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A study on physico-chemical parameters of Manasbal Lake, Kashmir, India

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Abstract
Water quality plays an important role in determining the status and condition of that fresh water ecosystem. Present investigation was undertaken to evaluate the water quality status of Manasbal Lake located at a distance of 30 km north from Srinagar. The lake was investigated for a period of 11 months from December 2019 to November 2020 and a total of 10 Physico-chemical parameters were analyzed at six different sites at monthly intervals by following standard methods. Among the various parameters recorded the Air temperature ranged from 2.7°-31 °C and Water temperature 3-29.7 °C, Depth 0.9-11.5m, Dissolved oxygen 6-11.2mg/l, pH7-9.2; Chloride 16-34.9mg/l, Free carbon dioxide0-18mg/l, Ammonical nitrogen 33.1-108 µg/l, Nitrate Nitrogen 190 - 353.2 µg/l and Total Phosphorous ranged from 131-288.1µg/l. The investigation revealed that almost all the above parameters show that the pollution load is increasing due to anthropogenic pressure untreated sewage and solid garbage from residential areas, fertilizers containing Nitrates and Phosphates which had resulted in the eutrophic condition of the lake. So immediate remedial measures should be taken for its protection from further depletion.

Keywords: Manasbal Lake, water quality, anthropogenic activities, eutrophic, nutrients

Introduction
Lakes are inland bodies of water that do not have a clear connection to the ocean. Physical, chemical, and biological properties found within these water bodies make up lake ecosystems. Fresh or saltwater can be found in lakes (in arid regions). Lakes are ephemeral in geological terms. They begin as a result of geological processes and end as a result of the loss of the ponding mechanism, or by evaporation due to changes in the hydrological balance, or sedimentation-induced filling. (Hutchinson, 1957) [11], who distinguished 11 major lake types, subdivided into 76 sub-types, reviewed the various mechanisms of origin. Lakes can be deep or shallow, permanent or transient. Lakes of all types share a large number of ecological and biogeochemical processes and are part of 'limnology' research. Lakes are excellent habitats in which ecosystem dynamics can be studied: interactions between biological, chemical and physical processes are often quantitatively or qualitatively distinct from those on the ground or in the air. Because water, soil, water and air have distinct boundaries, many ecosystem components are closely linked. A lake may occur anywhere in a river basin according to its origin (Chapman, 1996) [6]. Kashmir's valley is located in the Himalayan Mountains and enjoys a temperate climate with four distinct seasons. The high altitude valley is home to a diverse range of freshwater bodies, with lakes playing a particularly important ecological role. The Kashmir Lakes are located in the flood plain of the river Jhelum, where its vast meanders have carved swampy lowlands out of the Karewas terraces. (De-Terra & Paterson, 1939) [8].
Based on their origin, altitudinal situation, and biota, these lakes are classified as glacial, alpine, or valley lakes, and provide an excellent opportunity for studying the structure and functional processes of an aquatic ecological system (Zutshi *et al*., 1972; Kaul, 1977; Trisal, 1985) [38, 14, 30]. These lakes vary from being oligotrophic to eutrophic, while others are in the process of continuous change towards eutrophication (Kaul, 1979; Khan, 2008) [15, 17]. The Kashmir valley's water bodies are a rich source of natural products such as fish, fodder, and a variety of economically important plants. And the valley has always been considered rich in floral and faunal biodiversity. However, unplanned urbanization, deforestation, soil erosion, and the careless use of pesticides in horticulture and agriculture have resulted in a large inflow of nutrients into these lakes from catchment areas (Baddar and Romshoo, 2007) [3]. These anthropogenic effects not only degrade water quality but also have an effect on aquatic life in lakes, hastening the aging process of these bodies of water. As a result, most of the lakes in the Kashmir valley are eutrophicating (Kaul, 1979) [15].

Material and Methods

Study area

Manasbal Lake is located about 32km north of Srinagar (34°15′N, 74°40′ East) at an elevation of 1584 m (a.s.l). The catchment includes around 500 villages, a thriving timber industry, and a few lime kilns. The Lake covers an actual area of about 2.81km^2 (Wanganeo, 1984) [32] and it receives water from the catchment and the springs occurring in the basin (Zutshi and Khan 1978) [39].

