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SEASONAL VARIATIONS IN PHYSICO- CHEMICAL CHARACTERISTICS OF ANCHAR LAKE, KASHMIR

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ABSTRACT
Lakes are sometimes subjected to waste water discharges originating from different sources. Chemicals such as nitrogen, phosphorous and carbon in certain concentrations might distort and disrupt aquatic ecosystems. Eutrophication of inland water bodies has become synonymous with the deterioration of water quality, which interferes with most of its beneficial uses. Water depth was varying from 0.71 m to 1.73 m with an average of 1.28±0.07m, transparency 0.27 m to 0.93 with the mean value of 0.68±0.05 m, temperature between 3.1^{0}C and 25.6^{0}C, pH of water was on alkaline side (7.3 to 8.3), dissolved oxygen was found to be higher during autumn and winter seasons with an average dissolved oxygen content as 4.2±0.30 mg/L, free carbon dioxide ranged from 0.40 mg/L to 34.00 mg/L, Conductivity ranged from 296.4 µS/cm to 461.0 µS/cm, silicates ranged from 2.00 to 4.46 mg/L, Calcium fluctuated between 13.8 mg/L to 58.6 mg/L During this study period, the lower values of total phosphorous were recorded during autumn season and higher during warmer periods, total hardness ranged from 125.2 mg/L to 197.1 mg/L, total alkalinity ranged between 236.4 mg/L to 381.2 mg/L, Higher values of ammonical nitrogen were recorded during winter and lower during summer season, nitrate nitrogen values recorded were in the range 137.3 µg/L to 323.4 µg/L. Correlation among various parameters showed significant positive and negative trends. Considering all the parameters taken for the judgment, classification of water bodies put forth by various workers, present lake has been placed under eutrophic water body.

KEYWORDS: Lake, physico- chemical parameters, eutrophic, seasonal variation, Anchar Lake

INTRODUCTION

Water supports life on earth and around which the entire fabric of life is woven. The requirement of water in all lives, from micro-organisms to man, is a serious problem today because all water resources have been reached to a point of crisis due to unplanned urbanization and industrialization (Singh *et al.*, 2002). Lakes are subjected to various natural processes taking place in the environment, such as the hydrological cycle. Storm water runoff and discharge of sewage into the lakes are two common ways that various nutrients enter the aquatic ecosystems resulting in the death of those systems (Sudhira and Kumar, 2000). Physico-chemical and biological characterize any water body. The physical and chemical properties of freshwater body are characterized by the climatic, geochemical, geomorphological and pollution conditions. Various physico-chemical parameters were studied to analyze the water quality of the lake. The pollution of this lake is a matter of great concern, since it has reached an alarming level due to inflow of large volume sewage and solid wastes. The lake receives a large amount of raw sewage from its densely populated habitation. The water body is an eutrophic lake where the amount of nutrient is very high and oxygen depletion is prominent (Varughese *et al.*, 2004). The untreated wastewater contains effluent rich in phosphate, caustic soda and detergent etc. The phosphate and nutrient are two important nutrients in the lake loading through point and non- point pollution sources such as washing, bathing, agricultural activities in fringe area, joining of domestic raw sewage, cultivation of trapa and huge amount of aquatic Macrophytes. These nutrients support the fast growth of the aquatic plants mainly *Eichhornia crassipes*, *Hydrilla, Ceratophyllum* etc. as a result these plants lead to gradual shrinking of wetland area along with other complications like low light penetration, reduces oxygen concentration, clogging of water channels, lowers entertainment value of lake and some time the level of oxygen depletes so that it can lead to fish mortality also (Tamot And Sharma, 2006).

MATERIALS AND METHODS

Study Area

Anchar is a shallow basined lake with fluviatile origin, situated near Soura 12 km to the north west of Srinagar city at an altitude of 1583 m. s. l and lies within the geographical coordinates of 34º 20´- 34º 36´N latitude and 74º 82´ - 74º 85´ E longitudes in a semi urban conditions. Sprawled over a wide swath of the area along the east side of Srinagar-Ganderbal road, Anchar lake is in pathetic shape and waters of the lake are alkaline. Lake is barely visible with weeds growing dense and deep where water should have been.

