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Physicochemical Characteristics of Dal Lake and Measures Needed for its Improvement

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ABSTRACT
In this study all the four basins of Dal lake were studied for various physico-chemical parameters in all the seasons and the eight different vegetable gardens falling within the Dal Lake area were selected to study their impact on the water quality of the Dal. The various parameters were analysed and accordingly measures were suggested to restore the quality of Dal.

Introduction

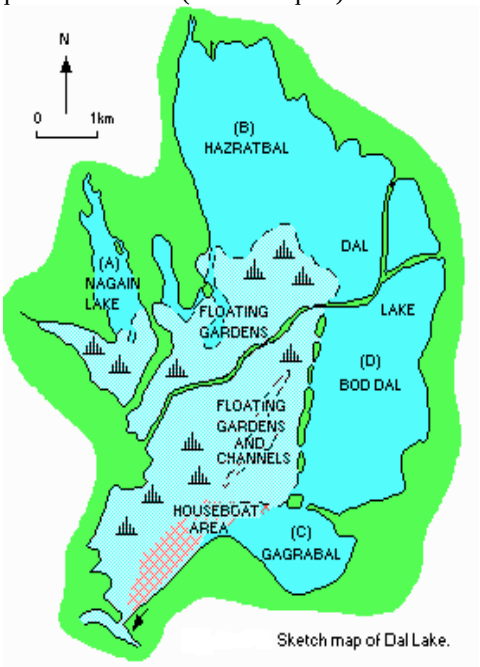
The valley of Kashmir, lying on the northern fringe of the Indian subcontinent, is a lacustrine basin of the intermountain depression existing between the Lesser and the Greater Himalaya. It is of Pleistocene origin formed as a result of tectonic activity (Zutshi and Khan, 1978).

Kashmir is a unique tourist area with one of the main tourist attractions in the most beautiful Dal Lake- a large body of sparkling water situated on the east of Srinagar City (summer capital of Jammu and Kashmir State) at the foot of Zabarwan mountains which rise upto 1000m above lake level. This lake has historically, since the day of Ashoka (250 BC), 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. Dal Lake is not only a major tourist attraction but it is a major source of drinking water for Srinagar city, during summer when demand of water is high.

Of late there has been a great concern about the fast deterioration of this lake's ecosystem which is not only shrinking in its surface area but its waters are also becoming contaminated As a consequence of a number of ecological factors, mainly through anthropogenic pressures, posing health hazards to many people and very life of the lake is also threatened. In order to assess the ecological state of Dal Lake an attempt is made to review the physico-chemical and biological characteristics of the lake ecosystem. Besides highlighting a number of threats that the lake is facing the review analyses the potential conservation measures proposed for its proper utilization and management.

Description of the study area

The lake is in the foothill formations of the catchment of the Zabarwan mountain valley, a subsidiary of the Himalayan range, which surrounds it on three sides. It lies to the east and north of Srinagar city and is integral to the city. The catchment area drained by the basin is 316 square kilometres (122 sq mi). The surface area of the lake is 18 square kilometres (6.9 sq mi) normally, but with floating gardens of lotus blooms, it is 21.2 square kilometres (8.2 sq mi) (an estimated figure of 22–24 square kilometres (8.5–9.3 sq mi) is also mentioned.



Sketch map of Dal Lake.

The main basin draining the lake is a complex of five interconnected (with causeways) basins namely, the Nehru Park basin, the Nishat basin, the Hazratbal basin, the Nagin basin and the Barari Nambal basin. Navigational channels provide the transportation links to all the five basins.

The lake is encircled by roads all along the periphery .This has resulted in irreversible changes along the shore line due to intense urban expansion for building activities.

