Biocatalysis and Agricultural Biotechnology 22 (2019) 101427

Contents lists available at ScienceDirect

Biocatalysis and Agricultural Biotechnology

journal homepage: http://www.elsevier.com/locate/bab

Deciphering the microalgal diversity and water quality assessment of two urban temple ponds in Pondicherry, India

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ARTICLE INFO

Keywords:
Microalgae
Diversity
Physicochemical parameters
Microphotography
Biofuels

ABSTRACT

Microalgae are rapidly gaining prominence as feedstock for biofuels and came in limelight as source of third generation liquid fuel. Selection of microalgae for biotechnological applications can be done only evaluating their occurrence and diversity in different habitats and environmental conditions. Microalgae dwell abundantly in rivers, lakes, tanks, ponds, other fresh and marine water environments or habitats. The diversity profile of microalgae indicates the anthropogenic activity in water bodies and extent of pollution. Commonly ponds are freshwater habitats classified under lentic ecosystem and among them temple ponds are more prone to human activity. So, there are more chances of finding or documenting large and diverse group of microalgae in temple ponds. The present study is an attempt to document microalgal diversity in two urban stagnant temple tanks located in Puducherry, India. Sample collection was performed in Sri Vedapureswarar temple and Sri Varadaraja Perumal temple ponds, Puducherry, India. A total of 70 species from 39 genera of microalgae were identified in the study. The diversity index showed that Chlorophyceae (Green Algae) members were dominant followed by Cyanophyceae (Cyanobacteria) and Bacillariophyceae (diatoms). Analysis of physico-chemical parameters revealed the presence of higher concentrations of certain macro and micronutrients and heavy metals in the temple tank. Occurrence of diverse algal forms in this water indicates they are tolerant to the varied physico-chemical conditions prevailing in the temple ponds. Further, systematic study of microalgae collected from the temple ponds will provide information on their suitability for various applications like renewable energy, bioremediation and industrial applications.

1. Introduction

Temple tanks or sacred tanks are manmade freshwater bodies commonly found associated with majority of temples in India. These temple tanks are known with different names such as Pushkarini, Kalyani, Kunda, Sarovara, Tirtham, Pukhuri, etc. In different regions of India. Since ancient times provision for water storage in temples has been a very essential part of Indian Temple architecture (Tadgell, 1990). They are protected areas located either within or outside the temple premises. The temple tank water is considered holy and devotees take dip in the water believing that the water washes away all their sins (Sulabha and Prakasam, 2006). The major water sources for these temple tanks are rainwater (rainwater harvesting) and the water used for cleaning the temple premises and for ritual purposes. It is very interesting to note that the used water has been channelled to the temple tank, stored and reused. These ponds in the temple vicinity serve a means of groundwater recharge, providing uncontaminated perennial source of water for rituals and maintains a good water balance in the regio. It also maintains proper microclimate and conserves aesthetics of the area.

The water gets enriched with nutrients by the organic and inorganic materials used for daily rituals. Temple ponds are open and exposed to sunlight, providing a suitable environment for microalgal and cyanobacterial growth. Indigenous freshwater systems are the hot spots of diverse and rare algal forms as a result of varying micro-habitats (Thajuddin and Subramanian, 2005). Such condition prevails in Sri Vedapureswarar temple and Sri Varadaraja Perumal temple, because the water is used for rituals and the temple tank is located inside the temple premises. These temple tanks within busy commercial zone are well guarded and protected from external disturbances. Microalgae including cyanobacteria can grow in any environment where moisture and sunlight are available. But some types of algae grow in specific

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https://doi.org/10.1016/j.bcab.2019.101427
Received 11 September 2019; Received in revised form 1 November 2019; Accepted 11 November 2019
Available online 12 November 2019

