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Research Article

ALGAL SPECIES DIVERSITY AND PALMER POLLUTION INDEX OF PUTTENAHALLI LAKE IN BENGALURU, INDIA

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ABSTRACT

In this Anthropocene period, due to high human interference for the developments in the fields of agriculture, industry and urban events, especially around lake water systems have affected significant changes in quality and quantity of the resources and enriched water with mineral nutrients, such as nitrogen and phosphorus as a consequence, lakes got enriched with increased algal productivity which in turn has led to oxygen depletion, recreational impairment, biodiversity loss and resulted in deterioration of habitat quality. The present study attempts to assess the water quality of Puttenahalli lake through phytoplankton studies. The Puttenahalli lake has been hysterically polluted by sewage discharge from two places, one from the underground drain in Nataraja layout and the other from an unknown source in the southern side which has led to a massive fish kill and organic load in the lake. The phytoplankton studies revealed the presence of harmful algal blooms like *Spirogyra* sp., *Mycrocystis* sp., *Cylindrospermopsis* sp., *Arcella* sp., *Anabena* sp., *Scenedesmus* sp., *Ulothrix* sp., *Ankistrodesmus* sp., *Cosmarium* sp., *Trachelomonas* sp., *Zygnema* sp., *Navicula* sp., *Synedra* sp., *Cymbella* sp., *Nitzschia* sp., *Cyclotella* sp., *Selenastrum* sp., diatoms sp., and many other cyanohabs were abundantly present in the studied lake. These Cyanobacterial blooms are currently a great threat to the ecological integrity and sustainability of lake water resources.

Keywords: *Algal blooms, Lake water, Phytoplankton, Sewage, Pollution*.

1. INTRODUCTION

Water is the elixir of life, it is a life giver and furthermore a life creator, a precious gift of nature to mankind and different species living on the planet and additionally the essential component of the life web of our planet [1-2]. Humans tend to depend on water for survival as well as economic welfare [3]. However, with fast expansion of population, the demand for water has also increased [4-5]. Humans highly rely on water resources for agriculture, transportation, recreation, and domestic uses like cleaning up utensils, laundry garments, bathing etc. But humans are over abusing water like masters to fulfil our greed and in turn contributing to the devastation of water bodies and as a result, it is quickly becoming a scarce commodity in most parts of the world [6-7]. The adequate amount of quantity and quality of the accessible water is most necessary condition to maintain sustainability [8].

Earlier water bodies were in the state of oligotrophy with desired aquatic life due to nutrient deficiency. But in this Anthropocene period, due to high human interference for the developments in the fields of agriculture, industry and urban events, especially around lake, water systems have effected significant changes in quality and quantity of the resources [9-10] and enriched water with mineral nutrients, such as nitrogen and phosphorus which intern resulted in ill modification of water bodies from oligotrophic to mesotrophic, eutrophic, and finally hypertrophic stage [11-12]. According to the U.S. Environmental Protection Agency (EPA), excess nutrients load is the major reason for impaired water quality in the urban lakes and uncontrolled human activities in and around the lakes results in waters enriched with nutrients [13-14].

In contrast to other major cities in India, Bangalore is the place where majority of lakes have been highly contaminated by human activities where in agricultural chemicals, fertilizers run offs, radioactive wastes, draining of industrial effluents and sewerage are the major contributors of eutrophication. As a consequence, lakes got enriched with nutrient loads increasing algal productivity which in turn has led to oxygen depletion, recreational impairment, biodiversity loss and resulted in deterioration of habitat quality [15].

Lakes are currently degraded by both natural and cultural eutrophication, which not only deteriorate their water quality but push them to the brink of extinction in the process of unplanned development, giving rise to the need for suitable conservation strategies. Unfortunately, over the years, lesser attention has been given to wetland losses in Bengaluru. The degradation of the wetlands has altered their functions, affecting the ecological balance.

The present study of Puttenahalli lake water body in Bengaluru attempts to assess the lake water quality through phytoplankton studies. Water quality evaluation for lake leads to information about their misuse by indicating the pollution status. Since the quality of aquatic life depends on water quality, a thorough assessment of the same becomes an integral part of water resource evaluation.

2. STUDY AREA

The lakes of Bengaluru are spread over about 4.8% of the city's geographical area wrapping both urban and rural areas. The selected lake is situated in urban Bengaluru and is predominantly rain fed lake which was earlier used for irrigation, agriculture and fish culturing etc.

