Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

# Exploring present status of Hydrochemistry and Sediment chemistry of Dal Lake, Kashmir and effect of anthropogenic, Disturbances on it

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## Abstract

Dal Lake (Lat. 340 – 6' N, 740-45' E, alt. 1583m) situated in the heart of Srinagar city, the summer capital of Jammu Kashmir State is under tremendous anthropogenic pressure. The myriad is ways in which people use the lake along with the numerous pollutant generating activities have stressed the lake ecosystem in diverse ways. Despite the fact that a number of restoration and conservation plans prepared by National and International agencies and implemented by state authorities, there is no significant improvement in Dal Lake environment, lake condition as a whole continue to deteriorate at an alarming rate. This study attempts to record the effect of human population on this lake taking into consideration the disturbed sites and undisturbed sites, involving the effect of human activities on this ecosystem. This study also highlights the latest pollution status of the lake by comparing the various physico-chemical parameters with the earlier data and suggests some remedial measures to save it from further deterioration.

***Keywords:*** Dal Lake; Hydrochemistry; Sediment chemistry; BOD; COD; Pollution; Kashmir; Anthropogenic activity.

***Abbreviations***: EC – Electrical conductivity; TDS - Total dissolved solid; COD - Chemical Oxygen Demand; BOD - Biological Oxygen Demand; TA - Total Alkalinity.

## Introduction

In present times, the aquatic ecosystems worldwide are being severely altered or destroyed at a rate greater than ever known in the human history. Dal Lake ecosystem (Lat. 340 – 6' N, 740-45' E, alt. 1583m) situated in the heart of Srinagar, the summer capital of Jammu & Kashmir State is under tremendous anthropogenic pressure for the last three decades. More than 50,000 people live within the lake itself in various hamlets besides living in houseboats. People use this lake, for personal purposes generating huge businesses out of it but producing numerous pollutant generating substances for it in the form of floating gardens and using fertilizers at large in the nearby paddy fields therefore these activities have deteriorated the lake ecosystem in diverse ways. These stresses have caused significant impairment to the lake quality (Ishaq, 1988).

The chemistry of lake water and sediment is a cumulative reflection of catchment geology, weathering and erosional processes as well as anthropogenic inputs. The chemical degradation of silicate and carbonate minerals is various processes, such as dissolution, hydrolysis, oxidation, and reduction (Gupta and Subramanian, 1998). The basic chemical reactions take place among silicates, carbonates, and rainwater, congruently or incongruently, gives rise to various ions and clay minerals (Freeze and Cherry, 1979). The concentration of the chemical constituents in water depends on the availability of the parent mineral for a particular constituent and its dissolving capacity. The concentration and abundance of the chemical constituents in lake sediments reflect the occurrence and abundance of these metals in rocks of their catchment areas and anthropogenic sources (Kaul, 1980).

Since many lakes are sinks of agricultural runoff and municipal and industrial waste water discharges, they become enriched with nutrients, sediments and associated heavy metals (Koussouris and Diapoulis 1989; Skoulikidis *et al*.


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Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

1988). Due to drastic rise in developments in the lake surroundings and very low dispersion and high mobilization rates, the lake water quality decreasing throughout the world has become a direct threat to many life forms (Koussouris *et al*.1987; Nag and Das 1993; Sujatha *et al*. 2001).

Being an urban type lake, municipal and domestic effluents have altered the surface water composition of Dal Lake, leading to increased eutrophication (Hutchinson, 1999). Moreover, excessive sedimentation rates enhanced by extensive soil erosion due to deforestation and an encroachment by surrounding population have dramatically reduced the lake volume (Chakrapani, 2002). The lake serves as a resource of drinking water, irrigation, fisheries, recreation, tourism, etc. Our comparative study is about the present pollution status of the Dal Lake and also suggests some remedial measures to stop the deteriorating condition of this lake.

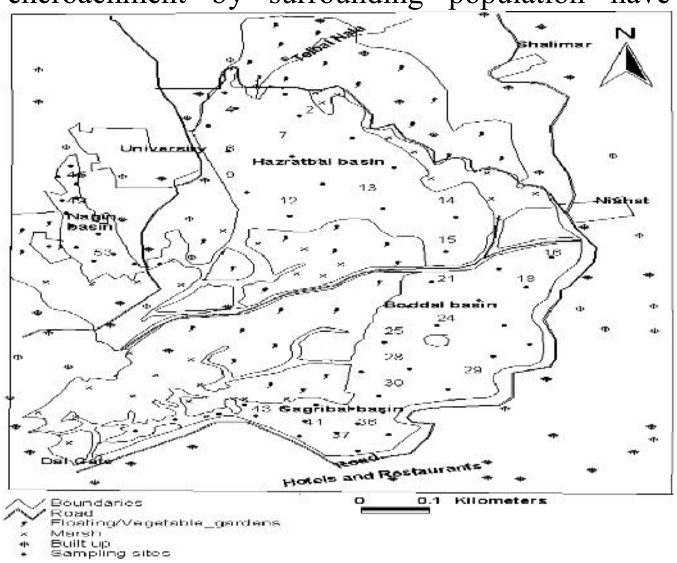


*Fig. 1.* Complete Location of Dal Lake

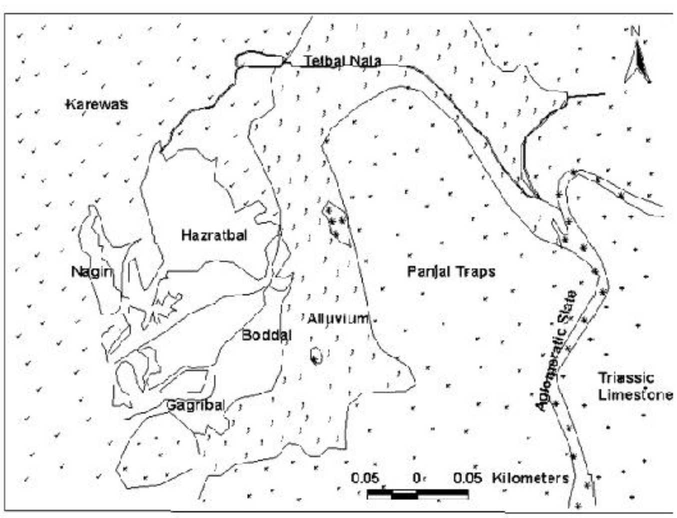


*Fig.2.* Geological map of Catchment area

## Study area

Dal Lake is a postglacial lake of shallow depth bounded on the south west by the state capital of Jammu & Kashmir India, Srinagar, and encompassed on the other sides by terraced gentle slopes at the base of precipitous mountains. This lake has historically been the centre of Kashmiri civilization and has played a major role in the economy of the state through its attraction of tourists as well as its utilization as a source of food and water (Reddy and Char, 2004).

Dal Lake is situated towards North-East of Srinagar city at an altitude of about 1,584 m above mean sea level. The lake lies between 34°6'N and 34°10'N latitude and 74°50'E and 74°54'E longitude and covers an area of about 11.50 $km^2$. The lake is mainly fed by a large perennial inflow channel, Telbal nala, which drains the largest sub-catchment area of about 145 $km^2$ and contributes to about 80% of the total inflow to the lake (Enex 1978; Zutshi and Vass 1978; Trisal 1987, Jellani 2006) as well as a number of small streams, viz., Peshpaw nala, Shalimar nala, Merakhsha nala, Harshi kul, etc., around the shore line besides some contribution from groundwater. The lake is divided into four basins: Hazratbal, Boddal, Nagin and Gagribal (Fig.1). The Nagin basin is the deepest basin (maximum depth of about 6 m), and Gagribal basin the shallowest (maximum depth 2.5 m). Of the total area of the lake, 4.1 $km^2$ is under floating garden or cultivation, 1.51 $km^2$ is submerged land and 2.25 $km^2$ under marshy conditions. The total volume is estimated to be 9.8x106 $m^3$ (Trisal 1987; Jeelani 2006). The Telbal nala with other small streams enters the lake at Hazratbal basin, then passes through Boddal basin, and finally drains into the river Jhelum from Gagribal basin side at the Dal Gate. The Nagin


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basin also receives water from the Hazratbal basin and leaves through the marshy area without any prominent outlet (Fig.2). Being an urban lake, the Dal Lake is surrounded by developed land, most of which is occupied by houses, hotels, restaurants and houseboats.

Geological evidences shows that Kashmir was once a glacial lake which occupied the whole area of the valley. The lake found its outlet in the South-West of Srinagar a few million years back. Of this long burial among the rocks there is ample evidence in the layers of sediment, mud and shells that have by now hardened into stone and solid rock, folded, controlled and faulted in many places along with the remains of plant and animal life that lived amidst them during different geological times. The Dal Lake, like other valley lakes lies in the flood plain of Jehlum river, whose broad meanders have cut swampy lowlands out of Karewa terraces. The position of the lakes shows that they are derived from enlarged oxbows and abandoned flood channels rather than from progressive shrinkage of the ancient lake. Wadia (1947) supported the view that the Kashmir valley lakes are formed from inundated parts of the Jehlum river. The total area of Dal catchment is 346 sq km. which is about twenty times more than the lake area. The catchments consist of mountain ranges on its north, north-east side and on the other sides it is enclosed by flat arable land. The main geological formation is dominated by Asslluvium, Karewas, Triassic Limestones, Panjal Traps and Agglomeratic slates (Downing *et al.,* 2006). Agglomeratic slates are pyroclastic slates, conglomerates and pyroclastic products. Panjal Traps are Permian volcanics consisting of thick series of andesites and basalts. Triassic Limestones consists of limestones, shales and sandstones. The Karewa deposits are Quaternary fluviolacustrine deposits which contain unconsolidated materials, such as light grey sand, dark grey clays, coarse to fine grained sands, gravels, marls, silts, varved clays, brown loams, lignite etc. (Wadia, 1971; Varadan, 1977; Datta, 1983; Jeelani 2006).

## Methodology

The Dal is a 'warm monomictic' lake and falls within the subtropical lake category. The seasonal changes in water temperature indicate homothermy setting in during late October and continuing until the spring (Trisal, 1977). Analysis of water samples and sediment samples had been done to monitor the natural and anthropogenic influences on chemistry of the water and sediment of the Dal Lake, Kashmir Himalaya (Pandit, 1999).

Twelve water samples were collected at various locations from the four basins of the Dal Lake in two seasons' summer, and winter. The samples were collected in pre washed sterile plastic containers with capacity of two liters. Sampling was done taking into consideration the disturbed sites i.e the sites where human hustle and bustle is at large and undisturbed sites are those where human activity involvement is limited. After sampling, the samples were immediately brought to analytical laboratory and kept at temperature below 40C and further analysis started without delay. An analysis was carried out according to the methods described already (APHA 1995; Trivedi and Goel 1984). Various physico-chemical parameters analyzed for water and sediment samples included those for pH (Digital pH meter DPH 504), Electrical conductivity (EC) (Digital EC meter DEM900). Total dissolved solid (TDS) was determined by oven dry method, Chemical Oxygen Demand (COD) was determined by reflux digestion method. Biological Oxygen Demand (BOD) was estimated by Azide modification of Winkler method. Total Alkalinity (TA) as $HCO^{3-}$, Calcium ($Ca^{2+}$), Magnesium ($Mg^{2+}$) total hardness (TH), Chloride ($Cl^{-}$), was estimated by standard titrimetry. Sulphate ($SO_4^{2-}$) by turbidometry, phosphate ($PO_4^{3-}$) by stannous chloride method, Nitrate ($NO_3^{2-}$) by Brucine method and Iron (Fe) by phenthroline method, all using HITACHI UV-VIS spectrophotometer. Sodium ($Na^{+}$) and potassium ($K^{+}$) by flame photometric method using Systronic 130 model.