Two islands built in the basin have further accentuated the restrictions in the flow conditions of the lake. As a result,

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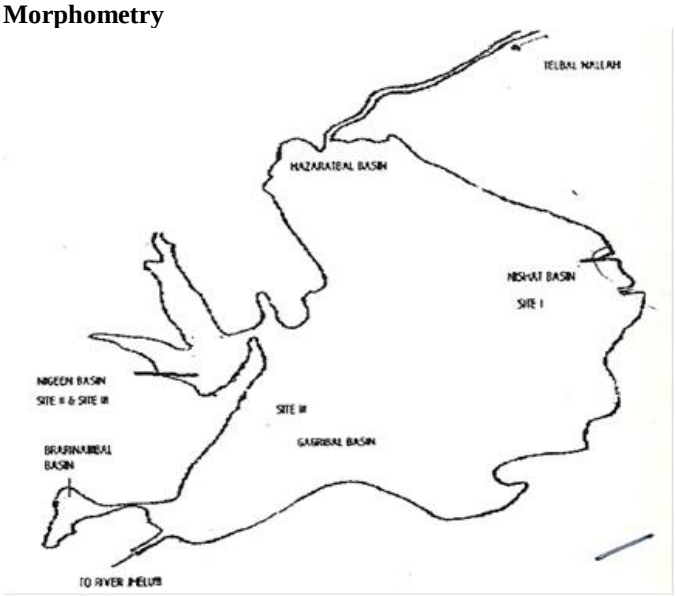
marshy lands emerged on the peripheral zones. Road building activities have been an additional factor of encroachment; the marshy lands mentioned are the foothill areas of Shankaracharya and Zaharbwan hills. These marshy lands have since been reclaimed and converted into large residential complexes.

Geologically, two versions for the lake formation have been theorised. One version is that it is a post-glacial lake remnant, which has undergone drastic changes in size over the years. The other theory is that it is of fluvial origin from an old flood spill channel or ox-bows of the Jhelum River. The dendritic drainage pattern of the catchment signifies poorly porous and poorly permeable nature of rocks. Lithologically, a variety of rock types have been discerned namely, igneous, metamorphic and sedimentary. The Dachigam Telbal Nallah system is conjectured to follow two major lineaments. Discontinuity surfaces seen in the terrain are attributed to the angular and parallel drainage pattern. The water table cuts the hill slopes, which is evidenced by the occurrence of numerous springs in the valley. Seismic activity in the valley is recorded under Zone V of the Seismic Zoning Map of India, which is considered the most severe zone where frequent damaging earthquakes of intensity IX could be expected. In the year 2005, Kashmir valley experienced one of the severe earthquakes measured at 7.6 on the Richter's scale, which resulted in deaths, large number of homeless, and in property damage.

Drainage

The lake is shallow with saucer-shaped basins, Zutshi and Khan (1978), while elaborating the lake typology of Kashmir has recognized the lake to be 'open drainage type'. Regular inflow and outflow of water takes place through the various channels flowing into and out of the lake. The main source of water are: (i) Telbal Nallah, a large perennial stream draining Dachigam National Park and entering the Hazratbal basin from its northern end, besides a number of other small streams (e.g., Doubkoul, Boutkoul, Harishkoul etc.) entering the Hazratbal basin, (ii) the outwash from the surrounding mountains on the western Boddal and Gagribal side. Water flows out of the lake through a weir and lock system at Dalgate. Part of water also flows out through Nallah Amir Khan which connects Nagin with Anchar lake

Morphometry



Morphometrically

The four basins of Dal lake differ markedly in regard to their area, volume, maximum depth, mean depth, index of short line development and other characteristics. (Kaul, 1977)

The lake which has been 7.44 km long and about 3.5 km broad and covering an area of 22 km^2 at the turn of this century has shrunk little over half of the area at present. The total water surface area of the lake is 11.45 km^2 and the total volume estimated to be 9.83×10^6 m^3. A sizable portion of the lake extending from the Hazratbal to Ganderbal is covered by floating gardens which constitute about 35 per cent of the whole lake (Trisal, 1977). The lake has been extensively encroached in this area to form artificial islands separated by canals. The floating islands (locally called Radh) and extensive marshes on maturity are subject to vegetable cultivation and construction of shop sites, residential houses, hotels etc. Besides agriculture and dwellings, these islands are extensively covered by willow (Salix sp.) trees. The illegal encroachment through creation of new floating islands, resulting in the formation of innumerable side water channels which get colonized by the obnoxious Salvinia-Lemna weed complex, is eating into the vitals of the lake system.

