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Changes in physico-chemical parameters at different sites of Dal Lake, Kashmir

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Abstract
The present study was carried on the surface and bottom waters of Dal Lake. The sampling was carried on monthly basis from December 2019 to November 2020. A total of 9 parameters were determined at six different sites. Our findings highlighted the deterioration of water quality in the lake due to anthropogenic activity in the lake and urbanization. The lake can be considered as eutrophic as evidenced by its shallow depth (1 to 3 m), low transparency (0.5 to 2.2 m), and higher concentrations of other nutrients such as phosphates, nitrates and chloride.

Keywords: Dal Lake, water quality, physico- chemical parameters, eutrophication, pollution

Introduction
Water is the Universal solvent, abundant and useful component, without it life is impossible. These water bodies are not only important for water, but also for their ecological importance as they provide habitat to aquatic flora and fauna including different species of birds. They may also comprise an important component for sustainable tourism and recreation. At present water resources are in a serious problem due to encroachment, unplanned urbanization and industrialization (Singh *et al*., 2002). Environmental status of lakes all over the World is in varying degrees of degradation. The Kashmir valley, in India is famous for its high mountain reaching to a height of 6000 meters, their elevations and depressions have created numerous, high altitude, fresh water lakes- The urban lakes of Kashmir including Dal Lake are facing a serious threat of encroachment due to anthropogenic pressures resulting in their gradual eutrophication and degradation.

Dal Lake, which is situated on the north-east of Srinagar at an altitude of 1583 masl and has been the centre of Kashmiri civilization. It is one of the most attractive tourist spots of international importance and fame in Kashmir. In 18th and 19th centuries Srinagar city started growing towards the lake resulting in far reaching changes in its surroundings. Bunds were laid that divided the lake in to various basins viz., Hazratbal basin, Nishat basin, Nehru park basin and Nigeen basin. Each basin maintains its individual character but these basins vary in their morphometery, water quality and biodiversity (Abubakr & Kundangar, 2005). It is perceived as vast expanse of water in a pristine landscape where one goes for recreation. It is a place of experiencing nature by way of boating, camping, fishing, swimming, bird watching, etc. While urban lakes are different from the common perception of lakes in general they too have value and functions, both ecosystem functions and social values. The biodiversity of lake and pond ecosystems is currently threatened by a number of human disturbances, of which the most important include increased nutrient load, contamination, and invasion of exotic species (Bronmark & Hansson, 2002). The ecological stress of the system is reflected by deterioration of water quality and increased levels of biological productivity. Hydrologic change is the most visible impact of urbanization. The organic and inorganic pollutant load in the Dal has accelerated the macrophytic growth which in turn has reduced the water quality and biological oxygen demand (BOD) of the lake and hence has reduced the recreational and aesthetic appeal of the lake The chemistry of lake water and sediment is a cumulative reflection of catchment geology, weathering and erosional processes as well as anthropogenic inputs.

Material and Methods
Study Area
The Dal Lake is known as 'Liquid Heart' of Srinagar. It is situated on the northeast of Srinagar at the altitude of about 1583 m and has been the centre of Kashmiri civilization.

18th and 19th centuries Srinagar city started to grow towards lake resulting the changes in its surroundings. Bunds were laid that divided the lake in the various basins viz., Hazratbal basin, Nishat basin, Nehrupark basin and Nigeen basin. Each maintains its individual character but these basins vary in their morphometery, water quality and biodiversity (Adnan and Kundangar, 2005). The lake is the multibasin fresh water post glacial lake with a shallow depth, positioned at mean latitude 34-60 N and longitude of 74-750 E. the perennial inflow channel known as Telbal Nallah enters the lake from north and brings water from a high altitude Mansar lake. Towards the southwest side an outflow channel discharges the lake water into the tributary of Jehlum River called *Tsunt Khul.* A small canal connects Dal Lake with Anchar Lake and acts as additional outflow channel, known as Nallah Amir Khan (Kundangar and Adnan, 2001)

Sampling sites

Six sampling sites were selected in the Dal Lake for the present study. These sites were (i) Site I Telbal Nallah (ii)Site II Near Dobhighat (iii) Site III Sonalnk (iv) Site IV Ropalank (v) Site V Laam (vi) Site VI Dal lock gate.