Six sites were selected for the whole lake

Site 1 (M): It is the littoral site located near the Main Ghat of Manasbal Garden (Ghat) which is dominated by aquatic macrophytes.

Site 2 (M): It is located on the eastern side of the lake, near the village of Gratbal, which is surrounded by residential hamlets.

Site 3 (M): It is located on the southern side of the lake near village the Kondabal where lime extraction is done.

Site 4 (M): It is located on the northern side of the lake near village Jarokabal.

Site 5 (M): It is situated in the lake's centre region. This is the lake's deepest portion, devoid of aquatic vegetation.

Site 6 (M): It is located on the western side of the lake. It is the lake's exit (Nunnyar Nalla) near Sumbal hamlet, from where the water drains into the Jhelum River. (Fig 1)

Fig 1: Map representing overall view of sites within Manasbal Lake

Water Sampling

Surface water samples were collected by hand from the sampling sites in one litre polyethylene bottles marked distinctly. For dissolved oxygen, water samples were collected in separate glass stoppered bottles of 125ml capacity and the fixation of samples was done at the site. Parameters like air temperature, water temperature, depth, were determined at the respective sampling sites and the detailed analysis for parameters like dissolved oxygen, pH, total phosphorous, free CO_2, chloride, nitrate nitrogen (NO_3-N), Ammonical nitrogen (NH4-N) was carried out in the laboratory by using the methods outlined in APHA (2012) [1].

Statistical Analysis

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

Results and Discussion

Air and Water temperature

The measurement of temperature is one of the most primary factors, since it affect the chemistry and biology of all biotic factors. Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism (Bade *et al.*, 2009) [2]. Air temperature is determined by the air masses over the particular land mass, climatic condition (Hutchinson, 1967) [12]. The maximum air temperature was recorded in the month of august 31.2 °C and minimum 2.7 °C in month of December at site S4 (M) respectively (Fig.2). The lowest air temperature in December was due to short photoperiod, cold atmosphere while the highest air temperature during August was due to clear atmosphere and higher solar radiation. Water temperature play an important role in the physico-chemical and physiological behavior of the aquatic system (Welch, 1952) [36]. Minimum Water temperature (3℃) was recorded in the December at site S3 (M) while the maximum (29.7°C) was observed in June at site S4 (M) (Fig 3.). The rise in water temperature, especially in June in the present study, can be attributed to an overall increasing trend in atmospheric temperature. The higher temperatures recorded in June can be due to increased solar radiation, clear atmosphere and topography (Kant and Raina, 1990) [13] while lower temperatures recorded in December was due to low ambient temperature and shorter photoperiod.

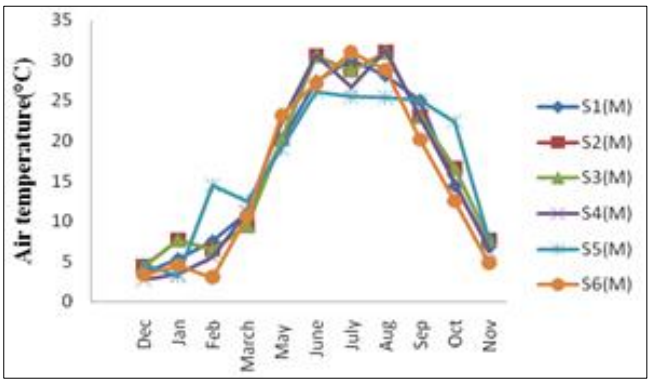

Fig 2: Monthly variation in air temperature (ºC) at different sites of Manasbal Lake.

