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A CONTRIBUTION TO THE SEASONAL DISTRIBUTION AND BIODIVERSITY OF FRESH WATER PHYTOPLANKTON OF KARAGAM LAKE, SRIKAKULAM, ANDHRA PRADESH, INDIA

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Abstract

In the present study, Seasonality and Species diversity of Phytoplankton studies were made on the Karagam Lake of Srikakulam District, Andhra Pradesh from November 2006 to October 2008. The phytoplankton population was represented by a Total taxa of 64 genera were recorded in this study. This includes Chlorophyceae (26 genera- 74 species), Bacillariophyceae (18 genera-41species), Cyanophyceae (17 genera-39 species) and Euglenophyceae (3 genera-8species). The abundant algal forms belong to Volvocales (9 genera, 12 species), Chlorococcales (7 genera, 16 species), Conjugales (9 genera, 43 genera), Nostocales (9 genera, 18 species) in Karagam lake.

Key words: Phytoplankton, Seasonal abundance, Karagam Lake

Introduction

The present investigation involves the Seasonality and species diversity of phytoplankton. Studies on seasonal abundance and distribution of phytoplankton were made by Barinova *et al.* (2006). Plankton as the primary producers acts as chief constituent of ecological pyramids; few genera aid as biological indicators of water quality (Odum, 1971; Patrick, 1971). Plankton has been used recently as an indicator to observe and understand changes in the ecosystem because it seems to be strongly influenced by climatic features (Beaugrand *et al*., 2000; Li *et al*., 2000, Soni and Thomas 2014.). Very few information was available in fresh water phytoplankton of coastal districts of India (Jyothi and Narasimha Rao, 2013A; 2013B; Renuka Devi and Narasimha Rao, 2013; Omesh Bajpai *et al* 2013, Bhanu Prakash *et al*. 2014; Jyotsna *et al*. 2014). Therefore investigations were carried out on Seasonality and Species diversity of Phytoplankton for a 2 years period (2006-08). In the present study seasonal changes different species of phytoplankton was studied.

Materials and methods

Phytoplankton study was made on Karagam Lake of Narasannapet mandal of Srikakulam district, A.P., India. Seasonal studies on phytoplankton present in the Karagam lake was studied for period of two years. Karagam Lake is situated at latitude of 18° 26' 44"and with longitude of 84° 01' 50". During the rainy season, water surface area is 4.72 hectares and water depth is 4 feet. Water samples were collected from 10 stations at each Pond for phytoplankton analysis.

Phytoplankton analysis was done by the following procedure.

Plankton analysis: The plankton of mesh number 25 of size 60 µm was used for collecting samples. (Senthilkumar and Sivakumar, 2008; Sivakumar and Karuppasamy, 2008; Leela Bhosale, 2010).The "surface samples" are collected as close to the water surface as possible, at 10 stations for every 15 days of each month from October 2006- October 2008 in-between 7am to 9 am and average values of two years were taken for study. The collected samples were stored in pre-cleaned two litre plastic bottles, and brought to the laboratory with precautions for further analysis. The samples were then filtered using 0.45 micron millipore filter and preserved hygienically **(**Trivedy and Goel, 1986; Maiti, 2003; Gupta, 2004; APHA, 2012). The samples collected into the 100ml polyethylene vials were preserved by adding suitable amounts of 1ml chloroform to act as the narcotizing agent and 2ml of 2% formalin for preservation and analyses.

Ten percent glycerin solution in distilled water was used as mounting fluid for the preparation of temporary and semi-permanent slides for microscopic study. A binocular compound microscope is used in the counting of plankton with different eyepieces such as 10X and 40X. The microscope is calibrated using an ocular micrometer. Phytoplankton were identified using standard monographs and manuals (Desikachary, 1959; Edmondson, 1963; Philipose, 1976; Prescott, 1984; Anand, 1998; Chapmann, Fritsch, 1948) and Photographs were taken with Cooplex Digital camera attached microscope.

Qualitative and quantitative evaluation of plankton

Sedgwick Rafter counting cell method:

The phytoplankton sample placed into the Sedgwick Rafter Counting chamber is allowed to stand on a flat surface for 20 minutes to enable the phytoplankton to settle. It is then transferred to the stage of an upright light microscope and securely positioned and counted

(Laskar and Gupta, 2009). The abundance of phytoplankton groups was calculated according to the following formulae (Welch, 1948)

N= (a x 100) C/L

Where N=Number of phytoplankton per litre of original water

A= Average number of phytoplankton in all counts in the counting cells

C=Volume of original concentrate in ml.

L=Volume of water passed through the net

The result was expressed as Unit/litre.

This method was cross checked with Drop count method.

Total plankton count per litre = A * (1/L) * (n/v) Where, A = number of organisms per drop

L = volume of original sample (l)

n = total volume of concentrated sample (ml)

v = volume of one drop (ml)

Results and discussion

The abundance of phytoplankton in Karagam lake was expressed in Table 1.

Table 1. Abundance of Phytoplankton in Karagam Lake

		Chlorophyceae												Bacillariophyceae						Cyanophyceae						Euglenophyceae		
S.No.	Months	Volvocales	%	Chlorococcales	%	Ulotricales	%	Oedogoniales	%	Conjugales	%	Chlorophyceae Total	%	Centrales	%	Pennales	%	Bacillariophyceae	%	Chroococcales	%	Nostocales	%	Cyanophyceae	%	Euglenophyceae	%	GRAND TOTAL
1	Nov	34000	20.48	24000	14.46	5000	3.01	2000	1.2	101000	60.84	166000	38.79	0	0	138000	100	138000	32.24	51000	45.54	61000	54.46	112000	26.17	12000	2.8	428000
2	Dec	34000	18.78	27000	14.92	2000	1.1	2000	1.1	116000	64.09	181000	41.8	2000	1.53	129000	98.5	131000	30.25	39000	35.78	70000	64.22	109000	25.17	12000	2.77	433000
3	Jan	26000	16.56	32000	20.38	2000	1.27	2000	1.27	95000	60.51	157000	40.15	3000	2.34	125000	97.7	128000	32.74	40000	41.67	56000	58.33	96000	24.55	10000	2.56	391000
4	Feb	43000	21.08	50000	24.51	4000	1.96	5000	2.45	102000	50	204000	44.74	2000	1.23	161000	98.8	163000	35.75	35000	46.67	40000	53.33	75000	16.45	14000	3.07	456000
5	Mar	37000	19.47	48000	25.26	3000	1.58	4000	2.11	98000	51.58	190000	40.77	0	0	161000	100	161000	34.55	49000	48.51	52000	51.49	101000	21.67	14000	3	466000
6	Apr	13000	16.67	21000	26.92	2000	2.56	1000	1.28	41000	52.56	78000	37.5	0	0	79000	100	79000	37.98	23000	50	23000	50	46000	22.12	5000	2.4	208000
7	May	26000	14.77	39000	22.16	2000	1.14	3000	1.7	106000	60.23	176000	44.11	0	0	143000	100	143000	35.84	22000	32.35	46000	67.65	68000	17.04	12000	3.01	399000
8	Jun	22000	14.19	34000	21.94	4000	2.58	4000	2.58	91000	58.71	155000	39.14	0	0	149000	100	149000	37.63	33000	41.25	47000	58.75	80000	20.2	12000	3.03	396000
9	Jul	24000	17.91	23000	17.16	4000	2.99	6000	4.48	77000	57.46	134000	36.61	0	0	137000	100	137000	37.43	34000	43.59	44000	56.41	78000	21.31	17000	4.64	366000
10	Aug	26000	17.45	24000	16.11	3000	2.01	8000	5.37	88000	59.06	149000	35.73	0	0	130000	100	130000	31.18	59000	48.76	62000	51.24	121000	29.02	17000	4.08	417000
11	Sep	28000	17.95	24000	15.38	1000	0.64	8000	5.13	95000	60.9	156000	39	0	0	140000	100	140000	35	38000	44.71	47000	55.29	85000	21.25	19000	4.75	400000
12	Oct	34001	19.03	28001	15.67	5333	2.98	6000	3.36	105332	58.95	178667	38.4	1333	0.84	157335	99.2	158668	34.1	48000	43.64	62003	56.36	110003	23.64	18000	3.87	465338
										Grand Total		1924667	39.89					1657668	34.35					1081003	22.4	162000	3.36	4825338
										Average Total		160388.92	39.89					138139	34.35					90083.583	22.4	13500	3.36	402111.5