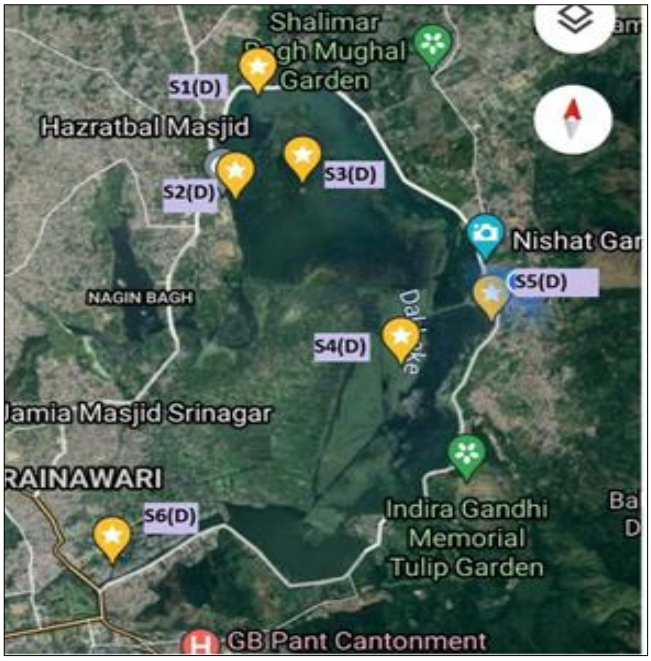

Fig 1: Map representing sampling sites in Dal Lake.

Site 1: This site is located on the northern side of the lake near Telbal area where the main inflow channel known as Telbal Nallah enters the lake. It is the main source of water to the Dal Lake and originates from the mountains of Dachigam which supplies about 80% of the water to the lake.

Site 2: This site is located near the Dobhighat area near the Hazratbal Shrine. As the name implies the place is known for washing of clothes since most of the inhabitants are involved in the trade.

Site 3: This is the central site (pelagic zone) of the lake known as Sona Lank. It comes under Nishat basin. It was constructed in the 15th century on the Hazratbal basin, the golden island was built by Zain Ul Abdin (1420-1470 AD)

Site 4: Char chinar, also sometimes called Char Chinari, ropa lank or rupa lank, is an island located on the bod dal, the silver island is marked with the presence of majestic chinar trees at the four corners, thus known as char- chinari was built by Sultan Hassan Shah (1475-1478 A.D.)

Site 5: This is the littoral site which is located near the Brein Laam village.

Site 6: This site is located at the exit of Dal Lake (Dal- lock-gate). It is situated amid a number of hotels and restaurants of the city dumping their waters into the lake.

Water Sampling

Water samples from the surface and the bottom of all the sites were collected in the one litre polyethylene bottles and for the collection of bottom water samples Rutner Sampler was used. For dissolved oxygen, water samples were collected in separate 125 ml glass stoppered bottles and the fixation of the 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 CO2, chloride, nitrate, nitrogen (NO3-N),Ammonical Nitrogen, was carried out in the AEM laboratory, Faculty of Fisheries using the standard methods as per A.P.H.A and Adoni.