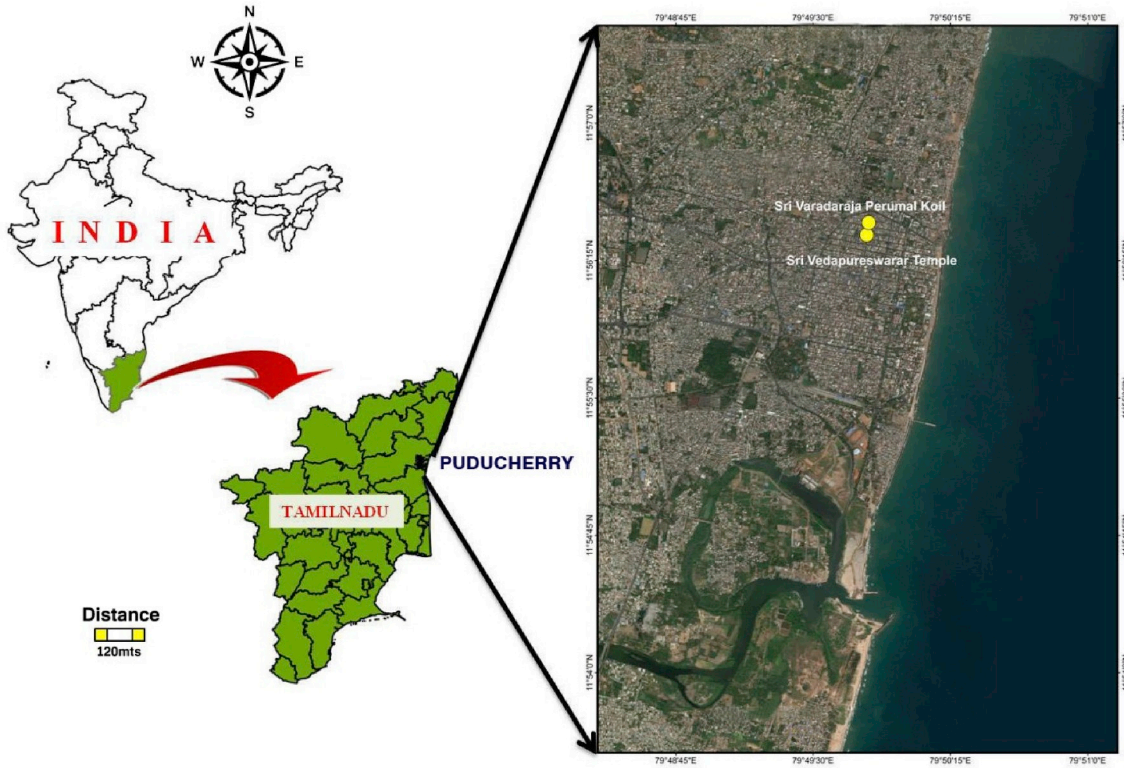

Fig. 1. Map showing the location of the two temples at Puducherry.

environment, therefore their distribution pattern, ecology, periodicity, qualitative and quantitative occurrence differs widely (Thajuddin and Subramanian, 2005). Algae plays an important role in any aquatic ecosystem viz. freshwater bodies, oceans, saline backwaters, estuaries, effluents and polar regions (Jeyachitra et al., 2004; PraveenKumar et al., 2007; Nagasathya and Thajuddin, 2008a, b; Muthukumar et al., 2007; LewisOscar et al., 2015a; LewisOscar et al., 2015b; Suresh et al., 2012, Thajuddin and Subramanian, 2002; Vijayan et al., 2014; Kumar et al., 2015). They are the primary producers in most of the aquatic ecosystems and regarded as important food and energy source for other organisms

Fig. 2. a) Sri Vedapureswarar Temple, b) Sri Varadaraja Perumal Temple, c) Microalgae found attached on the steps of the temple pond 2, d) Sample collection from the pond 1.

(Sukumaran et al., 2008; Garlapati et al., 2019). Phytoplanktons not only serve as food for aquatic animals but also play an important role in maintaining the biological balance and quality of water (Oscar et al., 2014). Distribution of phytoplankton show spatio-temporal variations due to hydrographical factors and serves as indicators of water quality in the given environment (Liu et al., 2004). Microalgae are rich source of protein, lipid and carbohydrate (Sharma et al., 2018, 2019; Kumar et al., 2019; Kim et al., 2019). Microalgae have been extensively used in biofuel study. Different biofuels like biodiesel, bioethanol, biobutanol, biohydrogen etc has been produced using microalgae as third generation fuel substrate (Mathimani and Pugazhendhi, 2018; Prabakar et al., 2018; Chi et al., 2019; Pugazhendhi et al., 2019). This study will provide information for future selection and screening of suitable microalgae strains from temple ponds for bioenergy production and other applications. Physicochemical characteristics of temple pond waters and their influence on diversity, seasonal distribution, quantitative and qualitative abundance of phytoplankton in different temple tanks in India has been reported (Anuja and Chandra, 2012; Bajpai et al., 2013; Girish Kumar et al., 2014; Sankaran and Thiruneelagandan, 2015; Palanivel and Umarani, 2016). However, in-depth literature survey revealed that no information is available on phycological studies of temple tanks of Puducherry region. Therefore, this investigation is the first report initiated with the objective of documentation of microalgal diversity of two temple tanks located in urban area of Puducherry. The microalgae present in the temple ponds prevent the tank water from getting contaminated and polluted from anthropogenic activities. Further this study gives a basic idea on utilizing these microalgae for biofuel production and other biotechnological applications.

2. Materials and methods

2.1. Geographical details of the sample collection site

The study sites selected for this investigation were two old temples located in the heart of the Puducherry, India. The samples for this study were collected during the pre-monsoon period from the two temple ponds. Geographic co-ordinates of the study sites are as follows. The Sri Vedapureswarar Temple situated at Latitude 13° 3′ 18″N and Longitude 80° 3′ 42″E and Sri Varadaraja Perumal Temple situated at Latitude 11° 56′ 27″N and Longitude 79° 49′ 48″E. The temple ponds are situated within the temple premises and well protected from the busy external activities (Figs. 1 and 2).

2.2. Sample collection

The phytoplankton samples were obtained from different sites of the temple ponds using plankton net (20 μm). The benthic and epilithic algal samples were scraped and transferred into sterile plastic bottles using sterile blades and forceps and were transported to the National Repository for Microalgae and Cyanobacteria- Freshwater (NRMC-F), India for taxonomic and cultural studies. One set of samples were preserved in 4% formaldehyde and then analyzed under a light microscope. The unfixed samples were transferred to Erlenmeyer flasks containing Chu 10 medium (Chu, 1942), BG 11 (N+/N-) medium (Rippka et al., 1979) and F/2 medium (Guillard and Ryther, 1962). The flasks were maintained in culture room under white fluorescence lamps (3000 lux), 14′10 L/D 25 ± 2C until they were examined.

2.3. Physico-chemical analysis of water samples

A part of the water sample was used to determine physico-chemical parameters of each pond. Physical parameters such as temperature and pH were recorded at the sampling sites. Chemical parameters such as calcium, chloride, nitrate, nitrite, carbonate and bicarbonate (alkalinity) and sulphate were determined for the two water samples using standard methods (APHA, 1989). Micronutrients like Ag, Au, Cd, Co, K, Mg, Na

Table 1
Diversity of microalgae in two temple ponds.

