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.
The abundance of phytoplankton groups was calculated according to the following formulae (Welch, 1948):

\[ N = \left( \frac{a}{100} \right) \frac{C}{L} \]

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 = \( A \times \left( \frac{1}{L} \right) \times \left( \frac{n}{v} \right) \)

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**

<table>
<thead>
<tr>
<th>Month</th>
<th>Volvatoccales</th>
<th>Chlorococcales</th>
<th>Ulothrix</th>
<th>Didymoideas</th>
<th>Conjugals</th>
<th>Chlorella</th>
<th>Chlorella Total</th>
<th>Centrales</th>
<th>Peronials</th>
<th>Bacillariophyceae</th>
<th>Bacillariophyceae %</th>
<th>Cyclotella</th>
<th>Cyclotella Total</th>
<th>Chlorella ocellata</th>
<th>Navicula</th>
<th>Cyclotella spp.</th>
<th>Cyclotella spp. %</th>
<th>Eunotia</th>
<th>Eunotia spp.</th>
<th>Eunotia spp. %</th>
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<th>Average Total</th>
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**Grand Total:** 124400 | 135768 | 443000 | 165104 | 112000 | 25177 | 12000 | 31368 | 428000

**Average Total:** 124400 | 135768 | 443000 | 165104 | 112000 | 25177 | 12000 | 31368 | 428000

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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 abundance 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 polypyranoideum, Eudorina illinoiensis, E.indica, E.elegans, Pandorina morum, Pleodorina illinoisensis* and *P.califoriceawere 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 zacharias* and *Actinastrum gracillimum were reported (Fig 2).*
Figure 2: Seasonal abundance 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 Chloroccaceae 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 obliquus, 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).

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**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*, *Staurastrum anatinum*, *S.habeebebens*, *S.manfelditii*, *S.muticum*, *S.turgescens*, *Cylindrocapsa geminelle var.minor* and *C.geminella* 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](image-url)
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, Epithemiae, 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). Apprao (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 Eunotiodae, 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 Acanthanthea, species such as Achnanthes exigua, A.lanceolata, A.microcephala, A.minutissima and Coccoeone 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. delicia, 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 frectangularis, N. radiosa var.tenella, N. rhynchocephala var.amphiceros, Pinnularia acrosphaerica and P. bicep Greg.var.amphicusula, Frustulia rhomboidis, Amphipleura pellucida and A. kutzing were reported. In Epithemiae, 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 Rhopalodria 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).
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, Gloecapsa decorticans, G.polydermatica and G.rupestris, Merismopedia glauca and M.punctata, Microcystis aeruginosa, M.flosaqua, 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.

![Cyanophyceae](Image)

![Chroococcales](Image)

![Chroococcaceae](Image)

**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, Lepiphytica, L.majuscula and L.perelegansand 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 (Fig 8).

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**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).

![Euglenophyceae-genus level](image)

**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 Mallamanavar 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 coefficient 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). Chlorophyceae 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, 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.

References
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