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ASSESSING MICROALGAL COMMUNITY STRUCTURE IN FIVE TEMPLE PONDS OF TIRUCHIRAPPALLI, TAMIL NADU

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ABSTRACT

Microalgae and cyanobacteria are key primary producers and rapid bioindicators of aquatic ecosystem health. This study systematically documented microalgal diversity across five temple ponds in Tiruchirappalli, Tamil Nadu (Panchavarna Samy, Nachiyar, Uyyakondan Thirumalai, Vayalur Murugan, and Periya Nachi Amman Temples). Sampling in the pre-monsoon (March) revealed 93 phytoplankton species (51 genera): 42 cyanobacteria, 34 green algae, and 17 diatoms. Physicochemical analyses showed strong gradients among ponds; for example, Pond-1 had high chloride and inorganic phosphorus, whereas Pond-5 had higher pH and sulfate. Correlation analyses indicated algal abundance was positively related to nitrate, sulfate, pH, and nitrite, but negatively related to chloride, ammonia, inorganic phosphorus, calcium, and magnesium. These patterns suggest nutrient availability and organic loading shape community composition. Many recorded taxa (e.g., Oscillatoria, Phormidium, Navicula, Synedra) are known pollution-tolerant genera, consistent with moderate nutrient enrichment. Biodiversity indices (Shannon's H′, Simpson's D) confirmed high diversity (Shannon H′ ≈ 2.8–3.4). We also performed multivariate analyses (PCA and hierarchical clustering) to explore community patterns, which showed ponds grouping by similar water chemistry. Although restricted to a single season, our study highlights the rich algal assemblages in temple ponds. These algae represent potential bioresources; many green algae have high lipid/carbohydrate content for biofuel and can bioremediate wastewater nutrients and metals. These findings provide a baseline inventory of temple-pond microalgae and insights into their ecological relationships and biotechnological potential.

Keywords: Microalgae; Phytoplankton; Temple ponds; Water quality; Biodiversity; Biofuel; Bioremediation; PCA; Palmer index; Shannon diversity

INTRODUCTION

Microalgae and cyanobacteria are primary producers that play vital roles in aquatic ecosystems by contributing to nutrient cycling, oxygen production, and energy transfer through food webs. Cyanobacteria, also known as blue-green algae, are photosynthetic prokaryotes that have existed for over three billion years, while microalgae comprise a diverse group of eukaryotic photoautotrophs found in freshwater and marine environments (**Yadav, 2017; Stanier, 1977**). These organisms respond rapidly to environmental changes and are widely recognized as effective bioindicators of water quality (**Shetty & Gulimane, 2023**).

Phytoplankton diversity and distribution are shaped by a range of physicochemical parameters, including nutrient levels, pH, temperature, and trace metal content (**George *et al*., 2012**). Because of this, studying microalgal assemblages can provide valuable insights into the ecological status of aquatic habitats. In particular, the composition and abundance of certain species can signal pollution or eutrophication, and indices such as Shannon diversity and Palmer's Pollution Index have been applied to interpret these patterns (**Palmer, 1969; Subramanian et al., 2023**).

Temple ponds, traditionally linked to Hindu religious practices, are widespread across India and represent a culturally important but ecologically underexplored class of freshwater ecosystems. In Tamil Nadu alone, there are over 2,000 such temple tanks (**Sankaran & Thiruneelagandan, 2015**). These ponds are routinely exposed to organic matter from ritual offerings, bathing, and seasonal rainwater runoff, creating dynamic aquatic environments that support diverse phytoplankton communities. Unlike urban lakes, many temple ponds are less affected by industrial effluents, offering a unique setting to study microalgal responses to moderate nutrient enrichment (**Prasanthkumar & Santhoshkumar, 2017**).

Despite their potential significance, many temple ponds in South India remain poorly characterized in terms of their microalgal diversity. A few studies in Chennai and nearby regions have reported between 17 and 67 microalgal species in temple ponds, indicating substantial variation and the possibility of unrecorded biodiversity (**Palanivel & Umarani, 2016; Ganesan & Arutselvan, 2019**). Moreover, certain algal strains particularly from the genera *Scenedesmus*, *Chlorella*, and *Oscillatoria* have industrial applications, including biofuel production and bioremediation of nutrients and trace metals (**Chi *et al*., 2019; Solomon & Uchai, 2017; Tchounwou *et al*., 2012**).

This study aims to systematically assess the microalgal diversity and associated water quality in five temple ponds of Tiruchirappalli, Tamil Nadu. We identify algal taxa through microscopy, analyze physicochemical and trace metal parameters, and evaluate correlations between environmental conditions and algal distribution. We also apply biodiversity indices and consider the ecological and biotechnological relevance of the findings. This work contributes to baseline data for temple pond ecosystems and highlights their potential as reservoirs of useful algal strains.

MATERIAL AND METHODS

Study area and Sampling

The study was conducted at five temple ponds located in the Tiruchirappalli district of Tamil Nadu, India. These sites included Panchavarna Samy Temple, Nachiyar Temple, Uyyakondan Thirumalai Temple, Vayalur Murugan Temple, and Sri Periya Nachi Amman Temple. Geographical coordinates for each site were recorded using GPS (Garmin eTrex 10):

- Panchavarna Samy Temple: 10.828770°N, 78.676559°E
- Nachiyar Temple: 10.827256°N, 78.674672°E
- Uyyakondan Thirumalai Temple: 10.814432°N, 78.659131°E
- Vayalur Murugan Temple: 10.830032°N, 78.628352°E
- Periya Nachi Amman Temple: 10.816355°N, 78.680508°E

Sampling was performed during the pre-monsoon season (March 2023) to ensure relatively stable water conditions(Figure1 and 2).