Statistical Analysis

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

Results and Discussion

Air and Water temperature

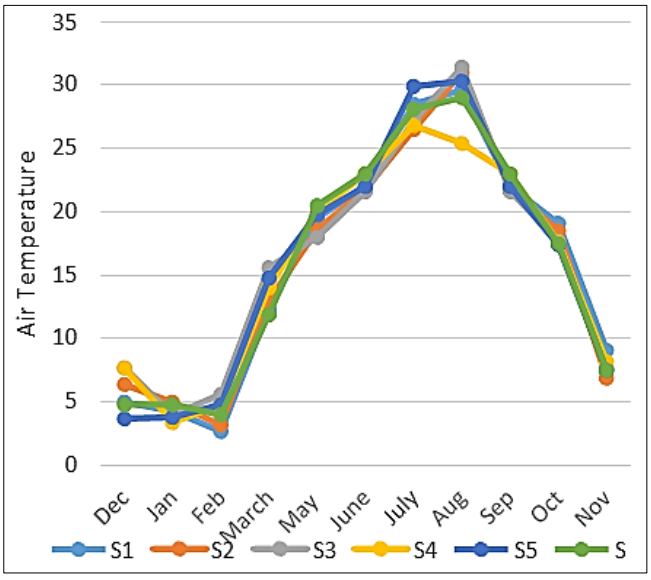

Fig 2: Monthly variation in the air temperature (0C) in Dal Lake

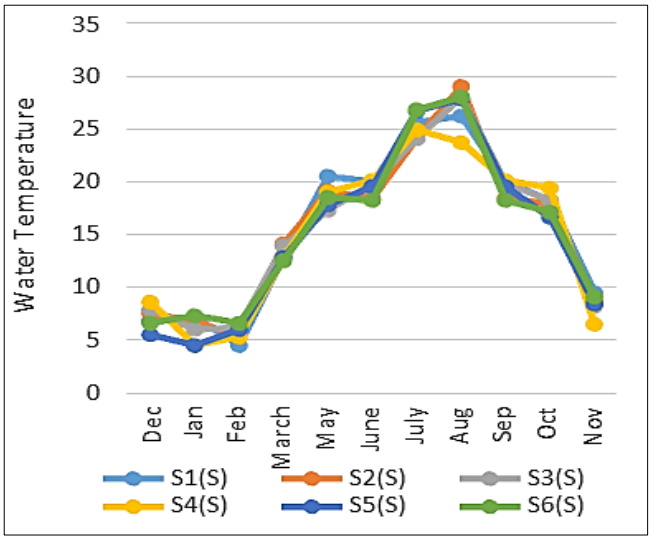

Fig 3: Monthly variation in the water temperature (0C) in Dal Lake

The lowest air temperature was recorded 2.70C during winter season in the month of February which may be due to the short photoperiod and cold atmosphere while the highest was 31.40C during summer season in the month of august that may be because of clear atmosphere and higher solar radiations. These results are in conformation with (Monisa and Balkhi., 2011; Sushil *et al*., 2014; Umer and Solanki., 2015; Indresa and Patra., 2014 and Abubakr *et al*., 2018) [24, 28, 16, 1] while the highest water temperature was recorded 290C in summer season because of higher solar radiations and clear atmosphere while the lowest was 4.50 C recorded during winter season due to higher water level, less solar radiations and low atmospheric temperature. These results are in accordance with Ahanger *et al.* 2012 who said that water temperature increases during summer months and decreases during colder months and plays an important role in governing the water quality as the chemical and biological reaction rates increases with increased temperature.

Depth

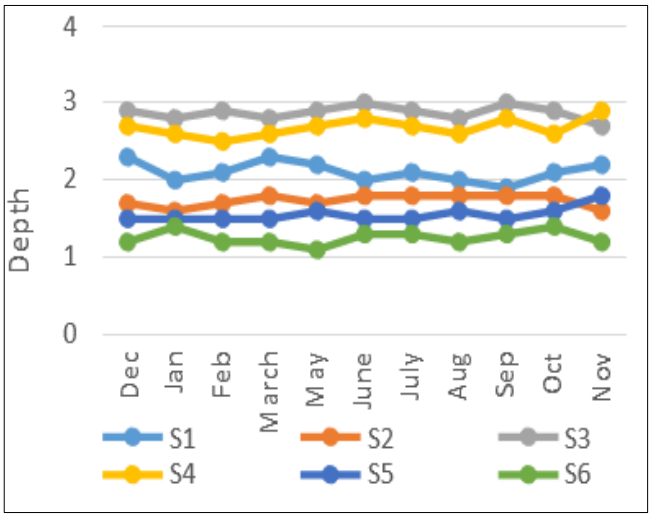

Fig 4: Monthly variation in the Depth (m) in Dal Lake

The depth of water at a particular site is one of the major physical factors which act as controlling factor for determining the water quality. Depth of water is determined by the volume of water column in an aquatic systems, which in turn is dependent on discharge rate of inflows and amount of precipitation received in the form of rain and anthropogenic activities (Bhat *et al*., 2013 and Sushil *et al*., 2014) [9, 29]. The depth of Dal Lake varied from the minimum of 1.1m in the month of May to the maximum of 3m in the month of September. Higher depth values can be accredited directly to higher precipitation rate resulting in more significant water discharge from the inlet (Kumar and Pandit., 2007).

pH

pH is the measure of acidity or alkalinity of water, hence it is important factor for water quality analysis. It explains certain biotic and abiotic ecological characteristics of aquatic systems in general. pH values showed a decreasing trend from surface to bottom. The minimum pH was recorded to be 6.2 in the month of January at bottom while the maximum pH of 8.1 in the month of July at surface. pH of water body is a diurnally variable property according to the temperature variation in the system (Ojha and Mandloi., 2004) [25]. The fluctuation in pH has been related to photosynthetic activities and also with dissolved oxygen by many workers (Abubakr, 2010; Kundangar *et al*, 1998; Wangneo *et al*, 1984) [4, 32]. Whitemore, 1989 [36]; Kaul and Handoo, 1980 [17] found that increased surface pH in water bodies is due to the increased metabolic activities of autotrophs. And lower pH value in bottom layers is due to the liberation of acids from decomposing organic matter under low O2 concentration.

