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Phytoplankton as bio indicators of water quality in two perennial lakes of Coimbatore district, Tamil Nadu, India

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Abstract

Phytoplankton communities are widely used to assess the present conditions about eutrophication status, and physical and chemical parameters of aquatic environment. Therefore, phytoplankton communities are named as bio-monitoring agent. The assessment of phytoplankton density provides a cost-efficient method to analyze eutrophication conditions in both fresh and marine water ecosystems. Hence, the present research was focused on the phytoplankton diversity in two perennial lakes of Coimbatore city, and they correlated with Palmer index to get knowledge about polluted conditions of lake water. Results from the study revealed, totally 36 species of phytoplankton were recorded under 23 genera, which includes 14 species of Cyanophyceae, 10 species of Chlorophyceae, 09 species of Bacillariophyceae and 03 species of Euglenophyceae. Phytoplankton density was dominated by the following order Cyanophyceae > Chlorophyceae > Bacillariophyceae > Euglenophyceae in two perennial lakes. Among these four major groups, Cyanophyceae and Chlorophyceae were abundantly found in two perennial lakes, and they are highly dynamic and bloom producing phytoplankton groups, which impair the basic use of surface water in aquatic ecosystems. They correlated with pollution indices by Palmer (1969) [34]. The two perennial lakes are impacted by various pollutions caused by pollutants such as agricultural wastes, municipal wastes, and industrial wastes are influence the density of phytoplankton communities and hydrographical profile of lake water. Therefore, continuous monitoring of two perennial lakes is very necessary for primary production and wetland ecosystems in Coimbatore district.

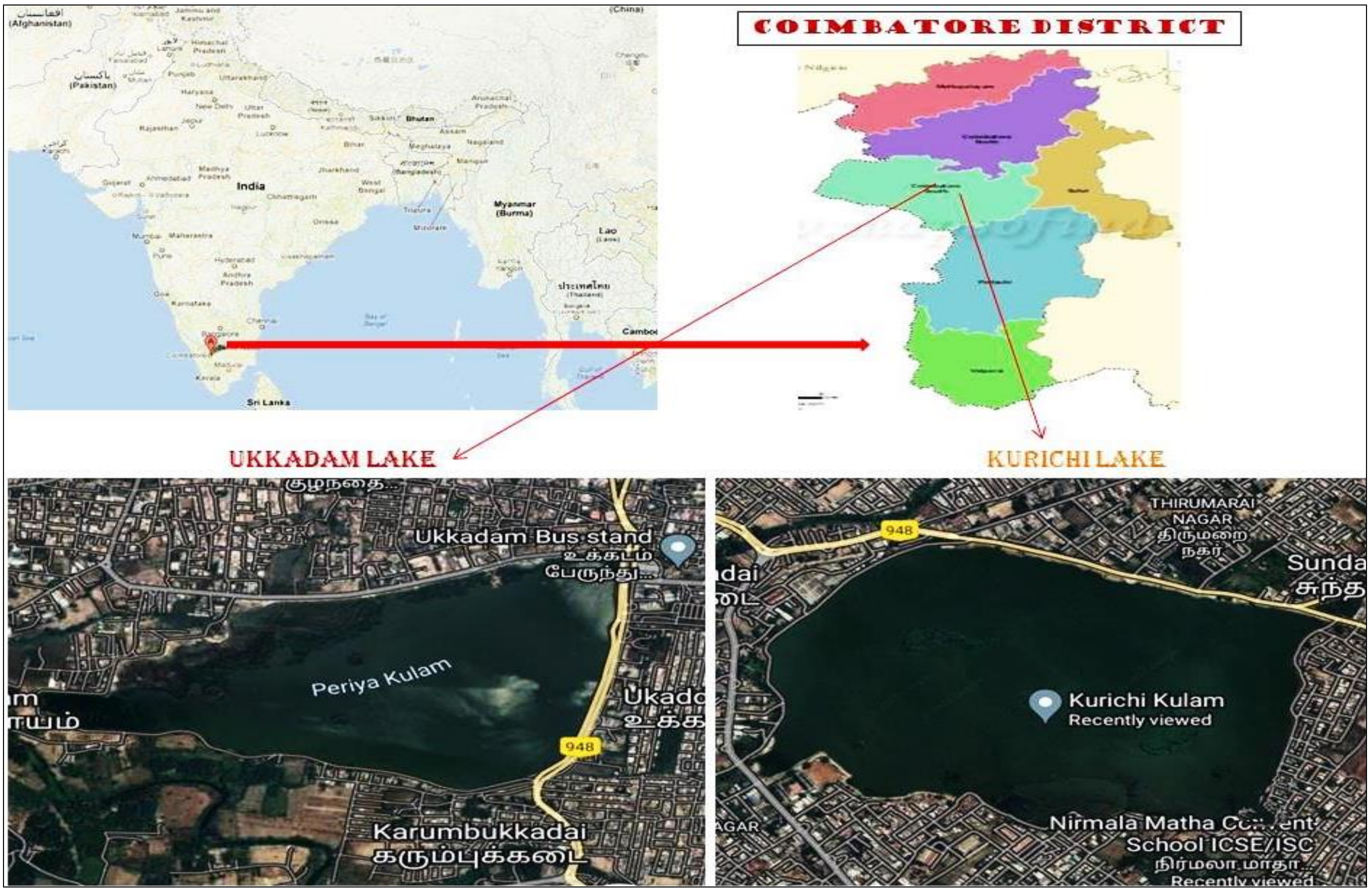
Keywords: phytoplankton; water quality; bio-indicator; pollution index

