Journal of Algal Biomass Utilization
J. Algal Biomass Utln. - Copyright © PHYCOSPECTRUM
ISSN: 2229 – 6905

Diversity of Micro algal populations at Sri Mani Nageswar temple pond, Kallepalli, Srikakulam, Andhra Pradesh, India.

Setu Madhava Rao,D[1]. and G.M.Narasimha Rao[2]

Dr. V.S.Krishna Govt. Degree & Postgraduate College (A) Visakhapatnam[1].

Department of Botany, Andhra University, Visakhapatnam[2].

Abstract:

Water is an essential natural resource. The water bodies are highly dynamic in ecological aspects. Many temples had established the ponds in and around the temples. The present investigation aimed to examine the seasonal abundance, species diversity of microalgae at Sri Mani Nageswara Temple pond, Kallepalli of Srikakulam, Andhra Pradesh from May 2014 to April 2016. Present investigation revealed that the microalgal population comprises of a total of 100 species belongs to 60 genera and 4 classes. Chlorophyceae consists of 32genera belongs to 51species, Cyanophyceae comprises of 16 genera and 22 species. Class, Bacillariophycee comprises of 13 genera and 20species and Euglenophyceae with 4genera and 7 species. A total 3058 org./ml were observed with maximum 427org./ml in March 2015 and minimum 81org./ml in August 2014. The seasonal variations were recorded monthly for a period of two years and Correlation Studies were conducted among various algal groups and total Phytoplankton of the Temple Pond.

Keywords: Micro algal Populations, Seasonal Abundance, Pearson's Correlation Matrix. Sri Mani Nageswara Temple Pond, Srikakulam, AP.

Introduction

Algae generally found in moist places, lentic and lotic water bodies. They are prime sources of primary productivity in the ecological food chain, food web (Sukumaran et al. 2008). Phytoplankton serves as primary producers for the aquatic environment and play a valuable role by regulating biological rhythms and water quality (Pandey et al. 1998). Micro Algae play an important role in producing natural compounds such as amino acids, single-cell proteins and commercially useful products (Bavithra et al. 2017). A few studies were done in freshwater phytoplankton of Andhra Pradesh (Munawar 1970, Kodarkar 1995, Jyothi and Narasimharao 2013 A&B, Bhanu Prakash et al. 2014 and Jyotsna et al. 2015, Setu Madhavarao et al. 2015).

India is a sacred land with many religious places for people to satisfy their devotional emotions. Temple is one of them to follow the religious offerings. People strongly believe nature on god and with the thought of gaining punya. Most of the temples in their vicinity have holy ponds. These are found inside or outside the temple area. This pond water is used for temple purposes, washing legs, holy dips, washing clothes, domestic utilization and sometimes irrigation and fish cultures. The waste substances such as milk, curd, ghee, ash, turmeric water, flowers and leaves mixed into the pond water from the temple after pooja, along with surface runoff and garbage dumping. By all these anthropogenic activities, the temple pond environment may be disturbed. So the phytoplankton communities are changes its taxa composition seasonally and acquired some pollution tolerant characters. Several investigations have been made on the limnology and algal flora of temple ponds in India (Ganapathi 1940, Maya et al. 2000, Prameela et al. 2001, Kavitha et al. 2005, Sulbha and Prakasam 2006, Thirugnanamoorthy and Selvaraju 2009, Baruah and Kakati 2009, Pathmanapan et al. 2010, Anuja and Chandra 2012, Pushpam et al. 2013, Girish Kumar et al. 2014 and Sankaran and Thiruneelagandan 2015). The present investigation was undertaken to study the seasonal distribution and abundance of micro algal population at Sri Mani Nageswara Temple pond, Kallepalli of Srikakulam, Andhra Pradesh.

Materials and Methods:

Study area: Seasonal studies on phytoplankton present in the Sri Mani Nageswara temple pond were carried out for a period of two years. Temple pond is located at latitudes 18.37°N and with longitude 83.92°E and it is 5k.m. away from the Srikakulam town, in Andhra Pradesh. The water surface area in the pond during the rainy season is around 1.5 hectare and depth is 5 meters. The water spread area in summer is around 0.50 hectares, with 1meter in depth (Fig. 1).

Sampling collection:- The plankton of mesh number 25 of size 60 µs was used for collecting samples. Water samples were collected as close to the surface from 5 points for physicochemical and Phytoplankton analysis every month in a two-year study period and average values were taken (Senthil Kumar and Sivakumar 2008, Sivakumar and Kurupaswamy 2008). A known value of the sample 1 Litre was filtered and added 4% of formalin and a few drops of Lugol's iodine solution at the spot for preservation. The samples were kept in the dark for 48 hours in an unmovable manner to allow the planktonic material comes into sedimentation. After that, the overlying water from the sample bottle was decanted, and the final volume was adjusted in 50 ml. To each 50ml of the solution, 3ml of glycerin was added to prevent the materials from becoming brittle (Transeau 1951).

