EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 5
Issue: 9
507-519
Year: 2018

MICROALGAL FLORA OF KARANEESWARAR TEMPLE POND, SAIDAPET, CHENNAI.

***P. Desingurajan, R. Dhamatharan and B. Sankaran**

Department of Plant Biology and Plant Biotechnology, Presidency College (Autonomous), Chennai – 05, Tamilnadu, India.

***Corresponding Author: P. Desingurajan**
Department of Plant Biology and Plant Biotechnology, Presidency College (Autonomous), Chennai – 05, Tamilnadu, India.

Article Received on 13/07/2018 **Article Revised on 02/08/2018** **Article Accepted on 22/08/2018**

ABSTRACT
Algae are commonly grown in fresh water and Seawater and also grown in soils, inside the rocks and fur of sloths and polar bears. Commercial products are obtained from macroalgae for a very long time. Microalgae are also important source of vitamins, minerals, proteins, polyunsaturated fatty acids, antioxidants, etc. In this study a total number of 93 species were identified from the temple tank dominated by green algae with 59 species Fourteen Bacillariophyceae, ten Euglenophyceae, eight Cyanophyceae and two Xanthophyceae members were identified.

KEYWORDS: Polyunsaturated fatty acids, green algae, antioxidants, Bacillariophyceae, Euglenophyceae, Cyanophyceae, Xanthophyceae.

INTRODUCTION
Algae are photosynthetic organisms that include prokaryotes (Cyanobacteria) and unicellular and multicellular eukaryotes. A precise definition of the group is elusive; they share many obvious characteristics with higher (land) plants, whereas their distinguishing features from other plant groups are varied and more subtle (Bold and Wynne, 1985). Algae commonly grow in fresh water and seawater, and several species grow in extremely high-salt environments, such as the Great Salt Lake, Utah, and the Dead Sea, in Israel. Within these aqueous habitats, some algae grow within a few hundred meter of the water surface, others in-habit the subsurface water column and a few thrive at the limits of the photic zone (which is often 200-300 m below the surface). Algae also grow in soils, inside rocks, in snow fields, and in more Exotic locations, such as the fur of sloths and polar bears. Finally, algae can either be free living or exist in association with other organisms (Lichens). They possess chlorophyll and can manufacture their own food through the process of photosynthesis. Algae have been estimated to include anything from 30000 to more than 1 million species (Michael D. Guiry, 2012).

Algae are classified based on its pigment, storage compound, thallus organization and chloroplast. Most of the algae are photosynthetic (like higher plants) or are closely related to organisms that are. Algae perform roughly 50% of the photosynthesis on this planet (John, 1994) and thus are instrumental in supporting the biosphere. The phytoplankton community is extremely important for the open sea environment, as it contributes most of the organic carbon available to pelagic food chains (Reynolds, 2006). The major algal product in the world today is nori, the algal blade (called a thallus) of certain species of the red macroalga *Porphyra*. Nori is a primary constituent of sushi, a Japanese food item that is becoming increasingly popular in the West. Its high protein content is one of the main reasons to consider them as an unconventional source of proteins. Microalgae are an important source of vitamins, minerals, proteins, polyunsaturated fatty acids, antioxidants, etc. (Pulz and Gross, 2004 and Gouveia et al., 2008). Microalgae possess many unique and interesting biochemical properties that are playing an increasingly important role in many aspects of daily lives from nutrition through to energy production (Sweetman, 2009).

The present study is concerned with species diversity of algae. It includes documenting the number of species in a Karaneeswarar temple pond in Chennai.

MATERIALS AND METHODS
Study area
The study area was Karaneewarar temple pond (Figure 1) in Saidapet, Chennai. The pond is associated with a temple having lord Shiva as its deity. The geographic coordinates of this temple pond is 18° 1' 29" North and 80° 13' 21" East. The pond occupies an area of 40000 square feet and the depth is about 35 feet. The pond exists for the past 400 years right from the origin of

Chennai city. The temple pond water used for pooja and other temple activities. The pond is maintained Hindu religious and cultural endowments (Government of Tamil Nadu).

Karaneeswara Temple Tank, Saidapet, Chennai
Figure 1

Collection of sample
The water samples were collected randomly from different spots in the pond. The water was collected using a plastic water jug by scooping up the water from the pond surface. It was brought to the laboratory immediately and was observed under light microscope for identifying microalgae. The study was done for ten months periodically. The sample collection was twice a month. The physico-chemical parameters of the pond water was analysed in Tamil Nadu Water Supply and Sewerage Board.

Isolation of microalgae
The water sample collected from the pond was subjected to laboratory examination. The medium used for isolation of microalgae was CFTRI medium. The sample water was added to the medium and incubated in suitable conditions. The microlagal growth of different species was luxuriant. The study included isolation of axenic microalgal culture. The microalgae were isolated by serial dilution method.

Laboratory growth conditions
The isolated culture was maintained at 24 ± 1°C in a thermo-statically controlled environmental chamber illuminated with cool white fluorescent lamps (Philips 40w, cool daylight, 6500k) at an intensity of 2000 lux in a 12/12 h light/dark cycle. The microalgae were grown in CFTRI culture media.

Medium composition
CFTRI Medium was prepared using the following Composition (Venkataraman, 1985).

Chemicals	-	**g/L**
$NaHCO_3$	-	4.5
K_2HPO_4	-	0.5
$NaNO_3$	-	1.5
K_2SO_4	-	1.0
NaCl	-	1.0
$MgSO_4.7H_2O$	-	0.2
$CaCl_2$	-	0.04
$FeSO_4$	-	0.01
pH	-	10

Identification
Microalgae present in collected water samples were observed using compound light microscope. Microalgae were identified by placing a drop of water on a glass slide and mounted with a cover slip over it. The microalgal cultures were microscopically examined using compound microscope. The microphotographs of microalgae were taken using Nikon digital camera (Coolpix E8400). The identification of algal species was done with the help of standard books and monographs (Fritsch, 1935; Desikachary, 1985 and Philipose, 1967). Internet resources were also used for identification.

