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Trophic status assessment of Anchar Lake, Kashmir

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Abstract
The present study was carried on a Anchar Lake situated at a distance of 14 km in northwest of Srinagar at an altitude of 1584 m within the geographical coordinates of Lat. 34°20' N and Long. 74°82'E. It is a single basined lake connected on the eastern side of Dal Lake through an inflow channel 'Nallah Amir Khan' via Gilsar and Khushalsar. Various physico-chemical parameters of water were assessed over a period of 12 months (December 2015 to November 2016) on monthly basis at four different sites. Results showed significant increase in Nitrate, Ammonia, Orthophosphate, Total Phosphorus indicating increased levels of pollutants in the lake due to anthropogenic pressures like discharge of sewage, agricultural runoff and urbanization.

Keywords: trophic status, Anchar lake, Kashmir, eutrophication

Introduction
Anthropogenic activities like agricultural practices and sewage run-off from urban areas have increased nutrient inputs many folds than the level of their natural occurrence, resulting in accelerated eutrophication and pollution (Zan *et al*. 2011) [16]. As a consequence, most of the lakes in the Kashmir valley are exhibiting eutrophication. It is now quite common that the lakes of Kashmir valley are characterized by nutrient enriched waters, excessive macrophytes, algae blooms and marshy conditions along the peripheral regions. Therefore, the present study was devised with an aim to know the present trophic status of Anchar Lake.

Description of study area
Anchar lake
Anchar lake is situated at a distance of 14 km in northwest of Srinagar at an altitude of 1584m within the geographical coordinates of Lat. 34°20' N and Long. 74°82' E. It is a single basined lake connected on the eastern side of Dal lake through an inflow channel 'Nallah Amir Khan' via Gilsar and Khushalsar. The lake, though close to Srinagar city, constitute both rural and urban characteristics in a typical rural environment. In recent years significant encroachments have been noticed within the lake. According to Lawrence (1895) the area of the lake in 1893-1894 was 19.54 km2, which has now been reduced hardly to 6.8 km2 of which 3.6 km2 is marsh. The lake is under tremendous biotic pressure and receives large quantities of domestic sewage from its immediate catchment (Adnan *et al*. 2008) [1].

Lake morphometery
The morphometric features of Anchar Lake are tabulated as follows. The lake is shallow with depth varying between 0.4m and 3.0m with the mean depth as 1.5m. The ratio of mean and maximum depth ranges from 0.60 to 0.67 which coupled with the shoreline development indicates the biconvex nature of the basin towards the water surface (Adnan *et al*. 2008) [1].

Surface area	680 (ha)
Maximum depth	3.0 (m)
Mean depth	1.5 (m)
Development of volume	1.5 (Dv)
Shoreline development	0.9 (DI)

Material and Methods
The present studies pertain to year 2015-2016. About six stations were selected representing all over lake and the results have been computed on annual average basis. The sampling was done on monthly basis and usually composite samples were considered for physico-chemical analysis. The water sampling was done usually during forenoon (900-1100hrs.). Water

transparency was measured with the help of a standard Secchi Disc (dia; 20cm). The water temperature was recorded by thermister while the pH and specific conductivity was measured using Systronic's pH and conductivity meters. Oxygen concentration was determined by Winkler's modified method. Pre- fixation of the samples was done in the field. For rest of the parameters standard methods given in APHA (2012), Trivedy *et al*. (1995) and Mackereth (1963) were followed using UV-spectrophotometer (Korea).

Results and Discussion

Hydro-chemical features

The investigation carried out over a period of time by authors during 2015-2016 clearly indicates that the lake is polluted to a large extent and there is general increase in its nutrient enrichment. The maximum concentration of chloride, Magnesium, Sodium, Potassium, Silicate, Iron, Ortho phosphates and Total phosphorus is recorded at the S.K. Institute of Medical Sciences which reflects the malfunctioning of the treatment plant set up by the hospital authorities and its visible impacts on the hydrochemical features of the lake. The recent Limnological investigations reveal that the average depth of the lake varied from 0.95m to 1.7m with an average value of 1.1m while an average value of 0.5m. However, the pH is still on alkaline side (7.9) with an average total alkalinity value of 169 mg/l. The specific conductivity ranged between 297 µs cm^{-1} to 510 µs cm^{-1} with an average value of 374µs cm^{-1}. The dissolved oxygen concentration in the lake water ranged from 5 mg/l to 7.2 mg/l with an average value of 5.5 mg/l. The chloride content ranged between 23.5 mg/l and 42 mg/l with an average value of 30.6 mg/l. The calcium content is predominated over magnesium and the ratio of calcium and magnesium is 1:9. The iron content is very high ranging between 690µg/l and 908µg/l, with an average value of 724 µg/l. The nitrate nitrogen content ranged from 558 µg/l to 641 µg/l with an average of 574 µg/l. Likewise the ammonical nitrogen content in the lake water is recorded between 231 µg/l and 381 µg/l with an average value of 303 µg/l. The average ortho phosphate and total phosphorus concentration in the lake water is recorded to be 402µg/l and 708µg/l respectively.

