International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 01-12-2020; Accepted: 16-12-2020: Published: 01-01-2021
www.botanyjournals.com
Volume 6; Issue 1; 2021; Page No. 01-08

Biodiversity and abundance of microalgae and cyanobacteria from freshwaters habitat of three districts of Tamil Nadu, India

Thangaraj R[1], Santhoshkumar S[2], Suresh A[3], Dhanasekaran D[4] and Thajuddin N[5]*
[1, 2, 3, 4,5] School of Life Science, Department of Microbiology, Bharathidasan University, Tiruchirappalli, Tamil Nadu, India
[2, 5] National Repository for Microalgae and Cyanobacteria- Freshwater, Bharathidasan University, Tiruchirappalli, Tami Nadu, India

Abstract
The present study revealed the diversity of microalgae and cyanobacteria in the fresh water samples from of Thanjavur, Karaikudi and Tiruchirappalli locations, Tamil Nadu, India. sA total of 94 species microalgae belonging to three taxonomic groups were identified, of which 47 species were belonging to Cyanophyceae, 16 species from Chlorophyceae and 37 species from Bacillariophyceae. *Oscillatoria* sp., *Nostoc* sp., *Microcystis* sp., *Chroococcus* sp., *Gloecapsa* sp., *Merismopedia* sp., *Lyngbya* sp. *and Anabaena* sp. (5%) were found to be among the cyanophyceaen family. Whereas, Bacillariophyceae, *Navicula* sp., *Cymbella* sp., *Gomphonema* sp., *Nitzschia* sp. *Cyclotella* sp. *Gyrosigma* sp. and *Grammatophora* sp. were predominant and in Chlorophyceae, *Cosmarium* sp., *Chlorella* sp. *Ankistrodesmus* sp. *Closterium* sp. and *Selanastrum* sp was found to be abundant. The environmental variables appear to play a significant role in determining the species richness and diversity.

Keywords: biodiversity, water analysis, correlation and cyanobacteria

Introduction

Cyanobacteria are a group of photosynthetic prokaryotes comprising more than 150 genera and 2200 species that play diverse yet significant roles in aquatic and terrestrial ecosystems [1]. Cyanobacteria are known as "Primary Producers" by ecologists point. Cyanobacteria display inhabits morphology structure and metabolism including photosynthesis and its regulation, N_2 fixation, metabolism of carbon, nitrogen and hydrogen: resistance to environmental stress and molecular evolution. Excessive growth of cyanobacteria called as Blooms, which represents a serious threat to aquatic ecosystems [2-6]. They are one of the significant primary producers in the natural ecosystems [7, 8]. Cyanobacteria are commonly found in diverse habitats [9] Filamentous cyanobacteria such as, *Nostoc* sp., *Spirulina* sp., *Arthrospira* sp., *Anabaena* sp., *Aphanizomenon* sp. and *Rivularia* sp. many others are particularly attractive for the production of high quality biomass, because they represent a source of protein and a variety of chemicals and pharmaceuticals [10]. Pigments such as phycobiliprotein, carotenoid and chlorophyll as natural colorants in food are gaining importance over the synthetic ones as they are non-toxic and non-carcinogenic [11]. [12, 13] reported that microalga FAME showed antimicrobial activity. Phycobiliproteins (PBP) are naturally occurring water soluble fluorescent pigments produced by cyanobacteria and some eukaryotic algae [14]. Our previous research reported that phycobilins mediated synthesis of nanoparticles from cyanobacteria showed antibacterial activity [15, 16]. The algal taxa both planktonic and benthic are important among other aquatic micro taxa which are found at different depths, where physicochemical properties of water influence the algal population and its occurrence [17, 18]. P^H and DO are very important factors which affects water eutrophication [19]. Analysis of biota represents qualitative characteristic of particular water system [20]. A water system dominated by green algae and diatoms is relatively clean oligotrophic water whereas dominance by bloom farming blue green algae indicates polluted or eutrophic condition. In several water bodies eutrophication has resulted in the changes of species composition and biomass of algal communities [19].The present investigation dealt with the collection diversity analysis and abundance of microalgae from different locations of Thanjavur, Karaikudi and Tiruchirappalli, Tamil Nadu, India.

Materials and Methods

Sample collection and study area

Cyanobacteria and microalgae samples were collected from different locations of Tiruchirappalli, Karaikudi and Thanjavur locations of Tamil Nadu, India. The sampling habitat includes freshwater, rice fields and stagnant water bodies. Samplings were done by using sample vials, plastic bags with aid of planktonic nets.

Isolation and maintenance of Cultures

The isolated cyanobacteria isolates were brought to the microalgal Germplasm, Department of Microbiology, Bharathidasan University, Tiruchirappalli and maintained with specific culture conditions. The cultures were grown in BG11 medium [21] Chu 10 medium [22] and F/2 medium [23]. All the collected cyanobacteria isolates were maintained at pH 6.8, 24 °C ± 2 °C light intensity of 14.4 ± 1Wm^2 a 16/8 h light/dark cycle photoperiod reported by [24] for further study.

Identification of Cyanobacteria by Light microscope

Morphological observations [presence and absence of sheath, shape and size of the vegetative cells, heterocysts, akinetes (if present), position, and branching pattern] of the axenic cultures of cyanobacteria images were captured at Micros Austria MCX500 microscope in 100X magnification, as described by Desikachary [25].

Determination of physicochemical properties of water samples

The physicochemical properties of water such as pH, temperature, alkalinity, nitrate, calcium, magnesium, chloride, conductivity, total dissolved solids, salinity, and dissolved oxygen were measured as per the following standard protocol [26].

