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ASSESSMENT OF PHYSICO-CHEMICAL PARAMETERS AND METAL ION LOAD IN DAL LAKE, KASHMIR.

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ABSTRACT

An investigation was carried out to monitor the pollution load of the Dal Lake Kashmir. Monthly variation of some physico-chemical parameters and metal Ions such as Temperature, pH, Total solids, Total dissolved solids, Hardness, Free carbon dioxide, Carbonates, Bicarbonates, Total nitrogen (Nitrites, Nitrates and Ammonical Nitrogen), Total Phosphates, Sodium, Potassium and Magnesium were determined during the period from March to August 2015. A total of fifty four (54) water samples from three sites of Dal Lake (Hazratbal, Nishat and Telbal) were collected.The results revealed highest values of various physico-chemical characteristics viz. temperature, pH, total solids, hardness and bicarbonates, and elemental load (Na & Mg) in the water samples collected from Hazratbal site followed by Nishat and Telbal. However, maximum concentration of total dissolved solids, free CO_2 and ammonical-N were observed at Telbal site. Moreover, at Nishat site comparatively higher concentration of carbonates, total phosphate, nitrate-N, nitrite-N and potassium were recorded. The investigation revealed that Dal Lake is under rapid pollution threat. Contaminants enter the lake through direct point sources, diffused agricultural sources and urban sources, which accelerated the macrophytic/microphytic growth and have reduced the water quality, the recreational and aesthetic appeal of the lake.

***Keywords*: *Contaminants, Dal Lake, Metals, Physico-chemical, Pollution*.**

I. INTRODUCTION

Water is one of the most essential natural resource available to mankind. Knowing the importance of water for sustenance and survival of life, the need for conservation and protection of water bodies particularly the fresh water bodies is being recognised everywhere in the world **[1].** Due to increased human population, industrialization, use of fertilizers and various human activities, the natural aquatic resources are facing heavy and varied pollution in aquatic environment leading to depletion of water quality and aquatic biota. Most of

wastewaters are dumped straight into lakes, rivers and other water bodies without any treatment. Lakes are not only the source of precious water, but provide valuable habitats to plants and animals, regulate hydrological cycles, effect microclimate and improve the aesthetic beauty of the landscape. Due to drastic rise in developments around the lake surroundings and very low dispersion and high mobilization rates, the deterioration of lake water quality throughout the world has become a direct threat to its flora and fauna **[2]**. The Dal Lake is the second largest lake of Kashmir covering an area of about 11.56 sq. km. It is situated between $34^{o}5' - 34^{o}6'$ N latitude and $74^{o}8' - 74^{o}9'$E longitude. It is a shallow open drainage type water body divided into five basins *viz*. Hazratbal, Gagribal, Nishat, Nigeen and 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 Marsar lake and Botkol. Besides, a number of other small streams (Meerakshah and Pishpavstreamlets) and surface runoff from surrounding mountains from Nishat and Gagribal side also enter into the lake. Dal Lake plays a major role in the economy of the state of jammu and Kashmir **[3]**. The lake has been attracting the attention of national and international tourists for centuries, a goldmine for inhabitants as it provides livelihood to thousands of people who draw benefits from it through a series of trade activities ranging from farming to fish production. It has been observed that pollution problem in the basins of Dal Lake of Kashmir is mainly due to addition of major plant nutrients particularly nitrogen and phosphorus derived from human wastes, detergents and agricultural practices. The organic and inorganic pollutant load in the Dal has accelerated the macrophytic/microphytic growth which in turn has reduced the water quality, the recreational and aesthetic appeal of the lake.

Each source of contamination has its own damaging effects on plants, animals and human **[4].** The water quality of Dal lake has deteriorated considerably in the last three decades due to illegal encroachments, hyper-eutrophication, organic matter dumping, sewage and other pollutants **[5]**.The Lake ecosystem and its survival will be in danger if the present rate of pollution continues unabatedly.