Puttenahalli lake is located in Southern part of Bengaluru urban district. It has extended area of about 13.25 acres with a perimeter of 1.1km. The lake is rain fed and receives water through surface runoff during monsoon from surrounding upland and has a regular inlet of sewage canal. The lake has been hysterically polluted by sewage discharge from two places, one from the underground drain in Nataraja layout and the other from an unknown source in the southern side which has led to a massive fish kill and organic load in the lake. The religious activities like idol immersion also created an unpleasant aquatic environment and lead to contamination of lake water quality.

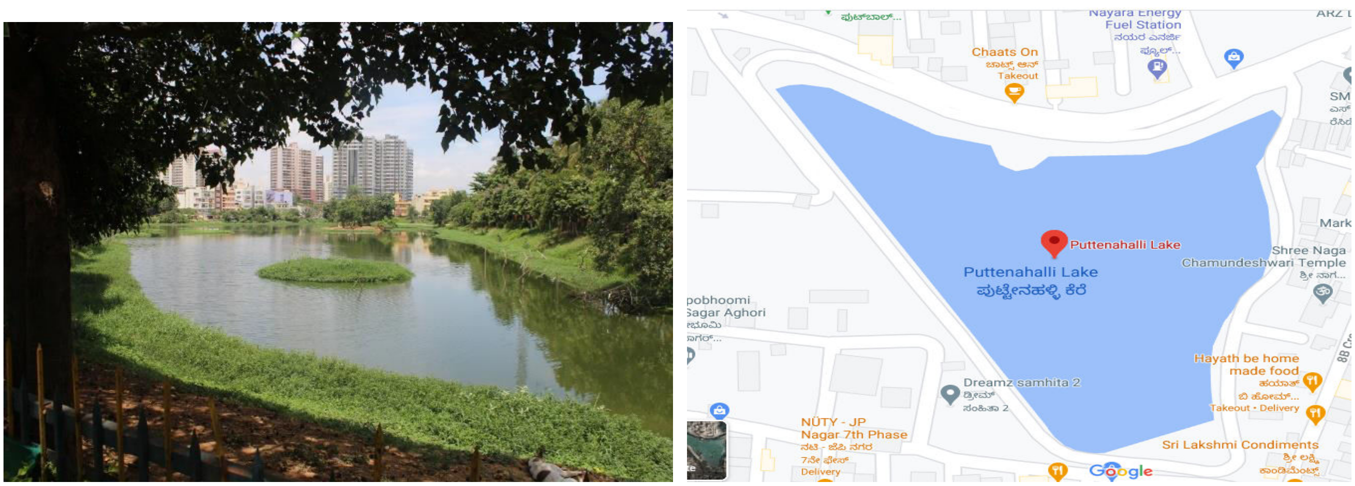


Fig. 1: Puttenahalli lake

3. METHODOLOGY

3.1. Selection of sampling area

In the present study, harmful algal blooms profile and Palmer Pollution Index were assessed in Puttenahali lake seasonally (pre-monsoon, monsoon and post-monsoon) in the year 2017, 2018 and 2019.

3.2. Methodology

3.2.1. Algae sampling

Algae samples were collected from a depth of 1.5 to 2.0cm below the surface water and filtered 10 litres of water through bolting silk cloth net (No.25) of mesh size of 63μm and same was repeated in 3 different sampling points. The algal samples were also collected using tow method. The collected phytoplankton samples were preserved using Lugol′s solution (can be examined for species within three months of collection) and the unpreserved samples has to be examined for species within first three days. The samples were shifted to the research laboratory for qualitative and quantitative analysis [16].

The collected lake water samples were subjected to qualitative and quantitative analysis of algal species. Lackey's drop method was followed for the documentation of algae species and algal species were analysed quantitatively using Sedgwick-Rafter cell. The Sedgwick-Rafter cell with the size of 50mm x 20mm x 1mm was used to count the plankters in random fields each consisting of one whipple grid. The total number of samples was determined based on 2 to 3 repeated subsamples. The algal species of each group were noted and the number of organisms in each genus was counted and tabulated. The algal species in the sample was identified using standard procedure [16-19] and calculated for the number of algal species per millilitre as follows:

For Sedgwick - Rafter cell (Field Counting)

Organisms per ml = $(C \times 1000mm^3)/(A \times D \times F)$

Where, C - Number of organisms counted per subsample, A - Area of a field (Whipple grid image area), mm^2, D - Depth of a field, (S-R cell depth) 1 mm, F - Number of fields counted, ml - Millilitre