Biodiversity and statistical analysis

All the statistical analysis was performed using SPSS statistical software (vesion 17.0 for Windows, SPSS, Chicago, IL, USA). Paleontological statastics software package (versiton 2.10 for windows, PAST, Copy right by [27].

Results and Discussion

In this study, freshwater samples were collected from different locations of Tamil Nadu Such as Thanjavur, Karaikudi and Tiruchirappalli in which benthic, edaphic and planktonic samples were collected based on the collection possibilities.

Identification of microalgae from collected samples

In the present study, collected microalgae samples were identified by using light microscope. Cyanobacteria and diatoms and green algae images were captured Micros Austria MCX500 microscope in 100X (Figure. 1-6).

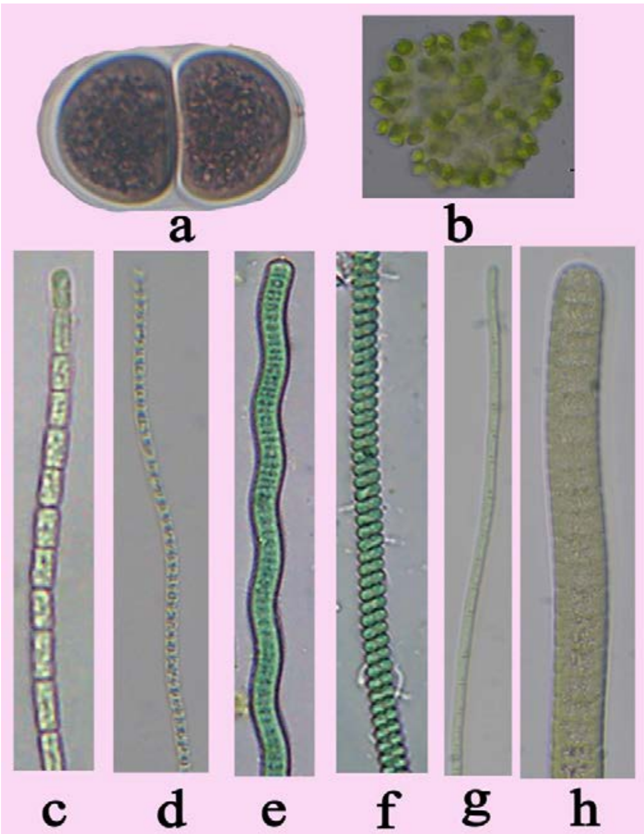

Fig 1: Microscopic view of cyanobacteria -(a-h)- (a) *Chroococcus turgidus*; (b) *Gomphosphaeria aponina*; (c) *Oscillatoria claricentrosa*; (d) *Oscillatoria pseudogeminata*; (e) *Arthrospira platensis*; (f) *Spirulina subsalsa*; (g) *Oscillatoria limnetica*; (h) *Oscillatoria rubescens*

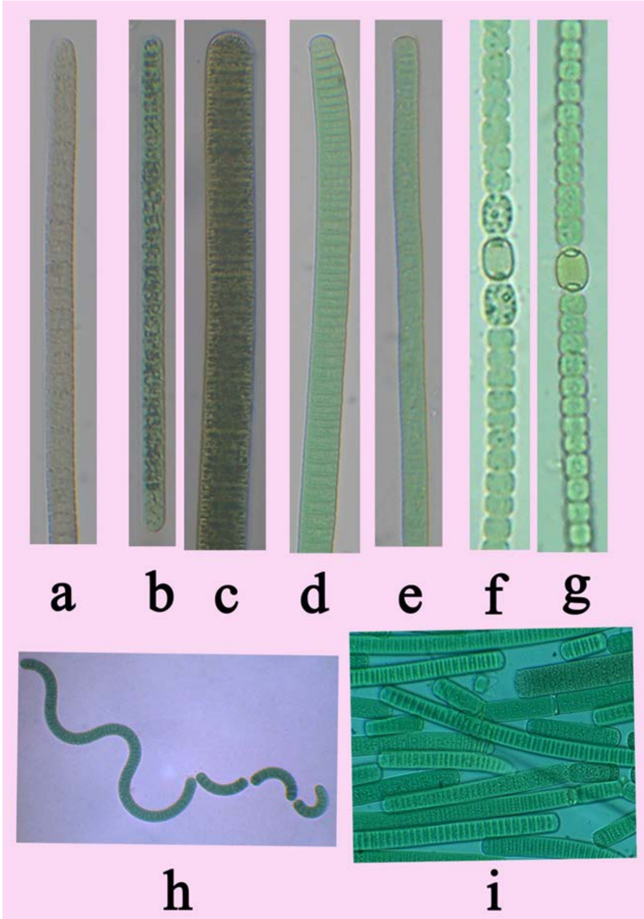

Fig 2: Morphology of cyanobacteria by microscopic view (a-i) - (a) *Oscillatoria boryana*; (b) *Oscillatoria perornata*;(c) *Oscillatoria subbrevis; (d) Oscillatoria princeps*; (e) *Oscillatoria chalybea*; (f) *Anabaena sphaerica*; (g) *Anabaena circinalis*; (h) *Arthrospira massartii*; (i) *Oscillatoria princeps*

