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Present trophic status of Anchar Lake, Kashmir: Assessment by water quality parameters

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Abstract
In the present study, various physico-chemical parameters of water were assessed over a period of six months on monthly basis at different lake sites with an aim to know the present trophic status of Anchar Lake. Results showed significant increase in Free carbon dioxide (13.82±3.98 mg/l); Nitrate-nitrogen (546.33±132.30 µg/l); Ammoniacal-nitrogen (208.11±59.42 µg/l); Ortho-phosphate (217.5±68.96 µg/l) and Total Phosphorus (534.38±131.66 µg/l) indicating increased levels of pollutants in the lake due to anthropogenic pressures like discharge of sewage, agricultural runoff and urbanization. The study recommends that preventive measures should be undertaken to protect this waterbody from further degradation.

Keywords: Anchar Lake, physico-chemical parameters, trophic status, anthropogenic factors, freshwater ecosystems

Introduction
Fresh water resources are most precious to earth. Increased demands on the resources have impacted heavily on natural aquatic ecosystems. The interdependence of aquatic and terrestrial ecosystems, including interactions by man, finds its most sensitive responses in lakes. The rapid changes that have been observed in the last few decades in chemical and biological properties of many water-bodies reflect the human influence on the environment (Stumm, 1986) [20]. Industrial development and population explosion have put more stress on the aquatic ecosystems resulting in deterioration of water quality and change in floral and faunal diversity. Moreover, this phenomenon is now quite common in valley lakes of Kashmir as they are characterized by excessive growth of macrophytic vegetation, anoxic deep water layers, and shallow marshy conditions along the peripheral regions and have high loads of nutrients in their waters (Jeelani and Shah, 2006; Khan, 2000; Koul *et al.*, 1990 & Adnan and Kundangar, 2018) [13, 16, 17].

Study Area and Study Sites
The present study was carried on Anchar Lake (34º 20′-34º 36′ N Latitude and 74º 82′-74º 85′E Longitude), which is a shallow basined lake having an area of about 5.8 km^2 situated near Soura, 7.1 kilometers away from Srinagar city, at an altitude of 1583 m.s.l. The lake is fed by a number of springs present in the basin itself and along its periphery. River Sindh enters the lake on its western side and forms a network of distributaries. Towards the north-east of this water basin is situated the complex of SKIMS (Sher-i-Kashmir Institute of Medical Sciences), draining its toxic influents into the lake. The runoff from the surrounding paddy fields including floating gardens and sewage from the surrounding human habitation is also drained into the lake, thereby further enhancing the nutrient levels of the lake (Adnan *et al.*, 2018). On the eastern bank, major portion of peripheral areas has been encroached by the locals. They have filled a large area within the lake and changed into vegetable gardens. Further, a number of channels from agriculture fields, effluents from settlements and surface runoff from catchment area, directly drain into it throughout the year. The lake outfalls into River Jhelum at Sangam on its north-east direction. The area of the lake in 1893-1894 was 19.54 km^2, which has now been reduced hardly to 6.8 km^2 of which 3.6 km^2 is marsh (Adnan and kundangar, 2008) [3].
Anchar Lake is facing a serious threat from anthropogenic activities in the catchment, because of which the lake's water chemistry has been altered. Moreover, presence of SKIMS hospital in the vicinity of lake also poses threat to its ecology. In order to know the impact of these activities on water chemistry of Anchar Lake, the present study has been envisaged with below mentioned objectives.

- To study the impact of anthropogenic activities on water quality of Anchar Lake, Kashmir.

For obtaining the present objectives, following three sampling sites has been selected and a brief description of these sites have been given below and shown on map (Fig, 1).