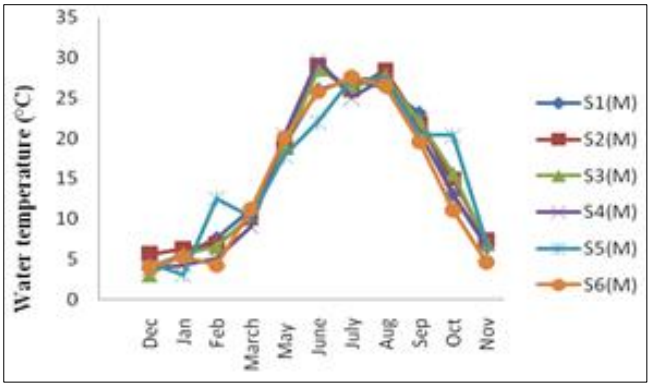

Fig 3: Monthly variation in Water temperature (ºC) at different sites of Manasbal Lake

Depth

Depth plays a significant role in concentrating ions in water mass, besides being an important determinant for the growth and development of various life forms of vegetation (Kaul and Handoo 1980) [16]. The depth at site S1 (M) varied from a minimum of 0.9m in the month of Feburary and March 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) [18]. The variation in the water level fluctuations during the course of study period depended on the amount of precipitation received in the form of rain and snow and also due to changes in the amount of water brought in by an ephemeral feeding channel. The most obvious factor that affects the productivity of a lake is its depth (Scheffer and Van Nes, 2007) [27].

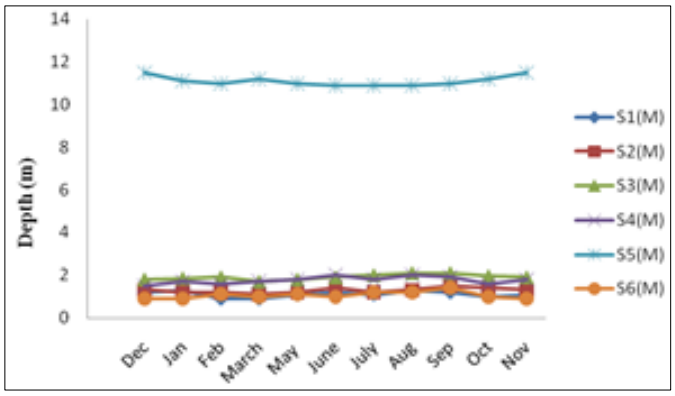

Fig 4: Monthly variation in Depth (m) at different sites of Manasbal Lake

Dissolved Oxygen

Dissolved Oxygen is probably the single most important environmental factor in an aquatic ecosystem life and for the assessment of trophic status of an ecosystem (Edmondson, 1966) [9]. Minimum Dissolved Oxygen (6mg/L) was observed in the month of July at site S1 (M) while the maximum D.O (11.2mg/L)) was observed in the month of December at site S4 (M) (Fig 5). Oxygen level is depleted in water bodies due to decomposition of organic wastes (Mustapha, 2003) [22]. Depletion of dissolved oxygen in water probably is the most frequent result of certain forms of water pollution. The extent of variability in dissolved oxygen concentration between the offshore and inshore areas may be dependent upon a number of factors such as temperature, decompositional activities, photosynthesis and the load of aeration (Kundangar and Abubakr, 2006) [20]. These results are in broad agreement with Wanganeo (1980) [31], Ganie *et al*., (2012) [10].

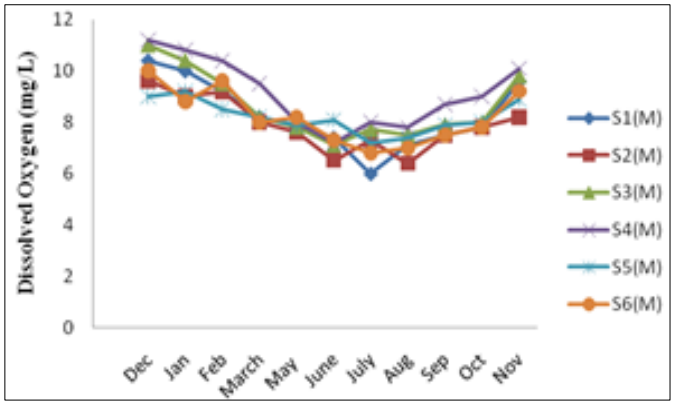

Fig 5: Monthly variation in the dissolved oxygen (mg/l) at different sites of Manasbal Lake

pH

The minimum pH was recorded to be 7 in the month of January at site S4 (M) while a maximum pH of 9.2 was recorded in the month of august at site S3 (M) (Fig 6). According to Whitmore (1989) [36] alkaline pH (>7.5) is mainly exhibited by eutrophic and mycotrophic lakes. Values above 9 have been attributed to extreme divergence from the equilibrium because of high photosynthetic activities (Hutchinson, 1967) [12].