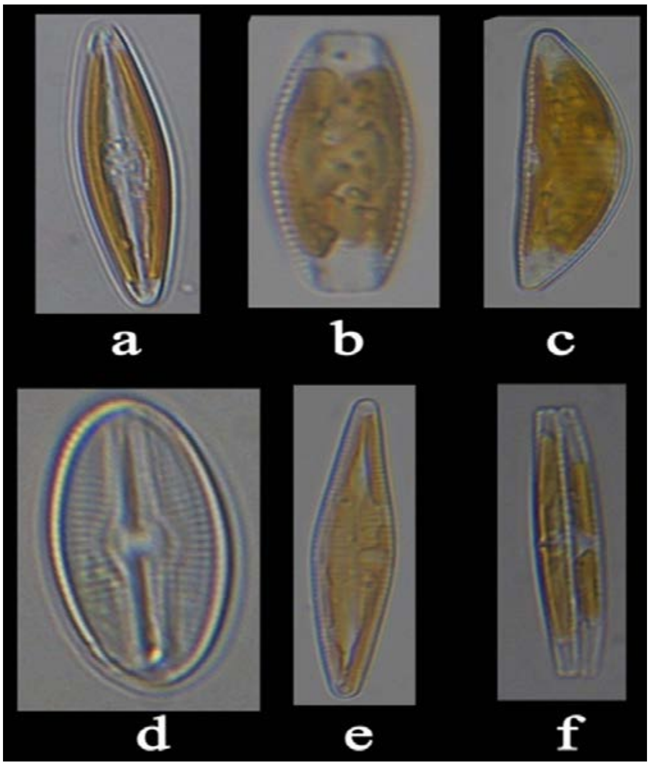

Fig 3: *Morphology of diatoms (a-f) a. Navicula cryptocephala*, b. *Amphora ovalis*, c. *Cymbella ventricosa*, d. *Cocconeis placentula*, e. *Gomphonema subtile*, f. *Nitzschia punctata*

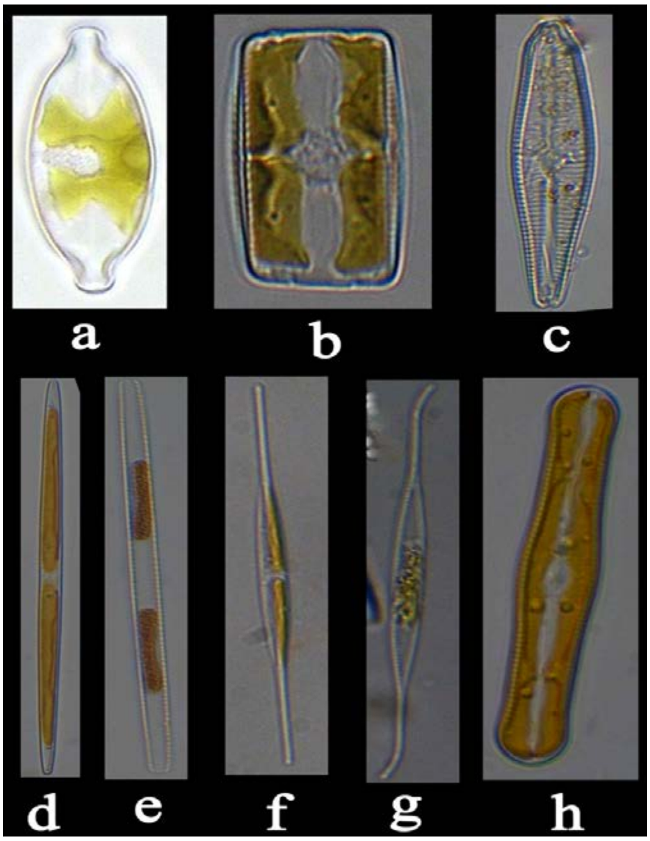

Fig: 4 Microscopic view of diatoms (a-h) - (a) *Anomoeoneis sphaerophora; (b) Trigonium arcticum;* (c) *Gomphonema constrictum;*(d) *Nitzschia insignis; (e) Nitzschia recta;*(f) *Nitzschia acicularis*; (g) *Nitzschia longissima;*(h) *Pinnularia interrupta*

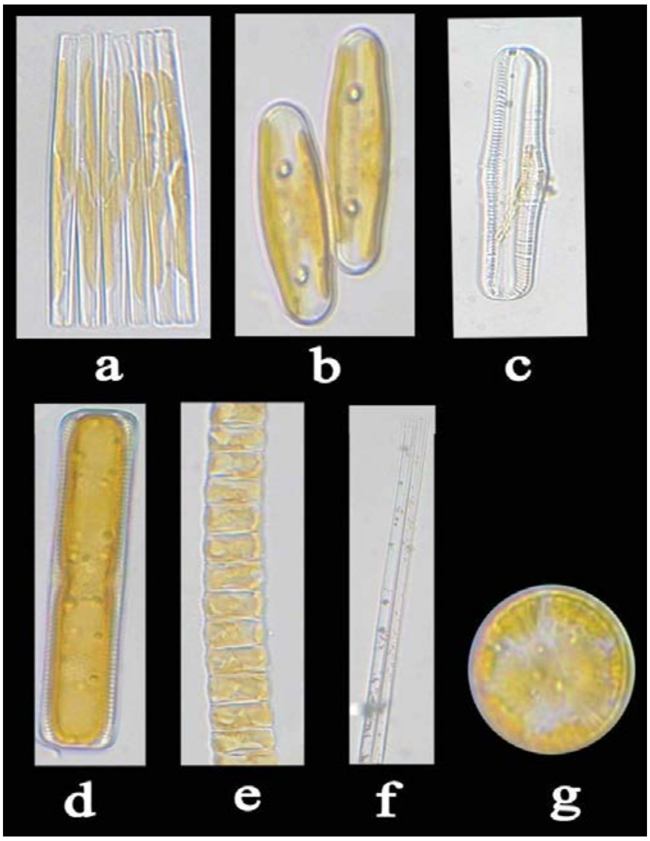

Fig 5: Microscopic view of diatoms (a-g)- (a) *Licmophora abbreviate*; (b) *Neidium iridis*; (c) *Caloneis silicula*; (d) *Trachyneis aspera*; (e) *Fragilaria capucina* (f) *Synedra splendens*; (g) *Cyclotella meneghiniana*