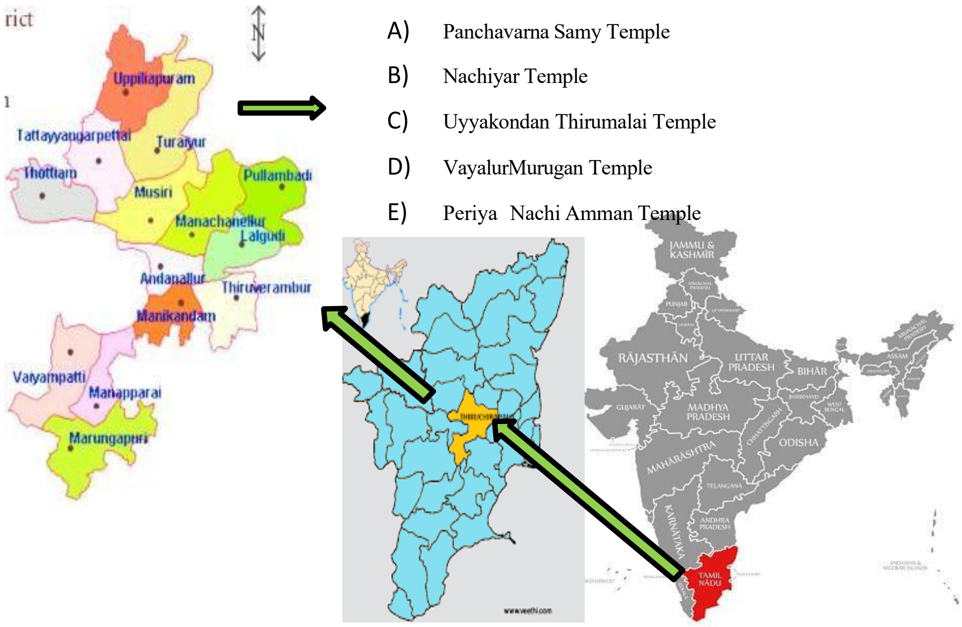

Figure 1 Geolocation of the sampling sites

Sample collection

Algal samples were collected using plankton nets (mesh size ~20 µm), sterile forceps, and vials. Collected material was transferred to sterilized Erlenmeyer flasks containing BG-11 (for cyanobacteria) and Chu-10 (for green algae) culture media (**Chu, 1942; Rippka *et al*., 1979; Muthukumar *et al*., 2007**). Samples were transported under cooled, dark conditions to minimize light-induced stress.A portion of each sample was fixed with 5% formaldehyde for microscopic observation. Cultures were maintained in a controlled culture room at 25 ± 2 °C under 12:12 light-dark cycles with 3000 lx fluorescent light until further analysis.

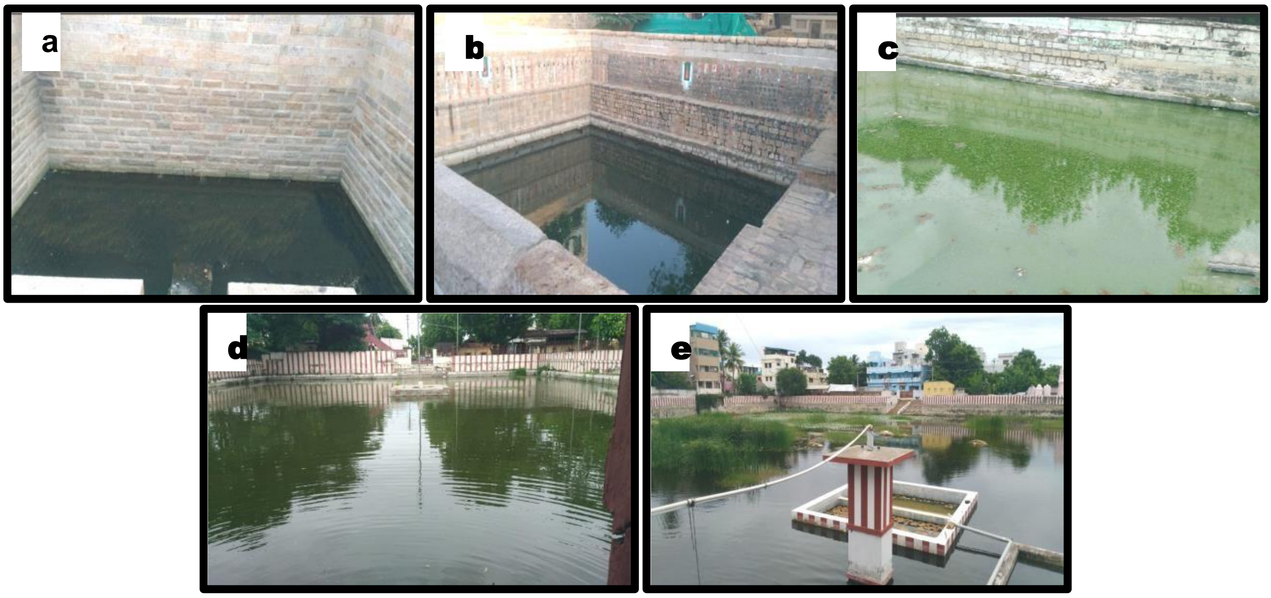

Figure 2 Sample sites a) Panchavarnasamy Temple, b)Nachiyar Temple, c)Uyyakondan Thirumalai Temple d)Vayalur Murugan Temple e)Sri Periya Nachi Amman