EXPERIMENTS AND RESULTS
The collected water sample immediately fixed with a 4% formalin solution in glass jars. The water sample collection for the study was done. Water collection was done every fortnight.

Physico-chemical properties of pond water
The physico-chemical parameters of the water sample were analysed (Table – 1) according to American Public Health Standards (APHA, 2000). The nature of the water sample can be analysed with physic-chemical analysis. Physico-chemical characteristics have an effect on the microalgal species diversity of any water body. The

water shows a near neutral pH value of 7.23. Permissible level of total dissolved solids. The values of different kinds of chemicals are also in the permissible limit. The B.O.D. and C.O.D. values were also favourable. The conditions are very much favourable for the growth and diversity of micro algae in the pond.

Table 1

Physico chemical analysis of water sample

	Date - 04/02/2016	Date - 21/04/2016
PHYSICAL EXAMINATION	Quantity/Quality	Quantity/Quality
Appearence	Clear	Clear
Colour	Colourless	Colourless
Odour	None	None
Turbidity NT Units	4.7	8
Total dissolved solids mg/L	178	182
Electical Condactivity Micro mho/cm	254	260
CHEMICAL EXAMINATION:		
pH	7.33	7.12
pH. Alkalinity as CaCO3 mg/L	0	0
Total Alkalinity as CaCO3 mg/L	72	80
Total Hardness as CaCO3 mg/L	62	76
Calcium as Ca mg/L	22	26
Maginesium as mg/L	2	3
Sodium as Na mg/L	28	20
Potassium as K mg/L	2	1
Iron as Fe mg/L	0.39	0
Manganese mg/L	0	0
Free Ammonia as NH3 mg/L	0.3	1.6
Nitrite as NO2 mg/L	0.8	0.08
Nitrate as NO3 mg/L	5	4
Chloride as Cl mg/L	26	22
Fluride as F mg/L	0.44	0.5
Sulphate as SO4 mg/L	18	20
Phosphate as PO4 mg/L	0.25	0.38
Tidys Test 4 hrs. as O2 mg/L	2.7	1
C.O.D - mg/L	26.6	9.2
B.O.D - mg/L	9.8	3

Identification of microalgae

A drop of pond water fixed with 4% formalin is kept in slide and microalgae present in it were observed and its genera were identified. The water samples were observed using compound light microscope. The microalgal cultures were microscopically examined using compound microscope.

Algae were identified by using of several monographs, Reference books, online libraries and Research articles.

Blue Green Algae

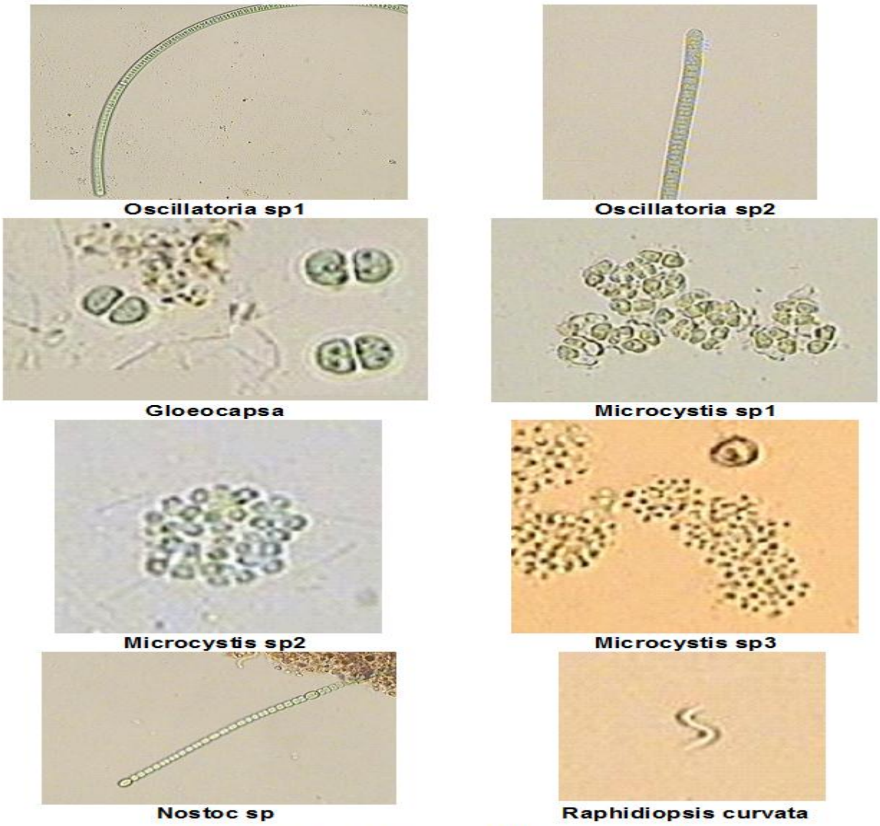


Plate 1 - Cyanophyceae (Blue green algae)

Chlorophyceae (Green Algae)

