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Changes in physico-chemical parameters along vertical gradient in Lake Manasbal, Kashmir

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Abstract
The vast resources of water in form of lakes, wetlands, streams and rivers, due to their peculiar natural conditions, are prime centres of cold water fisheries and thus have a major contribution in its development. Manasbal Lake is the deepest freshwater valley lake of Kashmir located in Ganderbal district at mean latitude of 34°15' N and longitude of 74°40'E. Manasbal Lake is warm monomictic urban lake in Kashmir and remains thermally stratified for 8–9 Months The present study on Manasbal Lake, was undertaken from December 2019 – November 2020 to determine various physico-chemical parameters like Temperature, Depth, Dissolved oxygen, pH, Chloride, Free Carbon Dioxide, Ammoniacal Nitrogen, Nitrate Nitrogen and Total Phosphorous along vertical gradient. The bottom levels of the lake was found to be oxygen deficit (O2 < 1 mg/L), which is indicative of the water body's more eutrophic nature. Clinograde type of Dissolved Oxygen curve was recorded, also pH values showed a decreasing trend while Free Carbon dioxide, Chloride, Nitrate Nitrogen, Ammoniacal Nitrogen and Total Phosphate showed increasing trend from surface to bottom waters.

Keywords: Manasbal Lake, water quality, clinograde, eutrophic, vertical gradient

1. Introduction
Lakes have been defined as a body of standing water, occupying a basin or lacking continuity with sea (Forel,1892) [9]. They are inland water bodies which are formed in rock basins of various sizes and shapes. The lakes in Kashmir are an important fishery resource and natural water reservoir for the people of the valley, since ancient time and have substantial impact on social and economic status of the local population as it provides potable water and fish, besides being used for recreation and irrigation of the agricultural land. The origin of the lakes in Kashmir is either tectonic or fluviatile, as all the lakes lie on the flood plains of river Jhelum.

The lakes of Kashmir are categorized into three different types: (i) Glacial mountain lakes, (ii) Pine forest lakes, and (iii) Valley lakes based on their origin, altitudinal situation and nature of biota they contain (Zutshi *et al.*, 1972, 1980; Kaul, 1977; Trisal, 1985) [51, 52, 17, 39]. The first series of lakes (Alipather, Gangabal, Kousernag, Kishansar, Marsar, Tarsar, Nundkhol, Toulian, Vishansar, Sheshnag) are classified as upper mountain lakes, forest lakes include Nilnag and the valley lakes include Dal, Anchar, Khanpur, Manasbal, Wular, Naranbagh, Tigam, Tilwan, Pashakuri (Pandit, 2002) [27]. The high altitude lakes are fed by snow-melt, precipitation and springs, whereas lakes of lower altitudes receive water from rivers, streams, and springs. High altitude lakes like Gangbal, Sheshnag, Tarsar, Marsar, Kausarnag, etc (alt. 3000-4000 m) in kashmir support fisheries while the relatively low altitude lakes of Kashmir (alt. 1587-1600 m) like Anchar, Dal, Nigeen, Manasbal and Wular lying in the flood plain of river Jhelum, have abundant macrophytic vegetation and support commercial fisheries. The escalating anthropogenic pressure in recent years, in and around Himalayan aquatic ecosystems including their watersheds has contributed to the mineral enrichment of these systems, leading to accelerated eutrophication. These anthropogenic effects not only degrade water quality but also have an effect on aquatic life in lakes (Kaul, 1979) [18]. Parameters such as temperature, turbidity, nutrients, hardness, alkalinity, dissolved oxygen etc are some of the important factors that determines the growth of living organisms in the water body (Smitha, 2013) [33]. Hence, water quality assessment involves the analysis of physico-chemical, biological and microbiological parameters that reflect the biotic and abiotic status of the ecosystem (Verma *et al.*, 2012) [40].

2. Material and Methods

2.1. Study area

Manasbal lake is the deepest freshwater valley lake of Kashmir, having an area of 280 ha, 25 ha of which is marshy, situated about 32 km northwest of Srinagar city at Safapur village in district Ganderbal, The lake is oblong in outline and extends in a northeast, southwest direction with a maximum length and breadth of 3.5 km and 1.5 km respectively (Abubakr & Kundangar, 2008) [1]. The Lake is positioned at mean latitude of 34°15' N and longitude of 74°40'E, at an altitude of 1583 meters above sea level and is fed mainly by groundwater and seasonally by an irrigational stream Lar kull, on the eastern side, which flows during summer season. It drains into the river Jhelum near village sumbal through a 1.6 km Nunnyar Nalla. The Lake covers an actual area of about 2.81 $km^{2.}$ (Wanganeo, 1984; Yousuf, 1988; Yousuf, 1992) [41, 48, 49]. Maximum length 3.5 km, Maximum breadth1.25 km, Mean breadth 0.802 km, Maximum depth 13 m, Length of shoreline 10.24 km, Total volume of water 12.8 x 10^6 m^3, Catchment area 30 km^2 (Wanganeo, 1984) [41].