Physico-chemical analysis of water samples

Water samples were collected concurrently from each site in acid-washed polyethylene bottles. On-site measurements included temperature and pH using a digital multi-parameter probe (Hanna HI98194). Additional parameters such as alkalinity, calcium, chloride, nitrate, nitrite, ammonia, inorganic phosphate, sulphite, and sulphate were measured in the laboratory using standard procedures outlined by **APHA (1975)**.Trace elements including silver (Ag), gold (Au), cadmium (Cd), cobalt (Co), potassium (K), magnesium (Mg), and sodium (Na) were quantified using Atomic Absorption Spectrophotometry (PerkinElmer Analyst 400). Calibration was performed using standard solutions, and quality control was ensured by running blanks and standard checks.

Taxonomic Identification and Microscopy

Algal taxa were identified based on morphological characteristics using standard taxonomic keys and reference monographs (**Philipose, 1967; Prescott, 1954; Desikachary, 1959, 1989**). Microphotographs were captured using a light microscope (MCX 500; Micros Austria) at 1000x magnification with oil immersion. Observed species were recorded, and pure cultures were established for select strains using serial dilution and plating on BG-11 and Chu-10 media**.**

Biodiversity and statistical analysis

Species diversity within each pond was assessed using standard biodiversity metrics including:

- **Shannon–Wiener Diversity Index (H′)**
- **Simpson's Diversity Index (D)**
- **Species richness and evenness**

These indices were calculated to assess overall diversity and community structure. To explore relationships between water quality and algal diversity, Pearson's correlation coefficients were calculated using SPSS v26 at 95% and 99% confidence intervals ($p < 0.05$ and $p < 0.01$).In addition, Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (Bray-Curtis similarity index) were performed using R software (version 4.2.2) to identify environmental gradients and group ponds based on community similarity.

RESULT

Study area and Sampling

The temple pond serves as a tranquil freshwater reservoir and is sustained by rainwater infusion. Decomposition of organic matter within the pond enhanced the nutrient content of the water. This study documented and presented the distribution patterns of phytoplankton across the five temple tanks (Table 1).

Table 1 Diversity of microalgal in five different temple ponds

Name of the organism	**Pond -1**	**Pond -2**	**Pond -3**	**Pond -4**	**Pond -5**
Cyanophyceae					
Anabaena sp	+	+	-	-	+
Anabena iyengarii	-	+	+	-	+
Aphanocapsa grevillei	-	-	+	+	-
Aphanocapsa pulchra	+	-	-	+	-
Aphanocapsa roeseana	-	+	-	-	+
Aphanothece microscopica	+	-	-	-	+
Arthrospira platensis	+	-	-	+	-
Calothrix linears	-	+	+	-	+
Calothrix sp	-	+	-	+	-
Chroococcus minor	+	+	-	-	+
Chroococcus minutus	+	+	-	+	+
Chroococcus turgidus	+	-	+	+	+
Cylindrospermum stagnale	-	+	-	+	+
Cylindrospermumcapsa	-	-	-	+	-
Gloeocapsa stegophila	-	+	-	-	+
Gloeocapsa turgid	+	-	+	+	-
Lyngbya kuetzingii	-	+	-	+	-
Lyngbya majuscule	+	-	+	+	-
Lyngbya martensiana	-	-	+	-	+
Lyngbya wollei	-	+	+	-	+
Merismopedia glauca	+	-	-	-	+
Microcystis aeruginosa	-	+	+	-	+
Microcystis robusta	+	-	-	+	-
Nostoc linckia	+	-	-	+	+
Oscillatoria brevis	-	+	+	-	+
Oscillatoria curviceps	+	-	+	-	-
Oscillatoria earlie	-	-	+	-	-
Oscillatoria formosa	-	+	-	+	+
Oscillatoria limnetica	+	+	-	+	-
Oscillatoria nigra	-	+	-	+	-
Oscillatoria obscura	+	-	-	+	+
Oscillatoria princeps	+	-	+	-	-
Oscillatoria subbrevis	+	+	-	+	-
Oscillatoria tenuis	-	+	+	-	+
Phormidium fragile	+	+	-	-	+
Phormidium tenue	-	+	+	-	-
Schizothrix sp	+	+	-	+	-
Scytonema bohneri	-	-	+	+	-
Scytonema hofmanni	+	-	+	-	+
Spirulina meneghiniana	-	+	-	+	-
Spirulina subsalsa	+	-	-	+	+
Synechococcus elongatus	-	-	+	+	+
Chlorophyceae					
Ankistrodesmus falcatus	+	-	-	-	+
Chlamydomonas sp	-	+	-	-	+
Chlorella vulgaris	+	+	+	+	-
Chlorococcum humicola	-	-	-	+	+
Closterium leibleinii	-	-	+	-	+
Closterium navicula	+	-	-	+	-
Closterium sp	+	-	+	-	-
Coelastrum microsporum	-	+	-	-	+
Colestrella sp	+	-	-	+	+
Cosmarium amoenum	-	+	-	-	+
Cosmarium phaseolus	-	+	+	-	+
Cosmorium sexnotatum	+	+	-	+	-
Cosmorium subalatum	+	-	-	+	-
Cosmorium subprotumidum	-	-	+	-	+
Cylindrocapsa geminella	+	+	-	+	-
Gloecystis sp	-	+	+	+	+
Kirchneriella schmidle	-	+	-	+	-
Monoraphidium littorale	-	+	-	+	-
Oocytsis	+	-	+	+	+
Pandorina	-	-	+	-	+
Pediastrum boryanum	+	+	-	-	-
Pediastrum duplex	-	+	+	-	+
Phytoconis	+	-	-	+	-