3.2.2. Palmer pollution index

The present study rated the lake water samples as high or low organically polluted, based on algae population by employing Palmer pollution index [20]. Palmer developed a list of 20 algal genera and 20 algal species which are most tolerant to organic pollution with individual pollution index score and formulated the pollution index scale as given below:

Classification of Palmer pollution status	
Pollution Index	Status of pollution
0-10	Lack of organic pollution
0-15	Moderate pollution
15-20	Probable high organic pollution
>20	Confirms high organic pollution

4. RESULTS AND DISCUSSION

Phytoplankton productivity and composition are influenced by the spatial and temporal dynamics of environmental factors. The relationship between the physico-chemical characteristics and plankton production of water bodies are of great importance in management strategies of aquatic ecosystems. The quality of water may be described according to their physico-chemical and plankton characteristics.

Microscopic examinations of phytoplankton recorded were grouped under Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae.

4.1. Phytoplankton diversity

A total of 77 species under 40 genera during pre-monsoon, 43 species under 27 genera during monsoon and 41 species under 26 genera during post-monsoon were identified and recorded. The Bacillariophyceae was found to be more dominant, followed by Chlorophyceae, Cyanophyceae and Euglenophyceae.

The total number of phytoplankton in pre-monsoon season was recorded to be 128/mL, out of that 29/mL belonged to Bacillariophyceae, 60/mL belonged to Chlorophyceae, 32/mL belonged to Cyanophyceae and 7/mL belonged to Euglenophyceae.

The total number of phytoplankton in monsoon season was recorded to be 79/mL, out of that 29/mL belonged to Bacillariophyceae, 28/mL belonged to Chlorophyceae, 17/mL belonged to Cyanophyceae and 5/mL belonged to Euglenophyceae.

The total number of phytoplankton in post-monsoon season was recorded to be 75/mL, out of that 25/mL belonged to Bacillariophyceae, 28/mL belonged to Chlorophyceae, 16/mL belonged to Cyanophyceae and 6/mL belonged to Euglenophyceae.

4.2. Diversity indices

4.2.1. Simpson Dominance Index (D)

The Dominance index was measured to determine whether or not particular species dominate in a particular aquatic system. The Simpson Dominance Index (D) for phytoplankton was found to be 0.017 during pre-monsoon, 0.027 during monsoon and 0.028 during post-monsoon.

4.2.2. Simpson Index (D)

The Simpson index value also ranges between 0 and 1, the greater the value, the greater the species diversity. The Simpson Index (D) for phytoplankton was found to be the highest (0.982) during pre-monsoon while monsoon ranged 0.972 value and post-monsoon shoed lowest Simpson index value of 0.971.

4.2.3. Shannon Index (H)

The Shannon index for phytoplankton was found to be 4.168 during pre-monsoon, 3.661 during monsoon and 3.624 during post-monsoon.

4.2.4. Equitability Index (EH)

The Equitability index takes a value between 0 and 1. The lower values indicate more diversity while higher values indicate less diversity. Specifically, an index value of 1 means that all groups have the same frequency. The

Equitability index for phytoplankton was found to be 0.971 during pre-monsoon, 0.979 during monsoon and 0.975 during post-monsoon.

4.2.5. Margalef Richness Index

In Margalef Richness Index, the higher diversity values reflect the suitability of habitat for the organism and have been reported to be correlated with longer food chain and complex food web of the ecosystems and also more stable community. The Margalef Richness Index has no limit value and it shows a variation depending upon the number of species. Margalef Richness Index for phytoplankton was found to be 14.86 during pre-monsoon, 9.383 during monsoon and 9.265 during post monsoon.

4.3. Algal Pollution Index

Palmer (1959) made the first major attempt to identify and prepare a list of genera and species of algae tolerant to organic pollution. Pollution-tolerant genera and species of four groups of algae from Puttenahalli lake was encountered as depicted in below table.