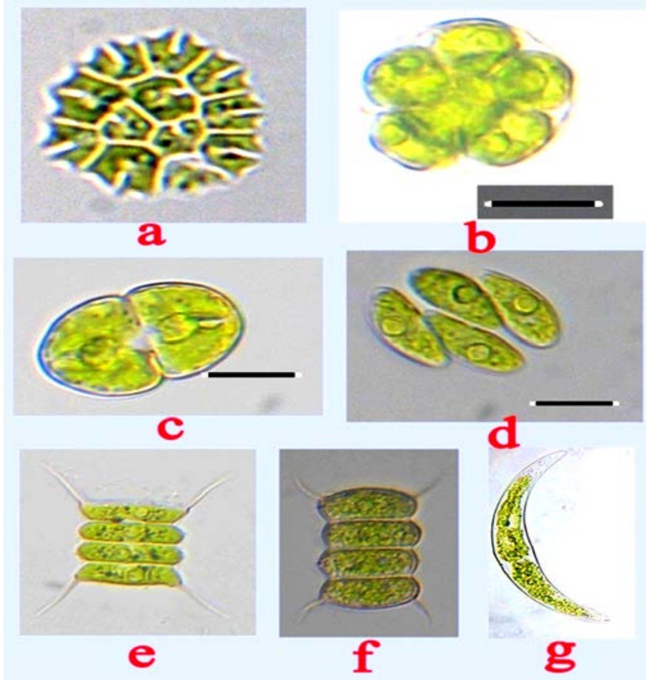

Fig 6: Mircoscopic view of Green algaea (a-f)- (a) *Pediastrum* sp.; (b) *Coelastrum microporum*; (c) *Cosmarium pseudopyramidatum*; (d) Scenedesmus graevenitzii; (e) *Scenedesmus maximus*; (f) *Scenedesmus biaudatus*; (g) *Closterium* sp.

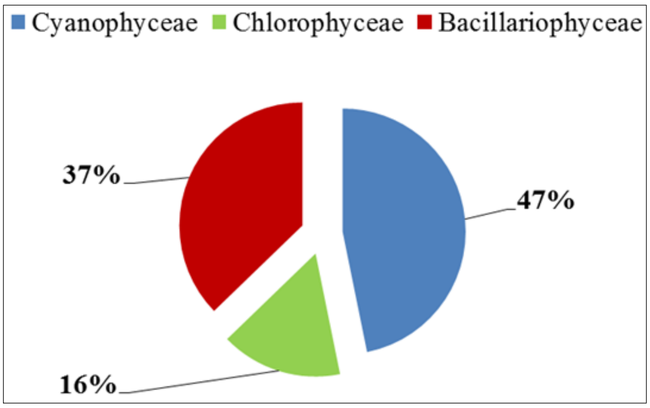

Fig 7: Microalgae family wise composition in collected location

Percentage of abundance of microalgae composition in collected locations

The microalgae (Cyanobacteria, green algae and diatoms) abundance in among all sampling locations (Table 1) of Karaikudi showed highest followed by Thanjavur and Tiruchirappalli. Moreover, the study reveals that maximum percentage was found to be Cyanophyceae (47%) followed by Bacillariophyceae (37%) and Cholorophyceae (16%) by family wise abundance in collected sampling locations (Fig. 7). The microalgae family wise composition of Thanjavur showed Cyanophyceae (49%), Bacillariophyceae (30%) and Chlorophyceae (21%). The microalgae order wise composition showed cyanophyceae family Chroococcales (42%) followed by Oscilltoriales (29%), Nostocales (21%) and Synecchococals (8%) in Thanjavur. The microalgae order wise composition Chlorophyceae family showed Sphaerpleales (50%) followed by Desmidiales (30%) and Chlorellales (20%). The microalgae order wise composition consisted of the Bacillariophyceae family Thanjavur showed Navculales (32%), Cymbellales (27%), Bacillariales (23%), Thalassiosirales (9%), Biddulphiales (5%) and Striatellales

(4%). Cyanophyceae showed ranked with species composition maximum percentage (29%) was found with *Oscillatoria* sp. this was followed by *Nostoc* sp. (19%), *Microcystis (14%)*, *Chroococcus* sp.(10%), *Gloecapsa* sp. (14%), *Merismopedia* (9%) and *Anabaena* sp. (5%). Bacilliriophyceae ranked second with maximum percentage of *Navicula* sp. (27%), *Cymbella* sp. (18%), *Gomphonema sp.* (9%), *Nitzschia* sp. (23%), *Gyrosigma* sp. (5%) *and Grammatophora* sp. (6%) *Amphora* sp. (5%), *Trigonium* sp. *(5%)* and *Cyclotella* sp. (4%). Chlorophyceae ranked third with maximum percentage of *Cosmarium* sp. (22%), *Chlorella* sp. (23%), *Selenastrum* sp. (22%), *Ankitrodesmus sp.* (11%), *Closterium* sp. (11%) *and Coelstrum* sp. (11%).