Hydrology

The hydrology of Dal Lake is complicated due to extreme diversity of catchments, ranging from Srinagar City to rice fields to high mountain ranges. Besides on the gauging of the major streams, the average annual flow has been estimated to be 291.9 million m^3 of which 80 per cent is contributed by the Telbal and 20 per cent by other sources. The measured total outflow from the two outlets, Dalgate and Amir Khan Nallah, is computed to be $275.6\times10^6m^3$ (ENEX, 1978). However, the water budget for the lake during 1981-82 showed an overall surface input of 214x106m3 and groundwater seepage of 90.5 x 106m3 which corresponds to the water loading of 25ma-1. The flushing rate during the latter study period was 16.4 times a-1 and residence time of water 22.16 days (Ishaq and Kaul, 1990). Monthly flushing rate of water (monthly discharge lake Volume), calculated from water budgets of the lake, showed peak value of 3.39 times for May which according to (Kaul et al., 1985) is primarily due to increased input of water in this month as a result of frequent rains coupled with snow-melt in the upper reaches of the vast mountainous catchment.

2. Methods

In order to know the quality and suitability of the water of four basins-Nehru Park, Nishat Hazratbal and Nagin for domestic and irrigation purposes water samples were collected in the months of March and June from these basins in air tight PVC bottles. From each basin four sampling sites were selected. The pH and conductivity were measured by pH and conductivity meters respectively (APHA, 1998). Alkalinity was determined titrimetrically by using standard sulphuric acid. Nitrite nitrogen TDS dissolved oxygen, total phosphorus, calcium and magnesium were determined titrimetrically. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined titrimetrically using standard EDTA.

3. Results and Discussion

From the table-01 the study sites did not show any marked difference in their pH values and the water seemed to be well buffered. However, maximum pH value has been observed in site I (spring) i.e., 8.62 and minimum pH value has been observed in site III 8.15 respectively.

Conductivity in all the sites has been decreased from spring to summer.

Maximum value of conductivity observed in site I in spring i.e., 595 µscm and minimum in site III 305 µscm. Concentration of dissolved oxygen in site II, III and site IV has increased from spring to summer 7.5 mg/l to 8.5 mg/l and from 4.2 mg/l to 5.0 mg/l respectively while as in site I the concentration of DO has been decreased from spring to summer i.e., 5.0 mg/l to 4.2 mg/l. As for the Total Alkalinity it varies from sampling sites, lesser values were observed in site III during summer i.e., 130 mg/l whereas higher value was observed in spring season i.e., 162mg/l at site I. the concentration of Calcium has been decreased in sites I, II and IV from spring to summer where as increased in site III. The concentration of Magnesium decreased from summer to spring at all site. The concentration of Nitrate Nitrogen and phosphorus was increased from spring to summer in all sites.

Table-01. Seasonal Variations of Hazratbal Basin.

Parameters	Units	Season	Site I	Site II	Site III	Site IV
pH		Spring	8.62	8.30	8.15	8.15
		Summer	8.6	8.5	8.3	8.42
Conductivity	µs/cm at 25°C	Spring	595	417	390	525
	µs/cm at 25°C	Summer	460	320	305	410
Dissolved oxygen	mg/l	Spring	5	6.8	7.5	5.0
	mg/l	Summer	4.2	7.0	8.2	6.0
Total Alkalinity	mg/l	Spring	162	136	130	147
	mg/l	Summer	150	147	139	158
T.D.S	mg/l	Spring	180	155	130	120
	mg/l	Summer	190	148	155	135
Calcium	mg/l	Spring	45.0	39.0	40.0	42.0
	µg/l	Summer	39.8	37.0	46.0	38.0
Magnesium	µg/l	Spring	9.5	6.2	5.9	8.0
	µg/l	Summer	8.4	5.2	5.5	7.5
Nitrate-nitrogen	µg/l	Spring	860	760	575	630
	µg/l	Summer	920	810	615	710
Total Phosphorus	µg/l	Spring	570	653	480	530
	µg/l	Summer	630	703	540	610

From the table-02 the study sites did not show any marked difference in their pH values and the water seemed to be well buffered. However, maximum pH value has been observed in site II (spring) i.e., 8.70 and minimum pH value has been observed in site III 8.07 respectively.