II. MATERIALS AND METHODS

2.1 STUDY AREA AND SAMPLING

The present work was carried out at Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. Three sites in Dal lake viz. Nishat, Telbal and Hazratbal were selected for carrying the present experiment. Water sample collection was done randomly from three selected locations.Three water samples were collected at random once in each month (March, April, May, June, July and August) from each location in 2 litre Van Dorn plastic bottles by dipping them 10cm below the water surface.

2.2 PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES

The physico-chemical parameters of the water samples collected from study sites were analysed as per "American Public Health Association" **[6]**. All the parameters were analysed within 24 hours of sampling following the standard methods.

2.3 METAL IONS IN WATER SAMPLES

All equipment used for sample collection, storage and analysis of metal Ions were pre-cleaned using high-purity nitric acid (GFS Chemicals Inc.) and rinsed with copious amounts of Milli-Q water to ensure that they are trace-metal free. After rinsing, the bottles were stored in double-bagged zip-lock polyethylene bags. The samples were collected in polypropylene bottles and filtered immediately through 0.45 µm and acidified with ultra-pure HNO_3 to pH<2 and stored at $4^{o}C$ prior to metal Ion analyses. The analysis of water samples for estimating metal ions Viz. Na, Mg and K was carried out using methodology given by APHA, 1998. The instrument setting and operational conditions were done in accordance with the manufacturer's specifications.

2.4 STATISTICAL ANALYSIS

The data was subjected to ANOVA using MINITAB® Statistical Software for Windows ver. 14 ***[7].** Data was compared for all parameters in water samples from the selected study sites using analysis of variance to test for differences amongst sites and sampling occasions (p = 0.05).

III. RESULT AND DISCUSSION

3.1 PHYSICO-CHEMICAL CHARACTERISTICS OF DAL LAKE WATER SAMPLES (TABLE 1):

Water temperature is one of the most important limnological parameters that play a prominent role in regulating nearly all physico-chemical characteristics and biological productivity of water as well as it controls the nutrient input and turnover **[8].**The surface water temperature of all the study sites revealed that the water temperature showed significant variation from March to August. The highest water temperature was observed at Hazratbal site exhibiting value of 26.0±1.0^{o}C, followed by Nishat with a value of 25.9±1.05^{o}C in the month of August whereas lowest water temperature of 15.5±0.50^{o}C was recorded at Telbal site in March. The variation in temperature observed in the present study is in agreement with **[9]**.

pH is considered as one of the most important chemical parameter of water since most of the aquatic organisms are adapted to an neutral pH. Considerable variation in pH was observed in different months at all the selected sites because of exposure to the air and other related biological activities **[10]**. The fluctuation in water pH at different sites of Lake ecosystem was almost similar during different months of the year. The Dal lake was characterized by high alkaline pH at Hazratbal (8.0±0.50) and Nishat (7.8±0.61) during the month of March whereas the pH of Telbal site was relatively low (7.2±0.20).

The examination of data indicated that total solid were maximum at Hazratbal site (321 mg/l) followed by Nishat site (320 mg/l) in the month of April whereas minimum value of total solids was recorded at Telbal site (105.8 mg/l) in the month of June. Total dissolved solids showed significant variation in different monthsat all the selected sites with Telbal site recording maximum values of total dissolved solids (173 mg/l). The water samples

of Hazratbal site recorded higher values of total hardness (154±7.21 mg/l), followed by Nishat site (146±5.56 mg/l) in the month of July. The results are supported by **[9],** who reported that high level of TDS is an indicator of potential concerns and warrants further investigation.

The water samples of Telbal site recorded highest free CO_2 values of 10.2±1.0 5 mg/l followed by 9.9±0.95 mg/l at Hazratbal site in March; whereas, the water samples of Nishat site recorded lowest content of free CO_2 with a value of 1.7±0.32 mg/l and 1.7±0.23 mg/l in the month of May and June, respectively. The value of CO_2 depends upon alkalinity and hardness. The high concentration of free CO_2 during March may be attributed to the decomposition of organic matter while low concentration of free CO_2 during months of higher temperature season could be due to high photosynthetic activity by autotrophs **[11]**.

