluated for checking the water quality of Dal Lake in different seasons. The experiments were carried out at the Environmental Science Department lab of AAA M Degree College, Bemina, Srinagar.

In deciding various other parameters such as pH, conductivity, saturation degree of gases and different types of alkalinity, temperature plays a key role [5, 6]. The water temperature ranged from 8.2^{0}C in winter to 25.1^{0}C in summer and 21.3^{0}C in autumn. The maximum temperature was recorded in summer season declining with a minimum temperature in winter season; the lake is warm monomictic [7, 8]. PH is an indicator of the hydrogen ion concentration in water and is an important element affecting the metabolism of the species that occupy it [5]. The ranges of pH ranged from 8.3 in winter, 8.5 in summer and 7.7 in autumn (table.2) the increase in the pH may be because of the use of pesticides and fertilizers for macrophytic vegetation produced on the floating gardens in Dal Lake. The calculation or numerical expression of a solution's ability to conduct electric current is conductivity. As much of the salts in the water are found in ionic forms capable of conducting current, the overall salt concentration is thus a safe and quick indicator (Mishra and Saxena 1993; Jameel 1998). The electrical conductivity of the water depends on the quantity of dissolved solids in it [11], the electric conductivity ranged from 245µScm^{-1} in winter, 237 µS cm^{-1} in summer and 106 µScm^{-1} in autumn season (Table-2). Oslen (1950) classified the water with conductivity values up to 200µScm^{-1} as oligo-mesotrophic and 200-500µScm^{-1} as ß-mesotrophic. The alkalinity of the water is the capacity to neutralize a strong acid and is characterized by the presence of hydroxyl ions capable of being combined with hydrogen ion. The presence of carbonates and bicarbonates that come from the weathering of rocks is mostly due to alkalinity [5]. The total alkalinity was observed to be lower during winter season (113 mg/L) and higher during autumn season (188 mg/L). The total hardness was higher in winter season (257 mg/L) followed by autumn season (215 mg/L) and was lesser in summer season (179 mg/L) (Table-2). The hardness of the lake water could be because of weathering of rocks which release bivalent salts like calcium and magnesium making the lake water hard. According to our calculations the water of the Dal Lake can be categorized as moderately hard to very hard. Calcium is one of the most plentiful compounds in the natural waters. Since it is found in high concentrations in the rocks, it is leached from them to contaminate the water. The amount of natural water typically ranges from 10 mg / L to 100 mg / L depending on the form of rock. Disposal of sewage is also an essential source of calcium [13]. The calcium levels were found to be high in winter season (47.5 mg/L) followed by summer season (23.2 mg/L) and lowest in autumn season (19.2 mg/L) (Table-2). Magnesium levels in winter season were 22.4 mg/L, with 12.5 mg/L in summer and with lowest levels 10.5 mg/L in autumn. Magnesium co-exists with calcium in all natural waters and its levels are always lesser than calcium levels. According to ISI (1986) the maximum permissible limit of magnesium in drinking water is 30 mg/L, which means the magnesium level in Dal Lake does not surpass limits. Chloride levels in Dal lake in winter season was 40.9 mg/L, 35.3 mg/L in summer and 15.7 mg/L in autumn. Chloride is added to the water usually through sewage and human excreta, its passage in water can be prevented by treating it in sewage treatment plants. Presence of chlorine in water is also the indicator of pollution in the water body. Total phosphate levels in Dal Lake in winter season was 551 µg/L, 245 µg/L in summer and 415 µg/L (Table-2) in autumn. The phosphate sources usually are detergent and agricultural effluents, which have lead to the algal blooms in the Dal Lake and in turn to eutrophication. The total dissolved solids in Dal Lake were 199 mg/L in winter, 105 mg/L in summer and 178 mg/L (Table-2) in autumn. The higher level of TDS in water indicates the presence of dissolved minerals and nutrients. The levels of dissolved oxygen were higher in summer season (11.6 mg/L) followed by 10.1 mg/L (Table-2) in summer and with lower levels in autumn season. The lower level of the dissolved oxygen in water is due to the dumping of organic wastes in the water. Turbidity in winter was found to be 15.5 NTU, 11.0 NTU in sum mar and 19.1 NTU (Table-2) in autumn. The turbidity is usually caused by the addition of organic matter, clay and silt to the water and therefore shows the optical appearance of water body. ISI (1986) prescribed 10 NTU as the limit of turbidity for drinking purposes. Nitrate levels were found to be higher in summer season (520µg/L) and autumn season (471µg/L) and with lower value of 293µg/L in winter. The higher nitrate levels in the water are due to the addition of nitrate rich fertilizers to the nearby lands and floating gardens of Dal Lake. Ammonical nitrogen levels were found to be higher in autumn season (250µg/L), 176µg/L in summer and 134.6µg/L (Table-2) in winter. The main sources of Ammonical nitrogen in the water is the detergents and other wastes from the house boats in the Dal Lake and the presence of human feaces. Water temperature was recorded as 8.2 ^{0}C in winter, 25.1 ^{0}C in summer and 21.3 ^{0}C (Table-2) in autumn. The water temperature is an important aspect which helps in determining various physical parameters of water.