2.1.1 Sampling site

This is the central site of the Lake, located near Cage Culture, (installed by Fisheries Department), opposite Jaroka Bagh, This is the lake's deepest portion, which remains devoid of aquatic vegetation. Water samples were collected from the pelagic zone vertically at different depth intervals surface, 3 meters, 6 meters, 9 meters and bottom. (Fig.1)

Fig 1: Map representing overall view and sampling site in Manasbal Lake

2.2 Water Sampling

Water samples were collected from various depths by using a Ruttner Sampler from the sampling site, and then water was collected in one litre polyethylene bottles marked distinctly. For dissolved oxygen, water samples were collected in separate 125ml glass stoppered bottles and the fixation of samples was done at the site. Parameters like Air temperature, Water temperature, Depth, were determined at the sampling site and the detailed analysis for parameters like Dissolved Oxygen, pH, Total Phosphorous, Free CO_2, Chloride, Nitrate nitrogen (NO3-N), Ammonical nitrogen (NH4-N) was carried out in the laboratory by using the methods outlined in (APHA, 2012) [4].

2.3 Statistical Analysis

The results obtained were analysed with the help of the appropriate statistical methods using Microsoft Excel.

3. Results and Discussion

3.1 Air and Water temperature

The temperature plays an important role for controlling the physico-chemical and biological parameters of water. It is considered the most important factor in the aquatic environment particularly for freshwater, (Singh and Mathur, 2005) [32]. Atmospheric temperature ranged from 3.2 ºC in January to 26.1 ºC in June (Fig.2). A characteristic depth wise variation in water temperature was recorded during different seasons. Water temperature ranged from 2.5 ºC at bottom to 27.3 ºC at the surface (Fig.3). The highest temperature was recorded in summer in the month of (july) at surface waters. This can be due to high solar radiation, clear atmosphere and high atmosphere temperature, (Swarnalatha and Narasingrao, 1998) [37]. The lowest temperature was reported in the month of (January) at the bottom due to cold low ambient temperature and shorter photoperiod (Bohra and Bhargava, 1977) [8].

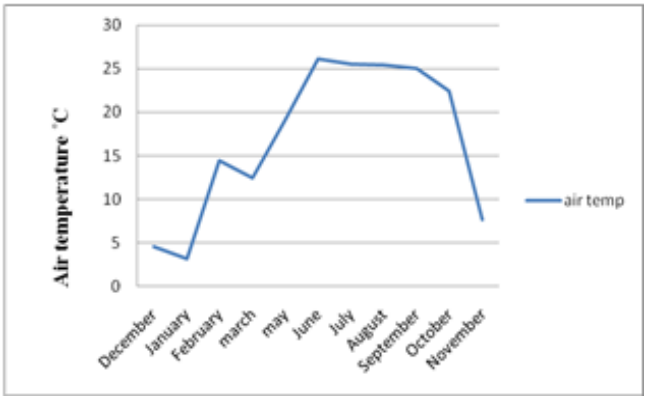

Fig 2: Monthly variation in air temperature (ºC) vertically in Manasbal Lake

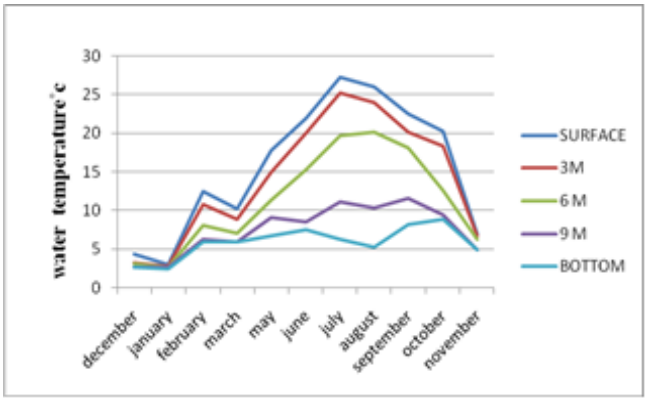

Fig 3: Monthly variation in water temperature (ºC) vertically in Manasbal Lake.