The microalgae family wise composition showed in Karaikudi Cyanophyceae (46%), Bacillariophyceae (38%) and Chlorophyceae (16%. Order wise abundance dominantly occurs Chroococcales (38%) followed by Nostocales (35) Oscillatoriales (24%) and Synechococales (4%). Sphaerpleales (42%) followed by Desmidiales (33%) and Chlorellales (25%). The Bacillariophyceae family order wise showed Navculales (36%), Cymbellales (32%), Bacillariales (11%), Thalassiosirales (7%), Striatellales (7%), Achnanthales (4%) and Licmophorales (3%). Cyanophyceae showed ranked with species composition consisted of maximum percentage *Nostoc* sp. (20%) was found with this was followed by *Oscillatoria* sp. (17%), *Lyngbya* sp. (17%), *Microcystis* sp. (13%), *Chroococcus* sp. (10%), *Anabaena* sp.(4%), *Arthospira* sp.(3%), *Gloecapsa sp.* (3%), *Aphanocapsa* sp. (3%) and *Merismopedia* sp.(3%). Bacilloriiphyceae ranked second with maximum percentage contribution of (25%) was found with *Navicula sp.* this was followed by *Cymbella* sp.(18%), *Gomphonema sp.* (17%), *Nitzschia* sp. (11%), *Gyrosigma* sp. (7%), *Trachyneis* sp. (4%), *Licmophora* sp. (4%), *Cocconeis* sp. (4%), *Pinnularia* sp. (4%) *Cycoltella* sp. (3%) *Amphora* sp. (3%) and *Mastogloia sp.* (3%). Chlorophyceae ranked third with maximum percentage contribution of *Chlorella* sp. (28%), *Cosmarium* sp. (18%), *Slenastrum* sp. (18%), *Scenedesmus* sp. (18%), *Closterium* sp. (18%). The microalgae family wise composition in Tiruchirappalli consisted Cyanophyceae (57%), Bacillariophyceae (28%) and Chlorophyceae (15%). Orderwise composition of Chroococcales (38%) followed by Nostocales (33%), Oscillatoriales (24%) and Snechococales (5%). Desmidiales (50%) followed by Sphaerpleales (25%) and Chlorellales (25%). The microalgae order wise composition consisted of the Bacillariophyceae family Tiruchirappalli showed Navculales (22%), Cymbellales (36%), Striatellales (14%), Thalassiosirales (14%), Bacillariales (7%) and Fragilariales (7%). In Tiruchirappalli Cyanophyceae showed ranked with species composition consisted of maximum percentage *Chroococcus* sp. (15%) was found and this followed by *Anabaena* sp.(15%), *Calothrix* sp. (15%), *Lyngbya* sp. (10%), *Nostoc sp. (10%)*, *Microcystis* sp. (10%), *Arthospira* sp.(5%), *Gloecapsa* sp. (5%), *Aphanocapsa* sp. (5%), *Oscillatoria* sp. (5%) and *Merismopedia* sp.(5%). Bacillariophyceae ranked second with the maximum percentage contribution of 20% of was found *Cymbella* sp. and this was followed by *Gomphonema* sp. (13%), *Navicula* sp. (13%), *Cyclotella* sp. (6%), *Anomoeoneis* sp. *(7%)*, *Amphora* sp. *(7%)*, *Syndra* sp. *(7%)*, *Gyrosigma* sp. *(7%)*, *Gramatophora* sp. *(*7%) and *Nitzschia* sp. (6%). Chlorophyceae ranked third with the maximum percentage contribution of 25% was found *Cosmarium* sp., *Closterium* sp. (25%), and *Chlorella* sp. (25%) this was followed by *Scenedesmus* sp. (13%) *Pediastrum* sp (12%).

The present study brings out that the members of the order Chroococcales were in abundance at all sampling location. The maximum percentage of Chroococcales has been recorded from Thanjavur (42%), whereas minimum recorded from Karaikudi and Tiruchirappalli (38%). The members of Nostocales were at the second position in respect of abundance. Karaikudi has (35%) of order Nostocales, which was the highest number of Nostocales recorded from the area, as against this, Tiruchirappalli (33%) and Thanjavur (29%) members. The members of Oscillatoriales are at the third position in respect of abundance. The maximum percentage of Oscillatoriales has been recorded from Thanjore (32%) whereas minimum from Karaikudi (29%). Karaikudi and Tiruchirappalli showed (24%) and (24%) respectively. The members of Snechococcales are at fourth position in respect of abundance. The maximum percentage of Snechococcales has been recorded from Thanjavur (8%) and this was followed by Tiruchirappalli and Karikudi showed (5%) and (4%). No members of order Pleurocapsales have been recorded from any sampling location. It is clear from the above discussion that the members of Chroococcales were in abundance. Chroococcales is followed by Nostocales on the basis of number of the species. The light and temperature conditions have a direct effect on the population dynamics of microalgal flora. Bright light favors the growth the members of Chroococcales, whereas, dim light enhance the presence of the members of Nostocales. Similarly, a moderate temperature between 20-40C was found suitable for the luxurious growth of Cyanobacterial taxa [28]. Species composition was significantly influenced by location, particularly for the orders Chroococcales and Nostocales. Chroococcales may have increased with location because, as unicellular organisms with rapid growth [29] they do not require a stable substrate with a fine texture and high organic matter content. In contrast, Oscillatoriales decrease the population. Nostocales are usually thought to be able to colonize young undeveloped soil because of their ability to fix nitrogen [9] which may be the limiting nutrient in this type of soil. Perhaps *Nostoc* was better adapted than many other phototrophs to cryoturbation and desiccation because it has well developed mucilaginous sheath, which protects against the cold and desiccation.