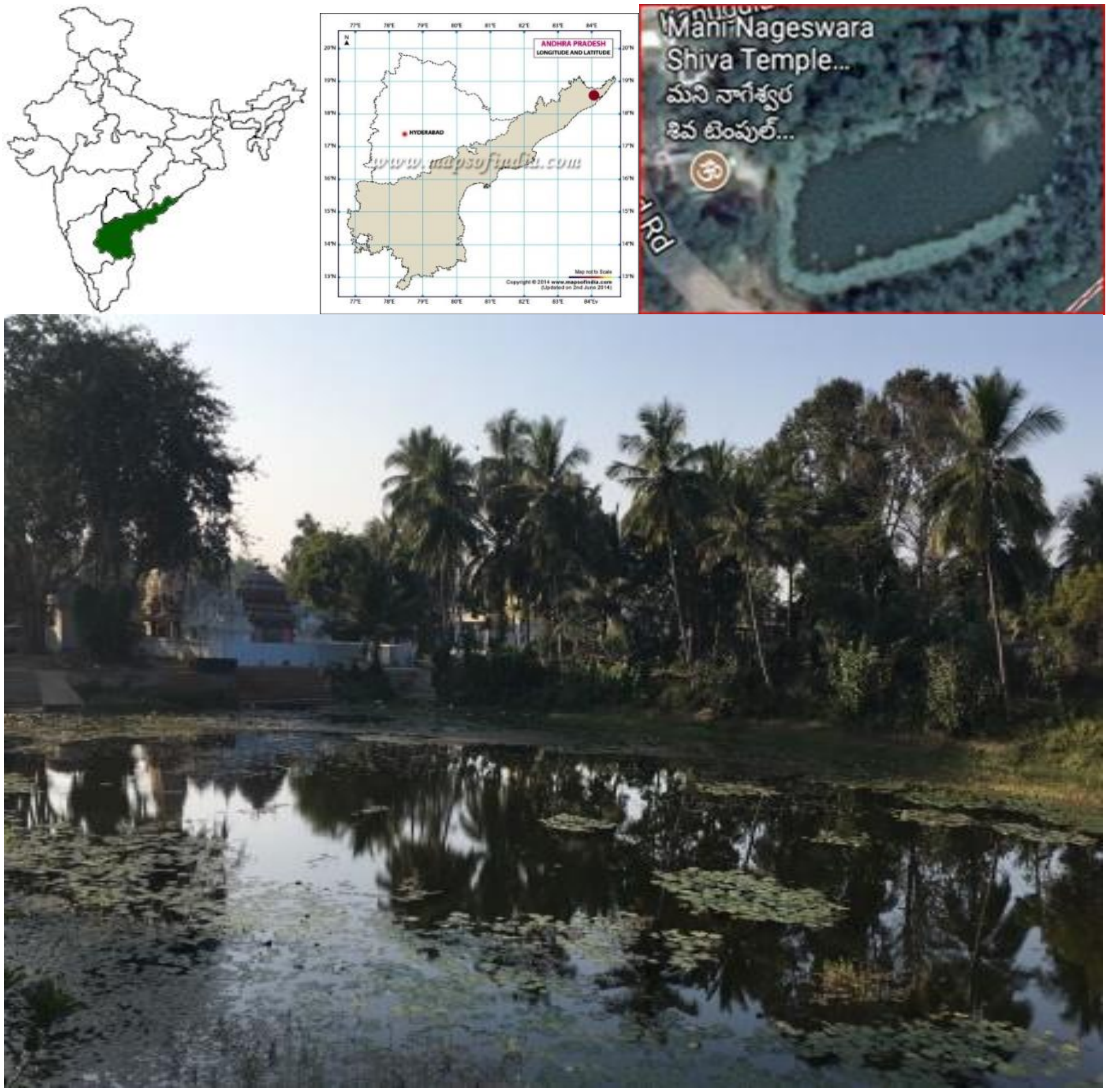


Fig.1. Map and Location of Sri Mani Nageswara Temple Pond, Kallepalli, A.P., India

Quantitative and qualitative Evaluation of Microalgae: The Phytoplankton consists of various forms like individual cells, colonies and filamentous forms were counted as an individual organism. When colonies of species counted, the average number of cells per colony was counted and the filament form, the average length of the filament, was measured. For the preparation of the temporary and semi-temporary slides for microscopic studies by 10%, glycerin solution was used as mounting fluid. A binocular compound microscope was used to count Phytoplankton with different magnifications such as 10x and 40x. They were recorded with photomicrographs under Nikon Coolpix 8400 Digital microscope camera. Identification of various taxa was made, up to species level with the help of standard keys (Desikachary 1959, Randhawa 1959, Philipose

1967, Prescot 1973, Anand 1998) Leela et al. 2010, Arulmurugan et al. 2010 and Ashok Kumar et al. 2011).

***Sedwick Rafter Counting Cell Method*:** The Sedwick Rafter Counting Chamber was used for easier counting processes for the number of organisms in ml of volume (Thakur et al. 2013 and Wetzel and Likens, 2000).

The abundance of phytoplankton groups was calculated according to the following formulae. N = (A x 100) C / L.

N = Number of Phytoplankton per litre of original water. A = Average number of Phytoplankton in the counting chamber. C = Volume of Original concentrate in ml.; L = volume of water passed through the net.

The results were expressed as the number of organisms/litre.

Results and Discussion

Temple tanks are the sacred places in natural habitats for diversified microorganisms, flora and fauna. They play an important role in the preservation and protection of the biodiversity of a particular ecological region. Phytoplankton was a significant component of water bodies. It also acts as an efficient bio-indicators of seasonality and to measure the quality of water. They have a short life span and respond quickly to environmental changes (Zebek 2004). The present investigation at Sri Mani Nageswara temple pond, Kallepalli, Andhra Pradesh, revealed four classes of Phytoplankton identified as members of Chlorophyceae (32genera-51species), Bacillariophyceae (13genera-20species), Cyanophyceae (16genera -22species) and Euglenophyceae (4genera –7species). Total 3058 org./ml was observed, maximum 472 org./ml in the month of March, 2015 and a minimum 81 org./ml in August 2014 (Fig.2). Cunqi Lie et al. (2010) observed the highest plankton abundance in spring and least in winter. The population density, trends showed a gradual increase during post-monsoon and summer season and attained a peak in the spring season. These results were supported by Brraich and Kaur (2015). Indian climatic conditions due to decreased water levels in summer increase the abundance of Phytoplankton by aggregation (Agale et al. 2013,a Setu Madhavarao and Narasimharao 2016). In the present investigation, the diversity of Phytoplankton was slowly declined during pre-monsoon months and the diversity and abundance were showed the lowest values in the monsoon period in the temple pond (Senthil Kumar and Sivakumar 2008). After the post-monsoon season, the turbidity of waters decreased gradually and the growth of the micro-algal population was increased in ponds. Algal productivity was higher in post-winter to summer seasons due to sufficient nutrient enrichment in water and adequate solar radiation (Tarakeshwar et al., .2011). The hierarchy of phytoplankton dominance in this temple pond, org./ml was shown below.

Chlorophyceae > Cyanophyceae > Bacillariophyceae > Euglenophyceae.

Similar observations were made by Tejaswini and Vijaya (2004) and Arulmurugan et al. (2010).

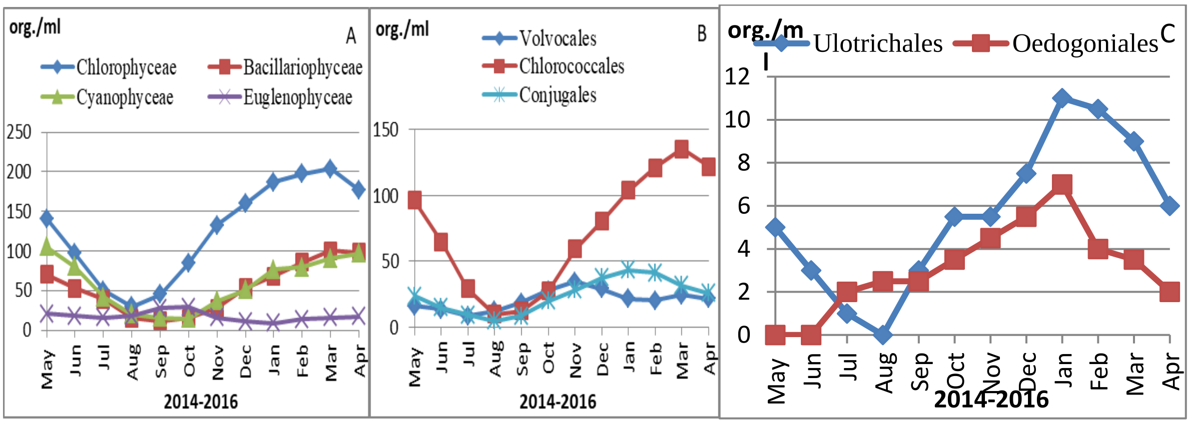


Fig. 2 Seasonal abundance of Total Phytoplankton and Chlorophyceae of Sri Mani Nageswara Temple Pond of Kallepalli village, Srikakulam district, Andhra Pradesh, during 2014 - 2016.