Introduction

The bio-monitoring process has become essential one in nowadays, because aquatic ecosystems are being polluting by various pollution activities like, increased human population, use of synthetic fertilizers, mixing of industrial effluent, sewage waste, agriculture runoff, and other land uses are one of the main reasons for the pollution of aquatic ecosystems (Holt and Miller, 2010) [22]. Hence, continuous monitoring of hydrographical characteristics is very important for controlling surface water pollution in aquatic ecosystems (Ravikumar *et al*. 2011) [38]. Plankton communities are microscopic, free-floating on the surface of both fresh and marine water ecosystems, and they react quickly to environmental changes of aquatic environment. In the past few decades, scientist were undertaken to estimate the plankton diversity and density in aquatic ecosystems, because they are used as pollution indicators of (bio-indicators) water quality parameters (Pomari *et al*., 2018) [37]. More than thousands of plankton species which remain undescribed and the maintenance of plankton diversity are very important in fresh and marine water ecosystems. In recent studies, scientists are reporting diversity patterns along specific gradients, such as latitude and altitude (Hillebrand, 2015). Plankton can be divided into two main groups like, phytoplankton and zooplankton. Phytoplankton study is the primary interest to exploit water resources for any scientific utilization. Species composition and population density of phytoplankton communities vary by various factor such as, hydrographical characteristics, nutrient load, and atmospheric temperature, which in turn reflect on the biodiversity of aquatic organisms within the aquatic environment (Boyd *et al*., 1998) [12]. Phytoplankton is collectively accounted as one of the important aquatic primary producers, and their density used to determine the wealth of biological resources in aquatic ecosystems. Phytoplankton communities are very good aquatic bio-indicators has long been documented by Smol and Stoermer, 2010, Muriel et al., 2004, and Bere and Tundsi, 2009. The major phytoplankton communities are belonging to order of Cyanophyceae, Chlorophyceae, Bacillariophyceae, and Euglenophyceae. The biodiversity and limnological studies provide a basic understanding of nature and help to monitor the aquatic environment (Mustapha, 2010). Hence, the current study was aimed to investigate the biodiversity of phytoplankton communities in two perennial lakes of Coimbatore district, and they correlated with pollution indices by Palmer (1969) [34].

Materials and methods

Ukkadam lake lies at 10º58'54"N and 76º57'17"E, Kurichi lake lies at 10º57'57"N and 76º57'48"E Coimbatore district, Tamil Nadu, India (Table 1 and Figure 1A & B). The surface water samples was collected form August-2022 to Septmeber-2022 at fifteen days interval, during early morning hours between 5.00 am to 7.00 AM at samples sites, at a same time phytoplankton samples were collected at depth of 1 meter by using Towing-Henson's standard plankton net (mouth diameter 0.35 nm) made up of nylon bolting cloth (mesh size 25 µm). The collected phytoplankton biomass, were immediately transferred to 100 ml specimen bottles containing 5% of neutralized formalin, and they were subjected to microscopic analysis. The taxonomic identification was done under the compound light microscope at a magnification of 40 X to 100 X and they were photomicrographic by using, Inverted Biological Microscope (Model Number INVERSO 3000 (TC-100) CETI) attached to the camera (Model IS 300).



