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Chemical Characteristics of Bottom Sediments of Dal Lake Srinagar, Kashmir

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Abstract

The aim of the current study is to investigate various chemical parameters and to determine the levels of various contaminants in bottom sediments. The data was collected from six different sites for a period of one year (June 2010 to May 2011). pH of the sediment samples were ranged from 6.2 (units) to 7.8 (units) and is significantly correlated with conductivity, chloride and nitrate. The range values of chloride, total phosphorus and sulphate of sediments showed wide fluctuations between different sites. Chloride showed significant correlation with total nitrogen and nitrate while total phosphorus was significantly related with sulphate. However, organic carbon, total nitrogen and Nitrate depicted less variation in range values with an overall average values of 8.0 ± 3.7, 1.5 ± 1.0 and 4.1 ± 4.4 respectively. Bray-Curtis cluster analysis depicted highest similarity between the site-2 and site-6 and lowest similarity was recorded between site's 1 and 5. The results of the present investigation suggesting increasing pollution load along the Dal lake which need to be monitored for the conservation of lake ecology.

Keywords

Sediment, Chemical Parameters, Pollution, Dal Lake

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1. Introduction

Lakes constitute one of the most important natural resource on earth. These productive ecosystems are immensely important for any geographical region as they play a significant role in its ecological sustainability. Sediment is loose sand, clay, silt and other soil particles that settle at the bottom of a water body USEPA, (2000). Bottom sediments are a mixture of material both, organic and inorganic, derived chiefly from the lake and its catchment, but material in trace quantities are also derived from the atmosphere (Battarbee, 1999). Characterization of bottom deposits is an important factor in the study of water quality in that it yields valuable information about the source of settleable material, the effect of the sediments on the quality of the overlying water, and the biological systems that will predominate. Sediment has ecological value, it forms a variety of habitats and environments for various sediment-dwelling species, such as benthos. Bottom sediments serve as a sink for such contaminants in the aquatic environment (Mucha *et al.*, 2000). During the course of time, these sediments get accumulated and form a very important component of lake ecosystem. Large quantities of contaminants such as nutrients, heavy metals and organic micro-pollutants are accumulated within the sediments of aquatic ecosystems (Cahill and Unger, 1993;

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Golden *et al.,* 1993 and Tuncel *et al*., 1993). In addition to this sediment also impact the quality of water as an outcome of their extremely dynamic nature due to variety of biogeochemical reactions and transformations (Ryding, 1985 and Bostrom *et al.,* 1988). Being a result of lake life, bottom sediments are extremely important for its nutrient economy, acting as sink or source of nutrients depending upon the redox conditions (Matisoff *et al*., 1985 and Sahoo, 2007). With the increasing anthropogenic pressure on inland fresh water resources because of sewage pollution, ground water Pollution, soil erosion, agricultural and industrial dumping of waste etc., it become highly important to monitor the sediment quality which ultimately accumulate all of these excessive wastes. Aquatic systems are subjected to strong variations of flow rate, substance input and transport, and sedimentation. Sediment analysis is increasingly important in evaluating qualities of the total ecosystem of a body of water. Sediment testing is not, or only minimally, affected by other influences. The suspended and precipitated (non-floating) substances and organic substances in waters are capable of adhering pollutant particles (adsorption). The sediments, both suspended and precipitated substances stored on the water bottom, form a reservoir for many pollutants and trace substances of low solubility and low degree of degradability (Biney, 1994 and Barbour *et al*., 1999). Pollutants are conserved in sediments over long periods of time according to their chemical persistence and the physical-chemical and biochemical characteristics of the substrata. This can allow conclusions to be drawn regarding sources of contamination. Since sediments act as a sinks and sources of contaminants in aquatic systems, chemical analysis for characterization of sediments also provides environmentally significant information about natural and anthropogenic influence on the water bodies.