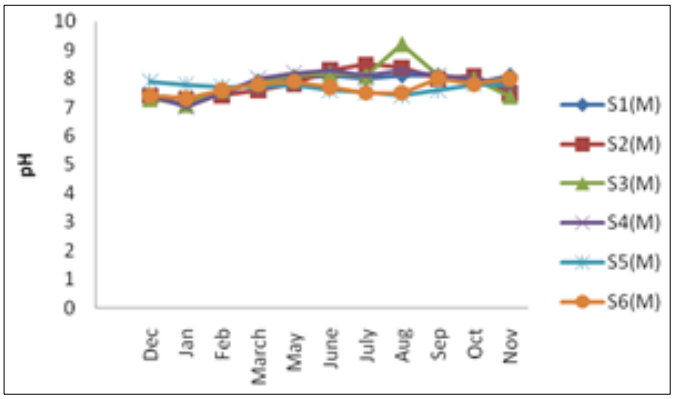

Fig 6: Monthly variation in pH at different sites of Manasbal Lake

Chloride

Chloride content in water is regarded as an indication of organic load of animal origin from the catchment area (Kumar *et al*., 2004) [19]. The minimum chloride content of 16 mg/L was recorded in the month of October at site S3 (M) to a maximum chloride content of 34.9 mg/L in the month of May at site S2 (M) (Fig 7). Higher levels of chloride tend to imply contamination by human activities, use of road salt, discharges from water softeners, human or animal waste disposal, leachate from landfills, and other activities. (Blum, 1957) [5] Who reported that high chloride content in water bodies could be due to sewage contamination? Yousuf and Qadri (1981) [37] reveals that the chloride concentration has significantly increased over past few decades in Kashmir valley lakes and has contributed to pollution.

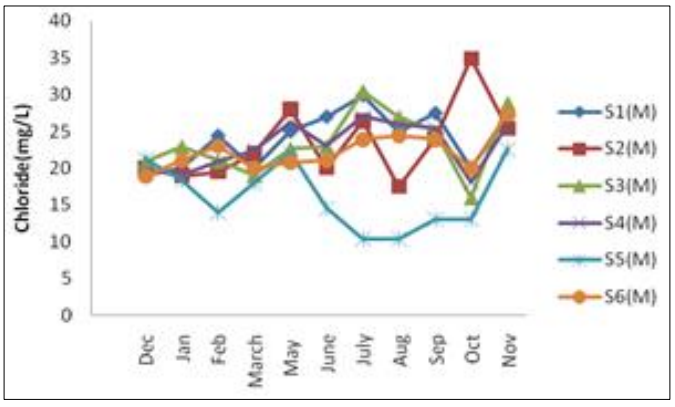

Fig 7: Monthly variation in chloride (mg/l) at different sites of Manasbal Lake

Free CO_2

The concentrations of free carbon dioxide was found to be absent at site S2(M),S3(M),S4(M) in the months June July and August to a max of 18 mg/l at site S4(M) in the month of January (Fig 8). The presence or absence of the free carbon dioxide in water is mostly governed by its utilization by algae during photosynthesis and also through its diffusion from air (Lianthuamluaia *et al*., 2013) [21]. Further, the increase in photosynthetic activity by aquatic plants leads to a decrease in free CO_2 in the spring and summer season (Wetzel, 2001) [35]. The carbon dioxide content of water depends upon the water

temperature, depth, and rate of respiration, decomposition of organic matter, chemical nature of the bottom and geographical features of the terrain surrounding the water body (Sakhare and Joshi 2002) [26].

