Limnological Investigation of Anchar Lake, Kashmir

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ABSTRACT

The present investigation on Anchar Lake was undertaken during 2000-01 and deals with the general water chemistry which helps us in understanding the trophic status of the lake undergoing rapid trophic evolution, being attributed to the heavy population pressure in the catchment of the lake

Key words: Limnology, nutrients, eutrophication, macrophytes, lake, Kashmir

INTRODUCTION

The lakes of Kashmir, embedded in the midst of the Himalayan mountains, are socio-economically and bioaesthetically indispensable aquatic ecosystems harbouring a rich and diverse gene pool. They not only provide food, fodder, green manure, vegetables but are also potential sources of recreation. In the present years some of the lakes have shown clear signs of cultural eutrophication due to rapidly expanding human populations in their catchment areas (Zutshi *et al.*, 1980, Pandit 1996,99) and fast urbanization in addition to natural siltation, threatening these invaluable ecosystems. Increased population explosion, utilization of lake waters for tourist traffic and disposal of sewage and sewerage from the adjoining human habitation, besides development of floating gardens for agricultural purposes and above all the effluents released form Sheri-Kashmir Institute of Medical Sciences (SKIMS), Soura (Bhat *et al.*, 2001) are greatly responsible not only for deterioration of the lake water but have also adversely affected the biotic communities. Though some literature on limnological aspects of Kashmir freshwaters have been published (Kaul *et al.*, 1978, Qadri and Yousuf, 1979, Kak, 1981; Sarwar, 1986,99, Yousuf and Shah, 1988 and Pandit, 1993, 96, 99, 2001), yet very little information is available on sub-urban lakes like Anchar. In this backdrop, limnological investigation on Anchar Lake were undertaken to provide a baseline data on the physcio-chemical characteristics of water

AREA OF STUDY

Anchar Lake, a shallow basined valley lake with fluviatile origin (altitude 1584 m a.s.l.), is situated 14 km to the northwest of Srinagar city within the geographical coordinates of 34° 20 - 34° 26 N lat. and 74° 8 - 74° 9 E long. (Fig 1)

Fig.1 Map of Anchar Lake showing various sampling sites.

The suburban lake, with its catchment comprising Srinagar city and a number of bordering villages, as such is connected to the Khushalsar Lake which in turn is connected to the famous Dal Lake through a small inflow channel - Nalla Amir Khan. However, a network of channels resulting in a delta-type formation from the cold water river Sind enter the lake on its western shore. In addition to these feeding channels, the lake is also supplied by a number of springs present in the basin itself and along its periphery. Towards the southeast of the lake is situated the complex of Sheri-Kashmir Institute of Medical Sciences (SKIMS) draining much of its effluents into the lake. The run-off from surrounding agricultural fields including floating gardens and the sewage and sewerage from the bordering human settlement's area are also drained into the lake resulting in its further nutrient loading. The waters, in general, are turbid due to silt impregnated waters coming from the Sind River

The catchment comprises arable land under paddy cultivation and long stretches of elevated land on northwest side, being used mainly for raising multiple crops. The lake is heavily infested with macrophytic growth and the littorals, constituting the major portion of lake are dominated by species like *Phragmites australis*, *Typha angustata* and *Spharganium erectum* and isolated strands of *Cyperus serotinus*. Severely polluted sites, especially receiving waste waters, are infested with thick patches of low-growing emergents like *Myriophyllum verticillatum*.

A number of floating gardens used for vegetable cultivation, being developed in the lake margins, result in a myriad of channels which are heavily infested with thick mats of obnoxious weed complexes- *Lemna-Salvinia*. Rooted floating-leaf types like *Trapa natans*, *Nymphoides peltata*, *Potamogeton natans* and *Hydrocharis dubia*, either form isolated patches or grow in association with other macrophytes. Deeper zones of the lake are, however, sparsely covered by the submergeds comprised mainly by *Ceratophyllum demersum* and *Potamogeton crispus*. Nevertheless, Anchar Lake has great diversity of plant communities with 20 associations (Zutshi, 1975), while Kak (1981) reported 42 macrophytic species from this dying lake. Infact, the Shallabogh wetland, harbouring a large population of migratory birds in winter is an extension of the Anchar Lake.