Scenedesmus acuminatus	+	-	-	+	+
Scenedesmus armatus	-	+	+	+	-
Scenedesmus bernardii	+	-	-	+	-
Scenedesmus denticulatus	+	+	-	-	-
Scenedesmus obliquus	-	+	-	-	+
Selenastrum sp	-	-	+	+	-
Selenastrum sp	+	-	-	+	-
Staurastrum pantanale	-	+	+	-	+
Stigeocolonium sp	+	-	-	-	+
Tetraedron minimum	-	+	-	+	-
Volvox sp	+	-	+	-	-
Bacillariophyceae					
Anomoeoneis sphaerophora	+	-	-	+	-
Asterionella formosa	+	+	-	+	+
Craticula ambigua	-	+	-	-	+
Cymbella sp	+	-	+	-	-
Diatoma vulgaris sp	+	+	-	-	+
Fragilaria crotonensis	-	+	+	+	-
Gomphonema sp	-	-	+	-	+
Navicula capitatoradiata	+	-	-	+	-
Navicula pupula	-	-	+	-	+
Navicula sp	-	+	+	-	-
Nitzschia obtusa	+	+	-	+	-
Nitzschia palea	-	-	-	+	+
Nitzschia sp	+	+	+	-	+
Pinnularia	-	+	-	+	+
Pleurosigma elongatum	+	+	-	+	-
Rhopalodia gibba	+	-	-	+	+
Synedra ulna	+	-	+	-	+

Microalgal Diversity and Identification

The five temple ponds surveyed supported a rich and diverse phytoplankton community. A total of 93 microalgal species belonging to 51 genera were identified through light microscopy, classified into three major taxonomic groups:

- **Cyanophyceae (Blue-green algae):** 42 species
- **Chlorophyceae (Green algae):** 34 species
- **Bacillariophyceae (Diatoms):** 17 species

Species were identified using morphological criteria under 1000x magnification using a Micros Austria MCX500 photomicroscope. Representative micrographs of key taxa are presented in Figures 3 and 4. The presence of genera such as *Chroococcus*, *Oscillatoria*, *Anabaena*, *Scenedesmus*, *Chlorella*, and *Navicula* highlights the community's functional diversity and potential tolerance to varying environmental conditions.