The analyses of samples were done according to the procedure prescribed by APHA (1998) manual. Present study comprises of interpretation and analysis of water

sample collected from four stations. The present work was divided into three parts:

(i) Pre- field preparation
(ii) Field work
(iii) Post-field interpretation

Pre- field study consisted of marking of sampling stations for water sample collection. During field work stations were established and water samples were collected. The samples were analyzed for different chemical and physical parameters. Pre- field study includes compilation of data generated and collected after testing of samples. Dissolved oxygen, temperature and pH were measured directly at the field by means of chemicals and instruments. Other water quality parameters were done on the same day in Hydrobiology Research Laboratory, Govt. Sri Pratap College Srinagar. Titration methods were used for total alkalinity and total hardness and the results were expressed as mg/L. The information and data generated from field work throws light on various aspects.

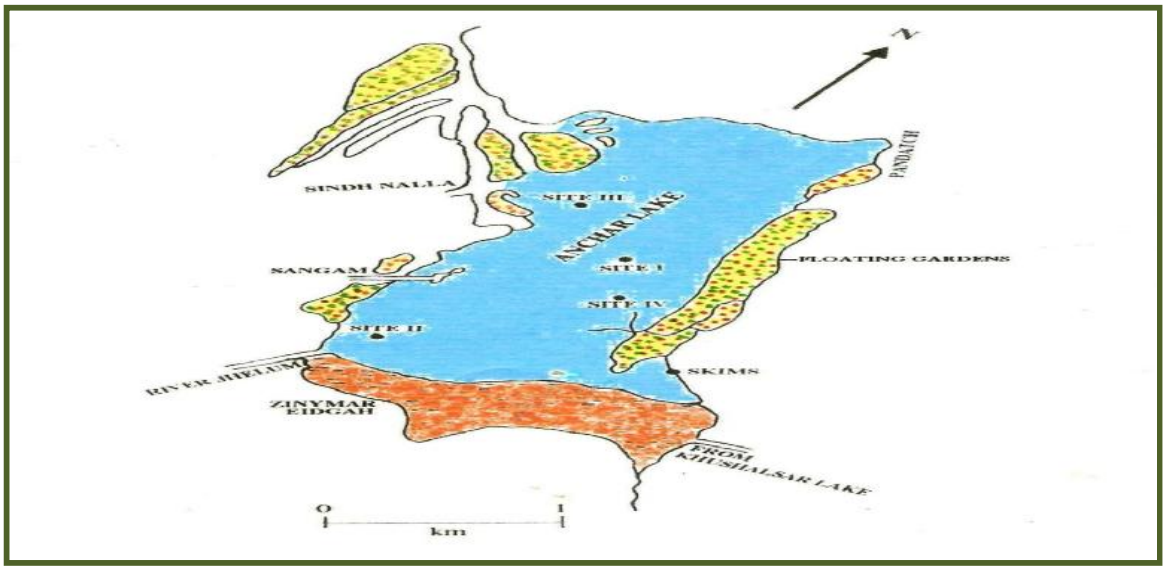

FIGURE 1: Map of study area showing location of different water sampling stations.

RESULTS AND DISCUSSION

Water depth showed large spatial and temporal variations during the study period of one year thereby indicating the gradual shallowing of the lake with the passage of time Water depth was varying from 0.71 m to 1.73 m with an average of 1.28±0.07 m. During the study period the water depth increased during autumn, winter and spring seasons and decreased during summer season. The shallowing of the lake is attributed to the process of continuous silting. In Anchar lake maximum depth was recorded during autumn and winter seasons and minimum in summer season due to evaporation and supply for the irrigation.

During the period of study, the secchi transparency ranged between 0.27 m to 0.93 m with the mean value of 0.68±0.05 m. The value when compared with the OECD (1982) falls within the category of eutrophic lakes. The cause of this has been attributed by them to the domestic effluents and sewage entering the lake, causing nutrient enrichment. During the investigation period the mean values recorded were 0.61±0.05m, 0.61±0.05m, 0.65±0.05m and 0.68±0.06m at site I, II, IV and III respectively in decreasing order and average transparency of the lake was recorded as 0.64±0.05m.