Sediment quality is an important environmental concern. Sediments may act both as a sink and a source of contaminants with respect to the


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| *Table 1.* Physico-Chemical Characteristics of Surface Water in Summer Season: (June 2007) | | | | |
|---|---|---|---|---|
| **Parameter** | **Hazratbal** | **Bod Dal** | **Gagribal** | **Nagin** |
| pH | 9.3 | 9.5 | 9.8 | 9.7 |
| E.C. | 255 | 205 | 125 | 260 |
| TA | 160 | 60 | 120 | 170 |
| $CaCO_3$ | 10 | 0 | 10 | 0 |
| $Cl^-$ | 17.04 | 14.2 | 11.36 | 17.04 |
| T.H. | 50 | 78 | 56 | 44 |
| Ca | 41.3 | 22.44 | 30.46 | 28.85 |
| Mg | 8.7 | 55.56 | 25.54 | 15.15 |
| TDS | 200 | 230 | 310 | 300 |
| $P\text{-}PO_4^-$ | 0.2 | 0.9 | 0.7 | 0.1 |
| $SiO_2$ | 3.2 | 2.4 | 1.6 | 2.2 |
| Fe | 1.5 | 0.9 | 0.6 | 0.8 |
| K | 2.1 | 1.9 | 1.2 | 2.9 |
| Na | 1.5 | 1.7 | 0.9 | 1.1 |
| $NO_3^-$ | 1.9 | 1 | 0.3 | 0.5 |
| $NH_3$-N | 22.1 | 7.5 | 5.3 | 19 |
| $SO_4^-$ | 30.4 | 30 | 10.6 | 30.6 |
| All in mg/L except pH and EC in (µS/cm) | | | | |

overlying water and to biota (Baudo *et al.* 1990). Many efforts have been undertaken to develop criteria for the assessment of environmental impacts on sediments, but there are no universally accepted guidelines for sediment quality (Chapman 1986; Forstner, 1989; Calmano *et al*. 1996).

Eleven freshly deposited bed sediments were also collected together with the water samples with a scoop from shallow sites and by means of an Ekman–Birge dredge from deeper sites. The sediment samples were packed in polythene zip bags prior to analysis. Samples were dried and properly mixed to carry out the various physic-chemical parameters and an aliquot of each sample was powdered in mortar and pestle, followed by geochemical analysis of the sediments. The pH, electrical conductivity (EC), chloride ($Cl^-$), sulphate ($SO_4^{2-}$), total alkalinity (TA) was determined by 1: 5 of soil suspension using a pH meter (Digital pH meter DPH504), and EC (Digital EC meter DEM900). Available phosphorus (Bray and Kurtz, 1945), Organic matter (OM) by Walkley and black method. Concentration of Calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), sodium ($Na^+$) and potassium ($K^+$) was determined by using the standard ammonium acetate method.

## Results and Discussion

### Water analysis

Physico-chemical parameters of water were analyzed and assessed in order to understand and comprehend the variation of the various parameters amongst the lake basins. Zutshi and Vass (1978), Trisal and Kaul (1983), Zutshi (1985), provided extensive data on different aspects on Dal Lake. It

| *Table 2.* Physico-Chemical Characteristics of Surface Water in Winter Season:(Dec – Jan 2007-08) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Hazratbal undisturbed** | **Hazratbal disturbed** | **Bod Dal undisturbed** | **Bod Dal disturbed** | **Gagribal undisturbed** | **Gagribal disturbed** | **Nagin undisturbed** | **Nagin disturbed** |
| pH | 8.82 | 7.92 | 8.76 | 8.89 | 8.45 | 7.66 | 8.78 | 9.83 |
| EC | 15 | 50 | 64 | 97 | 103 | 26 | 19 | 57 |
| TDS | 236 | 265 | 345 | 376 | 225 | 255 | 204 | 234 |
| DO | 11.86 | 13.49 | 12.35 | 18.21 | 16.85 | 13.33 | 13 | 14.79 |
| BOD | 3.702 | 3.222 | 0.83 | 0.74 | 0.75 | 0.68 | 0.65 | 0.89 |
| COD | 6.17 | 5.37 | 1.25 | 0.914 | 1.1 | 0.985 | 0.914 | 1.37 |
| T.H. | 130 | 138 | 88 | 116 | 126 | 186 | 122 | 118 |
| Na | 5.9 | 6.3 | 4.9 | 4.3 | 4.8 | 5.1 | 6.1 | 6.9 |
| K | 2.9 | 3.1 | 2.8 | 3 | 2.5 | 2.8 | 2.1 | 2.4 |
| Ca | 28.85 | 33.66 | 24.04 | 26.45 | 22.44 | 28.85 | 26.45 | 29.65 |
| Mg | 14.13 | 13.15 | 6.8 | 12.18 | 25.26 | 27.77 | 13.59 | 10.72 |
| Fe | 4.4 | 4.7 | 3.7 | 4.6 | 4.7 | 4.2 | 4 | 3.6 |
| Cl- | 22.72 | 17.04 | 10.65 | 14.2 | 19.76 | 17.04 | 22.72 | 11.36 |
| $CaCO_3$ | 0 | 10 | 0 | 10 | 10 | 0 | 20 | 0 |
| $HCO_3$ | 210 | 240 | 140 | 10 | 120 | 180 | 200 | 190 |
| $SO4_{2-}$ | 29.7 | 12 | 10.5 | 11 | 34 | 30 | 30.5 | 38.2 |
| $P\text{-}PO_4$ | 0.01 | 0.02 | 1.1 | 0.04 | 3.5 | 1.2 | 0.27 | 0.08 |
| Total P | 0.8 | 0.4 | 2 | 0.4 | 4.9 | 2.1 | 0.3 | 0.1 |
| NH3-N | 3.1 | 4.9 | 3.2 | 9.8 | 5.2 | 9.3 | 9.1 | 3 |
| $SiO_2$ | 2.1 | 1 | 0.6 | 0.7 | 2.3 | 2.2 | 0.8 | 0.9 |
| *All the values are in mg/L except pH and EC in (µS/cm) | | | | | | | | |


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Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

was established beyond any doubt that the lake was undergoing far reaching changes in its environment due to discharge of large quantity of waste from human settlements, agricultural lands and house boats. The ecological stress of the system is reflected by deterioration of water quality and increased levels of biological productivity.

The results of various physico-chemical characteristics of the Dal Lake water sample for the two seasons (summer and winter) are presented in the (Table 1 and 2). Natural water is usually alkaline due to presence of high concentration of carbonates. Considerable fluctuations in pH can be observed in natural water during day, season to season and within years because of exposure to the air and biological activities. The lake is characterized by highly alkaline pH during summer as well as in the winter season. The Gagribal basin shows high range of pH during summer season (9.8). The Hazratbal basin shows low values for pH (9.3). Although, during the winter season there are not evident changes in the pH, but in other seasons, Nagin disturbed basin shows high value of pH (9.83) and the basin Gagribal shows low value of pH (7.66). This alkaline range of the pH is attributed to the geological features of the catchment, comprising a karewa bed, composed of calcium carbonate rock and some other salts in high proportions. The considerable extension of the pH range in limestone regions is due to dissolved carbonates has also been reported by Reid (1971).

*Table 3.* Geo-Chemical Characteristics of Bed Sediment in Summer Season: (June 2007)

| Parameters | Bod Dal | Gagribal | Nagin |
|---|---|---|---|
| E.C. | 270 | 185 | 275 |
| pH | 7.2 | 6.8 | 6.9 |
| %OM | 81.11 | 64.63 | 96.4 |
| Ca | 40.08 | 56.11 | 30.64 |
| Mg | 19.49 | 19.49 | 38.98 |
| $Cl^-$ | 2.68 | 5.84 | 4.26 |
| $CaCO_3$ | 6 | 12 | 18 |
| $HCO_3$ | 24.4 | 30.5 | 61 |
| $SO_4^-$ | 10 | 22.44 | 14 |
| $PO_4^-$ | 21.5 | 8.5 | 45 |
| $P\text{-}PO_4^-$ | 12.5 | 1.4 | 1.6 |
| Na | 160 | 205 | 180 |
| K | 0.8 | 0.5 | 0.4 |
| $NH_3$-N | 8.4 | 6.1 | 2.4 |
| *All the values are in mg/L except pH and EC in (µS/cm) | | | |

Conductivity is a measure of capacity of substance or solution to conduct electric current. Conductivity determines the total dissolved solids in the water. The lake basins show medium level of electrolytic conductivity during summer as well as winter season. During the summer season the lake basin Nagin shows high values of E.C. (260µS/cm) and the Gagribal basin shows a lower value (125µS/cm). There is further decrease in the E.C. during the winter season because of temperature variation in the winter season there might be sudden fall in the electrolytic conductivity. Electrolytic conductivity increases with temperature at a rate of 1.9 per cent per °C. (Jamie Bartram and Richar Balance, 1996). The Gagribal basin slows high values of E.C. (103µS/cm) and the basin Hazaratbal undisturbed shows low value of E.C. (15µS/cm). The medium values of the electrolytic conductivity attributes to moderate levels of various anions and cations.

The DO in surface water comes from air or is produced by photosynthetic organisms like algae and plants in a water body. The oxygen content is decreased with increase in the temperature of water. It has negative impact on organic waste processing by the aerobic microorganisms. Some of the organic substances tend to decrease the DO in the water. The measurement of the DO is primary parameter in water pollution studies as it indicates aerobic or anaerobic nature of biological activities in water bodies (Trivedi, 1995).

The basin Boddal disturbed shows high values of DO (18.21mg/l) and the basin Hazratbal undisturbed shows low value of DO (11.86 mg/l). The dissolved oxygen concentration depends on the physical, chemical and biochemical activities in the water body, and its measurement provides a good indication of water quality. Changes in dissolved oxygen concentrations can be an early indication of changing conditions in the water body (Jamie Bartram and Richard Balance, 1996).


