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Limnological study of dal lake Srinagar j and k

Muzaffar U Zaman Khan[1], Ishtiyaq Majeed Ganaie[2], Kowsar Hussain Bhat[3]

Email: Muzaffarkhan722@gmail.com

ABSTRACT: Dal Lake, known as the jewel of kashmir, is a world famous lake in the city of srinagar,the summer Capital of Jammu and Kasmir state India. The current study aimed at analysing the various physico-chemical parameters of the lake and assessing its water quality using the methodology as given in APHA 1998. The results revealed higher values for nitrogen, showing the excessive use of nitrogenous fertilizers in the floating gardens of the lake and agricultural fields surrounding the lake. Phosphate values also remained on the higher side indicating the eutrophic nature of the lake. The values for iron were also high, while as the results for alkalinity revealed that the lake waters fall under the category of hard waters

KEY WORDS: Dal Lake, APHA, nitrogen, phosphate, fertilizers, floating gardens, eutrophic, alkalinity, hard waters.

INTRODUCTION

Fresh water bodies constitute only 3% of the total volume of water on earth, the remaining 97% being found in the oceans. These water bodies have a bearing on the economy as they provide potable water, fish and fodder. The fresh waters are however the most vulnerable habitats, most likely to be changed by the activities of man. It is because lakes acts as sinks for sewage and waste disposal while the rivers are naturally provided drains for the removal of waste to the sea. The useful aspects of these water bodies and their vulnerability by man's activities have necessiated their study and the study of various geological, Physico chemical and biological aspects of these water bodies comes under the scope of Limnology.

From the stand point of their nutrient content lakes may range from eutrophic (well nourished) and mesotrophic (moderately nourished) to oligotrophic (little nourished). Eutrophication results from increase in essential plant nutrients as nitrogen, Phosphorus, iron and carbon.

Cultural eutrophication differs from natural eutrophication in that it is greatly accelerated in the sense of geological time. As the term implies, man is the causative agent for enrichment of natural water in various ways.

Accelerated nutrient cycle and faster transport of soil constituents increase sedimentation rates and lead to enrichment with nutrients of surface waters followed by changes in chemical and biological composition of the aquatic habitats. Obviously a lake ecosystem has physical, chemical, biological and geological inputs and outputs. The substantial amount of disposals and discards of society reaches lakes. The quality of water body generally reflects the range of human activities within their Catchment area. In a broader sense potential perturbations of lakes may be related to population density and energy dissipation in the drainage area of the lake. Deposition of sediments is a continuous process as is seen in Dal, Anchar, Wular, Hokersar and Nilnag lakes and can fill a lake basin completely. For instance, in Dal Lake the denudation of mountainous Catchment results in heavy quantities of silt flowing into the lake system. Thus a total volume of silt brought in to the lake has been estimated at 80,000 tonnes per year out of which 70% is brought by the feeding channel, Telbal Nallah. In addition another 40,000 to 50,000 tones of dead weed and allochthonous material are added every year (ENEX, 1978).

This state of affairs calls for a detailed study of freshwater bodies not only to analyze the dynamics of and interaction among its structural components but also for the causes behind the cultural eutrophication. Only then can we go for the conservation of these natural resources for the multiple purposes of food supply, irrigation, drinking, recreation & tourist attraction.

GENERAL INFORMATION ABOUT THE PLACE OF WORK.

The Dal lake is known as the “Jewel of Kashmir”. This is the second biggest lake of Jammu and Kashmir.. It is in the east side of the ancient city of srinagar.

The Dal having catchments of about 316 km^2 is divided into several distinct basins namely Gagribal, the Bod Dal (large lake), Hazratbal basin and Lokat dal. During its survey in 1870, the Dal was extending from 5 to 6 miles from North to South and 2 to 3 miles from East to West. Presently, the Dal has shrunk and is devoid of its depth , fresh and transparent waters due to high rate of pollution.

“PERHAPS in the whole world” ,wrote Walter Lawrence in his famous book, the valley of Kashmir , “there is no corner so pleasant as the Dal lakes”.