Plenty work have been carried out on Dal lake by different researchers from time to time viz., Mukerjee, 1921, Dass, 1970; Vass and Zutshi, 1979; Zutshi and Ticku, 1990; Yousuf and Parveen, 1992; Zutshi and Gopal, 2000; Kundenger and Abubaker, 2004; Qadri and Yousuf, 2005; Iqbal *et al*., 2006; Yaqoob and Pandit, 2009; Saba and Wanageo,2010, Khan *et al*., 2012 and Mushtaq *et al*., 2013., whatever work have been carried out so far has been mainly focussed on physico-chemical parameters of water, macrophytic and planktonic dynamics. Structural community of benthic fauna. Therefore we carried out a study to understand the chemical characterization of bottom sediments samples collected from different Dal lake Srinagar, which is subjected to heavy pollution load. It is expected that the pollution data generated from such regular scientific study will help to implement compatible policies and programmes to gauge the extent of pollution.

2. Materials and Methods

2.1. Study Area

The Valley of Kashmir is a lacustrine basin of the intermountain depression existing between the lesser and Greater Himalayas characterized by numerous aquatic ecosystems of great ecological and economic importance. Freshwater lakes of Kashmir Himalayas have important multistage components like source of drinking water, irrigation, navigation, fishery, agriculture, socioeconomic development and recreation. However, in recent decades, the lake ecosystem has changed drastically and come into exacerbated trend because of disturbances in the catchment areas. As a result of heavy anthropogenic pressures, the lake surface area is shrinking with deterioration of water and sediment quality. The main problem of these lakes is nutrient enrichment from catchment area in the form of domestic wastewaters (residential areas) and runoff from agricultural fields.

Six sampling sites were chosen for the assessment of chemical characteristics of sediment of Dal lake (Fig. 1). Site-1 is located at a latitude 34° 08′ 44.6″N and longitude 74° 50′ 36.0″E near Habak sewage treatment plant where Boutkol enters in the Dal lake. The average depth of this site is 1.4 m. Site-2 is located within the centre of Hazratbal basin at latitude 34° 07′ 47.4″N and longitude 74° 50′ 38.0″E, having dense macrophytic growth and average depth of this site is 3.2 m. Site-3 is located in Nigeen basin (at latitude 34° 06′ 53.1″N and longitude 74° 50′ 07.3″E) near houseboats with the average depth of this site is 2.4m. Site-4 is located in dense floating garden area of Kandmohalla with average depth of 2.4 m, situated in Gagribal basin of lake at latitude 34° 05′ 58.6″N and longitude 74° 50′ 47.4″E). Site-5 is located with the centre of Gagribal basin at latitude 34° 04′ 54.8″N and longitude 74° 49′ 52.0″E, having dense macrophytic growth and average depth of this site is 4.0 m. Sitet site-6 is situated in Nishat Basin near Dock yard LAWDA at latitude 34° 07′ 41.4″N and longitude 74° 52′ 34.8″E; this site is regularly disturbed in summer months by manual deweeding processes. The average depth of this site is 3.0 m.

2.2. Sediment Sampling and Analysis

Sediment sampling was done with the help of Ekman's dredge (15×15× 15 cm^3), monthly from June 2010 to May 2011 at six locations. At each site the samples were taken in triplicates. The samples were packed in air tight polyethene bags and transported to the laboratory for further analysis. Different chemical parameters were analyzed on air dried samples. The air dried samples were grinded in pastel and mortar and weighed through 0.5mm sieve. Standard methods as given in Jackson (1973) and Page *et al.*, (1982) were followed to assess the chemical parameters of the sediments. pH and conductivity were carried out on dry (sediment water extract 1:1) basis with digital pH and conductivity meters. Chloride by argentometric method on 1:4 sediment water extract, organic matter: by Walkley and Black rapid titration method (Walkley and Black, 1965), total nitrogen: by Kheldahl's method (Bremner and Mulvaney, 1982), nitrate by Phenol-disulfonic acid method (Jackson, 1973), total phosphorus: by Olsen and Sommers (1982) method and Sulphate in sediment samples was determined by turbidity method.