Conductivity in all the sites has been decreased from spring to summer. Maximum value of conductivity observed in site I in spring i.e., 592 µscm and minimum in site III 1245 µscm. Concentration of dissolved oxygen in site I, III and site IV has increased from spring to summer while as in site II the concentration of D.O have been decreased from spring to summer i.e., 5.0 mg/l to 4.2 mg/l. As for the Total Alkalinity it varies from sampling sites, lesser values were observed in site I during summer i.e., 97 mg/l whereas higher value was observed in summer season i.e., 150 mg/l at site IV. However, the concentration of Calcium has been decreased in sites I from spring to summer where as increased in site II, III and IV. The concentration of Magnesium increased from summer to spring at all site. The concentration of Nitrate Nitrogen and phosphorus was increased from spring to summer in all sites.

From the table-03 the study sites did not show any marked difference in their pH values and the water seemed to be well buffered. However, maximum pH value has been observed in site II (spring) i.e., 8.9 and minimum pH value has been observed in site III (spring) 8.16 respectively.

Conductivity in all the sites has been decreased from spring to summer. Maximum value of conductivity observed in site II in spring i.e., 670 µscm and minimum in site III 310 µscm. Concentration of dissolved oxygen was decreased from

Table-02. Seasonal Variations of Nehru Park

Parameters	Units	Season	Site I	Site II	Site III	Site IV
pH		Spring	8.07	8.70	8.59	8.76
		Summer	8.30	8.68	8.60	8.80
Conductivity	µs/cm at 25°C	Spring	290	486	460	592
	µs/cm at 25°C	Summer	245	470	390	460
Dissolved oxygen	mg/l	Spring	7.9	6.0	7.5	6.3
	mg/l	Summer	8.8	5.0	8.2	6.8
Total Alkalinity	mg/l	Spring	97	138	136	142
	mg/l	Summer	107	125	147	150
T.D.S	mg/l	Spring	130	140	110	180
	mg/l	Summer	150	135	119	201
Calcium	mg/l	Spring	29.8	31.0	28.0	32.0
	µg/l	Summer	28.0	31.0	30.0	34.0
Magnesium	µg/l	Spring	5.0	8.5	6.0	7.4
	µg/l	Summer	5.5	9.2	6.4	8.0
Nitrate-nitrogen	µg/l	Spring	520	695	540	850
	µg/l	Summer	610	765	615	960
Total Phosphorus	µg/l	Spring	480	630	440	540
	µg/l	Summer	590	680	545	670

spring to summer in site I, II where as increased in site III and IV. As for the Total Alkalinity it varies from sampling sites, maximum value has been observed in site II during summer i.e., 201 mg/l whereas minimum value was observed in spring season i.e., 145 mg/l at site IV. However, the concentration of Calcium has been increased in sites II, III and IV from spring to summer where as decreased in site I. The concentration of Magnesium increased from summer to spring at all site. The concentration of Nitrate Nitrogen and phosphorus was increased from spring to summer in all sites.

Table-03.Seasonal Variations of Nigeen.

Parameters	Units	Season	Site I	Site II	Site III	Site IV
pH		Spring	8.6	8.9	8.1	8.2
		Summer	8.54	8.68	8.2	8.3
Conductivity	µs/cm at 25°C	Spring	645	670	395	380
	µs/cm at 25°C	Summer	595	590	310	325
Dissolved oxygen	mg/l	Spring	6.0	5.5	7.5	6.8
	mg/l	Summer	5.8	5.2	8.4	7.9
Total Alkalinity	mg/l	Spring	190	201	145	162
	mg/l	Summer	175	180	157	173
T.D.S	mg/l	Spring	160	197	155	140
	mg/l	Summer	180	192	166	151
Calcium	mg/l	Spring	38	45	31	35
	µg/l	Summer	36	47	31.5	37
Magnesium	µg/l	Spring	11.5	8.2	6.0	8.0
	µg/l	Summer	13.24	9.4	7.0	9.5
Nitrate-nitrogen	µg/l	Spring	1090	810	730	785
	µg/l	Summer	1230	985	795	832
Total Phosphorus	µg/l	Spring	885	720	575	620
	µg/l	Summer	810	802	630	705