Dal Lake Area in km^2

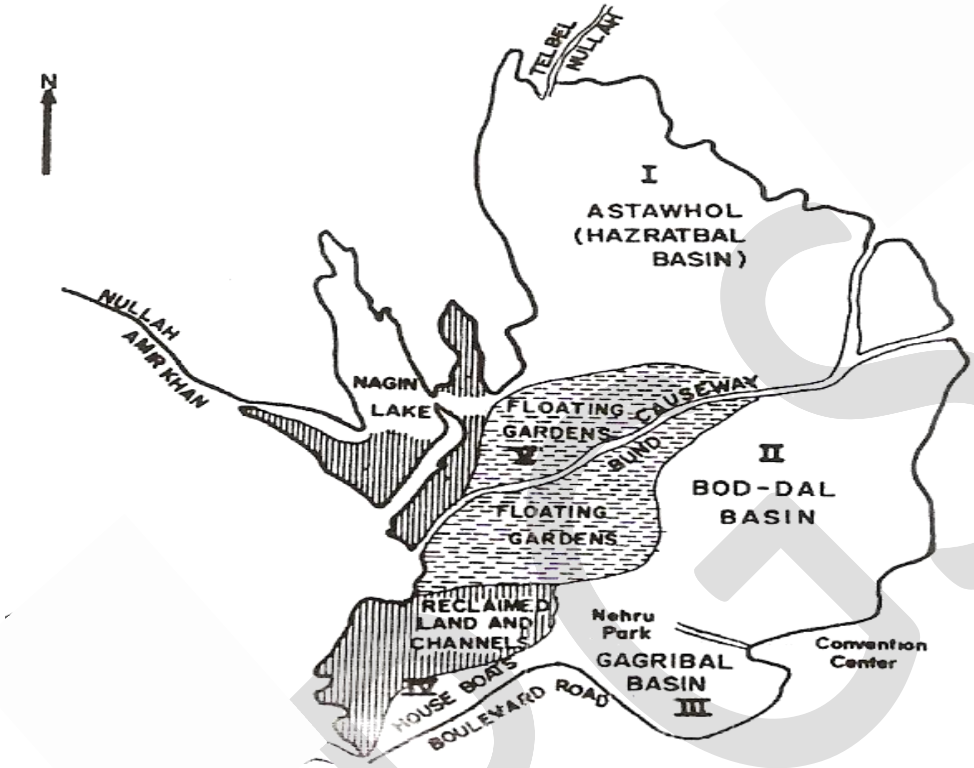
S.No.	Division	Open water Basin	Marshy land	Total area
01	Hazratbal	5.6	3.2	8.8
02	Bod Dal Basin	4.2	-	4.2
03	Gagribal Basin	1.3	-	1.3
04	Boulvard Basin	0.3	0.2	0.5
05	Floating Gardens	0.3	4.5	4.8
	Total	11.7	7.9	19.6

Source : Geography of Jammu and Kashmir (Hussain, M); 2003

LAKE CLIMATE

The climatic conditions of the Lake are temperate for major part of the year. The climate is characterized by warm summers having a maximum temperatures of 33^0C and cold winters with subfreezing temperatures.

Kaul 1979 states that the climate of Kashmir is highly variable and does not confirm to any de[illegible]. According to the author the winter is spread over longer period than the summer.



METHODOLOGY :

For the present study two sampling stations (i) Littoral zone (site – I) and (ii) Central zone (site – II) of Hazratbal basin were selected for detailed investigations. The water samples were analyzed for various physico-chemical parameters followed by the methodology in APHA,1998.

PHYSICAL PARAMETERS:

TEMPERATURE :

The atmospheric temperature at the sampling site was recorded with the help of Celsius thermometer, avoiding its exposure of mercury bulb to direct sunlight

WATER TRANSPARENCY:

Light penetration through lake water was measured with a secchi disc of 20 cm diameter painted white and black on upper surface and black on the lower surface.

$$T = \frac{X + Y}{2}$$

Where T, X and Y represent transparency in cm, depth at which the Disc could not be observed while lowering the rope and depth at which the disc was visible while raising the rope (poole and Atkin, 1929) .