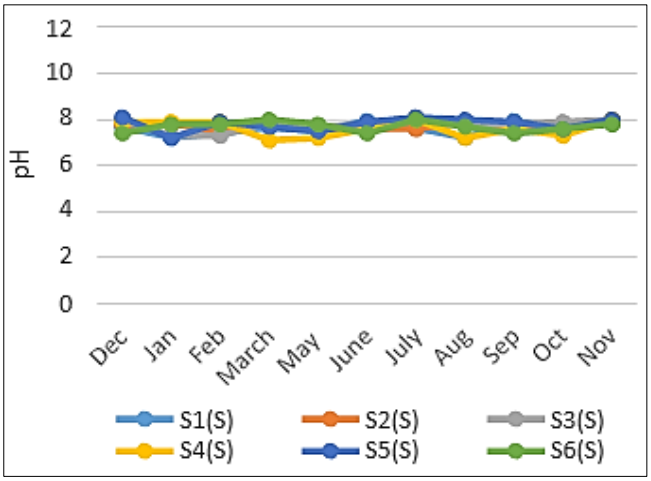

Fig 5: Monthly variation in the pH (m) at surface in Dal Lake

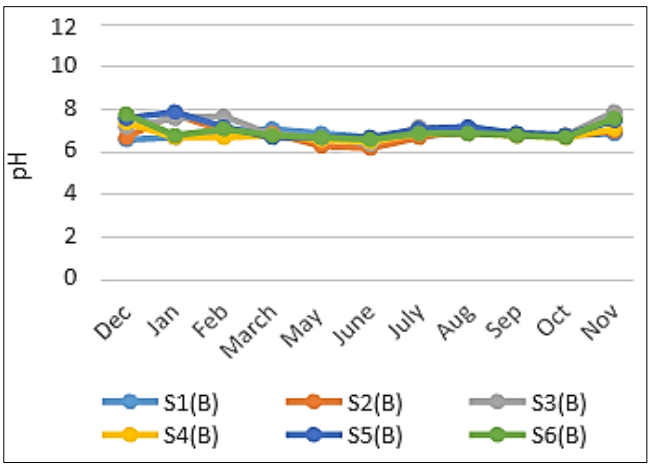

Fig 6: Monthly variation in the pH (m) at bottom in Dal Lake

Dissolved Oxygen

Dissolved oxygen is one of the most important parameter is assessing the water quality as it is essential in maintain the biotic forms in water. It is vital to the metabolism of every aquatic organism that possess aerobic respiration. Oxygen reflects the water quality status, physical and biological processes in the water as well as the metabolic balance of a lake (Laluraj *et al*., 2002) [21]. Dissolved oxygen was recorded maximum of

9.6 mg/l in the month of January on surface. The minimum was 0 mg/l in the month of august during summer season at bottom. The rate of oxygen depletion noticed in the bottom layers of Dal Lake is an indication of more eutrophic nature of the water body. Yousuf and Shah. 1988 and Bhat *et al.* 2013 [38, 10], also stated that the lowest value of dissolved oxygen during summer is due to increased amount of organic matter which consumes dissolved oxygen for decomposition. According to Broker and Edward, the decline in photosynthesis and increase in metabolism of dying vegetation may result in deficiency of oxygen and excessive amount of carbon dioxide in the aquatic system.

