

Comparative Assessment of Limnochemistry of Dal Lake in Kashmir

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Abstract

A comparative assessment of different water quality parameters of Dal Lake, Kashmir was carried out during 2005 and 2015 in order to assess the changes that have occurred over time. The data was collected from five stations of the Lake during both the years. The results obtained indicate that the water quality of Dal Lake has significantly deteriorated. The different water quality parameters such as dissolved oxygen, chloride, NH₄-N, NO₃-N and total phosphorus showed marked variation from 2005 to 2015 with One Sample t-test showing significant differences ($p=0.000$) over this period. The NSFQI ranges from 25-50 for both the years indicating the high pollution level and bad water quality of the Lake. The results of the present comparative investigation reflected increasing nutrient load in the Dal Lake which needs to be monitored for the conservation of Lake ecology.

Keywords: Water quality; Nutrients; Anthropogenic sources; Lake ecology; NSFQI

Introduction

Aquatic ecosystems especially Lakes are a reflection of the watershed and the topography, soil, geology as well as vegetation determine the kind of materials entering into the Lakes that in turn reflect on the water quality of these ecosystems [1]. In a natural state, aquatic ecosystems are largely controlled by geomorphic and physiographic factors such as geology, geomorphology and hydrology. Centuries of land use has, however, altered the geomorphology and hydrology of many aquatic systems [2]. Such anthropogenic transformation of the catchment area may accelerate the enrichment of nutrients and organic substances of waters, particularly in strongly changed urban landscape [3]. Nutrient enrichment of Lakes is one among the many major environmental problems encountered in the freshwater ecosystems around the world [4]. Though it stimulates the growth of plants (algae as well as higher plants), nutrient enrichment ultimately leads to deterioration of water quality and degradation of the entire ecosystem [5]. The process of nutrient enrichment is accelerated by the human activities in and around the freshwater ecosystems [5,6]. The chemistry of Lake Water is a cumulative reflection of catchment geology, weathering and erosional processes as well as anthropogenic inputs.

Lake ecosystems have been used to study a number of processes that are important in understanding limnological processes and chemical exchange between water and sediments. These ecosystems act as vessels for storing nutrients and sediments from flooding waters as well as surface runoff, thereby reducing the risk of eutrophication of other natural waters like streams and rivers. In present times, the aquatic ecosystems world-wide are being severely altered or destroyed by intensified agricultural practices and other developmental activities at a rate greater than ever known in the human history [7-9]. The activities of the continuously increasing population are causing changes in the Lake ecosystems which challenge the protection of these ecosystems and their use for ecosystem services [10-12]. Most urban and rural Lakes around the world have vanished under the pressure of cultural eutrophication and have led to worldwide environmental concerns [13]. In those Lakes which could endure, drinking water supply has been substantially reduced or become totally non-potable and/or flood absorption capacity is impaired and biodiversity is threatened besides the diminished fish production [14].

The state of Jammu and Kashmir (Lat. 32° 44'N, Long. 74° 54'E)

is endowed with a number of lentic and lotic water bodies situated at varying altitudes from 1600 to 4500 (m.a.s.l). The fresh water ecosystems of the state are different in character and exhibit various degrees of trophic evolution, ranging from oligotrophy, through mesotrophy to eutrophy. The Dal Lake situated to the north-east of Srinagar city, is one of the main elements that makes the valley of Kashmir an important and famous tourist resort. This Lake has, since ancient times, been the centre of Kashmiri civilization and has played an important role in the state economy through its attraction of tourists as well as its utilization as a source of food and water. The Lake is under tremendous anthropogenic pressure for the last three decades. The sewage and agricultural runoff from in and around the Lake are directly emptied into it. Moreover, faecal matter from the house-boats located in different basins of the Lake is disposed into the Lake bed. The cumulative impact of these human interferences has resulted in significant alterations to the entire Lake ecosystem. The Lake is moving towards dystrophy due to accelerated nutrient enrichments from different sources. Such activities have resulted in the deterioration of water quality, prolific growth of aquatic macrophytes and siltation. Keeping in view the above cited situation, the present investigation was undertaken to assess the changes in the water chemistry over a period of one decade during 2005-2015.

