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Statistical Analysis and Assessment of Physico-Chemical Parameters in Manasbal Lake, Ganderbal, Kashmir, India

Jahangeer Mohd Reshi[1], Manglesh Kumar Jawalkar[2], Ishtiyaq Ahmed Najar[3], Ahsan Ul Haq[4]

[1,2,4]Department of Environmental Science, Madhyanchal Professional University, Ratibad-Bhopal (M.P), India
[3]Department of Environmental Science, Govt. Degree College, Ganderbal, Kashmir (J&K), India

Email: [1]jahangeerevs@gmail.com

ABSTRACT: The current study was aimed to evaluate the Physico-chemical characteristics of Manasbal Lake. Water quality data collected over a two-year period from six sites was examined for 15 parameters. The ANOVA revealed that water temperature (F= 2.90, P < 0.05), electrical conductivity (F=12.5646, <0.05), DO (F= 7.189008, P < 0.05), BOD (F= 36.39959, P < 0.05), COD (F= 22.23, < 0.05), total alkalinity (F= 4.08, < 0.05) , Calcium (F= 14.66, P < 0.05), Magnesium (F= 13.17, P < 0.05), nitrate-nitrogen (F= 8.29, P < 0.05), total phosphorus (F= 16.36, P < 0.05), ammonical nitrogen (F= 13.58119, P < 0.05), total suspended solids (F= 11.79, P < 0.05) varied significantly within the sites, as well as among the seasons, whereas transparency (F= 0.048, P <0.05), pH (F= 2.45, P <0.05), and chloride (F= 2.9, P <0.05) showed no significant variation among the seasons but varied significantly within the sites. During the study the Physico-chemical characteristics revealed that Gratabal (S2), Kondabal (S1) and Jarokabal (S6) were the most disturbed sites than others due to influx of different kinds of waste materials from human habitation. According to the study, the primary sources of water quality deterioration in the investigated lake were untreated domestic wastewaters, agricultural runoff, solid waste, human and animal waste, and silt load from the nearby population and from Laar-Kuhl - a meager water route to the lake.

Key Words: ANOVA, Physiochemical, deterioration, waste material, Laar-Kuhl

1. INTRODUCTION

Lakes are the best accessible water resources on the earth's surface, having a total surface area of 2.67 $\times 10^6$ km^2 (1.8 % land area of the world) and a total volume of 181.9 $\times 10^3$ km^3 which is 0.8 % of total non-frozen terrestrial water reserves (Messager *et al.*, 2016). A lake is a reflection of its watershed and watershed landscape, the topography, soil, geology and vegetation determines the kinds of materials entering into the lake that in turn reflect its water quality (Monesh 2020; Bashir *et al.*, 2017; Dong *et al.*, 2010). The current study seeks to assess seasonal changes in the physicochemical characteristics of water at six sample locations in Manasbal Lake across four seasons in order to determine water quality variables responsible for seasonal variation among them while also identifying pollution sources.

2. MATERIALS AND METHODS

STUDY AREA

Lake Manasbal (34°14’ 38" N to 34° 15’ 26" N latitude and 74° 39’ 07" E to74°41' 20" E longitude) is situated at an altitude of 1584 m above sea level at Safapur village in district Ganderbal, which is about 32 km northwest of Srinagar city, Jammu and Kashmir, India (Naik *et al.*, 2017). The area's climate is defined by warm summers and cold winters (Rashid et al., 2013). The lake has a depth of 12 m and a surface area of approximately 22 km^2 (Naik *et al.*, 2017; Rashid *et al.*, 2013), and it gets water from springs in the basin (Lone *et al.*, 2017; Zutshi and Khan 1978; Rashid *et al.*, 2013). The lake has a surface area of 2.8 km^2, of which 0.25 km^2 is marshy. The lake has an oblong shape and spans northeast to southwest, with a maximum length and breadth of 3.5 km and 1.5 km, respectively. The lake has no significant input channels, thus water is supplied by precipitation (rain and snow fall) and springs. However, the lake is also supplied periodically by the Laar- Kuhl (stream let) irrigational stream on the eastern shore, which is only operative from spring till autumn. The Laar-Kuhl stream collects water from the Sindh nallah (a tributary of the river Jhelum) and irrigates agricultural areas along its path in the lake's vicinity, bringing in allochthonous material such as major and minor nutrients, polythene, bottles, and other debris. The lake is connected to the river Jhelum by a 1.6 km canal named Nunnyar nallah, which enters the river near Sumbal hamlet (Jamila *et al.*, 2014).