MATERIAL AND METHODS

The water samples were collected on monthly basis, during March 2000 to Feburary 2001, in one litre polyethylene bottles between 11.00 and 15.00 hr from four different sampling stations (Fig. 1), differing in water depth, vegetation and other biotic variables. Analysis of water samples for various parameters were done according to the standard methods of Mackereth (1963), Goltermann and Clymo (1979) and APHA (1998). Parameters like conductivity, pH, temperature, dissolved oxygen, water depth and transparency were analysed at the sampling stations. pH, conductivity and dissolved oxygen were recorded by means of digital meters (US make) while depth and transparency of the lake were noted by means of a secchi-disc.

Parameters like alkalinity, chlorides, calcium and magnesium, nitrogen (NO_3-N and NH_3-N), phosphorus (orthophosphates and total phosphates) and silicates of the lake water were analysed in the laboratory within 24 hr from the time of sampling using titrimetry and spectrophotometry. Similarly, the estimation of sodium and potassium elements was done by means of a flame-emission photometer.

RESULTS

The seasonal ranges and mean values for various physio-chemical features of lake water at different study sites are summarized in Tables 1-4. During the present investigation there were large fluctuations in the depth of waterbody with depth ranging from 0.62 to 1.73 m. The maximum (1.73 m) depth was recorded during spring at site I while minimum (0.62 m) was registered during winter at site III. The secchi visibility remained high (0.95 m) during winter at site II and low (0.24 m) during spring at site III. The water temperature of the lake ranged between 6.7 and 25.6° C, with minimum (6.7° C) at site III in winter and maximum (25.6° C) in summer at the same site. The dissolved oxygen values varied from 1.5 to 5.2 mg l^{-1}, with maximum (5.2 mg l^{-1}) dissolved oxygen content of the lake water during spring at site II as against the minimum (1.5 mg l^{-1}) during autumn at site I. The conductivity values, an indication of total nutrient concentration, fluctuated from 277.6 to 482.3 µS cm^{-1}, the highest being observed at site IV during spring and the lowest at site II during summer. The pH of the water was towards alkaline range and fluctuated from 7.9 to 8.41 units, the highest (8.41) being obtained at site III during summer and the lowest (7.9) at site I during spring. For calcium, the values varied between 27.4 and 52.8 mg l^{-1}. However, the highest calcium (52.8 mg l^{-1}) content was at site I during winter as against the lowest (27.4 mg l^{-1}) being recorded at site II during summer. Magnesium followed a trend similar to that of calcium and fluctuated from 6.62 to 19.8 mg l^{-1}. The Ca : Mg ratio was almost 3 : 1. The maximum value of the ion was recorded at site I during autumn and the minimum at site II during summer. The levels of sodium were found in the range of 3.1 to 17.9 mg l^{-1} in comparison to potassium (1.6 to 7.9 mg l^{-1}). However, the higher values for both these ions was noted during autumn. Total alkalinity of water in different seasons fluctuated from 110.6 to 381.3 mg l^{-1}. Again the amplitude of bicarbonate alkalinity values was great during autumn. The chloride concentration showed their minima and maxima between 18.6 and 52.5 mg l^{-1} at regular intervals, the maximum (52.5 mg l^{-1}) value being recorded at site IV during spring. While the maximum (4.47 mg l^{-1}) silicate level was obtained at site III during winter, the minimum (1.68 mg l^{-1}) of the ion was registered at site I during autumn. For ammonical nitrogen, the values were in between two extremes (180.0 and 568.3 µg l^{-1}) and for nitrate nitrogen it ranged between 135.0 and 321.6 µg l^{-1}. The highest values for both the two forms of nitrogen were, however recorded during autumn at sites III and IV respectively. The phosphate content of lake water revealed the mean concentration of orthophosphate phosphorus was quite low (127.6 µg l^{-1}) as compared to that of total phosphate phosphorus (471.8 µg l^{-1}) and the values were in between 35.3 and 178.3 µg l^{-1} and between 203.3 and 603.3 µg l^{-1} for these two form of phosphorus respectively.