Chlorophyceae

Algal forms reported in this Lake belong to the orders Volvocales, Chlorococcales, Ulotrichales, Oedogoniales and Conjugales(Table.1, Fig 1). In Karagam Lake, the maximum number of Chlorophyceae reported in February (44%) and less number of Chlorophyceae members in August (35%). Similar findings observed in the works of Venkateswarlu (1969 a,b), Tripathi and Pandey (1989) and Balasingh and Shamal (2007), Tiwari and Chauhan (2006), Sultana and Gupta (2009).

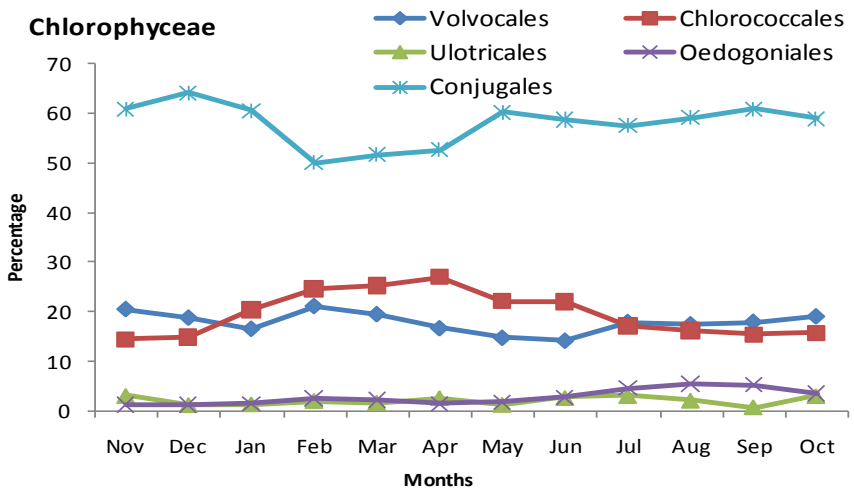


Figure 1: Seasonal abundace of Chlorophyceae members in Karagam Lake

Volvocales

Members of Volvocales were abundant (21.08%) in the month of February and minimum (14.19%) in the month of June. (Table 1 and Fig 2)**.** In the order Volvocales, algae belongs to families such as Chlamydomonadaceae, tetrasporaceae, Sphaerellaceae, Palmellaceae were reported and described family wise. Volvocales members are maximum in February with 21.08% and minimum with 14.19% in June (Fig.2). Active growth of Volvocales is possible in diluted waters as suggested by Jawale *et al.* (2009) studied 26 taxa of unicellular volvocales collected from Jalagaon district, Maharastra.

Members of Chlamydomonadaceae were reported below 1% throughout the study period. In the family Chlamydomonadaceae, species such as *Carteria acidicola, Chlamydomonas polypyrenoideum, Eudorina illinoiensis, E.indica, E.elegans, Pandorina morum, Pleodorina illinoisensis* and *P.californiea*were reported. Sphaerellaceae members were reported maximum (12.5%) in the month of July and minimum (2.94%) in the month of December. In this family sphaerellaceae, a single species *Volvox tertius* was reported. It was found in all months during the period of study. Members of Tetrasporaceae were reported maximum (26.5%) in the month of December and minimum (7.69%) in the month of January and April. In the family Tetrasporaceae, species such as *Apiocystis brauniana,Acanthosphaera zachariasi* and *Actinastrum gracillimum* were reported (Fig 2).