(Lat. 10.58°N and Long.76.57° E) (Lat.10.57°Nand Long.76.57° E)

Fig 1: Geographical description and Satellite views of two Perennial lakes of Coimbatore City

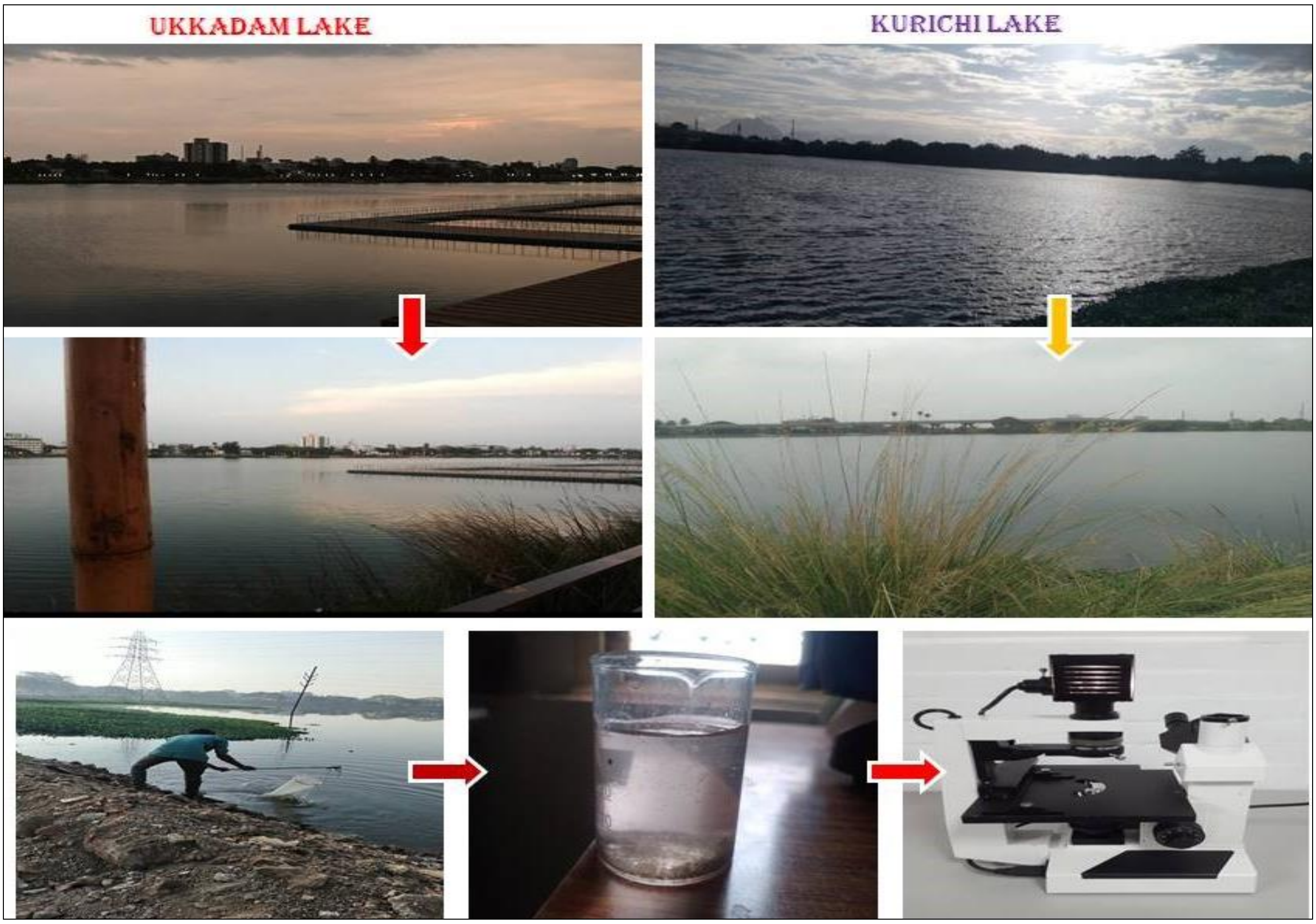


Fig 2: Photographic images of study areas and sample collections of two perennial lakes

The surface water samples transferred into the laboratory to analyse physico-chemical parameters like, water temperature, P^H, salinity, dissolved oxygen, total dissolved oxygen, electrical conductivity, phosphorus, nitrite, and chlorine by using "µP Based Water & Soil Analysis Kit" (Model 1160).