Table 1: Diversity of cyanobacteria from the four sampling locations

	Microalgae isolates	**S1**	**S2**	**S3**
1.	*Anabaena circinalis var.* crassa ghose	-	++	+
2.	*Anabaena naviculoides* (Fritsch)	-	-	+
3.	*Anabaena iyengarii (Bharadwaja)*	+	-	-
4.	*Aphanocapsa banaresensis(C.Nageli)*	-	+	-
5.	*Aphanocapsa litoralis (Hansgring)*	-	+	+
6.	*Aphanothece elachista (G.S. West)*	-	+	-
7.	*Arthrospira khannae (Drought & Strickland)*	-	+	+
8.	*Spirulina subsala* Gomont	-	+	+
9.	*Arthrospira spirulinoides* R. N. Singh	-	-	+
10.	*Calothrix parietina(Thuret ex Bornet & Flahault)*	-	+	+
11.	*Calothrix epiphytica* West& G.S. West	-	+	+
12.	*Calothrix Wembraensis (Lemmermann)*	-	-	+
13.	*Chroococcus limneticus* Lemmermann	-	+	-
14.	*Chroococcus minor (Kutz.) Nag.*	+	+	+
15.	*Chroococcus minutus (Kutz.) Nag.*	+	+	+
16.	*Chroococcus turgidus (Kutz.) Nag.*	-	-	+
17.	*Gloeocapsa compacta (Kutz.)*	+	-	-
18.	*Gloeocapsa crepidinum (Thuret)*	+	-	-
19.	*Gloeocapsa magma* (Kutz.)	+	+	+
20.	*Gomphosphaeria aponina* Kutz.	+	+	+
21.	*Lyngbya limnetica* (Lemmermann)	-	+	-
22.	*Lyngbya lutea* (Gomont)	-	+	-
23.	*Merismopedia glauca* Kutz.	-	-	+
24.	*Merismopedia punctata* Meyen	+	-	-
25.	*Merismopedia tenuissima* Lemmermann	+	+	-
26.	*Microcystis aeruginosa*(Kutz)	+	+	+
27.	*Microcystis flosaquae* Kichner	+	+	+
28.	*Microcystis robusta* Nygaard	-	+	-
29.	*Microcystis viridis* Lemmermann	+	+	-
30.	*Nostoc calcicola* Brebisson ex Bornet & Flahault	+	+	-
31.	*Nostoc commune* Vacher ex Born.et Flah.	+	++	-
32.	*Nostoc ellipsosporum* Robenhorst ex Bornet & Flahault	+	+	+
33.	*Nostoc hatei* S.C. *Dixit*	-	-	+
34.	*Nostoc muscorum* Ag.ex Born. et Flah.	+	+	-
35.	*Nostoc piscinale* Kutz.	-	+	-
36.	*Nostoc spongiaeforme* C.Agardh	-	+	-
37.	*Oscillatoria pernornata Skuja*	-	+	-
38.	*Oscillatoria subbrevis* Schmidle	+	-	-
39.	*Oscillatoria claricentrosa* C.B. Rao	+	-	-
40.	*Oscillatoria princeps* Gomont	+	+	+
41.	*Oscillatoria boryana* Gomont	-	+	-
42.	*Oscillatoria chalybea* Gomont	+	+	-
43.	*Oscillatoria rubescens* Gomont	+	+	-
44.	*Oscillatoria pseudogeminata G. Schmid*	+	+	-
45.	*Ankistrodesmus convolutus* Corda	+	+	-
46.	*Chlorella conductrix* K. Brandt	+	+	+
47.	*Chlorella parasitica* K. Brandt	-	+	-
48.	*Chlorella vulgaris* Beyerinck	+	+	+
49.	*Closterium costatum Ralfs*	+	+	+
50.	*Closterium* sp Nageli	-	-	+
51.	*Coelastrum microporum* Nageli	+	-	-
52.	*Cosmarium cyclicum* P.Lundell	+	+	+
53.	*Cosmarium pseudopyramidatum Lundell*	+	+	-
54.	*Pediastrum* sp.*Meyen*	+	-	+
55.	*Selenastrum gracile* Reinsch	+	+	-
56.	*Selenastrum sp.*	+	+	-
57.	*Scenedesmus obliquus Kutz.*	-	+	-
58.	*Scenedesmus maximum Kutz*	-	+	-
59.	*Scenedesmus biaudatus Kutz*	-	-	+
60.	*Amphora ovalis* Kutz.	+	+	+
61.	*Anomoeoneis sphaerophora* Ehernberg	-	-	+
62.	*Caloneis silicula* Ehernberg	-	-	+
63.	*Cocconeis placentula* Ehernberg	-	+	-
64.	*Cyclotella meneghiniana Kutz*	-	+	+
65.	*Cymbella ventricosa* C. Agardh	-	+	+

66.	*Cymbella aspera* Ehernberg	+	+	-
67.	*Cymbella cesatii* Grunow	+	-	+
68.	*Cymbella cymbiformis* C. Agardh	+	+	+
69.	*Cymbella ehrenbergii* Kutz.	-	+	-
70.	*Cymbella microcephala* Grunow	+	+	-
71.	*Gomphonema constrictum* Ehernberg	-	+	-
72.	*Gomphonema montanum* Grunow	+	+	+
73.	*Gomphonema parvulum* Kutz.	-	+	+
74.	*Gomphonema subtile* Ehernberg	+	+	-
75.	*Grammatophora oceanicai* Ehernberg	+	-	+
76.	*Gyrosigma acuminatum* Kutz.	+	++	+
77.	*Gyrosigma balticum* Ehernberg	-	+	-
78.	*Licmophora abbreviate* C. Agardh	-	+	-
79.	*Mastogloia smithii* W.Smith	-	+	-
80.	*Pinnularia interrupta* W.Smith	-	+	-
81.	*Navicula cryptocephala* Ehernberg	-	+	-
82.	*Navicula detenta* Hustedt	-	+	-
83.	*Navicula mutica* Kutz.	+	++	-
84.	*Navicula pupula* Kutz.	-	+	-
85.	*Navicula recta* J.Brun &Heribaud	+	+	-
86.	*Navicula rhynchocephala* Kutz.	+	-	+
87.	*Nitzschia acicularis* Kutz.	+	-	-
88.	*Nitzschia Longissim* Ralfs	-	+	-
89.	*Nitzschia amphibian* Gronow	-	+	-
90.	*Nitzschia insignis* Gronow	-	-	+
91.	*Nitzschia Palae (Kützing) W.Smith*	+	+++	-
92.	*Synedra splendens*Ehernberg	-	-	+
93.	*Trigonium arcticumCleve*	+	-	-
94.	*Trachyneis aspera*Ehernberg	-	+	-