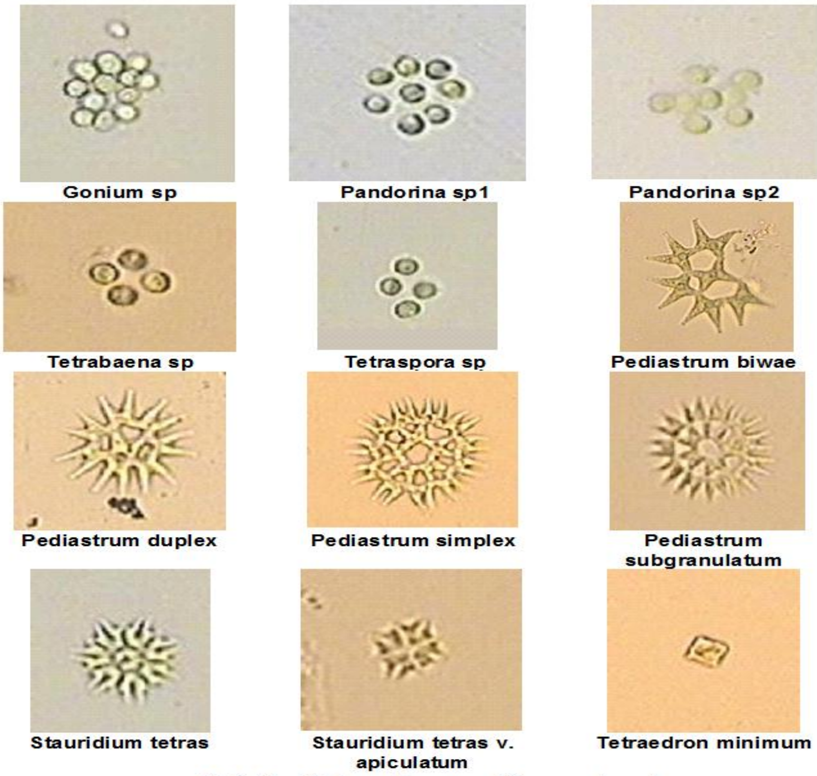


Plate 2 - Chlorophyceae (Green algae)

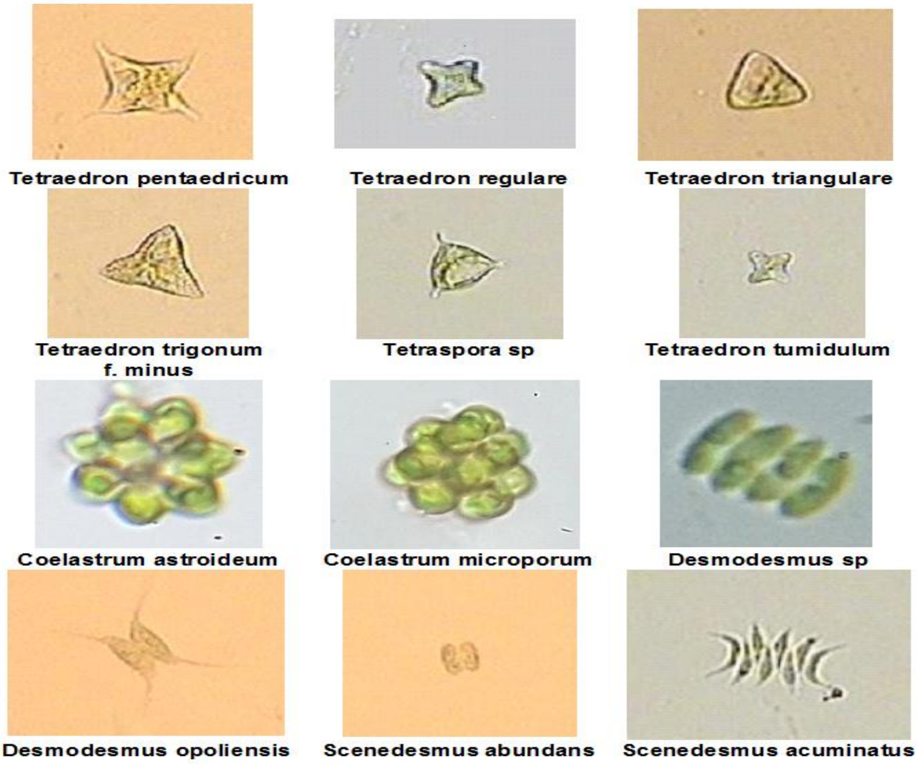


Plate 3 - Chlorophyceae (Green algae)