Materials and Methods

Study area and study sites

The Dal Lake (Lat. 34°-06'N, 74°-45'E) is an urban Lake that lies to the east of Srinagar city, at the foot of Zabarwan Hills, and is situated at an average elevation of 1583 m above mean sea level. Five sampling sites were selected for the determination of various physico-chemical parameters of water in four basins of Dal Lake (Figure 1). The sampling

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was carried out from January-November on a bimonthly basis during 2005 and 2015.

Physico-chemical features of water

The samples for physico-chemical characteristics of water were collected on bimonthly basis and were analysed as per the methods described by the Council for Scientific and Industrial Research as per CSIR in 1974 and American Public Health Association [15]. Water temperature was recorded on the spot with Celsius mercury thermometer calibrated up to 0.1°C, whereas samples for dissolved oxygen were fixed on-spot in accordance with the Azide modification of Winkler's method. Calcium, magnesium, chloride, ammonical-

nitrogen and total phosphorus were analysed as per methods given in APHA while nitrate-nitrogen was determined by salicylate method as per CSIR [16]. One sample t-test was done by using statistical software SPSS version 16.

NSF Water Quality Index (NSFWQI)

In order to calculate National Sanitation Foundation (NSF) Water Quality Index, results of five parameters (pH, Temperature, Dissolved Oxygen, Total Phosphorus and Nitrate) were transferred to the weighting curve for each parameter and Quality value (Q_i) was obtained. The Q_i value obtained was then multiplied by a weighting factor (W_i) for each parameter based on its importance in water quality. The results obtained were then added to arrive at an overall water quality index (WQI). The Water Quality Index was then compared to the WQI ranges defined by Brown et al. [17].

Results

Physico-chemical parameters of water were analyzed and assessed in order compare the variations of the various parameters in the Lake system. The data collected on bi-monthly basis during 2005 and 2015 at the selected sampling stations is depicted in Table 1 with mean and standard deviation values ($SD \pm$). The range values of both investigations during 2005 and 2015 are presented in Table 2. The bimonthly as well as range values reflect the changes in the different physico-chemical parameters that have occurred over a period from 2005-2015.

As is evident in Table 2, the overall range values depicted that conductivity, chloride, NH_4-N , NO_3-N and total phosphorus showed significant increase in concentrations while dissolved oxygen observed a declining trend. The range values of water temperature did not depict any marked variation between 2005 and 2015.

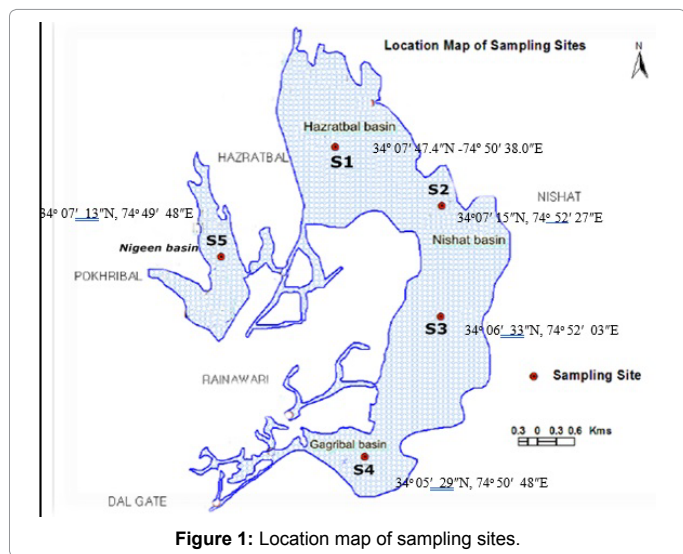


Figure 1: Location map of sampling sites.