The values of carbonates were found significantly variable in different months at different sites with highest carbonate concentration observed at Nishat site with a value of 42.3±2.56 and 42.2±4.16 mg/l in the month of August and July, respectively, whereas, the lowest values of carbonates were recorded at Telbal site with a value of 23±2.0 and 24.4±8.31 mg/l in the month of March and April, respectively.

Significant variation was found in bi-carbonate concentration at all the sites in different months. The highest values of bi-carbonate concentration was recorded at Hazratbal exhibiting value of 198.2±9.22 and 198±7.21 mg/l in the month of July and June, respectively; whereas water samples of Telbal recorded lowest concentration of bicarbonate with a value of 154.2±5.89 and 159±2.64 mg/l in the month of April and March, respectively. The relatively high content of total solids, total dissolved solids, total hardness, carbonates and bi-carbonates is attributed to the presence of nutrient load released into Dal Lake due to high anthropogenic activities in the catchment area such as domestic waste water, waste disposal, agricultural runoff and geological nature of drainage basin **[9].**

3.2 KEY NUTRIENTS IN DAL LAKE WATER SAMPLES (TABLE 2)

The data revealed highest concentration of phosphate at Hazratbal site (685.8±6.61µg/l) in the month of March followed by Nishat site (670.4±6.31) in the month of July; whereas, the water samples of Telbal site observed lowest concentration of total phosphate (305.7±5.80 µg/l) followed by Nishat site (309.8±7.83 µg/l) in the month of April, respectively. Phosphorus is an important nutrient for various metabolic processes and controlling the biological productivity especially in aquatic ecosystems. Phosphorus is regarded as the key element in the eutrophication process. From the present study, it can be concluded that Dal lake is significantly advanced in its trophic status and at present showing eutrophic status **[5].**

Nitrate is the most oxidized form of nitrogen and is an important plant nutrient. Due to its higher mobility as compared to other vital nutrients, its concentration in freshwater apart from autochthonous production is largely

regulated by waste water loading, agricultural runoff and ground water inputs. The results revealed that highest values of nitrate-N was recorded at Nishat site (538.2±10.84 µg/l) followed by Telbal site (528.5±9.04 µg/l) in the month of June whereas the lowest value of nitrate-N were recorded at Telbal site (316.9±4.43 µg/l) followed by Nishat site (340.2±6.76 µg/l) in the month of March. Maximum concentration of nitrite-N was noticed at Nishat site (70±5.29 and 68±9.84 µg/l) in May and April, whereas the water samples of Hazratbal recorded lowest concentration of nitrite-N (19±7.0 µg/l) in the month of June. These results are supported by the findings of **[12].**

When nitrogenous organic matter is destroyed by microbiological activity, ammonia is produced which is generally found in many surface and ground waters. Higher concentrations occur in water polluted by sewage, fertilizers, agricultural wastes or industrial wastes containing organic nitrogen, free ammonia or ammonium salts **[13].** It was found that the maximum concentration of ammonical-N was observed at Telbal site with a value of 311.6±2.16 µg/l and 296±7.81 µg/l in the months of July and August, respectively; whereas the lowest content of ammonical-N was recorded at Nishat site (101.8±4.95 µg/l) in August. The concentration of ammonia is usually low in aerobic water because it is utilized by plants. Since the values of ammonical nitrogen are quite high in the lake, they are suggestive of high degree of sewage pollution in the lake.