3.2 Depth

The depth of a water body is one of the major physical factors which act as a controlling factor for determining the water quality. Depth of water is determined by the volume of water column in an aquatic system, which is in turn dependent on the discharge rate of inflows and the amount of precipitation received in the form of rain and other anthropogenic activities. (Bhat *et al*., 2013 and Sushil *et al*., 2014) [6, 36]. The depth varied from a minimum of 10.8 m in the month of July and to a maximum depth of 11.5m at site S5(M) in the month of November and December (Fig.4). Higher depth values can be accredited directly to higher precipitation rate resulting in more significant water discharge from the inlet (Kumar and Pandit, 2007) [21].

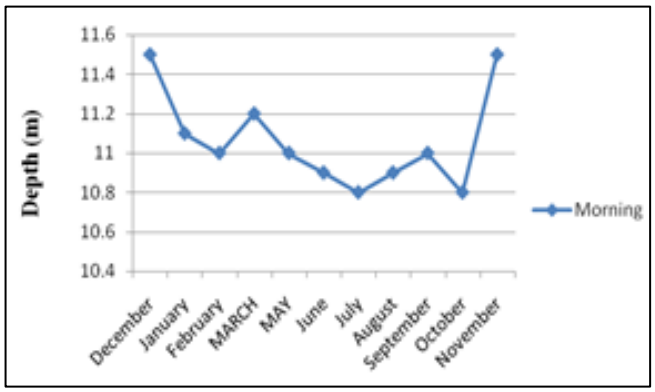

Fig 4: Monthly variation in Depth (m) at central site of Manasbal Lake

3.3 pH

pH is one of the very significant chemical characteristic of all waters, which explains certain significant biotic and abiotic ecological characteristics of aquatic systems in general. pH values showed a decreasing trend from surface to bottom during all seasons. The surface water showed a pH range from 7.4 to 8.33. The minimum pH was recorded to be 6.5 at the bottom in the month of December while a maximum pH of 8.33 was recorded at the surface in the month of June (Fig.5). pH of a water body is a diurnally variable property according to temperature variation in the system (Ojha and Mandloi, 2004) [25]. The alkaline nature of water in the epilimnion and upper layers of thermocline of water depicted the eutrophic and mesotrophic status of water (Whitemore, 1989; Kaul and Handoo, 1980) [44, 19] found that increased surface pH in water bodies is due to increased metabolic activities of autotrophs. And lower pH values in bottom layers is due liberation of acids from decomposing organic matter under low O2 concentration result in low pH.

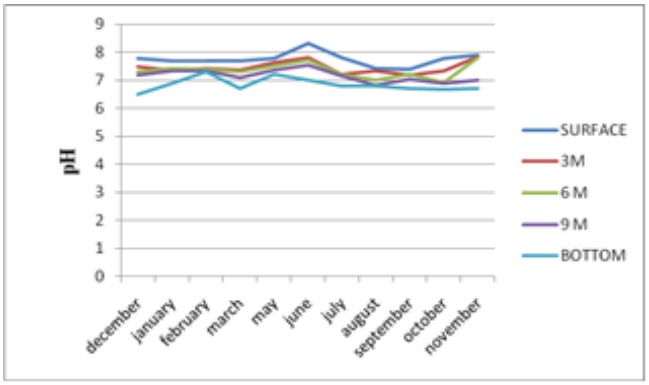

Fig 5: Monthly variation in pH vertically in Manasbal Lake.

3.4 Dissolved oxygen (D.O)

Dissolved oxygen (D.O) is a significant parameter of the water which is vital to the metabolism of every aquatic organism that possesses aerobic respiration. Dissolved Oxygen reflects the water quality status and physical and biological processes in waters as well as the metabolic balance of a lake (Laluraj *et al.*, 2002) [22]. Oxygen concentration in surface water ranged from 7.2 to 9.1 mg/l. Oxygen concentration depicted significant variations with regard to depth. Gradual decline from surface to 9m depth was recorded which finally resulted in its complete absence from June to November at 9m depth and complete absence at 12m depth depicting anoxic condition (Fig.6). Similar conditions were reported by (Jamila, 2018; Yaseen and bhat, 2021) [16, 45]. Clinograde type of curve was recorded which is characterized when productivity is high and thermal stratification occurs, oxygen depletion is likely to occur in the hypolimnion in summer and during winter stagnation under ice. This oxygen distribution is characterized by relatively higher oxygen content near the surface where phytosynthesis replenishes the supply (Goldman and Horne, 1983) [11]. The oxygen deficit is caused by the high productivity of the lake, depicting meso- to eutrophic nature of lake (Pandit and Yousuf, 2002; Gunkel and Casallas, 2002) [28, 13]. The rate of oxygen depletion noticed in the bottom layers of the Manasbal lake are an indication of the more eutrophic nature of the water body. DO content is affected by fluctuations in water temperature and addition of sewage waste demanding oxygen (Koshy and Nayar, 2000) [20]. Higher DO means rate of oxygen replenishment in water is greater than O2 consumption and this is healthy for almost all aquatic systems (Adak *et al.*, 2002) [2].