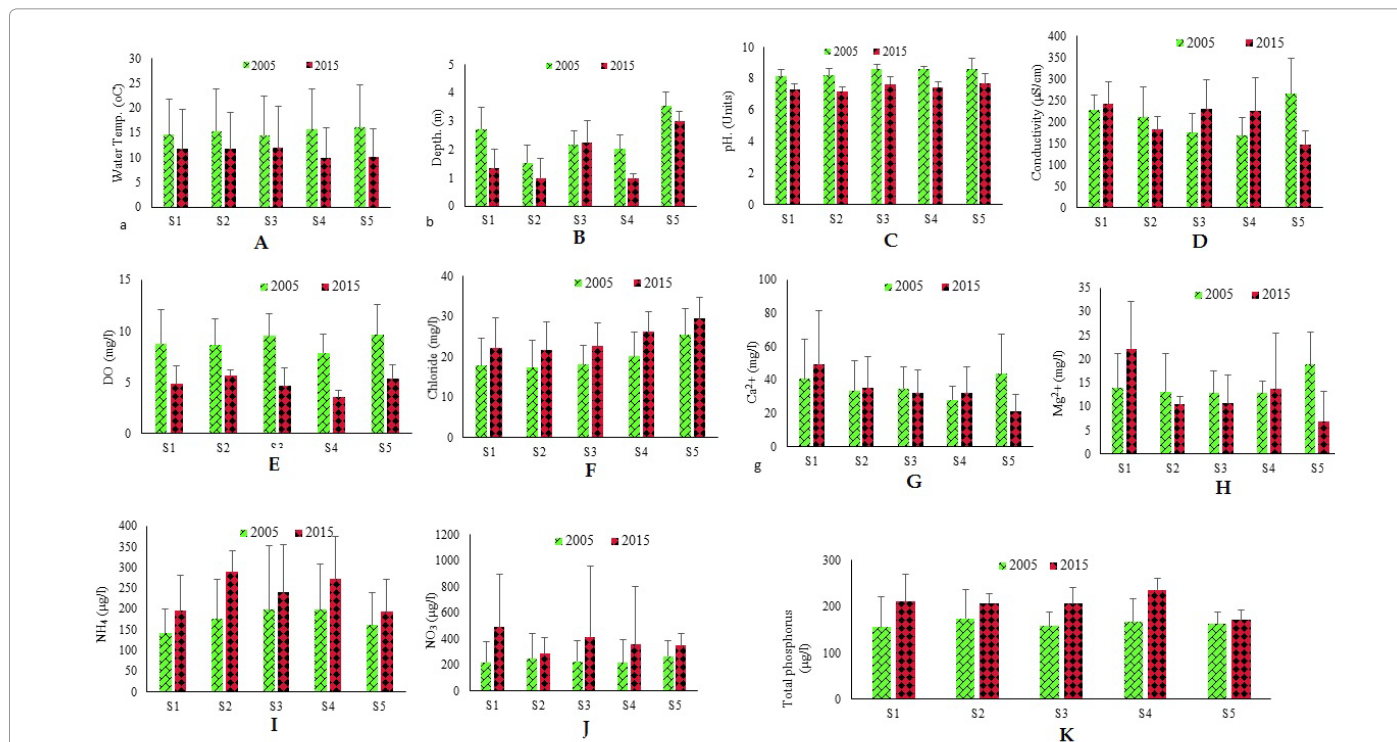


Figure 2: (a-k) Comparative assessment of different parameters of water quality of Dal Lake. [As reflected in Table 3, the NSFWQI values during both the periods (2005 and 2015) fall in the range of 25-50 which is an indication of the bad water quality].