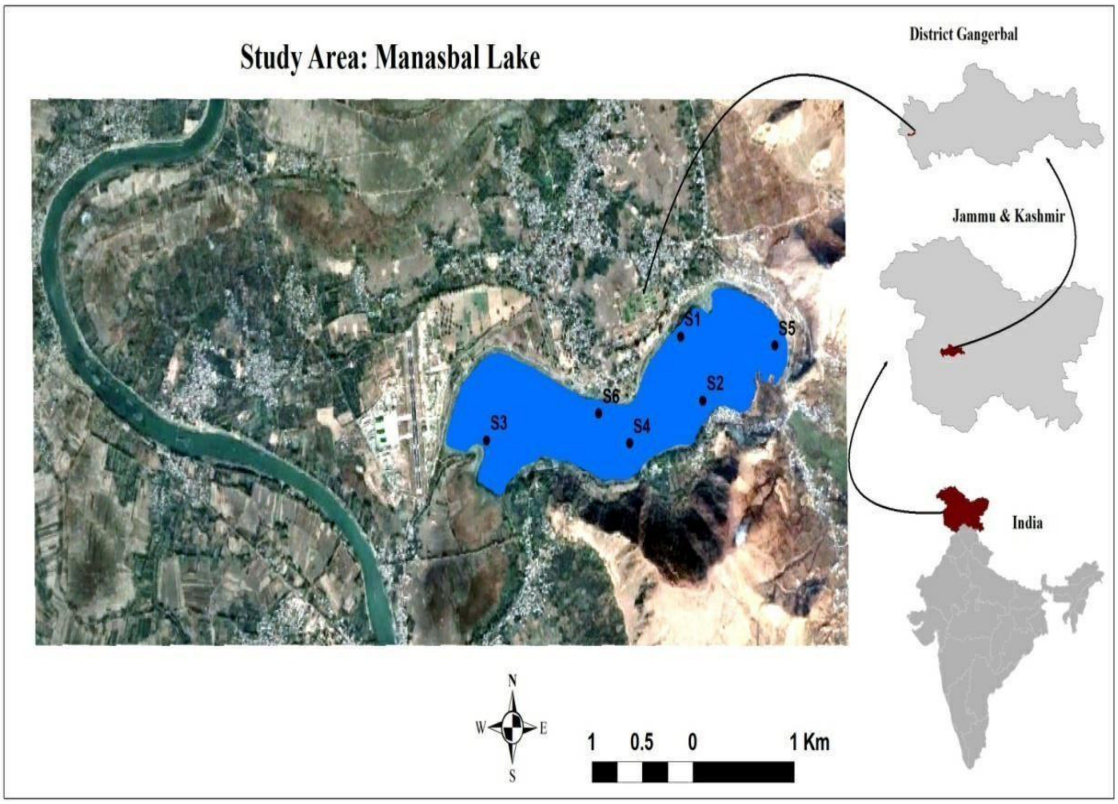

Figure 1: Manasbal Lake showing sampling sites.

3. SAMPLE COLLECTION AND CHEMICAL ANALYSIS

Water samples were collected from the six sites: Gratabal (S1), Kondabal (S2), Lake Outlet (S3), Centre (S4), Ghat Site (S5), and Jarokabal (S6) and kept in 1 L polyethylene plastic bottles that were previously cleaned with metal free soap, washed again and again with distilled water, immersed in 10% nitric acid for 24 hours, and ultimately washed with ultra pure water. All water samples were stored in insulated cooler, taken on the same day to laboratory and kept at 4°C till **f**urther processing and analysis (APHA 2017). During sample collection, water temperature (°C) was recorded in situ; pH and electrical conductivity (EC) were assessed using a pH meter and a conductivity meter, respectively. The versenate technique was used to determine the calcium (Ca) and magnesium (Mg) concentrations. The argentometric titration method, titrimetric (methyl orange) method, and gravimetric method were used to quantify chlorides, total alkalinity, and total suspended particles, respectively. Ammonical nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N) were measured using a spectrophotometer using the phenate and phenyl disulphonic acid methods, respectively. Dissolved oxygen content (DO) and biochemical oxygen demand (BOD_5) were determined using Winkler's method and chemical oxygen demand (COD) by dichromate method.

The data was examined using a statistical approach, two-way analysis of variance (ANOVA), at a 0.05 percent level of significance, to identify the significant variations among the seasons and within the locations for different water quality parameters.

4. RESULTS AND DISCUSSION

The water temperature fluctuated from 5° C to 24° C. The minimum of 5^0C during winter at Site-S4 and maximum of 24^0C was recorded at Site-S2 during summer. There was a significant variation ($P < 0.05$) in physicochemical characteristics within and among the sampling sites during the study. Temperature exhibited significant variation ($p<0.05$) within the sites as well as among the seasons. It varied significantly within the sites ($F= 2.90$, $P < 0.05$) and among the seasons ($F= 460.74$, $P < 0.05$). During the current investigation, the water temperature of Manasbal lake exhibited a close association with seasonal temperature, with highest values in summer and minimum values in winter, which is agreement with the predictions of previous researchers (Stefan and Hendzo, 1993). Temperate lakes are distinguished by their high summer and low winter seasonal values of water temperature.

