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RESEARCH ARTICLE

Ecological status and PhytoPlanktonic Enumeration of Dal lake , Kashmir.

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Abstract

Dal has been the cradle of Kashmiri civilization from times immemorial. Kashmir, the beautiful state is known as the paradise of India. People have linked the climate of the valley to that Switzerland until the end of May, and of southern France in July and August .Dal is a Himalayan urban lake which is mainly used for tourism. Fishery and agriculture is of secondary importance. It is one of the most beautiful lakes of India and the second largest lake in the State of Jammu and Kashmir. Dal Lake is unique in having hundreds of house boats which afford an opportunity to tourists to reside on the lake in an atmosphere of peace and tranquility. Besides the Moguls gardens and campus of the University of Kashmir is also located along the shores of the lake. Overlooking the lake are two hillocks which house the famous temples of Shankaracharya and Hari Parbat. A perennial inflow channel enters the lake from the north and supplies about 80% of the water. Towards the southwest side an outflow channel drains the lake water into a tributary of the River Jhelum. Parallel to this exit is a stone-lined canal which connects the lake with the tributary. This channel is used for movement of boats in and out of the lake and prevents inundation of floating gardens during high floods. The author intends to give an insight in to the spatiotemporal trends in the tourist flow and changes in the ecology and environment of the lake. The sustainability of the Dal Lake depends on the management and ecotourism

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INTRODUCTION

Dal Lake, an urban valley lake, is situated in the heart of Kashmir valley between 34'5'-34[1]6'N latitude and 74'8'-74'9'E longitude at an altitude of 1586 m. It is probably of fluvial origin having been formed from ox-bows of the River Jhelum. The lake is multi-basined with (i) Hazratbal, (ii) Boddal, (iii) Gagribal, and (iv) Nagin as its four basins**.** The Dal Lake is one of the most attractive fresh water lakes of India. Situated at an altitude of about 1586m above mean sea level, at the foothill of the Zabawan mountain - an offshoot of the Great Himalaya, this north-south

trending shallow water (2.5m deep) lake occupies the north-eastern part of the city of Srinagar. The main sources of water for Dal lake are:

- Telbal Nallah, a large perennial stream draining Dachigam National park to the east of the lake and entering the Hazratbal basin from its northern end.
- Botkol, draining water mainly from the northern and north western catchment, including water distributed by the Sindh Extension Canal, irrigation overflows and oozings in the lower green belt. Besides a number of other small streams, e.g. Meerakshah and Pishpav streamlets, etc. entering the Hazratbal basin.
- Numerous springs arising from the lake bed.
- The outwash from surrounding mountains on the Boddal and Gagribal side. Water flows out of the lake through a weir and lock system at Dalgate.
- Nallah Amir Khan which connects Nagin with Anchar lake via Khushalsar lake, which is now regulated.
- The Brari Numbal cut which is currently under construction.

Material and Methods .

Sampling for the qualitative enumeration of Planktons was carried out by hauling a plankton net through horizontal and vertical directions in the lake at different sampling site. The content collected in the tube attached to the lower end of plankton net were transferred to separate polythene marked tubes. The plankton samples samples were preserved in 4% Formalin. Identification was undertaken under microscope with the help of standard works on the group Edmondson (1975), Abbasi (1998), Hynes (1967), K.L. Sehgat (1983), Wetzel (2000).

Quantitative Enumeration of Individuals:

For quantitative analysis the plankton samples were collected by sieving known volume of lake water (litres) through the plankton net and were preserved with 4% formalin.

Subsequently, the samples were reduced to known volume of 10 ml in a test-tube. At the time of counting, the preserved sample was thoroughly shaken and 1ml of it was withdrawn with a wide mouthed glass pipette into Sedgwick rafter cell and studied under microscope. The whole cell was scanned for different Zooplanktons. The counts were made in triplicate and average of the values was taken to calculate the number of organisms per cubic meter of water by the formula given in AFMA (1995).

$$N = \frac{C \times V_1}{V_2 \times V_3}$$

Where,

C=Average number of organisms counted.

V_1=Volume of concentrated sample, ml.

V_2=Volume of counted sample, ml.

V_3=Volume of the grab sample, per litre.

Discussion:-

Phytoplankton Description:-

Although there are a number of major groups of phytoplankton, those relevant to the present study are Bacillariophyceae, Chlorophyceae, cyanophyceae and Euglenophyceae.

1. Bacillariophyceae (diatoms) is one of the most important groups of phytoplanktonic algae most species are sessile and associated with littoral substrata. Their primary characteristic is sillicified cell walls and both unicellular and colonial forms are common.
2. The chlorophyceae (green algae is an extremely large and morphologically diverse group is mostly fresh water in distribution.
3. The cyanophyceae (also known as Mycophyceae or blue-green algae) has been among the most studied of all the groups. It is a primitive group which has both prokaryotic and eukaryotic features in its cell structure and function.

4. Other algae include different categories among which the Euglenophyceae (euglenoid algae) forms a relatively large and diverse group but few species are truly planktonic.

Analysis and evaluation of seasonal and spatial growth characteristics of phytoplankton are somewhat difficult because of the array of environmental factor involved (Wetzel, 1983). Some important factors regulating growth and succession have been studied in detail by many authors and these are:

(a) Light and temperature (Steeman-Nielsen and Jorgensen, 1968a, 68b).
(b) Buoyancy regulation i.e. means of remaining within the photic zone by alternation of sinking rates (Lund, 1959, 65; Boney, 1981).
(c) Inorganic nutrient (Eppley and Thomas, 1969).
(d) Biological factors, viz. competition, predation etc. (Sagar and masler, 1969; Greeney et.al. 1973; Mallegraeff and Ringelberg, 1978; Tilman, 1980).

Several workers have tackled the problem of distribution and seasonal change in the abudance of phytoplankton; Pearsall (1923-32) was one of the pioneer workers in Europe in this field.

In the present study, members of four major groups have been identified i.e.; Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. These are described as below.

Qualitative Description:

During the present investigations, three main classes of algae i.e., chlorophyceae, Bacillariophyceae and Cyanophyceae were considered in detail and only preliminary studies were conducted with regard to the rest of the algae. A total of 289 phytoplankton algal taxa were identified out of which 129 belongs to chlorophyceae, 110 belongs to Bacilloriophyceae, 33 cyanophyceae and 17 from the other algae. The number of species of each taxa are presented in table 1.1 to 1.5 and detailed list of phytoplankton species observed during the period of investigation is presented in table 1.7 (a).

In general phytoplankton species were found to be relatively abundant in summer months as compared to the winter months when these were poorly represented. During autumn and spring the position was also intermediate.

Among Chlorophyceae most of the species were better represented at the sites S-I, S-II, S-III and S-VIII less so at site S-VI and S-VII.

The members of Volvocales and Chlorococcales were in particular very common at sites S-1, S-II, S-III, S-IV and S-VIII. The most important of these were Panderina morum, Pleodorina Californica, Eudorina elegans, volvox globator, chlorella vulgaris, various species of Ankistrodosmus and selenastrum, various species of Pedistrum especially P.simplex varduodenarium, P.duplex (No. of varieties) and P.araneesum varregulosum and various species of scenedesmus especially S.bijugatus, S.abandans; S.longus var. diaper and S.quadrieauda. At sites S-V and S-VII these species were either very poorly represented or oven totally absent, Further, at site S-VII pediastrum boryanum was very common as compared to the rest of the sites where from it was poorly recorded or even found to be absent.