For quantitative analysis of phytoplankton communities, 1 ml sample was taken and poured into the counting chamber of the Sedgwick Rafter. After allowing it to settle for some time, and they were counted. At least 5 counting were made for each group. The average values were taken. The total number of phytoplankton present in 1 litter of water sample was calculated (Santhanam *et al*., 1989) [40]. The phytoplankton species were identified by referring to the standard manuals, textbooks, and monographs by using Venkataraman, 1939 [44]; Iyengar and Venkataraman, 1951 [24]; Desikachary, 1959 [17]; Philipose, 1967 [35]; Adoni *et al*., 1987; Agarker *et al*., 1994 [3]; Anand 1989 and 1998 [5, 6]; Cox, 1996 [15].

Pollution indices by Palmer (1969) [34] based on the genus and species level, were used to rating the water quality parameters (low or high organic pollution). A pollution index factor was assigned to each genus and species. If there are >5 cells of a particular kind of algae must be identified and recorded (Table 1). The mean and standard deviation of the noted values were calculated and tabulated. The data of the experiment was entered in Microsoft Excel and analyzed by using Genstar computer-based statistical data analysis through one-way ANOVA and means were separated by DMRT at a 5% level of significance.

Table 1: Pollution indices factor by Palmer (1969) [34]

Pollution Indices (Palmer 1969) [34]	
0 to 10	indicates lacks organic pollution
10 to 15	indicates moderate pollution
15 to 20	indicates probable high organic pollution
> 20	confirmed organic pollution

Results and discussion

1. Physical-chemical characteristics in two perennial lakes

The average values of water quality parameters like, water temperature, P^H, salinity, dissolved oxygen, total dissolved oxygen, electrical conductivity, phosphorus, nitrite, and chlorine was analysed and calculated by using one-way ANOVA were depicted in Table 2.

Table 2: Analysis of physic-chemical parameters in perennial lakes of Coimbatore city.

Parameters	Ukkadam Lake	Kurichi Lake
Water temperature (°C)	24.26±0.96^a	26.99±0.42^b
P^H	7.06±0.25^a	7.20±0.35^b
Salinity (ppt)	0.926±0.06^a	1.159±0.25^b
DO (mg/l^{-1});	8.31±0.50^c	7.79±0.14^b
TDS (mg/l^{-1})	1021±24.06	1028±15.20
EC (µS cm^{-1})	1.42±0.13^a	2.035±0.24^b
Phosphorus µg/l^{-1})	35.41±0.28	33.14±0.09
Chlorides (mg/l^{-1})	2.65±0.45^a	2.98±0.70^b
Nitrite (mg/l^{-1})	0.673±0.10^a	0.773±0.13^b

WT: water temperature; **DO**: dissolved oxygen; **TDS**: total dissolved solids; **EC**: electrical conductivity.