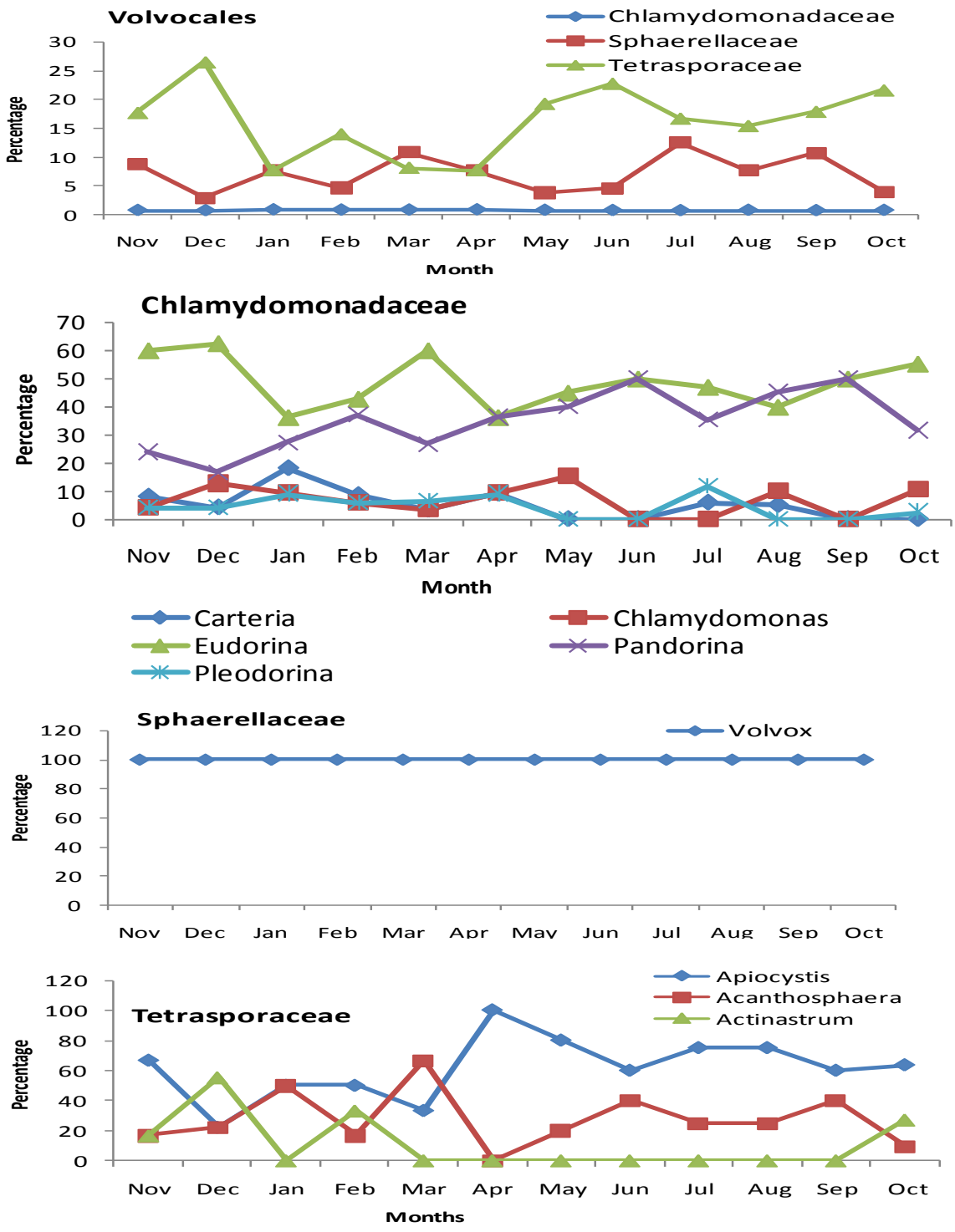


Figure 2: Seasonal abundace of phytoplankton in Karagam Lake: Different families in the order Volvocales

Chlorococcales

Members of the order Chlorococcales were abundant with 26.92% in April and minimum (14.46%) in November (Fig.3). In this order 16 species were reported which belong to 4 families. Seasonal changes in temperature and Chlorococcales shows direct relationship (Mary Christi *et al.* 2011). Members of Chlorococcaceae family were reported maximum (9.5%) in the month of April and not reported in the month of March (Fig.3).This family was represented by a single genus *Oocystis* and with a single species *Oocystis solitaria*. It was found maximum in all months except March. Chlorellaceae family was represented by a single genus *Chlorella vulgaris*. It was found maximum in the month of December with 11%, minimum (2%) in February and absent in the months of August, November and October (Fig.3). Hydrodictyaceae family was maximum (40%) in the month of March and minimum (21%) in the month of May and October (Fig.3). In this family, species such as *Pediastrum boryanum (Turp) meneghini, P.tetras, P.tetras var.tetrahedron* and *P.boryanum var.undulatum* were reported.

In Coelastraceae family, the algae reported were maximum (73.81%) in the month of October and minimum (52.17%) in the month of July (Fig.3). In this family species such as *Crucigenia tetrapedia, Tetraedron arthrodesmiforme*, *T.hastatum*, *T.trigonum, T.reticularis* and *T.zachariasi, Scenedesmus obliqus, S.quadricauda var.longispina, S.bijugatus f.parvus* and *S.armatus* were reported.

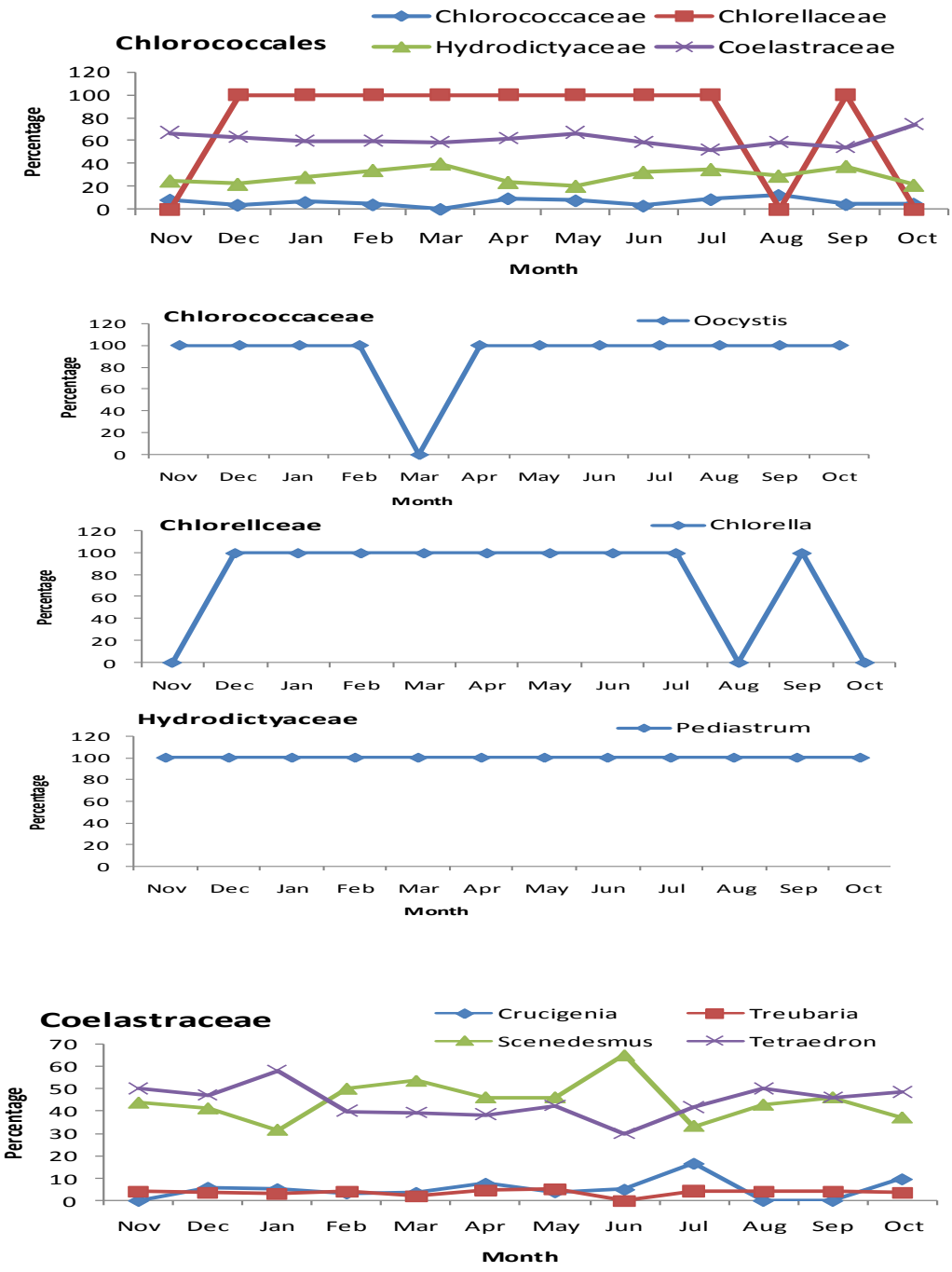


Figure 3: Abundance of phytoplankton in Karagam Lake: Different families in the order Chlorococcales