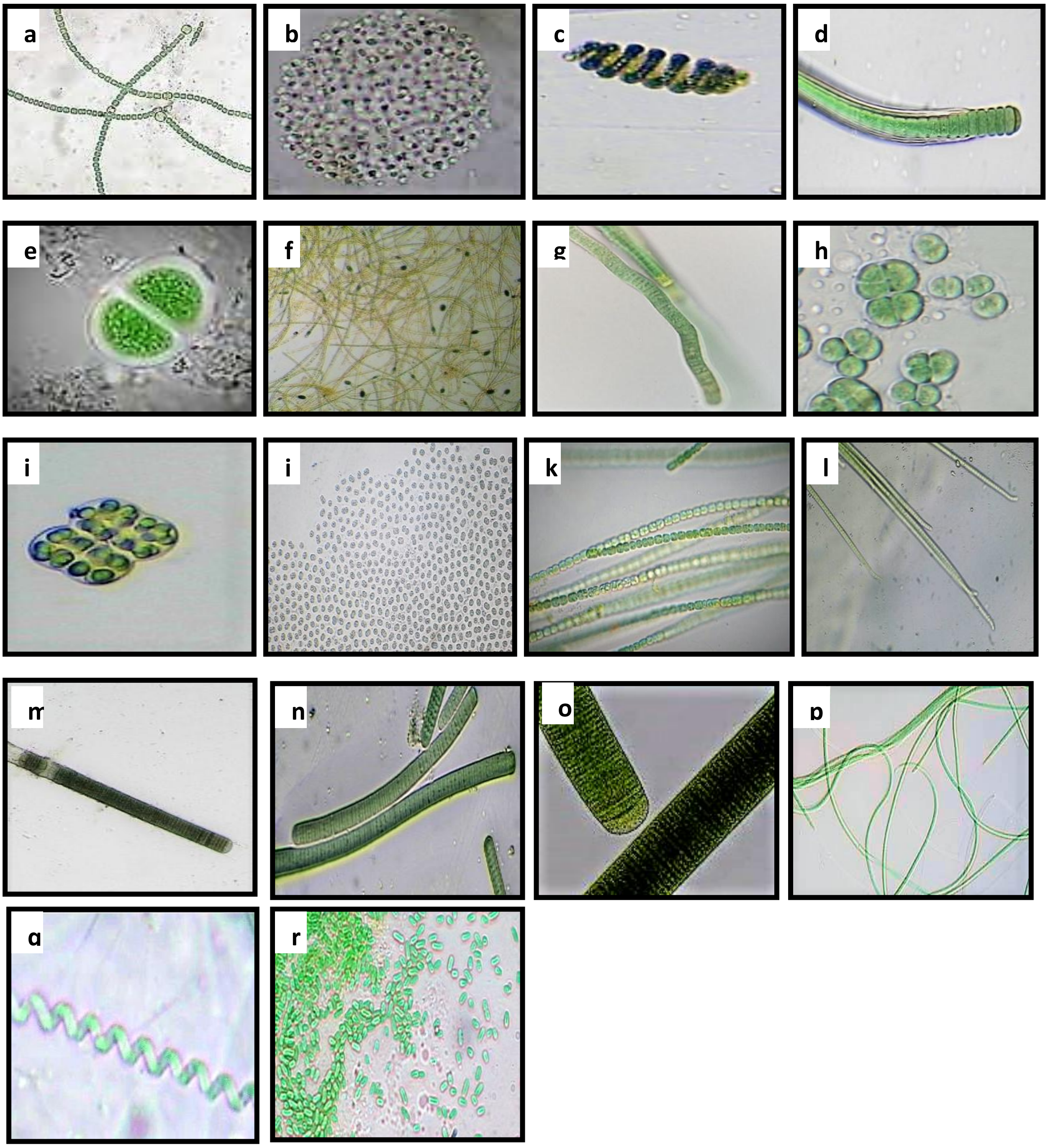

Figure 3 Microphotographs a)*Anabena* sp b)*Aphanocapsa grevillei* c)*Arthrospira* sp d)*Calothrix* sp e)*Chroococcus turgidus* f)*Cylindro spermum* g)*Lyngbya martensiana* h)*Chroococcus minutes* i)*Merismopedia glauca* j)*Microcystis aeruginosa* k)*Nostoc linckia* l)*Oscillatoria brevis* m)*Oscillatoria curviceps* n)*Oscillatoria tenuis* o)*Oscillatoria princeps* p)*Phormidium tenue* q) *Spirulina meneghiniana* r)*Synechococcus elongates*