2.3. Statically Analysis

The measured parameters varied over the years. The arithmetic means of each parameter were therefore calculated for each basin to obtain representative values for use in statistical analyses. The strength of relation between variables was ascertained using a Pearson correlation matrix of the data. Cluster analysis (CA) is a group of multivariate technique, which allows assembling objects based on the characteristics. The dendrogram provides a visual summary of the clustering processes, presenting a picture of the groups and their proximity with a dramatic reduction in dimensionality of the original data (Shrestha and Kazama, 2007).

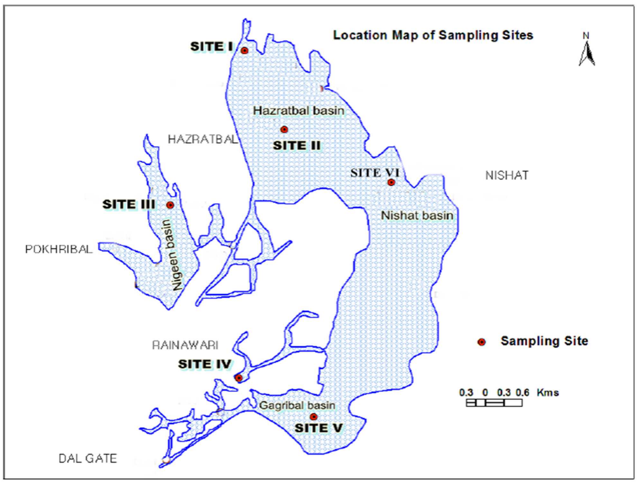

Fig. 1. Location map of sampling sites

3. Results and Discussion

The range value of different chemical parameters of bottom sediments during the present investigation are presented in Table 1 and monthly fluctuations of different chemical parameters of sediments at various sites are presented in Fig. 2 to Fig. 9. pH is a measure of the acidity or alkalinity of sediments. It is extremely important parameter since most of the chemical reactions are pH dependent. The pH values fluctuated from a minimum of 6.2 (units) at site-4 to the maximum value of 7.8 (units) at site-3 with an overall average of 7.1units ±0.20. The low pH values at site-4 may be due to decomposition of organic wastes at sites, as this site is located in dense floating gardens, where farmers dump organic wastes into bottom of the lake till it decomposes and it was used as manure in these floating gardens. The alkaline pH at site-3 may could be attributed to low pollution. In present study pH showed a significant positive relation with conductivity (r = 0.836), chloride (r =0.677) and nitrate (r = 0.863), Conductivity is influenced by a variety of factors like catchment geology, weathering rate, mineralization, lake type and trophic structure of the lake. Conductivity of sediments recorded its lowest value of 112 µS/cm at site-4 during December 2010 while highest value of 385 µS/cm during April 2011 at same site with an overall average value of 211 µS/cm ± 57.7. The highest conductivity values during winter may also be due to large decomposition of organic wastes from floating gardens as compared to spring months. It may also be due to direct drainage of sewage and runoff. As per Clarke and Wharton, (2001) direct drainage of domestic sewage into water bodies comparatively increases conductivity and other cation concentration in sediment profile. Conductivity was positively related with Nitrate (r = 0.863) and chloride (r =0.654). The significant positive relation between conductivity, chloride and nitrate signifies polluted status of bottom sediments of Dal lake. Chloride content of bottom sediments showed wide variation ranged from minimum value 28 mg/kg each at site- 3 during July 2010 to the maximum value of 300 mg/kg during February 2011 at site-5, with an overall average of 139 mg/kg ± 55.3. The chloride content at site-6 may be attributed to removal of upper sediment layers by mechanical excavation operations it may also be due to low decomposition of organic wastes. While high chloride content at site-5 may be due heavy pollution load in terms of emptied of both domestic as well as commercial sewage. According to Cole, (1975) disposal of sewage and other solid wastes into water bodies may result in high chloride content both in water as well as in sediments. The high concentration of chloride in sediments was directly related to dissolved nutrients and other cations in sediment composition (Chandrasekhar *et al.* 2003). The author reported that high level of chloride in sediments is an indicator of organic pollution by domestic sewage. In present study overall average chloride of bottom sediments depicted eutrophic status of Dal lake which was supported by strong positive significant correlation between chloride and total nitrogen (r=0.723) and between chloride and nitrate (r=0.786).