The class Chlorophyceae (32genera - 51 species) contributed 1506 org./ml to total Phytoplankton nearly 50% and was maximum 205 org./ml in February 2015 and minimum 29org./ml in August 2014 (Fig.2). In the present study, Chlorophyceae was the dominant class in the post-winter season (Murugesan and

Sivasubramanian 2005 and Seeta et al. 2016). The orders Volvocales (Chlamydomonadaceae-2 sps., Hematococcaceae – 1 sps. , Pamellaceae – 1sps. and Sphaerellaceae – 4 sps.), Chlorococcales (Chlorellaceae – 2sps., Chlorococcaceae – 4 sps. , Coelastraceae – 11sps. , Hydrodictyaceae – 6sps., Dictyospheraceae – 2sps. and Selenastraceae – 6sps.), Ulotrichales (Ulotrichaceae – 2sps.), Oedogoniales (Oedogoniacea – 1sps.) and Conjugales (Desmideaceae – 7sps., Gonatozygaceae – 1sps., Mesotaeniaceae – 1sps. and Zygnemataceae – 1sps.) were recorded under the class Chlorophyceae. The maximum abundance of Volvocales recorded in monsoon season (Hujare 2005). The Chlorococcales were increased during late winter and gradually decreased along with the rising temperature (Murugesan and Sivasubramanian 2008). Monsoon season favors the growth of desmids (Barman et al 2015). The common species were such as *Eudorina elegans Ehr., Pandorina morum (Mull) Bory,* and *Volvox aureus Ehrenberg* were dominant species of Volvocales, *Monoraphidium tortile West &G.S.West, Coelastrum asteriodeum De Notaris, Ankistrodesmus falcatus (Corda)Ralfs, Pediastrum simplex Meyen, Scenedesmus armatus (Chodat)Simth* and *Tetrahedron pusillum* Kutzing were dominant species of Chlorococcales, *Closterium acutum Brebisson* and *Cosmarium contractum* O. Kirchner were dominant species of Conjugales. The highest diversity of Chlorophyceae indicates relatively good health of a water body (Descy 1987 and Girish et al. 2014). In the present study, the genus *Scenedesmus* 4 species, *Pediastrum* 4species, *Tetrahedron* 4 species and *Cosmarium* 4 species were recorded to be dominant. Hutchinson (1967) suggested that desmids are considered as indicators of oligotrophic freshwaters. Even the desmids are present in the waters, but the pollution tolerant genera also dominant in the temple pond. As per the observations, it was concluded that this temple pond water gradually undergoes mesotrophic level of pollution (Photo Plate 1).

In the present investigation, Cyanophyceae (16genera -22species) was the second dominant class in the temple pond, totally 708 org./ml to the total Phytoplankton and maximum 122org./ml were in March 2015 and minimum 20org./ml were in September 2014 (Fig.3). Cyanophyceae contributes nearly 23% of the overall phytoplankton population (Jacklin and Regini 2011). Chroococcales were maximum in May 2014 and minimum in September 2014 (Kavith et al. 2005). Cyanophyceae represents two orders Chrococcales (Chroococcaceae –10sps.) and Nostacales (Ocillatoriaceae – 8 sps., Nostacaceae – 3sps. and Rivulariaceae – 1sps.) were recorded during the study period. In the present study, *Microcyatis aeruginosa Kutz* was abundant in high temperatures and low dissolved oxygen (Muthukumar et al. 2007). *Chroococcus disprsus (Keissler) Lemmermann, C. turgidus* (Kutzing) Nageli and *Merismopedia glauca* Ehrenberg) Kutzing were dominant species of this order. The luxuriant growth of the Chroorococcales was in March, April and May months in both the years of the study period (Sankar Hosmani and Vasanth Kumar 2000). Nostacales were contributing 380org./ml to the total microalgae, with a maximum of 57 org./ml in March 2015 and a minimum of 9 org./ml in August 2014. The abundance of the Nostacales members slowly replaced the members of the Chlorophyceae in late winter to early summer. The growth reaches a peak in March and April and gradually declines along with the temperature rise and low dissolved oxygen then, limited some species such as Oscillatoria species and Anabaena species. *Oscillatotoa major Vaucher ex Forti, O. princeps Vaucher ex Gomont Pharmedium innundatum* and *Nostoc commune Vaucher ex Bornet* were the dominant species observed as dominant species in Nostacales (Tiwari and Chauhan 2006 and Padmavathi and Veeraiah 2008) (Photo Plate 1).

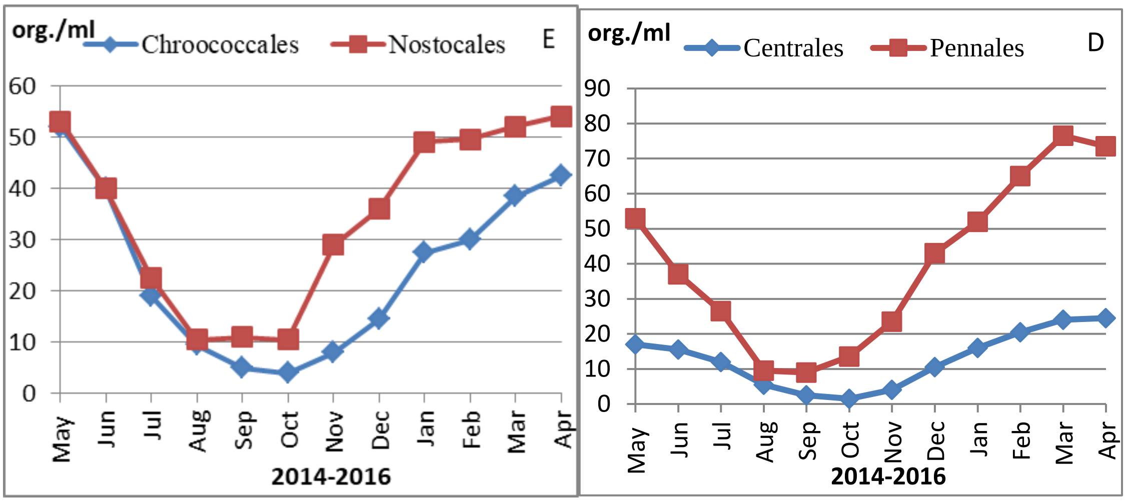


Fig. 3 Seasonal abundance of Cyanophyceae & Bacillariophyceae of Sri Mani Nageswara Temple Pond of Kallepalli village, Srikakulam district, Andhra Pradesh, during 2014 - 2016.