The transparency ranged from 0.2 to 6 m. The minimum value of 0.2 was recorded at Site-S2 during spring and maximum value 6m was recorded at Site-S4 during winter season. Transparency varied significantly within the sites ($F= 14296.19$, $P < 0.05$) but exhibited no significant change among the seasons ($F= 0.048$, $P <0.05$). Higher transparency values of water during the winter are ascribed to several reasons such as reduced plankton population (Zutshi and Vass, 1970), settling of debris in calm weather, and so on (Zutshi et al., 1980, Khan, 1986). Lower values in spring can be ascribed to silt and sand-laden water. Lower transparency values at Manasbal lake near inlet sites appear to be linked to huge quantities of swamp material received from the catchment. In general, the maximum transparency of water was observed in winter, followed by autumn, summer and the lowest during spring.

The pH of water fluctuated between 7.0 to 8.5, with lowest value of 7.0 was recorded at Site-S2 during autumn and highest value of 8.5 was registered at Site-S3 during summer. pH exhibited significant variation within the sites ($F= 17.52$, $P < 0.05$) but exhibited no significant change among the seasons (F= 2.45, P <0.05). The pH of the Manasbal lake was alkaline indicating that the lake was well buffered throughout the study period. These findings are in accordance with those of Zuber and Sharma (2007) and Parray *et al.*, (2010). The macrophyte-infested locations in Manasbal lake had higher pH than the other study sites, which appears to be a direct result of the enhanced photosynthetic activity of dense macrophytic vegetation. The lower pH is related to decomposition of organic matter.

The conductivity ranged from 259 µS/cm to 563 µS/cm. The minimum value of 295 µS/cm was recorded at Site-S3 during summer and maximum value of 563 µS/cm was recorded at Site-S2 during spring. Electrical conductivity showed significant variation within the sites (F=12.5646, <0.05) and among the seasons (F=23.29, <0.05). According to Ramana *et al.*, (2008), the high conductivity is caused by a large amount of surface runoff including sediments from the catchment areas, which are surrounded by agricultural fields and human habitations. Because of nitrogen absorption by plants during the peak growth season, conductivity values in the lake were at their lowest during the summer (Pandit, 1999).

The value of alkalinity varied from 46 mg/L to 242 mg/L. The minimum value of 46 mg/L was recorded at Site-S4 in summer and maximum value of 242 mg/L was recorded at Site-S1 during spring. Total alkalinity varied significantly within the sites (F= 4.08, < 0.05) as well as among the seasons (F= 27.08, < 0.05). The total alkalinity values were high showing the productive nature of the lake (Alikunhi, 1957). The increase in organic decomposition, which releases carbon dioxide, may be responsible for the high total alkalinity with values 242 mg/L at Site-S1 (Bharathi *et al.*, 1973 During the summer, there was a decrease in total alkalinity in Lake Manasbal, which can be explained by the fact that during the summer, the ice melts on the high mountains, causing a considerable rise in the quantity of water entering the lake. Cole (1975) associated low total alkalinity with enhanced photosynthesis, which uses CO_2 and eliminates bicarbonate by precipitating carbonates.

The chloride concentration varied from 5 mg/L to 30 mg/L. The minimum 5mg/L was at Site-S6 during winter and maximum concentration of 30 mg/L was at Site-S2 during autumn. Chloride varied significantly within the sites (F= 4.03, P < 0.05) but exhibited no significant change among the seasons (F= 2.9, P <0.05). The lake's high chloride concentration might be attributed to the presence of large quantities of organic materials, both allochthonous and autochthonous in origin (Pandit 1999). Swaranlatha and Narsingro (1998) also observed higher chloride concentrations in the summer. The maximum concentration was found at Site-S2, a sign of inorganic pollution, which was caused by sewage wastes including detergents, as well as sewage from human settlements drained into the lake (Shamim *et al.*, 2000 and Paramsivam and Srinivasan 1981).

The concentration of calcium ranged from 25.9 mg/L to 56.3 mg/L. The minimum concentration 25.9 mg/L was recorded at Site-S3 during summer and maximum value 56.3 mg/l was recorded at Site-S2 during spring. Calcium varied significantly within the sites (F= 14.66, P < 0.05) as well as among the seasons (F= 20.61, P <0.05). Ca concentration ranged from 52mg/L to 350 mg/L and was relatively high as compared to Mg. It might be attributed in part to the nature of the catchment region, which contains a preponderance of calcareous material. The decrease in Ca content during the summer was found to be directly related to the rapid increase in photosynthetic activity of macrophytes as they attained their peak growth and production during the season (Kaul *et al.*, 1980).