Ulotrichales: In Karagam Lake, Ulotrichales order vise percentage is maximum in November with 3.01% and minimum in Sept with 0.64% (Table 1& Fig 4). Similar findings were reported by Venkateswarlu and Reddy (1985). They found abundance of green algal flora like *Zygnema* and *Spirogyra* in less polluted spots which correlated with the present work. In this order, species such as *Ulothrix tenerrima and U.variabilis* were reported.
Oedogoniales: In the order Oedogoniales, a single species *Oedogonium princeps* was reported and maximum (5.37%) number was reported in the month of August and minimum (1.1%) in the month of December (Table 1& Fig.4).

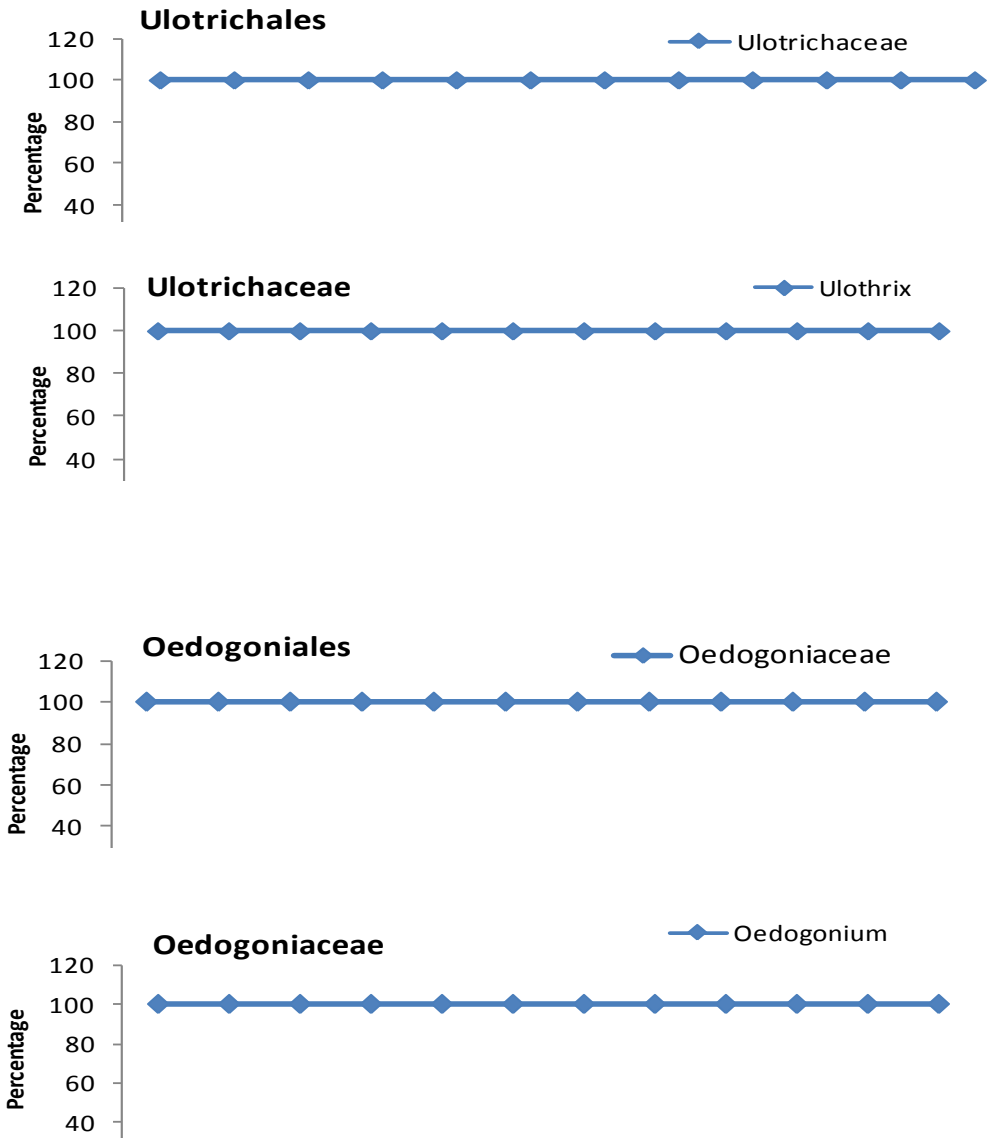


Figure 4: Abundance of phytoplankton in Karagam Lake: Different families in the order Ulotrichales and Oedogoniales

Conjugales: In the order Conjugales, maximum (64.09%) numbers of forms were reported in the month of December and minimum (50%) in the month of February. In this order, algae belong to 9 genera, 43 species. They belong to families such as Zygnemataceae, Gonatozygaceae and Desmidiaceae (Table.3). The members of Zygnemataceae family were reported maximum (28.42%) in the month of January and minimum (12.75%) in the month of February (Fig 5). In this family, species such as *Zygnema peliosporum* and *Spirogyra condensate, S.daedaleoides* and *S.setiformis* were reported (Fig 5). In the family Gonatozygaceae, a single genus *Gonatozygon* with 2 species *G.brebisonii* and *G.kinhanii* are reported. The members of this family were reported maximum (13.7%) in the month of January and minimum (2.27%) in the month of August (Fig 5).

Members of the family Desmidiaceae were reported maximum (78.4%) in the month of August and minimum (57.9%) in the month of January (Fig 5). In this family, *Closterium* (8sps), *Cosmarium* (18sps), *Euastrum bidentatum, E.elegans, E.didelta, Micrasterias mahabuleshwarensis, Staurastum anatinum, S.habeebens, S.manfelditii, S.muticum* , *S.turgescens, Cylindrocapsa geminelle var.minor* and *C.geminella wolle* were reported. Wehr and Sheath (2003) considered desmids as indicator of oligotrophic environment.