3.3 METAL ION (NA, MG AND K) CONCENTRATION OF WATER SAMPLES (TABLE 3)

The concentration of metal ions (Na, Mg and K) in water samples of Dal lake is presented in table 3. Water samples at different locations varied significantly with respect to metal ions viz. Na, Mg and K. Metal ion concentration of water samples at different locations followed the order Na>K>Mg. It was found that water samples of Hazratbal site recorded maximum concentration of Na (34.8±2.55 mg/l) and Mg (6.0±2.38 mg/l) in the month of July, whereas the minimum concentration of Na was observed in the water samples of Telbal site (18.7±4.93 mg/l) in the month of May and lowest Mg content (3.2±1.70 mg/l) was found in the water samples of Nishat site in the month of August respectively. The higher concentration of Na and Mg at Hazratbal site of Dal Lake might be due to the excess drainage of sewage into the lake that has been manifested due to high anthropogenic activities **[9].** Water samples of Nishat site recorded maximum concentration of K (18.3±3.20 mg/l) followed by Hazratbal site with K concentration of 18.0±1.73 mg/l in the month of July, whereas the water samples of Telbal site recorded lowest concentration of K (6.01±1.0 mg/l) in the month of May. Although potassium is a relatively abundant element, its concentration in natural fresh waters is usually less than 20 mg/l. The increase in metal ions (Na Mg and K) might be due to the fact that this region receives huge quantities of sewage and agricultural drainage water enter into Dal Lake whereas the monthly variation in metals may be attributed to the fluctuations in the amount of agricultural drainage water and sewage effluents discharged into the lake **[12]**.

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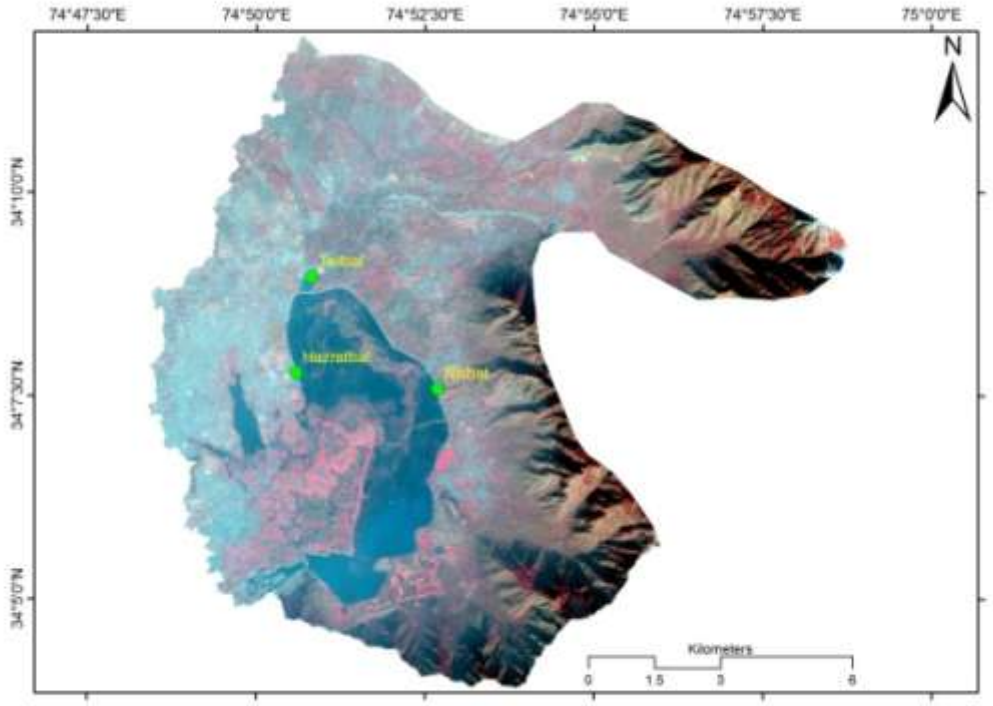
IV. FIGURES AND TABLES