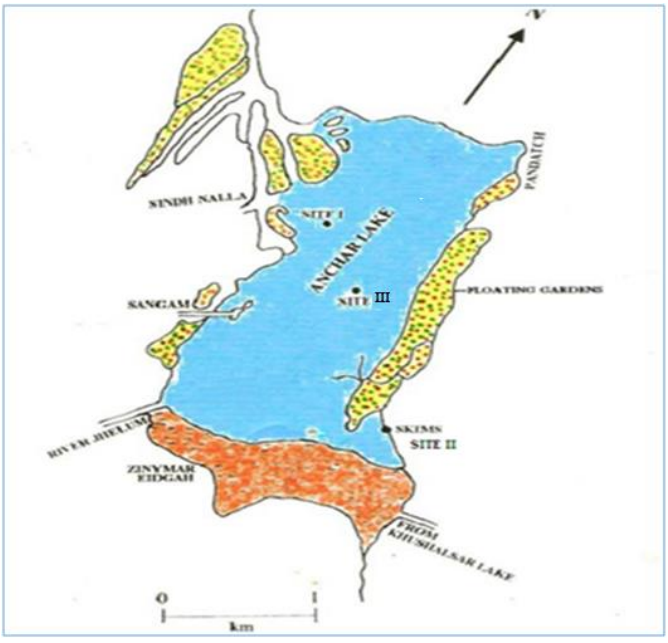
Site (I): This site is located at the mouth of Anchar lake where it receives fresh snow melt from River Sindh.

Site (II): This site is located towards north-east region of the lake. At this site, the lake receives effluent and sewage wastes from the drainage system of SKIMS and nearby habitation.

Site (III): This site is located near the Holy Shrine Jenab Sahib Soura. This site is located close to the point where lake receives wastes from human habitation living along the peripheries.

Materials and Methods

For assessing the water quality status of Anchar lake, surface water samples were collected by hand from the lake at designated sites using sampling bottles. The sampling was done usually between 10.00 A.M to 11.30 A.M. For dissolved oxygen, D.O bottles of 125ml capacity were used and the fixation of the samples was done on the spot. Air temperature, Water temperature, Depth, Transparency and pH were determined at the sampling spot and samples for detailed analysis (Free CO_2 (mg/L); Total alkalinity (mg/L); Nitrate-nitrogen (µg/L); Ammonical-nitrogen (µg/L); Orthophosphorus (µg/L) and Total phosphorus (µg/L)) were immediately transported to the Aquatic Environmental Laboratory, Faculty of Fisheries, Rangil, Ganderbal. The water analysis was carried out using the methods outlined in Adoni (1985) [4] and APHA (2012) [7].



(Source: www.maps-india.com**)**

Fig 1: Map of Anchar Lake Kashmir showing location of sampling stations

Results and Discussion

Air temperature

Temperature is an important factor that governs various parameters of water *viz*., pH, conductivity, total alkalinity, saturation level of gases (Khan, 2008) [15]. A rise in temperature of water leads to increase in the rate of chemical reactions besides reducing solubility of gases. Air temperature strongly influences lake temperature because it affects three important heat-exchange processes between water and the atmosphere - convective heat exchange, evaporative heat exchange, and the atmospheric emission of long-wave radiation (Edinger *et al*., 1968) [11]. During the present study, air temperature was recorded to be maximum (23 ^{0}C) in May and minimum (3 ^{0}C) in February. The overall mean air temperature of Anchar Lake was 10.73±8.0 ^{o}C. The variation in temperature that the air temperature increased during warmer months and decreased during colder months has also been reported by many workers (Balkhi *et al*., 1985; Shah, 1988) [8]. The variation in air temperature has shown graphically in Fig.,1.

Water temperature

Water temperature is one of the most important limnological parameter that plays a prominent role in regulating nearly all other physico-chemical characteristics of the water as well as biological productivity (Wetzel., 1983) [22]. The present data showed that the water temperature recorded higher values during summer months (12.5 ^{0}C) while low temperatures were observed during winter months (1.6 ^{0}C). The overall mean water temperature of Anchar Lake was 6.02±3.86 ^{o}C. The seasonal variation in temperature of different water bodies has also been reported by many workers (Balkhi *et al*., 1985; Shah, 1988) [8, 18]. The highest summer and lowest winter seasonal values in the water temperature indicate that the lake is of temperate type. The variation in water temperature has shown graphically in Fig.,2.