Parameters	Sites	2005								2015							
		January	March	May	July	September	November	Mean	SD±	January	March	May	July	September	November	Mean	SD±
Water temperature (°C)	S1	6	12	17	25	19	9	15	7.0	6	10.5	12.6	24	16	1	12	8
	S2	6	14	19	26	22	5	15	8.6	5.3	8.5	14.5	23	15.8	4	12	7.2
	S3	4	15	18	24	20	6	15	7.9	5.2	8.6	16	25.5	13.8	2.75	12	8.3
	S4	6	16	19	26	21	6	16	8.2	5	8.9	16.3	17	11	1.5	10	6.1
	S5	6	13	19	27	24	8	16	8.6	5	8	15.9	18	9.5	4.5	10	5.6
Depth (m)	S1	2.2	3.3	3.7	3.2	2	1.9	3	0.8	1.0	2.7	1	1.3	1	1	1	0.7
	S2	1.2	1.9	2.3	2	1	0.8	2	0.6	4	2.9	2.5	2.5	4	2.9	1	0.7
	S3	1.8	2.8	2.7	2.2	2	1.5	2	0.5	2.5	1.2	1.8	3	1	2.2	2	0.8
	S4	1.7	1.9	2.8	2.4	1.8	1.5	2	0.5	0.5	1	1.3	0.5	0.5	1.3	1	0.4
	S5	3.2	3.5	4.5	3.5	3.5	3	4	0.5	3	2.8	2.3	2.4	2.5	2	3	0.4
pH	S1	7.6	8.4	8.5	8.54	8.21	7.48	8	0.5	7.6	7.5	7.6	7.5	6.8	6.9	7	0.4
	S2	7.85	8.55	8.79	8.05	8.37	7.58	8	0.5	7.5	7	7	7.6	7	7	7	0.3
	S3	8.73	8.44	8.69	8.88	8.74	7.99	9	0.3	7.8	8.5	7.5	7.2	7.6	7.3	8	0.5
	S4	8.6	8.65	8.81	8.51	8.71	8.43	9	0.1	8	7.5	7.6	7.2	7	7.4	7	0.3
	S5	7.7	8.29	9.45	9.2	8.89	7.95	9	0.7	7	8.2	8.3	8.1	7	7.5	8	0.6
Conductivity (µs)	S1	239	223	228	226	173	279	228	34.0	230	210	340	200	245	220	241	51
	S2	296	104	220	275	161	206	210	71.2	200	200	120	180	200	190	182	31
	S3	172	118	222	228	142	168	175	43.4	200	210	360	240	180	190	230	67
	S4	150	128	216	219	127	168	168	41.3	180	200	380	220	195	180	226	77
	S5	281	393	210	315	233	161	266	82.5	110	124	160	120	160	200	146	34
Dissolved oxygen (mg/l)	S1	11.2	10	9.2	11.2	2.2	8.8	9	3.4	3	6.4	3	4	6	6.8	5	1.7
	S2	12	7	9.4	7.6	5	10.8	9	2.6	5	5	6	6	6	6	6	0.5
	S3	10.2	11.2	10.2	8.8	5.6	11.2	10	2.1	4	8	4.4	3	4.4	4.4	5	1.7
	S4	8.4	10.2	9	7.6	4.8	7.2	8	1.8	4	4	4	4	3	2.4	4	0.7
	S5	10.8	11.2	11.2	11.9	4	8.8	10	3.0	4	6.8	6.6	4	4.8	6.2	5	1.3
Chloride (mg/l)	S1	18	26	13	26	10	14	18	6.8	20	30	17	33	15	19	22	7.4