Class Bacillariophyceae (Photo Plate 1) was represented with 636 org./ml to the total phytoplankton percentage of 20.78%. Maximum 112 org./ml in March 2015 and minimum 11 org./ml in September 2014 in the present observation (Fig. 3). Similar observations were made by Sophia et al. 2012 and Kotadiya and Acharya 2013. Patrick et al. (1969) reported a reduction in diatoms when the water temperatures were between 35º- 40ºC. In the investigation of Sri Mani Nageswar temple pond has been recorded with two orders of Bacillariophyceae, Centrales (Discoidae – 5 sps.) and Pennales – Fragellariodae – 3sps, Naviculoidae – 10sps. and Nitzschiaoidae – 2sps.). The order Centrales was reported maximum in March 2015 with 27org./ml and minimum in October 2015 with 1org./ml. (Jyotsna et al. 2015). *Cocconeis pediculus Ehrenberg, C. placentula Ehrenberg, Cymbella affinis Kutzing* were the dominant species recorded. In the present work, Pennales were maximum in March 2015 with 85org./ml and minimum in September 2014 and August 2015 with 9org./ml. Pennales were abundant during March to June (Jackline and Regini 2011). *Nitzschia clostorium (Ehrenberg) W.Smith, N. commutate Rabenhorst, Navicula pupula Kutzing, Synedra ulna* (Nitzch) Ehr were the dominant members. Diatoms are treated as pollution stress-tolerant genera in the freshwater ponds (Venkateswarlu and Reddy 1985).

Euglenophyceae was contributing 209org./ml to Phytoplankton with 6.84% and maximum 30org./ml in September 2014 and October 2015 and minimum 8org./ml in January 2015 and 2016 (Fig.4). Similar observations made by Jacklin and Regini 2011 in temple pond of Munchirai, Kanyakumari District. The only one order Euglenales and single-family Euglenophyceae is representing with 7 species of 4 genera. The *Trachelomonas* genera were recorded with 3 species. *Euglena cunate Pringsheim* and *Trachelomonas hispida (Perty)F. Stein* were dominant species of all the members of Euglenophuceae recorded in the temple pond. *Euglena* and *Phacus* of Euglenophyceae class were abundantly occurring due to organic pollution (Anuja and Chandra 2014) (Photo Plate 1).

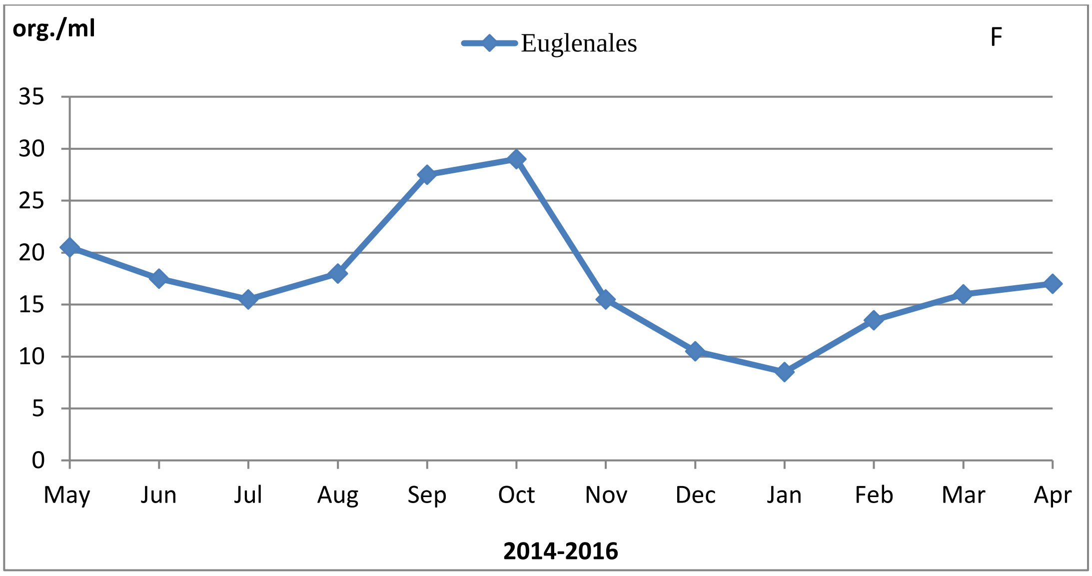


Fig. 4 Seasonal abundance of Euglenophyceae and some pollution tolerant species of Sri Mani Nageswara Temple Pond of Kallepalli village, Srikakulam district, Andhra Pradesh, during 2014 - 2016.

Pollution Indicator algae

The algal species diversity is very high, in rich nutrient conditions and suitable physical factors when there is no eutrophication. If the eutrophication occurs, the algal blooms might be formed in some seasons by some species like *Microcystis* or *Oscillatoria*. The pollution of the water body can be measured by using the microalgal communities. Because of their sensitivity, they are the best indicators (Kavith et al. 2005). Presence of pollution tolerating algae like *Oscillatoria, Pandorina, Ankistrodesmus, Nitzschia, Synedra, Microcystis, Chlorella, Spirogyra, Scenedesmus, Pinnularia, Gomphonema, Euglena and Phacus* can be used as the pollution indicators (Palmer1969 and Annuja and Chandra 2015). In the investigated temple pond, the algal species diversity was observed, but some of the pollution indicators also recorded (Table 1). This condition indicates that the temple pond slowly turns to oligotrophic level to mesotrophic level of water quality.

Correlation studies

The correlation between physicochemical parameters and phytoplankton abundance was in Sri Mani Nageswara Temple Pond during May 2014 to April 2016 (Table 2). Total phytoplankton showed strong positive correlation with transparency (r= 0.87), pH (r= 0.64), total alkalinity (r= 0.88), total hardness (r= 0.86), chlorides (r= 0.91), potassium (r=0.88), sodium (r=0.71), calcium (r=0.58), nitrogen (0.34) Chlorophyceae (r= 0.95), Bacillariophyceae (r= 0.97) and Cyanophyceae (r= 0.91). It showed negative correlation with total suspended solids (r= -0.65) dissolved oxygen (r= -0.21) and Euglenophyceae (r= -0.52). Baruah and Kakati (2012) noticed a positive correlation with pH, total alkalinity, chlorides and nitrogen.