CHEMICAL ANALYSIS:

The chemical analysis of the water sampling for various characteristics was carried out using the methods outlined in APHA, 1998.

HYDROGEN ION CONCENTRATION:

The P^H of the water samples was measured by using an Elico-digital P^H meter. Before use the P^H meter was calibrated each time against buffer solutions of known Hydrogen ion concentration usually on P^H4, P^H7 or P^H9.

SPECFIC CONDUCTIVITY:

The Specific conductivity of water samples was determined by using a systronics direct reading conductivity meter. The instrument was calibrated by using N/10 KCl solution at 25^0C. The results are expressed as µs at 25^0C.

DISSOLVED OXYGEN:

To a sample collected in a 250 ml glass bottle, 1 ml of each magnesium sulphate solutions and alkaline iodide azide solution was added one after the other with separate pippets. The precipitate (mangnous hydroxide floc) formed was dissolved after about four minutes with the help of concentrated Sulphuric acid. The fixed samples were carried to the laboratory where these were titrated against 0.025 N Sodium thiosulphate solution, using starch solution as indicator. The end point was noted at the first disappearance of blue colour. The amount of DO present was then calculated by using the formula.

$$DO\ (mg/l) = \frac{\text{Vol. of the titrant} \times 0.2 \times 1000}{\text{Vol. of sample}}$$

Where 0.2 value represent 1 ml of sodium thiosulphate equivalent to o.2 mg of oxygen.

ALKALINITY:

For estimation of phenolphthalein alkalinity (i.e alkalinity due to P^H and CO_2) a sample volume of 50ml was titrated against 0.02 N H_2SO_4 in presence of phenolphthalein indicator till disappearance of Pink colour. Volume of titrant used was noted. Then for estimation of total alkalinity (i.e, alkalinity due to OH, CO_3 and HCO_3) the same sample was titrated with 0.02 N NaOH in presence of methyl orange indicator till the color changes from Yellow to orange. The total volume of titrant was noted. On the other hand, when there was found no Pink color formation after addition of phenolphthalein indicator, the sample was run through the same procedure followed by the addition of methyl orange indicator as mentioned above for total alkalinity. Then phenolphthalein alkalinity (P) and total alkalinity (T) were calculated by using the formula as given below:

Phenolphthalein alkalinity (P) as mg/l CaCo3

$$= \frac{\text{Volume of titrant used} \times N \times 50{,}000}{\text{Volume of sample}}$$

Total alkalinity (T) as mg/L = $\frac{\text{Volume of titrant used} \times N \times 50{,}000}{\text{Volume of sample}}$

CALCIUM HARDNESS:

To 25 ml of water sample 2ml of 1N NaOH buffer and a spatula of Solochrome dark blue powder were added. Titration against EDTA was continued till the colour of the sample changed from, light pink to blue. The calcium hardness was then calculated by using the formula given below:

Calcium hardness as mg/l $CaCO_3$

$$= \frac{\text{Volume of titrant used } (V_2) \times 1000 \times 1.05 \text{ (mol. wt. of } CaCO_3)}{\text{Volume of sample}}$$

MAGNESIUM HARDNESS:

To 25 ml of water sample 25 ml of distilled water and 1 ml of magnesium buffer were added one after the other followed by 2 drops of Erichrome Black – T indicator. Titration against EDTA was continued till the colour of the sample changed from purple to blue. The magnesium content of the water sample was the estimated by the following formula.

Mg/L= [Total Hardness (as mg $caco_3$/L) **-** Calcium Hardness (as mg $caco_3$/L] × 0.243

CHLORIDE:

To 100 ml of water sample,1 ml of Potassium Chromate indicator were added. Once the yellow colour was formed, the sample was titrated against standard silver nitrate solution (0.0141) to a faint brick red colour formation. Then in accordance with the formula given in APHA (1998), the chloride content of the sample was calculated. The formula is given as:

Chloride mg/l = $\frac{\text{Volume of titrant used} \times 35.46 \times 0.0141 \times 1000}{\text{Volume of sample}}$

SULPHATE:

To 100 ml of the water sample add 20 ml of sulphate buffer and take the absorbance at 420 nm. Then add one spatula of Barium chloride. Stire well, with magnetic stirrer till turbidity develop. Now again take absorbance at 420 nm (Post absorbance).