	S2	30	14	12	20	12	16	17	6.9	32	22	16	14	27	20	22	6.8
	S3	26	21	15	19	14	14	18	4.8	32	27	22	17	18	20	23	5.8
	S4	17	22	31	21	14	16	20	6.1	21	28	34	28	21	25	26	5
	S5	30	36	22	25	18	22	26	6.5	33	38	27	29	23	27	30	5.3
Ca ²⁺ (mg/l)	S1	32	24	28	18	70	72	41	23.9	55	46	36	43	23	28	39	12
	S2	33	24	18	25	68.8	33	34	18.2	45	47	42	54	8	16	35	19
	S3	28	24	31	24	48	54	35	12.9	41	46	38	39	11	18	32	14
	S4	28	31	26	14	32	38	28	8.0	41	46	41	40	13	12	32	15
	S5	42	42	22	16	74.4	68	44	23.6	24	19	38	25	9	13	21	10
Mg ²⁺ (mg/l)	S1	17	11	4	14	11	26	14	7.4	15	12	7	86	7	6	22	29
	S2	13	7	5	10	17	27	13	8.0	12	12	9	12	9	9	11	1.5
	S3	19	12	6	10	14	16	13	4.6	10	12	6	22	8	6	11	5.5
	S4	16	14	10	11	11	15	13	2.5	11	14	7	37	6	7	14	11
	S5	23	17	8	17	20	28	19	6.7	7	17	4	11	1	1	7	5.7
Ammonia (µg/l)	S1	110	70	240	114	152	160	141	58.3	122	110	260	282	280	120	196	86
	S2	320	230	218	82	80	126	176	95.9	347	300	235	320	315	220	290	51
	S3	500	170	198	108	90	122	198	153.3	389	175	231	375	140	130	240	116
	S4	400	170	240	106	110	160	198	110.5	431	245	223	358	160	220	273	101
	S5	160	82	290	79	176	182	162	77.8	200	234	210	308	107	100	193	79
Nitrates (µg/l)	S1	80	325	160	115	500	130	218	162.3	285	1200	680	55	440	280	490	404
	S2	260	352	110	92	580	115	252	190.9	290	455	320	145	375	140	288	126
	S3	106	450	225	91	385	95	225	158.3	255	600	1430	100	60	58	417	537
	S4	93	165	285	102	550	100	216	179.2	145	145	1250	230	280	85	356	443
	S5	350	380	155	93	380	240	266	123.3	370	330	325	300	525	250	350	94
Total phosphorus (µg/l)	S1	123	144	240	152	56	216	155	66.2	127	288	260	166	200	220	210	59
	S2	126	260	216	120	212	108	174	63.5	200	230	230	200	200	180	207	20
	S3	148	172	132	144	136	212	157	30.2	210	260	230	185	160	190	206	36
	S4	196	144	248	118	125	176	168	49.3	220	230	220	286	230	225	235	25
	S5	152	184	164	148	127	196	162	25.2	165	200	168	190	160	143	171	21