Chlorophyceae showed strong positive correlation with transparency (r= 0.91), total alkalinity (r= 0.72), total hardness (r= 073), chlorides (r= 0.84), potassium (r= 0.76), magnesium (r= 0.60), Bacillariophyceae (r= 0.86), and Cyanophyceae (r= 0.75), positive correlation with pH (r= 0.44), calcium (r= 0.34) while strong negative correlation with total suspended solids (r= -0.77) Phosphates (r=- 0.45) and Euglenophyceae (r=-0.52). Aarti Devi and Neha Antal (2013) studied a positive correlation between Chlorophyceae and Calcium, Magnesium and pH and while negative correlation with Phosphates.

Bacillariophyceae showed strong positive correlation with transparency (r=0.73), pH (= 0.71), COD (r= 0.62), total alkalinity (r= 0.93), total hardness (r= 0.82), chlorides (r= 0.86), potassium (r= 0.86) and cyanophyceae (r= 0.92), while negative correlation with total suspended solids (r= -0.47) dissolved oxygen (= -0.36) and Euglenophceae (r= -0.52). Ajayan et al. 2013 recorded a positive correlation between COD, TA, and chloride and Bacillariophyceae.

Cyanophyceae showed positive correlation with temperature (r= 0.48) transparency (r= 0.72), total dissolved solids (r= 0.63) COD (r= 0.79), BOD (r= 0.62), pH (r= 0.81), total alkalinity (r= 0.97), total hardness (r= 0.91), chlorides (r= 0.88), potassium (r= 0.88), calcium (r = 0.83), sodium (r= 0.80), magnesium (r=0.73), nitrates (r= 0.58), electrical conductivity (r= 0.50), phosphates (r= 0.22) while negative correlation with TSS (r= -0.42), DO (r= -0.54), Euglenophyceae (r= -0.46). Ajayan et al. 2013 noted a positive correlation between temperature, BOD, COD, TA, and chloride Padmavati and Veeraiah (2008) noticed a positive correlation between total alkalinity and blue green algae. Physical factors such as total alkalinity, pH and nitrates are responsible for the abundant growth of blue green algae (Michael, 1969). Aarti Devi and Neha Antal (2013) studied a positive correlation between Cyanophyceae with temperature, chlorides, phosphates and nitrates.

Euglenophyceae showed positive correlation with water temperature (r= 0.36), electrical conductivity (r= 0.39), phosphates (r= 0.17) and total suspended solids (r= 0.08) while negative correlation with total alkalinity (r= -0.54), transparency (r= -0.31) calcium (r= -0.34). Ajayan et al. 2013 recorded a positive correlation between phosphates and Euglenophyceae.

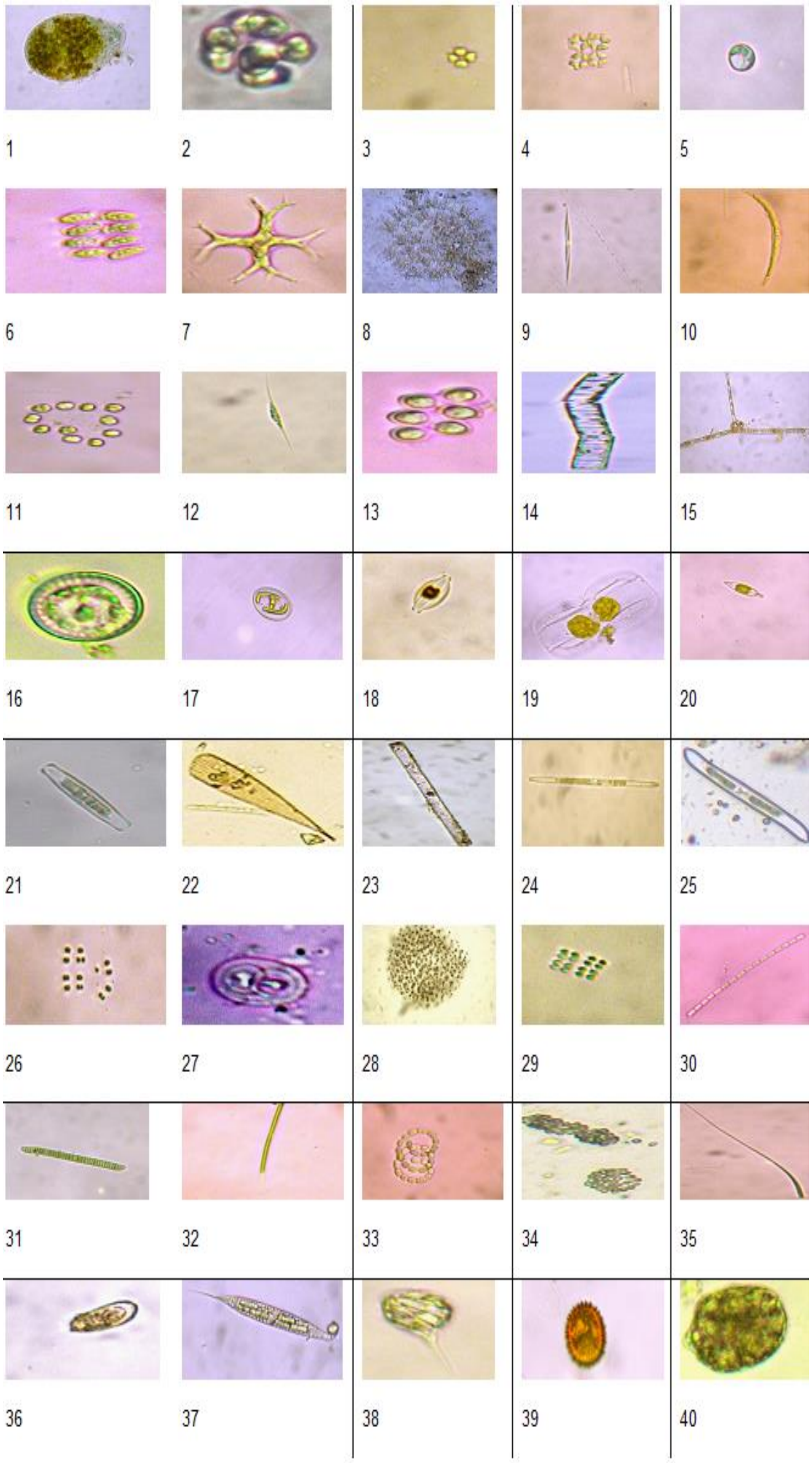
Table 1 Some pollution tolerant species of Sri Mani Nageswara Temple Pond of Kallepalli village, Srikakulam district, Andhra Pradesh, during 2014 - 2016.