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| *Table. 4.* Geo-Chemical Characteristics of Bed Sediment in Winter Season: (Dec – Jan 2007-08) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Hazratbal undisturbed** | **Hazratbal disturbed** | **Bod Dal undisturbed** | **Bod Dal disturbed** | **Gagribal undisturbed** | **Gagribal disturbed** | **Nagin undisturbed** | **Nagin disturbed** |
| E.C. | 265 | 270 | 285 | 290 | 180 | 185 | 280 | 285 |
| pH | 7.1 | 7.3 | 8.7 | 8.6 | 7.9 | 8.2 | 7.5 | 7.9 |
| %OM | 88.7 | 90.3 | 95.6 | 89.9 | 93.8 | 92.7 | 98.1 | 97.8 |
| Ca | 34.75 | 26.87 | 10.38 | 36.87 | 19.23 | 14.28 | 15.43 | 27.86 |
| Mg | 31.18 | 46.78 | 45.82 | 27.28 | 19.49 | 38.98 | 21.44 | 34.11 |
| $Cl^-$ | 7.1 | 8.52 | 7.1 | 5.68 | 8.52 | 9.94 | 5.68 | 4.26 |
| $CaCO_3$ | 3 | 6 | 3 | 3 | 0 | 0 | 3 | 3 |
| $HCO_3$ | 15.25 | 21.35 | 15.25 | 21.35 | 15.25 | 18.3 | 18.3 | 12.2 |
| $SO_4^-$ | 39 | 37 | 7.5 | 11 | 18 | 20 | 15 | 32 |
| $PO_4^-$ | 5.5 | 5.5 | 5.5 | 4.5 | 14 | 6 | 7 | 5.5 |
| $P\text{-}PO_4^-$ | 14.3 | 6.4 | 8.1 | 8.1 | 10.4 | 6.4 | 2.6 | 4 |
| Na | 250 | 250 | 210 | 230 | 170 | 190 | 270 | 260 |
| K | 0.6 | 0.9 | 0.8 | 0.7 | 0.5 | 0.7 | 0.7 | 0.4 |
| $NH_3$-N | 5.9 | 5.7 | 5.3 | 5.2 | 3.2 | 6.4 | 6.1 | 6.4 |
| * All in mg/L except pH and EC in (µS/cm) | | | | | | | | |

The biochemical oxygen demand (BOD) is an empirical test, in which standardized laboratory procedures are used to estimate the relative oxygen requirements of wastewaters, effluents and polluted waters (Jamie Bartram and Richard Balance, 1996). BOD indicates concentration of biological waste in the biodegradable organic waste in the water body. More the organic matter in the water, there will be less oxygen concentration. The BOD indicates the degree of biodegradable waste in the water. The raw domestic sewage shows in the ranges of 350-500mg/lt. depending upon consumption of water/person/day (Trivedi, 1995). The lake basin Hazratbal undisturbed shows elevated value for BOD (3.702mg/L) and basin Nagin undisturbed shows low values for BOD (0.65 mg/l) during the winter season.

| *Table 5.* Physico-Chemical Characteristics of surface water in year 1977 | | | | |
|---|---|---|---|---|
| **Parameters** | **Hazratbal** | **Bod Dal** | **Gagribal** | **Nigeen** |
| EC | 115-409 | 130-483 | 116-336 | 204-423 |
| pH | 8.1-9.1 | 7.5-9.3 | 8.2-9.6 | 8.0-9.7 |
| DO | 3.4-10.7 | 2.7-10.4 | 2.4-10.2 | 1.2-10.4 |
| T.A. | 76-173 | 56-208 | 17-136 | 81-269 |
| Ca | 14.1-1.7 | 14.6-61 | 17.2-6.2 | 5.2-5.2 |
| Mg | 0.4-15.9 | 0.6-9.2 | 0.7-8.7 | 1-18.3 |
| Na | 5..0-38 | 4.0-40 | 4.0-34 | 10.0-62 |
| K | 1.0-22 | 1.0-12 | 0-10 | 2.0-30 |
| $SiO_2$ | 0.2-19.5 | 0.3-14.9 | 0.3-14 | 0.3-32.5 |
| $NH_3$-N | 7-225 | 4-503 | 2-243 | 5-599 |
| Amm. N | 37-726 | 26-627 | 24-705 | 43-1357 |
| Total P | 151-4233 | 136-8106 | 136-5060 | 121-4182 |

The chemical oxygen demand (COD) is the amount of oxygen consumed by organic matter from boiling acid potassium dichromate solution. It provides a measure of the oxygen equivalent of that portion of the organic matter in a water sample that is susceptible to oxidation under the conditions of the test. It is an important and rapidly measured variable for characterizing water bodies, sewage, industrial wastes and treatment plant effluents (Jamie Bartram and Richard Balance, 1996). COD is an imperative parameter, which is an indicator of

| *Table 6.* Physico-Chemical Characteristics of surface water in year 1996 | | | | |
|---|---|---|---|---|
| **Parameters** | **Hazratbal** | **Bod Dal** | **Gagribal** | **Nigeen** |
| EC | 115-409 | 130-483 | 116-336 | 204-423 |
| pH | 8.1-9.1 | 7.5-9.3 | 8.2-9.6 | 8.0-9.7 |
| DO | 3.4-10.7 | 2.7-10.4 | 2.4-10.2 | 1.2-10.4 |
| T.A. | 76-173 | 56-208 | 17-136 | 81-269 |
| Ca | 14.1-1.7 | 14.6-61 | 17.2-6.2 | 5.2-5.2 |
| Mg | 0.4-15.9 | 0.6-9.2 | 0.7-8.7 | 1-18.3 |
| Na | 5..0-38 | 4.0-40 | 4.0-34 | 10.0-62 |
| K | 1.0-22 | 1.0-12 | 0-10 | 2.0-30 |
| $Sio_2$ | 0.2-19.5 | 0.3-14.9 | 0.3-14 | 0.3-32.5 |
| $NH_3$-N | 7-225 | 4-503 | 2-243 | 5-599 |
| Ammonium nitrate | 37-726 | 26-627 | 24-705 | 43-1357 |
| Total P | 151-4233 | 136-8106 | 136-5060 | 121-4182 |


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Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

both biodegradable and non biodegradable waste present in the water body. It is expressed by the demand of oxygen by organic substances and chemical oxidizing agents. The Hazaratbal undisturbed basin shows a towering range for the values of COD (6.17mg/lt) and the basin Bod Dal disturbed shows low values for COD (0.914 mg/l).

The amount of a strong acid needed to neutralize the alkalinity is called the total alkalinity, T, and is reported in mg l-1 as CaCO3 the alkalinity of some waters is due to the bicarbonates of calcium and magnesium. The pH of such water does not exceed 8.3 and its total alkalinity is practically identical with its bicarbonate alkalinity. The basin Nagin shows high total alkalinity (170mg/l) and the basin Bod Dal shows low values for total alkalinity (60mg/l) during summer season. In natural as well as polluted waters there are many salts such as carbonates, silicates, phosphates, and borates which are responsible for imparting to quality of water. Alkalinity itself is not harmful to human. The water bodies with alkalinity, less than 100mg/lt are desirable for domestic use.

Hardness of water is due to major cations present in the water body. Calcium and magnesium are principle cations that impart the hardness to water. Bicarbonates and carbonates of calcium and magnesium cause hardness in water because of hydrolysis they naturally change into cations. A natural hardness of water depends on geological nature of drainage basin. There are also seasonal variations in water hardness. The water of Bod Dal shows high values for total hardness (78 mg/l) and the basin Nagin shows moderate values for total hardness (44 mg/l). The values for total hardness through winter season are much fluctuating from that of summer season. The basin Gagribal disturbed demonstrates high value for total hardness (186 mg/l) and the basin Bod Dal disturbed shows moderate value for total hardness (88 mg/lt).

*Table 7* Physico-Chemical Characteristics of Surface water in Summer for year 2006

| Parameters | Hazratbal | Bod Dal | Gagribal | Nagin |
|---|---|---|---|---|
| Ca | 12.2–17.3 | 10.5–14.9 | 11.3–16.4 | 10.1–14.6 |
| Mg | 5.2-8.2 | 4.2-6.2 | 4.4-6.7 | 3.7-5.2 |
| Na | 2.2–3.9 | 1.5–2.4 | 1.6–3.5 | 1.9–2.8 |
| K | 1.1–2.2 | 1.1–1.7 | 1.1–2.4 | 1.1–1.8 |
| $HCO_3$ | 46–60 | 34–58 | 37–58 | 37–55 |
| Cl- | 12.9–20.7 | 11.4–14.7 | 13.7–18.6 | 11.2–15.2 |
| $SO_4^{2-}$ | 1.8–3.4 | 1.5–2.3 | 2.2–3.4 | 1.3–2.4 |
| $NO_3$ | 1.4–2.3 | 1.4–2.4 | 9.7–13.9 | 4.7–8.6 |
| pH | 9.3–9.6 | 8.9–9.7 | 8.5–9.0 | 9.4–9.6 |
| TDS | 200–220 | 206–216 | 224–230 | 213–237 |

*Table 8.* Physico Chemical Characteristics of Surface Water in Winter for year 2006

| Parameters | Hazratbal | Bod Dal | Gagribal | Nagin |
|---|---|---|---|---|
| Ca | 27.9–45.7 | 20.2–26.7 | 25.6–43.7 | 20.1–26.2 |
| Mg | 10.1-15.9 | 7.3-10.5 | 10.3-15.9 | 7.2-10.3 |
| Na | 5.5–6.5 | 4.4–5.6 | 5.2–6.4 | 4.2–5.2 |
| K | 2.3–3.8 | 2.1–2.6 | 2.2–3.3 | 2.1–2.7 |
| $HCO_3$ | 127–201 | 96–128 | 123–198 | 97–125 |
| $Cl^-$ | 10.5–15.4 | 7.5–10.3 | 10.3–15.4 | 7.3–10.4 |
| $SO^{42-}$ | 2.9–6.7 | 2.5–3.4 | 4.5–6.2 | 2.4–3.7 |
| $NO^3$ | 1.1–2.2 | 1.1–2.2 | 4.6–6.4 | 2.5–5.2 |
| pH | 8.0–8.9 | 8.2–8.9 | 7.4–8.7 | 8.0–8.7 |
| TDS | 240–251 | 225–252 | 235–269 | 230–267 |

Calcium dissolves out of almost all rocks and is, consequently, detected in many waters. It is observed that the high values of calcium during the summer season are in the Hazratbal basin (41.3 mg/l) and the basin Bod Dal shows low values of calcium (22.44mg/l). Through the winter season the basin Hazratbal shows elevated values for calcium ions (33.66mg/l) and the basin Bod Dal undisturbed shows low values for calcium (24.04 mg/l). The calcium content in the lake, in general, is high and hence, according to the classification of lakes developed by Ohle (1934), Dal Lake would fall within the category of calcium-rich waters.

Magnesium is a relatively abundant element in the earth's crust and hence a common constituent of natural water. Waters associated with granite or siliceous sand may contain less than 5 mg of magnesium per litre. Water in contact with


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Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

dolomite or magnesium-rich limestone may contain 10-50 mg l-1 and several hundred milligrams per litre may be present in water that has been in contact with deposits containing sulphates and chlorides of magnesium. It is observed that the magnesium is high in concentration in the summer season for the basin Bodal (55.56 mg/l) and the basin hazratbal less t value for manganese (8.7mg/l). Through the winter season Gagribal disturbed basin shows soaring values of magnesium (27.77 mg/l) and the basin Bodal undisturbed shows evaluated value of the magnesium (6.8 mg/l).