DISCUSSION

Anchar Lake is a semi-urban and small-sized waterbody with a mean depth of 1.6 m. Since the investigated lake has the maximum depth of only 1.73 m, it can be considered as eutrophic (Rawson, 1955). The light penetration is greatly diminished in most of months due to silt loaded inflow from river Sind (Zutshi *et al.*, 1980). The nutrient pool of the lake gets modified due to sewage outfalls from the adjoining human habitation, agricultural fields and above all the effluents coming from Sheri-

Table 1. Physico-chemical characteristics of Anchar Lake at four sampling sites (Spring)

S.No.	Parameters	Site I	Site II	Site III	Site IV	Range	Mean
1	Depth (m)	1.73	1.48	0.97	1.36	0.97-1.73	1.38
2.	Transparency (m)	0.69	0.81	0.24	0.45	0.24-0.81	0.54
3.	Temperature (°C)	22.4	22.8	22.5	22.0	22.0-22.8	22.4
4.	Dissolved oxygen (mg l^{-1})	4.52	5.2	4.5	3.4	3.4-5.2	4.4
5.	pH	7.90	8016	8.19	8.15	7.90-8.19	8.1
6.	Conductivity (µS cm^{-1})	408.3	362.3	381.0	482.3	362.3-482.3	408.4
7.	Ca (mg l^{-1})	35.2	31.8	31.3	37.2	31.3-37.2	33.8
8.	Mg (mg l^{-1})	9.40	9.61	9.16	12.9	9.16-12.9	10.2
9.	Na (mg l^{-1})	-	-	-	-	-	-
10.	K (mg l^{-1})	-	-	-	-	-	-
11.	Alkalinity (mg l^{-1})	273.0	256.6	358.3	356.2	256.6-358.3	311.0
12.	Chloride (mg l^{-1})	41.0	40.4	50.0	52.5	40.4-52.5	45.9
13.	Silicates (mg l^{-1})	3.11	2.96	3.14	3.19	2.96-3.19	3.1
14.	NH_3-N (µg l^{-1})	210.0	208.0	195.0	350.0	195.0-350.0	240.7
15.	NO_3-N (µg l^{-1})	304.0	255.3	237.6	284.6	237.6-304.0	270.3
16.	TOPP (µg l^{-1})	54.3	35.3	39.3	72.6	35.3-72.6	50.3
17.	TPP (µg l^{-1})	302.0	203.3	284.3	357.6	203.3-357.6	286.3

Table 2. Physico-chemical characteristics of Anchar Lake at four sampling sites (Summer)

S.No.	Parameters	Site I	Site II	Site III	Site IV	Range	Mean
1.	Depth (m)	1.16	1.26	0.99	0.72	0.72-1.26	1.03
2.	Transparency (m)	0.51	0.55	0.39	0.27	0.27-0.55	0.43
3.	Temperature (°C)	24.3	24.5	25.6	25.2	24.3-25.6	24.9
4.	Dissolved oxygen (mg l^{-1})	4.27	4.16	3.6	3.76	3.6-4.27	3.9
5.	pH	7.97	8.14	8.41	8.06	7.97-8.41	8.14
6.	Conductivity (μS cm^{-1})	282.0	277.6	330.3	438.6	282.0-438.6	332.2
7.	Ca (mg l^{-1})	30.18	27.4	27.7	33.54	27.4-33.54	29.7
8.	Mg (mg l^{-1})	8.94	6.62	8.42	12.1	6.62-12.1	9.02
9.	Na (mg l^{-1})	3.76	3.1	6.55	6.12	3.1-6.55	4.8
10.	K (mg l^{-1})	3.0	1.6	3.15	2.7	1.6-3.15	2.6
11.	Alkalinity (mg l^{-1})	110.6	147.3	160.6	121.6	110.6-160.6	135.0
12.	Chloride (mg l^{-1})	18.6	33.3	38.6	40.6	18.6-40.6	32.7
13.	Silicates (mg l^{-1})	3.13	3.19	3.06	3.25	3.06-3.25	3.15
14.	NH_3-N (μg l^{-1})	237.15	187.5	180.0	282.5	180.0-282.5	221.8
15.	NO_3-N (μg l^{-1})	140.6	247.6	215.0	230.0	140.6-247.6	208.3
16.	TOPP (μg l^{-1})	80.0	98.0	66.6	76.6	66.6-98.0	80.3
17.	TPP (μg l^{-1})	572.6	505.0	371.6	603.3	371.6-603.3	513.1