From the other orders of Chlorphyceae the important species that were particularly very common at sites S-I, S-II, S-III and S-VIII were Ulothrix zonata, stigecelonium tenua, oedogonium crassum, O. mierogonum, various species of spirogyra, Mougeotia sps., Zygnema sphaericum, cosmerium moniliforme. C.botrytis, Euastrm insulare, staurastrum gracile, S.tetracerum and S.radians. At sites S-V and S-VII these species were either very poorly represented or even totally absent except for the species of spirogyra which were equally common at site 1 as at sites S-I, S-II, S-III, S-VI and S-VIII. In contrast to the above mentioned species some of the desmids like cosmarium quadrum, C.tumidum forma inflata, C.binum; C.vensutum f.minus, C.rectangulare, C.subundulatum and staurastrum iotanum were better represented from the sites S-V and S-VII. Some of them were absent from the rest of the sites. Some of the species like Binuclearia tatrana, Uronema elongatum, conatozyon monetanium, Penium cucurbitum and some species of cosmarium were almost equally represented at all the sites.

Like chlorophceae most of the diatoms also were better represented from the sites S-I, S-II, S-III, and S-VIII. The species very common or even abundant at the sites S-I, S-II, S-III, and S-VIII were oscinodiseus sps. Cyclotells operculate, C.comta, Nelosira ereneria, H sranulata N. varians, synedra ulna, S.capitata, Achnanthes exilis, A.microcephala; A.biasolettiena, A.lanceolate, Gomphonema acuminatum ver. Coronata G.constrictum var. capitatum, G.parvulum, G.sracile; Navicula rediosa var. acuta, Epithomia turpida var. granulata, E. argus var. amphicephala, Nitzschia palea N. subtilis, N. subtilis var. paleacea, N. amphibia, N. parvula and Hantzschia amphioxys. At sites S-V and S-VII these species were either very poorly represented or even totally absent.

On the other hand species like Asterionella formosa, Tabellaria flocculosa, Coconeis Placentula, C. pedieulus, Cymbella ventricosa, C. cymbiformis, Gomphonema geminatum, G. subtilis, Mastogloia grevillei, Cymatopleura solea and surirella ovata were better represented at the sites S-V and S-VII oven some of these species being absent from the rest of the sites.

Some of the species like Fragilaria tenuicornis, F. construens, Amphora ovalis, Cymbella tumida, C.cistula, C.affinis, C.laevis, C.Lanceclata, Encyoneme caespitosum, Comphonema constrictum var. curte, Navicula radiosa and Rhopalodia gibba were almost equally represented at all the sites.

From the class cyanophyceae almost all the species had better representation at the sites S-I, S-II, S-III, and S-VIII. The important species were chrococcus turgidus Synechocystis pevalekii Aphanecapsa biformis, Hicrocyatis acruginosa, M.aeruginosa, F.ophaerodictycides, M.Robusta, M.elebans, Merismopedia glauca, oscillatoria linosa, O.ornata var. crassa, O.princeps, Spirulina gigantea, Phormidum ambiguum, Anabacena constricta, A. circinalis, Aphanizomenon flosaquae and calothrix sps. These species were poorly represented at sites S-V and S-VII.

From the rest of the algae Trachelomonas armata, Botryococcus Braunii, Tribonema sps. Bumilleria Klebsiana, Phacus acuminata, Phacus trioueter and various species of Euglena especially Euglena acus are the important species that were very common at sites S-I, S-II, S-III, and S-VIII as compared to the rest of the sites where from whenever recorded these were present in traces. On the other hand some species like Glenodium sps. Peridinium intermedium. P.anglicum had better representation at sites S-V and S-VII.

Quantitative Description:

In general the peak period of total phytoplankton was recorded in summer (particularly in June) with secondary peak in October; while the depression was observed from January to March throughout the area under study. The class wise studies revealed that Chlorophyceae and Bacillariophyeeae also had their peak periods in June with secondary peak in Octobers in case of Chlorophyecea and from September to November in case of Bacillariophceae. Cyanophyceae and other algae had their peak periods from July to November and June to August respectively with secondary peak in October in case of the other algae. The depression period was observed from January to April in case of the other algae. The depression period was observed from January to April in case of Cyanophyceae and in January and February in case of Chlorophyceae, Bacillariophceae and other algae.

While studying the vertical distribution of phytoplankton higher populations per unit volume were almost always observed in bottom waters as compared to the surface waters except in May 2009 when higher populations in surface waters were recorded at site S-VII. The difference in the density of populations at different sites ranged from 115 cells/ cc at site S-VII in February 2009 to 9355 cells/ cc at site S-II in November 2009.

With regard to the density of total phytoplankton at individual sites it was observed that the site S-I, S-II, S-III and S-VIII were always taking the lead with a maximum population of 20615 cells/ cc at site S-II in October, 2009 and minimum population of 2705 cells/ cc at site S-VII in January, 2009 on the other hand least densities were throughout recorded at the site S-VII with a maximum population of 6375 cells/ cc. The results recorded at site S-IV, S-V and S-VI where always found to be intermediate between the above two types of sites Here a maximum population of 13840 cells\cc was recorded at site S-V in June 2009 and a minimum population of 5190 cells/ cc at site S-VI in January 2009.

The classes wise populations also followed the same trend with the highest densities of all the three classes viz. Chlorophyeae Bacillariophyeae and Cyanophyeae recorded from to sites S-I, S-II, S-III, S-IV and S-VIII the lowest ones from the sites S-V and S-VII with site S-VI figuring in between.

From the sites S-I, S-II, S-III, S-IV and S-VIII the maximum populations of Chlorophyceae of 6505 cells/ cc was recorded at site S-II in October that of Bacillaeriophycea of 9355 cells/ cc at site S-II in November and that of Cyanophyeae of 5070 cells/cc at site S-II in October. At these sites the minimum populations of Chlorophyceae 400 cells/ cc and Bacillariophyeeae of 1800 cells/ cc at site S-IV in January and that of Cyanophyceae of 270 cells/ cc at the site S-V again in January.

No definite pattern with regard to the population density at the various sites was observed in case of other algae. However the maximum population of 1450 cells/ cc at sites S-II in August and the minimum Population of 115 cells/ cc at site S-VII in February were recorded respectively.

Population Dynamics:

On relative basis the highest percentage of different phytoplankton groups recorded was Bacillariophyceae 86.34% at site S-VI in summer, Chlorophyceae 31.51% at site S-V in spring, Cynophyceae 33.92% at site S-V in autumn and other algae 11.83% at site S-VII in summer. The least percentage of these groups were recorded Bacillariophyceae 38.95% at site S-VIII in summer, Cholorophyceae 1.5% at site S-VI in summer, Cynophyceae 5.37% at site S-VI in summer and other Algae 1.99% at site S-VI in summer.

Bacillariophyceae:

Bacillariophyceae formed the largest group among phytoplankton and on an average it contributed 48.06% to the total number of population. The population of the group fluctuated from 1800 ind/l in august at site S-VII to 9355

ind/l in November at site S-II. The highest average value for Bacillariophyceae was recorded 60.67% in winter while as lowest average was recored 45.96% in autumn.

Chlorophyceae:

Chlorophyceae formed the second largest group among Phytoplankton during the present investigation and contributed on an average 23.80% to the total population. The population of the group fluctuated from 400 in Jan. at site S-VII to 6315 in June at site II. The highest average value for chlorophyceae was recored 27.67% in spring while as lowest average was recorded 17.72% in winter.