*Table 5a* Pearson Correlation matrix of chemical Parameter of surface water in summer season June 2007

| | E.C. | $HCO_3$ | $CO_3$ | $Cl^-$ | T.H. | Ca | Mg | TDS | $P\text{-}PO_4^-$ | $SiO_2$ | Fe | K | Na | Nitrate | $NH_3$-N | $SO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E.C. | 1 | | | | | | | | | | | | | | | |
| $HCO_3$ | 0.49 | 1 | | | | | | | | | | | | | | |
| $CO_3$ | -0.39 | 0.29 | 1 | | | | | | | | | | | | | |
| $Cl^-$ | 0.99 | 0.58 | -0.30 | 1 | | | | | | | | | | | | |
| T.H. | -0.35 | -0.99 | -0.31 | -0.45 | 1 | | | | | | | | | | | |
| Ca | 0.30 | 0.70 | 0.75 | 0.40 | -0.64 | 1 | | | | | | | | | | |
| Mg | -0.37 | -0.97 | -0.51 | -0.47 | 0.96 | -0.84 | 1 | | | | | | | | | |
| TDS | -0.48 | 0.17 | -0.11 | -0.46 | -0.33 | -0.38 | -0.09 | 1 | | | | | | | | |
| $P\text{-}PO_4^-$ | -0.72 | -0.96 | -0.07 | -0.79 | 0.90 | -0.64 | 0.89 | -1.15 | 1 | | | | | | | |
| $SiO_2$ | 0.76 | 0.24 | 0.09 | 0.76 | -0.07 | 0.58 | -0.27 | -0.90 | -0.42 | 1 | | | | | | |
| Fe | 0.65 | 0.30 | 0.30 | 0.67 | -0.15 | 0.73 | -0.38 | -0.88 | -0.43 | 0.98 | 1 | | | | | |
| K | 0.90 | 0.52 | -0.62 | 0.88 | -0.44 | 0.02 | -0.32 | -0.06 | -0.72 | 0.39 | 0.25 | 1 | | | | |
| Na | 0.45 | -0.48 | -0.32 | 0.38 | 0.62 | -0.08 | 0.47 | -0.89 | 0.24 | 0.72 | 0.61 | 0.16 | 1 | | | |
| Nitrate | 0.56 | 0.12 | 0.28 | 0.57 | 0.03 | 0.64 | -0.22 | -0.95 | -0.26 | 0.96 | 0.98 | 0.14 | 0.72 | 1 | | |
| $NH_3$-N | 0.89 | 0.79 | 0.03 | 0.93 | -0.67 | 0.68 | -0.74 | -0.39 | -0.92 | 0.75 | 0.73 | 0.74 | 0.16 | 0.60 | 1 | |
| $SO_4$ | 0.93 | 0.12 | -0.57 | 0.88 | 0.02 | 0.04 | 0.00 | -0.61 | -0.41 | 0.76 | 0.60 | 0.80 | 0.71 | 0.58 | 0.67 | 1 |

*Table 6a.* Pearson Correlation matrix of chemical Parameter of surface water in winter season 2007-08

| | EC | pH | COD | BOD | DO | Free $CO_2$ | TDS | $CO_3$ | $HCO_3$ | Ca | Mg | T.H. | $Cl^-$ | $SO_4^-$ | $P\text{-}PO_4^-$ | $PO_4^-$ | $NH_3$-N | Fe | Na | K | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EC** | 1 | | | | | | | | | | | | | | | | | | | | |
| **pH** | -0.30 | 1 | | | | | | | | | | | | | | | | | | | |
| **COD** | -0.47 | 0.24 | 1 | | | | | | | | | | | | | | | | | | |
| **BOD** | -0.45 | 0.25 | 0.93 | 1 | | | | | | | | | | | | | | | | | |
| **DO** | 0.12 | 0.06 | -0.13 | -0.14 | 1 | | | | | | | | | | | | | | | | |
| **Free $CO_2$** | -0.18 | 0.30 | -0.43 | -0.44 | 0.68 | 1 | | | | | | | | | | | | | | | |
| **TDS** | 0.49 | 0.40 | -0.22 | -0.20 | 0.52 | 0.17 | 1 | | | | | | | | | | | | | | |
| **$CO_3$** | 0.12 | -0.09 | -0.38 | -0.36 | -0.32 | -0.07 | -0.20 | 1 | | | | | | | | | | | | | |
| **$HCO_3$** | -0.82 | -0.07 | 0.40 | 0.38 | -0.07 | 0.23 | -0.78 | -0.21 | 1 | | | | | | | | | | | | |
| **Ca** | -0.64 | 0.59 | 0.36 | 0.36 | -0.44 | -0.02 | -0.22 | -0.39 | 0.43 | 1 | | | | | | | | | | | |
| **Mg** | 0.01 | -0.75 | -0.13 | -0.13 | -0.51 | -0.58 | -0.42 | 0.04 | 0.08 | -0.06 | 1 | | | | | | | | | | |
| **T.H.** | -0.39 | -0.29 | 0.02 | 0.01 | -0.58 | -0.43 | -0.38 | -0.15 | 0.27 | 0.46 | 0.83 | 1 | | | | | | | | | |
| **$Cl^-$** | -0.45 | -0.26 | 0.45 | 0.45 | -0.55 | -0.56 | -0.64 | 0.49 | 0.37 | 0.00 | 0.43 | 0.35 | 1 | | | | | | | | |
| **$SO_4^-$** | -0.33 | -0.37 | 0.16 | 0.14 | -0.63 | -0.25 | -0.93 | 0.02 | 0.67 | 0.35 | 0.47 | 0.45 | 0.42 | 1 | | | | | | | |
| **$P\text{-}PO_4^-$** | 0.51 | -0.97 | -0.30 | -0.31 | 0.08 | -0.27 | -0.19 | 0.09 | -0.13 | -0.74 | 0.62 | 0.11 | 0.11 | 0.19 | 1 | | | | | | |
| **$PO_4^-$** | 0.47 | -0.95 | -0.18 | -0.19 | 0.13 | -0.32 | -0.13 | -0.02 | -0.13 | -0.72 | 0.63 | 0.14 | 0.12 | 0.12 | 0.98 | 1 | | | | | |
| **$NH_3$-N** | 0.00 | 0.04 | -0.49 | -0.47 | -0.40 | -0.18 | 0.15 | 0.59 | -0.39 | 0.02 | 0.38 | 0.47 | 0.24 | -0.19 | -0.08 | -0.12 | 1 | | | | |
| **Fe** | 0.37 | -0.37 | 0.18 | 0.20 | -0.48 | -0.90 | 0.06 | 0.30 | -0.49 | -0.32 | 0.55 | 0.28 | 0.53 | -0.06 | 0.40 | 0.45 | 0.39 | 1 | | | |
| **Na** | -0.57 | 0.28 | 0.27 | 0.25 | -0.26 | 0.29 | -0.67 | -0.10 | 0.78 | 0.61 | -0.26 | -0.01 | 0.11 | 0.70 | -0.43 | -0.50 | -0.41 | -0.62 | 1 | | |
| **K** | 0.20 | 0.22 | 0.34 | 0.36 | 0.22 | -0.35 | 0.71 | -0.58 | -0.48 | 0.08 | -0.01 | 0.09 | -0.27 | -0.60 | -0.12 | 0.03 | -0.02 | 0.36 | -0.60 | 1 | |
| **$SiO_2$** | 0.10 | -0.88 | -0.14 | -0.15 | -0.31 | -0.47 | -0.43 | -0.11 | 0.14 | -0.20 | 0.95 | 0.69 | 0.28 | 0.49 | 0.78 | 0.79 | 0.13 | 0.42 | -0.23 | -0.04 | 1 |

The results of a determination of total dissolved solids (TDS) can be used to check the accuracy of analyses when relatively complete analyses have


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been made on a water sample. This is accomplished by comparing the value of calculated TDS with the measured value. Through investigation of water sample the basin Gagribal shows high value (310 mg/l) and the basin Hazratbal shows low values for TDS 200 (mg/l). During the winter season the basin Bod Dal shows higher values for TDS (376 mg/l) and the basin Nagin undisturbed shows low values for TDS (210mg/l). The high concentrations of TDS decrease the palatability and may cause gastrointestinal irritation in human and may particularly also have laxative effects (WHO, 1996).

Sulphate is an abundant ion in the earth's crust and its concentration in water can range from a few milligrams to several thousand milligrams per litre. Industrial wastes and mine drainage may contain high concentrations of sulphate. Sulphate also results from the breakdown of sulphur-containing organic compounds. The presence of sulphate ions in the lake water under natural conditions is due to reaction of water with sulphate containing rocks and with biochemical oxidation of sulphides and other compounds of sulphur. The water from Lake basin during summer season shows moderate value of Sulphate ions. The Nagin basin shows high value (30.6 mg/l) during the summer season and the Gagribal basin shows very low value for Sulphate ions (10.6 mg/l). Through the winter season the Nagin basin shows elevated values (38.2 mg/l) and the basin Bod Dal disturbed shows low values (10.5 mg/l).

Sodium is a common element and present to some extent in most natural waters. Concentrations vary from negligible in freshwater to considerable in seawater and brackish water. The permeability of agricultural soil is harmed by a high ratio of sodium ions. Sodium concentrations higher than a few mg/ l are undesirable in feed water for high-pressure boilers. When compounded with certain anions (e.g. chloride), sodium imparts a salty taste to drinking water and, if the concentration is sufficiently high, consumers may not be willing to drink it. There is not much variation in the sodium ions during summer season. The basin Bod Dal shows high values for sodium ions (1.7 mg/l) and the basin Gagribal is showing moderate value of sodium ions (0.9 mg/l). During winter Nagin disturbed shows a value of (8.9mg/l) and Bod Dal shows moderate value of (4.3mg/l).

After oxygen, silicon is the most abundant element in the earth's crust. It is a major constituent of igneous and metamorphic rocks, of clay minerals such as kaolin, and of feldspars and quartz. Although crystalline silica is a major constituent of many igneous rocks and sandstones, it has low solubility and is therefore of limited importance as a source of silica in water. It is likely that most of the dissolved silica in water originates from the chemical breakdown of silicates in the processes of metamorphism or weathering. The basin Hazratbal shows high values for the reactive silicate ions (3.2 mg/l) and the basin Gagribal shows low values for silicate ions (1.6 mg/l). During the winter season the silicate ions shows much fluctuation from that of the summer season. The basin Gagribal disturbed shows high values (2.2 mg/l) and the basin Bod Dal undisturbed shows low values for reactive silicate ions (0.6 mg/l).

Although potassium is a relatively abundant element, its concentration in natural fresh waters is usually less than 20 mg/l. The basin Nagin shows high value for potassium ion during the summer season (2.9 mg/l) with that of the basin Gagribal that shows a lower value for potassium ions (1.2 mg/l). During the winter season the Hazratbal undisturbed basin shows elevated values for winter season (3.1 mg/l) and the basin Nagin undisturbed shows low values for the potassium ions (2.1 mg/l) Phosphorus compounds are present in fertilizers and in many detergents. Consequently, they are carried into both ground and surface waters with sewage, industrial wastes and storm run-off. High concentrations of phosphorus compounds may produce a secondary problem in water bodies where algal growth is normally limited by phosphorus; in such situations the presence of additional phosphorus compounds can stimulate algal productivity and enhance eutrophication


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*Table 7a.* Pearson Correlation matrix of chemical Parameter of Bed Sediment in summer season June 2007

| | E.C. | Ph | %OM | Ca | Mg | Cl- | CO3 | $HCO_3$ | $SO_4$- | $PO_4^-$ | P-PO4⁻ | Na | K | NH3-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E.C. | 1 | | | | | | | | | | | | | |
| Ph | 0.66 | 1 | | | | | | | | | | | | |
| %OM | 0.90 | 0.26 | 1 | | | | | | | | | | | |
| Ca | -0.95 | -0.38 | -0.99 | 1 | | | | | | | | | | |
| Mg | 0.54 | -0.28 | 0.86 | -0.78 | 1 | | | | | | | | | |
| Cl- | 0.84 | 0.96 | 0.52 | -0.62 | 0 | 1 | | | | | | | | |
| CaCO3 | 0.05 | -0.72 | 0.48 | -0.37 | 0.87 | -0.5 | 1 | | | | | | | |
| HCO3 | 0.40 | -0.42 | 0.76 | -0.68 | 0.99 | -0.16 | 0.93 | 1 | | | | | | |
| SO4- | -0.93 | -0.89 | -0.68 | 0.77 | -0.20 | -0.98 | 0.31 | -0.05 | 1 | | | | | |
| PO4- | 0.80 | 0.08 | 0.98 | -0.95 | 0.94 | 0.35 | 0.64 | 0.87 | -0.53 | 1 | | | | |
| P-PO4- | 0.47 | 0.97 | 0.04 | -0.16 | -0.49 | 0.87 | -0.86 | -0.62 | -0.76 | -0.15 | 1 | | | |
| Na | -0.87 | -0.94 | -0.57 | 0.67 | -0.06 | 0.95 | 0.44 | 0.09 | 0.99 | -0.41 | -0.84 | 1 | | |
| K | 0.23 | 0.88 | -0.22 | 0.09 | -0.69 | 0.72 | -0.96 | -0.80 | -0.57 | -0.40 | 0.97 | -0.67 | 1 | |
| NH3-N | 0.66 | -0.13 | 0.92 | -0.87 | 0.99 | 0.15 | 0.78 | 0.95 | -0.35 | 0.98 | -0.35 | -0.21 | -0.58 | 1 |

processes (Jamie Bartram and Richard Balance, 1996) Phosphate is present in the water body in organic and inorganic forms. Various human activities including disposal of sewage, household and industrial waste generally enhances the content of phosphate in water body.