The organic carbon content during present study showed considerable variations between different sites. The range values was fluctuated from lower value of 0.5 % at site-1 during December 2010 to the higher value of 19.0 % in August 2010 at site-4, with an overall mean value of 8.0 % ± 3.7. The low organic carbon at site-1 may be due to presence of low decomposition of organic matter and low primary productivity, as there was absence of macrophytes at site-1 and the sediment of composition this site was mostly sand. According to Bianchini *et al.* (2006) and Rejmankova and Houdkova (2006) the organic carbon content of sediments is dependent on supply of organic matter via primary productivity, its subsequent retention in sediments and the rate of microbial decomposition. The high values of organic carbon at site-4 could be attributed to high organic loading from the nearby floating gardens and the process of dumping of organic matter of these floating gardens into the lake bed. Last and Ginn, (2009) reported high organic carbon content in bottom sediments may be due to increased decomposition of organic wastes the nutrient load in sediments were considerably increased. During the present investigation the total nitrogen of sediments of Dal lake fluctuates from 0.1 % at site-1 in different months to the maximum value of 5.3 % during February 2011 at site-2 with an overall annual average value of 1.5 % ± 1.0. The low nitrogen content in the sediments of site-1 may be due to low nutrient loading from catchments. Aquatic ecosystems receive nitrogen loadings mainly from anthropogenic sources like sewage, and agricultural runoff and from natural inputs such as atmosphere and catchment. The higher values of total nitrogen in sediments of site-2 might be attributed to presence of excessive macrophytic growth and decomposed organic matter at bottom. As per Marathe *et al.* (2011) direct discharge of domestic sewage in freshwater lakes, mainly due to spreading of sewage enriched with total nitrogen over the lake bottom increases nitrogen content of bottom sediments.

In present study nitrate nitrogen depicted fluctuations between different sites. The lowest concentration of NO_3-N (0.1 ppm) was recorded at site's-1, 3 and 5 during November 2010 while maximum concentration of (2.2 ppm) was recorded at site-6 during December 2010. The overall average value of NO_3-N was 4.1ppm ± 4.4. Low nitrate in sediments could also be due to presence of low organic matter. As per Eriksson and Anderson, (1999) and Wetzel, (2001) the lowest concentration of NO_3-N could be due to denitrification process and inhibition of nitrification rate by organic matter especially lignin. The high nitrate concentration at site-6 could be due presence of large decomposed organic matter in bottom. The high nitrate content in sediments of site-6 could be due to leaching and surface run off of nitro-phosphate fertilizers from nearby floating gardens into lake as well as from domestic sewage. Jeelani and Shah (2006) reported high concentration of NO_3-N in Dal lake and attributed it to input of fertilizers and sewers from catchment areas. Sediments are considered as sinks for phosphorous in lakes. Total phosphorus loading resulting from watershed development has long been recognized as an important factor affecting lake trophic status (Vollenweider, 1968; Dillon and Kirchner, 1975 and Canfield, 1983).Total phosphorus concentration of bottom sediments during the present work depicted wide variations. The range value fluctuated from a minimum of 13 ppm at site-6 during March 2011 to the maximum of 149 ppm during December 2010 at site-3, with an overall annual average of 54 ppm ± 40.0. High phosphorus concentrations at site-3 could be due to runoff of nitro-phosphate fertilizers and dumping of organic material from nearby floating gardens. Saba and Wanganeo, (2008) also reported that increased runoff from urban catchments particularly in Srinagar city and increased phosphorus loading from Telebal and Dachigam catchments were the major factors which were responsible for increase in total phosphorus in Dal lake. According to Tukura, *et al.* (2012), the high values of total phosphorus in sediments may be due to dead organic matter present in sediments. Total phosphorus in present study showed significant positive correlation with sulphate (r = 0.924). The range values of sulphate of sediment in present investigation depicted wide fluctuation from a minimum of 45 ppm at site-6 during June 2010 to the maximum of 170 ppm during September 2010 at site-3 with an overall annual average of 57 ppm ± 44.5. The low sulphate concentration in sediments at site two could be due less decomposition or organic wastes. According to Holmer and Starkholm (2001) the decomposition process of aquatic plants during winter period may result in increase in sulphate concentration in lake sediments. Wieder and Laung, (1988) reported that high sulphate levels in aquatic sediments may also be related to high levels of other cations present in the sediment composition.