S. No	Name of the Organism	Family	Pond 1	Pond 2
CYANOPHYCEAE (Cyanobacteria)				
1	*Microcystis aeruginosa* (Kutz)	Microcystaceae	–	+
2	*Chroococcus minutus* (Kutz) Nag	Chroococcaceae	+	+
3	*Chroococcus turgidus* (Kutz) Nag		+	+
4	*Merismopedia* sp.	Merismopediaceae	+	+
5	*Spirulina* sp	Spirulinaceae	+	+
6	*Spirulina subsalsa* (Oerst) ex Gomont		–	+
7	*Oscillatoria earlei* (Gardner)	Oscillatoriaceae	+	+
8	*Oscillatoria formosa* (Bory) ex Gomont		+	+
9	*Oscillatoria obscura* (Bruhl)		–	+
10	*Oscillatoria princeps* (Vaucher) ex Gomont		+	+
11	*Oscillatoria subbrevis* (Schmidle)		+	+
12	*Oscillatoria tenuis* (Bory) ex Gom		+	+
13	*Phormidium* sp.	Phormidiaceae	+	+
14	*Lyngbya* sp.	Oscillatoriaceae	–	+
15	Calothrix sp.		+	+
16	*Calothrix linearis* (Gardner)	Rivulariaceae	+	+
CHLOROPHYCEAE				
17	*Pandorina morum* (Müller) Bory	Volvocaceae	+	+
18	*Chlorococcum humicola* (Nägeli) Rabenhorst	Chlorococcaceae	+	+
19	*Chlorella* sp.	Chlorococcaceae	+	+
20	*Chlorella vulgaris* (Beyerinck)		+	+
21	*Tetraedron minimum* (Braun) Hansgirg	Hydrodictyaceae	+	–
22	*Tetraedron trilobulatum* (Reinsch) Hansgirg		+	–
23	*Pediastrum boryanum* (Turpin) Meneghini	Hydrodictyaceae	+	–
24	*Pediastrum duplex* (Meyen)		+	–
25	*Pediastrum simplex* (Meyen)		–	+
26	*Pediastrum tetras* (Ehrenberg) Ralfs		+	+
27	*Ankistrodesmus falcatus* (Corda) Ralfs	Selenastraceae	+	+
28	*Ankistrodesmus* sp.		+	–
29	*Kirchneriella schmidle* (Kirchner) Möbius	Selenastraceae	+	+
30	*Kirchneriella* sp.		+	+
31	*Monoraphidium littorale* (Hindák)	Selenastraceae	+	–
32	*Monoraphidium contortum* (Thuret)		–	+
33	*Selenastrum* sp.	Selenastraceae	+	–
34	*Coelastrum microsporum* (Nägeli)	Scenedesmaceae	+	–
35	*Coelastrum reticulatum* (Dangeard)	Scenedesmaceae	–	+
36	*Coelastrella* sp.	Scenedesmaceae	+	+
37	*Scenedesmus armatus* (Chodat)	Scenedesmaceae	+	+
38	*Scenedesmus bijugatus* (Kützing)		+	–
39	*Scenedesmus denticulatus* (Lagerheim)		+	+
40	*Scenedesmus intermedius* (Chodat)		+	+
41	*Scenedesmus obliquus* (Turpin) Kützing		+	+
42	*Scenedesmus quadricauda* (Turpin) Brébisson		+	+
43	*Scenedesmus quadricauda* var. *bicaudatus* (Hansgirg)		+	–
44	*Scenedesmus protuberans* (Fritsch)		+	–
45		Scenedesmaceae	+	+

(continued on next page)

Table 1 (*continued*)

S. No	Name of the Organism	Family	Pond 1	Pond 2
	Tetrastrum heteracanthum (Chodat)			
46	*Stigeocolonium* sp.	Chaetophoraceae	–	+
47	*Closterium* sp.	Closteriaceae	+	+
48	*Closterium* sp.		+	–
49	*Closterium navicula* (Brébisson) Lütkemüller		+	+
50	*Cosmarium* sp	Desmidiaceae	+	–
51	*Crucigeneilla crucifera* (Kuntze)		+	–
BACILLARIOPHYCEAE				
52	*Cyclotella meneghiniana* (Kützing)	Stephanodiscaceae	+	+
53	*Synedra ulna* (Nitzsch) Ehrenberg	Fragilariaceae	+	–
54	*Fragilaria intermedia* (Grunow)	Fragilariaceae	+	+
55	*Rhopalodia gibba* (Ehrenberg) O. Müller	Rhopalodiaceae	+	–
56	*Nitzschia* sp.	Bacillaraceae	+	+
57	*Nitzchia sigmoidea* (Nitzsch) W. Smith	Bacillaraceae	+	+
58	*Nitzschia palea* (Kützing) W. Smith	Bacillaraceae	+	+
59	*Gomphonema* sp.	Gomphonemataceae	+	–
60	*Amphora* sp	Catenulaceae	–	+
61	*Cymbella* sp.	Cymbellaceae	+	–
62	*Pleurosigma elongatum* W. Smith	Pleurosigmataceae	+	–
63	*Gyrosigma acuminatum* (Kützing) Rabenhorst	Naviculaceae	–	+
64	*Navicula* sp.	Naviculaceae	+	–
65	*Craticula ambigua* (Ehrenberg) D.G.Mann	Stauroneidaceae	+	+
EUGLENOPHYCEAE				
66	*Euglena viridis* (O. F. Müller) Ehrenberg	Euglenaceae	+	+
67	*Euglena sanguine* (Ehrenberg)		–	+
68	*Euglena* sp		–	+
69	*Phacus longicauda* (Ehrenberg) Dujardin	Euglenaceae	+	–
70	*Phacus* sp.		+	–
Total	58	48		

" + " indicates presence, "-" indicates absence.

and Ni were also examined using Atomic Absorption spectrophotometer (AA6200, Shimadzu, Japan). The experiments were run in triplicate for each sample and the average values of the chemical parameters were recorded.