Water quality changes

The water quality of Anchar Lake (Table 1) reveals that the lake water as a whole seems to be well buffered. The average secchi transparency of the lake water is low (0.4m-0.5m) which could be attributed to the increased quantity of suspended material present in the lake basin. The average specific conductivity values in the lake are showing an increasing trend which can deteriorate the physical-chemical and bacteriological status of the lake waters to great extent. Zutshi and Khan (1988) [17] regard the higher conductivity values as an indication of higher trophic level. Similar views have been expressed by young *et al.* (1972) [15], Berg *et al.* (1958) [3], Mathew and Vasudevan (2000) [10], Agarwal and Kannan (1996) [2]. The oxygen concentration in Anchar Lake has depleted during the last decade. According to Das & Pande (1982) [4] the depletion of oxygen particularly in the bottom waters are due to anaerobic bacteria who take over the process of decomposition of biological organic material releasing foul smelling hydrogen, methane and ammonia. These gases not only deplete oxygen in water but are toxic, killing most of the plankton, algae and zooplankton in the lake. Wanganeo *et al*. (1997) [14] regard the dependence of oxygen concentration in water on temperature, plankton population and the degree of sewage pollution. The average chloride content in the Anchar Lake during the last decade is recorded to be between 27-30.6 mg/l which are quite high. Thresh *et al*. (1944) [7] suggested that high chloride contents indicate the presence of organic matter, presumably of animal origin which happens in this case too. Mathew *et al*. (2000) [10] related elevated chloride content to flow of sewage while Moyle (1956) [11] and Ghose and Sharma (1986) [5] attributed the higher values of pollution. The average iron content in the lake water during the last decade is recorded to be between 500-724 µgl^{-1} which is quite high. According to lund (1965) [9] the availability of the iron content seems to be dependent on the organic matter present. Jumppanen (1976) [8] attributed the increase in the iron content to oxygen deficit. The increasing trends of nitrogen and phosphorus as revealed by the investigations (Table 1) is indicative of higher trophic level of the lake waters and is in conformity with Hutchinson (1957) [6] who also reported the increase of phosphorus as a result of sewage contamination. Thresh *et al*. (1944) [7] have attributed the nitrogen richness of a fresh body to the pollution of animal origin. According to McCaull and Crossland (1974) [12] the most important factors responsible for eutrophication of freshwater lakes are phosphorus (Po_4-p) and nitrogen (No_3-N). However, Schindler *et al*. (1971) [13] singled out phosphorus for attention because it is believed to be nutrient frequently controlling eutrophication. Nitrogen and phosphorus can be considered as two of the major elements limiting primary production in Anchar Lake.

Table 1: Showing minimum, maximum and mean values of Lake Water parameters of Anchar Lake

Parameters	Units	2015-2016		
		Min	Max	Avg.
Depth	m	0.95	1.7	1.1
Transparency	m	0.5	0.8	0.5
pH		7.8	8.2	7.9
Conductivity	µS cm^{-1}	297	510	374
Dissolved oxygen	mg/l	5	7.2	5.5
Chloride	mg/l	23.5	42	30.6
Total alkalinity	mg/l	158	191	169
Calcium	mg/l	48.5	74.5	60
Magnesium	mg/l	5.3	9.9	7.2
Iron	µg/l	690	908	724
Nitrate nitrogen	µg/l	558	641	574
Ammonical nitrogen	µg/l	231	381	303
Ortho phosphate	µg/l	182	698	402
Total phosphorus	µg/l	550	910	708

Nutrient balance

Since a close relationship exists between the quantity of nutrients entering the lake and its degree of trophic status, a measurable kind of trophic index can be calculated. A load tolerance model incorporating mean depth, flushing rate and critical level of phosphorus was used to obtain the degree of eutrophication. The nutrient balance of the lake is estimated as under:

		Phosphorus (Tones/Year)	Nitrogen (Tones/year)
1.	Input from catchment area	1.53	66
2.	Human wastes	1.43	13.52
3.	Springs and precipitation	2.77	2.87
	Total Nutrient Input	5.73	82.39

Conclusion

In the present study, a visible deterioration in water quality of Anchar Lake has been observed over a period of time. The possible reason being increase of population, rapid expansion in the urban and agricultural practices in the immediate catchment. In generation, high volume of waste material has resulted in gradual degradation of aquatic resources. The study reveals high input of nutrients and organic biomass into the lake's basin, resulting in increased levels of productivity. Therefore, we can expect water quality to deteriorate further unless authorities are willing to manage the activities to ensure safe water quality of lake.

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