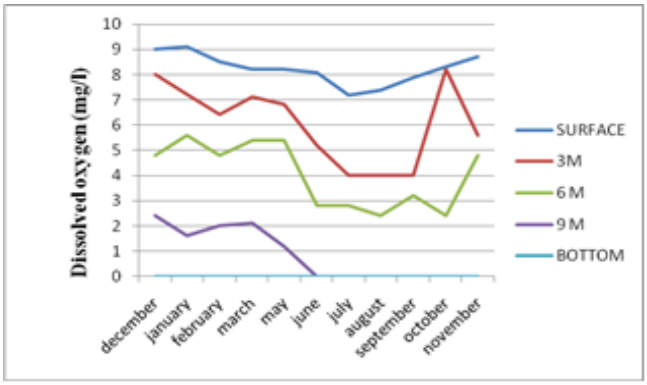

Fig 6: Monthly variation in the dissolved oxygen (mg/l) vertically in Manasbal Lake

3.5 Chloride

The concentration of chlorides can be related to purity or impurity of water (Solanki and Pandit, 2006) [34]. The chloride content varied from 5.8mg/l at surface in month of May to 32.55 mg/l at bottom in the month of December (Fig.7). The chloride content in the bottom waters was higher than surface waters which might be attributed to the presence of decomposed organic matter in the deeper waters. The high chloride concentration indicates the presence of organic matter, presumably of animal origin (Tresh *et al.*, 1944; Yousuf and Qadri, 1981) [38, 46] reveal that the chloride concentration has significantly increased over past few decades in Kashmir valley lakes and has contributed to the pollution.

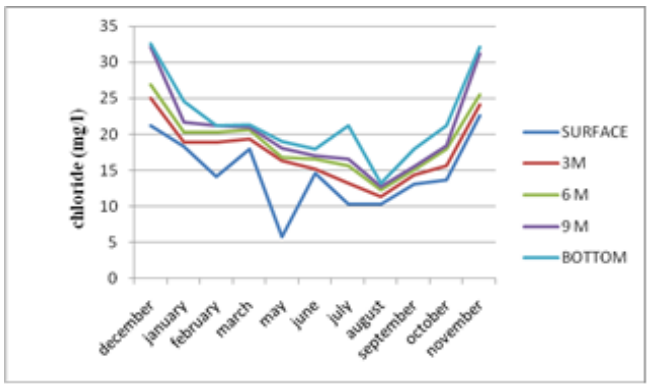

Fig 7: Monthly variation in chloride (mg/l) vertically in Manasbal Lake

3.6 Free CO_2

Free CO_2 is essential for photosynthesis and its concentration affects the phytoplankton, and its productivity. The amount of CO_2 in water usually shows an inverse relationship with oxygen (Radhika *et al.*, 2004) [30]. The surface water showed absence of free carbon dioxide in the month of june. It varied from 4.52 at surface waters to 24.64 at the bottom layer (Fig.8). A distinct vertical gradient was recorded from bottom to surface layers. In bottom layer concentration of carbon dioxide was quite high as compared to upper layers. The hypolimnetic waters were observed to contain large quantities of carbon dioxide throughout the year as a result of decomposition of organic matter, indicating the productive nature of the lake (Reche and Pace, 2002) [31].