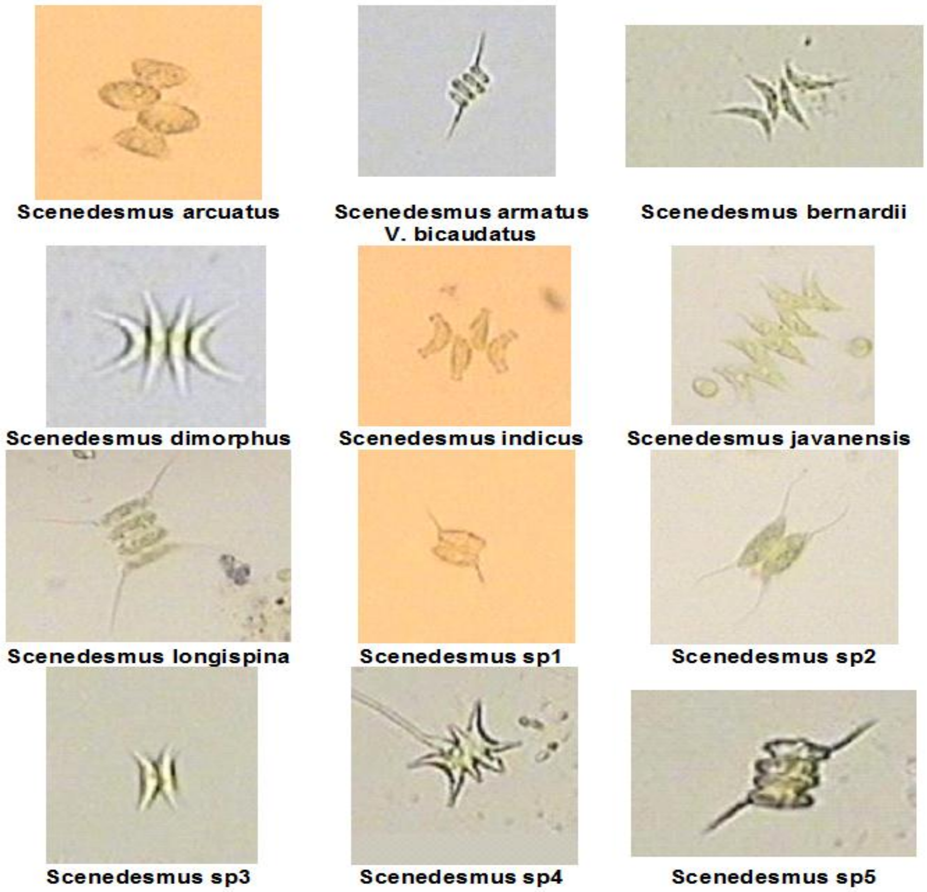
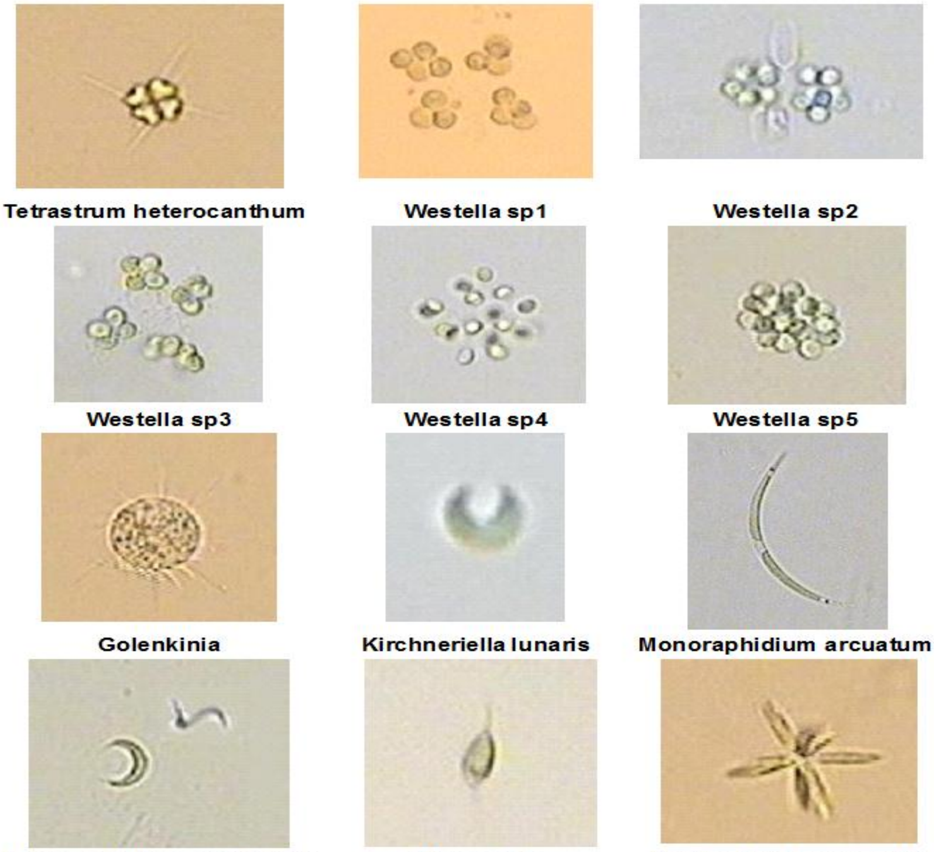


Plate 4 - Chlorophyceae Green algae



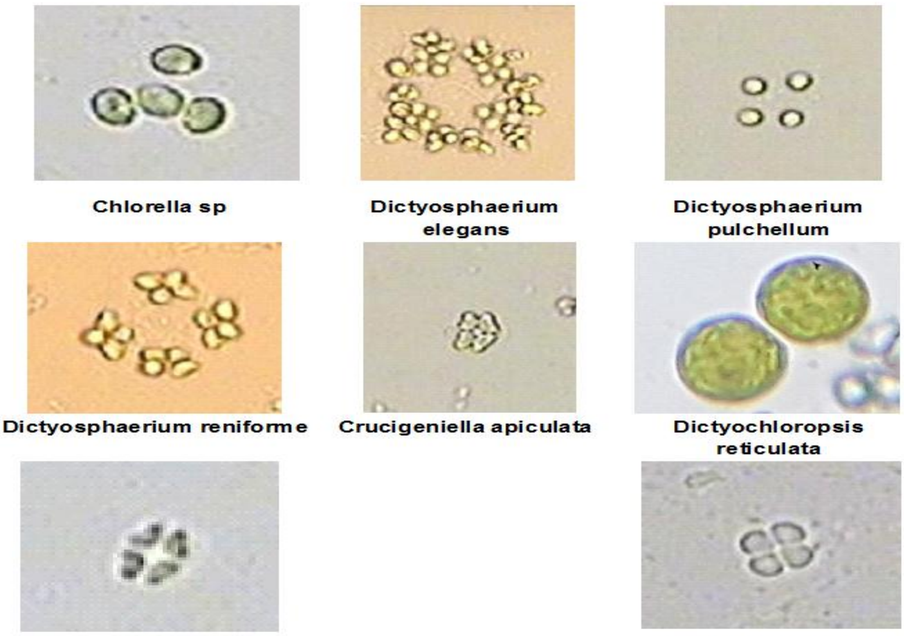
Tetrastrum heterocanthum | Westella sp1 | Westella sp2