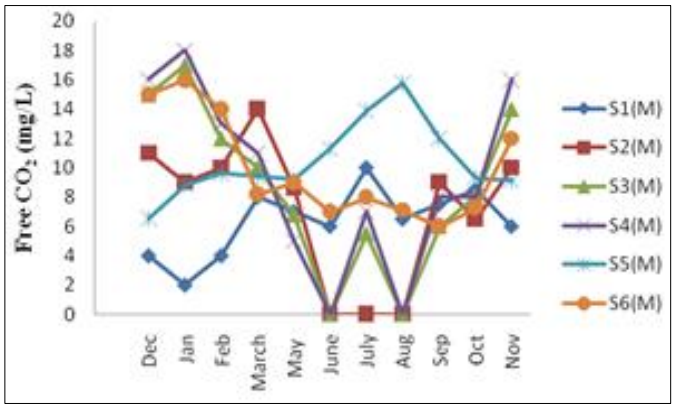

Fig 8: Monthly variation in Free CO_2 (mg/l) at different sites of Manasbal Lake

Ammonical Nitrogen (NH4-N)

Ammonical nitrogen in particular the unionized compound, is one of the major environmental pollutants in freshwater aquatic systems that is physiologically harmful to aquatic organisms and affects ecosystem functionality (Benli *et al*., 2008) [4].The highest concentration of Ammonical-nitrogen (108µg/l) was observed in December at site S1(M) and lowest during August (33.1µg/l) at site S4 (M) (Fig.9) which is directly governed by the presence of domestic sewage, runoff of the nitrogenous fertilizers from the catchment area and use of these fertilizers within the lake. Lower values of ammonia during summer (August) could be due to the photosynthetic assimilation by autotrophs (Pandit, 1999) [23]

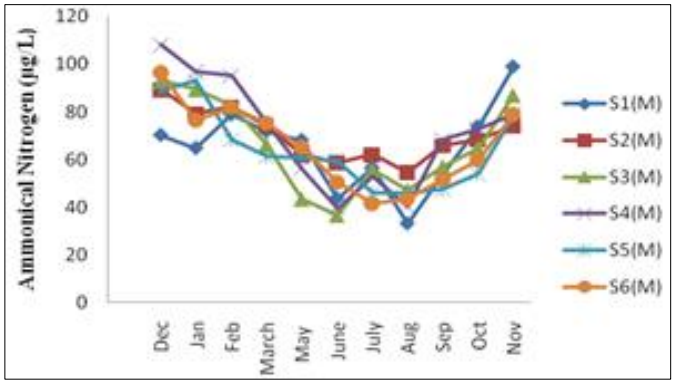

Fig 9: Monthly variation in ammonia (µg/l) at different sites of Manasbal Lake

Nitrate nitrogen (NO_3-N)

Nitrate mostly occurs in water bodies from the draining basin, ground water and precipitation (Wetzel, 1983) [34]. During the present study Nitrate nitrogen ranged from a minimum 190 µg/l at S5 (M) in the month of July to max of 353.2 µg/l at sit S3 (M) in the month of December (Fig.10). An increase in the concentration of Nitrate Nitrogen was observed, that can be related to oxidation of ammonical nitrogen to Nitrate (Toetz, 1981) [29]. Higher concentrations of nitrates in fresh waters have been correlated with domestic sewage (Sylvester 1961) [28] and phytoplankton density (Paulose and Maheshwari 2007) [25]. Furthermore, agricultural runoff also contributes to the higher nitrate content of water bodies (Chouhan and Sharma 2007) [7].

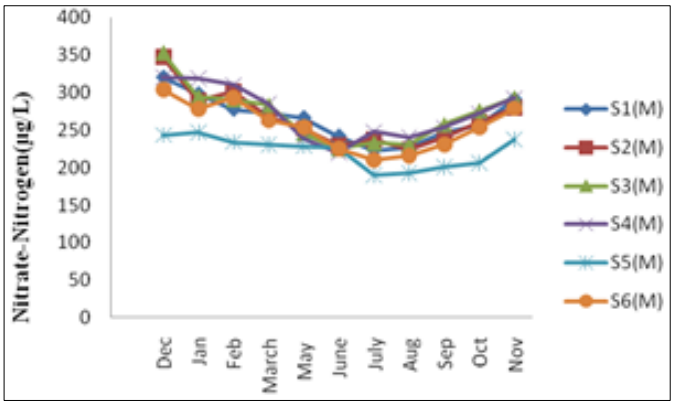

Fig 10: Monthly variation in nitrate content (µg/l) different sites of Manasbal Lake