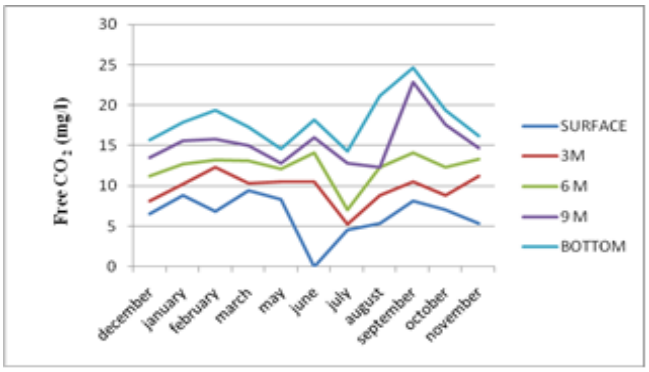

Fig 8: Monthly variation in Free CO_2 (mg/l) vertically in Manasbal Lake

3.7 Ammoniacal Nitrogen

Ammonia is basically a product of decomposition. Its concentration during the study period was generally low because of the utilization of nitrogenous compounds like NH4-N by plants. The highest concentration of Ammoniacal Nitrogen was observed in the month of March at bottom layer (308.7 µg/l) and lowest at surface waters in July (45.24µg/l) (Fig.9). The low value of Ammoniacal Nitrogen during warmer months is attributed to the photosynthetic assimilation by autotrophs during their growth in summer (Pandit, 1999) [26]. The minimum values in the surface layers of the present lake were recorded during stagnation period as also recorded by (Yousuf, 1979) [47] for the same lake. Vertical distribution of NH4 -N concentration in the Manasbal Lake revealed an increasing trend towards bottom. In anaerobic hypolimnion where animals are scarce, ammonium is formed at amino-acid degradation of proteins carried out by ammonificating bacteria, occurring in the water column and sediments (Gorlenko *et al.*, 1977; Howarth *et al.*, 1988; Stolp, 1996) [12, 14, 35] and thus rising ammonium-nitrogen in the bottom layers.

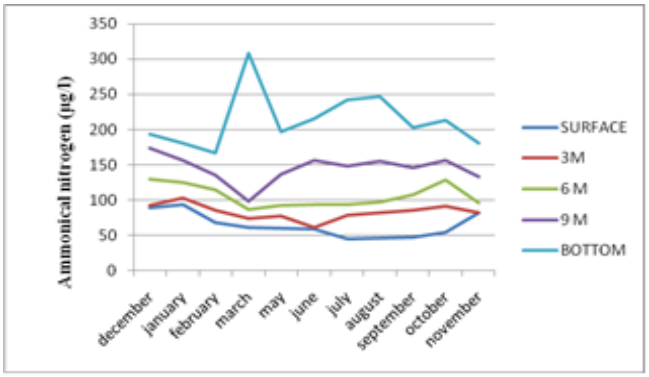

Fig 9: Monthly variation in ammonia (µg/l) vertically in Manasbal Lake

3.8 Nitrate nitrogen

Nitrate nitrogen pollution of surface waters is mainly due to discharge of industrial, municipal, domestic wastewaters and agricultural runoff including animal feedlots. Nitrogen pollution by high nitrate can cause eutrophication in surface waters (Fried, 1991; Mlitan *et al.*, 2015) [10, 24]. Nitrate is the common form of inorganic nitrogen entering the freshwater from the precipitation, ground water and draining basin, mostly occurring in low concentration under natural conditions (Wetzel., 1983) [43]. During the present study Nitrate nitrogen ranged from a minimum 191 µg/l at surface waters in the month of August to max of 393.8 µg/l at bottom layer in the month of January (Fig.10) According to (Hutchinson, 1957) [15] a well marked maximum of NO_2 is to be expected in the hypolimnion at a place where the O_2 concentration decreases most rapidly. (Anigri, 1972 and Maulood *et al.*, 1978) [3, 23] also found an increase in the NO_2 content towards bottom.