Assessment of physico-chemical characteristics and biological diversity are used to get knowledge about the current status aquatic environment (Piha and Zampokas, 2011) [36]. Species composition and community structure are mostly depends on the water quality parameters (Balarabe, 2001) [7]. During the study period, physico-chemical characteristics are slightly fluctuated in two perennial lakes and this may be due to various factors like, light intensity, and higher sedimentation are modifying the species composition of phytoplankton communities (Chaudhary and Pillai, 2009). Devika et al., (2006) suggested the water quality parameters have direct contact with the phytoplankton diversity in aquatic environment. In the present study, water temperature, P^H, salinity, dissolved oxygen, total dissolved solids, electrical conductivity, phosphorus, nitrite, and chlorine were described by the Trivedi and Goel,1986, Wetzel and Likens, 1991, and APHA, 2005. Water temperature plays crucial role in aquatic biodiversity, and if any moderate fluctuation in surface water temperature can greatly influences the biodiversity of aquatic organisms (Davis et al., 2013). During the study period, water temperature range between Ukkadam and Kurichi lake is 24.26ºC and 26.99ºC respectively. The water temperature is increased due to the environmental factors like, global warming, and unpredictable environmental changes in environment. P^H is used to determine status of lake water is acidic, alkaline or neutral. P^H helps in the growth of aquatic organisms (Sagar et al., 2012). In the present study, P^H range from Ukkadam and Kurichi lake is 7.06 and 7.20 respectively. P^H increased due to the various reasons like, anthropogenic activities, mixing of industrial effluents, agricultural runoff and etc. Salinity plays crucial role in aquatic ecosystems. The analysis of salinity level is used to determine the status of salt content in water bodies and also used for assessing the pollution conditions. The salinity range between Ukkadam and Kurichi lake is 0.926 ppt and 1.159 ppt. Salinity plays crucial role in measuring the conditions about biological process and hydrochemistry of the aquatic ecosystems (Hassan et al., 2004). Salts originate from the weathering of rocks and soil, the dissolution of lime in the aquatic environment, sedimentation of gypsum, and followed by the other minerals. Salinity increased due to the higher sedimentation of carbonate rocks, and eutrophication process. The dissolved salts remain in the soil and water which affects the aquatic environment (Nielsen, et al., 2003). Dissolved oxygen is considered as important factor for aquatic biota and also used to determine the stock rating of aquatic organisms (Borse and Bhave, 2001). Dissolved oxygen varies daily or seasonally by the surrounding environmental factors. In the present study, DO ranges from Ukkadam and Kurichi lake is 8.31mg/ L to 7.79 mg/ L respectively. DO decrease due to the addition of containing organic matter, anthropogenic influences, and dumping of municipal wastes in to aquatic environment (Chekryzheva, 2014). Total dissolved solids and electrical conductivity is one of the important physico-chemical characteristics, to assess the pollution status of lake water. Higher amount of dissolved solids are affects the aquatic organisms and induce bloom forming phytoplankton species. In the present study, TDS ranged from Ukkadam and Kurichi lake 1021 mg/ L and 1028 mg/L and EC range from Ukkadam and Kurichi lake is 1.42 (µS cm-1) and 2.035 (µS cm-1) respectively. Total dissolved solids and electrical conductivity increase due to the higher amount of sedimentation at base of aquatic environment, seasonal variations and higher salinity level also increase the TDS and EC in aquatic environment. High amount of nitrate, phosphorus and chlorides were indicated that lake is eutrophication (Ngupula, 2013) [31].

In present study, phosphorus range between Ukkadam and Kurichi lake is 35.41mg/L and 33.14 mg/ L, nitrate range from Ukkadam and Kurichi lake is 0.673 mg/L and 0.773 mg/L, and chlorides range from Ukkadam and Kurichi lake is 2.65 and 2.98±0.7 mg/L respectively. Nitrate concentration was increased due to the discharge of sewage waste, use of synthetic fertilizers, anthropogenic influences, agricultural wastewater, and high amount of nitrogen fertilizers. Nitrate, phosphorus, and chlorides are the main nutrients that remain deficient in contaminated water (Kishe, 2009) [25]. Results from the study revealed that water temperature, P^H, salinity, dissolved oxygen, total dissolved solids, electrical conductivity, phosphorus, nitrite, and chlorine are moderately fluctuated during study period, but they positively support to aquatic organisms in two perennial lakes of Coimbatore district.

2. Phytoplankton population density with percentage composition in two perennial lakes

The population density was recorded in the range in Ukkadam lake 2,936 Ind./L and Kurichi lake 2420 Ind./L. In the present observation, phytoplankton percentage composition shows that Cyanophyceae holds the top rank at two perennial lakes and followed by Chlorophyceae, Bacillariophyceae, and Euglenophyceae (Table 3 and Figure 2, 3).

Table 3: Phytoplankton population density with percentage composition in two perennial lakes of Coimbatore city

Plankton group	Ukkadam Lake	Kurichi Lake
	Total (Ind./L) &%	Total (Ind./L) &%
Cyanophyceae	987±42^{a} (34%)	857±29^{b} (35%)
Chlorophyceae	892±30^{a} (30%)	736±34^{b} (30%)
Bacillariophyceae	760±31^{a} (26%)	618±26^{ab} (26%)
Euglenophyceae	297±32^{a} (10%)	209±28^{ab} (9%)
Total	2,936	2,420

Each season value is overall average of mean ± SD (n=20; 5 sites × 2 months). Mean values within the same row sharing different superscript are significantly different (P<0.05)