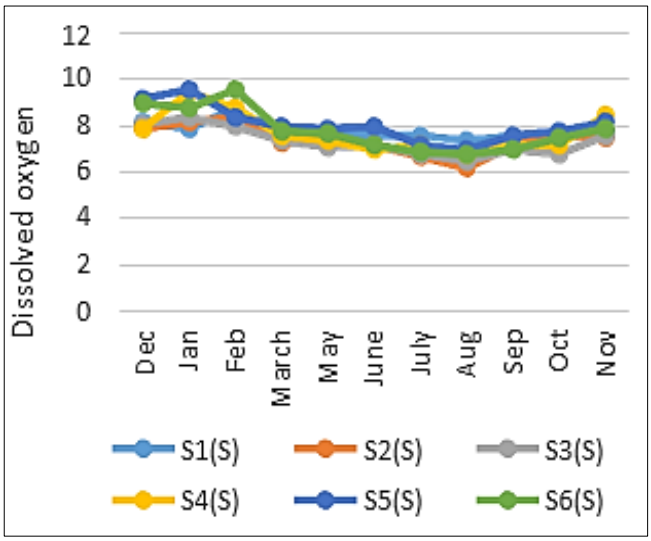

Fig 7: Monthly variation in the DO (mg/l) at surface in Dal Lake

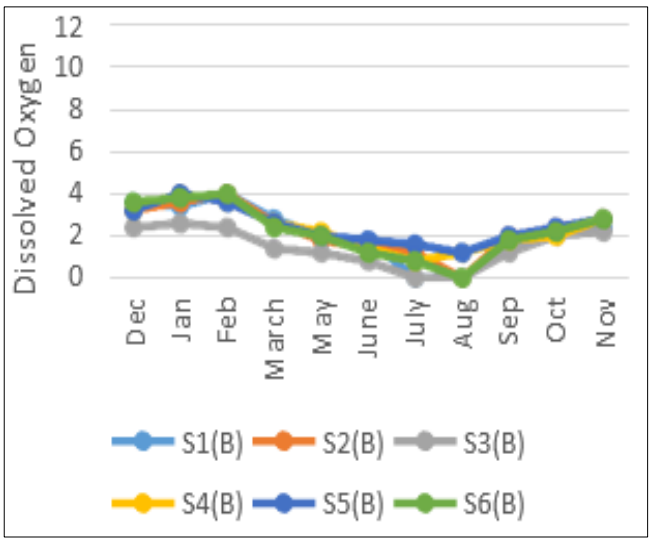

Fig 8: Monthly variation in the DO (mg/l) at bottom in Dal Lake

Chloride

Chloride content in water body is usually recorded as an indication of organic load of animal origin from the catchment area (Kumar *et al*, 2004) [18]. Its increased concentration is considered as an indicator eutrophication and pollution due to sewage (Chourasia and Adoni, 1985) [12]. The chloride content varied from 23 mg/l in the month of August to 53 mg/l in the month of December. The chloride content in the bottom waters was higher the surface waters which might be attributed to the presence of organic matter in the deeper waters. (Tresh *et al*., 1944; Yousuf and Qadri, 1981) [30, 37] reveal that the chloride concentration has significantly increased over past few decades in Kashmir valley lakes and has contributed to the pollution.

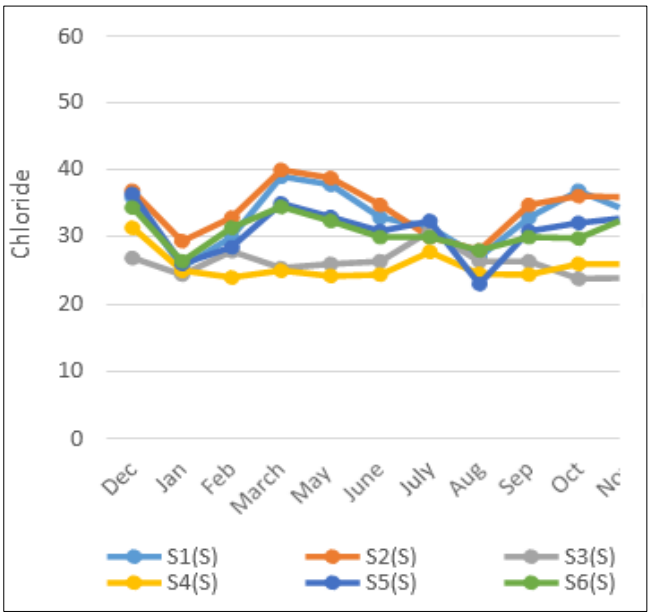

Fig 9: Monthly variation in the Chloride (mg/l) at surface in Dal Lake

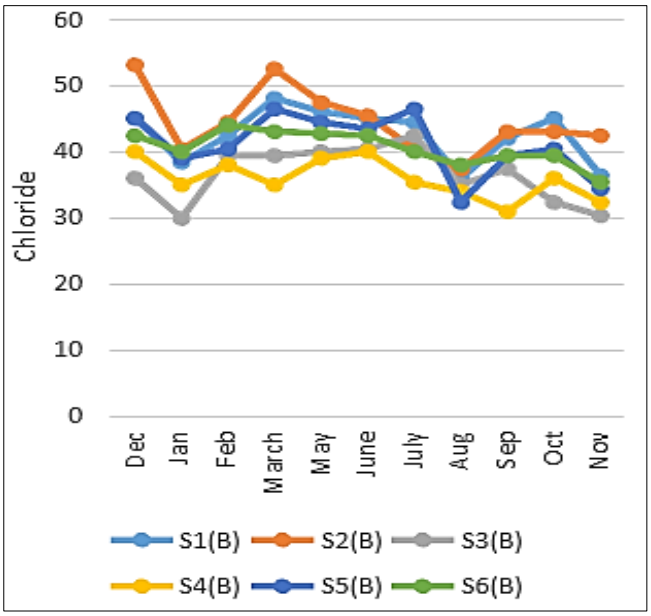

Fig 10: Monthly variation in the Chloride (mg/l) at bottom in Dal Lake

Free Carbon Dioxide

Free carbon dioxide is the essential chemical property of water column. As it is used for photosynthesis by planktons and macrophytes and its concentration effects their productivity. The free carbon dioxide range varied from 3mg/l

at surface to 21 mg/l at bottom. The concentration of free carbon dioxide was quite at bottom as compared to surface. These results are in accordance with Ahanger *et al*., who revealed that carbon dioxide liberated during respiration and decay of organic matter depends upon the water temperature, depth, rate of respiration and chemical nature of bottom which also holds true for the present study. These results are also in conformation with Abubakr *et al*, 2018 [1].