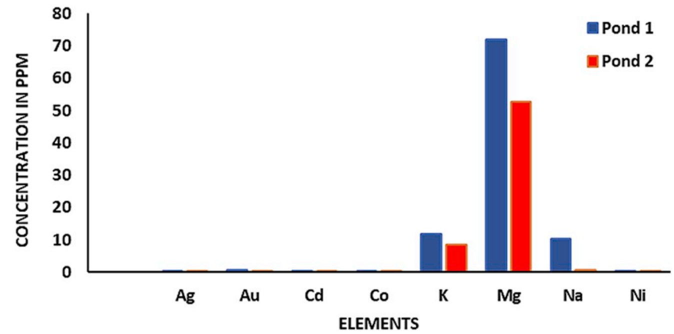

Fig. 4. Physico-chemical parameter of the water samples collected from Sri Vedapureswarar Temple (Pond 1) and Sri Varadaraja Perumal Temple (Pond 2).

2.4. Identification and cultivation for pure culturing of the diversity

The microalgae and cyanobacteria present in the water samples were identified based on the morphology of the individual taxa. The published reports and standard monographs (Philipose, 1967; Prescott, 1954a,b; Desikachary, 1959, 1988; 1986, 1989) were used for identification. Micro-images of the algae were recorded using photomicroscopic system (MCX 500, Micros, Austria) and diversity was recorded. The identified taxa were subjected to purification by streaking on standard media mentioned above.

3. Results and discussion

Temple pond is a stagnant source of freshwater, replenished by means of rainwater. The draining of organic materials in the temple pond increases the nutrient level of the water. In the present study, the distribution of phytoplanktons in the two temple tanks were documented and presented in Table 1. Seventy species of phytoplanktons belonging to 27 families and 39 genera were recorded. Of these, 35 were chlorophycean members (50%), 16 species of cyanophyceae (22.8%), 14 species of bacillariophyceae (20%) and 5 species of euglenophyceae (7.1%). The overall density of phytoplankton was higher in Sri Vedapureswarar temple (Pond-1) with 58 species than in Sri Varadaraja Perumal temple (Pond-2) with 48 species (Fig. 3). The 70 species of phytoplankton reported in the present study is much higher than the 38 taxa from Sri Thiyagarajaswamy temple tank, Thiruvottiyur (UmaraniPalanivel et al., 2017), 29 species in Sri Nageswarar temple Kundrathur, 38 species in Sri Dhenupuriswarar temple tank, Madambakkam, Chennai (Palanivel and Umarani, 2016), and 18 and 17 species in Pandakkal and Palloor temple ponds respectively (Girish Kumar et al., 2014). The phytoplankton population exhibited

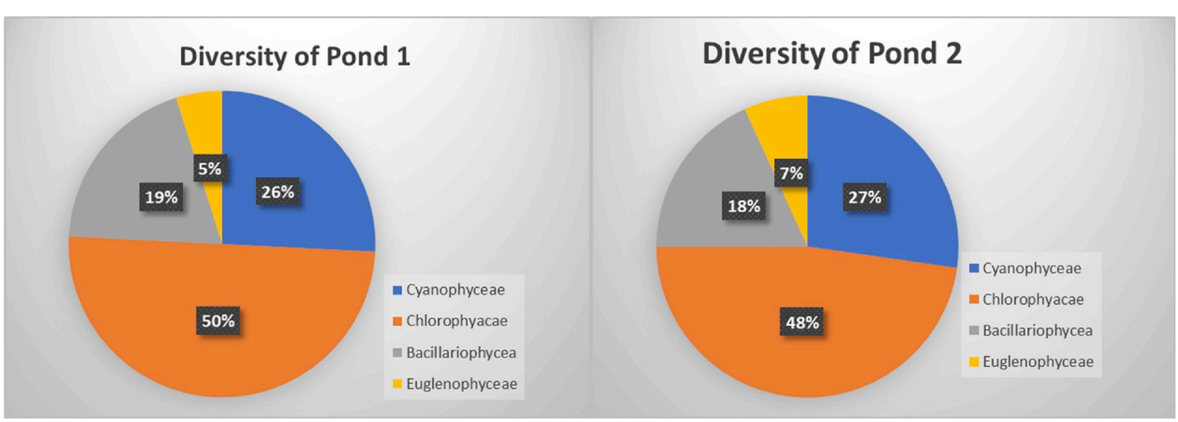

Fig. 3. Diversity of cyanobacteria, green algae and diatoms in sri vedapureswarar temple (Pond 1) and sri varadaraja Perumal temple (Pond 2). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