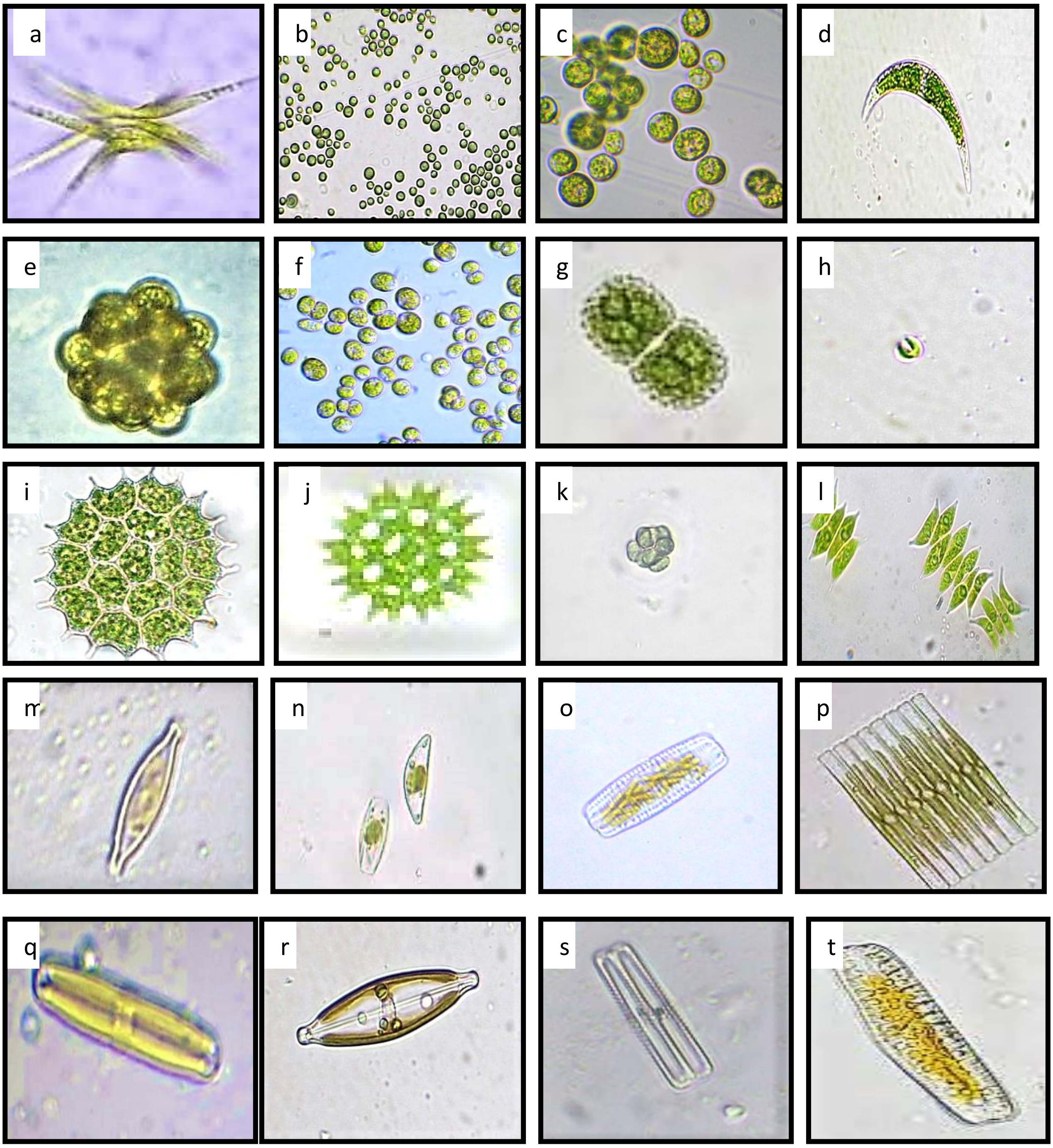

Figure 4 Microphotographs a)*Ankistrodesmus falcatus* b) *Chlorella vulgaris* c) *Chlorococcum humicola* d) *Closterium* sp e) *Coelastrum microporum* f) *Colestrella* sp g) *Cosmarium amoenum* h) *Kirchneriella schmidle* i) *Pseudopediastrum boryanum* j) *Pediastrum duplex* k) *Phytoconis* sp l) *Scenedesmus acuminatus* m) *Anomoeoneis sphaerophora* n) *Cymbella* sp o) *Diatoma vulgaris* sp p) *Fragilaria crotonensis* q) *Navicula pupula* r) *Navicula* sp s) *Nitzschia* sp t) *Rhopalodia gibba*

Phytoplankton Abundance and Distribution Across Ponds

Species richness and composition varied between ponds (Table 1). Pond-4 exhibited the highest diversity with 50 species, followed by Pond-5 with 49 species. Ponds 1 and 2 each supported 48 species, while Pond-3 recorded the lowest richness, with only 37 species. This spatial variation suggests a strong influence of localized environmental factors such as nutrient levels and ionic composition.The dominance of specific genera (*Oscillatoria*, *Phormidium*, *Microcystis*, *Navicula*) in nutrient-enriched ponds points to their pollution-tolerant nature, consistent with high Palmer Index scores used to detect organic pollution(Figure 5).

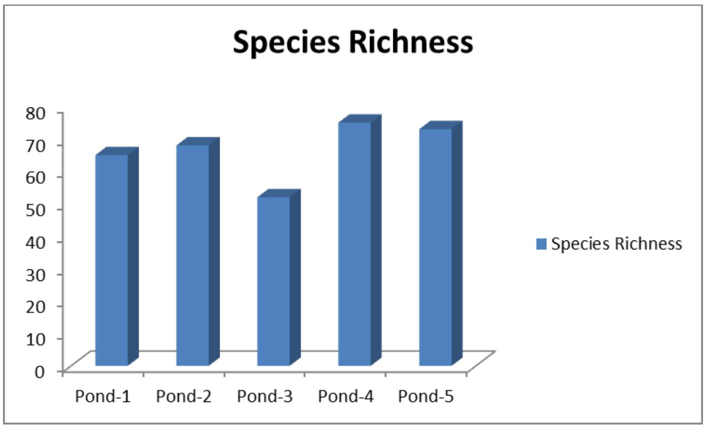

Figure 5 Species richness

Physicochemical Characteristics of Pond Waters

Table 2 summarizes the measured physicochemical parameters across the five ponds. Notable trends include:

- **pH:** Ranged from **7.3 (Pond-1)** to **8.2 (Pond-5)**, indicating slightly alkaline conditions across all sites.
- **Chloride:** Highest in **Pond-1 (230 mg/L);** lowest in **Pond-5 (127 mg/L).**
- **Nitrate:** Highest in **Pond-4 (8.6 mg/L),** supporting high algal productivity; lowest in **Pond-2 (4.7 mg/L).**
- **Ammonia and Inorganic Phosphorus:** Lowest in **Pond-2**, indicating reduced organic loading, while **Pond-1** exhibited high levels of both nutrients.
- **Sulphate:** Highest in **Pond-5 (52 mg/L).**
- **Calcium and Magnesium:** Pond-3 and Pond-1 showed relatively high concentrations, possibly influencing species composition.

These variations underline the **distinct nutrient regimes** and water quality conditions in each pond.

Table 2 Analysis of physicochemical parameters of water from different temple ponds

S.No	Parameters	Pond-1	Pond-2	Pond-3	Pond-4	Pond-5
1	pH	7.3	8.1	7.6	7.4	8.2
2	Chloride(mg/L)	230	135	215	175	127
3	Nitrate(mg/L)	6.5	4.7	5.3	8.6	8.2
4	Nitrite(mg/L)	1.5	1.1	1.2	1.3	1.1
5	Ammonia (mg/L)	1.8	0.53	3.4	0.5	1.2
6	Inorganic phosphorus(mg/L)	5.2	1.8	2.7	1.6	2.8
7	Sulphite (mg/L)	0.1	0.2	0.1	0.1	0.3
8	Sulphate (mg/L)	45	38	25	42	52
9	Calcium (mg/L)	98	40	105	83	72
10	Magnesium (mg/L)	43	32	37	43	22