+++ Dominant, ++ Co dominant, + Rare, - absent
S1- Thanjavur, S2- Karaikudi and S3- Tiruchirappalli

Physicochemical parameters for collected water samples
Water quality (Table 2) analysis revealed that the highest pH value of 8.13 was recorded at Thanjavur, the lowest 7.12 at karaikudi, and the pH value of 7.5 was recorded at Tiruchirappalli. The minimum concentration of calcium was recorded at Thanjavur the highest concentration was found 124mg/L at Tiruchirappalli whereas, the concentration of Karakudi showed 94mg/L of calcium. The lowest magnesium value of 22mg/L was recorded in Tiruchirappalli and Thajavur showed the concentration of highest value at 84mg/L. Lowest percentage of diverse Bacillariophyceae and chlorophyceae were taken 10 and 9 respectively. The site indicate that this habitat suffered due to sewage from domestic area and hence lost the sensitive species which created a niche that becomes available to more tolerant species (Pandey et.al., 2000). DO and nitrate supports the growth of Chlorophyceae and Bacillariophyceae.

Table 2: Physicochemical parameters for collected water samples

S. No.	Physioparameter	Thanjavur	Karaikudi	Tiruchirappalli
1.	P^H	8.13	7.12	7.5
2.	Temperature˚C	32	31	33
3.	Carbonate(mg/l)	82.4±3.2	40.8±2.4	54.3±1.8
4.	Bicarbonate(mg/l)	179±4.8	248.6±3.8	138.3±7.2
5.	Chloride(mg/l)	485±2.7	347±5.2	194±7.5
6.	Calcium(mg/l)	78.6±4.2	94.7±3.1	124±2.1
7.	Magnesium(mg/l)	84±1.6	46±4.5	22±2.4
8.	Total Phosphrous	1.2±0.4	1.8±0.6	2.2±0.8
9.	Inorganic Phosphate(mg/l)	3.4±0.7	2.6±0.3	1.8±0.5
10.	Sulphate(mg/l)	24.7±2.7	18.4±2.1	13.7±1.8
11.	sulphide(mg/l)	13.4±1.3	18.7±2.2	8.7±3.2
12.	Ammonia(mg/l)	2.7±0.4	1.9±0.6	1.4±0.3
13.	Nitrate(mg/l)	42.8±3.4	36.7±2.1	28.7±1.8
14.	Nitrite(mg/l)	4.8±0.8	6.7±1.1	9.4±1.4

Statistical analysis
Correlation between microalgae abundance and physico-chemical parameters: Correlation co efficient matrix is calculated among 14 physico –chemical parameters (Table 3). The positive correlation microalgae with pH, Temperature, Carbonate. Negative correlation of microalgae with bicarbonate, nitrate, nitrite, ammonia, sulphate, sulphide, phosphate, inorganic phosphate, magnesium, calcium and chloride.

Table 3: Correlation matrix between physiochemical parameter and occurance of the algal species

Correlations

	pH	Temp	Carbonate	Bicarbonate	Cl	Ca	Mg	PO_4	inorganicphos	SO_4	SO_2	NH_3	NO_3	NO_2	TAS
pH	1														
Temp	.372	1													
Carbonate	.998*	.318	1												
Bicarbonate	-.503	-.989	-.453	1											
Cl	.594	-.526	.639	.396	1										
Ca	-.477	.638	-.527	-.519	-.990	1									
Mg	.714	-.384	.753	.246	.987	-.956	1								
PO_4	-.704	.397	-.744	-.260	-.990	.960	-1.000**	1							
Inorganic phos	.617	-.500	.662	.369	1.000*	-.986	.992	-.993	1						
SO_4	.681	-.426	.722	.290	.994	-.968	.999*	-1.000*	.996	1					
SO_2	-.404	-.999*	-.351	.994	.496	-.611	.352	-.365	.470	.394	1				
NH_3	.716	-.381	.755	.243	.987	-.955	1.000**	-1.000*	.991	.999*	.349	1			
NO_3	.555	-.566	.602	.440	.999*	-.996	.979	-.982	.997*	.987	.537	.978	1		
NO_2	-.536	.584	-.584	-.460	-.998*	.998*	-.974	.977	-.995	-.983	-.556	-.973	-1.000*	1	
TAS	-.918	-.711	-.893	.805	-.225	.088	-.377	.363	-.254	-.334	.735	-.379	-.178	.156	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). Temp-Temperature, Cl- Chloride, Ca- calcium,Mg-Magnesium, PO4- Phosphate, SO4- Sulphate, SO2- Sulphide, NH3- Amonia, NO3- Nitrare, NO2- Nitite, TAS- Total algal species

Conclusion

The diversity of microalgae in India are still very fragmentary, especially in the moist soil and pond water. In this study, cyanobacteria with detailed microscopic analysis were reported from different Tiruchirappalli, Thanjavur and Karaikudi locations of Tamil Nadu. The study contributed an understanding to enormous algal diversity freshwater habitat. Thus, the study permits the need for continuous assessment of the phytoplankton composition and the physicochemical variables influencing them for betterment of upcoming microalgal applications.