Table 1. The range value of different chemical parameter of lake bottom sediments During 2010-2011

Parameters	**Minimum**	**Maximum**	**Mean**	**SD±**
pH (units)	6.2	7.8	7.1	0.20
Conductivity (µS/cm)	112	385	211	57.7
Chloride (mg/kg)	28	257	139	55.3
Organic carbon (%)	0.5	17.7	8.0	3.7
Total nitrogen (%)	0.1	3.9	1.5	1.0
NO_3-N (ppm)	0.1	15.4	4.1	4.4
Total phosphorus (ppm)	13	149	54	40.0
Sulphate (ppm)	7	170	57	44.5

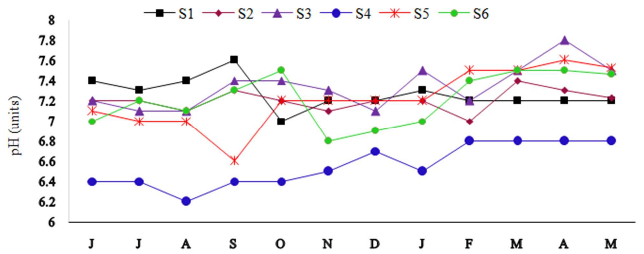

Fig. 2. Monthly variation in pH (units) of sediments at different sites in Dal lake during 2010-11

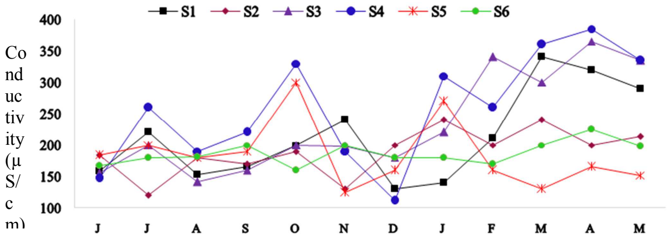

Fig. 3. Monthly variation in conductivity (µS/cm) of sediments at different sites in Dal lake during 2010-11

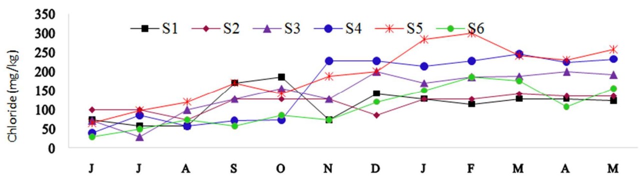

Fig. 4. Monthly variation in Chloride (mg/kg) of sediments at different sites in Dal lake during 2010-11

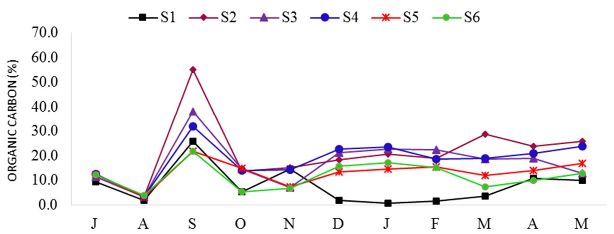

Fig. 5. Monthly variation in organic carbon (%) of sediments at different sites in Dal lake during 2010-11

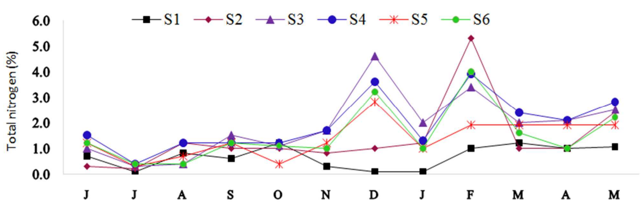

Fig. 6. Monthly variation in total nitrogen (%) of sediments at different sites in Dal lake during 2010-11