From the table-04 the study sites did not show any marked difference in their pH values and the water seemed to be well buffered. However, maximum pH value has been observed in site I (spring) i.e., 8.98 and minimum pH value has been observed in site IV (spring) 8.06 respectively.

Conductivity in all the sites has been decreased from spring to summer.

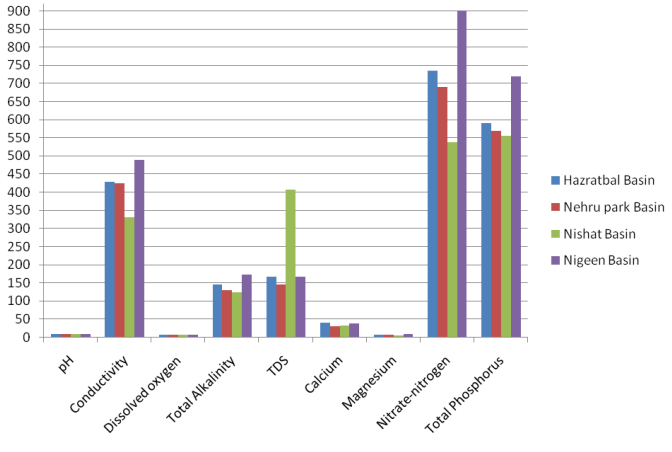
Maximum value of conductivity observed in site I in spring i.e., 460 µscm and minimum in site IV (summer) 210 µscm. Concentration of dissolved oxygen was increased from spring to summer in site II and IV where as decreased in site I and III. As for the Total Alkalinity it increased from spring to summer in all sites, maximum value has been observed in site I during summer i.e., 150 mg/l whereas minimum value was observed in spring season i.e., 102 mg/l at site IV. However, the concentration of Calcium has been decreased in all sites from spring to summer, maximum value was observed in site I (spring) 35.0 µg/l and minimum value observed in site IV (summer) 28.2 µg/l. The concentration of Magnesium decreased from spring to summer in sites I, II and IV whereas increased in sites III. The concentration of Nitrate Nitrogen and total phosphorus was increased from spring to summer in all sites.

Table 4. Seasonal Variations of Nishat

Parameters	units	Season	Site I	Site II	Site III	Site IV
pH		Spring	8.98	8.35	8.66	8.06
		Summer	8.6	8.42	8.5	8.1
Conductivity	µs/cm at 25°C	Spring	460	395	362	245
	µs/cm at 25°C	Summer	392	240	340	210
Dissolved oxygen	mg/l	Spring	7.2	7.8	6.5	8.2
	mg/l	Summer	6.8	8.2	6.0	8.8
Total Alkalinity	mg/l	Spring	140	120	130	102
	mg/l	Summer	150	140	105	110
T.D.S	mg/l	Spring	208	180	140	130
	mg/l	Summer	695	620	650	640
Calcium	mg/l	Spring	35.0	34.5	33.0	32.0
	µg/l	Summer	32.5	31.2	32.0	28.2
Magnesium	µg/l	Spring	5.8	4.5	5.2	4.0
	µg/l	Summer	6.5	5.0	5.8	5.7
Nitrate-nitrogen	µg/l	Spring	602	520	580	350
	µg/l	Summer	720	590	608	440
Total Phosphorus	µg/l	Spring	560	510	540	442
	µg/l	Summer	715	598	620	462

Table 5. Variation in Physico-Chemical parameters of four basins.