Table 3. Physico-chemical characteristics of Anchar Lake at four sampling sites (Autumn)

S.No.	Parameters	Site I	Site II	Site III	Site IV	Range	Mean
1.	Depth (m)	1.72	1.36	0.96	0.72	0.72-1.72	1.99
2.	Transparency (m)	0.70	0.66	0.53	0.34	0.34-0.70	0.55
3.	Temperature (°C)	16.9	16.5	16.6	16.8	16.5-16.9	16.7
4.	Dissolved oxygen (mg l^{-1})	1.5	2.1	4.06	2.03	1.5-4.06	2.42
5.	pH	7.94	7.99	8.15	8.12	7.94-8.15	8.05
6.	Conductivity (μS cm^{-1})	326.6	337.6	308.6	320.0	308.6-337.6	323.2
7.	Ca (mg l^{-1})	49.8	49.9	45.4	52.1	45.4-52.1	49.3
8.	Mg (mg l^{-1})	19.8	18.9	16.06	18.2	16.06-19.8	18.2
9.	Na (mg l^{-1})	15.74	14.7	14.8	17.9	14.7-17.9	15.7
10.	K (mg l^{-1})	7.4	6.6	7.4	7.9	6.6-7.9	7.3
11.	Alkalinity (mg l^{-1})	350.6	320.0	381.3	338.6	320.0-381.3	347.6
12.	Chloride (mg l^{-1})	20.2	23.3	21.3	22.0	20.0-23.3	21.6
13.	Silicates (mg l^{-1})	1.68	1.97	2.48	2.28	1.68-2.48	2.1
14.	NH_3-N (μg l^{-1})	393.3	490.0	568.3	513.3	393.3-568.3	491.2
15.	NO_3-N (μg l^{-1})	199.0	258.3	210.0	321.6	199.0-321.6	247.2
16.	TOPP (μg l^{-1})	146.6	121.6	178.3	178.3	121.6-178.3	156.2
17.	TPP (μg l^{-1})	482.6	267.6	361.6	501.6	267.6-501.6	403.3

Table 4. Physico-chemical characteristics of Anchar Lake at four sampling sites (Winter)

S.No.	Parameters	Site I	Site II	Site III	Site IV	Range	Mean
1.	Depth (m)	1.67	1.31	0.62	0.67	0.62-1.67	1.07
2.	Transparency (m)	0.75	0.95	0.55	0.31	0.31-0.95	0.64
3.	Temperature (°C)	7.4	7.0	0.67	6.8	6.7-7.4	6.9
4.	Dissolved oxygen (mg l^{-1})	3.85	3.50	4.0	3.11	3.11-4.0	3.6
5.	PH	8.08	8.02	8.21	8.18	8.02-8.21	8.12
6.	Conductivity (µS cm^{-1})	375.0	377.0	292.0	279.0	279.0-377.0	330.7
7.	Ca (mg l^{-1})	52.8	48.6	52.75	47.4	47.4-52.8	50.3
8.	Mg (mg l^{-1})	17.2	17.9	14.6	14.7	14.6-17.9	16.1
9.	Na (mg l^{-1})	9.0	9.0	9.0	8.0	8.0-9.0	8.7
10.	K (mg l^{-1})	3.0	3.0	3.0	2.8	2.8-3.0	2.9
11.	Alkalinity (mg l^{-1})	310.0	298.0	294.0	292.0	292.0-310.0	298.5
12.	Chloride (mg l^{-1})	28.0	26.0	19.0	29.0	19.0-29.0	25.5
13.	Silicates (mg l^{-1})	3.20	3.88	4.47	4.40	3.20-4.47	3.98
14.	NH_3-N (µg l^{-1})	362.5	396.0	420.0	450.0	362.5-450.0	407.1
15.	NO_3-N (µg l^{-1})	135.0	140.0	182.5	280.0	135.0-280.0	184.3
16.	TOPP (µg l^{-1})	137.5	120.0	162.0	161.0	120.0-162.0	145.1
17.	TPP (µg l^{-1})	425.0	372.5	385.0	425.0	372.5-425.0	401.8