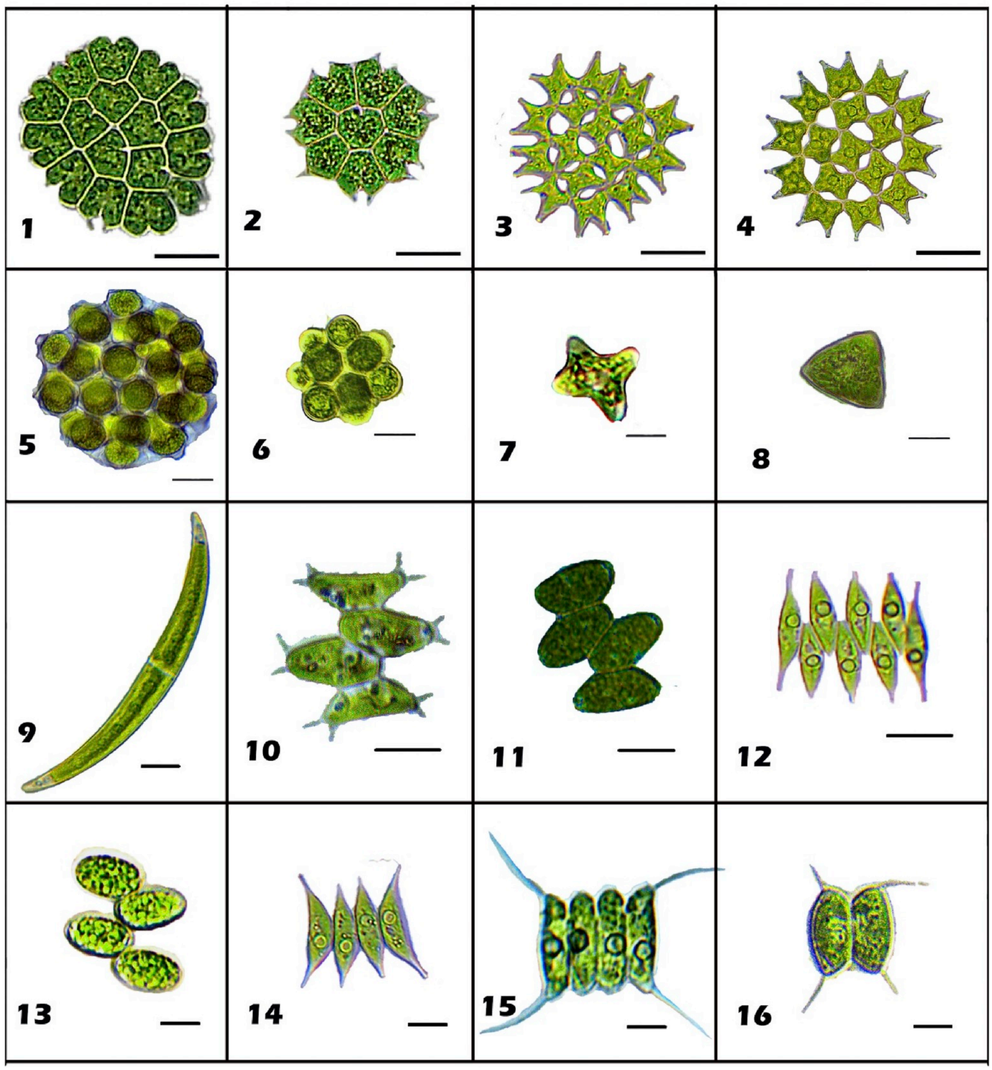

Plate 1. Microphotographs of (Scale bar measures 10 μm) 1,2) Pediastrum tetras, 3) Pediastrum boryanum, 4) Pediastrum duplex, 5) Coleastrum reticulatum, 6) Coleastrum sp., 7) Tetraedron minimum, 8) Tetraedron trilobulatum, 9) Closterium sp., 10) Scenedesmus denticulatus, 11, 12, 13) Scenedesmus spp., 14) Scenedesmus obliquus, 15) Scenedesmus protuberans, 16) Scenedesmus quadricauda.

considerable variation in diversity in the two temple ponds of the present study, even though they are located within 100 m distance. Around 33 species were common to both ponds, whereas 18 species were found only in Pond-1 and 12 species were recorded only in Pond-2. Among the microalgae, the class Chlorophyceae was the prominent group followed by Cyanophyceae and diatoms. This is in concordance with the observations of Anuja and Chandra (2012), Palanivel and Umarani (2016), UmaraniPalanivel et al. (2017) and Desingurajan et al. (2018) in temple tanks as well as in open ponds (Arulmurugan et al., 2011). On the other hand, dominance of blue green algae was reported by Elayaraj and Selvaraju (2015) in Pasupatheswarar temple pond and by Laxmi, (2015) in three sacred ponds of Kurukshetra, India. Recently Sharma et al. (2019) reported the dominance of Bacillariophyceae in a diversity study conducted in freshwater pond ecosystem from southern Assam.

Nearly 31 species of green algae were recorded in Pond-1 and only 21 species in Pond-2 (Plate 1, 2, 3). The species like *Coelastrum microsporum, Monoraphidium littorale, Pediastrum duplex, Pediastrum boryanum, Scenedesmus quadricauda* var *bicaudatus, Scenedesmus protuberans, Tetraedron minimum, Tetraedron trilobulatum* and *Phacus longicauda* recorded in Pond 1, were absent in Pond-2. It was observed that the diversity of Cyanophycean members (16 species) was higher in Pond 2 in comparison with Pond-1 (12 species). *Lyngbya* sp, *Microcystis aeruginosa*, *Oscillatoria obscura* and *Spirulina subsalsa* were recorded only in Pond- 2. The diversity of diatoms was higher in Pond-1 and less in Pond-2. Twelve species of diatoms were recorded in Pond-1 whereas only eight in Pond-2. *Cymbella* sp, *Gomphonema* sp, *Navicula* sp were absent in Pond- 2 whereas *Craticula ambigua* and *Gyrosigma acuminatum* were recorded only in Pond-2. Three Euglenophycean members were recorded in each pond, only *Euglena viridis* was common in both the ponds. Plankton species composition and abundance depends on the environmental conditions including, temperature, dissolved oxygen, pH and turbidity, in addition to grazing, competition and disease. Generally, microalgae are prominent organisms of the aquatic food web; their reduction will drastically affect the life of the higher tropical animals. The observed higher diversity of microalgae in Pond-1 may be due to more anthropogenic activity and more nutrients when compared to Pond 2.