Cyanophyceae:

Cyanophyceae formed the third largest group among Phytoplankton during the present investigation and contributed 22.48% to the total population. The population of the group fluctuated from 270 in January at site S-V to 5070 in October at site S-II. The average maximum value was recorded 27.69% in autumn while as average minimum value was recorded 15.58% in spring.

Conculsion :

Unfortunately, the past remedial measures to ameliorate the lake environs, advocated by the planners and decision makers for the Dal Lake's revival, have mainly focused on engineering practices, unplanned tourism development and sometimes unscientific practices and have therefore met no evident success.

To ameliorate the lake condition, it is imperative to generate the credible up- to- date information about the present and past status of the biophysical aspects of the environment in the entire catchment. The improved understanding of the resources at landscape level shall strengthen our abilities to understand and quantify the cause- effect relationships.

It is finally concluded that to restore and maintain the glory and ecology of the Dal Lake and its catchment an integrated ecological, engineering and participatory approaches need to be adopted. Raising and managing community plantations, executing engineering works, eco-friendly tourism activities, promotion of civic sense and securing the land boundaries can be visualized for accomplishing the objectives.

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TABLE 1.1 - SHOWING MONTHLY FLUCTUATION IN "Cholorophyceae Density" (ind/lt) AT SELECTED SITES OF DAL LAKE IN 2009

MONTH	S-I	S-II	S-III	S-IV	S-V	S-VI	S-VII	S-VIII	TOTAL	RANGE		DIFFERENCE	MONTHLY MEAN
JAN	1415	1390	1100	1060	835	890	**400**	800	**7890**	**400.00**	**1415.00**	**1015.00**	1,795.63±2,478.85
FEB	1500	1480	1275	1270	1205	1105	500	1090	**9425**	**500.00**	**1500.00**	**1000.00**	2,168.75±2,945.77
MAR	1395	1460	2270	2020	2290	1085	535	1086	**12141**	**535.00**	**2290.00**	**1755.00**	2,860.88±3,801.86
APR	2515	2535	2365	2300	2435	2050	900	2115	**17215**	**900.00**	**2535.00**	**1635.00**	3,989.38±5,368.69
MAY	2530	2690	2335	2403	2400	2200	1395	2165	**18118**	**1395.00**	**2690.00**	**1295.00**	4,213.25±5,630.86

JUN		5500	6315	5535	4015	4290	4815	1715	5490	**37675**	**1715.00**	**6315.00**	**4600.00**	8,731.25±11,776.69
JUL		2745	3000	2605	2605	2700	2455	1100	2380	**19590**	**1100.00**	**3000.00**	**1900.00**	4,554.38±6,101.44
AUG		2700	2940	2700	2665	2800	2500	1200	2500	**20005**	**1200.00**	**2940.00**	**1740.00**	4,663.75±6,222.21
SEP		3600	4605	3265	2390	2460	2355	1195	1890	**21760**	**1195.00**	**4605.00**	**3410.00**	4,990.00±6,850.16
OCT		5380	**6505**	5370	3095	3490	3755	1235	5275	**34105**	**1235.00**	**6505.00**	**5270.00**	7,853.75±10,730.88
NOV		1900	2085	1556	1200	1635	1590	810	1990	**12766**	**810.00**	**2085.00**	**1275.00**	2,954.00±3,985.47
DEC		1485	1760	1670	1270	1665	1645	515	1785	**11795**	**515.00**	**1785.00**	**1270.00**	2,763.13±3,673.70
TOTAL		**32665**	**36765**	**32046**	**26293**	**28205**	**26445**	**11500**	**28566**	**222485**	**11500**	**37665**	**26165**	**1795.63**
RANGE	**Min**	**1395.00**	**1390.00**	**1100.00**	**1060.00**	**835.00**	**890.00**	**400.00**	**800.00**	**7870**	**400.00**	**1415.00**	**1000.00**	**2168.75**
	Max	**5500.00**	**6505.00**	**5535.00**	**4015.00**	**4290.00**	**4815.00**	**1715.00**	**5490.00**	**37865**	**1715.00**	**6505.00**	**5270.00**	**8731.25**
DIFFERENCE		**4105.00**	**5115.00**	**4435.00**	**2955.00**	**3455.00**	**3925.00**	**1315.00**	**4690.00**	**29995**	**1315.00**	**5090.00**	**4270.00**	**6562.50**
SITE MEAN		**2722.08**	**3063.75**	**2670.50**	**2191.08**	**2350.42**	**2203.75**	**958.33**	**2380.50**	**18540**	**958.33**	**3138.75**	**2180.42**	**4145.21**

TABLE 1.2 - SHOWING MONTHLY FLUCTUATION IN "Bacillariophyceae Density" (ind/lt) AT SELECTED SITES OF DAL LAKE IN 2009

MONTH	S-I	S-II	S-III	S-IV	S-V	S-VI	S-VII	S-VIII	TOTAL	RANGE		DIFFERENCE	MONTHLY MEAN
JAN	3820	3990	4205	3400	3515	3200	1915	3600	**27645**	**1915.00**	**4205.00**	**2290.00**	6,433.75±8,598.05
FEB	4000	4015	4315	3985	4000	3700	2095	4005	**30115**	**2095.00**	**4315.00**	**2220.00**	7,028.75±9,353.57
MAR	3985	4065	4270	3915	3915	3695	2135	3900	**29880**	**2135.00**	**4270.00**	**2135.00**	6,971.88±9,279.71
APR	4015	4115	4015	3765	3605	3400	2105	3865	**28885**	**2105.00**	**4115.00**	**2010.00**	6,719.38±8,978.52
MAY	4415	4500	4300	3805	3745	3615	1900	3905	**30185**	**1900.00**	**4500.00**	**2600.00**	6,994.38±9,403.15
JUN	9015	8915	8515	6775	6535	5695	2905	6300	**54655**	**2905.00**	**9015.00**	**6110.00**	12,536.88±17,116.97
JUL	5460	5860	5170	4120	4200	4200	2000	4005	**35015**	**2000.00**	**5860.00**	**3860.00**	8,071.25±10,943.05
AUG	3985	4305	3800	3500	3600	3485	**1800**	3500	**27975**	**1800.00**	**4305.00**	**2505.00**	6,495.63±8,708.56

SEP	6270	7595	6850	4385	4055	3510	2975	3500	**39140**	**2975.00**	**7595.00**	**4620.00**	9,001.25±12,290.87
OCT	7305	8190	7745	6030	5005	5300	2750	6360	**48685**	**2750.00**	**8190.00**	**5440.00**	11,258.13±15,216.72
NOV	7970	**9355**	7240	4670	6065	6185	3285	6805	**51575**	**3285.00**	**9355.00**	**6070.00**	11,897.50±16,130.97
DEC	6860	7640	6815	4190	5470	5895	2805	5795	**45470**	**2805.00**	**7640.00**	**4835.00**	10,510.00±14,204.29
TOTAL		**67100**	**72545**	**67240**	**52540**	**53710**	**51880**	**28670**	**55540**	**449225**	**28670**	**73365**	**44695**	**6433.75**
RANGE	**Min**	**3820.00**	**3990.00**	**3800.00**	**3400.00**	**3515.00**	**3200.00**	**1800.00**	**3500.00**	**27025**	**1800.00**	**4115.00**	**2010.00**	**6495.63**
	Max	**9015.00**	**9355.00**	**8515.00**	**6775.00**	**6535.00**	**6185.00**	**3285.00**	**6805.00**	**56470**	**3285.00**	**9355.00**	**6110.00**	**12536.88**
DIFFERENCE		**5195.00**	**5365.00**	**4715.00**	**3375.00**	**3020.00**	**2985.00**	**1485.00**	**3305.00**	**29445**	**1485.00**	**5240.00**	**4100.00**	**6041.25**
SITE MEAN		**5591.67**	**6045.42**	**5603.33**	**4378.33**	**4475.83**	**4323.33**	**2389.17**	**4628.33**	**37435**	**2389.17**	**6113.75**	**3724.58**	**8123.75**