Westella sp3 | Westella sp4 | Westella sp5

Golenkinia | Kirchneriella lunaris | Monoraphidium arcuatum

Monoraphidium contortum | Schroederia | Actinastrum hanszschii

Plate 5 - Chlorophyceae Green algae



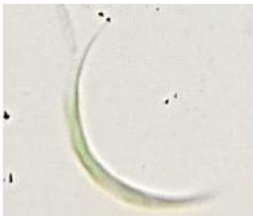
Chlorella sp | Dictyosphaerium elegans | Dictyosphaerium pulchellum

Dictyosphaerium reniforme | Crucigeniella apiculata | Dictyochloropsis reticulata

Crucigenia crucifera | Crucigenia quadrata

Plate 6 - Chlorophyceae Green algae

Elakatothrix gelatinosa



Closterium sp

Staurastrum diacanthum

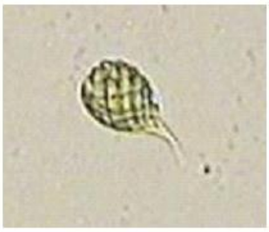
Plate 7 - Streptophyta (Higjer plant like algae)

Euglenophytes

Lepocinclis sp1

Lepocinclis sp2

Phacus longicauda



Phacus pyrum

Phacus sp1

Phacus sp2

Trachelomonas sp1

Trachelomonas sp2

Trachelomonas sp3

Trachelomonas sp4

Plate 8 - Euglenophytes

Xanthophyceae

Plate 9 - Xanthophyceae

Bacillaoriophyceae

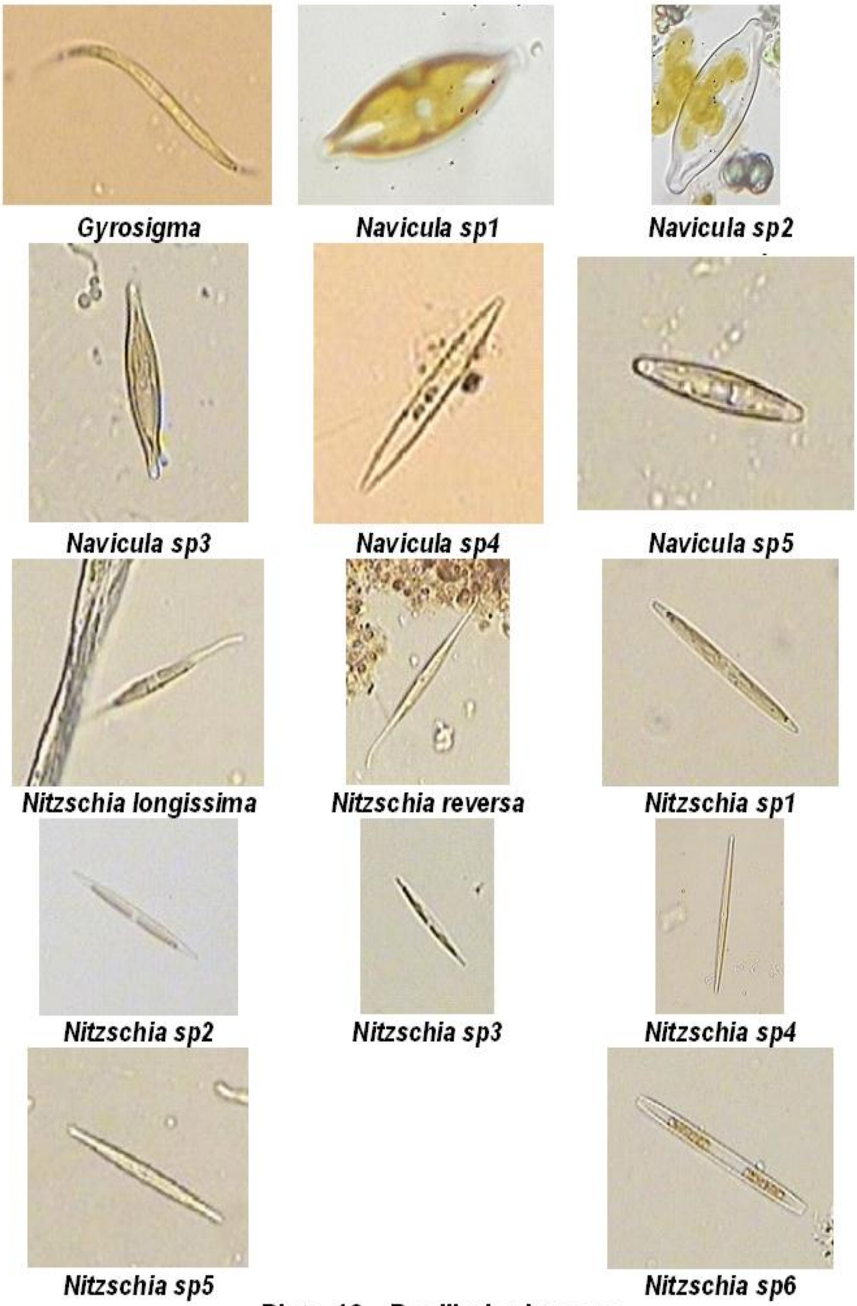


Plate 10 - Bacillariophyceae

Table 2: List of species identified from Karaneeswarar temple pond.