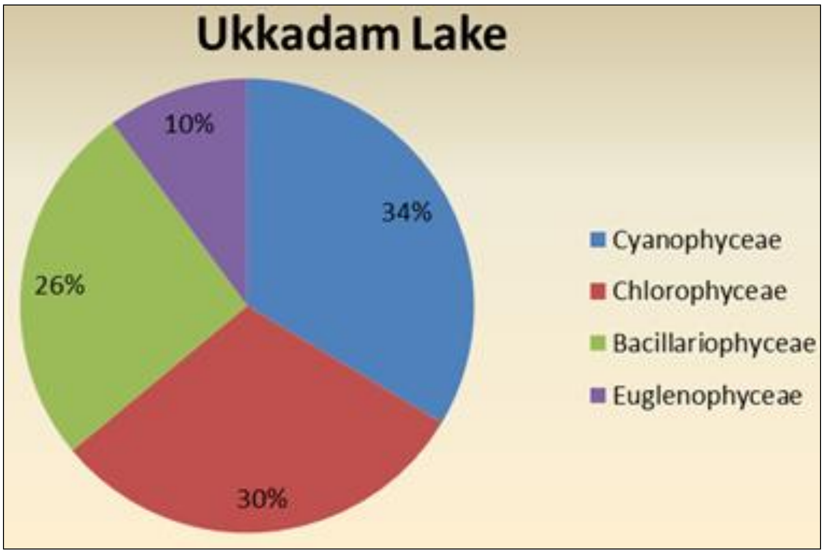


Fig 2: Percentage composition of phytoplankton species recorded in the Ukkadam Lake during the study period

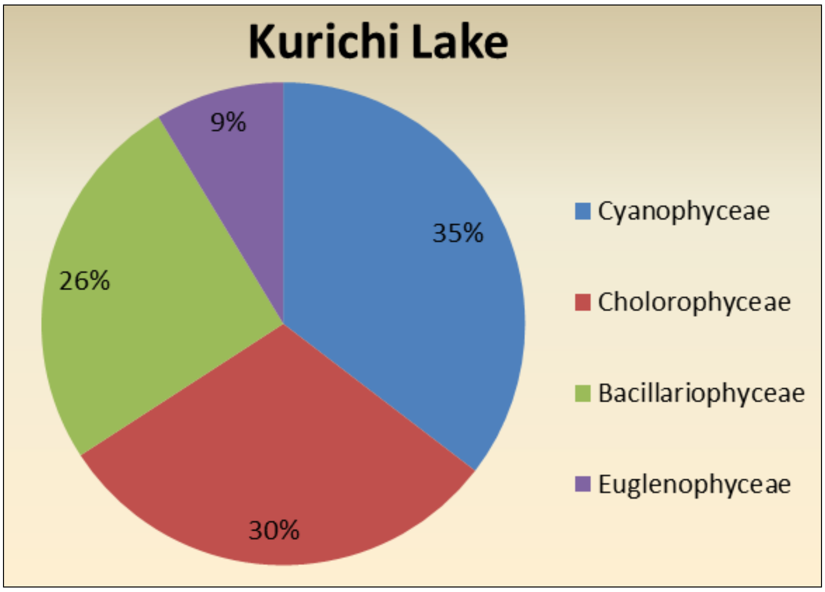


Fig 3: Percentage composition of phytoplankton species recorded in the Kurichi Lake during the study period

3. Morphologically identified phytoplankton species in two perennial lakes

Totally 36 species of phytoplankton recorded under 23 genera, which includes 14 species of Cyanophyceae 10 species of Chlorophyceae, 09 species of Bacillariophyceae and 03 species of Euglenophyceae. In Ukkadam lake 12 species of Cyanophyceae, 09 species of Chlorophyceae, 09 species of Bacillariophyceae and 02 species of Euglenophyceae. In Kurichi lake 12 species of Cyanophyceae, 09 species of Chlorophyceae, 09 species of Bacillariophyceae and 03 species of Euglenophyceae (Table 4). Algal populations not only impact the intensity of light, temperature, and rich of nutrients, but also by influences of zooplankton through predator-prey interaction (Mohan and Priyadarshinee, 2022) [28]. Phytoplankton communities are very sensitive to environmental changes in aquatic ecosystems (Yun et al., 2014). They are highly dynamic to environmental variables, because they can produce blooms during the unfavourable environmental conditions (Ibrahim and Nafiu, 2017) [23]. Blooms are present in all aquatic environment, they are autotrophic organisms and receives their essential nutrients from dissolved chemicals and serve as indicators of the trophic state in their environment (Aboim *et al*., 2019) [1]. Especially Cyanophyceae can produce toxic blooms like, cylindrospermosin, and hepatotoxin, and some phytoplankton species create offensive tastes and odours or toxic substance in aquatic ecosystems (Escaravage and Prins, 2002) [19]. However, high temperature, nutrients enrichment, global warming, toxic substances, pesticides, and mix of heterotrophic microorganism activities influenced the growth of phytoplankton species (Omaka et al., 2014; Li *et al*., 2019) [33, 26].