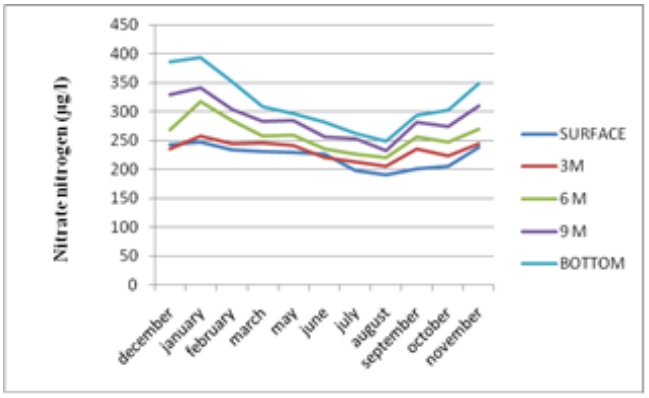

Fig 10: Monthly variation in Nitrate content (µg/l) vertically in Manasbal Lake

3.9 Total phosphorous

Phosphorus is available in water in different forms viz., orthophosphates, condensed phosphates, and organically bound phosphates (Bandela *et al.*, 1999) [5] and is considered as a critical limiting nutrient of fresh water systems (Rabalais, 2002) [29]. Presence of Phosphorous in excess, more than 30 µgl-1 in water bodies is regarded as a major nutrient triggering eutrophication (Welch, 1980) [42]. In the present study phosphorus ranged from a minimum of 143.4 in the month of January at 3 meters to a maximum of 398.1µg/l in the month of July at bottom layer (Fig.11). No definite pattern of fluctuation was recorded in the vertical distribution in the Manasbal Lake and large variations were recorded between different layers. Constant addition of even low levels of nitrogen and phosphorous to an aquatic environment could greatly stimulate algal growth (Zimba *et al.*, 2001) [50]. Due to the anoxic conditions in hypolimnion during summer, hypolimnetic phosphorus concentration in the lake reached extremely high values due to remobilization of P from sediments (Bluszcz *et al.*, 2008) [7], same was recorded in present study in Manasbal Lake, High values of total phosphorus were recorded in summer.

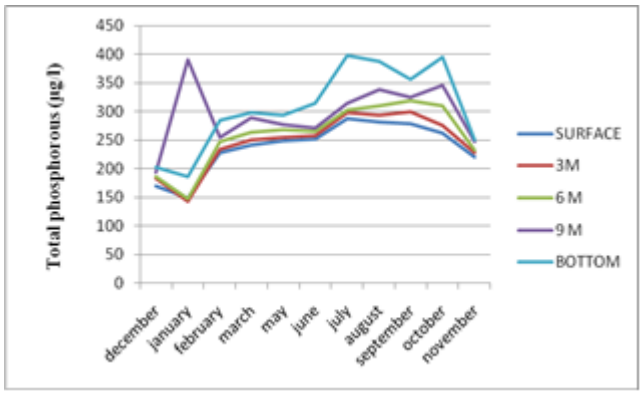

Fig 11: Monthly variation in total phosphorous content (µg/l) vertically in Manasbal Lake

Table 1: The minimum and maximum values of Physico chemical parameters at central site (vertically) of Lake Manasbal

	Surface		3 Meter		6 Meter		9 METER		BOTTOM	
Parameters	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Water temperature ˚C	3.0	27.3	2.8	25.2	2.7	20.1	2.7	11.6	2.5	8.9
pH	7.4	8.3	7.2	7.9	6.9	7.8	6.8	7.6	6.6	7.3
Dissolved oxygen (mg/l)	7.2	9.1	4.0	8.2	2.4	5.6	0.0	2.4	0.0	0.0
Chloride (mg/l)	5.8	22.7	11.3	25.0	12.3	26.9	12.7	32.1	13.2	32.6
Free Co_2 (mg/l)	4.5	9.4	5.2	12.3	7.0	14.1	12.3	22.9	14.3	24.6
Ammoniacal-Nitrogen (µg/l).	45.2	93.4	61.3	103.5	86.4	129.3	98.7	173.9	166.9	308.7
Nitrate-Nitrogen (µg/l).	191.0	247.3	206.1	257.4	221.1	316.8	232.4	341.2	249.1	393.7
Total phosphate (µg/l).	149.5	287.5	143.4	299.5	147.4	319.0	193.1	390.7	185.4	398.3

4. Conclusions

Pollution in water bodies is mainly due to addition of major plant nutrients particularly Nitrogen and Phosphorus, derived from human wastes, fertilizers, detergents, agricultural runoff etc. at an accelerated rate. The nutrients are chiefly responsible for an increase in organic production and the overall deterioration of water quality. Lake revealed a higher nutrient concentration in the deeper layers than surface layers. The lake is receiving various sources of pollution as agricultural runoff, domestic effluents and municipal wastes; this has altered the surface sediment composition, contributing to eutrophication thereby reducing the aesthetics of the lake. Agriculture land use in the catchment area and excessive use of fertilizers in the nearby Mughal gardens should be checked.