Parameters	Units	Hazratbal Basin	Nehru park Basin	Nishat Basin	Nigeen Basin
pH		8.42	8.43	8.44	8.56
Conductivity	µs/cm at 25°C	427.7	424.12	330.5	488.75
Dissolved oxygen	mg/l	6.2	6.27	7.48	6.28
Total Alkalinity	mg/l	146	130.25	124.62	172.87
TDS	mg/l	167.62	145.62	407.87	167.62
Calcium	mg/l	40.85	30.5	32.3	37.56
Magnesium	mg/l	7.02	7.0	5.31	9.18
Nitrate-nitrogen	µg/l	735	689	537.5	901.5
Total Phosphorus	µg/l	589.5	569.7	555.8	718.37



Graph shows Variation in Physico-Chemical parameters of four basins

While comparing the average results of chemical parameters of four basins (table 5) we observe that the concentration of conductivity, total alkalinity, Nitrate Nitrogen, magnesium, and total Phosphorus are highest in Nigeen basin than Hazratbal basin which inturns is higher than Nehru Park Nigeen basin have lower vaues than all other basin. In case of dissolved oxygen lower value is observed in Nishat Basin and higher in Hazratbal Basin.

Physico-chemical characterization of soils of vegetable gardens and floating gardens around Dal Lake

Table 6 shows the variation of physico-chemical characterization of soil of vegetable gardens and floating gardens around Dal Lake. These parameters are also discussed below:

pH

Based on the pH values, soils of the study sites were found to be slightly alkaline in general. The highest pH of 7.66 and 7.86 at the Nigeen floating garden and Dal floating garden respectively can be attributed to the deposition of mulch used in the preparation of floating gardens for the cultivation of vegetables. Stevenson (1986), Brady and Weil (1996) and Miller and Gardiner (1998) believed that the ammonia gas was produced by decomposing plant and animal residue and the foliage of living plants which on coming in contact with moisture of soils forms ammonium hydroxide. This inorganic compound consequently increased pH of the soil towards alkaline side.

Moisture content

During summer the moisture content (%) in the processed soil samples of all the study sites in general was minimum than in other seasons as the evaporation of water is greatly influenced by temperature. Consequently during warm or hot days, the evapo-transpiration at the leaf surface or surface of the moist soil is quite high. The moisture content exhibited higher values for floating garden soils (both Dal and Nigeen) especially for the spring season when the cultivators prepare the floating gardens by dumping macrophytes as moisture retention capacity for soils gets enhanced by its rich organic matter content which has also been reported by Tan (2000).

Organic Matter

The organic matter content in the soils typically ranges between 0.10% and 0.5% (Bear, 1964). However, in the soils under investigation it ranged between 3.61% and 11.0% which was significantly higher. The values of organic matter and organic carbon were low during the summer season which could be attributed to the use by growing crops.

Table 6. Physico-chemical characterization of soils of vegetable gardens and floating gardens around Dal Lake

S/No	Parameters	Nitrogen Veg Garden (1)			Nigeen Floating garden			Nigeen Veg Garden (2)			Babadam Veg Garden		
		Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
1	Temperature (^oC)	16.60	24.50	18.70	18.60	27.10	20.70	16.00	24.30	17.50	15.60	24.10	17.70
2	Moisture content (%)	31.90	18.30	51.81	81.30	77.40	79.30	28.72	24.30	24.20	27.50	23.40	25.40
3	pH	7.62	7.44	7.61	8.00	7.69	7.74	7.37	7.12	7.57	7.20	7.28	7.28
4	Conductivity (dS/m)	0.77	0.35	1.59	0.80	1.08	2.06	0.44	1.63	1.31	0.64	1.14	1.23
5	Loss on ignition (%)	17.81	14.06	14.69	62.50	37.03	32.40	26.50	18.01	16.95	14.70	11.62	12.30
6	Calcium (meg.)	323.33	283.33	270.00	364.20	299.00	315.00	279.00	186.66	165.00	273.30	200.00	140.00
7.	Magnesium (meg.)	223.33	213.33	205.00	245.00	200.00	189.00	170.00	153.30	105.00	260.00	179.00	165.00
8	Organic Carbon	4.67	2.46	2.88	5.94	3.21	3.40	5.05	3.03	3.29	5.13	2.10	2.78
9	Organic matter (%)	8.03	4.23	4.95	10.21	5.52	5.84	8.68	5.21	5.65	8.82	3.61	4.78
10	Phosphorus (µg/g)	1201.00	1057.00	1020.00	870.00	745.00	665.00	1254.00	1076.00	1093.00	1020.00	700.00	656.00
11	Potassium (mg/g)	115.80	61.50	70.92	104.87	79.69	85.43	128.50	84.22	81.71	126.66	52.91	68.95
12	Total nitrogen (%)	0.35	0.16	0.19	0.36	0.19	0.23	0.49	0.21	0.26	0.34	0.16	0.19
13	Carbon nitrogen ratio	13.34	15.37	15.15	14.02	16.29	14.78	12.12	14.42	12.65	15.08	13.12	14.63