The average monthly temperature fluctuated between a minimum of 3.1 ºC in January to a maximum of 25.6 ºC with an average of 16.34±2.22. Water temperature was as usually high in summer and low in winter season. The low temperature was observed in the month of January 2011 and peak of high temperature was observed in the month

of July, 2010. It is because of the shallowness of the lake and consequently the volume of water in contact with air, a close relationship exists between atmospheric temperature and water temperature and as such the water is warmer during summer and colder during winter, although the annual amplitude of variation in water temperature was between 3.1 ºC and 25.6ºC during the period of study. The high temperature of water bodies is the result of low water depth and volume of water which remains in contact with air (Zutshi *et al.*, 1980).

The present investigation revealed that the pH of lake water ranged between 7.96 and 8.39, showing its alkaline nature. pH was lower in the early summer during the study period and higher values were observed in the autumn and winter seasons and average pH of the lake was recorded as 8.0±0.02. The lower pH during other season was evidently due to the increased decomposition under low water depth. In case of Anchar lake, the high pH value is probably due to the addition of hydroxyl, bicarbonate and carbonate anions (Zutshi *et al.,* 1980).

TABLE 1: Physico chemical Characteristics of Anchar Lake during June 2010 to May 2011

S.No	Parameter	Range of variation		Mean ±SE
		Min	Max	
1	Depth (m)	0.71	1.73	1.28±0.07
2	Transparency (m)	0.27	0.93	0.64±0.05
3	Temperature (^{0}C)	3.1	25.6	16.34±2.22
4	pH	7.96	8.39	8.0±0.02
5	Dissolved oxygen (mg/l)	2.0	06.9	4.2±0.30
6	Free Carbon dioxide (mg/l)	4.0	34.00	18.05±1.56
7	Total alkalinity (mg/l)	236.4	381.2	326.4±11.03
8	Conductivity (µS/cm)	296.4	461.10	363.7±10.73
9	Silicates (mg/l)	2.00	4.46	3.18±0.19
10	Total hardness (mg/l)	125.2	267.4	198.4±7.10
11	Chlorides (mg/l)	20.2	52.8	33.5±3.19
12	Calcium (mg/l)	13.8	58.6	31.10±2.57
13	Magnesium (mg/l)	3.7	16.8	8.73±0.76
14	Total Phosphate Phosphorus (µg/l)	287.7	512.4	394.1±21.42
15	Ortho Phosphate Phosphorus (µg/l)	51.4	179.6	117.3±12.11
16	Ammonical Nitrogen (µg/l)	210.3	499.3	336.3±21.60
17	Nitrate Nitrogen (µg/l)	137.3	323.4	252.5±9.89
18	Sodium (mg/l)	2.5	17.8	9.25±1.14
19	Potassium (mg/l)	2.1	9.2	4.65±0.51

TABLE 2: Trophic status of Anchar lake, Srinagar

S. No.	Parameters	Unit	Min	Max	Mean ± SE	Trophic Status	References
1.	Electrical Conductivity	µS/cm	296.4	461.0	363.7±10.73	Eutrophic	Olsen (1950)
2.	pH	-	7.96	8.39	8.0±0.02	Alkaliphilous	Venkateshwarlu,1983
3.	Free Carbon dioxide	mg/L	4.00	34.00	18.05±1.56	Hard	Reid and Wood, 1976
	Total Alkalinity	mg/L	236.4	381.2	326.4±11.03	Nutrients Rich	Spence, 1964
4.	Total Hardness	mg/L	125.2	267.4	198.4±7.10	Hard	Sawyer, 1960
5.	Chlorides	mg/L	20.2	52.8	33.5±3.19	Polluted	Ohle, 1934
6.	Nitrate	mg/L	137.3	323.4	252.4±9.89	Mesotrophic	Vollenweider, 1968
7.	Total Phosphorous	µg/L	287.7	512.4	394.1±21.42	Polytrophic	Lee *et al.*, 1981
8.	Transparency	m	0.29	0.93	1.28±0.07	Eutrophic	Lee *et al.*, 1981
	Trophic Status					Eutrophic	