*Table 8a. Pearson Correlation matrix of chemical Parameter of Bed Sediment in winter season Dec – Jan 2007-08.*

| | E.C. | pH | %OM | Ca | Mg | Cl- | $CaCO_3$ | $HCO_3$ | $SO_4^-$ | P-$PO_4^-$ | $PO_4^-$ | Na | K | $NH_3$-N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E.C. | 1 | | | | | | | | | | | | | |
| pH | 0.25 | 1 | | | | | | | | | | | | |
| %OM | 0.10 | **-0.79** | 1 | | | | | | | | | | | |
| Ca | 0.36 | 0.43 | -0.62 | 1 | | | | | | | | | | |
| Mg | 0.22 | 0.64 | -0.17 | -0.17 | 1 | | | | | | | | | |
| $Cl^-$ | **-0.77** | 0.29 | -0.43 | -0.37 | 0.29 | 1 | | | | | | | | |
| $CaCO_3$ | 0.78 | 0.57 | -0.18 | 0.38 | 0.46 | -0.34 | 1 | | | | | | | |
| $HCO_3$ | 0.07 | 0.34 | -0.50 | 0.18 | 0.11 | 0.31 | 0.34 | 1 | | | | | | |
| $SO_4^-$ | 0.04 | 0.42 | -0.36 | 0.51 | 0.21 | 0.05 | 0.40 | -0.15 | 1 | | | | | |
| P-$PO_4^-$ | -0.69 | -0.44 | 0.18 | -0.30 | -0.57 | 0.32 | -0.57 | -0.26 | -0.15 | 1 | | | | |
| $PO_4^-$ | -0.24 | 0.56 | -0.71 | 0.38 | -0.06 | 0.32 | -0.17 | -0.14 | 0.24 | 0.20 | 1 | | | |
| Na | **0.80** | 0.08 | 0.14 | 0.40 | 0.05 | -0.67 | **0.74** | 0.06 | 0.42 | -0.61 | -0.36 | 1 | | |
| K | 0.22 | 0.55 | -0.33 | -0.21 | 0.58 | 0.41 | 0.51 | **0.75** | -0.16 | -0.40 | -0.09 | 0.07 | 1 | |
| $NH_3$-N | 0.43 | 0.07 | 0.13 | 0.06 | 0.42 | -0.25 | 0.35 | 0.04 | 0.32 | **-0.82** | -0.43 | 0.65 | 0.15 | 1 |

The water basins show low concentration of inorganic phosphorus in summer as well as in winter season. Through the summer season the Bod Dal basin shows high values (0.9 mg/l) and the basin Nagin shows low values for the inorganic phosphorus (0.1 mg/l). During the winter season there is much variation in the inorganic phosphorus content. The basin Gagribal undisturbed shows fascinating values for the inorganic phosphorus contain (3.5 mg/l) and the basin Hazratbal undisturbed shows extremely low occurrence of inorganic phosphorus (0.01 mg/l). During the winter season the fluctuation amongst the total phosphorus is enthralling. The basin Gagribal undisturbed shows high values for total phosphorus (4.9 mg/lt) and the basin Nagin disturbed shows low values (0.1 mg/l).


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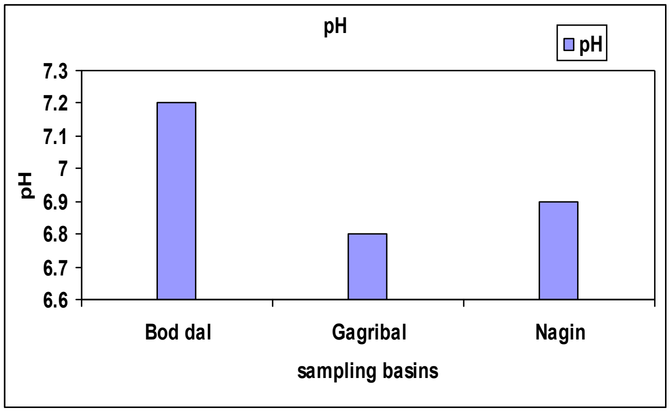


*Fig. 3*. pH variation of sediment during summer season

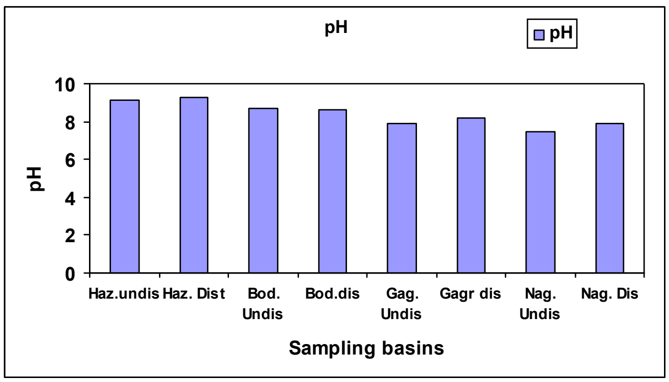


*Fig.4.* pH variation of sediment sample during winter

When nitrogenous organic matter is destroyed by microbiological activity, ammonia is produced and is therefore found in many surface and ground waters. Higher concentrations occur in water polluted by sewage, fertilizers, agricultural wastes or industrial wastes containing organic nitrogen, free ammonia or ammonium salts (Nimptsch, 2007). Certain aerobic bacteria convert ammonia into nitrites and then into nitrates. Nitrogen compounds, as nutrients for aquatic micro-organisms, may be partially responsible for the eutrophication of lakes and rivers (Alena Mudroch *et al*., 1977). Ammonia can result from natural reduction processes under anaerobic conditions. During the summer season the Hazratbal basin shows elevated values (22.1mg/l) and the basin Gagribal shows low values for NH3-N (5.3 mg/l). Through the winter season the NH3-N values shows much fluctuation. The basin Bod Dal disturbed shows higher values (9.8 mg/l) and the basin Nagin disturbed show low concentration of (3 mg/l).

Iron is an abundant element in the earth's crust, but exists generally in minor concentrations in natural water systems. The form and solubility of iron in natural waters are strongly dependent upon the pH and the oxidation- reduction potential of the water. In a reducing environment, ferrous iron is relatively soluble. An increase in the oxidation-reduction potential of the water readily converts ferrous ions to ferric ions. The presence of inorganic or organic complex-forming ions in the natural water system can enhance the solubility of both ferrous and ferric iron. Surface waters in a normal pH range of 6 to 9 rarely carry more than 1 mg of dissolved iron per liter. The iron contain in the basin is more altering from summer season to the winter season (Figs.3, 4). The summer season shows high concentration of the iron in Hazratbal basin (1.5 mg/l) and the basin Gagribal shows low concentration of the iron (0.6 mg/l). During the winter season the basin Hazratbal disturbed and Gagribal undisturbed shows high values (4.7 mg/l) and the basin Nagin disturbed shows low