Sl. No.	Name of the Pollution Indicator	Pollution rating
1	*Microcystis aeruginosa Kutz*	05
2	*Oscillatoria princeps West et West*	05
3	*Pandorina morum Bory*	03
4	*Spirogyra pratensis Transeau*	02
5	*Ankistrodesmus falcatus (Corda) Ralfs*	02
6	*Nitzschia palea Wm. Sm*	03
7	*Synedra ulna Nitz (Ehr)*	03
8	*Chlorella valgaris Beijerinck*	03
9	*Scenedesmus armatus (Chodat) Smith*	02
10	*Gomphonema parvulum (Kuetz)*	01
11	*Pinnularia viridis (Nitzsch) Ehrenberg*	02
12	*Euglena cuneata Pringsheim*	05
13	*Phacus horridus Pochmann*	02

Table 2. Correlation Matrix among the physicochemical variables with phytoplankton abundance of Sri Mani Nageswara Temple Pond, during May 2014 to April 2016

.

Name of the parameter	Chlorophyceae	Bacillariophyceae	Cyanophyceae	Euglenophyceae	Total Phytoplankton
Air Temp.	-0.15	0.26	0.48	0.31	0.14
Water Temp.	-0.24	0.18	0.39	0.36	0.05
Transparency	0.91	0.73	0.72	-0.31	0.87
Conductivity	-0.03	0.27	0.50	0.39	0.22
TSS	-0.77	-0.47	-0.42	0.08	-0.65
TDS	0.20	0.40	0.63	0.31	0.41
pH	0.44	0.71	0.81	-0.26	0.64
DO	0.09	-0.36	-0.54	-0.20	-0.21
COD	0.23	0.62	0.79	-0.04	0.51
BOD	0.08	0.47	0.62	0.14	0.35
TA	0.72	0.93	0.97	-0.54	0.88
TH	0.73	0.82	0.91	-0.21	0.86
Chlorides	0.84	0.86	0.88	-0.30	0.91
Calcium	0.34	0.68	0.83	-0.34	0.58
Magnesium	0.60	0.62	0.73	-0.19	0.69
Potassium	0.76	0.86	0.88	-0.23	0.88
Sodium	0.53	0.76	0.8	-0.11	0.71
Nitrates	0.11	0.41	0.58	0.16	0.34
Phosphates	-0.45	0.02	0.22	0.17	-0.17



1. Chlamydomonas ehrenbergii 2. Pandorina morum 3. *Microtenium pucellum.4. Crucigenia crucifera 5.* Chlorella volgaris 6. *Scenedesmus armatus 7. Tetraedron angolense 8. Pediastrum boriyana 9. Ankistrodesmus falcatus 10. Closterium purvulum 11. Dictyosphaerium puchellum 12. Scorideria indica 13. Coelastrum microporum 14. Ulotrix zonata* 15. *Oedogonium globosum 16. Cyclotella antique 17. Coccuneis placentula 18.* Cymbella *deliculata 19. Amphora normanii 20. Navicula pupela 21.Pinnularia viridis 22.Gomphonema dicutamum 23.Synedra ulna* 24.Nitschia palea 25.Nitschia cummunata 26.Choorococcus disperses *27.Gleocapsa rupestris* 28.Microcystis *aeruginosa 29.Merismopedia gluca 30.Lyngbya majuscula* 31.Oscillatoria limosa *32.Pharmedium inumdatum 33.Anabaena beckeii 34.Noctoc communis 35.Rivularia curvata 36.Euglena cuneata 37.E. acus 38.Lepocinclis ovum 39.Traclomonas regulosa 40.Phacus horridus*

Conclusion

In the present investigation at Sri Mani Nageswara temple pond, Kallepalli, Andhra Pradesh, 4 classes of Phytoplankton identified as members of Chlorophyceae (51species), Bacillariophyceae (20 species), Cyanophyceae (22species) and Euglenophyceae (7species). Total 3058 org./ml was observed, maximum 472 org./ml in the month of March 2015 and minimum 81 org./ml in August 2014. Good water indicators such as desmids (*Cosmarium* 4 species) and Pollution indicators such as *Pandorina elegans, Coelastrum asteriodeum, Ankistrodesmus falcatus*, *Scenedesmus acutus, Nitzschia commutata*, *Synedra ulna*, *Microcyatis aeruginosa, Oscillatotoa major, Euglena sp. .and Phacus sp.* were also recorded in this pond water.

Acknowledgment

The authors convey their sincere thanks to the Head of the Department of Botany, Andhra University, Visakhapatnam, AP., for providing laboratory facilities and Nikon Coolpix 8400 Digital microscope camera.

References

Aarti Devi and Neha Antal. 2013 Variation in Phytoplankton Diversity and its Relationship with Abiotic Environment of a Temple Pond in Birpur (J&K) India. Uni. J. of Envl.Res.and Tech. , Vol. 3, (2) : 181-189.

Agale, M. C., Patil J. V. and Patel, N.G..2013 Study of seasonal variations of Phytoplankton and their correlation with physico-chemical parameters of Budaki Medium Irrigation Tank, Shirpur. Dist.Dhule (M.S.) India. *European J. of Zool. Res.* : 2 (3):8-16.

Ajayan K.V., Selvaraj M. and Thirugnanamoorthy K. 2013 Phytoplankton Population of Ananthapura Temple Lake of Kasaragod, Kerala. Insight Botany. 3 (1): 6.14.

Anand N..1998 Indian freshwater Microalgae. Bishen Singh Mahendrapal Singh, 1998 23-A, Cannaught Place, Dehra Dun.

Anuja, J. and Chandra, S.,2012 Studies on fresh water algae in relation to chemical constituents of Thiruneermalai temple tank near Chennai, India-I. *Int.J.Curr.Sci*. 4:21-29.

Anuja, J. & Chandra, S., 2015 Pollution Indicating Algae of Thruneelimalai Temple Tank. Pallavaram, Chennai, *J. of Sci. & Tech.* Vol. 3 No.1 pp.49-55.

Ashok Kumar N. et al..2011 A preliminary report on Planktonic Algae of Temple tank of Kancheepuram District, tamilnadu, India. *Int. J. of Curr. Res.* Vol. 3 (12); 404-415.

Balasingh G.S.R. 2010 Studies on Phytoplankton diversity and seasonal abundance of a perennial pond in Kanyakumari-tamilnadu, India, *J. of Basic and App. Biol*., 4, 188-193.

Barman D**.,** Deka S.J. and Barman B.. 2015 Seasonal Diversity and Habitat characteristics of Algae of Wetlands in the West Garo Hill, Meghalaya, India. *Res. J. of Recent. Sci.* ; Vol. 4, 274-279.