S.No.	Species
1	*Actinastrum hanszschii* Lagerheim
2	*Chlorella* Beijerinck
3	*Closterium* Nitzsch ex Ralfs
4	*Coelastrum astroideum* De Notaris
5	*Coelastrum microporum* Nägeli
6	*Crucigenia crucifera* (Wolle) O.Kuntze
7	*Crucigenia quadrata* Morren
8	*Crucigeniella apiculata* (Lemmermann) Komárek
9	*Desmodesmus* (Chodat) S.S. An, T. Friedl and E. Hegewald
10	*Desmodesmus opoliensis* (P.G.Richter) E.Hegewald
11	*Dictyochloropsis reticulata* (Tschermak-Woess) Tschermak-Woess
12	*Dictyosphaerium elegans* Bachmann
13	*Dictyosphaerium pulchellum* H.C. Wood
14	*Dictyosphaerium reniforme* Bulnheim
15	*Elakatothrix gelatinosa* Wille
16	*Gloeocapsa* Kützing, F.T.
17	*Golenkinia* Chodat, R
18	*Gonium*, Müller, O.F.
19	*Gyrosigma* Hassall
20	*Kirchneriella lunaris* (Kirchner) Möbius
21	*Lepocinclis* sp1, Perty, 1849
22	*Lepocinclis* sp2
23	*Microcystis* sp1 Lemmermann, 1907
24	*Microcystis* sp2
25	*Microcystis* sp3
26	*Monoraphidium arcuatum* (Korshikov) Hindák
27	*Monoraphidium contortum* (Thuret) Komárková-Legnerová
28	*Navicula* sp1 Bory, 1822
29	*Navicula* sp2
30	*Navicula* sp3
31	*Navicula* sp4
32	*Navicula* sp5
33	*Nitzschia longissima* (Brébisson) Ralfs
34	*Nitzschia reversa* W. Smith
35	*Nitzschia* sp1
36	*Nitzschia* sp2
37	*Nitzschia* sp3
38	*Nitzschia* sp4
39	*Nitzschia* sp5
40	*Nitzschia* sp6
41	*Nostoc* Vaucher ex Bornet and Flahault
42	*Oscillatoria* sp1 Vaucher ex Gomont
43	*Oscillatoria* sp2
44	*Pandorina* sp1 Bory
45	*Pandorina* sp2
46	*Pediastrum biwae* Negoro
47	*Pediastrum duplex* Meyen
48	*Pediastrum simplex* Meyen
49	*Pediastrum* ovatum (Ehrenberg) A.Braun
50	*Pediastrum subgranulatum* (Raciborski) J.Komárek & V.Jankovsk
51	*Phacus longicauda* (Ehrenberg) Dujardin
52	*Phacus pyrum* (Ehrenberg) W. Archer
53	*Phacus* sp1 Dujardin
54	*Phacus* sp2
55	*Raphidiopsis curvata* F.E.Fritsch & M.F.Rich
56	*Scenedesmus abundans* (O.Kirchner) Chodat

57	***Scenedesmus acuminatus* (Lagerheim) Chodat**
58	***Scenedesmus arcuatus* (Lemmermann) Lemmermann**
59	***Scenedesmus armatus* var bicaudatus (Guglielmetti) Chodat**
60	***Scenedesmus bernardii* G.M. Smith**
61	***Scenedesmus dimorphus* (Turpin) Kützing**
62	***Scenedesmus indicus* Philipose ex Hegewald, Engelberg & Paschma**
63	***Scenedesmus javanensis* Chodat**
64	***Scenedesmus longispina* Chodat**
65	***Scenedesmus* sp1**
66	***Scenedesmus* sp2**
67	***Scenedesmus* sp3**
68	***Scenedesmus* sp4**
69	***Scenedesmus* sp5**
70	***Schroederia* Lemmermann**
71	***Staurastrum diacanthum* A.Lemaire**
72	***Stauridium tetras* (Ehrenberg) E.Hegewald**
73	***Tetrabaena* (F.Dujardin) E.Fromentel**
74	***Tetraedriella* sp1 Pascher**
75	***Tetraedriella* sp2**
76	***Tetraedron minimum* (A.Braun) Hansgirg**
77	***Tetraedron pentaedricum* West & G.S.West**
78	***Tetraedron regulare* Kützing**
79	***Tetraedron triangulare* Korshikov**
80	***Tetraedron trigonum* f. Minus**
81	***Tetraedron trigonum* (Nägeli) Hansgirg**
82	***Tetraedron tumidulum* (Reinsch) Hansgirg**
83	***Tetraspora* Link ex Desvaux**
84	***Tetrastrum heterocanthum* (Nordstedt) Chodat**
85	***Trachelomonas* sp1**
86	***Trachelomonas* sp2**
87	***Trachelomonas* sp3**
88	***Trachelomonas* sp4**
89	***Westella* sp1 De Wildeman**
90	***Westella* sp2**
91	***Westella* sp3**
92	***Westella* sp4**
93	***Westella* sp5**

4. DISCUSSION

Algae are the primary producers for all the oceans and seas, an area that covers 71% of the Earth's surface. Algae occur in freshwater lakes, ponds and streams as well as on and in soil, rocks, ice, snow, plants and animals. The algae are tremendously diverse. These are at least seven distinct phylogenetic lineages that arose independently during geological time and that evolved at different rates (based upon molecular clocks). Consequently, the algae *in toto* do not form a single, cohesive group, and they must be considered a polyphyletic assemblage. Recently, electron microscopy is being augmented by, or replaced by, gene sequence comparisons. Both electron microscopy and molecular sequencing are time consuming and expensive methods that slow the descriptions of new species. Time consuming methods for describing new algal species, a reduction in the number of algal systematists, a reduction in funds to support systematic research, and phycologically unexplored geographical areas act synergistically to hamper the rate of accessing algal biodiversity.