Table 6. (continued)

S/No	Parameters	Mir Mohalla Veg Garden			Kadu Mohalla Veg Garden			Botapora Veg Garden			Dal Lake Floating Garden		
		Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
1	Temperature (^oC)	15.00	24.00	17.70	14.60	24.00	17.50	15.30	24.00	17.00	18.00	26.60	20.00
2	Moisture content (%)	34.50	26.20	24.90	29.60	24.80	25.60	42.40	26.90	27.60	78.40	74.80	54.00
3	pH	7.36	7.30	7.37	7.26	7.19	7.31	7.50	7.28	7.38	7.96	7.64	7.80
4	Conductivity (dS/m)	0.42	0.92	1.62	0.70	0.96	1.23	0.39	1.08	1.26	0.34	1.06	1.89
5	Loss on ignition (%)	15.12	13.55	14.70	13.78	12.18	12.47	27.18	22.00	21.00	44.26	44.00	37.40
6	Calcium (meg.)	326.66	233.33	185.00	226.00	156.60	190.00	296.20	220.00	215.00	444.20	306.00	395.00
7.	Magnesium (meg.)	243.33	173.33	150.00	186.60	143.90	110.00	226.60	178.60	155.50	326.30	276.00	284.00
8	Organic Carbon	5.12	2.23	3.02	4.85	2.59	2.76	6.30	3.49	3.16	6.40	4.27	3.51
9	Organic matter (%)	8.80	3.83	5.21	8.34	4.45	4.74	10.83	6.00	5.43	11.00	7.34	6.03
10	Phosphorus (µg/g)	1021.00	920.00	889.00	1191.00	1079.00	1041.00	1116.00	1005.00	996.00	870.00	693.00	662.00
11	Potassium (mg/g)	126.98	55.79	75.02	120.28	63.89	68.06	100.59	86.34	78.00	118.36	106.15	87.17
12	Total nitrogen (%)	0.40	0.16	0.23	0.39	0.18	0.20	0.50	0.26	0.24	0.46	0.29	0.27
13	Carbon nitrogen ratio	12.80	13.93	13.13	12.43	14.38	13.80	12.60	13.42	13.16	13.91	14.72	13.00

Russell and Russell (1950) have also reported that the decomposition rates of organic matter do increase at the weather warms and furnishes maximum plant growth conditions. The high values were observed during the spring reason when the soil was being prepared for the cultivation by adding sediments rich in dead plant matter.

Exchangeable calcium and magnesium

During the present study the Ca^{2}+ content in the soils was found to vary in the range of 156.60 and 444.20 meq./100g while as Mg2+ content varied between 1110.0 and 326.60 meq./100g. Calcium and Magnesium levels declined generally during late summer for all sites quite likely as a result of soil leaching and uptake by the developing vegetation. Higher values of Nigeen floating garden and Dal floating garden could be due to the addition of dead macrophytes during the preparation of these gardens in early spring season.

Total phosphorus

The average content of phosphorus in soils ranged between 662 and 1191µg/g which was fairly higher in concentration than general soils. However, total phosphorus appeared to be in higher amounts during spring months and in lower quantity during summer season. According to (katznelson, 1977) the values of total phosphorus in Dal as well as Nigeen go on decreasing during the peak cultivation period of summer and this can be attributed to leaching which may be occurring there.