TABLE 1.3 - SHOWING MONTHLY FLUCTUATION IN "Cyanophyceae Density" (ind/lt) AT SELECTED SITES OF DAL LAKE IN 2009

MONTH	S-I	S-II	S-III	S-IV	S-V	S-VI	S-VII	S-VIII	TOTAL	RANGE		DIFFERENCE	MONTHLY MEAN
JAN	1570	1680	1550	715	790	800	**270**	900	**8275**	**270.00**	**1680.00**	**1410.00**	1,872.50±2,627.02
FEB	1435	1570	1255	970	990	1100	600	1200	9120	600.00	1570.00	970.00	2,100.63±2,849.67
MAR	1335	1495	1370	1005	1200	1005	615	1195	**9220**	**615.00**	**1495.00**	**880.00**	2,138.13±2,873.87
APR	1300	1315	970	845	800	815	500	795	**7340**	**500.00**	**1315.00**	**815.00**	1,672.50±2,301.18
MAY	1500	1615	1485	1315	1295	1100	615	1200	**10125**	**615.00**	**1615.00**	**1000.00**	2,343.75±3,158.17
JUN	2300	2985	2490	2000	2215	2415	1070	2100	**17575**	**1070.00**	**2985.00**	**1915.00**	4,106.25±5,469.32
JUL	2605	3415	2915	2785	3000	3000	1315	3000	**22035**	**1315.00**	**3415.00**	**2100.00**	5,183.13±6,837.58
AUG	2690	3400	2935	2615	2900	2915	1315	2905	**21675**	**1315.00**	**3400.00**	**2085.00**	5,082.50±6,732.00
SEP	4600	4695	4495	2995	4395	3940	2015	3920	**31055**	**2015.00**	**4695.00**	**2680.00**	7,188.75±9,684.10
OCT	3510	**5070**	4485	3110	4005	3195	1280	4075	**28730**	**1280.00**	**5070.00**	**3790.00**	6,743.75±8,956.82
NOV	3075	3400	3765	2470	4030	3425	1175	4005	**25345**	**1175.00**	**4030.00**	**2855.00**	5,951.88±7,893.93

DEC		2670	2920	2760	2145	2570	2450	1040	3075	**19630**	**10400**	**30750**	**2035.00**	4,573.75±6,116.41
TOTAL		**28590**	**33560**	**30475**	**22970**	**28190**	**26160**	**11810**	**28370**	**210125**	**11810**	**34345**	**22535**	**1672.50**
RANGE	**Min**	**1300.00**	**1315.00**	**970.00**	**715.00**	**790.00**	**800.00**	**270.00**	**795.00**	**6955**	**270.00**	**1315.00**	**815.00**	**1672.50**
	Max	**4600.00**	**5070.00**	**4495.00**	**3110.00**	**4395.00**	**3940.00**	**2015.00**	**4075.00**	**31700**	**2015.00**	**5070.00**	**3790.00**	**7188.75**
DIFFERENCE		**3300.00**	**3755.00**	**3525.00**	**2395.00**	**3605.00**	**3140.00**	**1745.00**	**3280.00**	**24745**	**1745.00**	**3755.00**	**2975.00**	**5516.25**
SITE MEAN		**2382.50**	**2796.67**	**2539.58**	**1914.17**	**2349.17**	**2180.00**	**984.17**	**2364.17**	**17510**	**984.17**	**2862.08**	**1877.92**	**3923.75**

TABLE 1.4 - SHOWING MONTHLY FLUCTUATION IN "Other Algae Density" (ind/lt) AT SELECTED SITES OF DAL LAKE IN 2009

MONTH	**S-I**	**S-II**	**S-III**	**S-IV**	**S-V**	**S-VI**	**S-VII**	**S-VIII**	**TOTAL**	**RANGE**		**DIFFERENCE**	**MONTHLY MEAN**
JAN	200	305	285	200	275	300	120	285	**1970**	**120.00**	**305.00**	**185.00**	467.50±610.38
FEB	215	285	250	235	250	280	**115**	235	**1865**	**115.00**	**285.00**	**170.00**	439.38±578.44
MAR	200	375	370	405	415	500	270	415	**2950**	**200.00**	**500.00**	**300.00**	712.50±906.34
APR	295	355	275	245	270	300	150	380	**2270**	**150.00**	**380.00**	**230.00**	530.63±701.4
MAY	205	315	260	240	245	300	165	300	**2030**	**165.00**	**315.00**	**150.00**	481.88±627.35
JUN	900	1115	915	850	800	885	595	986	**7046**	**595.00**	**1115.00**	**520.00**	1,649.00±2,185.83
JUL	1135	1375	1200	1035	1100	1105	700	1100	**8750**	**700.00**	**1375.00**	**675.00**	2,045.63±2,715.53
AUG	1185	**1450**	1405	1160	1200	1100	640	1175	**9315**	**640.00**	**1450.00**	**810.00**	2,180.63±2,893.11
SEP	450	910	650	325	240	1030	190	290	**4085**	**190.00**	**1030.00**	**840.00**	965.00±1,300.13
OCT	805	850	765	670	700	790	200	410	**5190**	**200.00**	**850.00**	**650.00**	1,196.88±1,628.09
NOV	435	515	565	440	560	610	195	605	**3925**	**195.00**	**610.00**	**415.00**	926.88±1,218.94
DEC	310	495	390	340	500	595	250	575	**3455**	**250.00**	**595.00**	**345.00**	825.00±1,069.17
TOTAL	**6335**	**8345**	**7330**	**6145**	**6555**	**7795**	**3590**	**6756**	**52851**	**3520**	**8810**	**5290**	**439.38**
RANG	**Min**	**200.00**	**285.00**	**250.00**	**200.00**	**240.00**	**280.00**	**115.00**	**235.00**	**1805**	**115.00**	**285.00**	**150.00**	**439.38**

E	**Max**	**1185.00**	**1450.00**	**1405.00**	**1160.00**	**1200.00**	**1105.00**	**700.00**	**1175.00**	**9380**	**700.00**	**1450.00**	**840.00**	**2180.63**
DIFFERENCE		**985.00**	**1165.00**	**1155.00**	**960.00**	**960.00**	**825.00**	**585.00**	**940.00**	**7575**	**585.00**	**1165.00**	**690.00**	**1741.25**
SITE MEAN		**527.92**	**695.42**	**610.83**	**512.08**	**546.25**	**649.58**	**299.17**	**563.00**	**4404**	**293.33**	**734.17**	**440.83**	**996.11**

TABLE 1.5 - SHOWING MONTHLY FLUCTUATION IN "Total Phytoplankton Density" (ind/lt) AT SELECTED SITES OF DAL LAKE IN 2009