Depth

Greater the depth of light penetration, less it can be considered as limiting the primary productivity of phytoplankton in the water column. The mean depth of Anchar lake was found to be 0.87±0.20 m. The maximum depth was recorded in March (1.2 m) and minimum in May (0.5 m). Decrease in depth in Anchar lake is a result of nutrient enrichment due to fertilizers and wastes from the inhabitations thereby reducing light penetration. The same has been reported by (Ahanger., 2012) [6] that the maximum depth recorded during autumn and minimum in summer season is due to discharge of heavy loads of domestic sewage and agricultural runoff. The variation in depth has shown graphically in Fig.,3.

Transparency

Transparency is one of the important physical properties of water, indicative of degree to which sunlight can pass through water. The mean transparency of Anchar lake was 0.234±0.08m. During the present study, overall low values of transparency in Anchar lake is due to silt content in water which comes through run off from catchment area and fertilizer influx from agriculture which trigger growth of aquatic flora (especially phytoplankton) during warmer periods (summer) (0.17 m) and maximum during winter (0.40 m). The results are in confirmation with (Zutshi and Vass, 1970) [23], who also observed while studying high altitude lakes of Kashmir that the. low values of transparency in Anchar Lake is due to silt content in water which comes through run off from catchment area and fertilizer influx from agriculture which trigger growth of aquatic flora (especially phytoplankton) during warmer periods (summer).The variation in transparency has shown graphically in Fig.,4.

pH (Hydrogen Ion Concentration)

The term pH reflects the activity of the hydrogen ion. pH is the measurement of acidity or alkalinity of water solution, hence it is an important factor for water quality analysis. The overall pH recorded during the present investigation was 7.33±0.38, with a max. pH of (8) recorded in the month of January and a min. value of (6.8) in May. However, Adnan and kundangar (2008) [3], while working on Anchar lake revealed an average pH of 8.6, indicating that there has been a considerable change in pH value over the years. The pH values recorded in the present study were low, which can be attributed to lower rates of photosynthetic activity, a fact also revealed by Agarkar and Garode (2001) [5]. The variation in pH has shown graphically in Fig.,5.

Dissolved oxygen

Dissolved oxygen is one of the most important parameter directly effecting survival and distribution of organisms in an ecosystem. It is critical for the survival of most forms of aquatic life besides being the most reliable criterion in examining the trophic status and the magnitude of eutrophication (Edmondson, 1966) [12]. Mean D.O. was found to be 5.78±1.76 mg/L in Anchar lake with low concentration of dissolved oxygen in the month of May (4 mg/L) mainly at SKIMS site and max. in January (8.5 mg/L). The low D.O. can be attributed to high trophic status and high biological oxygen demand. Adnan and Kundangar (2008) [3], while working on fresh water-bodies of Kashmir has attributed that decline in D.O. concentration is because of incoming sewage. The same can be true for Anchar lake especially at site II, where discharge of hospital waste from SKIMS directly flows into the lake. These results are also in agreement with the work of (Ahangar *et al.*, 2012) [6]. The variation in dissolved oxygen has shown graphically in Fig.,6.

Free CO_2

The free carbon dioxide is an indicator of the biological respiration activities of an aquatic ecosystem. It alters the pH of water by forming carbonic acid, which further dissociates into carbonates and bicarbonates. During the present study, the mean free CO_2 in Anchar Lake was found to be 13.82±3.9 mg/L with max. value recorded in the month of May (15.2 mg/L) and a min of (7 mg/L) in January. The high values of free carbon dioxide content during the present study is an indication of high degree of pollution (Todda, 1970) [21]. The variation in free carbon-dioxide has shown graphically in Fig.,7.

Total alkalinity

Alkalinity plays an important role in determining the ability of water to support algal growth and other aquatic life. Alkalinity is a measure of buffering capacity of water and is important for aquatic life in a freshwater system (Kaushik and Saxena., 1989) [14]. During the present study, overall mean alkalinity was 170.38±22.63 (mg/L) in Anchar Lake with a max. value of (198 mg/L) in March and min. of (125 mg/L) in May. These findings are in agreement with Sharma *et al.*, 2015 [19], while studying water quality of Dal lake found that the higher values of alkalinity registered during summer might be due to the presence of excess of free CO_2 product as a result of decomposition process coupled with the mixing of sewage and domestic waste. The variation in total alkalinity has shown graphically in Fig.,8.