4.1 SAMPLIG AREA



4.2 TABLE 1 PHYSICO-CHEMICAL CHARACTERISTICS OF DAL LAKE WATER SAMPLES.

Parameter	Sites	March	April	May	June	July	August	Mean ±SD	CD(p<0.05)
Temperature (^oC)	**Telbal**	15.5 ±0.50	16.9 ±0.81	18.3 ±0.96	20.3 ±0.85	21.9 ±1.21	24.7 ±1.68	19.6 ±3.39	1.190
	Nishat	16.3 ±0.81	17.8 ±1.08	19.4 ±3.21	23.5 ±1.11	24.3 ±0.88	25.9 ±1.05	21.2 ±3.89	
	Hazratbal	16.8 ±1.11	18.1 ±0.95	19.5 ±0.87	23.6 ±1.73	24.5 ±0.86	26 ±1.00	21.42±3.77	
	Mean ±SD	16.2±0.65	±0.62	19.06±0.66	±1.87	23.56±1.44	±0.72		
	CD(p<0.05)	0.842							
pH	**Telbal**	7.2 ±0.20	7.5 ±0.60	7.3 ±0.20	7.6 ±0.37	7.6 ±0.15	7.2 ±0.30	7.4±0.18	0.346
	Nishat	7.4 ±0.11	7.6 ±0.26	7.6 ±0.15	7.8 ±0.10	7.8 ±0.61	7.4 ±0.66	7.6±0.17	
	Hazratbal	7.5 ±0.50	7.6 ±0.28	7.6 ±0.10	8 ±0.50	8 ±0.50	7.5 ±0.26	7.7±0.23	
	Mean ±SD	7.366±0.15	7.56±0.05	7.5±0.17	7.8±0.2	7.8±0.2	7.36±0.15		

	CD(p<0.05)	0.244							
Total solids (mgl^{-1})	**Telbal**	195 ±9.16	246 ±4.58	243 ±6.24	105.8 ±5.4	163.8 ±8.84	198.6 ±3.3	191.95±525	6.548
	Nishat	314.4 ±3.2	320 ±8.00	267 ±8.18	168.5 ±3.5	248.9 ± 8.48	270 ±6.55	264.8±54.8	
	Hazratbal	319.8 ±8.6	321 ±7.54	301 ±8.54	143.2 ±1.9	268.4 ±8.90	286 ±9.16	273.23±668	
	Mean ±SD	276.4±70.54	295.6±43.0	270.3±29.14	139.1±31.5	226.8±55.90	251.5±46.5		
	CD(p<0.05)	4.630							
TDS (mgl^{-1})	**Telbal**	107 ±6.24	173 ±9.84	166 ±5.56	95.2 ±2.10	96 ±1.00	96 ±3.60	122±36.9	5.473
	Nishat	124 ±6.08	130 ±7.00	127 ±4.35	83 ±5.29	114.8 ±5.73	101 ±5.29	113.3±18.1	
	Hazratbal	118.5 ±6.1	142 ±6.24	139 ±4.35	113.8 ±6.1	115 ±4.58	104 ±4.58	122.05±151	
	Mean ±SD	116.5±8.67	148.3±22.18	144±19.97	97.33±15.51	144±19.97	97.33±15.51		
	CD(p<0.05)	3.870							
Hardness (mgl^{-1})	**Telbal**	74 ±5.29	75 ±4.00	73.1 ±5.17	80 ±2.00	89±4.00	86 ±3.46	79.5±6.69	5.910
	Nishat	88 ±12.16	99.2 ±5.25	75.7 ±8.32	74±3.00	146 ±5.56	94 ±7.21	96.1±26.3	
	Hazratbal	89 ±6.08	115.4 ±8.2	111.9 ±7.6	112 ±7.00	154 ±7.21	121 ±5.29	117.2±21.0	
	Mean ±SD	83.66±8.38	96.53±20.33	86.9±21.68	88.66±20.42	129.66±35.44	100.33±18.13		
	CD(p<0.05)	4.179							
Free Co_2 (mgl^{-1})	**Telbal**	9.0 ±1.47	3.4 ±1.21	1.7 ±1.53	1.7 ±1.47	1.8 ±0.72	5.6 ±1.53	3.86±2.94	1.025
	Nishat	9.9 ±0.95	4.2 ±1.30	3.2 ±1.38	3.1 ±0.81	2.3 ±0.81	4.4 ±0.45	4.51±2.74	
	Hazratbal	9.7±0.62	5.73±3.37	4.73±4.02	3.8±2.52	3.46±2.46	5.56±1.15		
	Mean ±SD	9.0 ±1.47	3.4 ±1.21	1.7 ±1.53	1.7 ±1.47	1.8 ±0.72	5.6 ±1.53	3.86±2.94	
	CD(p<0.05)	0.725							
Carbonates (mgl^{-1})	**Telbal**	23.0 ±2.00	24.4 ±8.31	28.8 ±7.27	29 ±2.64	30.1 ±7.04	28 ±2.64	27.21±2.84	4.783
	Nishat	36.1 ±7.10	38.2 ±4.23	40.2 ±3.36	40 ±4.58	42.2 ±4.16	42.3 ±2.56	39.83±2.38	
	Hazratbal	32.2 ±3.38	32.6 ±3.41	33.9 ±2.25	37 ±4.58	39.2 ±4.95	36.8 ±9.71	35.28±2.80	
	Mean ±SD	30.43±6.72	31.73±6.94	34.3±5.71	35.33±5.68	37.16±6.30	35.7±7.21		
	CD(p<0.05)	3.382							
Bicarbonates	**Telbal**	159 ±2.64	154.2±5.89	166.8±5.30	172 ±4.35	168.3 ±7.42	160.2 ±9.94	163.4±6.68	6.558