MONTH	S-I	S-II	S-III	S-IV	S-V	S-VI	S-VII	S-VIII	TOTAL	RANGE		DIFFERENCE	MONTHLY MEAN
JAN	7005	7365	7140	5375	5415	5190	**2705**	5585	**45780**	**2705.00**	**7365.00**	**4660.00**	10,569.38 ±14,297.83
FEB	7150	7350	7095	6460	6445	6185	3310	6530	**50525**	**3310.00**	**7350.00**	**4040.00**	11,737.50 ±15,721.26
MAR	6915	7395	8280	7345	7820	6285	3555	6596	**54191**	**3555.00**	**8280.00**	**4725.00**	12,683.38 ±16,834.12
APR	8125	8320	7625	7155	7110	6565	3655	7155	**55710**	**3655.00**	**8320.00**	**4665.00**	12,911.88 ±17,347.84
MAY	8650	9120	8380	7763	7685	7215	4075	7570	**60458**	**4075.00**	**9120.00**	**5045.00**	14,033.25 ±18,816.41
JUN	17715	19330	17455	13640	13840	13810	6285	14876	**116951**	**6285.00**	**19330.00**	**13045.00**	27,023.38 ±36,533.48
JUL	11945	13650	11890	10545	11000	10760	5115	10485	**85390**	**5115.00**	**13650.00**	**8535.00**	19,854.38 ±26,591.22
AUG	10560	12095	10840	9940	10500	10000	4955	10080	**78970**	**4955.00**	**12095.00**	**7140.00**	18,422.50 ±24,553.61
SEP	14920	17805	15260	10095	11150	10835	6375	9600	**96040**	**6375.00**	**17805.00**	**11430.00**	22,145.00 ±30,063.71
OCT	17000	**20615**	18365	12905	13200	13040	5465	16120	**116710**	**5465.00**	**20615.00**	**15150.00**	27,052.50 ±36,506.98
NOV	13380	15355	13126	8780	12290	11810	5465	13405	**93611**	**5465.00**	**15355.00**	**9890.00**	21,730.25 ±29,205.25
DEC	11325	12815	11635	7945	10205	10585	4610	11230	**80350**	**4610.00**	**12815.00**	**8205.00**	18,671.88 ±25,052.18

TOTAL		**134690**	**151215**	**137091**	**107948**	**116660**	**112280**	**55570**	**119232**	**934686**	**55570**	**152100**	**96530**	**10569.38**
RANGE	**Min**	**6915.00**	**7350.00**	**7095.00**	**5375.00**	**5415.00**	**5190.00**	**2705.00**	**5585.00**	**45630**	**2705.00**	**7350.00**	**4040.00**	**11737.50**
	Max	**17715.00**	**20615.00**	**18365.00**	**13640.00**	**13840.00**	**13810.00**	**6375.00**	**16120.00**	**120480**	**6375.00**	**20615.00**	**15150.00**	**27052.50**
DIFFERENCE		**10800.00**	**13265.00**	**11270.00**	**8265.00**	**8425.00**	**8620.00**	**3670.00**	**10535.00**	**74850**	**3670.00**	**13265.00**	**11110.00**	**15315.00**
SITE MEAN		**11224.17**	**12601.25**	**11424.25**	**8995.67**	**9721.67**	**9356.67**	**4630.83**	**9936.00**	**77891**	**4630.83**	**12675.00**	**8044.17**	**17188.82**

TABLE 1.6 - PRESENTS MEAN PERCENTAGE OF DIFFERENT PHYTOPLANKTON GROUPS, SEASON WISE

	WINTER				SPRING				SUMMER				AUTUMN			
	MEAN FOR JANUARY & FEBRUARY				MEAN FOR MARCH, APRIL & MAY				MEAN FOR JUNE, JULY & AUGUST				MEAN FOR SEPTEMBER, OCTOBER & NOVEMBER			
SITES	CHLOROPHYCEAE	BACILLARIOPHYCEAE	CYANOPHYCEAE	OTHER ALGAE	CHLOROPHYCEAE	BACILLARIOPHYCEAE	CYANOPHYCEAE	OTHER ALGAE	CHLOROPHYCEAE	BACILLARIOPHYCEAE	CYANOPHYCEAE	OTHER ALGAE	CHLOROPHYCEAE	BACILLARIOPHYCEAE	CYANOPHYCEAE	OTHER ALGAE
S-I	20.59	55.25	21.23	2.93	27.18	52.41	17.45	2.95	27.21	45.90	18.88	8.01	24.02	47.56	24.69	3.73
S-II	19.50	54.40	22.09	4.01	26.92	51.06	17.82	4.21	27.19	42.33	21.74	8.74	24.54	46.75	24.48	4.23
S-III	16.68	59.85	19.70	3.76	28.70	51.82	15.75	3.73	26.98	43.51	20.75	8.76	21.80	46.70	27.26	4.24
S-IV	19.69	62.40	14.24	3.68	30.20	51.59	14.22	4.00	27.21	42.18	21.68	8.92	21.59	48.72	25.05	4.63
S-V	17.20	63.36	15.01	4.43	31.51	49.81	14.57	4.11	27.70	40.56	22.96	8.77	20.70	41.28	33.92	4.09
S-VI	17.54	60.66	16.70	5.10	26.59	53.38	14.55	5.48	1.5	86.34	5.37	1.99	21.58	42.02	29.59	6.81
S-VII	14.96	66.67	14.46	3.91	25.08	54.41	15.33	5.18	24.55	41.00	22.62	11.83	18.72	52.07	25.83	3.38
-VIII	15.60	62.77	17.33	4.29	25.17	54.73	14.96	5.14	29.26	38.95	22.59	9.20	23.40	42.59	30.67	3.34
OTAL	**141.77**	**485.36**	**140.77**	**32.10**	**221.34**	**419.21**	**124.65**	**34.80**	**196.39**	**380.77**	**156.61**	**66.23**	**176.35**	**367.70**	**221.50**	**34.45**
IEAN	**17.72**	**60.67**	**17.60**	**4.01**	**27.67**	**52.40**	**15.58**	**4.35**	**24.55**	**47.60**	**19.58**	**8.28**	**22.04**	**45.96**	**27.69**	**4.31**

Table : 1.7(a) Present List of Phytoplankton Species Observed During the Period of Investigation

Chlorophyceae:

Panderina morum (Muller) Bory, Plcodorina californica shaw, Eudorina elegans Ehrenb, Volvox globator (L.) Ehrenb, V. mononad Smith, Palmodictyon viridi kuetz, Sehrcederia planctonica (skuja) comb. Chlorella vulgaris Beijerinck, Tetraedron minimum (A. Br. Hansg.), T. hastatum (Reinsch) Hansg, Oocystis solitaria wittr, C. elliptica N.west, O. Irregularis (Petkof) Print, Ankistrodesmus convolutus (corda), A. spirelis (Turner) Lemm, A. falcatus (corda) Ralfs, A. Fatcatus (corda) Ralfs var, A. falcatus (corda) Ralfs var. radiatus (chod.), Selenestrum westii G.M. smith, S. gracile Reinsch, S. bibralanum Reinsch, Pediastrum simplex meyen, P. simplex Meyen var. duodenarium (Bailey) Rabenh, P. duplex Meyen var. gracillimum W & G.S. west, P. duplex Meyen var. genuinum (A.Br.) Hensg, P. duplex Meyen var. subgranulatum Raciberski, P. duplex Meyen var. clathratum (A.Br.) Lagerh, P. duplex Meyen var. coronatum Racib, P. duplex Meyen var. reticulatum Lagerh, P. boryanum (Turpin) Menegh , P. boryanum (Turpin) Menegh. Var. longicorne Reinsch, P. tetras (Ehr.) Ralfs, P. tetras (Ehr.) Ralfs Var. exicum (Rabenh.) Hansg, P. tetras (Ehr.) Ralfs. Var. tetraedron (corda) Hansg, P. araneosum (Racib) Racib var. regulosum (G.S. west) G.M. smith, P. angulosum (Ehr.) Menegh. var. laevigatum Racidb, P. ovatum (Ehr.) A. Br, Coelastrum microporum Naegeli, C. cambricum Archer var. intermedium (Bohlin)G.S. west, C. cambricum Archer var. intermedium (Bohlin) G.S. West, Scene desmus obliquus (Turp.) Kuatz, S. dimorphus (Turp.) Kuetz, S. bijugatus (Turp.) Kuetz, S. Denticulaluslagerh, S. abundans (Kirchner) chod, S. armatus (chod.) G.M. smith var. bicaudatus (Guglielmetti) chodat, S. areuatus (Lemm.) Lemm., S. longus Meyen var. dispar (Breb.) G.M. smith, S. longus Meyen var. naegelii (Breb.), S. quadricauda (Turp.) Breb, S. quedricauds (Turp.) Breb. var. westii G.M. smith, S. quadricnuda (Turp.) Breb. var. longispina (chod.) G.M. smith, S. quadricauda (Turp.) Breb. var. auadrispina (chod.) G. M. Smith, S. qusdricauda (Turp.) Ereb. var. bicaudatus Hensg, B. quadlaminata Joa, Crucigenia crucifera (Wolle) collins, Binuelearia tatrana wittr, Horaidium subtile (Kuetz. Heering), Ulothrix subtilissima Rab, U. rorida Thuret, U. zonata Kuetz, U. onema elongatum Hodgetta, Microspora tumidula Hagen, M. amoena (Kuetz.) Lagerh, Sphaeroplea sps. Agardh, Cladophora sps. Kuetz, Stigeoclonium tenua Rabenh, Aphancchaete repens A. Br., Protoderma viridi Kuetz, Oedogonium orassum (Hass. Wittr.), O. concatenatum (Hass.)Wittr., O. excavatum Joa., O. microgonum, Bulbochaete intermedium De Bary, Cylindrocystis Brebisaonii Menegh, Spirogyra hyalina cleve, S. jacense Rhandhawa, S. ouedrilaminate Joa, S. manoramae, Mougectis sps. Agardh, M. maltae skuja, Zygnema kashmirense misra, Z. sphaericum Misra, Gonatozygon monotanium De Bary, Penium cucurbitum Biss., P. polymorphum Perty, Closterium kutsingii Breb, C. ehronbergii Menegh, C. praelongum Breb. var. brevine west &West, Cosmarium tetreopthalmum Bred, C. quadrum Lund, C. quinarium Lundell, C. granetum Breb, C. subeostatum Nordst, C. tumidum forma inflata schmidle, C. margaritatum (Lund.) Roy & Biss., C. scopulorum Borge, C. scabrum Turn, C. binum Nordst, C. reniforme (Ralfs.) Areg., C. impressulum Elfv., C. moniliforme (Turp.) Relfs, C. circulare Reinsch fa, C. bioculatum Breb, C. punetulatum Breb, C. nitidulum De Not, C. norimbergense fa. depresse west et wet., C. vensutum (Breb.) Arch. F. minus wille, C. schliephackeanum Grun, C. schliephackeanus Grun, C. botrytis (Bory) Monegh, C. subundulatum wille, Euastrum insulare (Wittr.) Hoy., E. subtrilobullatum Forest, E. bidentatum Naeg, E. bidentatum var. speciosum (Boldt.) schmidle, Pleurotaenium simplicissimum Grondbled, Spondylosium planum (Wolle.) West & West, Spondylosium hexacerum (Ehr.) wittr, Xanthidium antilopaoum Kuetz, Staurastrum gracile Ralfs, S. cytocerum Breb, S. iotanum wolle, S. tetracarum Ralfs, S. unicorne Turn, S. nodulosum Presectt, S. muticum Breb, S. trihastiforum G.M. smith, S. radians west & west.

Bacillariophyceae:

Coscinodisous sps. Ehrenberg, Cyelotells operculata Kuets, C. comta Ehr. (Kuets.), C.

menerhiniana Kuetz, Melosira arenaria Moore, M. granulata (Ehr.) Rlafs, M. varians Ag., Asterionella formosa Hassall, Ceratoneis arcus (Ehr.) Kuetz, Diatoma vilgare Bory, Fragilaria tenuicornis Heib, F. construens (Ehr.) Grunow, F. construens (Ehr.) Grun. var. venter, Meridion circulare (Grev.) Ag., Synedra ulna (Nitzsch) Ehr., S. capitata Ehr., S. pulchella (Ralfs.) Kuetz., S. acus (Kuetz.) Grun, Tabellaria flocculosa (Roth.) Kuetz, T. fenestrata (Lyngb.) Kuetz, Eunotia arcus Ehr., E. pectinalis (Dillw.) Rabh, E. Praerupta Ehr., E. gracilis (Ehr.) Racib, Achnanthes exilis Kuetz, A. microcenphala Kuetz, A. microcephala Kuetz. var. typica A. Cl., A. biasolettiana Grun., A. lanceolata Bred. var. dubia, Coconeis placentula Ehr., C. pediculus Ehr., Rhoicosphenia curvata (Kuetz.) Grun., Amphipleura pellucida Kuetz. (Kuetz.), Amphora ovalis (Kuetz.) Kuetz, A. ovalis Kuetz. var. pediculus Kuetz, A. ovalis Kuetz, var. affinis Kuetz, Cymbella tumida Breb, C. ventricoaa Kuetz, C. gastroides Kuetz, C. gastroides Kuetz, Var. minor, C. cistula Hempr, C. cistula Hempr. var. maculata, C. cuspidata Kuetz, C. affinis Kuetz, C. laevis Naeg, C. lanceolata Ehr., C. aspera (Ehr.) 01, C. ehrenbergii Kuetz, C. leptoceros Kuetz, C. obtusa Greg, C. Helvetica Kuetz, C. cymbiformis (Kuetz.) Van Heurck, Encyonema prostratum Ralfs, E. Caespitosum Kuetz, Gomphonema acuminatum Ehr, G. accuminatum var. coronata (Ehr.) wm. smith, G. acuminatum var. Brebisson (Kuets.) cleve, G. constrictum Ehr., G. constrietum var. capitatum Ehr., G. constrictum var. curta (Ehr.) van Heurck, G. montanum var. commutatum sehumann (Grun.), G. subapicatum Fritsch & Rich, G. angustatum Kuetz, G. augur Ehr., G. augur Ehr. var. genuinum Mayen, G. augur var. Gautieri (Ehr.) van Heurek, G. olivaceum Kuetz, G. parvulum Kuetz, G. lanceolatum forma turris (Ehr.) Hust., G. intricatum Kuetz, G. geminatum (Lyngb.) Ag., G. subtilis Ehr., G. gracile Ehr., Mastogloia grevillei Wm. Sm., Navicula ambigua Ehr., N. cuspidata Kuetz, N. cuspidata var. halophila (Kuetz) Grun., N. oculata Breb., N. brevis Greg., N. radioss Kuetz, N. radiesa var. acuta (Kuetz.) Van Nerek Heurck, N. radiosa var. tenella (Kuetz.) Van Man Heurck, N. peregrina (Ehr.) Kuetz. var. menisculus Schum., N. gibba Kuetz., N. capitata Ehr., N. cryptooephala Kuetz., N. dieephala Wm. Sm., Pinnularia acrospaeria Preb., P. viridis var. genuina A. Cl., Pleuresigma scalproides Rab., Stauroneis phoenicentron (Nitzsch) Khr., S. anceps var. amphicelphala (Ehr.) van Heurck, Epithemia turgida (Ehr.) Kuetz., E. turgida (Ehr.) Kuetz. var. granulata van Heurck, E. sorex Kuetz., E. Argus Kuetz. var. amphicephala Grun., Rhopalodia gibba (Ehr.) O. Muller., R. gibba (Ehr.) O. Mueller var. ventricosa (Kuetz.) Grun., Nitzschia palea (Kuetz.) Wm. Sm., N. subtilis Grun., N. subtilis Grun. var. paleacea Grun., N. satagnorum Rab., N. amphibia Grun., N. sigma W. Sm. var. rigidula Grun., N. clausii Hantzsch., N. parvula Lewis, Hantzschia amphioxys (Ehr.) Grun. var. pusilla Dippel, Cymatopleura solea (Breb.) W. smith, Surirella ovata kuetz., S. ovata Kuetz. var. pinneta (W.smith) Hust.