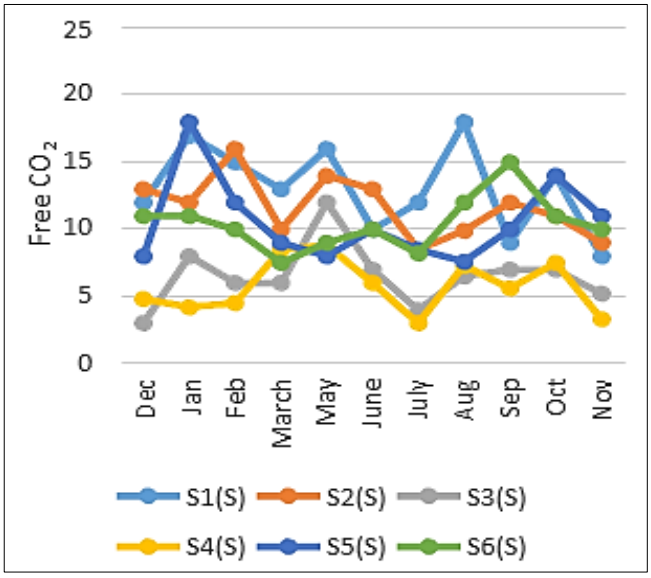

Fig 11: Monthly variation in the Free Carbon dioxide (mg/l) at surface in Dal Lake.

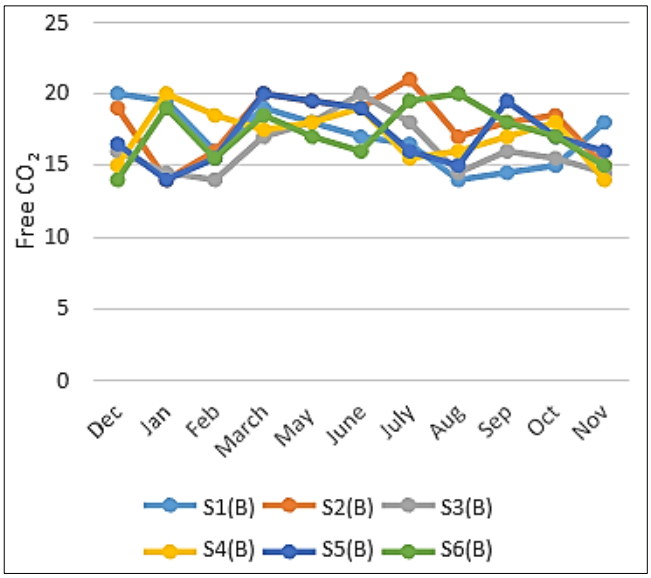

Fig 12: Monthly variation in the Free Carbon dioxide (mg/l) at bottom in Dal Lake.

Ammonical-Nitrogen

Ammonia is basically a product of decomposition. The highest concentration of 510µg/l of Ammonical nitrogen was observed at bottom of the lake and lowest was recorded 148 µg/l at the surface. The minimum values in the surface lake of the lake during stagnation period by Yousuf, 1979 [40]. Wetzel, 2000 [35] also attributed that high level of ammonia in the lakes may be because of its release from the sediments under low oxygen level at which nitrification of ammonia ceases and the absorptive capacity of sediments is reduced. In anaerobic bottom where animals are scarce, ammonia is formed by the amino-acids degradation of proteins carried out by ammonificating bacteria occurring in the water column and sediments. (Gorlent *et al*., 1977; Howarth *et al*., 1988; Stolp, 1996) [15, 39, 27] and thus rising ammonium nitrogen in the bottom layers.

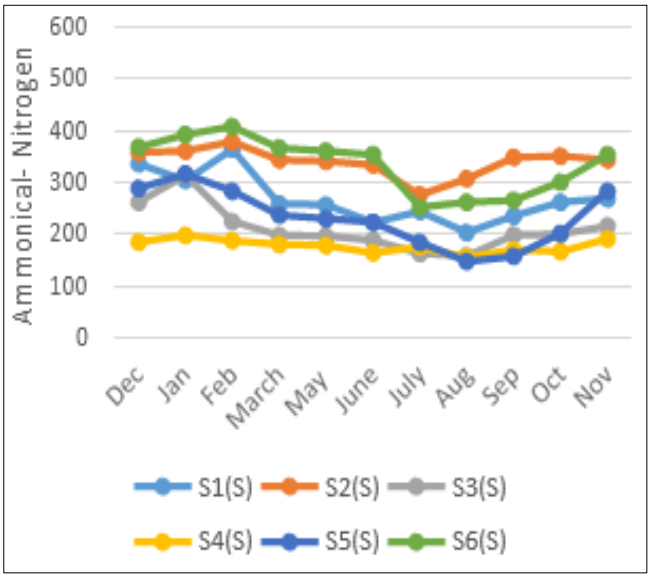

Fig 13: Monthly variation in the Ammonical- Nitrogen (µg/l) at surface in Dal Lake.