IRON:

TO 25 ml of the water sample, add 0.5 ml of 1 : 1 Hcl, 1 drop of bromine water and 0.5 ml of potassium thiocyanate one after the other. Record the reading at 480 nm.

NITRATE (NO_3-N) :

Free chlorine interferes with the nitrate determination. If the sample is having residual chlorine, remove it by addition of 0.05 ml (one drop) of sodium arsenite solution for each 0.1 mg of chlorine. Take 10 ml of sample or aliquot diluted to 10 ml in a 50 ml of test tube. Put all the tubes in a wire rack. Place the rack in cool water bath and add 2 ml of Nacl solution. Add 10 ml of H_2So_4 solution after mixing the contents thoroughly swirling by hand. Now add 0.5 ml of brucine and mix thoroughly. Place the rack in a hot water bath with boiling water exactly for 20 minutes. Cool the contents again in a cold water bath and take the reading at 410 nm.

NITRITE (NO_2-N) :

To 50 ml of colorless filtered sample add 1 ml of each EDTA, Sulphanilic acid, a- naphthylamine hydrochloride and sodium acetate solutions in sequence. A wine red colour will appear in the presence of nitrites. Take the reading at 520 nm .

AMMONIA (NH_3 – N):

To 100 ml of the sample add 1 ml of zinc sulphate (ZnSo4) and 0.5 ml of 6N NaoH one after the other. Allow it to stand for 10 minutes till the whole precipitate settles down the bottom of flask. Now take 50 ml of supernatant sample carefully, so that no precipitate is their in this solution and add one drop of EDTA and 2 ml of Nesler reagent to this aliquot. Allow it to stand for 10 minutes. Take the reading at 520 nm.

ORTHOPHOSPHATE (PO_4-P) :

To 100 ml of water sample, add one drop of phenolphthalein indicator. If pink colour develops, add strong acid to decolorize it. Then add 4 ml of ammonium molybedate and 0.5 ml of stannous chloride one after the other and allow it to stand for 10 minutes to develop color. Note the reading at 690 nm.

TOTAL PHOSPHORUS:

TO 25 ml of water sample add 1 ml of H_2So_4 and 5 ml of HNO_3 one after the other. Digest it over the hot plate. After cooling off the flasks add 20 ml of distilled water and one drop of phenolphthalein indictor. Titrate it against 1 N NaoH till pink color appears. Raise the sample volume up to 100 ml by adding distilled water and add 1-2 drops of strong acid solution to discharge the pink colour. Now add 4 ml of ammonium molybedate and 0.5 ml of stannous chloride to this sample and allow it to stand for 10 minutes to develop colour. Note the reading at 690 nm.

RESULTS

The results obtained for various physicochemical parameters are shown below in the tables from table 1 to table 16

Physico–Chemical parameters:

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Table – 1 Variation In Air And Water Temp (^{0}C) at two sites of Dal Lake

	Site I		Site II	
	Air	Water	Air	Water
Maximum	18.5	16.5	21.2	17.1
Minimum	8.0	6.3	6.7	6.1
Average	15.35	11.9	14.1	12.2

Table – 2 variation in Secchi Transparency (m) at two sites of Dal Lake

	Site I	Site II
Maximum	2.15	2.5
Minimum	1.5	1.75
Average	1.78	2.06

Table – 3 variation in conductivity (µs) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	346	351	319	331
Minimum	327	333	262	275
Average	334	341	299	315

Table – 4 Column variations in PH at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	8.06	7.81	7.97	7.9
Minimum	7.4	7.3	7.60	7.58
Average	7.79	7.5	7.7	7.7

Table – 5 Column variation in total alkalinity (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	129	144	120	129
Minimum	91	100	96	77
Average	108	118	112	102

Table – 6 variations in D. O. (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	12.4	12.8	12.0	11.2
Minimum	6.0	4.8	7.5	6.0
Average	8.4	8.3	9.8	9.1