5. References

1. Abubakr, A. and Kundangar, M.R.D. Ecological Status of some Floodplain Lakes within Jhelum river basin, Kashmir. Nature Environment and Pollution Technology 2008;7(4):791-728.
2. Adak MD, Adak S, Purohit KM. Studies on water quality of village Timjore, Orissa: Part-I Physico-chemical parameters. Indian J of Envntl. Prtcn 2002;22(9):1040-1046.
3. Angiri GG. Hydrological conditions in the Inshore Region of Karwar during 1965-67. Ind. J Fish. 1972;19:156-162.
4. APHA. Standard methods for examination of water and waste water.22ndedn. American Public Health Association, Washington D.C., USA 2012.
5. Bandela NN, Vaidya DP, Lomte VS, Shivanikar SV. The distribution pattern of phosphate and nitrogen forms and their interrelationships in Barul Dam water, Poll. Res 1999;18(4):411-414.
6. Bhat SA, Meraj G, Yaseen S, Bhat AB, Pandit AK. Assessing the impact of anthropogenic activities on spatio-temporal variation of water quality in Anchar lake. International Journal of Environmental Sciences 2013;3:1625-1630
7. Bluszcz P, Kirilova E, Lotter AF, Ohlendrof B, Zolitschka. Global radiation and onset of stratification as forcing factors of seasonal carbonate and organic matter flux dynamics in a hypertrophic hard water lake (Sacrower See, North eastern Germany). Aquat. Sci. 2008;14:73-98.
8. Bohra OP, Bhargava SC Abiotic factor, chlorophyll pigment and primary production in two lakes of Jodhpur. Geobios 1977;4:215-216.
9. Forel FA. Le j'Uman: monographie! limnologique, F. Rouge, Lausanne 1892-1904.
10. Fried JJ. Nitrates and their control in the EEC aquatic environment. Ecol. Sc 1991;20:3-11.
11. Goldman CR, Horne AJ. Limnology. Ed. 1st. Mc Graw-Hill International Book Company 1983, 108-111
12. Gorlenko VM, Dubinina GA, Kuznetsov CI. Ekologija vodnyh mikroorganizmov [Ecology of water micro-organisms]. Moscoy 1977.
13. Gunkel G, Casallas. Limnology of an equatorial high mountain lake - Lago San Pablo, Ecuador: The significance of deep diurnal mixing for lake productivity Limnologica 2002;32:33-43.
14. Howarth RW, Cole JJ, Marino R, Lane J. Nitrogen fixation in freshwater, estuarine and marine ecosystems: Rates and importance. Limnology and Oceanography 1988;33:669–687.
15. Hutchinson GE. A Treatise on Limnology, Geography, Physics and Chemistry. Wiley, New York 1957;1:1015.
16. Jamila I. Effect of thermal stratification on various Physico- Chemical parameters of the Manasbal Lake. International journal of advance research in science and engineering 2018;7:174-184
17. Kaul V. Limnological survey of Kashmir lakes with reference to tropic status and conservation. Int. J India