Trace Metal Concentrations

Table 3 presents elemental profiles for each pond. Key findings include:

- **Silver (Ag):** Highest in **Pond-5 (0.3725 ppm).**
- **Gold (Au):** Peak value in **Pond-3 (0.7431 ppm).**
- **Cadmium (Cd):** Ranged from **0.0269 to 0.0887 ppm**, highest in **Pond-5.**
- **Cobalt (Co):** Highest in **Pond-5 (0.6778 ppm),** indicating potential metal stress on resident algal communities.
- **Potassium (K):** Highest in **Pond-3 (12.6610 ppm).**
- **Magnesium (Mg):** Elevated in **Pond-2 (88.2281 ppm).**

These differences in metal concentrations suggest differential exposure to trace metals, potentially selecting for metal-tolerant algal species in ponds such as Pond-5.

Table 3 Trace metals in the temple pond water (concentration in ppm)

S. No	Parameters	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
1	Ag	0.1612	0.1524	0.2789	0.3223	0.3725
2	Au	0.1052	0.2851	0.7431	0.6253	0.1126
3	Cd	0.0269	0.0486	0.0712	0.0662	0.0887
4	Co	0.3694	0.2584	0.5416	0.2275	0.6778
5	K	12.3551	9.6528	12.661	11.0153	8.7621
6	Mg	65.0151	88.2281	52.5312	62.5876	71.0121

Correlation Between Environmental Factors and Algal Diversity

Table 4 presents Pearson correlation coefficients between total algal strains (TAS) and measured physicochemical parameters. Key observations:

- **Positive correlations:**
  - ○ Nitrate (r = +0.566)
  - ○ Sulphite (r = +0.355)
  - ○ pH (r = +0.130)
  - ○ Nitrite (r = +0.116)
  - ○ Strongest positive: Sulphate and TAS (r = +0.8637, $p < 0.05$)
- **Negative correlations:**
  - ○ Chloride (r = -0.522)
  - ○ Ammonia (r = -0.916, $p < 0.01$)
  - ○ Inorganic phosphorus (r = -0.045)
  - ○ Calcium (r = -0.510)
  - ○ Magnesium (r = -0.082)

These relationships suggest that moderate levels of nitrate and sulphate support higher algal abundance, while excess ammonia and chloride may inhibit growth. The strong negative correlation between TAS and ammonia indicates a possible toxicity threshold, aligning with earlier studies on nutrient overload in enclosed freshwater bodies.

Table 4 Correlation co-efficient analysis of physic – chemical properties of water sample and total microalgal diversity of different temple ponds

	pH	Chloride (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	Inorganic phosphorus (mg/L)	Sulphite (mg/L)	Sulphate (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	TAS
pH	1										
Chloride (mg/L)	-0.864*	1									
Nitrate (mg/L)	-0.140	-0.201	1								
Nitrite (mg/L)	-0.892*	0.785	0.163	1							
Ammonia (mg/L)	-0.279	0.687	-0.380	0.149	1						
Inorganic phosphorus (mg/L)	-0.423	0.617	-0.062	0.725	0.393	1					
Sulphite (mg/L)	0.916**	-0.847	0.181	-0.701	-0.356	-0.206	1				
Sulphate (mg/L)	0.248	-0.476	0.665	0.092	-0.638	0.227	0.580	1			
Calcium (mg/L)	-0.730	0.848	0.198	0.617	0.743	0.525	-0.598	-0.286	1		
Magnesium (mg/L)	-0.942**	0.764	-0.043	0.802	0.119	0.245	-0.960**	-0.354	0.491	1	
TAS	0.130	-0.522	0.566	0.116	-0.916**	-0.045	0.355	0.863*	-0.510	-0.082	1

* : Significant at 0.05% ; ** : Significant at 0.01% : TAS – Total Algal Strains

Biodiversity Indices and Multivariate Patterns

Shannon–Wiener diversity index (H′) values across ponds ranged from 2.78 to 3.39**,** confirming moderately high species richness. Simpson's diversity index (D) values supported this trend, with relatively even community structures across ponds. These values reflect stable and complex algal communities, particularly in nutrient-balanced ponds like Pond-4 and Pond-5(Figure 6).

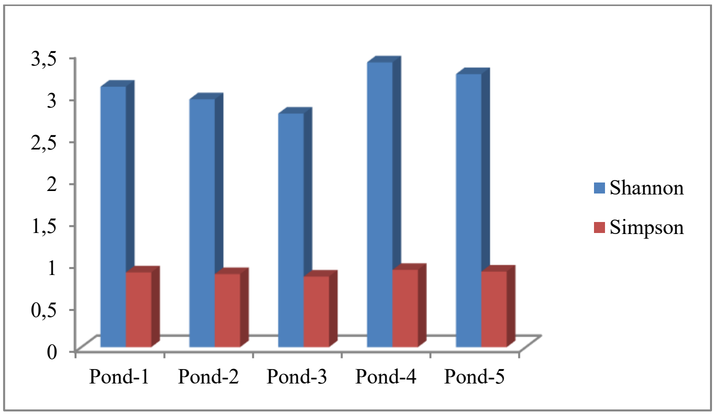

Figure 6 Simpson's diversity index and Shannon–Wiener diversity index

Additionally, Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (Bray-Curtis similarity) revealed grouping patterns based on environmental similarities(Figure7and8):

- Pond-1 and Pond-4 clustered together, likely due to similar nutrient profiles.
- Pond-2, with low nutrients and metals, formed a distinct group.