Table – 7 Variations in Calcium Hardness. (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	32	38	32	35.2
Minimum	24	30	25.6	25.6
Average	29.5	36	29.6	31.2

Table – 8 Column variations in Mg (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	4.8	7.7	7.7	7.7
Minimum	3.8	3.8	4.8	1.9
Average	4.3	5.2	5.7	4.5

Table – 9 Column variations in Chloride (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	34	15	10	11
Minimum	9.5	8.5	6.5	7.0
Average	15.8	10.6	9.1	10.2

Table – 10 Column variations in Sulphate (mg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	41	40	28.5	30.9
Minimum	13.6	14.3	12.2	12.2
Average	22.8	22.7	20.2	21.3

Table – 11 Column variations in Iron (µg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	556	201	143	191
Minimum	47.9	86.3	86.3	57.5
Average	215.6	131.6	83.5	93.1

Table – 12 Column variations in Nitrate – Nitrogen (µg/l) at two sites of Dal Lake

	Site I	Site II

	Surface	Bottom	Surface	Bottom
Maximum	844	1147	873	850
Minimum	728	401	699	745
Average	783	739	776	794

Table – 13 Column variations in Nitrite - Nitrogen (µg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	58.7	50.9	88.7	39.0
Minimum	19.3	23.8	16.0	18.4
Average	39.8	37.9	36.3	25.1

Table – 14 Column variations in Ammonia – Nitrogen in (µg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	152	209	172	156
Minimum	12.9	10	12.9	28.7
Average	57	104	121	115

Table – 15 Column variations in PO4 - P (µg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	67	122	105	99
Minimum	36	52	74	24
Average	52.6	86.4	92.7	53

Table – 16 Column variations in Total Phosphorous (µg/l) at two sites of Dal Lake

	Site I		Site II	
	Surface	Bottom	Surface	Bottom
Maximum	308	280	304	280
Minimum	48	135	96	86
Average	175	201	167	151

DISCUSSION

The various parameters investigated in Dal lake for a period of four months and the seasonal fluctuations of different physical and chemical factors have been treated separately and their influence up on one another discussed.

The water temperature followed air temperature rather closely as is common for small bodies of water (Wetzel, 1975). In an aquatic ecosystem water transparency is one of the most important features that controls the energy relationship at different trophic levels. Transparency of Dal lake ranged from 1.5 to 2.15 m. Rawson (1960), Pechlaner (1968 to 71) have used water transparency as an index of eutrophication in lakes. Low transparency in the lakes could be due to silt content in water which comes through inflow channels. Similar situation was reported by Zutshi (1968) in case of Anchar lake.

According to Zutshi et al (1980) light Penetration in water is considerably reduced either as a result of high Plankton density or due to large quantities of suspended matter.

At site –I P^H of Dal lake ranged from 7.4 to 8.06 units. While at the bottom it ranged from 7.58 to 7.9. The lake did not exhibit much difference in their P^H values. The lake water seems to be well buffered as no abrupt changes were observed in the P^H values. This is in conformity with the findings of Khan and Zutshi (1980) when total alkalinity is greatest the bicarbonate system prevails and P^H range is usually on the alkaline side as is the case with present findings.

Increased specific conductivity values have been suggested as an indication of high trophic level (Berg et al 1958). Many workers related increase in electric conductivity to the state of enrichment. Applying this criterion to the Dal lake (327 to 346µs) it is observed that the lake is at a higher level of enrichment. The overall value of conductivity come close to other semi drainage lakes of the region as reported by Zutshi and Vass (1977).. There was not much difference between bottom and surface conductivity values at both the sites.

The average value of D.O in the bottom waters of Dal lake was less than the surface water at both the sites. The higher concentration of oxygen content in the surface water could be attributed to aerial saturation. Also the metabolic activities like microbial respiration consumes dissolved oxygen and hence reduce the bottom oxygen concentration.

Dissolved Oxygen changes in the water column have been regarded as most reliable parameter in assessing the trophic status and the magnitude of Eutrophication in an aquatic ecosystem (Edmondson, 1966). In the present study the lack of hypolimnic o_2 deficit may be due to shallow depth resulting in mixing of the water mass.