The comparisons from 1977-2017 has been shown in Table-5; according to the comparisons the pH over the period of time has increased making Dal lake acidic in nature. The conductivity has also showed an increasing trend which makes the Dal lake ß-mesotrophic [12]. The levels of dissolved oxygen have also reduced over time due to the direct or indirect duping of wastes in the lakes. As already discussed the presence of chlorine in the water bodies is the indicator of pollution, the chorine levels have shown an increasing trend which indicates water of Dal Lake is polluted.

Table 1: Parameters evaluated for water quality

Parameters	Methods and instrumentation
pH	pH meter
Electrical Conductivity	Conductivity meter
Total Alkalinity	Titration method
Hardness of water (calcium & magnesium).	EDTA Titration method
Chloride	Titration method
Total phosphate	Stannous chloride method
Total Dissolved solids	TDS meter
Dissolved oxygen	Winkler's method
Nitrates	Phenol disulphonic method
Turbidity	Nephelo turbidity meter
Ammonical Nitrogen	Nesserilization method
Water Temperature	Graduated Celsius Thermometer

Table 2: Different seasonal phases of Kashmir region.

Seasons	Months	Duration	Mean Temperature (^{0}C)
Spring	March-May	3	9.4-18
Summer	June-August	3	25-27
Autumn	September-November	3	21-8.1
Winter	December-February	3	1.06-2.5

Table 3: Comparisons of different physico-chemical parameter values (1997-2017).

Parameters	Units	Hazratbal basin		Bod Dal		Gagribal		Nigeen		Nishaat Intake		Nehru Park	
		1977-1995	2008-2017	1977-1996	2008-2017	1977-1996	2008-2017	1977-1996	2008-2017	1977-1995	2008-2017	1977-1996	2008-2017
pH	-	8.7	7.6	6.1	7.7	7.6	8.5	7.7	8.3	7.3	8.3	8.5	8.9
Conductivity	μScm^{-1}	975.2	354.2	330.7	974.5	322.7	285.7	355.5	224.2	103	198.2	143	938.2
Dissolved Oxygen	mg/L	7.07	5.1	7.5	4.5	6.9	5.2	5.6	5.2	11.6	7	10.8	5.5
Total-Alkalinity	mg/L	109.75	104.5	101.5	158.7	87	139	141	121.7	95.9	125.3	94.5	149
Calcium	mg/L	18.4	189.7	33.1	143.5	20.1	130.6	28.8	125.0	27.2	86.5	24.3	82.9
Magnesium	mg/L	9.32	57.9	7.7	53.8	7.35	42.1	10.0	77.5	2.1	72.4	2.0	74.1
Chloride	mg/L	3.0	12.5	11.3	15.2	9.8	11.32	5.7	13.6	31.5	12.5	6.8	11.07
TDS	mg/L	317.3	298.5	412	187.9	132.1	244.7	177.6	122.8	237.5	205.1	190	434.2
Nitrates	µg/L	248	10.9	323.25	12.38	232	12.0	331.5	11.4	122.5	13.0	10.6	14.1

Table 4: Results of water quality from three different seasons (2019)