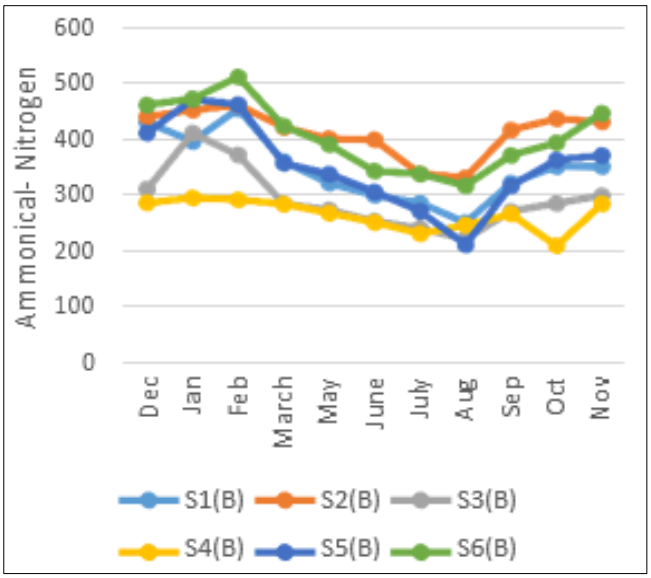

Fig 14: Monthly variation in the Ammonical- Nitrogen (µg/l) at bottom in Dal Lake.

Nitrate-Nitrogen

Nitrate is essential nutrient for photosynthetic autotrophs and in some cases have been identified as the growth limiting nutrient. Nitrate is common form of inorganic nitrogen entering the freshwater from the precipitation, the groundwater and draining basin, mostly occurring in low concentration under natural conditions (Wetzel, 1983) [34]. During the present study nitrate- nitrogen ranged from a minimum 273.7 µg/l in the month of March to the maximum of 750 µg/l in the month of February. (Anigri, 1972 and Moulood *et al*., 1978) [6, 22] also found an increase in nitrate content towards bottom. Abubakr and Kundangar, 2004 [2] also reported progressive increase in nitrogen and phosphorous in the lakes and attributed it to the sewage

contamination while studying the changing biodiversity of seven lakes of Kashmir. Nitrogen pollution by high nitrate concentration can cause eutrophication in surface waters (Fried, 1991; Mlitian *et al*., 2015) [13, 23].

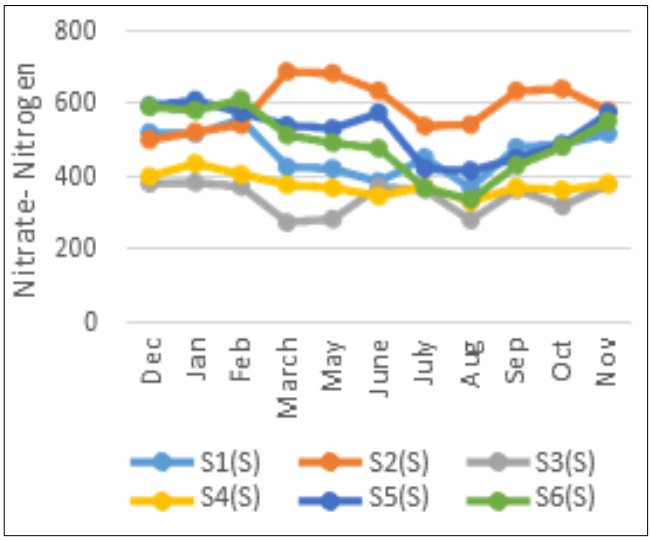

Fig 15: Monthly variation in the Nitrate - Nitrogen (µg/l) at surface in Dal Lake.

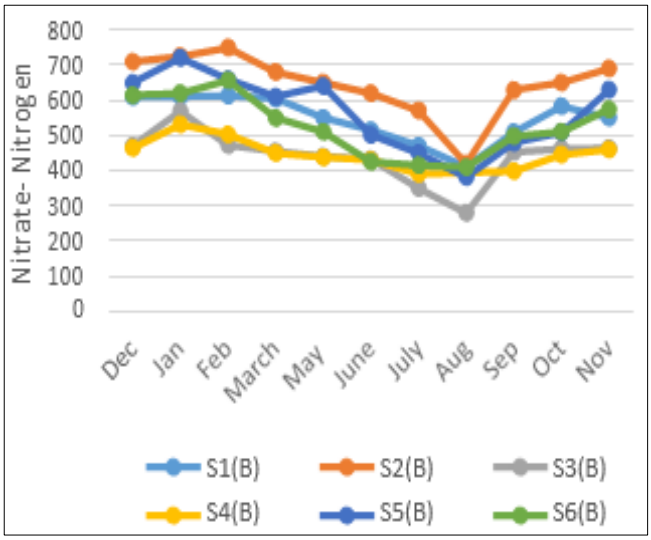

Fig 16: Monthly variation in the Nitrate- Nitrogen (µg/l) at bottom in Dal Lake.