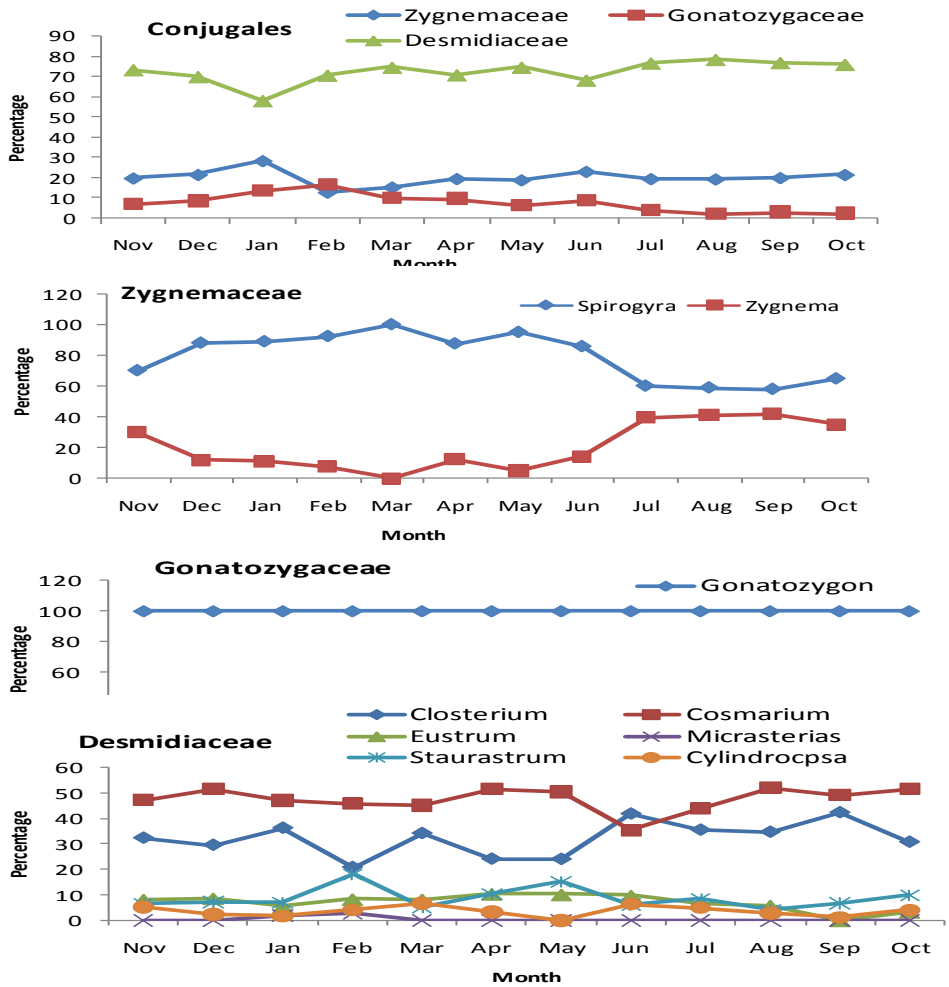


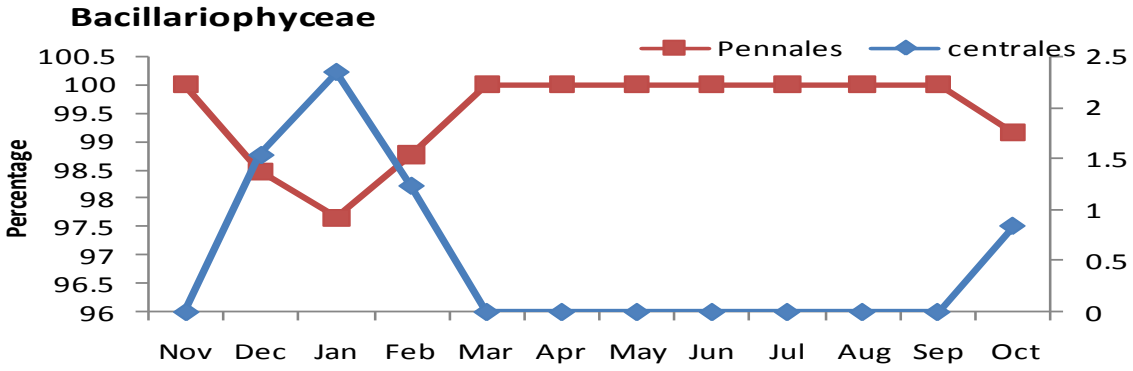
Figure 5: Abundance of phytoplankton in Karagam Lake: Different families in the order Conjugales

Bacillariophyceae

Diatoms are dominant in oligotrophic waters. Patrick *et al.* (1969) reported a reduction in diatoms when the water temperatures were between 35 and 40°C. Similar trend was observed in present investigation. Members of Bacillariophyceae were recorded maximum (37.98%) in the month of April and minimum (30.25%) in the month of December (Table 1 and Fig 6). 41 species of 17 genera belongs to orders Centrales and Pennales were reported in this class. Centrales was represented by a single division Discoidae. Oder Centrales was maximum in 2.34% in January (Table 1& Fig 6). Similar observations were reported in the works of Satpathy *et al.* (2007) and Pareek *et al.* (2011). In Discoidae, a single species *Melosira granulate* was reported in the months of December, January, February and October and not reported in the months of November and March to September.

In the Pennales order, algae belongs to divisions such as Fragilarioidae, Naviculoidae, Epithemoidae and Nitzchioidae were reported. They were abundant in November, March to September and minimum (97.7%) in January (Table 1& Fig 6). Khemakhem *et al.* (2010) found highest phytoplankton density in early summer ($3.13x10^6$ cells/L) represented by diatoms, especially *Nitzschia longissima* in Karagam Lake. Similar findings were reported by Pareek *et al.* (2011). Appa rao (1992) found peak growth of diatoms in monsoon which correlated with present work. Fragilarioidae members were found maximum in the month of January with 21% and minimum in the month of June with 8% (Table 1& Fig 6). In this division, species such as *Synedra tabulata, S.ulna var.aequalis, S.ulna var.splendens, Meridion circulare and Diatoma vulgaris* were reported. In Eunotioidae, species *Eunotia bilunaris* and *Eunotia fallax* were maximum (10.1%) in the month of December and reported minimum (3.2%) in the month of January (Fig 6). In Achananthoideae, species such as *Achnanthes exigua, A.lanceolata, A.microcephala, A.minutissima* and *Cocconeis placetula* were reported. They were observed maximum (24%) in the month of March and minimum (9.2%) in the month of August (Fig 6).