Parameters	Winter season 2019 (Dec-Feb)	Summer season 2019(June-August)	Autumn season 2019 (Sept-Nov)	Units
pH	8.3±0.3	8.5±0.7	7.7±0.6	
Electrical conductivity	245±14	237±16	106±2.4	μScm^{-1}
Total Alkalinity	113.5±20.3	131.7±28.1	188.0±7.0	mg/L
Total Hardness	257.0±34.5	179.8±34.3	215.1±21.0	mg/L
Calcium	47.5±8.5	23.2±2.5	19.2±1.3	mg/L
Magnesium	22.4±2.8	16.1±2.1	10.5±0.3	mg/L
Chloride	40.9±22.3	35.3±2.5	15.7±1.4	mg/L
Total Phosphate	551±21.2	245±23.2	415±45.3	µg/L
Total dissolved solids(TDS)	199±11.8	105±31.8	178±2.9	mg/L
Dissolved oxygen	10.1±0.9	11.6±0.10	3.3±0.6	mg/L
Turbidity	15.5±1.0	11.0±0.3	19.1±1.7	N.T.U
Nitrates	293±10.2	520.2±60.3	471±22.9	µg/L
Ammonical Nitrogen	134.2±11.3	176±12.0	250±0.7	µg/L
Water Temperature	8.2±4.0	25.1±3.0	21.3±1.3	^{0}C

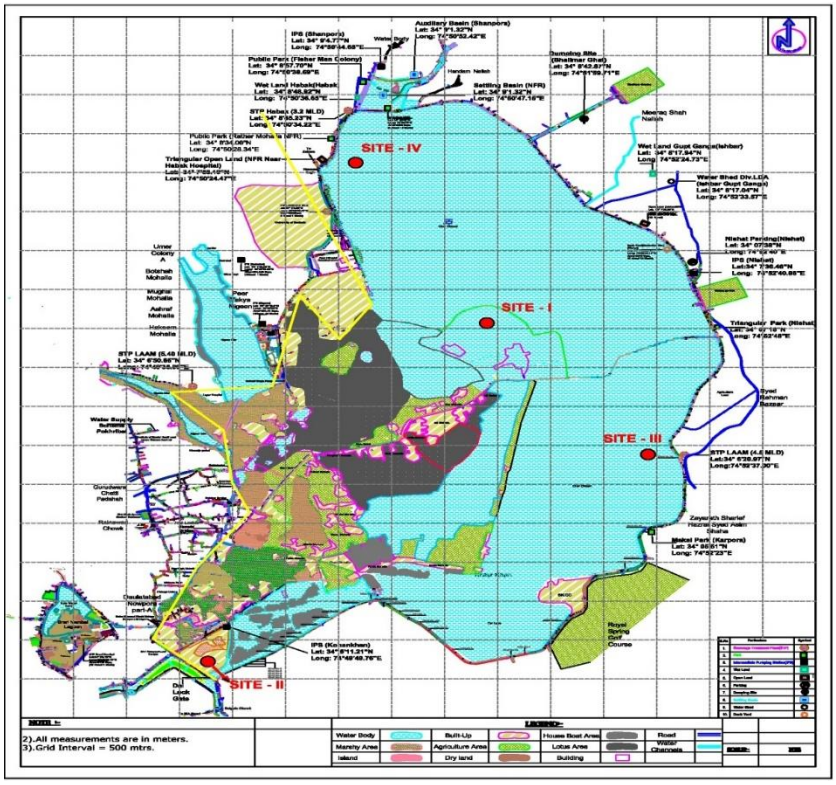

Fig 1: Map of Dal Lake showing the selection sites for sample collection."

5. Conclusion

This analysis shows the declining water quality of the Dal Lake. It is a very popular tourist attraction in UT of Jammu and Kashmir and acts as an economic boom for different communities. As per the findings of this analysis it is clear that the water quality of the lake has declined over time and is unfit for domestic use. House boats, tourist strain, agricultural runoff and hotel sewage are the major causes of water quality deterioration, so the State Pollution Control Board and LAWDA must take different steps by developing and implementing various awareness campaigns and regular monitoring to save the dying water body.

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