Table 1: Bi-monthly values of various physico-chemical parameters of water of Dal Lake during 2005 and 2015.

Parameters	2005		2015	
	Min	Max	Min	Max
Water temperature (°C)	4	26	1	26
Depth (m)	0.8	3.7	0.5	2.9
pH	7.6	9.5	6.8	8.5
Conductivity (µs)	104	393	180	380
Dissolved oxygen (mg/l)	4	11.2	3	8
Chloride (mg/l)	10	36	14	38
Ca ²⁺ (mg/l)	14	70	8	54
Mg ²⁺ (mg/l)	4	28	1	86
Ammonia (µg/l)	79	500	110	431
Nitrate (µg/l)	80	580	58	1430
Total phosphorus (µg/l)	56	216	143	286

Table 2: Range values of various physico-chemical parameters of water quality of Dal Lake during 2005 and 2015.

Parameters	2005				2015				WQI Ranges (Brown et al., 1970)		
	Results	Q _i	W _i	Q _i W _i	Test Result	Q _i	W _i	Q _i W _i	Range	Quality	
pH	8	84	0.11	9.24	7	88	0.11	9.68	90-100	Excellent	
Change in temp (°C)	15	91	0.10	9.1	11	93	0.10	9.3	70-90	Good	
DO (% Saturation)	41.8	33	0.17	5.61	32.5	21	0.17	3.57	50-70	Medium	
Total Phosphorus (mg/L)	0.163	93	0.10	9.3	0.206	91	0.10	9.1	25-50	Bad	
Nitrate Nitrogen (mg/L)	0.236	97	0.10	9.7	0.38	97	0.10	9.7	0-25	Very bad	
WQI				42.95	WQI				41.35		
Water Quality				Bad	Water Quality				Bad		

Table 3: NSF-Water Quality Index (WQI) for different water quality parameters during 2005 and 2015.

As reflected in Table 3, the NSF-WQI values during both the periods (2005 and 2015) fall in the range of 25-50 which is an indication of the bad water quality.

While comparing the water quality of the Lake during 2005 and 2015, it was observed that almost each parameter showed wide variations except water temperature in which fewer fluctuations were observed (Figure 2a). In case of depth, the decreasing trend from 2005-2015 was observed at site-1, site-2, site-4 and site-5 while site-3 showed a slight increase in depth. A significant decrease in depth was recorded at site-1. For depth, the t-test showed significant variation from 2005 to 2015 (Figure 2b). pH was found alkaline at all the sites. Conductivity showed an increased trend at site-1, site-3, and site-4 from 2005-2015 while at site-2 and site-5 it showed a declining trend. The t-test reflected significant variation (P=0.000) in conductivity at all sites during the two study periods (2005 and 2015) (Figure 2c). In the present investigation it was observed that the values for dissolved oxygen depicted significant decline in its concentration during 2015 as compared to 2005 at all sites in the Lake (Figure 2d). During 2005, the minimum dissolved oxygen (8 mg/l) was recorded at site-4 and maximum (10 mg/l) at sites 3 and 4. However, during 2015 the lowest dissolved oxygen concentration (4 mg/l) was again recorded at site-4 while highest concentration (6 mg/l) was recorded at site-2. The t-test reflected a strong significant variation (P=0.000) in dissolved oxygen concentrations in Dal Lake from 2005-2015. The comparative investigation of various physico-chemical parameters of Dal Lake showed an increased trend in chloride content at all sites over the period (Figure 2e) which was supported by the significant values of t-test (P= 0.000). It was also observed that calcium and magnesium content showed wide variation at site-1 and site-5 during 2005 and 2015 (Figures 2f and 2g). During 2005, the range values of calcium content fluctuated from 14 mg/l to 70 mg/l as compared to 8 mg/l to 54 mg/l in 2015. The magnesium content also

depicted broad variations in range values fluctuating between 4 mg/l-28 mg/l and 1mg/l- 86 mg/l in 2005 and 2015 respectively.

The comparative analysis of ammonical nitrogen between 2005 and 2015 depicted increased trend at all sites (Figure 2h) with significant t-test values (P<0.05). In case of nitrate nitrogen, all the sites exhibited significant increase in the concentration from 2005-2015 (Figures 2i and 2j), which is also supported by the significant values of t-test (P= 0.000). While comparing total phosphorus concentration between 2005 and 2015, it was observed that total phosphorus increased in Dal Lake from 2005 to 2015 almost at each site (Figure 2k). One sample t-test showed significant difference (p<0.05) between the data obtained from 2005 and 2015.

Discussion

The natural Lakes of Kashmir experience varied anthropogenic pressures. This is particularly so in case of Dal Lake. The Lake is of special ecological and socio-economical interest besides being an important tourist attraction. Recently there has been a great concern about the fast deterioration of this Lake ecosystem. The present comparative study depicted an increasing trend from 2005 to 2015 for various water quality parameters such as conductivity, chloride, NH₄-N, NO₃-N and total phosphorus. It may be due to cumulative impact of all the anthropogenic activities operating in and around the Lake. Water temperature during the present study was observed lowest in winter and highest during summer months. The variations in water temperature may be due to different timings of collection, influence of the season and the effect of atmospheric temperature. In a water body, the depth of water at a particular site is one of the major physical factors which act as a controlling factor for determining the water quality. Depth plays an important role in concentrating ions in water mass, besides being an important determinant for the growth and development of