The physicochemical characteristics of the two temple ponds are presented in Table 2 and Fig. 4 The pH of both ponds was around 6.8, this value is tending towards neutral which is also within the values of WHO (6.5–8.5). Neutral to slightly alkaline pH range is regarded the most favourable (Sharma et al., 2019) and is congenial for aquatic life due to greater availability of most of the nutrient elements and increased biological activities under this pH range (Boyd, 1979). The temperature

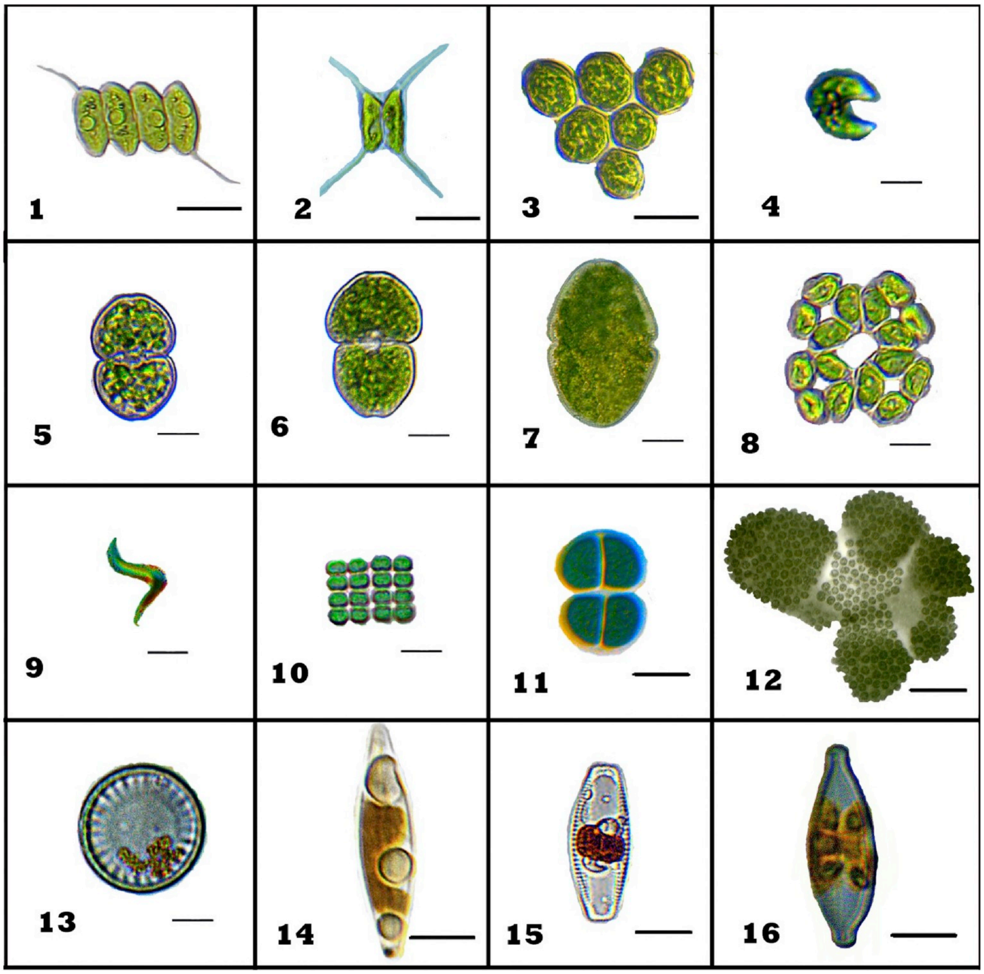

Plate 2. Microphotographs of (Scale bar measures 10 μm) 1) Scenedesmus quadricauda var bicaudatus, 2) Scenedesmus opoliensis, 3) Chlorococcum humicola, 4) Kirchneriella sp., 5, 6 & 7) Cosmarium spp., 8) Crucigeneilla crucifera, 9) Monoraphidium contortum, 10) Merismopedia sp., 11) Chroococcus turgidus, 12) Microcystis aeruginosa, 13) Cyclotella meneghiniana, 14) Navicula sp., 15) Amphora sp.

recorded was 34 °C & 32 °C (air & water) in Pond-1 and 33 °C and 29 °C (Air and Water) in Pond-2 during the time of sample collection. The high temperature range along with light is the major regulatory factor for the development of phytoplanktons (Whitford and Schumacher, 1963). Electrical conductivity was higher in both ponds with 1400 & 1300*μmhos*/cm in Pond 1 and Pond 2 respectively. EC is the ability of water to conduct electric current and depends on the ionic concentration of water (Agbaire et al., 2015). Natural waters usually have EC values of 20–1500 *μmhos/cm* (Boyd, 1979). However, the standard limit set by WHO is 250 *μmhos*/cm. The colour and turbidity of water are closely related and is a measure of the ability of water to transmit or restrict light penetration and limit photosynthesis and is influenced by suspended particles and particulate organic matter. The turbidity of water samples (35 mg in Pond- 1 & 28 mg in Pond- 2) was also found higher than the standard value. TDS recorded in this study were 1020 and 840 mg/l for Pond-1 and Pond-2 respectively. It is an indication of the load of dissolved substances. These values are very high to the standard given by WHO. The total hardness represents the sum of calcium and magnesium concentrations were found to be lower than the standard value (600 mg/l). Calcium is the most abundant ions in fresh water and is important in shell construction, bone and scale building of aquatic fauna. The level of calcium was 112 and 72 mg/l in Pond-1 and 2 respectively, which is within the recommended value. Magnesium is often associated with calcium, but its concentration remains generally lower than calcium. Accordingly, Mg level recorded was 42 and 45 mg/l in Pond-1 and 2 respectively and was well within the standard value. Magnesium is essential for chlorophyll synthesis and acts as a limiting factor for the growth and reproduction of phytoplankton. The chloride level recorded was 330 and 320 mg/l in both Ponds, which is significantly higher than the WHO recommended value (250 mg/l). Since most of the water soluble salts in a pond environment generally occur in Cl-form, the higher amount of Cl-ions in pond water indicates the amount of soluble salts present. The importance of Cl-ions lies in its ecological role to regulate water salinity. Sulphate, nitrate, and ammonia levels were also within the standards prescribed. However inorganic phosphate was higher than the standard value.