(mgl^{-1})	**Nishat**	177 ±6.08	170 ±7.93	190.6±4.73	190.2±8.83	196 ±7.81	183.2 ±8.51	184.5±9.70	
	Hazratbal	198 ±7.93	186.2 ±8.8	194.5±6.61	198 ±7.21	198.2 ±9.22	180.1 ±2.85	192.5±7.62	
	Mean ±SD	178±19.51	170.13±16 00	183.98±15 00	186.73±13 34	187.5±16.60	174.5±12.48		
	CD(p<0.05)	4.637							

4.3 TABLE 2 SHOWING THE CONCENTRATION OF NUTRIENTS IN DAL LAKE WATER SAMPLES

Parameter	**Sites**	**March**	**April**	**May**	**June**	**July**	**August**	**Mean ±SD**	**CD(p<0.05)**
Total Phosphat (ugl^{-1})	**Telbal**	355.2 ±7.0	305.7 ±5.8	401.1 ±2.7	511.6±6.50	515.6 ±8.06	318.9 ±5.2	401.35±93 0	6.164
	Nishat	380.2 ±7.5	309.8 ±7.8	502.3±8.57	569 ±5.56	670.4 ±6.31	660 ±2.00	515.2±147 3	
	Hazratbal	685.8 ±6.6	509.2 ±7.4	568.4±6.02	600.4±7.72	650 ±7.55	532.2 ±7.4	591±68.14	
	Mean ±SD	473.73±18 .0	374.9±116 32	490.6±84.2 6	560.33±45 02	612±84.10	503.7±172 3		
	CD(p<0.05)	4.359							
Nitrate-N (ugl^{-1})	**Telbal**	316.9 ±4.4	382.8 ±7.1	403.2 ±9.2	528.5 ±9.0	514.4 ±8.50	385.6 ±8.6	421.9±82.6	7.471
	Nishat	340.2 ±6.7	450 ±8.54	502.2 ±8.4	538.2±10.8	523.1 ±8.70	380.9 ±5.4	455.7±80.5 9	
	Hazratbal	396 ±7.93	436.5 ±6.8	513.4 ±7.6	522 ±8.54	486 ±7.54	423 ±9.00	462.8±51.6 5	
	Mean ±SD	351.0±40.6 4	423.1±35.5 4	472.93±60 64	529.56±8.1 5	507.83±19.4	396.5±23.0 6		
	CD(p<0.05)	5.283							
Nitrite-N (ugl^{-1})	**Telbal**	**24 ±7.21**	**22 ±8.18**	**19 ±9.53**	**23 ±7.21**	**34 ±9.84**	**25 ±7.54**	**24.5±5.09**	6.989
	Nishat	51 ±8.00	68 ±9.84	70 ±5.29	62 ±7.54	19 ±7.21	39 ±7.54	51.5±19.68	
	Hazratbal	31 ±7.21	26 ±7.00	22 ±7.54	19 ±7.00	22 ±4.58	28 ±5.56	24.66±4.45	
	Mean ±SD	35.33±14.0 1	38.66±25.4 8	37±28.61	34.66±23.7 5	25±7.93	30.66±7.37		
	CD(p<0.05)	4.942							