The concentration of magnesium ranged from 6.4 mg/L to 14.0 mg/L. The minimum concentration 6.4 mg/L was recorded at Site-S3 during summer and maximum value 14.0 mg/L was recorded at Site-S2 during spring. Magnesium showed significant variation within the sites (F= 13.17, P < 0.05) as well as among the seasons (F= 27.71806, P <0.05). Like calcium, magnesium also fluctuated seasonally in the lake, with a drop in concentration during the summer months correlating to peak macrophyte development. Low magnesium concentration in the summer may be attributed to plant absorption in the synthesis of chlorophyll-porphyrin metal complexes and enzymatic processing (Wetzel, 1975).

The dissolved oxygen fluctuated from 2 mg/L to 10 mg/L, with minimum value of 2 mg/L was recorded at Site-S6 during autumn and maximum value 10 mg/L at Site-S4, during spring. DO differs significantly among the sites (F= 7.189008, P < 0.05) as well as within the seasons (F= 101.67, P< 0.05). The current findings of this study revealed that dissolved oxygen concentrations were highest in the spring and lowest in the autumn. It may be due to the fact that as the temperature rises in the spring, the plant community in the water body blooms, releasing enormous amounts of dissolved oxygen into the water column. Furthermore, high winter dissolved oxygen levels can be related to poor photosynthetic activity (Vass *et al.,* 1977; Qadri *et al.*, 1981). Lower amounts of dissolved oxygen in autumn than in other seasons may be attributed to an increased rate of organic matter decomposition (Lewis, 2000; Okbah and El-Gohary, 2002).

The BOD of the water body varied from 19 mg/L to 57 mg/L with minimum value of 19 mg/L was recorded at Site-S4 during winter. The maximum value 57 mg/L was recorded at Site-S6 during summer and autumn seasons. BOD showed a significant variation within the sites (F= 36.39959, P < 0.05) as well as among the seasons (F= 151.36, P < 0.05). It was obvious that the BOD level increased steadily from winter to summer. Summer BOD maxima can be attributed to increased rates of microbial activity and decomposition caused by high temperatures (Singh *et al.,* 2002), an increase in agricultural runoff (Sachidanandmurthy and Yajurvedi 2006), and high organic matter loading (Sawhney 2008). Lower BOD levels during the winter can be attributed to a slow decomposition rate caused by low temperatures; high dissolved oxygen concentrations, and decreased microbial activity (Bhat *et al*., 2013).

The COD of the water fluctuated from 60.8 mg/L to 170 mg/L. The minimum value of 60.8 mg/L was recorded at Site-S4 during spring, while as maximum value 170 mg/L was recorded at Site-S6 during summer and autumn seasons , with significant variation within the sites (F= 22.23, < 0.05) as well as among the seasons (F= 136.61, < 0.05). Seasonally, the greatest COD levels were reported at polluted locations during the summer, while the lowest levels were found at least contaminated sites during the winter. When the data were compared, it was shown that COD had higher values during the summer months. The increasing anthropogenic pressures, such as agricultural runoff, sewage, domestic waste, and huge mounds of cow dung, are linked to the higher COD value at Site-S6. (Kundangar and Abubakar 2004 and Khuhawari *et al.,* 2009).

The ammonical nitrogen concentration varied from to 18 μg/L to 121 μg/L. The minimum value 18 μg/L was recorded at Site-S3 during summer and maximum value 121 μg/L was recorded at Site-S2 during winter. Ammonical Nitrogen exhibited significant variation within the sites (F= 13.58119, P < 0.05) as well as among the seasons (F= 27.93, P <0.05). The comparatively greater concentration of ammonical nitrogen in Manasbal lake may be ascribed to the presence of domestic sewage and the rapid rate of decomposition, as well as the usage of nitrogenous fertilizers in the catchment areas (Paulose and Maheshwari 2008). The lower value of ammonical nitrogen during summer is related to the photosynthetic absorption by autotrophs during their growth in late spring and early summer (Pandit, 1999).

The nitrate nitrogen value varied from 100 μg/L to 408 μg/L. The minimum concentration of 100 μg/L was recorded at Site-S3 during summer and maximum value 408 μg/L was recorded at Site-S2 during autumn. It indicated significant variation within the sites (F= 8.29, P < 0.05) as well as among the seasons (F= 8.28, P <0.05). The increased nitrate-nitrogen levels found in Manasbal lake indicate the nutrient-rich conditions of the lake. The increased nitrate concentration might be due to the presence of a huge quantity of domestic sewage, decaying organic matter, and agricultural runoff carrying nitrate fertilizers (Sylvester, 1961; Tatwat and Chandel, 2007).