Dissolved oxygen oscillated from 02.9 mg/L in May, 2011 to 6.9 mg/L in January, 2011 with an average of 4.2±0.30 mg/L throughout the study (Table 1). Dissolved oxygen was found to be higher during autumn and winter seasons with an average dissolved oxygen content as 4.2±0.30 mg/L. However, in case of Anchar Lake, the overall moderate content of dissolved oxygen is due to high biological oxygen demand during decomposition of organic matter. The values obtained for investigated water body recorded higher amount of dissolved oxygen during winter and low values during summer months, thus clearly reflecting an inverse relation of dissolved oxygen with the temperature. Dissolved oxygen level during winter can also be attributed to low biological activity (Vass *et al*., 1977; Qadri *et al.*, 1981).

The concentration of free carbon dioxide during the study period ranged from 0.40 mg/L to 34.00 mg/L with an average of 18.05±1.56. The free carbon dioxide was high during autumn and winter seasons during the one year study period. High concentration of free carbon dioxide during the warmer period may be due to the decomposition of organic matter, utilizing dissolved oxygen and liberating carbon dioxide .

During the period of study, it ranged between 296.4 µS/cm to 461.0 µS/cm with an average of 363.7±10.73 (Table 1). The conductivity values, however, indicate that the maximum conductivity was observed in the summer period. The higher conductivity values throughout the entire period of study place this water body in mesotrophic water bodies (Olson, 1950). The higher conductivity values, as obtained during the peak summer months, are the result of availability of various minerals due to the fast rate of decomposition during this period .

The concentration of silicates ranged from 2.00 to 4.46 mg/ L with an average of 3.18±0.19 mg/ L. Lower values of silicates were recorded in autumn months while as higher values in the winter and spring seasons. Thus the silicate content of the water is low as this mineral is utilized in the growth and multiplicating diatoms (Sarwar, 1986, 1987, 1988, 1989). In the present study silicates content was found to be higher during summer season due to higher evaporation rate.

In the present study, during the observation period the values of chlorides fluctuated between 20.2 to 52.8 mg/L with an average of 33.5±3.19 mg/L (Table 1). In Anchar lake higher values of chlorides were observed during summer and lower value in winter season due to dilution factor of rain water entering into the lake confirming the observations of earlier workers. The higher concentration recorded during warm months (summer) may be attributed to the sewage contamination and higher evaporation rate .

It fluctuated during the period of one year study between a minimum of 13.8 mg/L to 58.6 mg/L with an average of 31.10±2.57 mg/L. The values indicate a definite trend during this one year study, which depicted low values in summer and high values in winter season. The concentration of calcium, therefore, remained generally high placing the wetland in Ca^{++} rich type according to a pioneering German limnologist, Ohle (1934).

Like calcium, magnesium also showed a regular trend of low values in cold months and high values in summer period. During the investigation period, the annual values ranged from 3.7 to 16.8 mg/L with an average of 8.73±0.76 mg/L . Low magnesium content is possibility due to its uptake by the plants in the formation of chlorophyll-porphyrin metal complexes and in enzymatic transformation (Wetzel, 1975).

During the study period, the concentration of total phosphate phosphorous ranged from 287.7 to 512.4 µg/L with an average of 394.1±21.42 µg/L. During this study period, the lower values were recorded during autumn season and higher during warmer periods.

The high concentration of both the forms of phosphorous during warm periods can be attributed to decay and subsequent mineralization of dead organic matter and surface runoff (Cole, 1975), while low concentration during summer is attributed to the utilization of nutrients by autotrophs (Kaul *et al*., 1978). On the basis of classification Lee *et al*. (1981) Anchar lake can be placed under eutrophic water bodies (Table 2).

The concentration of orthophosphate phosphorous during the study period ranged from 51.4 µg/L to 179.6 µg/L with an average of 117.3±12.11 µg/L (Table 1). During this study, lower values were recorded during spring season and higher values during autumn and winter seasons. The low orthophosphate-phosphorous content in waters is due to the formation of an insoluble calcium-phosphate complex. Such a phenomenon is activated when removal of some inorganic nutrients has to be done which acts as a removal agent of dissolved organic matter by absorption (Wetzel 1974).The high concentration of both the forms of phosphorous during warm periods can be attributed to decay and subsequent mineralization of dead organic matter and surface runoff (Cole, 1975), while low concentration during summer is attributed to the utilization of nutrients by autotrophs (Kaul *et al*., 1978). The concentration of total phosphate phosphorous was quite high as compared to the orthophosphate phosphorous. During this study period, the lower values were recorded during autumn season and higher during warmer periods.