Table 4. List of phytoplankton species identified and Palmer pollution index factor in two perennial lakes of Coimbatore city

Groups	Phytoplankton species	Ukkadam Lake	Kurichi Lake
Cyanaophyceae (blue green algae) (14 species)	*Chroococcus cimneticus*	+	+
	Chroococcus dispersus	+	+
	Chroococcus varius	+	-
	Merismopedia glauca	+	+
	Merismopedia nova	+	+
	Microcystis aeruginosa	-	+
	Oscillatoria limnetica	+	+
	Oscillatoria princeps	+	+
	Oscillatoria curviceps	+	+
	Nostoc communes	+	-
	Nostoc flagelliforme	+	+
	Nostoc calcicola	+	+
	Spirulina laxissima	+	+
	Spirulina flavovirens	-	+
Chlorophyceae (Green algae) (10 species)	*Ankistrodesmus falcatus*	+	-
	Clostridium acerosum	+	+
	Coelastrum microporium	-	+
	Eudorina elegans	+	+
	Scenedesmus acuminatus	+	+
	Scenedesmus dimorphus	+	+
	Scenedumus quaricauda	+	+
	Spirogyra hyaline	+	+
	Pandorina morum	+	+
	Pediastrum duplex	+	+
Bacillariophyceae (diatoms) (9 species)	*Cyclotella meninghiana*	+	+
	Cocconesis placentula	+	+
	Melosira granulate	+	+
	Melosira varians	+	+
	Gomphonema parvulum	+	+
	Navicula cuspidate	+	+
	Nitzchia palea	+	+
	Nitzschia acicularis	+	+
	Synedra ulna	+	+
Euglenophyceae (3 species)	*Lepocinclis ovum*	+	+
	Phacus pleuronectus	+	+
	Trechelomonas volvocina	-	+
Total	36	32	33

0 to 0 = indicates lacks organic pollution; 10 to 15 = indicates moderate pollution; 15 to 20 = indicates probable high organic pollution and > 20 or more = confirmed organic pollution (Palmer, 1969) [34].

4. Pollution index factor in two perennial lakes (Palmer, 1969) [34]

Algal pollution indices of Palmer (1969) [34] based on the genus and species, were used to rating of water quality (**Table 4,5**).

Table 5: Palmer pollution index factor for phytoplankton in two perennial lakes of Coimbatore city

Groups	Phytoplankton genus	Ukkadam Lake	Kurichi Lake
Cyanaophyceae (Blue green algae) (6 genus)	Chroococcus	3	2
	Merismopedia	2	2
	Microcystis	-	1
	Oscillatoria	3	3
	Nostoc	3	2
	Spirulina	1	2
Chlorophyceae (Green algae) (8 genus)	Ankistrodesmus	1	-
	Clostridium	1	1
	Coelastrum	-	1
	Eudorina	1	1
	Scenedumus	3	3
	Spirogyra	1	1
	Pandorina	1	1
	Pediastrum	1	1
Bacillariophyceae (diatoms) (6 genus)	Cyclotella	1	1
	Cocconesis	1	1
	Melosira	2	2
	Gomphonema	1	1
	Navicula	1	1
	Nitzchia	2	2
	Synedra	1	1
Euglenophyceae (3 genus)	Lepocinclis	1	1
	Phacus	1	1
	Trechelomonas	-	1
Total	23	32	33

*0 to 0 = indicates lacks organic pollution; 10 to 15 = indicates moderate pollution; 15 to 20 = indicates probable high organic pollution and > 20 or more = confirmed organic pollution (Palmer, 1969) [34].