The total phosphorus concentration fluctuated from 52 μg/L to 350 μg/L. The minimum concentration 52 μg/L was recorded at Site-S3 during summer and maximum value 350 μg/L was recorded at Site-S2 during autumn. Total phosphorus varied significantly within the sites (F= 16.36, P < 0.05) as well as among the seasons (F= 70.46, P <0.05). Phosphorus levels in Manasbal Lake may be high owing to sewage influx, agricultural runoff contaminated with phosphate (used as fertilizer), and other effluents. The presence of high levels of phosphorus indicates a eutrophic condition, which can lead to algal blooms (Bhat *et al.,* 2001 and Pandit and Yousuf (2002).

The total suspended solids showed a range of 199.2 mg/L to 433.0 mg/L. The minimum concentration 199.2 mg/L was recorded at Site-S3 during summer and maximum value of 433.0 mg/L was recorded at Site-S2 during spring. It varied significantly within the sites (F= 11.79, P < 0.05) as well as among the seasons (F= 23.298, P <0.05). In the present study the increasing concentration of TSS may be due to increased surface runoff from nearby catchment area with large quantity of domestic wastewater, solid waste and fertilizers. Similar results were observed by Tiwari (2005). The increased TSS values in the spring season may also be related to the deposition of various salts in water as a result of higher evaporation rates during the warmer months (Pedge & Ahirrao 2013). The decreased TSS value at the outflow might be attributed to very little or no turbulence as well as the sedimentation process.

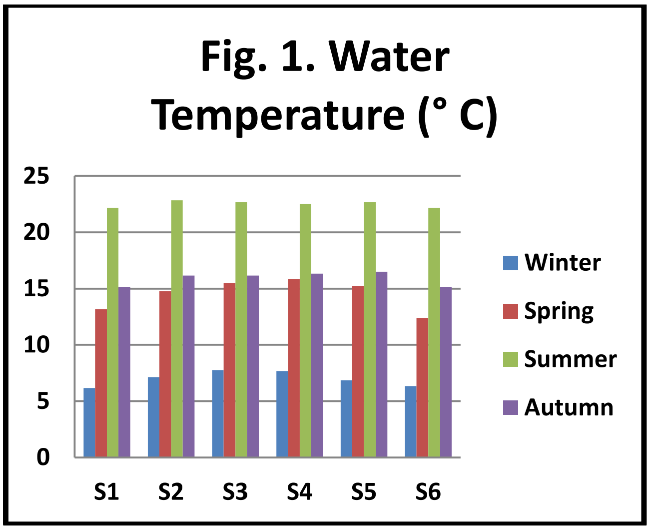

Fig. 1. Water Temperature (° C)

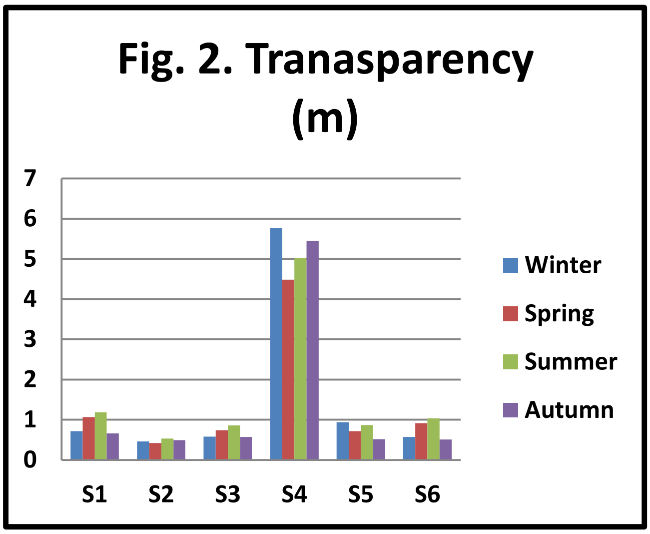

Fig. 2. Tranasparency (m)