Cyanophyceae:

Chroococcus turgidus (Kuetz.) Naeg., C. minutus (Kuetz.) Naeg., C. dispersus (Keissler) Lemm., C. monatus Hansg. var. hyalinus Roa., Synechocystis pevalekii Erceg., Aphanccapsa bifrormis A. Br., Microcystis aeruginosa Kuetz., M. aeruginosa f. sphaerodictyoides Elekin, N. robusta (Clark) Mygaard, M. pseudefilamentous Crow., M. elebans (Breb.) kuetz., Aphanotheca stagnina (spreng.) A. Br., Merismopedia punctata Meyen, M. convoluta Breb., M. glauca (Ehrenb.) Naeg., Coelosphaerim kuetzingianum Naeg., Gomphosphaeria lacustris Chodat., Oscillatoria limosa Ag., O. ornsta Kuetz. oz. Gomont var. crassa Roa, O. annae van goor, O. princeps Vaucher ox Gomont, Spirulina gigantea Schmidle., Phormidium amibiguum Gomont, Lyngbya palmatum Bruhl et Biawas, L. hieronymusii Lemm., Anabaena constricta (Ssafer) Geitl., A. circinalis (Kuetz.) Rab., A. anomala Fritsch, A. fertilissima Roa., Aphanizomenon flosaguae (L.) Ralfs., Cylindrospermm schaerica Prasad, Calothrix sps. Agardh, Glectrichia sps.Agardh

Other Algae:

Dinobryon sertularia Ehrenb., Cryptomonas sps. Ehr., Glenodinium sps. Stein, Peridinium umbocatum, P. intermidium Thomson, P. anglicum West, Ceratium hirundinella (O.P.M.) Schrank, Euglena acus Ehr., E. spirogyra Ehr., E. truncata Walton var. baculifera Thompson, E. acutisima Lemm., Phacus acuminata stokes, P. triqueter (Ehr.) Duj., Trachelomonas armata (Ehr.) stein, Botryococcus Braunii Kuetz., Tribenema sps., Bumilleria klebsiana pascher

FIGURE 1.2 - MONTHLY FLUCTUATION IN "BACILLARIOPHYCEAE DENSITY" (ind/lt) AT SELECTED SITES OF DAL LAKE '2009'

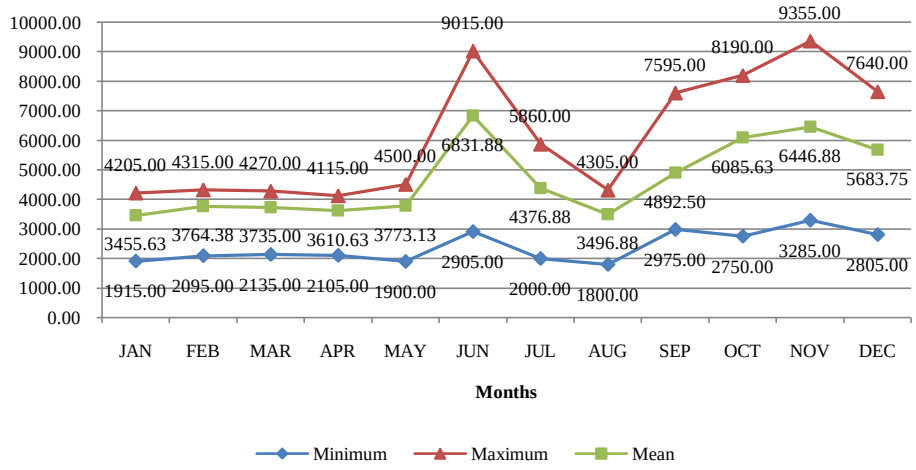

FIGURE 1.3- MONTHLY FLUCTUATION IN "CYANOPHYCEAE DENSITY" (ind/lt) AT SELECTED SITES OF DAL LAKE '2009'

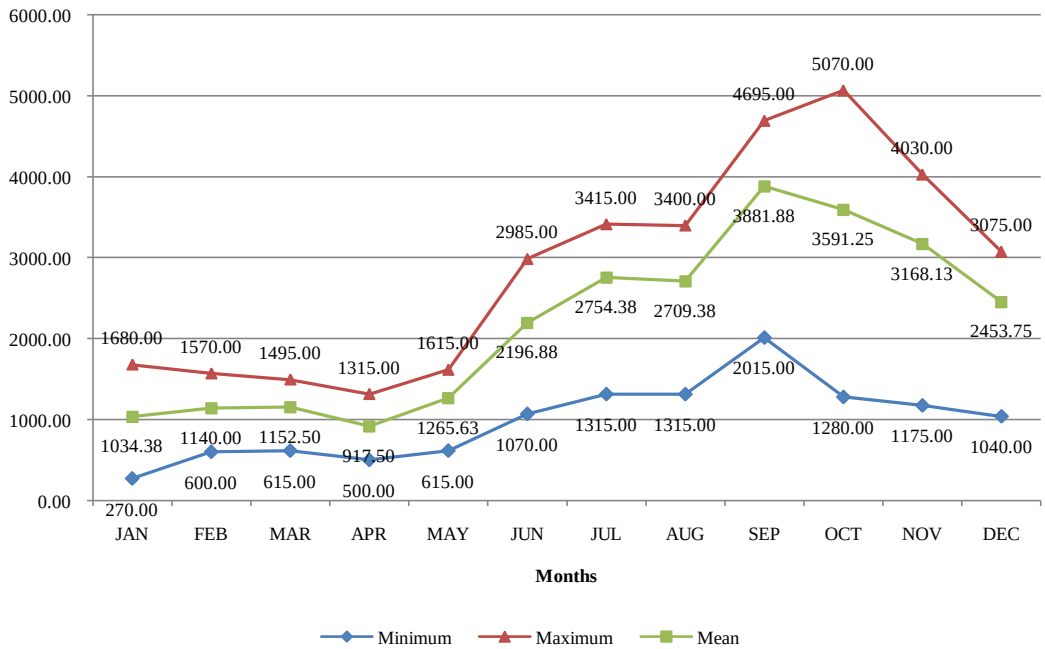

FIGURE 1.4 - MONTHLY FLUCTUATION IN "OTHER ALGAE DENSITY" (ind/lt) AT SELECTED SITES OF DAL LAKE '2009'