Pollution-tolerant phytoplankton species are correlated with by Palmer indices. The Palmer (1969) [34] indices, based on the tolerance of phytoplankton species and genus. Cyanophyceae, Chlorophyceae, and Bacillariophyceae members can tolerate in highly polluted conditions, and their presence are suggesting they are eutrophic (Sharma and Yadav, 2020) [41]. In the present study was carried out by the Palmer indices by genus level and species level. The Palmer indices at species level was ranged between in Ukkadam lake, 12 species of Cyanophyceae, 09 species of Chlorophyceae, 09 species of Bacillariophyceae and 02 species of Euglenophyceae. In Kurichi lake 12 species of Cyanophyceae, 09 species of Chlorophyceae, 09 species of Bacillariophyceae and 03 species of Euglenophyceae, and followed by genus level was ranged from in Ukkadam lake, Cyanophyceae 05, Chlorophyceae 07, Bacillariophyceae 06, and Euglenophyceae 02. In Kuruchi lake is Cyanophyceae 06, Chlorophyceae 07, Bacillariophyceae 06, and Euglenophyceae 03 respectively. During the study period, *Nitzchia palea*, *Scenedesmus quadricauda*, *Pediastrum duplex*, *Chroococcus varius*, *Merismopedia nova*, *Spirogyra laxissima*, *Navicula cuspidate*, *Pandorina morum*, *Merismopedia glauca*, *Nostoc calcicola*, *Oscillatoria curviceps*, *Cyclotella meninghiana*, *Gomphonema parvulum*, *Cocconesis placentula*, *Nitzschia acicularis*, and *Synedra ulna* was dominant pollution-indicating phytoplankton species were observed in two perennial lakes of Coimbatore district (Vutukuru *et al*., 2012; Basavaraja *et al*., 2012) [45, 9]. *Chroococcus, Nostoc, Merismopedia, Spirogyra, Oscillatoria,* and *Scenedumus* were observed genus in highest number and most common (Basavaraja *et al*., 2013) [8]. They are pollution-tolerant genus and they abundantly found in rich organically polluted water (Mahadev and Hosmani, 2005) [27]. *Microcystis, Nostoc, Scenedesmus*, and *Oscillatoria* genus can produce cyano-toxins during unfavourable environmental conditions and also by the high amount of organic nutrients present in aquatic ecosystems. The cyanobacterial toxin is very dangerous for both primary and secondary consumers. They may cause serve health effects like, head ache, vomiting, gastro-intestinal problems, and etc. In some times, they may lead to death also. The removal of cyanotoxins from water bodies is very risk work and it consume more cost. Hence, Chlorination is the method to detoxify the cyanotoxins from water bodies, but it definitely affects the life of aquatic biota. Therefore, this method is only applies for drinking water governed by municipal office. Around the India, more than 5000 of lakes are polluted by cyanotoxins, and they affect directly either indirectly. Therefore, continuous monitoring of water bodies are essential to maintain stranded biological diversity and aquatic food web in environmental ecosystems.

Conclusion

Results from the study revealed that phytoplankton species diversity is correlated with pollution indices. The presents of *Microcystis, Nostoc, Oscillatoria, Merismopedia, Chroococcus, Synedra, Cocconesis*, and *Scenedumus* are used to determine the present changes of hydrographical characteristics and biological circumstances of aquatic environment. Hydrographical characteristics like, water temperature, p^H, salinity, DO, TDS, EC, phosphorus, nitrate, and chlorine moderately fluctuated during the study period. All the parameters are positively supports to life of aquatic organisms in in two perennial lakes of Coimbatore district. *Chroococcus, Synedra, Microcystis, Nostoc, Scenedesmus*, and *Oscillatoria* genus were only found rich in organically polluted water bodies. Therefore, present study suggests that two perennial lakes that are affected by various pollutions by their surrounding environment such as, entry of municipal wastes, sewage waste, and agricultural runoff is the major cause of eutrophication. However, the assessment phytoplankton communities are very important, because they reflected the pollution status of lake water, and the present study was concluded two perennial lakes are moderately polluted. Hence, the continuous monitoring of water quality parameters will provide the knowledge about phytoplankton diversity, to maintain the primary production and restore the aquatic biota in the aquatic environment.

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Disclosure statement

Conflict of Interest: The authors declare that there are no conflicts of interest.

Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

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