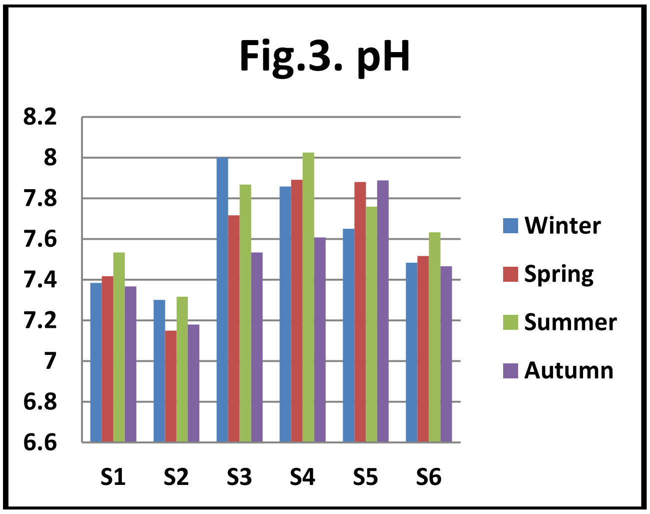

Fig.3. pH

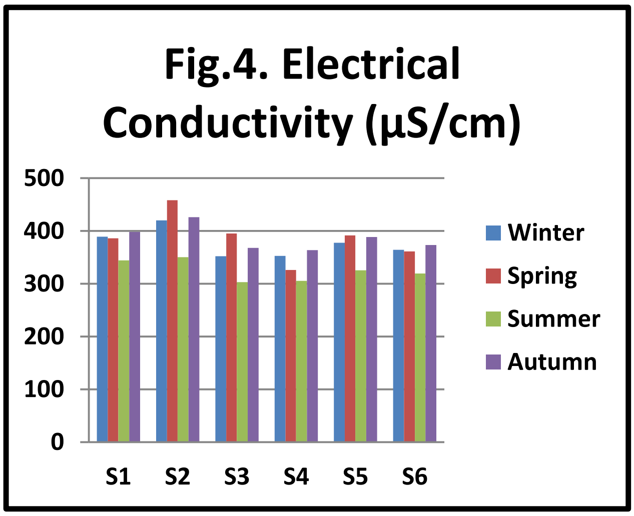

Fig.4. Electrical Conductivity (µS/cm)

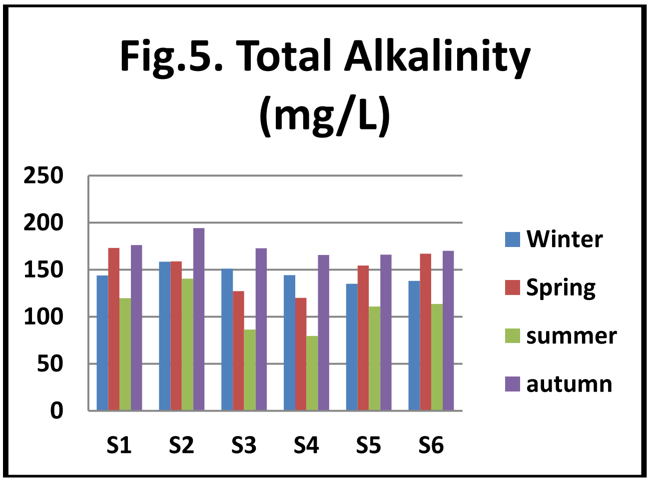

Fig.5. Total Alkalinity (mg/L)

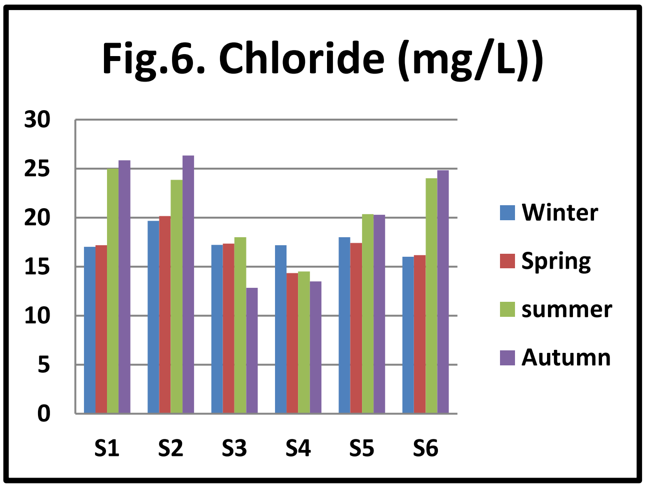

Fig.6. Chloride (mg/L))

Figure 1, 2, 3, 4, 5 and 6 showing seasonal fluctuations in water temperature, transparency, pH, electrical conductivity, total alkalinity and chloride respectively of Manasbal Lake at different sites.

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Fig.7. Calcium (mg/L)

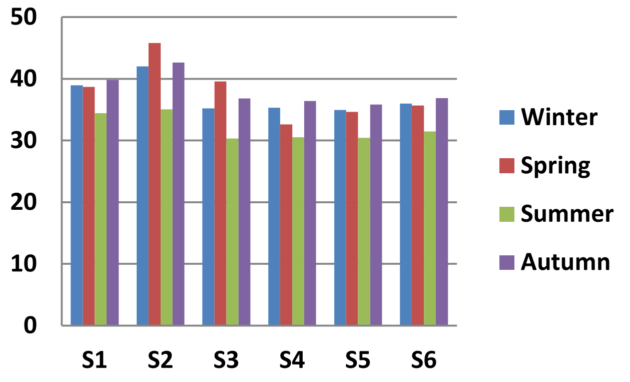


Fig.8. Magnessium (mg/L)