At site - I the range of alkalinity varied from 91 to 129 (X = 108). At site – II the range was 96 to 120 (X = 112) for the period of 4 months. Earlier Moyle has classified the lake waters as soft, medium and hard on the basis of total alkalinity values. According to this classification waters having alkalinity up to 40 mg l^{-1} are soft, with 40 – 90 mg l^{-1} medium and above 90 mg l^{-1} as hard. If this categorization is applied, Dal lake falls under the hard water type, with bicarbonate alkalinity prevailing throughout the year.

Bottom alkalinity values of the lake were comparatively higher at site – I which may probably be due to the precipitation of carbonate from sediments by aquatic organisms and their subsequent conversion to bicarbonate by carbonic acid.

Chloride content of Dal lake varied from a minimum value of 9.5 mg l^{-1} to maximum value of 34 mgl^{-1} (X = 15.8) . Thresh et al (1944) attributed high chloride concentration of water to organic pollution of animal origin. Cole (1975) concluded that human and animal excreation contains on an average 5g cl^{-1}. On the basis of water quality criteria the chloride content of Dal lake falls within the acceptable limit (< 200mg l^{-1}), but were generally high when compared to the other valley lakes, with an exception of Trigam lake Kashmir, in which high concentration of chloride were reported (Khan, 1978) .

Calcium is generally the dominant cation in Kashmir lakes (Zutshi, 1980) Zutshi and Khan (1977) recorded a ratio of 4:1 for Calcium and magnesium in some Kashmir Lakes. In the Present study a ratio of 7:1 for Ca and Mg was obtained in Dal Lake. Calcium being predominant in the Lake because of predominance of lime rich rocks in their Catchment. It is related to agricultural fertilizers (lime and superphosphate) used in the floating gardens, in the paddy cultivation in the lake Catchment. The lake may be classified as calcium rich, as it depicted a range of 24 to 32 mgl^{-1} (X=29.5 mgl^{-1}).

But Mg content remains generally low (mean = 4.3 mg l^{-1}) for Dal lake. The low concentration may be due to uptake of Mg^{2+} by plants in the formation of Chlorophyll, magnesium poiphyrin metal complex and in enzymatic transformation (Wetzel, 1975).

The ammonical–nitrogen in Dal Lake ranged between 10 to 209 μgl^{-1}(X =104) at site - I and 12.9 to 172 (X=121) at site – II. The ammonia concentration of the lake fall within the acceptable limits of 0.5 mgl^{-1}.

Ellis et al (1946) stated that the amount of ammonia and ammonia compounds in unmodified natural waters is very small ($0.1 mgl^{-1}$) while quantities more than 1 mgl^{-1} are indicative of organic pollution. Rybok and Sikorsha (1976) also observed that more than 99% of total N to be constituted by ammonia in sewage effected zones of the lake.

The nitrate content in the Dal Lake ranging between 72.8 to 844 μgl^{-1} ($\bar{X}$ = 783) during the study period. At site – II it ranges from 699 to 873 ($\bar{X}$ = 776).

High levels of nitrogen in the lakes may be due to use of fertilizers by Dal dwellers for their floating gardens and by local inhabitants for their agricultural land on the lake shores. Cooke (1966) has observed the rapid increase in nitrate content usually after rains and strong winds. Caulton (1970) has suggested that the nitrate – nitrogen probably comes predominantly from the atmosphere and entering the water body via rains. Nitrate nitrogen is an unstable product of either nitrification of free ammonia or denitrification of nitrates. The concentration in the water depends on the relative abundance of nitrifying and denitrifying bacteria and their activity (Munawar, 1970)

The Ortho – Phosphate concentration ranged from 36 to 67µgl-1 ($\bar{X}$ = 52.6) at site - I and 74 to 105 ($\bar{X}$ = 92.7) at site – II. Surface waters of the lake recorded slightly higher values of PO_4 – P ($\bar{X}$ = 92.7) at site II which may be attributed to the regeneration of Po_4 from the decaying plant and animal remains as pointed out by Cooper (1958). Phosphate concentration remained low during the month of February, this may be due to the quick uptake and subsequent storage of phosphate by the plankton, locking up of phosphate in the dense macrophytic vegetation that abounds in the lake and formation of insoluble calcium phosphate complex due to its basically being a small lake. Sawyer et al (1945) suggested that 0.3 mg l^{-1} of PO_4 – P and $0.15 mgl^{-1}$ of No_3 –N are critical levels beyond which algal bloom may appear indicating cultural eutrophication.