Members of Naviculoidae were abundant with 56% in June and minimum (40%) in December (Fig 6). In this division, species such as *Anomoneis sphaerophora, Cymbella affinis, C. cesati, C. cymbiformis, C. delicatula, C. ehrenbergii, C. microcephala, C .turgidula, C. ventricosa, Calonies silicula, Gyrosigma acuminatum, G. attenuatum, Navicula confervacea, N. cuspidata, N. pupula kutz.f.capitata, N. pupula frectantularis, N. radiosa var.tenella, N. rhynchocephala var.amphiceros, Pinnularia acrosphaerica* and *P. bicep Greg.var.amphicephala, Frustulia rhomboids, Amphipleura pellucida* and *A. kutzing* were reported. In Epithemioideae, the algal members were maximum (6.4%) in the month of January and minimum (0.6%) in the month of March. In this division, a single species *Rhopalodia gibba* was reported. In this division species such as *Nitzschia hungarica, N.sublinearis, N.thermalis, N.tryblionella* were reported in every month. In the division, algal members were reported maximum (13%) in the month of February and minimum (8%) in the months of November and December (Fig 6)


Bacillariophyceae
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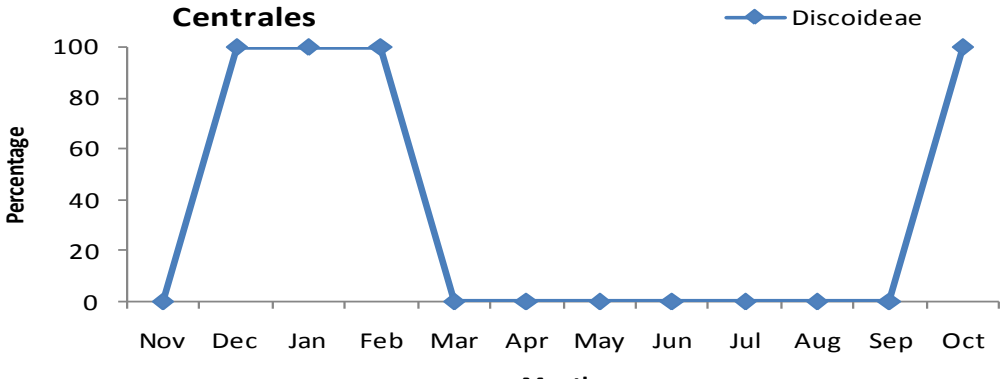
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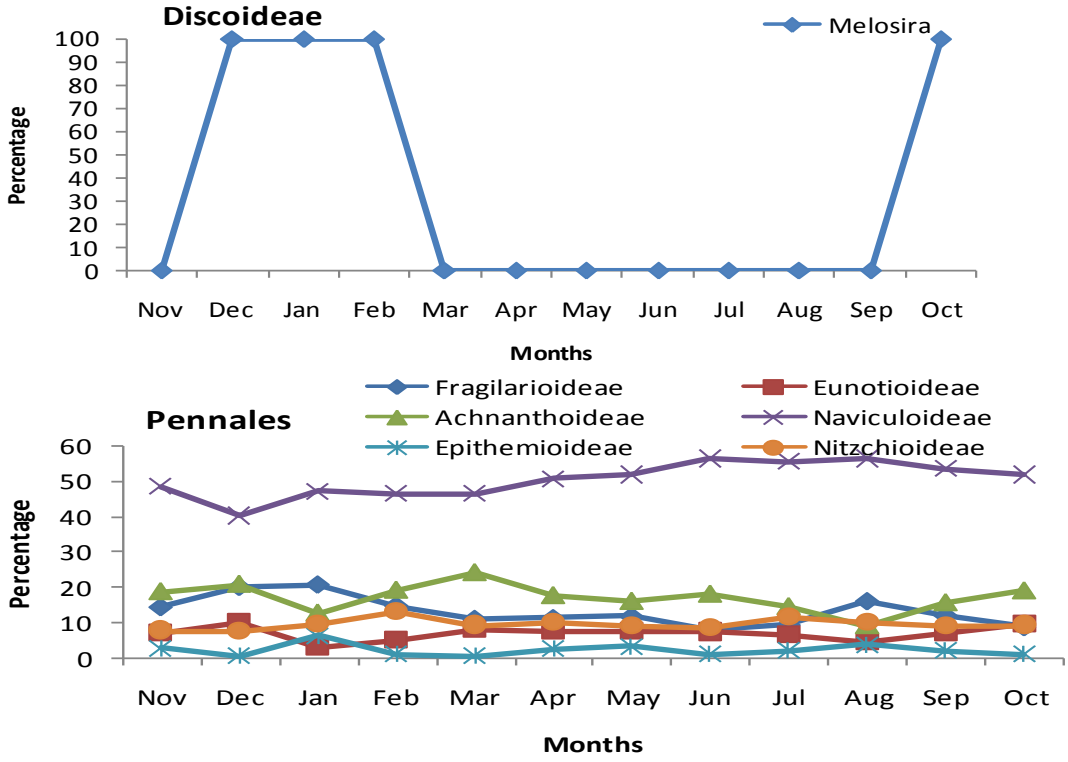
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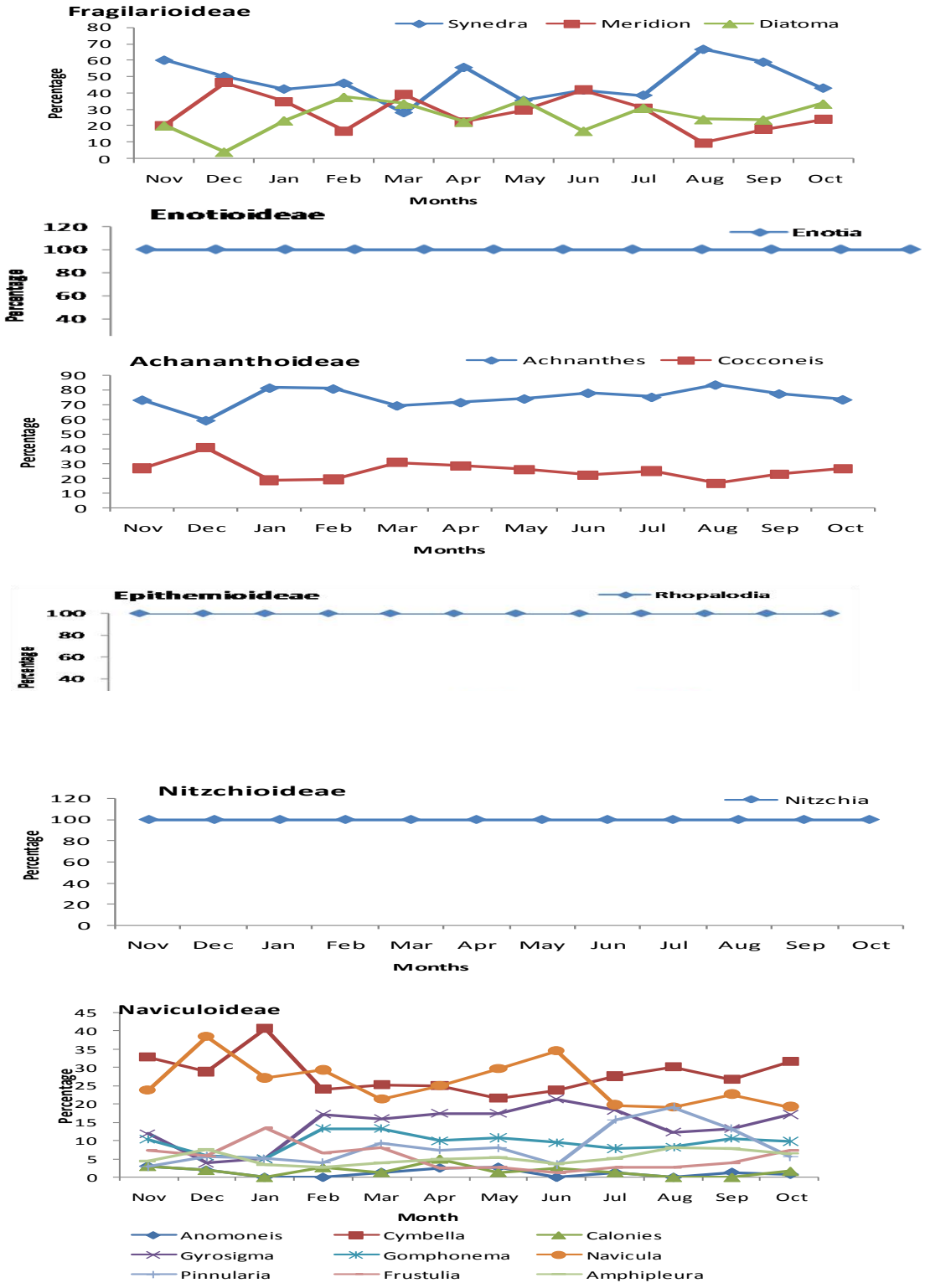