The growth of microalgae is not only depending on macronutrients but also require micronutrients (Sunda et al., 2005). Therefore, the level of trace metals in the pond waters was also determined using atomic absorption spectrophotometric analysis. Their concentrations varied in two ponds (Table 3). Trace metals are present in algal cells in extremely small quantities (<4 ppm) and are an essential component influencing algal physiology. Iron (Fe), manganese (Mn), cobalt (Co), zinc (Zn), copper (Cu) and nickel (Ni) are the six most important trace metals required by algae for various metabolic functions ranging from photosynthetic electron transport, respiratory electron transport, sulphate reduction, nitrate and nitrite reduction, dinitrogen fixation and detoxification of reactive oxygen species etc. (Sunda, 2001; He et al., 2010) and constitute part of the sediment or bedrock materials of aquatic systems. Generally heavy metals present in the aquatic system have physiological and biochemical pressures on the phytoplankton. They also play major role in enzyme activity and oxidation reduction

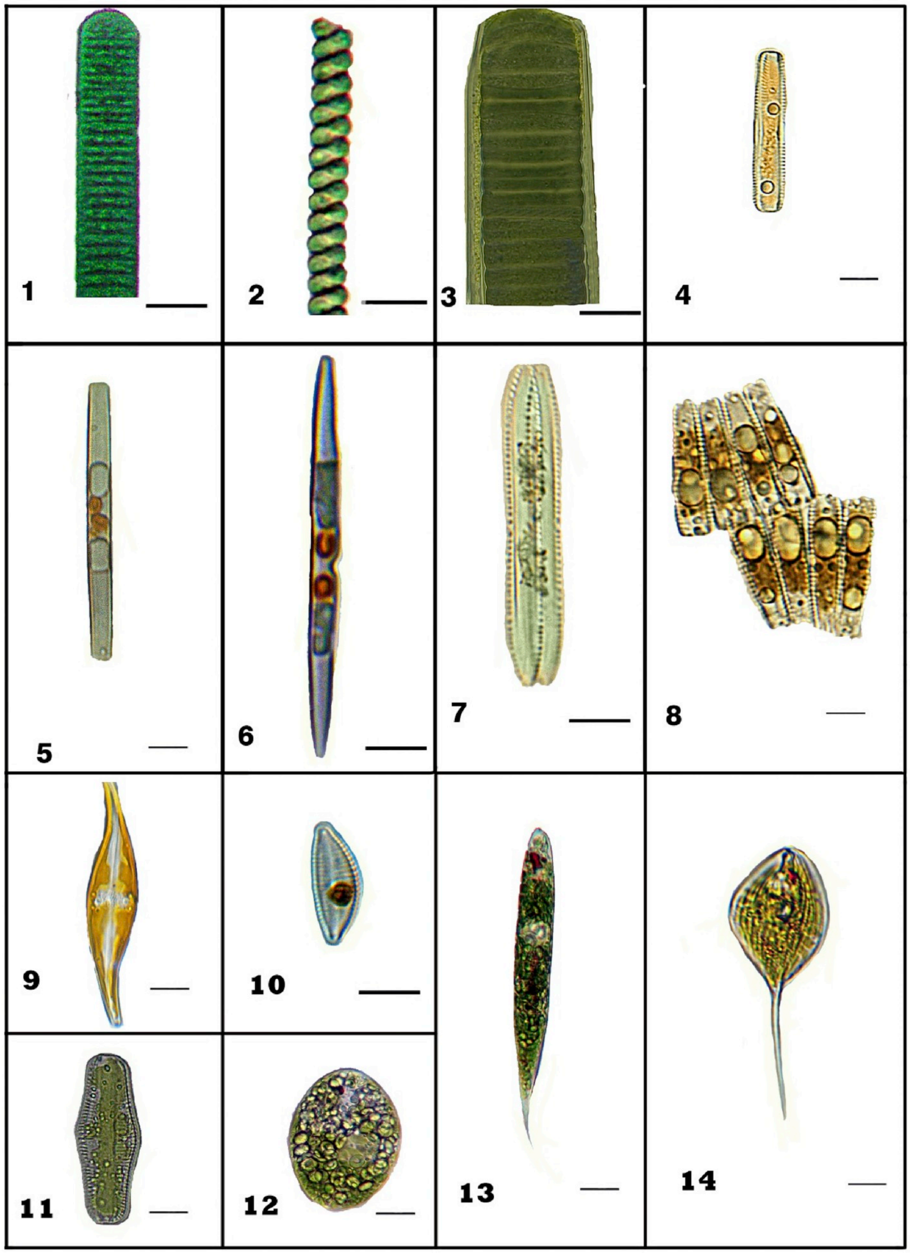

Plate 3. Microphotographs of (Scale bar measures 10 µm) 1) Oscillatoria obscura, 2) Spirulina subsalsa, 3) Lygnbhya sp., 4) Nitzschia palea, 5) Fragilaria intermedia, 6) Synedra ulna, 7) Nitzschia sp., 8) Gomphonema sp., 9) Gyrosigma acuminatum, 10) Cymbella sp., 11) Rhopalopdia gibba, 12) Euglena sanguinea, 13) Euglena sp., 14) Phacus longicauda.