Total Phosphorus

Phosphorus present in excess amount of 30µg/l in water bodies is regarded as major nutrient triggering eutrophication Welch, 1980 [33]. It is available in water in different forms such as orthophosphates, condensed phosphates and organically bound phosphates (Bandela *et al*., 1999) [8] and is considered as critical limiting nutrient of freshwater system (Rabalias, 2012). During present study phosphorus range from the minimum of 235.9 µg/l in the month of December at surface to the maximum of 750.5µg/l in the month of August at the bottom. The total phosphorus concentrations were higher at the bottom than surface layers can be due to remobilization of phosphorus from sediments (Bluzez *et al*., 2008).

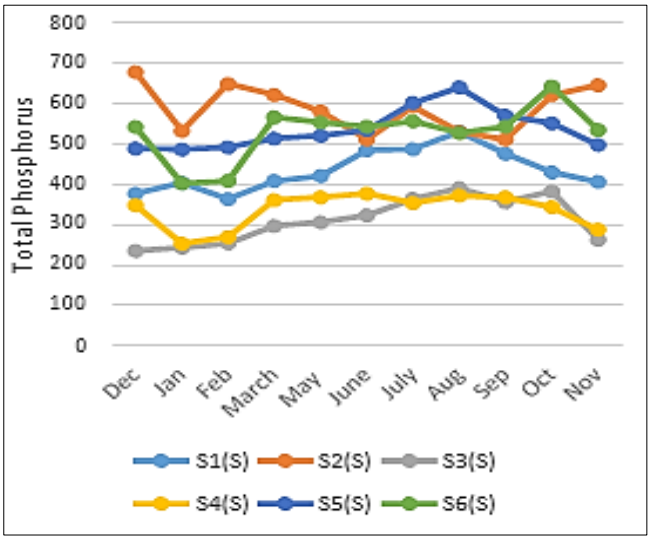

Fig 17: Monthly variation in the Total phosphorus (µg/l) at surface in Dal Lake.

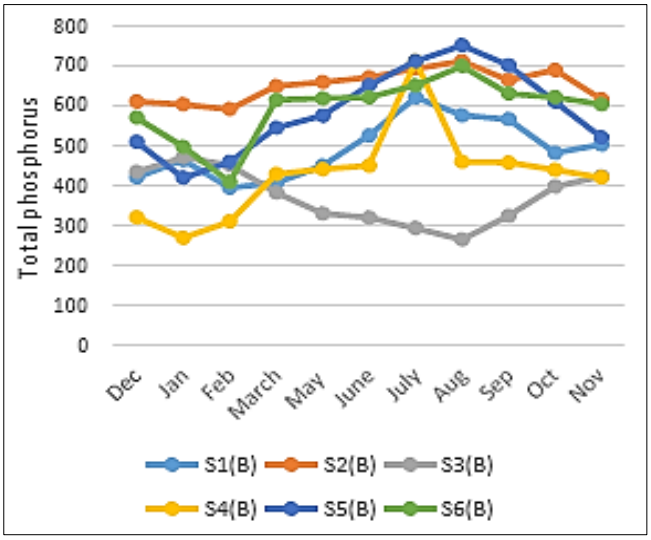

Fig 18: Monthly variation in the Total phosphorus (µg/l) at bottom in Dal Lake

Table 1: The minimum and maximum values of Physico – Chemical parameters of surface and bottom of Dal Lake

	Surface		Bottom	
Parameters	MIN	MAX	MIN	MAX
Water Temperature (0C)	4.5	29	4.5	29
pH	7.1	8.1	6.2	7.9
Dissolved Oxygen (mg/l)	6.2	9.6	0	4
Chloride(mg/l)	23	40	30	53
Free CO2 (mg/l)	3	18	14	21
Ammonical-Nitrogen(µg/l)	148	407.3	208.8	510.3
Nitrate- Nitrogen(µg/l)	273.7	685.5	280.5	750
Total Phosphorus(µg/l)	235.9	677.8	266	750.5

Conclusions

As per the study and results pertaining to the different sites, the increasing disturbances from the various anthropogenic are the cause of deterioration of water quality to great extent. The elevated levels of chloride, nitrate, total phosphorus indicates the effect of run-off from floating gardens and untreated sewage from houseboats. The high values of free carbon dioxide, ammonia, nitrate, nitrite and total phosphorus at the bottom of the lake is an indication of nutrient enrichment. The present findings reveal that the lake water

can improve provided all the sewage entering the lake is treated, which will in turn depend on how much reduction at various input sources is achieved. It may be therefore, concluded that the water quality of Dal lake was observed to be polluted as the result of direct drainage of sewage from the nearby residential areas and from inner side human habitation particularly houseboats. The physico-chemical parameter obtained in this lake could be used as baseline and reference point when assessing further changes caused by natural or anthropogenic activities in the lake.

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