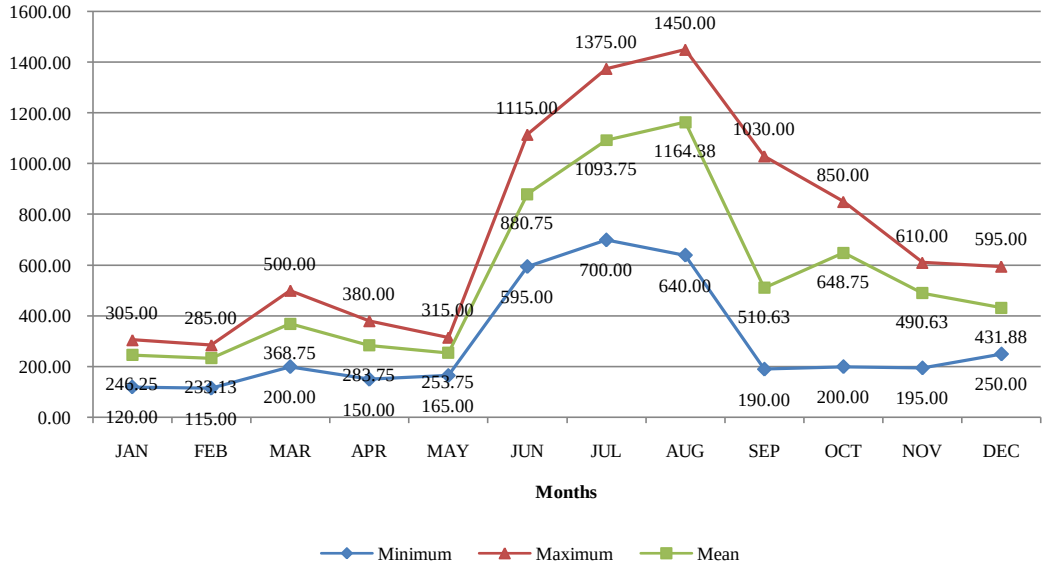

FIGURE 1.5 - MONTHLY FLUCTUATION IN "TOTAL PHYTOPLANKTON DENSITY" (ind/lt) AT SELECTED SITES OF DAL LAKE '2009'

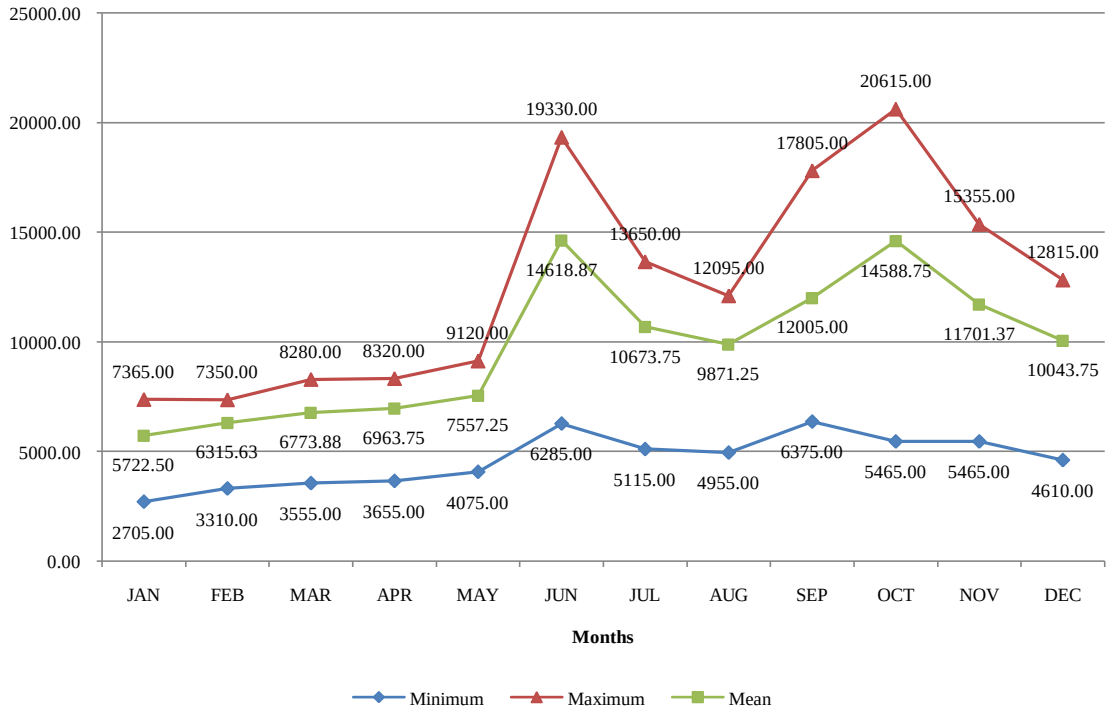

FIGURE 1.6 - PRESENTS MEAN PERCENTAGE OF DIFFERENT PHYTOPLANKTON GROUPS, SEASON WISE

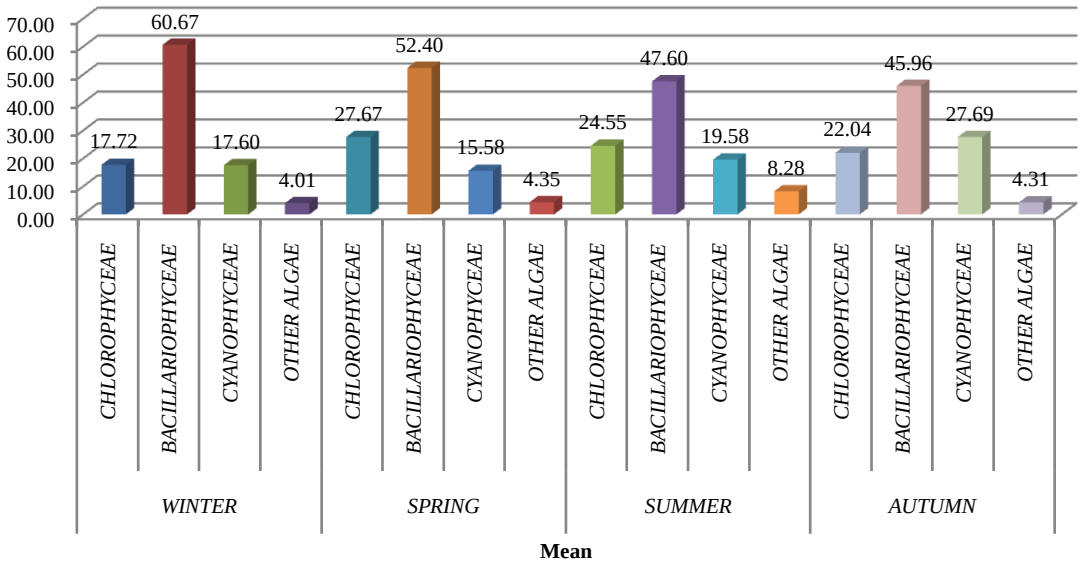

FIGURE 1.7 - PRESENTS PERCENTAGE WISE DIFFERENT PHYTOPLANKTON GROUPS