Kashmir of Institute of Medical Sciences (SKIMS), Soura (Bhat *et al.*, 2001). Under such conditions only pollution tolerant species of algae particularly belonging to Myxophyceae and obnoxious weed complexes like *Lemna-Salvinia* which thrive well under eutrophic water flourish. The high temperature recorded is the result of low water depth and consequently the volume of water in contact with air as observed by Zutshi and Vass (1971) and Pandit (1980) in other eutrophic waterbodies. Low values of dissolved oxygen (mean=3.6mg l^{-1}) is an indication of a tendency towards a anoxic condition. However, in case of Anchar Lake the overall moderate content of dissolved oxygen is in consonance with the growth and abundance of macrophytes and phytoplankton of the lake releasing oxygen during photosynthesis. The pH values recorded during the present study were indicative of the alkaline nature of the waterbody. In case of Anchar Lake, the high pH value is probably due to the production of salicilic acid by the hydrolysis of silicates in the rock beds of the catchment areas (Zutshi *et al.*, 1980). The overall high conductivity of Anchar Lake depicted high ionic concentration. The lower values recorded during spring and summer due to locking up of nutrients during these seasons and the higher values during winter were related to the abundance of nutrients which are released in the decomposition process of organic matter (macrophytes and animals). In general, the hardness of water was very high at the study sites, a fact also observed by Rai (1974) who attributed it to the inflow of sewage effluents. However, the low magnesium content was possibility due to its uptake by the plants in the formation of chlorophyll-magnesium-porphyrin metal complex and in enzymatic transformations (Wetzel, 1975), thereby confirming 3:1 ratio for Ca^{++} and Mg^{++} recorded for other waterbodies (Kaul *et al.*, 1978; Zutshi *et al.*, 1980). The high chloride concentration of the lake may be related to the presence of large amounts of organic matter of both allochthonous and autochthonous origin and sewage contamination. High chloride content was due to sewage contamination (Blum, 1957) and is related to organic pollution of animal origin (Thresh *et al.*, 1944).

The relatively low content of nitrate-nitrogen in the investigated lake may be attributed to profuse and luxuriant macrophytic growth which utilize it during photosynthesis while the comparatively high content of ammonical nitrogen may be due to too much use of nitrogen fertilizers in floating vegetable gardens and heavy anthropogenic pressure in the catchment area resulting in organic pollution, being manifested by the prolific growth of obnoxious weeds like *Salvinia natans* and *Lemna* sp., a fact also revealed by Ellis and Wastfall (1946) and Pandit *et al.* (1978). Phosphorus like nitrogen is another key element for the productivity of waters. On the basis of total phosphorus values the lake can be placed in the eutrophic category (Strem, 1930; Vollenweider, 1968). In case of Anchar Lake, the maximum phosphate concentration has not exceeded much due to calcium-phophate co-precipitation in spite of progressive increase in human settlements and the use of fertilizers in paddy fields bordering the lake. Nevertheless, the moderate levels of phosphorus concentration may also be due to quick uptake and subsequent storage by biotic communities.

In conclusion, it is quite convincing that the lake shows signs of accelerated cultural eutrophication due to heavy anthropogenic pressure, siltation and the effluents released from SKIMS complex have increased the nutrient levels of the lake's environment during the recent years, a fact also revealed by Bhat *et al.* (2001).

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