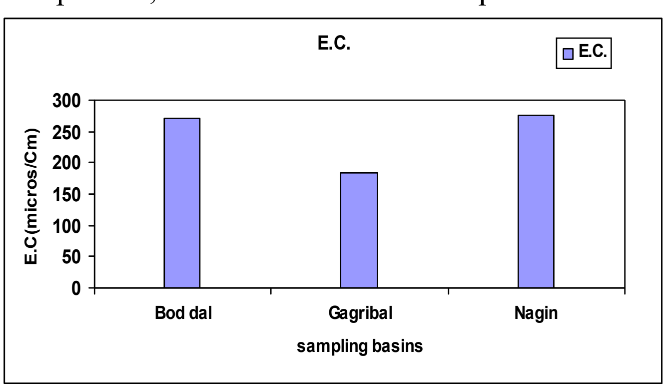


*Fig.5.* E.C. variation of sediment sample during summer season

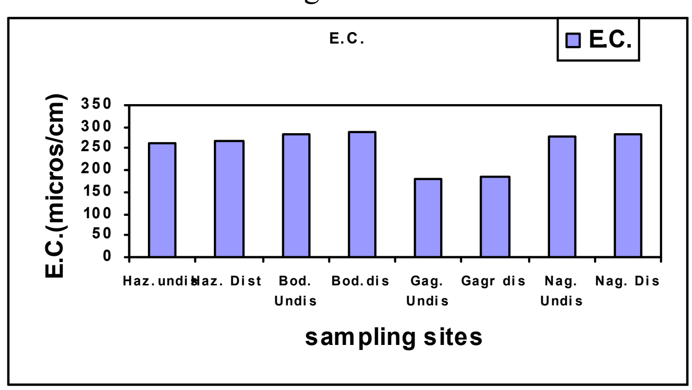


*Fig.6.* E.C. variation of sediment sample during winter season

Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

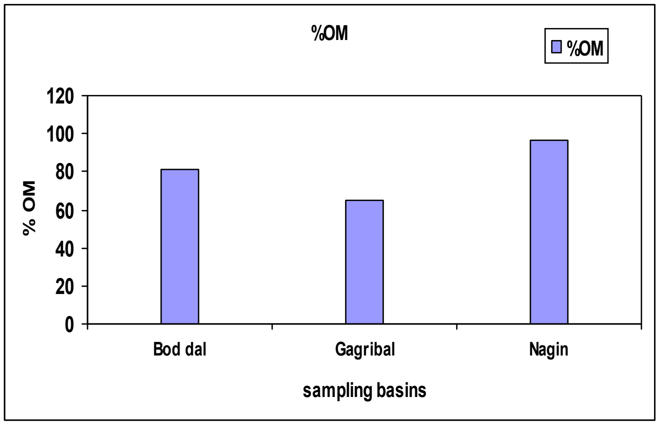


*Fig.7.* %OM variation of sediment during summer season

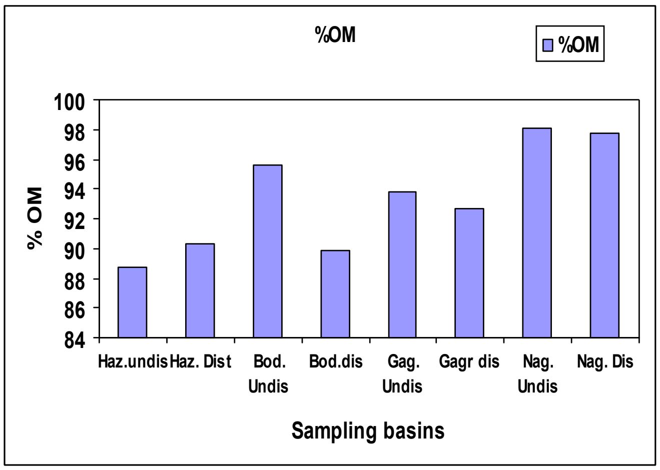


*Fig.8.* %OM variation of sediment during winter season

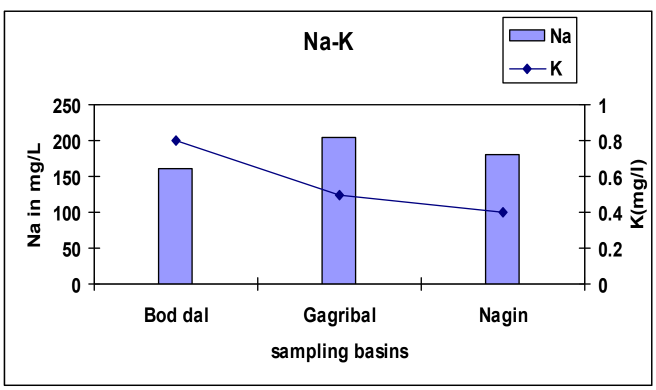


*Fig.9.* Na-K variation of sediment during Winter season

concentration of the ferrous ions (3.6 mg/l) Chlorides.

The greatest sources of chlorides in natural water bodies are due to disposal of sewage and industrial waste. Chloride anions are usually present in natural waters. A high concentration occurs in waters that have been in contact with

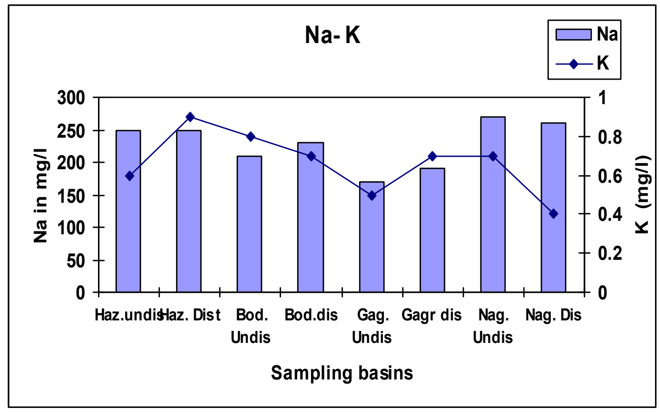


*Fig.10.* Na-K variation of sediment during winter season

chloride-containing geological formations. Otherwise, high chloride content may indicate pollution by sewage or industrial wastes or by the intrusion of seawater or saline water into a freshwater body or aquifer. High chloride content has a corrosive effect on metal pipes and structures and is harmful to most trees and plants. The basins Nagin and Hazaratbal shows same concentration for chloride ions (17.04 mg/lt) and the basin Gagribal shows low concentration for chloride ions (11.36 mg/lt). During the winter season there is much more alteration as well as rise in the concentration of the chloride ions. The basins Hazratbal undisturbed and Nagin undisturbed shows high concentration of chloride ions (22.72 mg/l) and the basin Bod Dal undisturbed shows low concentration in chloride ions (10.65 mg/l).

## Sediment analysis

The lake substratum is mainly organic with appreciable quantities of calcareous deposits (Trisal and Kaul, 1983). Tectonic activities are known to induce high sedimentation rates (Fernex *et al.* 2001). The sedimentation rates in the Kashmir Valley, being tectonically active, should be higher than other zones. For the quantification of the dissolved load entering the lake, it is necessary to quantify the chemical weathering rates for the contributing streams. A set of analytical data on 11 lake bed sediment samples (Table 3 and 4) revealed that there is no more fluctuation in the electric conductivity. The conductivity ranges between 275-185µS/cm in summer season and 180-290µS/cm in winter season. The variation in the


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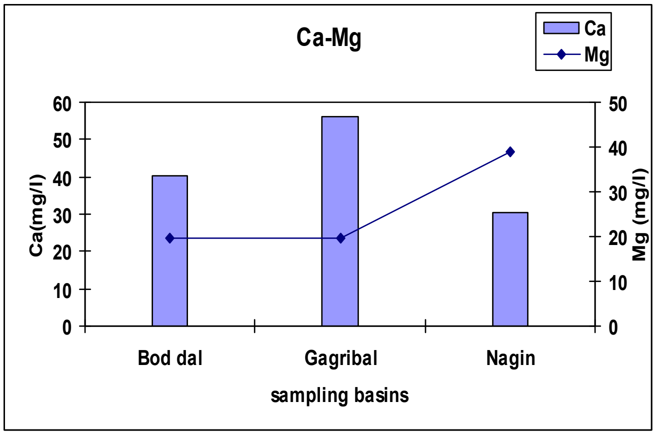


*Fig.11.* Ca-Mg variation of sediment during summer season

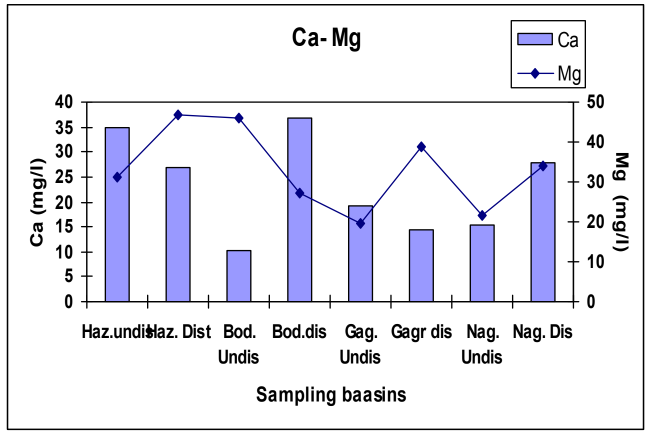


*Fig.12.* Ca-Mg variation of sediment during winter season

concentration of E.C. is shown in the (Figs.5, 6, 17) for summer and winter season respectively. There is also not much variation in alkaline conditions of the lake sediment; the values had show slight alkaline nature of the sediment. The summer season show the pH values between the range of 6.8-7.2 and the winter sediment conditions are fluctuating between 7.1- 8.7 (Fig.18). The sediment pH, however, does not appreciably vary within various seasons of the analysis period (Trisal, 1987). Sediments, in general, are rich in mineral nutrients. The general order of cations is $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and the order of anions is $HCO_3 > SO_4^{2-} > Cl^-$. The high concentration of $Ca^{2+}$ and $HCO^3$ indicates the intense chemical weathering of the catchment area (Fig.19). Ca2+ is derived mainly from carbonates with some inputs from silicates (Figs.11, 12). Similarly HCO3 is derived from silicates and carbonates. The origin of $Cl^-$ is mostly from evaporates, rainfall and pollution sources. The significant increase of Cl- concentration in the Nagin and Gagribal basins in summer and Gagribal and Hazratbal basin in winter reflects lithogenic and anthropogenic sources, respectively (Figs.13, 14). The presence of evaporates in the Karewa deposits in the catchment area and input of sewage in the Gagribal basin may be attributed to lithogenic and anthropogenic sources of $Cl^-$ concentration.

The concentration of $Na^+$ varies in between 160 - 205 mg/l in summer season and 170 - 270 mg/l in winter season. The dissolution of evaporates can be an important source for Na (Fig.20). There is trifling variation in the concentration of $K^+$ ions during summer as well as winter season the value

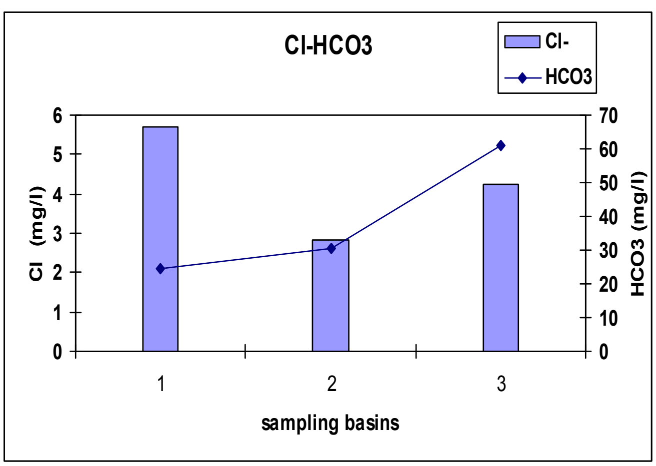


*Fig.13.* Cl – $HCO_3$ variation of sediment during summer season

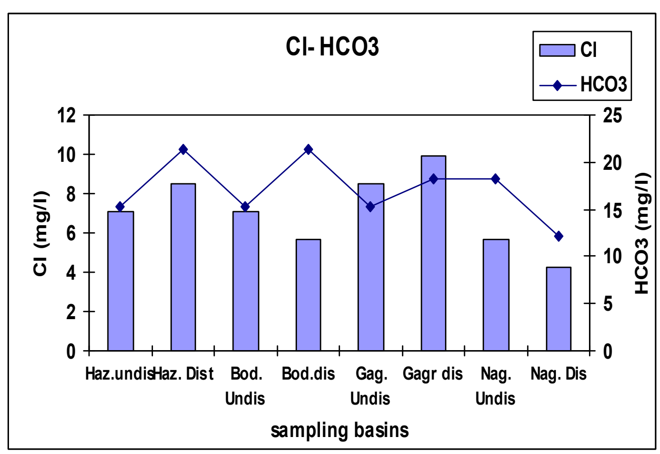


*Fig.14.* Cl – $HCO_3$ variation of sediment during winter season

ranges between 0.4 - 0.8 in summer season and 0.4 - 0.9 in winter season. $K^+$ showed a definite regularity in its seasonal and spatial distributional pattern, which is attributed to its low geochemical mobility. In addition to the source of $K^+$ rocks, contributions from groundwater, atmospheric precipitation, sediments and decomposed plants within the lake cannot be neglected (Fig.21).