At site–I the range of total phosphate in the Dal lake was 48 to 308 μgl^{-1} ($\bar{X}$=175μgl^{-1}) and site–II between 96 to 304μgl^{-1}($\bar{X}$ = 167μgl^{-1})Dal lake on the basis of this parameter seems to be enriched. Welch (1952) and Ruttner (1953) reported smaller amounts of phosphorus in waters free from contaminating effluents. Hutchinson (1957) related the increase in phosphorus as a result of sewage contamination. Schindler et al (1971) believe total phosphorus to be a nutrient most frequently controlling eutrophication. Vollenweider (1972) regarded phosphorus as a key element in the processes of eutrophication. The increase in the phosphorus content may be related to the migratory flocks of bird and pertuberations caused by man in the Catchment.

Next to phosphorus and nitrogen, iron is often considered to be one of the most important chemical Factor for the development of phytoplankton (Rodhe, 1948). As to the range of concentration of iron suitable for algae, the information is more scarce than for nitrogen and phosphorus. Chu (1942) gives the range of 0.02 – 0.8 Fe mg l^{-1} and the values for Dal lake (0.047 – 0.55 mgl^{-1}) fall within the same range. These values are much higher than the permissible levels of 0.05 mg l^{-1}(water resources centre, Canada, 1968) beyond which the water is unfit for human consumption.

The above study makes it clear that the various physico-chemical parameters of the lake are not in their normal range and as such the lake water is not suitable for consumption and also the lake diversity is under serious threat mainly as a result of various anthropogenic activities which are changing the water quality and threatening its very existence.

Dal Lake Restoration

Acknowledging the socio – economic importance of the Lake and grave concern voiced by the people, several proposals have been put forth from time to time. They include Srinagar Master Plan of 1971, Lake Area Master Plan by Stein (1972) ENEX conservation Report (1978), Dal lake Development Report by Riddle (1985), Dal lake conservation Plan (Iram Consultants New Delhi, 1997) and yet another project report of Alternate Hydro – Electric Deptt. University of Roorke (2000).

Some common measures suggested by these reports are :

An effective monitoring mechanism for monitoring the Dal lake conservation Programme which should comprise of eminent Limnologists, researchers, experts who have been associated closely with Dal lake studies during the Lake execution Programme to some international agency/organization well – known for Lake Conservation and management practices.

Prioritization of the works for Dal conservation and completion of jobs on stipulated time frame.

Rehabilitation of Dal dwellers keeping in view their socio–economic conditions.

Effective enactment of laws for encroachments, conservations of open water bodies with floating gardens, land masses.

Restrictions of vegetable gardens, floating gardens, growing of lily pads, Nadru cultivation and demarcation of zones for such activities.

Aeration, oxidation and ozonization of water effected with algal blooms under close scientific monitoring.

Designing of eco – tourism development plan based on carrying capacity of the lake and with proper alignment of houseboats as envisaged in the project.

Scoring out the possibility of Bio–tech. method (Constructed Wetland Treatment Compartments) for wastewater treatment as in vogue in Canada, Italy, US and other European countries.

Devising method for houseboat sanitation through floating septic tank with proper solid – waste management through NGOs and eco – activists.

Awareness campaigns through NGOs and educational institutions and strict adherence to water act 1974.

Marking executing agencies accountable before the monitoring cell body overlooking the Dal conservation program.

Promoting the research and development activities through on line monitoring devices as in Japan.

Cleansing and training of peripheral springs and diversion of their freshwaters to supplement water budgets.

Empowerment of LAWDA.

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