Acknowledgment

The authors are grateful to DST [DST/STAC/CO2-SR-163/13(Grand C)/2013] for the financial support. DBT/BT/IN/Indo-UK/SuBB/23/NT/2013 for the Mobile Taxonomy laboratory facility. DBT NRMC-F [BT/PR7005/PBD26/357/2012/2015] for the culture maintenance facility**.**

Conflict of interest statement

We declare that we have no conflict of interest

References

1. Woese CR. Bacterial evolution. Microbiologcal Reviews. 1987; 51:221-271.
2. Nagasathya A, Thajuddin N. Diatom diversity in hypersaline environment. Journal of Fisheries and Aquatic Science. 2008; 3(5):328-333.
3. Mubarak Ali D, Divya C, Praveen Kumar R *et al*. Scanning Electrom Microscopical structural studies on diatoms. International Journal of Microbiological Research. 2010; 1(2):72-74.
4. Mubarak Ali D, Divya C, Gunasekaran M *et al*. Biosynthesis and characterization of Silicon–Germanium oxide nanocomposite by Diatom. Digest Journal of Nanomaterials and Biostructures. 2011; 6(1):117-120.
5. Thajuddin N, Ilavarasi A, Baldev E *et al*. Stress Induced Lipids Accumulation in Naviculoid Marine Diatoms for Bioenergy Application. International Journal of Biotechnology for Wellness Industries. 2015; 4:18-24.
6. Santhoshkumar S, Baldev E, Thangaraj R *et al*. Microalgal diversity different freshwater ponds around Thanjavur, TamilNadu. Seaweed research utilization. 2016; 38(1):115-126.
7. Field CB, Behrenfeld MJ, Randerson JT *et al*. Primary production of the biosphere: integrating terrestrial and oceanic components. Science. 1998; 281:237-240.
8. Ohkouchi N, Kashiyama Y, Kuroda J *et al*. The importance of diazotrophic cyanobacteria as primary producer during cretaceous oceanic anoxic event. Biogeoscience. 2006; 3:467-478.
9. Whitton BA, Potts. The ecology of cyanobacteria: their diversity in time and space. Alphen aan den Rijn: Kluwer Academic. Soils and rice fields. In: Whitton BA, Potts M, eds, 2000, 233-255.
10. Gantar M, Svirčev Z. Microalgae and cyanobacteria: Food for thought. Journal of Phycology. 2008; 44(2):260-268.
11. Chaneva G, Furnadzhieva S, Minkova K *et al*. Effect of light and temperature on the cyanobacterium *Arthronema africanum*-a prospective phycobiliprotein-producing strain. Journal of Applied Phycology. 2007; 19:537-544.
12. Mubarak Ali D, Praveenkumar R, Shenbagavalli T *et al*. New reports on anti-bacterial and anti-candidal activities of fatty acid methyl esters (FAME) obtained from *Scenedesmus bijugatus* var. *bicellularis* biomass. RSC Advances. 2012; 2:11552-11556.
13. Suresh A, Praveenkumar R, Thangaraj R *et al*. Microalgal fatty acid methyl ester a new source of bioactive compounds with antimicrobial activity. Asian Pacific Journal Tropical Disease. 2014; 4(2):S979-S984.
14. Pandey VD, Pandey A, Sharma V. Biotechnological applications of cyanobacterial phycobiliproteins. Journal Current Microbiology Applied Science**.** 2013**;** 2:89-97.
15. Thangaraj R, Santhoshkumar S, Baldev E *et al*. Evaluation of antibacterial activity of zinc oxide nanoparticles synthesized using phycobilins of *Anabaena variabilis* NTSS17. Journal of coastal life medicine. 2015; 3(12):944-949.
16. Thangaraj R, Mubarak Ali D, Thajuddin N. Antibacterial activity silver nanoparticles synthesized

using Phycobiliproteins of *Anabaena iyengarii*. Research Journal of Biotechnology. 2020; 15(1):183-189.
17. Thirugnanamoorthy K, Selvaraju M. Phytoplankton diversity in relation to physico-chemical parameter of Gnanaprekasam temple pond of Chidambram in Tamilnadu, India. Recent Res Sci Technol. 2009; 1:235-238.
18. Musharaf K, Farrukh H, Shahana M. A fraction of fresh water algae of Kalpani stream and adjoining area of district Mardan, Pakistan. Int J Biosci. 2011; 1:45-50.
19. Khan FA, Ansari AA. Eutrophication: an ecological vision. Bot Rev. 2005; 71(4):449-482.
20. Gower AM. Water quality in catchment ecosystem Eds. John Wiley and Sons, California, 1980, 117.
21. Rippka R, Deruelles J, Waterbury JB *et al*. Generic assignments, strain histories and properties of pure cultures of cyanobacteria. J Gen Microbio. 1979, 111,161.
22. Chu SP. The influence of the mineral composition of the medium on the growth of planktonic algae. 1. Methods and culture media. J Ecol. 1942; 30:284-325.
23. Guillard, Lorenzen. The standard culture medium for freshwater diatoms from habitats with neutral to high pH. Journal of Phycology. 1972; 8:10-14.
24. Singh P, Singh SS, Elster J *et al*. Molecular phylogeny, population genetics and evolution of heterocystous cyanobacteria using nifH gene sequences. Protoplasma. 2013; 250:751-764.
25. Desikachary TV. Cyanophyta. New Delhi: Indian Council of Agricultural Research, 1959.
26. APHA, Standard methods for the Estimation of water and wastewater. 19th Edn. American Health Associations, Washington, 1998.
27. Hammer O, Harper DAT, Ryan PD. PAST: Paleontological statstics software package for education and data analysis. Palaeontol. Electron, 2001, 4.
28. Khare A. Cyanobacterial biodiversity of the sub-Himalayan belt of Kumaon region Ph.D. Theis, MJP Rohilkhand University, Bareilly, India, 2007.
29. Nielsen NS. Size dependent growth rates in eukaryotic and prokaryotic algae emeplified by greenalgae and cyanobacteria: Comparisons between unicells and colonial growth forms. Journal of Plankton Research. 2006; 28:489-498.