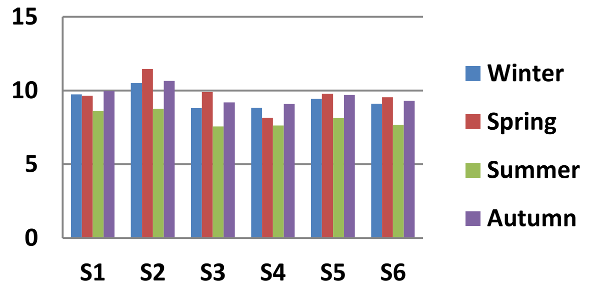


Fig.9. DO (mg/L)

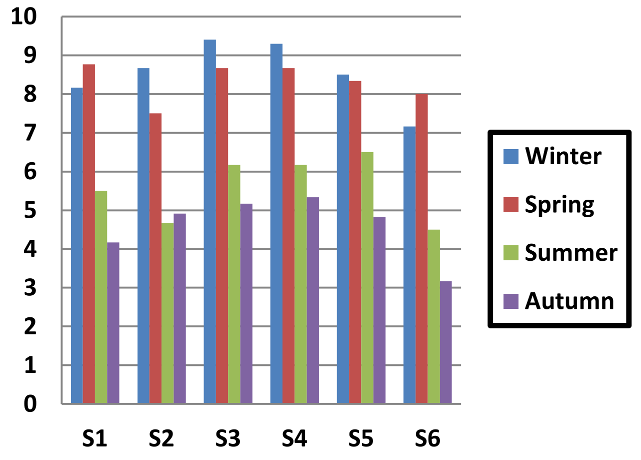


Fig.10. BOD (mg/L)

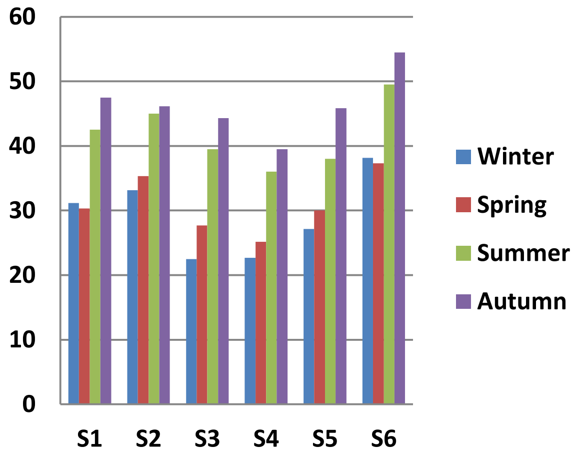


Fig.11. COD (mg/L)

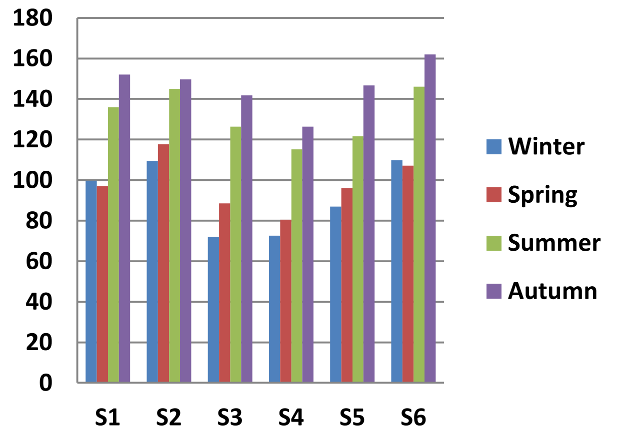


Fig.12. NH_4-N (µg/L)