Atmospheric, agricultural and anthropogenic sources are the only nitrogen sources in the area. $NH_3$-N concentrations show a reverse correlation with all the major ions being high in the Bod Dal basin in summer season and in Gagribal and Nagin basin during winter season. The higher values of $NH_3$-N at the Gagribal and Nagin basins are the

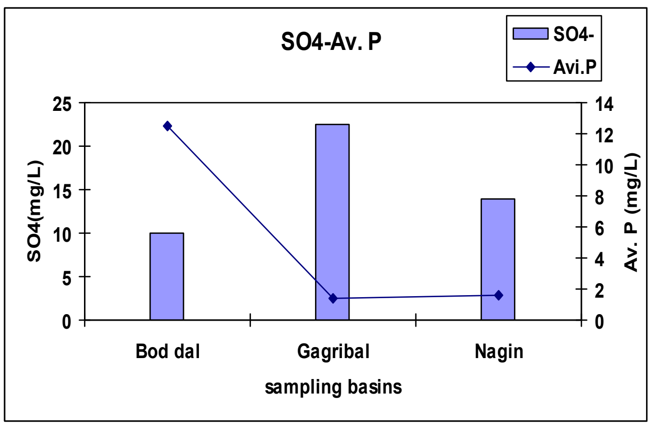


*Fig. 15.* $SO_4^{2-}$ - Av.P variation of sediment during summer season

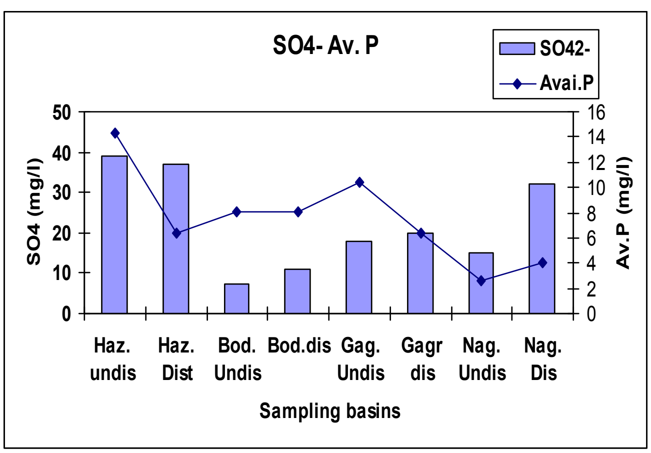


*Fig.16.* **$SO_4^{2-}$ -** Av.P variation of sediment during winter season

warning signal of water pollution as values approach up to 6.4mg/l. The overall increase of $NH_3$-N concentration during summer is attributed to the input of fertilizer in areas under agriculture and floating gardens (Figs.9, 10). The low concentration of most of the ionic constituents in summer and higher values in winter reveals the contribution of summer snow melt from the entire catchment area which causes dilution of ionic components.

During the summer and winter seasons the Nagin basin is showing soaring deliberation for the organic matter in the bed sediment. The variation in the concentration of % OM is shown in (Figs.7, 8) for summer and winter season respectively. The high organic matter might be due to deterioration, eutrophication of the lake as well as sewage disposal into the lake (Liikanen, 2003). The sulphate concentration is high in Gagribal basin

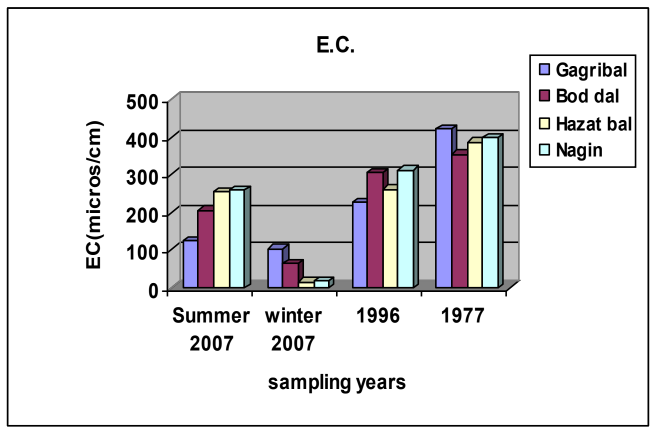


*Fig.17.* Variation of E.C. in water

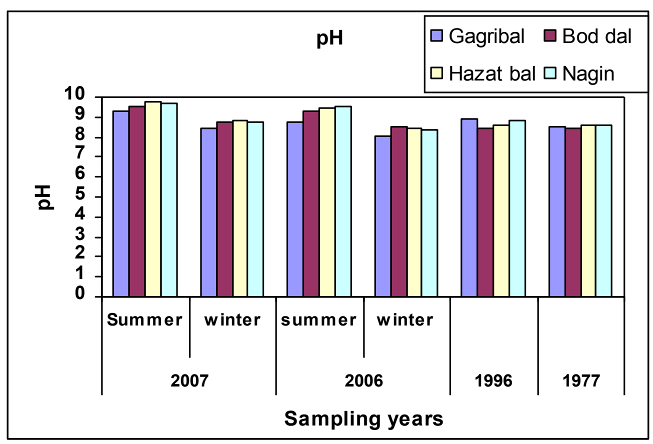


*Fig.18.* Variation of pH in water

during the summer season, through the winter season the basin Hazratbal shows high values for the $SO_4$ ions. The concentration for available


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Indian J. Innovations Dev., Vol. 1, No. 7 (July 2012) ISSN 2277 - 5390

phosphorous is high in Boddal basin and low in Gagribal basin during the summer season. Through the winter season the basin Hazratbal shows high concentration for available phosphorus concentration. The graphical representation for $SO_4^{2-}$ and Available phosphorus shows negative correlation amongst them. The variation in concentration of $SO^{4-}$ Av. P. is shown in Figs.15, 16.

**Comparison of Water Quality with previous data**

The tables 5, 5a, 6, 6a, 7, 7a and 8, 8a give comparisons of some important parameters for the last four decades and show the degradation and deterioration in the water quality. In series of papers, Zutshi and Vass (1978), Trisal and Kaul (1983), Zutshi (1985), Jeelani (2006), these scientists provided extensive data on different aspects on Dal Lake. It was established beyond any doubt that the lake was undergoing far reaching changes in its environment due to discharge of large quantity of waste from human settlements, agricultural lands and house boats. The ecological stress of the system is reflected by deterioration of water quality and increased levels of biological productivity. The Graphical representation for the water quality for the last four decades is also supporting the fact that Dal Lake is undergoing deterioration and eutrophication. According to the graphs the pH of the water is slanting towards the highly alkaline nature. The conductivity, alkalinity of calcium of lake is escalating from last four decades till date. The concentration of Sodium, Potassium and Silicates were high in 1996 but from 2006- 2007 there is a considerable decrease in their respective concentrations. The concentration of calcium and magnesium is constantly rising from the year 1977 till 2007.

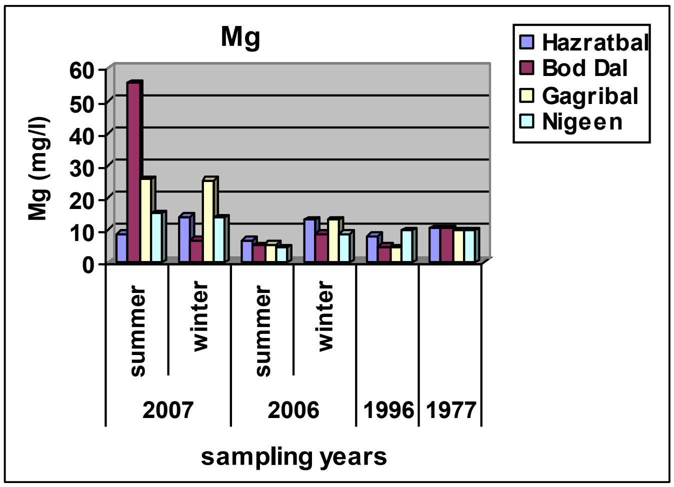


*Fig.19.* variation of Mg. in water

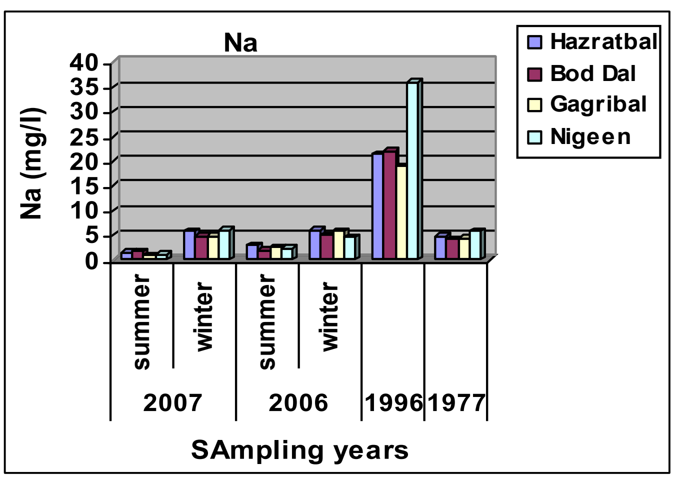


*Fig.20.* variation of Na. in water

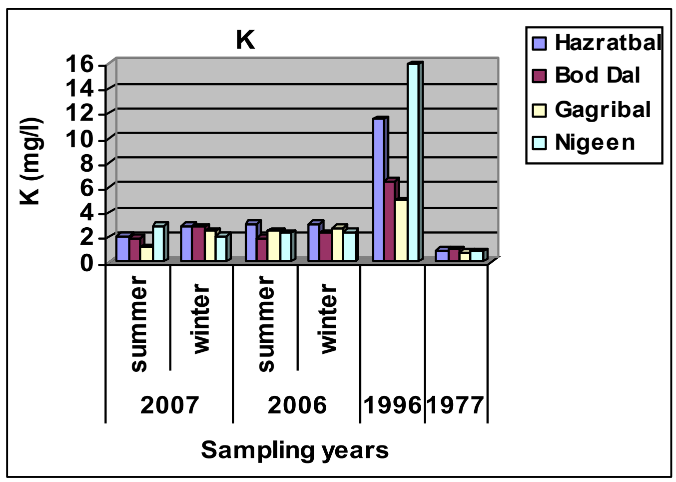


*Fig.21.* variation of $K^+$ in water

## Correlation analysis

### *Water and Sediments*

Correlation analysis is a preliminary descriptive technique to estimate the degree of association among the variables involved. The purpose of the correlation analysis is to measure the intensity of association between two variables. Such association is likely to lead to reasoning about causal relationship between the variables. In this


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study, the relationship between various elements has been studied using Pearson correlation matrix. Most of the parameters were found to bear statistically significant correlation with each other indicating close association of this parameter with each other.

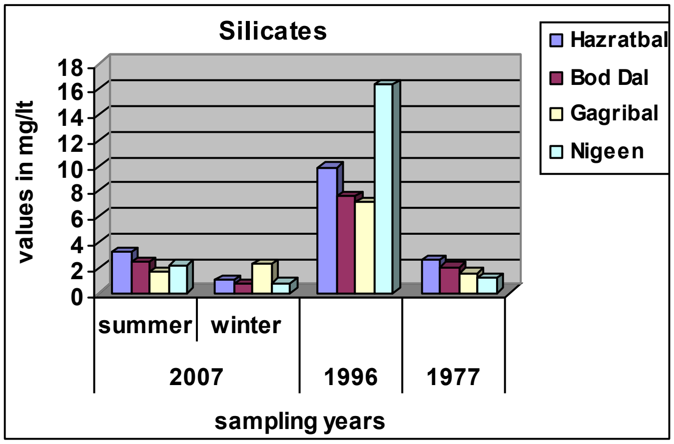


*Fig.22.* variation of Si in water

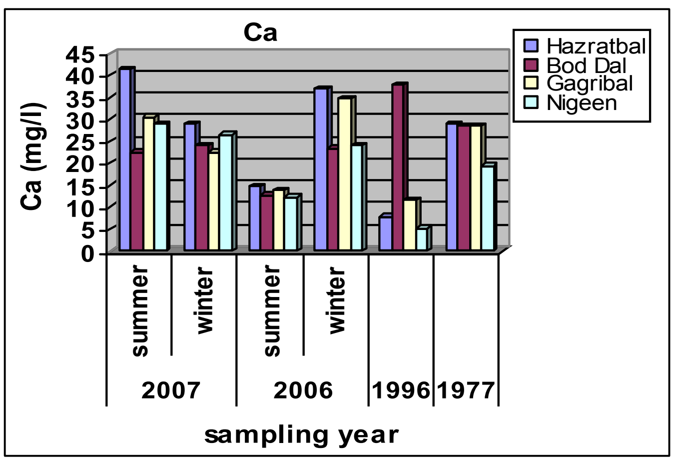


*Fig.23.* variation of E.C. in water

The correlation analysis of water sample was analyzed and shown in the Tables 5, 6. There is a strong correlation between EC and $Cl^-$, $SiO_2$, K, $SO_4$, $NH_3^-$, as there is strong correlation between Fe and $Cl^-$, $SiO_2$ (Fig.22). The Ca shows strong correlation for $HCO_3$, $CO_3$ shows the water type lake may be $Ca^-$ $HCO_3$, $Ca^-$ $CO_3$ for summer season as there is no correlation of this parameter with each other at winter season (Fig.23). For winter season in the correlation matrix the P content is negatively correlated with the pH of water. At lower pH, microbial uptake is enhanced (McGrath *et al*. 2001) causing a decrease of reactive phosphorous in the water.