Nitrate-nitrogen

Nitrates are essential nutrients for many photosynthetic autotrophs and in some cases have been identified as a growth limiting nutrient. The presence of nitrates in any aquatic ecosystem depends on the activity of nitrifying bacteria. During the present study, overall mean nitrate in Anchar lake was 546.3±132 µg/L with a max.value of (690 µg/L) in March and a min. value of (325 µg/L) in April. The higher nitrate concentration in Anchar lake may be attributed to the direct discharge of large quantity of untreated domestic sewage, decaying of organic matter and the agricultural runoff that brings along with it nitrates. Abubakr and Kundangar (2004) [1] also reported the progressive increase in nitrogen and phosphorus in lakes and attributed it to sewage contamination. The variation in nitrate-nitrogen has shown graphically in Fig.,9.

Ammoniacal-nitrogen

Ammonia, the chief excretory product of aquatic invertebrates is a nutrient which is preferred over nitrate by the phytoplankton community and other aquatic plants in certain environmental conditions. In the present study, the mean ammonia was found to be 208.11±59.4 µg/L in case of Anchar lake with a max. value of (76 µg/L) in April and min. value of (32 µg/L) in March. The same has been reported from Anchar Lake by (Bhat., 2013) [9]. The relatively higher concentration of Ammonical- nitrogen in Anchar lake may be attributed to entry of domestic sewage, use of nitrogenous fertilizers in the catchment areas. The variation in Ammoniacal- nitrogen has shown graphically in Fig.,10.

Orthophosphate

Phosphorus is an essential element for fertility of lakes and is regarded as key nutrient in the productivity of waters. During the present study, the overall mean ortho-phosphates in Anchar Lake was 217.5±68.9 µg/L with a max. value of (285 µg/L) in April and a min. value of (110 µg/L) in December. The same has been inferred by Abubakr and Kundangar, (2004) [1] while studying the changing biodiversity of seven lakes of Kashmir reporting that increase in nitrogen and phosphorus in lake waters are attributed to sewage contamination. The progressive increase of phosphorus and nitrogen in Anchar lakes is the main cause of changing the trophic status of the lakes. The variation in orthophosphate has shown graphically in Fig.,11.

Total phosphorus

Phosphorus plays a significant role in the biological productivity of an aquatic ecosystem. Phosphorus enters an aquatic ecosystem from human generated sewage and agricultural runoff. During the present study, the mean total phosphorus was 534.38±131.6 µg/L in Anchar lake with a max. value of (655 µg/L) in December and a min. value of (309 µg/L) in April. High values of phosphorus in Anchar lake may be due to the influx of sewage, agricultural runoff probably contaminated with phosphate (applied as fertilizer) and other effluents. The presence of high amounts of phosphorous indicate its eutrophic nature, leading to subsequent algal blooms. The high anthropogenic pressure, contaminated with sewage and other pollution effluents recorded high concentration of phosphorus as is also advocated by Bhat *et al.* (2001) [10]. The variation in total phosphorus has shown graphically in Fig.,12.