various life forms of vegetation [18]. During the present study the significant decline in depth from 2005-2015 at site 1, 2, 4 and 5 may be attributed to various human induced factors like siltation, unplanned dredging/de-weeding operations, accumulation of de-weeded material, farming activities in floating garden areas (disposal of organic material into Lake bed for manure as well as construction of floating gardens), and direct disposal of solid wastes into the Lake. The decrease in depth in a water body is an indication of evolutionary process and changing its trophic status towards dystrophication [19,20]. pH is an important parameter that determines the suitability of water for various purposes. Although, the pH was alkaline during the present study, however, the values were found to be comparatively lower during 2015 indicating a slight gradual change in the well buffered system which may be attributed to increasing pollution levels in the Lake over the period.

Conductivity has been used for assessing the trophic status of water bodies [21] and has also been regarded as a pollution indicator in shallow Lakes [22]. The conductivity values showed increasing trend from 2005-2015. This might be due to ever increasing anthropogenic inputs of various contaminants in the form of silt, sewage and fertilizers. The high conductivity according to Ramana et al. [23] is due to the large amount of surface runoff containing sediments from the catchment areas having intensive crops and human habitations around. Dissolved oxygen is one of the important parameters in water quality assessment, related to biological activities and trophic status of an aquatic ecosystem. In aquatic systems oxygenation is the result of imbalance between processes of photosynthesis, degradation of organic matter and re-aeration coupled with physico-chemical properties of water [24,25]. The significant decline in dissolved oxygen over the period (2005-2015) might be due to increasing inputs of nutrients which results in luxuriant growth of macrophytes and weeds in the Lake system. The low levels of dissolved oxygen in shallow water bodies may be attributed to the removal of free oxygen through respiration by bacteria and other animals and as well as oxygen demand for macrophytes and for their decomposition. Depletion of dissolved oxygen in water probably is the most frequent result of certain forms of water pollution [26]. Chloride is present in nearly all-natural waters with varying concentration, depending on the geochemical conditions of the area. According to Chandrasekhar et al. [27] the presence of chloride concentration in a water body is used as an indicator of organic pollution by domestic sewage. In the present study, higher values of chloride were recorded during 2015 at all sites as compared to 2005. The high concentration of chloride in Dal Lake could be attributed to direct drainage of sewage from houseboats and other human settlements. The sewage discharge in the Lake system is on an increase due to increase in the Dal dwellers populations in the Lake interiors as well as increase in number of houseboats from 2005 to 2015. This is in agreement with Blum [28] and Murthuzasab et al. [29] who reported that high chloride content in water bodies could be due to sewage contamination. Thresh et al. [30] related increased chloride to organic pollution of animal origin. In the present investigation, calcium and magnesium content did not show much variation between 2005 and 2015 except at site-1 (Hazratbal basin) and site-5 (Nigeen basin). Higher Ca^{2+} content in Nigeen and Hazratbal basins may be partly due to increased run off from the catchment area which has predominance of calcareous material. The magnesium content in Hazratbal basin may be due to the enhanced agricultural run-off from catchment through Telbal and Boutkol inlets and from floating gardens located in Dal Lake. These findings were in high conformity with the findings of Ishaq and Kaul [31] who reported that higher concentration of both Ca^{2+} and Mg^{2+} in Dal Lake can be attributed to their leaching from agricultural soils. They further pointed

out that farming procedures followed in the agricultural areas of Telbal sub-catchment are assumed to be responsible. Higher Mg^{2+} values may be due to release of this cation from macrophytes by decomposition [32,33]. Due to appreciable calcium and magnesium hardness, Dal Lake can be classified as calcium rich [34]. Ca^{2+} and Mg^{2+} concentration of freshwater bodies of Kashmir Valley has been associated with thick population of plankton, especially Cyanophyceae [35].