Environ Sci 1977; 3:29-44.
18. Kaul V. Water characteristics of some fresh water bodies of Kashmir. Curr Trends Life Sci. 1979; 9:221-246.
19. Kaul V, Handoo JK. Physicochemical characteristics of Nilnag-a high altitude forest lake in Kashmir and its comparison with valley lakes; Proc. Indian National Sci. Acad. B. 1980;46(4):528-541.
20. Koshy M, Nayar TV. Water quality of River Pamba at Kozencherry. Poll. Res 2000;19(4):665-668.
21. Kumar R, Pandit AK. Physico-chemical characteristics of water in Hokersar wetland in Kashmir Himalaya. Pollut. Res 2007;26:73-79.
22. Laluraj CM, Padma P, Sujatha CH, Nair SM, Kumar NC, Chacko J. Base-line studies on the chemical constitutes of Kayamkulam Estuary near to the newly commissioned NTPC power station. Indian J of Envtl. Prtcn 2002;22(7):721-731.
23. Maulood BK, Hinton GC, Boney AD. Diurnal variation of phytoplankton in Loch Lomond (Glassgow). Hydrobiol. 1978; 58(2): 99-117.
24. Mlitan AM, Abofalga A, Swalem A. Impact of treated wastewater on some physicochemical parameters soil and its fungal content. Int. J Env. Sc. Develop 2015;6(5):369-374.
25. Ojha P, Mandloi AK. Diurnal variation of pH in freshwater fish culture pond, Ecol., Env. and Cons 2004;10(1):85-86.
26. Pandit AK. Trophic structure of plankton community in some typical wetlands of Kashmir, India. Limnological Research in India (SR Mishra) Daya Publishing House. Delhi 1999, 190-224.
27. Pandit AK. Plankton as indicators of trophic status of wetlands. In: Ecology and Ethology of Aquatic Biota. (Arvind Kumar, ed.). Daya Publishing House, New Delhi 110002. 2002, 341-360
28. Pandit Anil K, Yousuf AR. Trophic status of Kashmir Himalayan lakes as depicted by the water chemistry. J Res. Dev 2002;1:1- 12.
29. Rabalais NN. Nitrogen in aquatic ecosystem. Ambio 2002;31(2):102-12.
30. Radhika CG, Mini I, Gangadevi T. Studies on abiotic parameters of a tropical fresh water lake- Vellayani Lake, Trivandrum, Kerala. Poll. Res 2004;23(1):49- 63.
31. Reche I, Pace ML. Linking dynamics of dissolved ofrganic carbon in a forested lake with environmental factors. Biogeochemistry 2002;61:21-36.
32. Singh RP, Mathur P. Investigation of variations in physicochemical characteristics of a fresh water reservoir of Ajmer city, Rajesthan. Indian Journal Environmental Sciences 2005;9:57-61.
33. Smitha. Physico-chemical analysis of the freshwater at River Kapila, Nanjangudu Industrial Area, Mysore, India. International Research Journal of Environment Sciences 2013;2:59-65.
34. Solanki, Pandit BR. Trophic status of lentic waters of ponds water of Vadodara, Gujarat state, India. International Journal of Bioscience Reporter 2006;4:191-198.
35. Stolp H. Microbial Ecology: Organisms, Habitats, Activities. Cambridge University Press, USA 1996.
36. Sushil M, Reshi JM, Krishna M. Water quality status and responsible factors for variation in Anchar lake, Kashmir. Journal of Environmental Science, Toxicology and Food Technology 2014;8(2):55-62 .
37. Swarnalatha N, Narasingrao A. Ecological studies of Banjara lake with reference to water pollution. Journal of Environmental Biology 1998;19:179-186.
38. Tresh JC, Suckling EV, Beale JF. Chemical and zoopklankton studies of lentic habitats in North Eastern New South Wales. Australian Journal Marine Freshwater Research 1944;21:11-33.
39. Trisal CL. Trophic status of Kashmir Lakes. In: Proc. Nat. Symp. Evalu. Environ., Geobios Supplement (Misra, S. D., Sen, D. N. and Ahmad, I. eds.), Jodhpur, India 1985, 164-170
40. Verma, PU, Purohit AR, Patel NJ. Pollution status of Chandlodia Lake located in Ahmedabad Gujarat. International Journal of Engineering Research and Applications 2012;2:1600-1610.
41. Wanganeo A. Primary Production Characteristics of a Himalayan Lake in Kashmir. Int. Revue ges. Hydrobiol., 1984;69(1):79-90
42. Welch EB. Ecological effects of waste water. Cambridge University Press, Cambridge, 1980, 337.
43. Wetzel RG. Limnology. 2nd Edition, Saunders College Publishing, Philadelphia. PA, 1983; 767.
44. Whitemore TJ. Florida diatom assemblages as indicators of trophic state and pH. Limnol. Oceanogr 1989;34(5):882-895.
45. Yaseen T, Bhat SU. Assessing the Nutrient Dynamics in a Himalayan Warm Monomictic Lake. Water Air Soil Pollut 2021;232:111.
46. Yousuf AR, Qadri MY. Ecology of *Diaphanosoma brachyurum* Lieven (Cladocera: Crustacea) in Lake Manasbal, Kashmir. J Indian Inst. Sci 1981;63(C):35-42.
47. Yousuf AR. Limnology and Fisheries of Manasbal Lake. Ph.D. thesis. Univ. Kashmir 1979.
48. Yousuf AR. Copepod plankton of Manasbal Lake, Kashmir. Journal of Indian Institute Science 1988;68:3017-313.
49. Yousuf AR. Biotic Communities and their role in the tropic conditions in Kashmir Himalayan Lakes, Technical Report submitted by the University of Kashmir, CSIR Research Project 1992.
50. Zimba P, Grimm CC, Dionigi CP, Weirich C. Phytoplankton community structure and off-flavor levels in Louisiana catfish ponds. Journal of the World Aquaculture Society 2001;32(1):96-104.
51. Zutshi DP, Kaul V, Vass KK. Limnological studies of high altitude Kashmir lakes. Verh Inter Verin Limnol 1972;118:599-604.
52. Zutshi DP, Wanganeo A, Raina R. Limnology of a man-made lake. Geobios 1980;7:320-324.