Algae being a vital group of bacteria and plants in aquatic ecosystem are important component of biological monitoring programs for evaluating water quality. They are suited to water quality assessment because of their nutrient needs, rapid reproduction rate, and very short life cycle. Algae are valuable indicators of ecosystem conditions because they respond quickly both in species composition and densities to a wide range of water conditions due to changes in water chemistry. For example, increases in water acidity due to acid-forming chemicals that influence lake pH levels, as well as heavy metals discharged from industrial areas, affect the composition of genera that are able to tolerate these conditions. Algal community variability over time can result from seasonal changes in temperature and light availability (Biggs, 1996). Of primary importance from an ecological and public health perspective is the abundance of nutrients containing nitrogen (N) and phosphorus (P) that flow into lakes, reservoirs, streams and rivers resulting in eutrophic conditions. The N:P ratio often determines which algae genera are dominant, present or absent in these nutrient affected water bodies. Microscopic analysis of water samples collected from lakes, streams and other bodies determines the diversity and density of algal species and provides potentially useful early warning signs of deteriorating conditions.

With respect to the total number of described species worldwide the best source of information is provided by Chapman, 2009. He has used a mixture of databases and expert opinion to come up with a figure of 1.9 Million species (Michael D. Guiry, 2012). Among 1.9 Million described species, the number of described algae should be analysed. Most of the reliable estimates of algal species, such as Chapman (2009) and the IUCN Red List (2010) relied on AlgaeBase for their figures. So we should look for the current numbers there (as of June 2012). AlgaeBase list shows that the total number of algal species described up to June 2012 is 43918. Around 28618 more is identified but yet to be described. About totally there are 72536 algae identified till date.

Investigations in tropical regions is leading to the discovery of many new species (Neustupa *et al.*, 2007; Rindi and López-Bautista, 2007; Eliáš *et al.*, 2008; Zhang *et al.*, 2008; Neustupa *et al.*, 2009). Green algae are one of the most diverse groups of eukaryotes and include morphological forms ranging from flagellated unicells, coccoids, branched or unbranched filaments to multinucleated macrophytes and taxa with parenchymatic tissues (Pröschold and Leliaert, 2007). Dating based on molecular data suggests that the most recent common ancestor of all green algae may have existed 1100-1200 million years ago (Yoon *et al.*, 2004).

Cyanobacteria (blue-green algae) with a single class, mostly equally distributed between marine and freshwater/terrestrial habitats. The best taxonomic source for the Cyanophyceae is CyanoDB. It is estimated that the number of described species is about 5,000, with about 3,000 undescribed species. For the Rhodophyta (red algae), currently with six classes, around 7200 species is described species. The red algae are predominantly present in marine. The Charophyta numbers to a probable total of about 5,000 species. The Chlorophyta is estimated to be around 9500 species, described around 4500 and undescribed around 5000. The Cryptophyta described species is about 200, and there is probably an equal number of undescribed species.

The Haptophyta members are mostly marine numbers includes about 500 described species and very few undescribed species. The Ochrophyta (Heterokontophyta, heterokonts) currently with 18 classes includes the brown algae, the diatoms, and the Xanthophyceae. It includes primarily marine or primarily freshwater (and/or subaerial) organisms. Of the 18 classes currently included in the Ochrophyta, 11 have 50 or less species described, and only two (Bacillariophyceae and Phaeophyceae) have more than 1,500. The greatest difficulty within the Ochrophyta, and consequently the algae in general, is in assessing the numbers of diatoms. The Catalogue of Diatom Names has accumulated 62,000 names of genera, species, and infraspecific ranks. According to Mann and Droop (1996), there are likely to be more than 200,000 species of diatoms, of which they claim that 10% have been named. It is very clear, however, that the supposition that diatom species are in general ubiquitous and endemism is rare is not supported by recent studies (Vanormelingen et al. 2008).

The Microalgae studied in the temple pond had 93 species represented by 37 Genera. About 25 Genera with 59 species were representatives of Green algae. The number of species of *Scenedesmus* was high and it was represented by 14 species. It was *Tetraedron* represented by seven species. *Westella* and *Pediatrum* were five and four respectively. *Dictyosphaerium* was represented by three species. Coelastrum, Crucigenia, Desmodesmus, Monoraphidium, Pandorina, Stauridium, had a representation of two species each. All other genera were represented by one species each.

Blue green algae were represented by five genera represented by eight species. About ten species were identified from euglenophyceae under three genera. Two species of xanthophyceae and 14 species of diatoms was identified.

Microalgal diversity study of algae not only provides an opportunity to unearth the new species existing in this world. It also helps in culturing few species and finding its biochemicals and finding its commercially importance. High value biochemicals from micro-algae comprise of β-carotene, astaxanthin, vitamins, amino acids, antioxidants, polyunsaturated fatty acids (PUFAs) and polysaccharides which form an important commercial market (Spolaore *et al*., 2006).

Microalgal research has many advantages as they have the ability to convert CO2 to useful materials through photosynthesis. Microalgae are used as single cell protein as food supplement. They are used as human nutritional supplements, as animal feed additives, in aquaculture, and in cosmetics. It is used by astronauts during space travel. Microalgae are tapped as a source for useful secondary metabolites. Recently, algae have been associated with regulating environmental pollution. These can help in removing pollutants from the surroundings, restoring contaminated sites and preventing further pollution.

Microalgae are also used in Bioremediation. Phycoremediation is a novel technique that uses algae to clean up contaminated soil and water. The first ever phycoremediation plant with *Chroococcus turgidus* has been working from September 2006 at SNAP industry very successfully (Sivasubramanian *et al*, 2009).