Ammonia in water is produced by microbiological degradation of organic nitrogenous matter. Free ammonia is an important parameter indicating pollution. Surface waters generally have lesser ammonia than bottom waters because it is liberated often from the decomposing organic matter of the Lakes and its release in the deep layers is governed by anoxic conditions [18]. During both the years, ammonical nitrogen showed statistically significant differences between various sites. It is clearly evident from Figure 2i that $\text{NH}_4\text{-N}$ is comparatively higher during 2015. The high ammonical nitrogen concentration in Dal Lake may be attributed to upwelling of bottom ammonical nitrogen to surface by anthropogenic activities viz., dredging and de-weeding operations which were operated at large scale in 2015. According to Wetzel [36] loss of oxidized micro zone at the sediment-water interface under anoxic conditions in hypolimnion releases significant amount of ammonia in overlying waters, thus leading to high concentration of ammonia. Another reason for more ammonia nitrogen concentration during 2015 might be due to excessive decomposition of organic wastes and runoffs from floating garden areas as compared to 2005. As per Zuber [37], higher decomposition of organic matter in shallow water bodies accelerates the formation of ammonical nitrogen. Nitrate which is the end product of nitrification and starting point of denitrification is generally present in higher concentrations than nitrite and ammonia. The presence of nitrate in fresh water bodies depends mostly upon the activity of nitrifying bacteria, domestic and organic sources. In the present investigation the values of nitrate nitrogen showed statistically significant differences between the two study periods at all sites. Nitrate-nitrogen depicted marked increased trend from 2005-2015. The high concentration of nitrate-nitrogen during 2015 may be attributed to increasing dewatering and dredging operations. It may also be attributed to rapid fertilizer runoff and direct disposal of untreated sewage from in and around the Lake. 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 sewage from barracks being dumped into the Lake [38]. Similar findings by Jeelani and Shah and Bhat et al. [39,40] explain the elevated concentrations of nitrate-nitrogen. Phosphorus is considered to be the critical limiting nutrient, causing eutrophication of fresh water systems [41]. It is a major nutrient that triggers eutrophication and is required by algae in small quantities [42]. Present comparative study depicted strong significant differences between the data obtained during 2005 and 2015. The possible reason might be the increasing levels of eutrophication in the Lake system. The significant increase in total phosphorus from 2005 to 2015 is due to excess runoff from floating gardens as well as from agriculture catchment areas through Telbal and Boutkul streams. Phosphate enters the Lakes through domestic wastewater, accounting for the accelerated eutrophication [43]. Increased concentration of phosphate and nitrate nitrogen in Lakes results in enhanced productivity [44]. The average phosphorus in Dal Lake was recorded as $156 \mu\text{g/l}$ and as per Welch [45] a water body may be considered as eutrophic if the total phosphorus value ranges between $20\text{-}30 \mu\text{g/l}$. As per this classification, Dal Lake can be put under eutrophic category.

The results of NSFQI for Dal Lake waters during both the years

are in the range of 25-50 and indicate the bad water quality of the Lake which is further attributed to the continuous inflow of sewage, agricultural run-off and other wastes into the Lake. It also depicts the unsuitable Lake management strategies that are being adopted to restore as well conserve the Lake ecosystem.

Conclusion

The present comparative study on the water quality of Dal Lake concludes that the Lake has been significantly polluted from last few years as a result of direct drainage of sewage, run-off and disposal of solid wastes. Current anthropogenic activities (dredging and de-weeding operations, farming activities in and around the Lake) in the Lake are also responsible for its eutrophic status.

The existing situation of the Dal Lake, if not controlled properly, may cause severe ecological harm and lead it to dystrophic status in the near future. As such, attention is invited to look into the management of water quality as well as biological spectrum of the Lake along with the developmental processes and conservation strategies that are in practice in the Lake.

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