Figure 6: Abundance of phytoplankton in Karagam Lake: Different families in the orders Centrales and Pennales

Cyanophyceae

In this study, Cyanophyceae members were reported maximum (29%) in the month of August and minimum (16.5%) in the month of February (Table 1 and Fig 7). In the class Cyanophyceae, algae belong to orders Chroococcales and Nostocales were reported. Low amount of D.O. reduced the cyanobacterial population. Similar trend was observed in Karagam Lake. This also correlated with the works of Subha and Chandra 2005, Pingale and Deshmukh 2005, Rani *et al.* 2005, Omesh Bajpai *et al* 2013.

In Chroococcales, species such as *Aphanocapsa biformis*, *A.delicatissima*, *A.grevillei* and *A.pulchra, Aphanothece clathrata, Chroococcus macrococcus, C.minutus, C. pallidus, Dactylococcopsis fascicularis, Gloeocapsa decorticans*, *G.polydermatica* and *G.rupestris, Merismopedia glauca* and *M.punctata, Microcystis aeruginosa, M.flosaquae, M.lamelliformis, M.robusta, Pelogloea bacillifera*, *Snechocystis aeruginosa,S.devaleki* were reported. They were found maximum (50%) in the month of April and minimum (32.35%) in the month of May (Table 1 and Fig 7). Padmavathi and Veeraiah (2008) reported that summer season promoted the growth of *Microcystis*. They noticed a positive correlation between total alkalinity and blue green algae. Similar observations were reported in the present investigation.

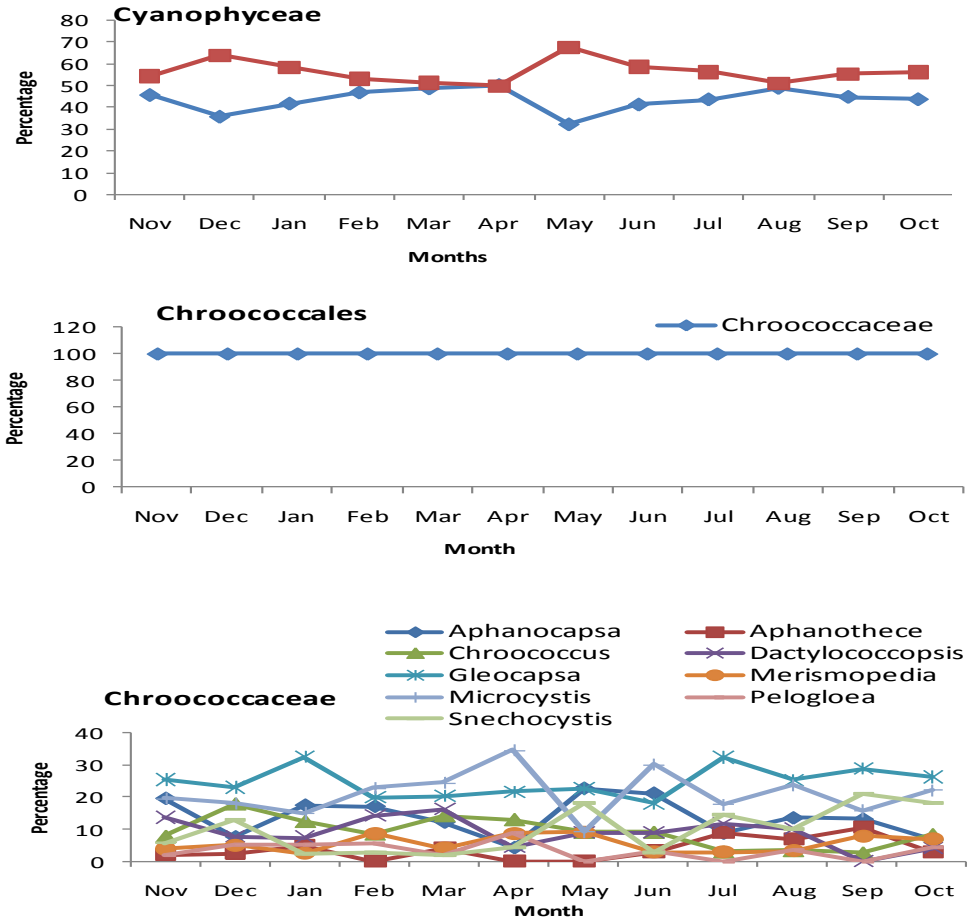

Figure 7: Abundance of phytoplankton in Karagam Lake: Different families in the order Chroococcales

In the order Nostocales, the algae belongs to families such as Oscillatoriaceae, Nostocaceae and Scytonemataceae were reported (Table 1, Fig 8). They were abundant with 64.2% in the month of December and minimum 50% in the month of April. In the family Oscillatoriaceae, algae were reported maximum (93.55%) in the month of October and minimum (66%) in the month of January (Fig 8). In this family, species such as *Oscillatoria chalybea* , *O.rubescens* , *O.tanganyikae*, *Phormidium tenue*, *Spirulina gigantea*, *S.major* and *S.princeps*, *Arthospira platensis*, *Lyngbya birgei*, *L.epiphytica*, *L.majuscula* and *L.perelegans*and *Trichodesmium erytraeum* were reported. In this family, the algal members were reported maximum (32.14%) in the month of January and minimum (3.23%) in October (Fig 7). In Nostocaceae family, species such as *Nostoc comminutum*, *N.linkia* and *N.punctiforme* and *Anabaena sphaerica* was found maximum (60%) in the month of August, minimum (7.14%) in December and absent in the month of October (Fig 8). In the family Scytonemataceae, a single species *Scytonema simplex* was maximum (6.82%) in the month of July and minimum (1.79%) in the month of January (Fig8).