These findings highlight the functional structuring of algal communities along chemical gradients.

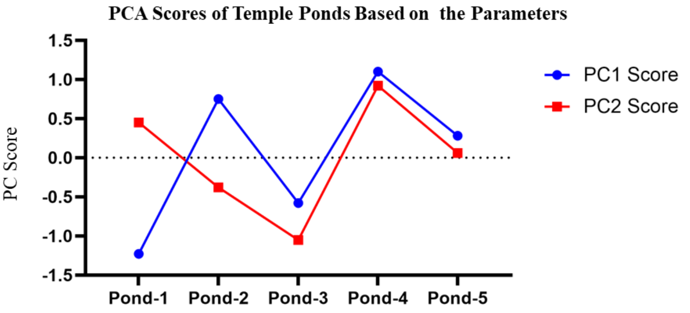

Figure 7 PCA Score of Parameters

Figure 8 Hierarchical dendrogram showing clustering of the five temple ponds based on physicochemical and elemental parameters using Ward's linkage method. Ponds with similar environmental profiles group together, supporting PCA findings.

DISCUSSION

The current study revealed a remarkably high diversity of phytoplankton, with 93 species across 51 genera identified from five temple ponds in Tiruchirappalli, Tamil Nadu. This level of diversity significantly exceeds previous findings in similar ecosystems. For instance, **Palanivel and Umarani (2016)** reported only 29 species in the Sri Nageswarar temple pond and 38 species in the Dhenupuriswarar tank. **Girish Kumar *et al.* (2014)** found just 18 and 17 species in the Pandakkal and Palloor temple tanks, respectively. **Ganesan Narchonai and Chithirai Arutselvan (2019)** reported 58 and 48 species in other sacred ponds. These comparisons highlight the exceptional biodiversity found in the current study and suggest temple ponds may function as underrecognized biodiversity reservoirs.

The dominant taxonomic groups included Cyanophyceae, Chlorophyceae, and Bacillariophyceae. The presence of genera such as *Oscillatoria*, *Anabaena*, and *Microcystis* recognized indicator species in Palmer's pollution index suggests varying levels of organic enrichment among ponds. This aligns with observations in **Subramanian *et al.* (2023)**, who found seasonal differences in diversity and water chemistry, emphasizing summer dominance in algal abundance, possibly due to enhanced light and nutrient availability.

Quantitative analyses using Shannon–Wiener (H′) and Simpson's Diversity Index (D) revealed values ranging from 2.78 to 3.39 and 0.84 to 0.92, respectively, confirming a moderately high and stable community structure. These findings are consistent with other freshwater biodiversity reports in tropical regions **(Subramanian *et al.*, 2023; Dhakal, 2014).**

Moreover, Pearson correlation analysis demonstrated significant relationships between phytoplankton abundance and environmental parameters. Positive correlations were observed with nitrate, nitrite, sulphite, and pH, indicating these factors promote phytoplankton growth. In contrast, negative correlations with ammonia, chloride, calcium, and inorganic phosphate suggest inhibitory effects or ecological stress, possibly from nutrient imbalance or ionic toxicity.

To further understand ecological structuring, Principal Component Analysis (PCA) and Hierarchical Cluster Analysis were performed. PCA revealed that Pond-4 and Pond-5 grouped together based on shared nutrient profiles, particularly higher sulphate and nitrate, while Pond-2 appeared ecologically distinct, likely due to its low nutrient and trace metal content. The dendrogram supported this grouping pattern, showing clear clusters aligned with water quality differences.

Trace metal analysis revealed pond-specific concentrations of silver (Ag), gold (Au), cadmium (Cd)**, and** cobalt (Co), which may influence species distribution. Metals like Fe, Mn, Co, Zn, and Cu are known to support algal physiology, acting as cofactors in metabolic processes **(Sunda *et al.*, 2005; Tchounwou *et al.*, 2012).** However, elevated levels can also induce oxidative stress, impacting community dynamics.

Taken together, these findings underscore the strong link between microalgal community structure and water chemistry, including both macro- and micronutrients. The variability observed among ponds suggests a complex interplay of biotic and abiotic factors, offering valuable insights into ecosystem function, monitoring, and conservation of these culturally and ecologically important freshwater habitats.

CONCLUSION

This study provides a comprehensive baseline on the microalgal diversity in temple ponds of Tiruchirappalli, revealing a rich and varied phytoplankton community shaped by localized environmental gradients. The detection of 93 microalgal species, alongside their correlations with water chemistry**,** highlights the ecological value of these traditional water bodies.

The use of statistical tools including biodiversity indices, PCA**,** correlation analysis, and hierarchical clustering allowed for detailed interpretation of how environmental factors influence microalgal distribution. The presence of potential bioindicator taxa, such as *Oscillatoria* and *Anabaena*, further suggests that temple ponds can serve as effective sites for ecological monitoring**.**

Given the increasing pressures of urbanization, climate change, and neglect of traditional water systems, this study underscores the need for continued monitoring**,** management, and restoration efforts**.** The findings also support the biotechnological potential of freshwater microalgae from temple ponds in applications like biofuel, bioremediation**, and** nutraceutical production.

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