***Remedial Measures***

The lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachments eutrophication (from domestic and industrial effluents) and silt (Bhishm Kumar, 2007). The human settlements and public effluent sources are the chief factors for the degradation of lakes, particularly the urban lakes. From the foregoing account it is clear that the condition of the Dal lake has reached a critical stage from the hydrological and ecological angles and if proper conservation measures are not taken, the lake is likely to further deteriorate as it is clearly evident that the anthropogenic activities are affecting the water quality and causing the sediment pollution (Sly, 1978). The lake is facing problems such as excessive weed growth, deterioration in water quality, discharge of sewage and nutrients into the lake and deposition of silt (Zhang, 1998). Therefore, some remedial measures are required to prevent further deterioration of the lake. The management of the sewage from house boats and nearby resorts should be the first step to mitigate the problem. An improved regional sanitation and waste disposal program needs to be initiated. The sewage treatment plant is the cheap and necessary treatment which can be given to sewage and which can also reduce the enrichment of nutrients in the lake as we can use manure from the same.

Further encroachments in the lake area should be totally stopped. An effective moratorium on the construction of new houseboats, hotels and restaurants within the lake should be declared, which of course needs legal sanction. Future expansion of Srinagar should be planned according to the capacity of the land. Future tourist development, including the number of tourists, should be based on the capacity of the land, the provision of amenities, services and energy supplies rather than the mere promotion of tourism for economic gains. Reforestation is a practical and effective means of reducing soil erosion. It is recommended that the reforestation program be accelerated and that positive steps be taken to control grazing on the slopes which are prone to soil erosion. Likewise the problem of eutrophication can be overtaken with the help of plantation on the mountain slopes.

The proper Dredging and cleaning activities of lake can also be helpful to reduce the sedimentation of lake. The main cause for continued degradation of Lake Environment has been public apathy and government indifference. A meaningful interpretation of the causes and mechanisms of perturbations in the lake is only possible if periodic surveys of different ecological aspects are carried out. A short-term cross-sectional study of a few years gives an incomplete picture. This emphasizes the need to monitor the lake's environment on a regular basis.

## Conclusion

Detailed surveys of Dal Lake carried out by various investigators indicate that the lake has reached a critical condition from the environmental point of view. The water of four basins of the Dal Lake is alkaline and is characterized by medium TDS and EC. The geochemical characteristics of the Lake water is mostly influenced by the lithology of the basin and weathering of carbonate and silicate rocks. Anthropogenic activities show an impact on both water and sediment chemistry of the lake, particularly in portions proximate to habitation/hotels/houseboats/sewer drains, etc., (the Gagribal basin and some patches of the Nagin basin). The consequences of increasing nutrient load are all too apparent, through deterioration of water quality characteristics and symptoms of eutrophication (Tchobanoglous, 1985) . Direct discharge of untreated human wastes from houseboats and settlements adjoining the lake has further aggravated the nature and extent of pollution. Human encroachments and siltation have combined with natural processes to reduce the area of open water within the lake. Previous correlation with available data also shows continuous increase in the drastic conditions in water quality. Various measures proposed for the conservation of the lake include afforestation of the catchment area, control of grazing in the catchment area, installation of a sewage system and continuous monitoring of the lake environment. All these measures are expected to reduce the nutrient level, which is quite unfavorable at present, and help in increasing the aesthetic appeal of the lake (Alka Jain, 1999).

## References

1. Alena Mudroch, José M Azcue and Paul Mudroch (1997) Manual of physico-chemical analysis of aquatic sediment. published by CRS Press.
2. Alka Jain, SC Rai, J Pal and Sharma E (1999) Hydrology and nutrient dynamics of a sacred lake in Sikkim Himalaya Hydrobiologia. *Kluwer Academic Publishers*. 416, 13–22,
3. APHA (1995) Standard methods for the examination of water and wastewater, 19th edn. American Public Health Association, Washington, D.C., 1467.
4. Bhishm Kumar SP, Rail RMP, Saravana Kumar NU, Surjeet Singh and Diwedi VK (2007) Sedimentation rate in North Indian lakes estimated using 137Cs and 210Pb dating techniques. *Current science,* 1416, 92, 10.
5. Calmano, W Hong J and Forstner U (1993) Binding and mobilization of heavy metals in contaminated sediments affected by pH and redox potential. *Water sci technol.* 28, 223-235.
6. Chakrapani GJ (2002) Water and sediment geochemistry of major Kumaun Himalayan lakes, India. *Environ Geol* 43, 99–107.
7. Chapman PM (1986) Sediment quality criteria from the sediment quality triad. An example. *Environ toxicol chem.* 5, 957-964.
8. Datta NK (1983) Geology, evolution and hydrocarbon prospects of Kashmir Valley. *Pet Asia J* 171–177.
9. Downing JA, Prairie YT, Cole JJ, Duarte CM, Tranvick LJ, Striegel RG, McDowell, WH, Kortelainen P, Melack JM and Middleburg JJ (2006) The global abundance and size distribution of lakes, ponds and impoundments. *Limnology and Oceanography,* 51, 2388-2397.
10. Enex (1978) Study of the pollution of Dal Lake, Srinagar, Kashmir (India), report submitted by the Enex Consortium to the Jaipur and Kashmir government.
11. Fernex F, Valle PZ, Sanchez RH, Michaud F, Parron C, Dalmasso J, Genevieve BF, Manuel GA (2001) Sedimentation rates in Lake Chapala (Western Mexico): possible active tectonic control. *Chem Geol*. 177, 213-228.


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12. Forstner U (1989) Contaminated sediments. In Bhattacharji S, Friedman GM, Neugebauer HJ and Seilacher A 9Eds), Lecture notes in earth science. Springer verlag, Berlin.

13. Freeze RA and Cherry JA (1979) Groundwater. Prentice Hall, Englewood Cliffs, NJ

14. Gupta LP and Subramanian V (1998) Geochemical factors controlling the chemical nature of water and sediments in the Gomti river. *India Env. Geol*. 36 (1–2), 102–108.

15. Hutchinson, GE (1969). Eutrophication, Past and Present, in G.A. Rohliceh, Eutrophication, National Academy of Sciences, Washington DC. 17-26

16. Ishaq M and Kaul V (1988) Distribution of minerals in Himalayan lake. *Trop. Ecol*. 29, 41–49.

17. Jamie Bartram and Richard Balance (1996) Water Quality Monitoring-A practical guide to the design and implementation of fresh water quality studies and monitoring programmes. UNEP\WHO

18. Jeelani, G, Shah AQ (2006) Geochemical characteristics of water and sediment from the Dal Lake, Kashmir Himalaya: constraints on weathering and anthropogenic activity. *Environ Geol*. 50, 12–23.

19. Kaul V, Trisal CL and Kaul S (1980) Mineral Removal Potential of Macrophytes in Two Lakes of Kashmir, *J Ind Botanical Soc*, 55, 113-123.

20. Koussouris T and Diapoulis A (1989) Lake Mikri Prespa. Ecological changes from natural and anthropogenic causes. *Toxicol Environ Chem.* 20, 49–52.

21. Koussouris T, Diapoulis A and Balapoulos E (1987) Limnological situations in two shallow Greek lakes. *Geo journal,* 14, 377–379.

22. Liikanen A and Martikainen PJ (2003) Effect of ammonium and oxygen on methane and nitrous oxide fluxes across sediment– water interface in a eutrophic lake. *Chemosphere*, 52, 1287–1293.

23. McGrath, JW, Cleary S, Mullan, A and Quinn, JP (2001) Acidstimulated phosphate uptake by activated sludge microorganisms under aerobic laboratory conditions. *Water Resource*, 35(18), 4317–4322.

24. Nag JK and Das AK (1993) Trace metal levels in drinking water scenario of Hooghly district. *Ind J Environ Protect,* 13, 20–22

25. Nimptsch J and Pflugmacher S (2007) Ammonia triggers the promotion of oxidative stress in the aquatic macrophyte Myriophyllum mattagrossense. *Chemosphere*, 66, 708–714.

*26.* Pandit AK (1999) Fresh warer ecosystems of the Himalaya. Published by *Informa health care.ppno*

27. Reddy MS and Char NVV (2004) Management of Lakes in India**,** Blackwell Publishing Asia Pty Ltd.

28. Reid GK (1971) Ecology of Inland waters and Estuaries. Reinhold publishing Corporation, New York. 159, 181.

29. Skoulikidis NT, Bertahas I and Koussouris T (1998) The environmental state of freshwater resources in Greece (rivers and lakes). *Env Geol* 36(1–2), 1–17.

30. Sly PG (1978) Sedimentary processes in lakes. In Lakes: Chemistry, Geology and Physics (ed. Lerman, A), *Springer-Verlag*, 65–89.

31. Sujatha SD, Sathyanarayanan S, Satish PN and Nagaraju D (2001) A sewage and sludge treated lake and its impact on the environment Mysore India. *Env. Geo.* l40, 1209–1213.

32. Tchobanoglous G and Schroeder ED (1985) Water quality. USA: Addison-Wesley Publishing Company.

33. Trisal CL (1987) Ecology and conservation of Dal Lake Kashmir. *Water Resources Dev* 3, 44–54.

34. Trisal CL and Kaul S (1983) Sediment Composition, Mud-Water Interchanges and the Role of Macrophytes in the Dal Lake, Kashmir, *Int. Revue ges. Hydrobiol.*, 68,671-682.

35. Trivedi RK and Goel PK (1984) Chemical and biological methods for water pollution studies. *Env Publ Karad*, India 215.

36. Varadan VKS (1977) Geology and mineral resources of the state of India Part X Jammu and Kashmir state. *Geol Sur Ind* 30, 1–71.

37. Wadia DN (1971) Geology of India. Tata McGraw Hill, New Delhi pp 34.

38. Zhang H and Forde BG (1998) An Arabidopsis MANS box gene that controls nutrient induced changes in root architecture. *Science*, 279, 407–409.

39. Zutshi DP (1985) The Himalayan lake ecosystem. In Singh, J.S. (ed.), Environmental Regeneration in Himalaya: Concept and Strategies. *The Central Himalayan Environment Association and Gynodaya Prakashan, Nainital* 325–338.

40. Zutshi DP and Vass KK (1978) Limnological studies on Dal Lake Srinagar: chemical features. *Ind J Ecol.* 5, 90-97.


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