Baruah PP, and Bhaswati Kakati 2009: Studies on phytoplankton community in a high-land temple pond of Assam, India. *Indian J. of Environ Ecoplan* 16(1): 17-24.

Baruah PP, and Bhaswati Kakati, 2012 Water quality and Phytoplankton diversity of Gopeswar temple freshwater pond in Assam (India) Bangladesh J. botany, 41 (2) 181-185.

Bavithra P., Brammavidhya S., Kumar T. and Arun Prasath V. 2017 . Screening and Identification of Microalgal Diversity from Thiyagaaja Swamy Temple Tank, Thirivarur, Tamilnadu. *Life Science Archives (LSA)* ; Vol. 3(5) PP. 1157-1162.

Bhanu Prakash. M, Jyothi Kaparapu and Narasimha Rao G. M..2014 Seasonal variations of phytoplankton community structure in relation to Physico-chemical factors in Lake Kolleru, Andhra Pradesh, India. *J. Algal Biomass Utln*. 5 (3): 1 – 7.

Brraich O.S. and Kaur R. 2015. Phytoplankton Community Structure and Species Diversity of Nangal Wetland, Punjab, India. *Int. Res J. of Biol. Sci.* Vol. 4(3), 76-83, Cunqi Liu, Lusan Liu, Huitao Shen,.2010 Seasonal variations of phytoplankton community structure in relation to physico-chemical factors in Lake Baiyangdian, China. *Int. Soc. for Environ, Infor. Sci, Annual. Conf. (ISEIS).*

Das A.K..2000 Limno-Chemistry of some Andhra Pradesh Reservoirs. *J. Inland Fish. Soc.of India*. 32 (2): 37-44.

Descy JP.1987 Phytoplankton Composition and Dynamics in the River Meuse (Belgium), *Arch, Hydrobiol. Suppl* ;78:225-245.

Desikachary T.V, 1959: Cyanophyta. Indian Council of Agricultural Research, New Delhi.

Ganapathi S.V. 1940 The ecology of Temple Tank contain -ing a permanent bloom of Microcystis aeruginisa. *J. of Natural Histology* 42(1): 65-77.

Girish Kumar E, Rekha C., Pradeep Kumar G., Sasikala K. and Sivadasan K.K. 2014. Diversity of Planktonic Algae of selected temple ponds of Mahe (U.T. of Puducherry), India. *Int.Sci.J.* Volume- 1 Issue-3, 48-53.

Hujare, M.S.2015 Hydrobiological studies of some water reservoirs of Halkanangale tehsil (Maharastra). Ph.D. thesis submitted to Shivasi University Kolhapur, India.

Hutchinson G.E.1967. A treatise on limnology. Vol. II. Introduction to lake biology and the limnoplankton. *John Wiley and Sons, Inc*.N.Y 1115.

Jacklin Jemi R. and G.S. Regini Balasingh,.2011 Studies on Physico-Chemical Characteristics of Freshwater Temple Ponds in Kanyakumari District (South Tamil nadu), *Int. l J. of Geo.Earth and Env. Sci*.**,** 1(1**)**, 59-62.

Jyothi K. and Narasimha Rao, G.M. 2013a Seasonal Distribution of Phytoplankton in Riwada Reservoir, Visakhapatnam, Andhra Pradesh, India. *Nat. Sci. Biol*. ; 5 (3): 290-295.

Jyothi Kaparapu and Narasimha Rao, G.M.2013b Diversity and Seasonal Variation of Phytoplankton in relation to Physico Chemical Parameters in Thatipudi reservoir, Visakhapatnam. *Seaweed Res. Utiln*. 35(1and2):1-9.

Jyotsna N, Subbarangaiah G, and Narasimha Rao, G.M. 2014 Seasonal variation of Micro algae in relation to the physic-chemical Parameters of Karagam Lake Srikakulam District, A.P. India. *J. Algal Biomass Utln*. 5 (4): 68-73.

Kavitha, A., Regini Balasingh G. S. and Raj A.D.S.*2005* Freshwater phytoplankton assemblages of two temple ponds of south Tamil Nadu. *Indian Hydrobiol,* 8(1): 61 – 65.

Kodarkar MS.,1995 Conservation of lakes. *Indian Association of Aquatic Biologists (IAAB) Hyderabad publication* 3:1-82.

Kotadiya, N.G. and Acharya, C.A. 2013 Comparative study of Phytoplankton Diversity in two fresh water body of rural area of Ahmedabad. *Life Sci. Leaflets*. 4: 85-91.

Krishnamurthy V. 2000 Algae of India and Neighbouring Countries 1. Chlorophycota. *Science Publishers Inc., USA*, pp 210.

Leela j.B., Surekha N.D. and Anjali B.S. 2010 a Phyto-plankton diversity of four lakes in Satara district, Maharastra State. *The Bioscan.* 5(3): 449-454.

Leela j.B., Surekha N.D. and Anjali B.S. 2010b Seasonal variations in occurrence of Phytoplankton and primary productivity of some selected lakes in Maharastra. *The Bioscan, Special issue*, Vol.2; 569-578.

Leela, J.B., Patil, S.M., Suresh, N.D. and Sathe, S.S. 2010 Occurrence of Phytoplankton in the water bodies of Miraj Tahasil of Maharashtra. *The Ecoscan.* 4(1): 73-76.

Maya S., Prammela S.K. and Menon S. V 2000: A preliminary study on the algae flora of Temple Tank of Southern Kerala, *Phykos*., 39, 77-83.

Michael RG 1969 Seasonal trends in physicochemical factors and plankton of a freshwater fishponds and their role in fish culture. *Hydrobiologia,* 33: 144-160.

Munawar M. 1970 Limnological studies on freshwater ponds of Hyderabad, India. The Biosense distribution of unicellular and colonial Phytoplankton in polluted and unpolluted environments. *Hydrobiol*. 36(1):105-138.

Murugesan, S. and Sivasubramanian, 2005 V. Freshwater green algae from porur lake, Chennai. India. *Hydrobiol*. 11(1):133-140.

Murugesan S. and Sivasubramanian V 2008: Freshwater diatoms from Porur Lake, Chenni. Indian Hydrobiol. 11(1): 149-154.

Muthukumar, C., Muralitharan, G., Vijayakumar, R., Panneerselvam, A., and Thajuddin, N. 2007 : Cyanobacterial Biodiversity from different freshwater ponds of Thanjavur, Tamilnadu (India). *Acta Bot. Malac*. 32:17-25.

Padmavathi, P. and Veeraiah, K. 2008 Studies on the influence of *Microcystis aeruginosa* on the ecology and fish production of carp culture ponds. *Afr. J. of Biotech*, vol. 8(9): 1911-1918.