Fig: Graphs Showing Monthly Variations In Physico-Chemical Parameters

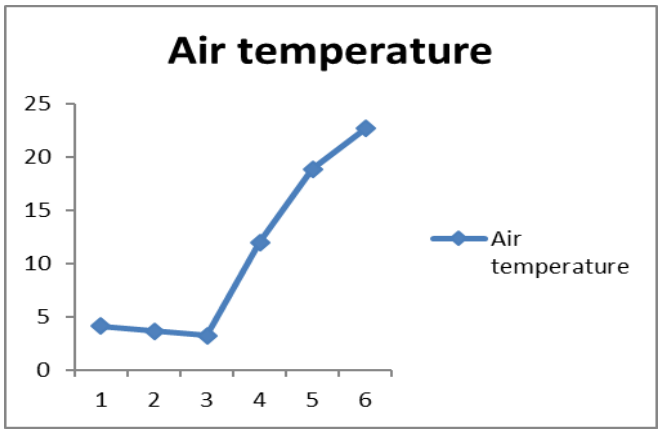


Fig 1: Monthly variations in the air temperature in Anchar Lake

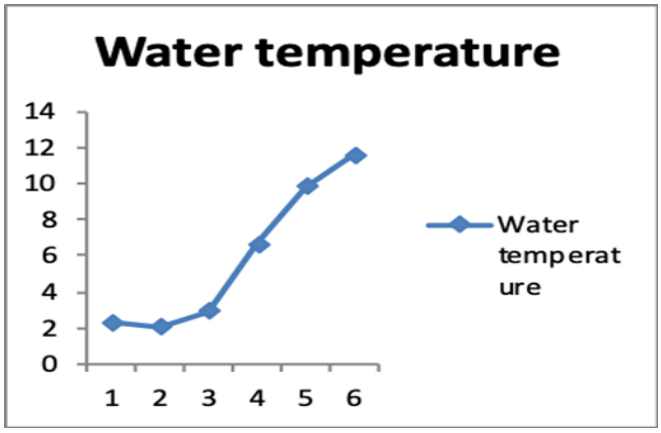


Fig 2: Monthly variations in the water temperature in Anchar Lake

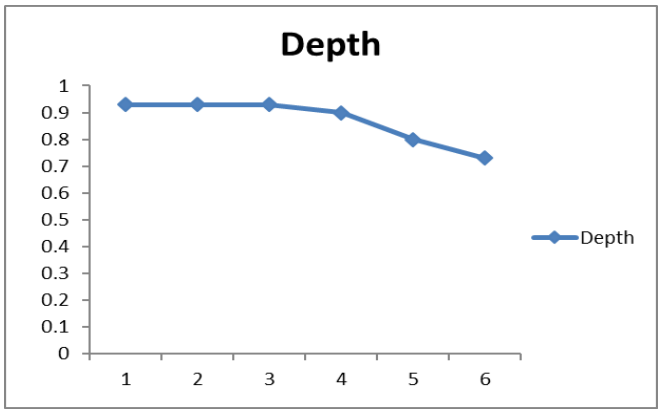


Fig 3: Monthly variations in the Depth in Anchar Lake

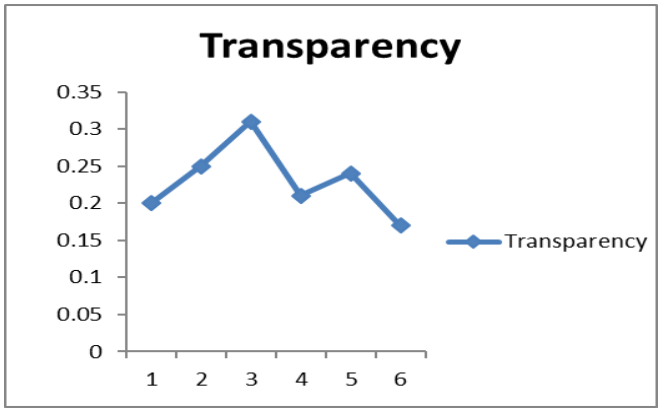


Fig 4: Monthly variations in the Transparency in Anchar Lake

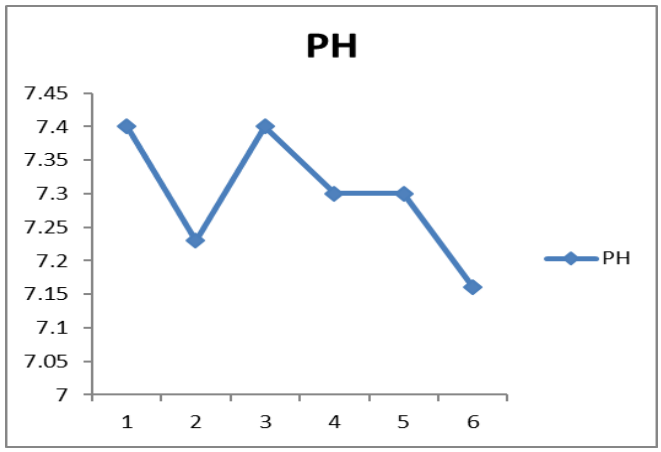


Fig 5: Monthly variations in pH in Anchar Lake

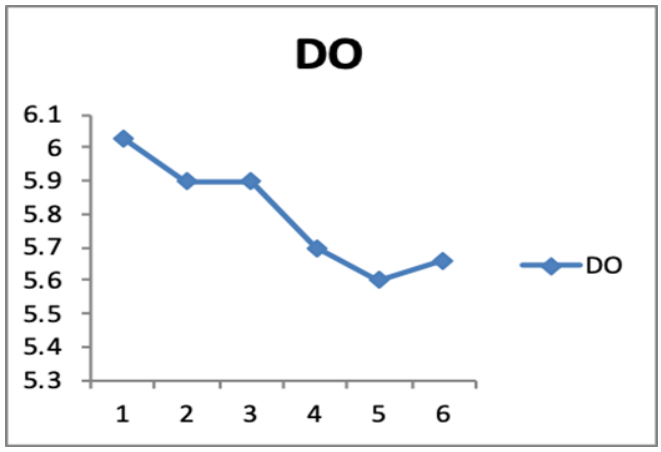


Fig 6: Monthly variations in DO in Anchar Lake

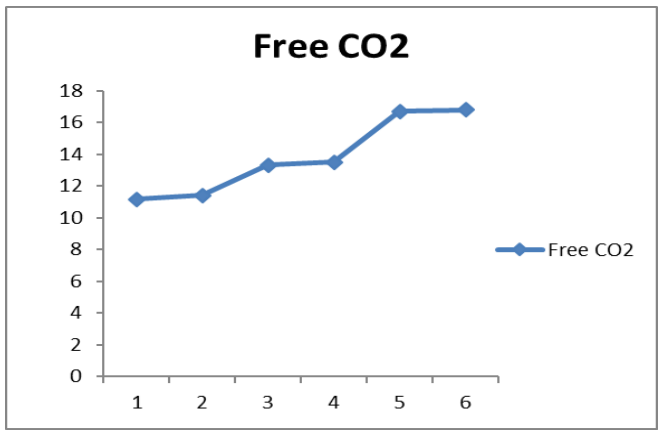


Fig 7: Monthly variations in Free CO_2 in Anchar Lake