During the investigation period the values of sodium were recorded in the range of 2.5 to 17.8 mg/L with an average of 9.25±1.15 (Table 1). Sodium values were found to be higher during autumn months and moderate during summer season. The sodium and potassium content of this lake is compatible with the findings of Zutshi (1968) and Zutshi *et al*., (1980) in various Kashmir lakes. The present investigation also indicates that the lake is undergoing accelerated eutrophication.

During the present study period the values of potassium ranged between 2.1 to 9.2 mg/L with an average of 4.65±0.51 mg/L (Table 1). Higher values were recorded during autumn and winter months and lower during summer and spring seasons .

The concentration of total hardness during the study period ranged from 125.2 mg/L to 197.1 mg/L with an average of 147.6±6.68 mg/L. Higher values were recorded during summer season and lower during autumn and winter season. Anchar lake according to classification of Sawyer (1960) has been placed under the category of hard water. The decrease in the concentration of bicarbonates during summer confirm the findings of Sahai and Srivastava (1976) recorded low concentrations of bicarbonates from June to October owing to its increased use in carbon

assimilation by phytoplankton and submerged Macrophytes during photosynthesis.

The values recorded were in the range of 236.4 mg/L to 381.2 mg/L with an average of 326.4±11.03 mg/L (Table 1). During autumn, winter and spring season higher values were observed and during summer season lower values were recorded . In the present study, the total alkalinity ranged from 236 mg/L to 387.2 mg/L during the summer season, which corroborated the observation of Kaushik (1992), Garg *et al*., (2006 and 2009), Jayabhaye *et al.,* (2008) and Telkhade *et al.,* (2008). Anchar lake can be placed in the category of nutrient rich (Spence, 1964) and highly productive (Alikunhi, 1957) water bodies.

The nitrate and phosphate are two important constituents that immensely help in the growth of the plants where they present. If they are present in lake and ponds they excessively promote the growth of aquatic weeds and polluting our aquatic resources. During the investigation period, the ammonical nitrogen values recorded were in the range 210.3 mg/L to 499.3 mg/L with an average of 336.3±21.60 mg/L (Table 1). Higher values were recorded during winter and lower during summer season. Since the values of ammonical nitrogen are quite high in the lake, they are suggestive of high degree of sewage pollution in the lake.

During the investigation period the values of nitrate nitrogen recorded were in the range 137.3 µg/L to 323.4 µg/L with an average of 252.5±9.89 µg/L. Higher values were recorded during summer and spring and lower values during winter seasons. The values of nitrate nitrogen are also quite high along with phosphates. The high concentration of NO_3-N during the period of warmer months may be due to the presence of fertilizers used in the vast catchment area and the end products of complete nitrification. Deleterious levels of almost all the physico-chemical parameters were observed. The overall observation of the data indicated a fast deterioration of water quality in the available water resources, the pollution source being both point and non- point sources. It is therefore needful that urgent steps be taken to ensure effective water resources management.

Correlation among various parameters

Water temperature showed moderate positive correlation with magnesium, silicates and nitrates. Transparency also has shown moderate positive correlation with dissolved oxygen and low degree of positive correlation with free carbon dioxide, calcium and nitrates. PH showed moderate positive correlation with total alkalinity and low degree of positive correlation with total phosphate phosphorous and nitrate. Total alkalinity exhibited very high positive correlation with magnesium, fairly high degree of positive correlation with nitrate and potassium and moderate positive correlation with sodium. Calcium also showed very high degree of positive correlation with magnesium. Silicates had exhibited moderate negative correlation with sodium and fairly high degree of negative correlation with potassium. Total hardness showed low degree of negative correlation with orthophosphate, ammonical nitrogen and nitrate

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