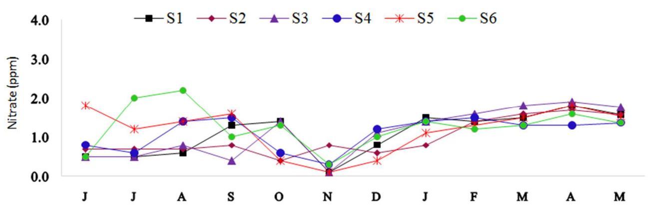

Fig. 7. Monthly variation in Nitrate (ppm) of sediments at different sites in Dal lake during 2010-11

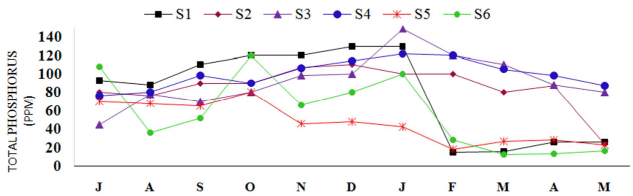

Fig. 8. Monthly variation in total phosphorus (ppm) of sediments at different sites in Dal lake during 2010-11

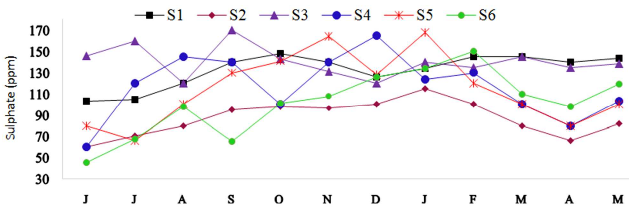

Fig. 9. Monthly variation in sulphate (ppm) of sediments at different sites in Dal lake during 2010-11

By applying Bray-Curtiz similarity index, it was evident from dendrogram (Fig. 10) different sites of Dal lake did not depicted any significant variation in the similarity percentage with each other on the basis of sediment chemistry. The highest similarity was recorded between site-2 and site-6 (95.5%) and lowest similarity was recorded between site-1 and site-5 (89.4%). The highest similarity between site's 2 and 6 may be due to similar bottom composition and low decomposition. It could be also due to the fact that both these sites receives sewage from nearby domestic areas. While lowest similarity between site's 1 and 5 can be attributed to the fact that sediments of site-1 were less contaminated as in comparison to site-5 which is located in houseboat area and receives large amount untreated sewage and other wastes. The other sites were almost 90% similar to each other.

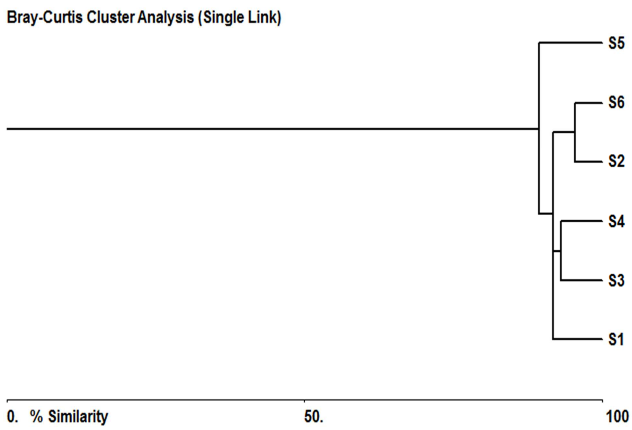

Fig. 10. Dendrogram of similarity percentage between different sites of Dal lake on the basis of Sediment chemistry

4. Conclusion

Present study conclude that different chemical parameters of Dal lake showed its eutrophic nature. A perusal of present data depicted high levels of pollution in the bottom sediments almost at each site along the lake ecosystem due to various human disturbances occurring inner side as well as outside of the lake ecosystem. It was further conclude dumping of sewage, organic matter and faecal matter from house boats and other human habitation inside the lake were responsible for its eutrophic nature. The present work suggest need for implement of common objectives, compatible management strategies for the conservation of the lake ecosystem. The existing situation of the Dal lake if not controlled properly may cause severe ecological harm and lead it to distrophic status in near future.

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