Potassium

The concentration of potassium occurred in the range of 55.9 and 126.98 mg/g. The values of potassium at almost all sites appeared to follow the trend spring>autumn>summer. Interventions in the form of addition of potassium fertilizrs by cultivators can also be a reason for the increased values in Nigeen vegetable garden (2) and in Botapora vegetable garden in summer season as compared to autumn season because during early growth at seedling stage potassium requirement are high. Interpretation of the findings can be attributed to the removal of potassium from the soil by the growing crops during summer season and return of potassium to the soils by the vegetative parts and roots between the growing seasons that have an effect similar to that of potassium fertilization. Grimes (1966) verified that potassium diffused from dead plant residues under moist condition and that plants absorbed it. Potassium is likely to be taken up in excess with need (Stinner et al., 1984).

Total Nitrogen

The quantity of nitrogen in surface generally ranges between 0.02% and 0.25% and is as a rule related to the amount of soil organic matter (Bear, 1964). In the soils of the floating and vegetable gardens under study, the amount of total nitrogen, which ranged between 0.16% and 0.50%, was in general found to be in fairly higher amounts as these soils are in receipt of high amount of organic matter in the form of microflorae/mulch. The nitrogen levels were seen to increase with the onset of rains in the late fall and reached peak in spring. The concentrations dropped through the spring and remained low during summer. This would suggest that more soil nitrogen is used in the earlier growing season.

Carbon: nitrogen ratio

On the whole C/N ratio, which is related to the high values of both organic carbon and total nitrogen, was found to vary between a minimum of 13.0 and a maximum of 16.89 in case of floating gardens while as in vegetable gardens the ratio fluctuated between minimum of 12.12 and a maximum of 15.37. However, these values fall in the category of high fertile soils.

Temperature

The surface soil of Mir Mohalla, Gadu and Botapora vegetable gardens was always found to retain less moisture than the floating gardens. The soils of floating gardens were thus cooler. Floating gardens at Nigeen and Dal were always exhibiting high temperature compared to all other sites probably due to warming of epilimnetic water beneath and around these floating gardens which keeps them at higher temperature than other vegetable gardens not surrounded by water. It has been observed that the soil on the floating gardens is highly fertile which was revealed by high values of organic matter, total nitrogen and phosphorus ratio.

Factors responsible for deterioration of the lake

Indiscriminate removal of vegetation through mechanical harvesting has several impacts on hydrological regime, sediment characterization and several other biotic components. Since macrophytes take up large quantities of nutrient supply, pestisides and heavy metals it is obvious that if large scale deweeding is done nutrient level may rise to deleterious proportions in the lake water leading to the formation of algal blooms. Removal of vegetation cover restricts homing of water fowl to limited areas as most of the suitable ecological niches of birds get destroyed. Lake Ecosystem gets disturbed as the water transparency, dissolved oxygen gets reduced, overall ionic concentration, phosphorus and plankton increases. Untreated wastewater from commercial establishments and human settlement along the shores and within the lake itself finds its way into the lake. The flow of water in Dal Lake is greatly impeded by artificial barricades, bunds channels, floating gardens etc.

Measures needed to Restore Dal Lake

There should be controlled use of fertilizers particularly on fields adjacent to the lake ecosystem. Removal of floating gardens in the lake. Encroachment in the lake area should be stopped. Construction of sewage system or diverting waste water or treated effluent to location outside its catchment area. It is important to devise means to allow substantial loss of nutrients from the lake ecosystem by removal of barricades, bunds etc. In addition to the above measures, to activate the springs at the bottom of the lake. The shore is a filter for undesired releases into the lake; therefore conservation of the natural condition of the shore plays an important role in lake management. Reforestation should be done as it is a practical and effective means of reducing soil erosion. Steps should be taken to control grazing on the slopes which are prone to soil erosion. The environment of the lake should be monitored on regular basis.

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