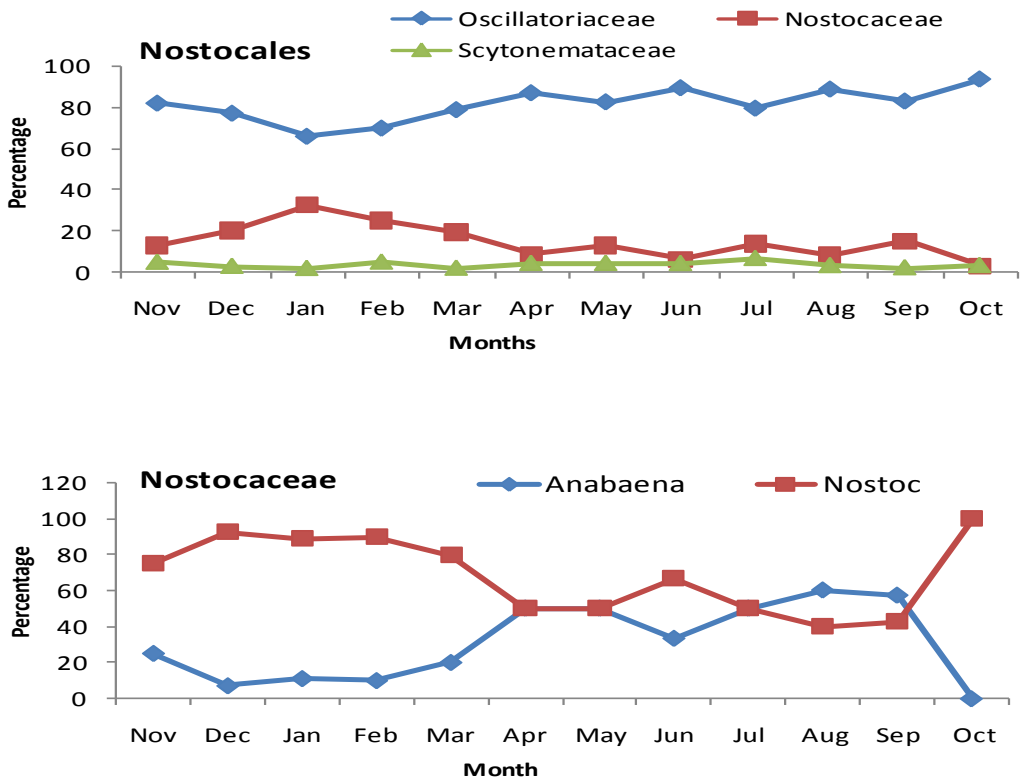

Figure 8: Abundance of phytoplankton in Karagam Lake: Different families in the order Nostocales

Euglenophyceae

In Karagam Lake Euglenophyceae was 3.33% of all the algae recorded. This class was represented by 3 genera *Euglena*, *Phacus* and *Trachelomonas* with species *Euglena acus, E.gracillus, E.polymorpha, E.spirogyra, Phacus acuminatus, P.moniliatus*, *Trachelomonas hispida* and *T.superba*. It was found maximum in Dec and May with 41.67% and minimum in September with 21.05% (Fig 9). Similar studies were reported by Ramanujam and Siangbood (2009) and Thiruganamoorthy and Selvaraju (2009).

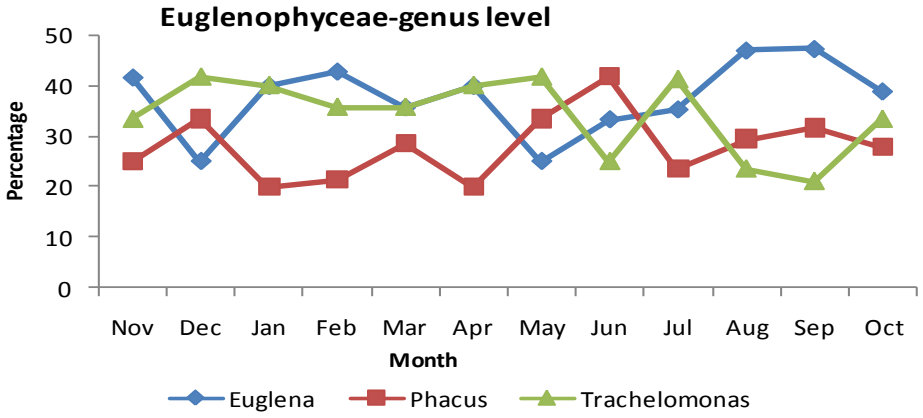

Figure 9: Abundance of phytoplankton in Karagam Lake: Different families in Euglenophyceae

Low amount of D.O. reduced the cyanobacterial population in the present investigation (Rani *et al.* 2005). Cyanophyceae have shown very close positive relation with temperature and phosphate (Harsha and Mallammanavar 2004). Similar findings were found in present investigation. Bacillariophyceae members have shown significant positive relation with temperature, chlorine and phosphate (Chitra and Meera 2004). The domination of bluegreen algae, observed frequently when there are low numbers of diatoms and green algae, is an indicator of eutrophication which correlated with the present work (Elzbieta Zebek 2005). Correlation between Chlorophyceae and different physicochemical factors such as high temperature, chloride, total dissolved solids, phosphate and dissolved oxygen was reported by Tripathi and Pandey (1989). Muthukumar *et al.* (2009) studied correlation co-efficient of physicochemical properties of water samples and cyanobacterial species and found significant positive correlation between dissolved oxygen (r=0.9803), bicarbonate (r=0.9928) and carbonate (r=0.941). Low amount of D.O. reduced the cyanobacterial population. Similar trend was observed in Karagam Lake. This also correlated with the works of Rani *et al.* 2005, Soni and Thomas 2013&2014).

Conclusion

Distribution of microalgal flora in Karagam Lake indicates that the dominant members belongs to Chlorophyceae (26 genera) followed by Bacillariophyceae (18 genera), Cyanophyceae (17 genera) and Euglenophyceae (3 genera). Cholorophyceae members dominated followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. The domination of bluegreen algae, observed frequently when there are low numbers of diatoms

and green algae, is an indicator of eutrophication. The use of phytoplankton as biological indicators of pollution is represented by the occurrence of pollution tolerant algal species in the water body (Palmer, 1969). The unwanted wastes in fresh water bodies leads to loss of biodiversity and ecological imbalance in fresh water ecosystems. So the experimental studies in fresh water ecosystems were dire necessity in present day situations. To overcome this serious problem, re modification of the fresh water body is needed by adding required nutrients which ultimately leads to preserve the biodiversity of diatoms and desmids which can be used in pharmaceutical industries.

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