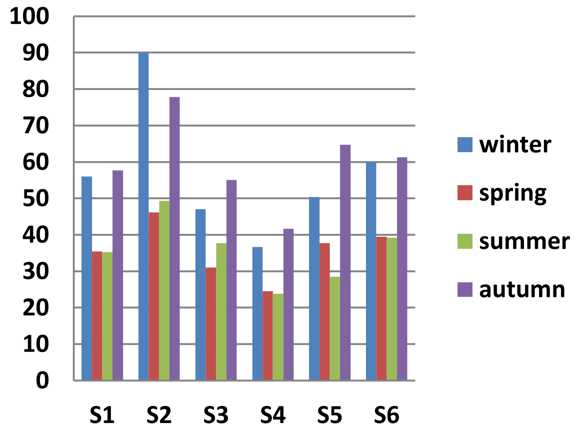
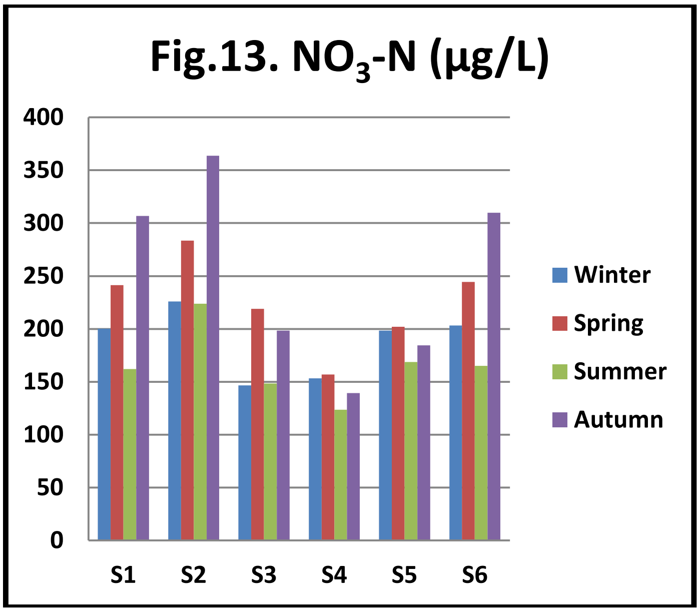
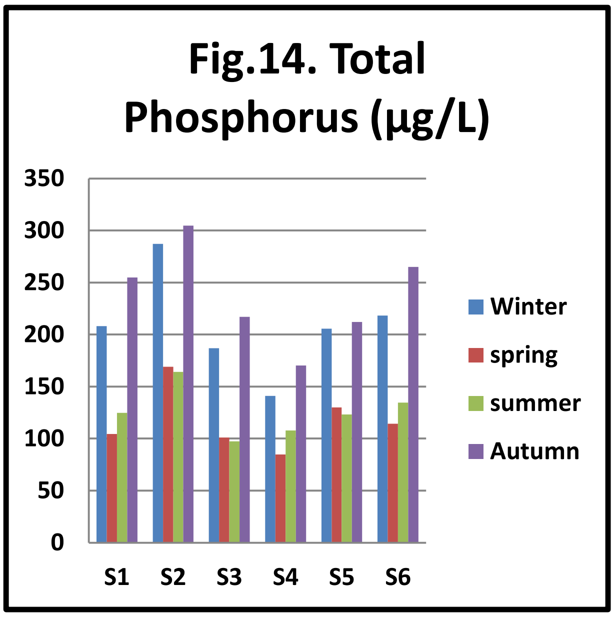


Figure 7,8,9,10,11 and 12 showing seasonal fluctuations in Ca, Mg, DO, BOD, COD and NH_4-N respectively of Manasbal lake at different sites.





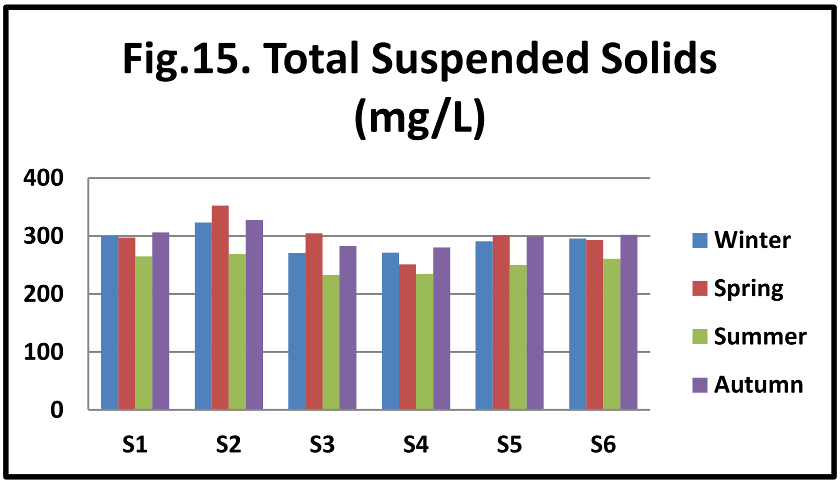


Figure 13, 14 and 15 showing seasonal fluctuations in NO_3-N, total phosphorus and total suspended solids respectively of Manasbal lake at different sites.

5. CONCLUSION

According to the findings of this study, the Manasbal Lake is being altered as a result of cultural eutrophication caused mostly by human pressures such as encroachment, siltation, and excess nutrient load. Though the amount of pollution varies from site to site, with the greatest influence being reported in locations receiving wastewaters from Kondabal, Gratabal, and Jarokabal regions, yet the impact is felt throughout the lake. It is clear from the study that the lake has experienced rapid eutrophication as a result of anthropogenic pressure, which has changed the water chemistry and trophic status of the Lake.

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