Palmer C.M. 1969 A composite rating algae tolerating organic pollution. *J. Phycol*., 5: 1-2.

Pandey, U., Tyagi H.R. and Rai N. 1998: Algal flora and physico – chemical environment of FatehSagar Lake. *Phykos.,* 37(187): 29-30.

Pathmanapan Arulmurugan**,** Subramani Nagaraj, and Narayanaswamy Anand, N 2010. "Biodiversity of fresh water algae from temple tanks of Kerala", *Rec. Res. in Sci and Tech,* Vol. 2, pp. 58-71.

Patrick R.,Crum, B. and Coles J 1969: Temperature and manganese as determining factors of in the presence of diatoms or blugreen algal floras in streams. *Proc. Nat. Acad. Sci. USA*. 64: 472-478.

Prameela, S.K., Mayaa, S and menon,S.V. 2001 Phytopankton diversity of temple tanks of four coastal district of Kerala*. Procedings of 13 th Science Congress. Thrissur, Keral, India*. PP. 203- 204.

Philipose, M.T, 1967. Chlorococcales. Monogaraphs on algae. ICAR publications New Delhi. 1-365.

Prescott, G.W.1973 : Algae of the Western Great Lakes areas. *Wm C. Brown, Iowa 452.*

Pushpam, Maria. Bhagan P., Umayoru V. and Kumaraswamy, A. 2013 : Comparative Analysis of Physicochemical Parameters of Two Famous Temple Tanks in Kanyakumari District, S.india. *Int. J. Tren. Engi. Tech.,*2: 235-240.,

Randhawa M.S. 1959 : Zygnemaceae, *Indian Concil of Agricultural Research, New Delhi*, 317 – 318. PP.

Sankar Hosmani P. and Vasanth Kumar L. 2000 Biochemical aspects of water pollution in two lakes of Mysore city. Lake, Section 6- Limnology, watershed Hydrology and Monitoring – Paper 3.

Sankarn B.and Thiruneelagandan E. 2015: Microalgal diversity of Pathasarathy temple tank, Chennai, India, *Int. J. Curr. Microbiol. App. Sci.;* 4(4): 168- 173

Seeta**,** Y, K. Navatha and P. Manikya Reddy.,2016 Distribution of *Pediastrum* in Dal lake, Kashmir, India.*J. Algal Biomass Utln*. 7 (1): 56-61.

Senthilkumar, R., and Sivakumar, K., 2008. "Studies on phytoplankton diversity in response to abiotic factors in Veeranam lake in the Cuddalore district of Tamil Nadu", *J. of Environ Biol,* Vol. 29, pp. 747-752.

Setumadhavarao D., Jyothi Kaparapu and Narasimha Rao, G.M. 2015, Micro Algae Population in Mangroove Habitats of the Visakhapatnam, East Coast of India. J. Algal Biomass Utln. Vol. 6 (2), 5-10.

Setumadhava Rao D. and Narasimha Rao G.M. 2016 : Seasonal abundance of Phytoplankton in relation to Physicochemical features of Venkamma cheruvu Veeraghattam, Srikakulam (Dist.) A.P. India. IOSR J. of Pharmacy and Biol.Sci. Vol. 11 (4) Ver. IV Pp. 91-98.

Setumadhavarao D 2018: - Some ecological studies on seasonal distribution and composition of Micro Algae in relation to Physicochemical features in four temple ponds of Srikakulam and Vizainagaram districts, Andhra Pradesh, Ph.D Thesis, Andra University, Visakhapatnam.

Sivakumar, K. and Karuppaswamy R. 2008: Factors effecting productivity of phytoplankton in reservior of Tamilnadu, India, American- Eurasian *J. of Botany.* 1(3): 99-103.

Sophia Barinova, Jai Prakash Keshri, Subhabrata Ghosh, Jayanta Sikdar. 2012: The influence of the monsoon climate on Phytoplankton in the Shibpukur pool of Shiva temple in Burdwan, West Bengal, India. *Limnological Review*. 12, 2; 47- 63.

Srivastava P.N. and Odhwani B.R. 1992 : Algae from the inland salt pans. I. *Ind. Bot. Soc.* 71: 23-27.

Subbramaniah 1972: The biology of blue –green algae of Sambhar lake salt works. Symposium of the Taxonomy and Biology of Blue-Green algae, madras (ed. Desikachary, TV.) PP. 439-441.

Sulabha V. and Prakasam V. R. 2006 : Limnological features of Thirumullavaram temple pond of Kollam municipality, Kerala *J. of Environ. Biol*, 7(2): 449- 451.

Sukumaran, M. Brintha M. and Mathavanpillai M. 2008 : Species composition and diversity of Phytoplankton of Pechiparai dam. India. *J. of Theor. And Expl. Bio.,* 4(4):157-161.

Tarakeshwar Senapati, Subhabrata Ghosh and Tirthankar Mandal. 2011 : Variation in phytoplankton diversity and its relation with physicochemical parameters of a semi lentic water body of Golapbag, West Bengal, India. *Int. J. of Curr. Res.* Vol. 3, Issue, 7, pp.053-055.

Tejaswini G. and Vijaya K. 2004 : Studies on Algal Diversity in Temple Ponds from North Goa. *Indian Hydrobiol*, 7 (1 and 2): 67-71.

Thakur R.K., Jindal, R., Uday Bhan Singh and Ahluwalia, A.S. 2013 : Plankton diversity and water quality assessment of three fresh water lakes of Mandi (Himachal Pradesh, India) with special reference to planktonic indicators. *Environ. Monit. Assess* 185 (10): 8355 – 73.

Thiruganamoorthy, K. and Selvaraju, M. 2009 : Phytoplankton diversity in relation to physico-chemical of Gnanapekasam temple pond of Chidambaram in Tamilnadu, India. *Recent Res.in Sci. and Tech*. Vol 1(5).

Tiwari A. and Chauhan S.V.S. 2006 : Seasonal phytoplanktonic diversity of Kitham Lake, Agra. *J. of Envronl. Bio.* 27(1): 35-38.

Transeau, E.N. 1951:. Zygnemaceae. Ohioi State University Press. Columbus. USA. 26.

Venkatewarlu V. and Reddy M.P. 1985. Algae as biomonitor in rever ecology sym. Biomonitoring state. *Envirn.,* pp. 183-189.

Wetzel RG and Likens GE. 2000 :Limnological Analyses. 3rd ed. Verlag, New York, Inc. N.Y.

Zebek E. 2004 : Species biodiversity of net Phytoplankton as an indicator of trophic changes in the urban lake *Jeziorak Mały. Teka Kom. Ochr.Kszt. Środ.Przyr.*, 1: 316-321.