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Ammonical-N (ugl^{-1})	**Telbal**	**235 ±8.00**	**234.5 ±9.3**	**195.5 ±8.0**	**285.9 ±7.1**	**311.6 ±2.16**	**296 ±7.81**	**259.7±44.8**	7.463
	Nishat	198.2 ±8.1	186.4±11.6 5	125.6 ±10.	153.7 ±8.5	161.7 ±6.55	101.8 ±4.95	154.5±36.3	
	Hazratbal	204.2 ±7.5	197 ±7.81	238 ± 8.54	214.2 ±8.8	225.6 ± 9.0	206.7 ±6.68	214.2±15.1	
	Mean ±SD	212.46±19 74	205.96±25 27	186.3±56.7 5	217.93±66 17	232.9±75.22	201.5±97.20		
	CD(p<0.05)	5.277							

4.4 TABLE 3 SHOWING METAL ION (NA, MG AND K) CONCENTRATION OF WATER SAMPLES

Parameter	**Sites**	**March**	**April**	**May**	**June**	**July**	**August**	**Mean ±SD**	**CD(p<0.05)**
Sodium (mgl^{-1})	Telbal	19.2 ±5.07	19.2 ±5.02	18.7 ±4.93	18.9 ±3.55	19.2 ±1.74	19.7 ±4.70	19.15±0.33	3.832
	Nishat	20.5 ±6.08	22.3 ±2.56	22.8 ±2.55	27.5 ±7.08	33.6 ±5.24	23.01 ±4.3	24.95±4.82	
	Hazratbal	20.5 ±2.29	26.8 ±3.01	29.00 ±3.6	29.6 ±2.16	34.8 ±2.55	27.23 ±3.3	27.98±4.64	
	Mean ±SD	20.06±0.75	22.76±3.82	23.5±5.18	25.33±5.66	29.2±8.68	23.31±3.77		
	CD(p<0.05)	2.710							
Potassium (mgl^{-1})	**Telbal**	6.06 ±4.29	6.05 ±3.54	6.01 ±1.00	7.7 ±1.53	9.6 ±2.53	9.1 ±3.48	7.42±1.63	2.784
	Nishat	8.2 ±5.25	8.96 ±2.62	11.2 ±3.30	14.7 ±3.23	18.3 ±3.20	17.4 ±3.32	13.12±4.30	
	Hazratbal	7.9 ±3.95	7.4 ±0.60	9.4 ±2.27	15.2 ±0.72	18 ± 1.73	17.6 ±2.94	12.58±4.90	
	Mean ±SD	7.38±1.15	7.47±1.45	8.87±2.63	12.53±4.19	15.3±4.93	14.7±4.85		
	CD**(p<0.05)**	1.969							
Magnesium (mgl^{-1})	Telbal	5.00 ±1.80	4.7 ±0.70	4.78 ±0.83	5.00 ±1.11	5.00 ±0.60	4.1 ± 0.65	4.76±0.34	0.951
	Nishat	4.00±0.70	5.00 ±2.00	4.1 ±1.60	3.5 ±1.80	3.5 ±0.62	3.2 ±1.70	3.88±0.64	
	Hazratbal	4.5 ±1.80	4.1 ±1.12	3.5 ±1.3	5.00 ±2.23	6.00 ±1.30	6.00 ±2.38	4.85±1.017	
	Mean ±SD	4.5±0.5	4.6±0.45	4.12±0.64	4.5±0.86	4.83±1.25	4.43±1.42		
	CD(p<0.05)	0.673							

V. CONCLUSION

It was concluded from the study that the physico-chemical parameters and elemental load was highest at Hazratbal, followed by Nishat and lowest at Telbal, which could be attributed to enhanced anthropogenic activities. The water quality of Dal lake has deteriorated considerably due to illegal encroachments, hyper-eutrophication, organic matter dumping, sewage and other pollutants. Direct discharge of untreated human wastes

from houseboats and 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 area of open water within the lake. Various measures proposed for the conservation of the lake include afforestation of the catchment area, control of grazing in the catchment area, installation of a sewage treatment system and continuous monitoring of the lake environment. All these measures are expected to reduce the nutrient level, which is quite unfavourable at present, and help in increasing the aesthetic appeal of the lake.

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