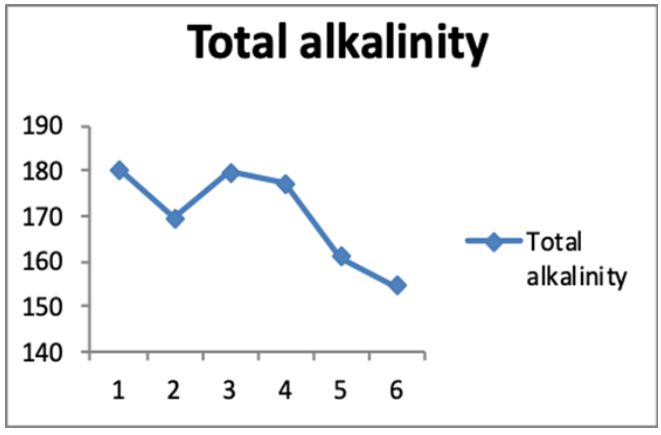


Fig 8: Monthly variations in Total alkalinity in Anchar Lake

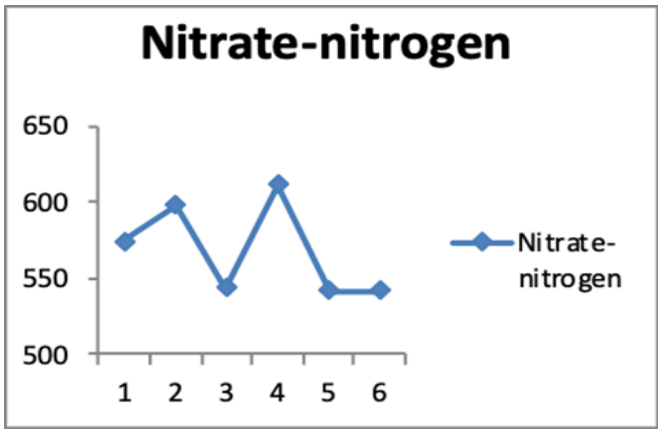


Fig 9: Monthly variations in nitrate-nitrogen in Anchar Lake

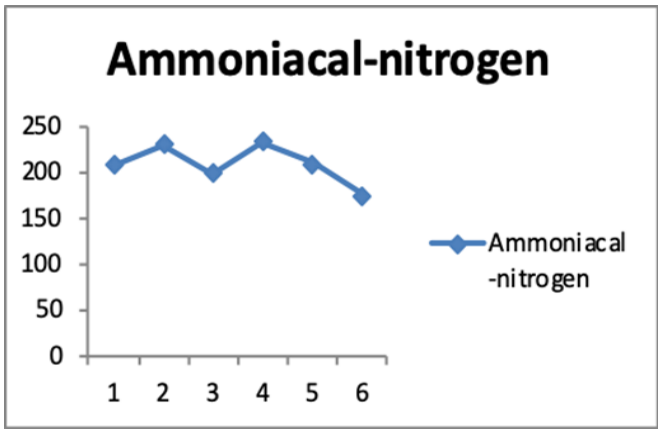


Fig 10: Monthly variations in ammoniacal-nitrogen in Anchar Lake

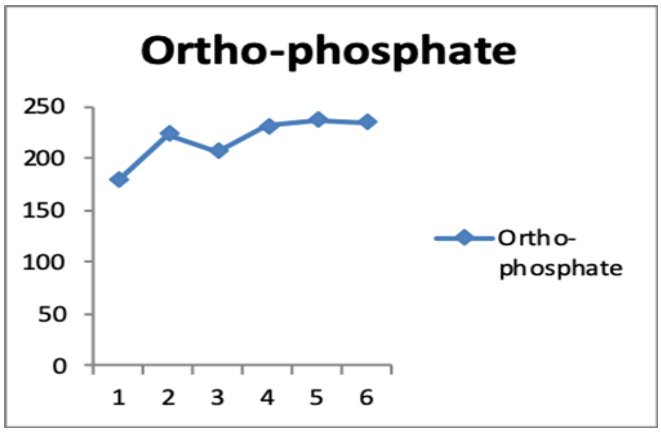


Fig 11: Monthly variations in Ortho-phosphate in Anchar Lake

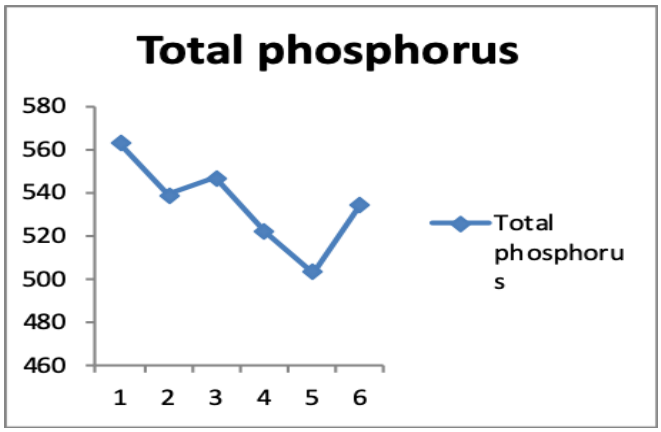


Fig 12: Monthly variations in Ortho-phosphate in Anchar Lake

Table 1: Overall average values of physico-chemical parameters of the Anchar Lake with Mean ± S.D

S. No.	Parameters	(Mean±S.D)
1.	Air temp. (ºC)	10.73±8.00
2.	Water temp. (ºC)	6.02±3.86
3.	Max. depth (m)	0.87±0.20
4.	Transparency (m)	0.234±0.081
5.	pH	7.33±0.38
6.	Dissolved oxygen (mg/L)	5.78±1.76
7.	Free CO_2 (mg/L)	13.82±3.98
8.	Total alkalinity(mg/L)	170.38±22.63
9.	Nitrate-nitrogen (µg/L)	546.33±132.30
10.	Ammonical-nitrogen (µg/L)	208.11±59.42
11.	Orthophosphorus (µg/L)	217.5±68.96
12.	Total phosphorus (µg/L)	534.38±131.66

Conclusion

Anchar Lake has reached a critical stage from ecological point of view. The rate of eutrophication has reached to its maximum, particularly near site II (SKIMS) due to the discharge of waste coming out from hospital. It is therefore, suggested that urgent steps must be undertaken by State Govt. of Jammu & Kashmir for its conservation and management before the lake will become ecologically ill.

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