5. SUMMARY

1. The microalgal flora of Karaneeswarar temple pond in Saidapet, Chennai was studied.
2. The Physico-chemical analysis of the water sample was done. The physical and chemical analysis report reveals that it is conducive for microalgal growth.
3. The total number of species identified in the study was 93 (Table 2).
4. It was dominated by Green algae members.
5. There were 25 genera belonging to green algae with 57 species. *Scenedesmus* was dominating genera representing 14 species followed by *Tetraedron* (Seven species). *Westella* and *Pediastrum* were having five and four genera respectively.
6. Fourteen species of Bacillariophyceae.
7. Ten species of Euglenophyceae.
8. Eight species of Cyanophyceae
9. Two species of Xanthophyceae were totally identified.
10. An axenic culture of *Navicula* sp was isolated using CFTRI medium.

6. REFERENCES

1. Becker, E. W. (2007). Microalgae as a source of protein. *Biotechnology Advances*, *25*(2): 207–210.
2. Biggs, B. 1996: Patterns in benthic algae of streams. Pp. 31–56 in Stevenson, R.; Bothwell, M.L.; Lowe, R.L. (Eds): Algal ecology. Academic Press, San Diego.
3. Bold H. C. and Wynne M. J. 1985. Introduction to the algae. Englewood (NJ): Prentice-Hall.
4. Chapman, A. D. 2009. Numbers of Living Species in Australia and the World, 2nd ed. Report for the Australian Biological Resources Study. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra, Australia, 80 pp.
5. Desikachary, T.V. (1959). Cyanophyta, I.C.A.R., New Delhi.
6. Eliáš, M., Neustupa, J. and Škaloud, P. (2008). Elliptochloris bilobata var. corticola var. nov. (Trebouxiophyceae, Chlorophyta), a novel subaerial coccal green alga. Biologia, 63: 791-798.
7. Fritsch, F.E., (1907). The sub-aerial and freshwater algal flora of the tropics.
8. A phytogeographical and ecological study. Annals of Botany, 21: 235-275.
9. Fritsch, F.E., (1935). Structure and reproduction of the algae. Vol. I and II. Cambridge University Press Cambridge.
10. http://www.cyanodb.cz/
11. http://lkcnhm.nus.edu.sg/dna/organisms/details/645
12. http://www.panoramio.com/
13. Gouveia, A.E. Marques, J.M. Sousa, P. Moura, N.M. Bandara (2010), Microalgae – source of natural bioactive molecules as functional ingredients, Food Science & Technology Bulletin: Functional Foods, 7: 21–37.
14. IUCN (International Union for Conservation of Nature) Red List of Threatened Species: http://www.iucnredlist.org.
15. John, D. M. (1988). Algal growths on buildings: a general review and methods of treatment. Biodeterioration Abstracts, 2: 81-102.
16. Mann, D. G. and Droop, S. J. M. 1996. Biodiversity, biogeography and conservation of diatoms. Hydrobiologia, 336: 19–32.
17. Michael D. Guiry, 2012. How many species of algae are there? J. Phycol., 48: 1057–1063.
18. Neustupa, J., Eliáš, M. and Šejnohová, L. (2007). A taxonomic study of two Stichococcus species (Trebouxiophyceae, Chlorophyta) with a starch enveloped pyrenoid. Nova Hedwigia, 84: 51-63.
19. Neustupa, J., N ěmcova, Y., Eliáš, M. and Škaloud, P. (2009). Kalinella bambusicola gen. et sp. nov. (Trebouxiophyceae, Chlorophyta), a novel coccoid Chlorella like subaerial alga from Southeast Asia. Phycological Research, in press.
20. Philipose, M.T. (1967). Chlorococcales. I.C.A.R.. New Delhi.
21. Pröschold, T. and Leliaert, F. (2007). Systematics of the green algae: conflict of classic and modern approaches. In J. Brodie & J. Lewis (Eds.), Unravelling the algae: the past, present and future of algal systematics, (The Systematics Association Special Volume Series 75, 123-53). Boca Raton, London and New York: CRC Press.
22. Pulz O. and Gross, W. 2004. Valuable products from biotechnology of microalgae. Appl. Microbiol Biotechnol, 65: 635-648.
23. Reynolds, C.S. 2006. Ecology of phytoplankton. Cambridge, Cambridge University Press.
24. Rindi, F. and López-Bautista, J. M. (2008). Diversity and ecology of Trentepohliales (Ulvophyceae, Chlorophyta) in French Guiana. Cryptogamie, Algologie, 29: 13-43.
25. Spolaore P, Joannis-Cassan C, Duran E. and Isambert A. 2006. Commercial applications of microalgae. *Journal of Bioscience and Bioengineering*, 101: 87-96.
26. Sweetman E. 2009. Microalgae: its applications and potential. International Aqua Feed. Perendale Publishers Ltd. UK.
27. Thajuddin, N. & Subramanian, G. 2005. Cyanobacterial Biodiversity and potential application in Biotechnology. Current Science, 89(1): 47-57.
28. Vanormelingen, P., Verleyen, E. & Vyverman, W. 2008. The diversity and distribution of diatoms: from cosmopolitanism to narrow endemism. Biodiv. Conserv., 17: 393–405.
29. Venkataraman, L.V. & Becker, E.W. (1985). In *Biotechnology and Utilization of algae – The Indian Experience*. Dept. of Science and Technology, New Delhi, India.
30. Yoon, H. S., Hackett, J. D., Ciniglia, C., Pinto, G. and Bhattacharya, D. (2004). A molecular timeline

for the origin of photosynthetic eukaryotes. Molecular Biology and Evolution, 21: 809-818.

31. Zhang, J. M., Huss, V. A. R., Sun, X. P., Chang, K. J., and Pang D. B. (2008). Morphology and phylogenetic position of a trebouxiophycean green alga (Chlorophyta) growing on the rubber tree, *Hevea brasiliensis*, with the description of a new genus and species. European Journal of Phycology, 43: 185-193.