Total phosphorous

Phosphorous is one of the key elements involved in eutrophication of lake in the present study phosphorus ranged from a minimum of 131 in the month of December at site S4 (M) to a maximum of 388.1µg/l in the month of august at site S2 (M) (Fig. 11). This may be due to both allochthonous and autochthonous inputs, when the metabolic activity in the water starts to gear up (Wanganeo, 1980) [31].The major sources of phosphorus are domestic sewage, detergents, agricultural effluents (fertilizers) and neutral waste waters Higher levels of phosphorus have been associated with the sewage contamination (Hutchinson 1967) [12]. Welch, 1980 [33] is also of the opinion that the presence of phosphorous in excess of 30 µg/l in water bodies is regarded as a major nutrient triggering eutrophication. Hence the present study shows that higher total phosphorous levels in lake as indicative of pollution (Pathak and Mankodi, 2013) [24].

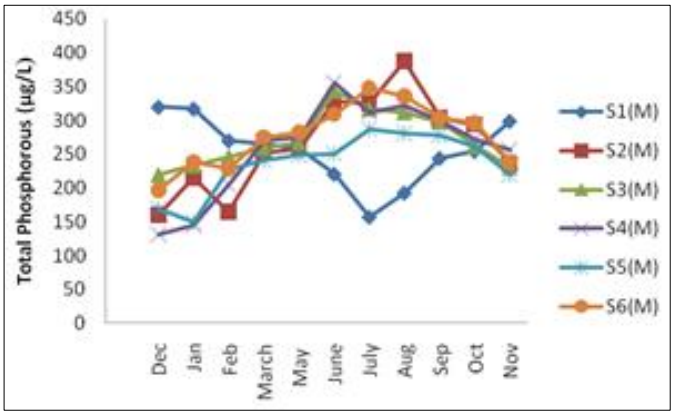

Fig 11: Monthly variation in total phosphorous content (µg/l) at different sites of Manasbal Lake

Table 1: The minimum and maximum values of Physico-chemical parameters at six sites of Manasbal Lake

Parameters	1(M)		2(M)		3(M)		4(M)		5(M)		6(M)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Air temperature (°C)	3.5	30.1	4.3	31	4.3	31	2.7	31.2	3.2	26.1	3	26.1
Water temperature (°C)	4	27.2	5.6	29	3	28.6	3.8	29.7	3	27.3	4	27.6

Depth (m)	0.9	1.3	1.1	1.5	1.7	2.1	1.5	2	10.9	11.5	0.9	1.4
Dissolved O2(mg/l)	6	10.4	6.4	9.6	7.1	11	7.2	11.2	7.2	9.2	6.8	10
pH	7.1	8.1	7.3	8.5	7.1	9.2	7	8.3	7.4	7.9	7.3	8
Free Co2(mg/l)	2	10	0	14	0	17	0	18	6.5	15.8	6	16
Ammonical-nitrogen (µg/l).	33.1	99	54.6	89.4	36.6	93	39.6	108.1	45.9	93	41.6	96.5
Nitrate-Nitrogen(µg/l)	223	320.4	224.2	346.9	224.6	353.2	219.2	320.3	190	247.4	209.8	303.7
Total Phosphorous(µg/l)	156.7	319.9	159.8	388.1	220.1	343.5	131	356.1	149.3	287.5	196.2	348.7

Conclusions

Lakes serve as an important repository of indispensable flora and fauna and always have been a source of attraction for the tourists and local masses. In the present study, the physico-chemical parameters at different Sites of Manasbal Lake varied considerably. The higher values of nitrogen and phosphorous obtained in the study indicates the enrichment of nutrients leading to eutrophication of Lake. This could be due to anthropogenic activities, untreated sewage and solid garbage disposal from surrounding residential areas which had led to the degradation of water quality. It is recommended to periodically monitor the lake which is necessary for assessing the quality of water for human and animal consumption as well as for aquatic life.

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