Table 1: Plankton diversity index

Diversity index	Pre-monsoon	Monsoon	Post-monsoon
Taxa_S	73	42	41
Individuals	127	79	75
Dominance_D	0.017	0.027	0.028
Simpson_1-D	0.982	0.972	0.971
Shannon_H	4.168	3.661	3.624
Evenness_e^H/S	0.884	0.925	0.914
Margalef	14.86	9.383	9.265
Equitability_J	0.971	0.979	0.975

Table 2: Palmer Pollution Index based on Genera

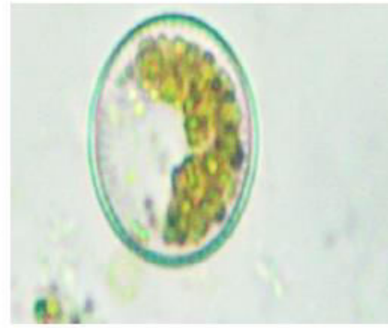
Algal Genera	Pollution index	Pre- monsoon	Monsoon	Post -monsoon
Microcystis	1	1	1	1
Ankistrodesmus	2	2	-	-
Chlamydomonas	4	-	-	-
Chlorella	3	-	3	3
Closterium	1	1	1	1
Cyclotella	1	1	1	1
Euglena	5	5	-	-
Gomphonema	1	1	1	1
Lepocinclis	1	-	-	-
Melosira	1	1	-	1
Micractinium	1	-	-	-
Navicula	3	3	3	3
Nitzschia	3	3	3	3
Oscillatoria	4	4	3	3
Pandorina	1	-	-	-
Phacus	2	2	-	2
Phormidium	1	-	-	-
Scenedesmus	4	4	4	4
Stegioclonium	2	-	-	-
Synedra	2	-	2	-
Total Score		**28**	**22**	**23**
Pollution level			**High organic pollution**	

Classification of Palmer (1959): 0-10= Lack of organic pollution; 0-15= Moderate pollution; 15-20= Probable high organic pollution; 20 or more = Confirms high organic pollution.

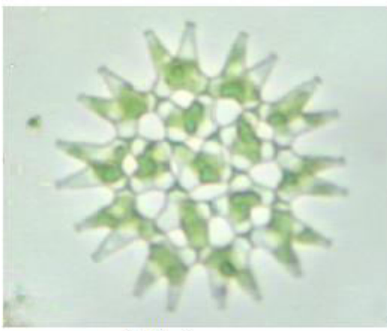
Puttenahalli lake which is highly polluted organically has recorded highest pollution index score of 28 during pre-monsoon, 22 in monsoon and 23 during post-monsoon. The highest Palmer pollution index was recorded in the lake during all three seasons revealing threatened condition of the lake.

Anabena sp.

Scenedesmus sp.



*Cyclotella*sp.



Pediastrum sp.

Synedra sp.

Mycrocystis sp.

The present research study illustrates that the algal diversity was high during pre-monsoon and there was a fall in phytoplankton diversity and numbers were low during monsoon. Chlorophyceae was observed to be the most dominant group. Similar interpretations of Chlorophyceae dominance were observed in the periodicity of phytoplankton studies [21] and algal flora of river water [22]. Species of *Navicula* sp., *Oscillatoria* sp., *Scenedesmus* sp., *Microcystis* sp., and *Synedra* sp., prevailed abundantly in the studied lake and these algae species are the most prominent indicators in Palmer pollution index list. The dominance of *Navicula* sp., *Oscillatoria* sp., *Scenedesmus* sp., *Microcystis* sp., and *Synedra* sp. in polluted water bodies were observed [23-25]. The Phytoplankton scenario of Puttenahalli lake depicts the eutrophic condition of the lake due to high human interferences such as domestic and industrial waste disposal in the form of sewage and solid wastes.

5. CONCLUSION

Puttenahalli lake has been hysterically polluted by sewage discharge from two places, one from the underground drain in Nataraja layout and the other from an unknown source in the southern side which has led to a massive fish kill and organic load in the lake. The lake is highly polluted even after rejuvenation. The religious activities like idol immersion also created an unpleasant aquatic environment and leads to contamination of lake water quality. Though the lake is regularly maintained by citizen forum, it lacks proper fencing towards the outlet region and lake water is highly eutrophicated with rich organic load and fowl smelling water. The surface water of the lake appeared green covered with macrophytes and many harmful algal blooms were witnessed from the lake water. It is clear from the study that, phytoplankton ecology in Puttenahalli lake is greatly influenced by anthropogenic factors. Phytoplanktons are considered as an important indicator portraying eutrophication which will further aid in evaluating the impact of influencing factors. The present investigation bids a base line data on the status of the lake ecosystem which can be used as a tool to formulate the conservative strategy to protect the water body from further deterioration.

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None declared

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