reactions (Tchounwou et al., 2012). The most reported toxic and carcinogenic metals of greater public health concern are arsenic, cadmium, chromium, lead and mercury (Tchounwou et al., 2012). But in the case of microalgae, trace elements act as micronutrients at low concentrations, while at high concentrations they become toxic. All the metals tested are within the threshold level. However, the levels of the trace metals are present within the prescribed levels. The data indicates that the temple ponds are unique aquatic ecosystem harbouring phytoplanktons which can survive and grow in that environment though some of the physicochemical components are higher than the standard values. In view of this organic pollution level was assessed based on the organic pollution tolerant genera present in these two temple ponds. A look at Table 4 shows occurrence of few species that have been reported as indicators of organic pollution. They are *Microcystis aeruginosa, Oscillatoria* sp., *Phormidium* sp., *Chlorella* sp., *Pandorina* sp, *Closterium* sp, *Ankistrodesmus* sp, *Scenedesmus* sp, *Euglena* sp., *Phacus* sp., *Cyclotella* sp., *Gomphonema* sp., *Navicula* sp., *Nitzschia* sp., and *Synedra* sp. Palmer (1969) categorized the range of organic pollution by the tolerance capacity of the algal species and assigned a numerical value. Palmer's genus index was used during the study and the values are presented in Table 4. When the values are lesser than fifteen then the organic pollution is absent, if it is between 15 and 20 there is a possibility of organic pollution on the other hand, if greater than 20, it indicates high level organic pollution. In the present investigation Palmer's genus index shows high level of organic pollution. Thus, the two ponds fall under the category of high organic pollution whereas Pond-1 is highly polluted with organic pollutants than Pond-2. Thus, this study suggests that the diversity and abundance of microalgae can be used to assess the level of pollution in temple tanks. Apart from this, the present study will also explore the potential applicability of temple pond microalgae towards bioremediation and biofuel production etc.

Table 2
Physicochemical characteristics of two temple pond water.

S. No.	Parameters	Units	Pond-1	Pond-2	WHO values
	Air temperature	Celsius	34 °C	31 °C	‘35 °C
	Surface water Temperature	Celsius	32 °C	29 °C	–
1	pH (at 25 °C)		6.8	6.9	6.5–8.5
2	EC (at 25 °C)	μS/cm	1400	1130	300
3	TDS (at 30 °C)	$mg\ L^{-1}$	1028	840	500
4	Colour	HU	60	80	–
5	Turbidity	NTU	31	28	10
6	Odour		Objectionable	Objectionable	–
7	Total Hardness (as $CaCO_3$)	$mg\ L^{-1}$	450	360	600
8	Calcium (Ca)	$mg\ L^{-1}$	112	72	200
9	Chlorides (Cl)	$mg\ L^{-1}$	330	310	250
10	Nitrate (NO_3)	$mg\ L^{-1}$	5.2	2.9	50
11	Sulphate (SO_4)	$mg\ L^{-1}$	52	35	500
12	Fluoride (as F)	$mg\ L^{-1}$	0.42	0.22	–
13	Total Iron (Fe)	$mg\ L^{-1}$	0.12	0.15	–
14	Inorganic Phosphate (PO_4)	$mg\ L^{-1}$	4.7	5.2	0.005–0.2[a]
15	Sulphite (SO_2)	$mg\ L^{-1}$	<0.1	<0.1	0–0.5[a]
16	Nitrite (NO_2)	$mg\ L^{-1}$	1.2	1.4	–
17	Ammonia (NH_4)	$mg\ L^{-1}$	3.7	2.1	–

[a] Aquaculture Pond Water standard (Boyd, 1979)

Table 3
Trace metals in the temple pond water.

S.No.	Elements	Pond 1	Pond 2
		concentration in ppm	
1	Ag	0.1723	0.3632
2	Au	0.6358	0.1070
3	Cd	0.0664	0.0776
4	Co	0.5461	0.4936
5	K	11.7966	8.6258
6	Mg	72.0616	52.6423
7	Na	10.2708	0.6510
8	Ni	0.4204	0.3689

4. Conclusion

Microalgae are natural ecosystem producing variety of gases like CO_2, O_2, CH_4 and H_2 for maintaining or balancing the environment. These abilities of microalgae have promoted them as potential candidates of biofuel studies. They can be possibly used in several biotechnological applications due to their rapid growth, simple cell structure and chemical composition. Microalgae applications range from are food, fertilizer, agriculture, secondary metabolites (enzymes, vitamins, proteins, lipids) to bioremediation. The basis of these applications is to understand the population or diversity of microalgae dwelling in different environments. Microalgae dwelling in freshwater temple ponds are most feasible forms of organisms growing under same condition. The present study gives us a detailed view on the type of microalgal diversity in the freshwater temple ponds. This basic information on microalgae distribution and abundance would form a useful tool for further ecological assessment and monitoring of the ecosystem as well as for the development of algal biotechnology. Thus, the study permits the need for continuous assessment of the phytoplankton composition and the physicochemical variables influencing them for betterment of future microalgal applications.

Table 4
Palmer Pollution rating of Organic pollution index of algal genera in two temple tanks (Palmer, 1969).

Name of the pollution indicating algal species	Pollution Index	Pond-1	Pond-2
Chlorophyceae			
Ankistrodesmus	2	2	2
Chlorella	3	3	3
Closterium	1	1	1
Pandorina	1	1	1
Scenedesmus	4	4	4
Cyanophyceae			
Microcystis aeruginosa	5	–	5
Oscillatoria	5	5	5
Phormidium	1	1	1
Bacillariophyceae			
Nitzschia	3	3	3
Navicula	3	3	–
Synedra	2	2	–
Gomphonema	1	1	–
Euglenophyceae			
Euglena	5	5	5
Phacus	2	2	–
Total score		33	30

The numerical values for pollution classification: 0–10 = lack of organic pollution; >10–15 = moderate pollution; >15–20 = probable high organic pollution; or more = high organic pollution.

Acknowledgement

The financial support from the Department of Biotechnology, Government of India is gratefully acknowledged (Project reference: BT/PR/6619/PBD/26/310/2013 and DBT [BT/PR7005/PBD26/357/2015].

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