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A PILOT STUDY ON DIVERSITY AND BIOMONITORING OF ARIYALUR POND, TIRUVALLUR DISTRICT, TAMIL NADU, INDIA: WITH SPECIAL REFERENCE TO ALGAE

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ABSTRACT

Plants from natural habitat has proved to be a very good resource and has broad spectrum of benefits for human welfare. A preliminary study was conducted in two different seasons *viz.* monsoon and post-monsoon season to document the diversity of algae and bio monitoring purpose at Ariyalur pond of Tiruvallur district. This lentic ecosystem is located about 18 km from the state's capital Chennai and measures 63.5 acres of land with perimeter of 2789m. A total number of 41 algae species belongs to four different classes Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were reported. The study was dominated by class Chlorophyceae with 23 species (56.10%) followed by Bacillariophyceae (26.83%) and Cyanophyceae (12.19%). The seasonal variation among Monsoon (28 species) and Post Monsoon (26 species) seasons from the study area were also documented. Biomonitoring is considered to be a key process that enables biological indicators to survey the ecological healthiness of the habitat. Palmer Pollution Index were also calculated to measure the level of pollution from the study area. It divulges that high organic pollution was found during post monsoon season and light organic pollution in monsoon season. This increase of organic pollution is due to high anthropogenic activities mainly cleaning of heavy vehicles, agricultural runoff and so on.
***Keywords* :** Algae, Diversity, Bio monitoring, Ariyalur pond.

Introduction

Biomonitoring is considered as a significant process that assessing the state and ongoing changes in natural habitats. Bio-indicators can be defined as "living organisms including microorganisms, plants and animals which are used to measure the healthiness of the natural habitat". Generally biological indicators are used to evaluate the healthiness of the environment and play vital role in detecting changes in the environment. The major advantages associated with utilizing bio-indicators are as followed,

- Biological elements are surveyed and their impacts can be measured.
- May help us to find early stage diagnosis of pollution in an environment.
- Economically viable approach when compared with other monitoring systems.

Biological indicators (bio-indicators) are also defined as particular species or communities which by their presence, provide information on the surrounding physical or chemical environment or both at a particular site. The environmental pollution can be measured using the phytoplankton community because they are the best indicators (Hosmani and Bharathi, 1982). When the algal species diversity is rich it indicates that the nutrient level is high and there is no eutrophication (Ajayan *et al.,* 2013). Presence of pollution tolerating algae can be used as the pollution indicator (Palmer, 1969). Eutrophication can be measured by studying the phytoplankton population of the water bodies (Hegde, 1986).

Algae are good indicators of water quality of water bodies (Brook, 1965). Algae are simple chlorophyll bearing organisms, with no differentiation of roots, stems and leaves. Palmer (1969) investigated organic pollution rating of algal indices genera and species and purified organic pollution tolerant species such as: *Euglena, Oscillatoria, Chlamydomonas, Scenedesmus, Chlorella, Nitzschia, Navicula* and *Stigeoclonium*. Phytoplanktons are the best indicators for environmental pollution (Hosmani, 1988). The various characteristics of phytoplankton population are useful in evaluation of eutrophic potential of water bodies (Hegde, 1986). Their biological effects and prediction of impacts are helpful in restoration measures for reversing the process of eutrophication in water bodies.

Previously Hosmani and Bharathi (1980) investigated algal distribution in various water bodies of the state of Karnataka and enlisted indicator algal species of as organic pollution. The algal density and diversity of water bodies were influenced by the biological indicators as evaluated by Adoni (1985). Later, Hosmani (1977) used algal diversity index as a measure of aquatic organic pollution. Hosmani (1988) investigated the seasonal changes in freshwater bodies of Dharwad in Karnataka, and showed that high load of organic influence algal blooms of Franceia ovalis, *Euglena elastica*, *Euglena gracilis* and *Trachelomonas charkowensis*. Since algae can quickly respond to physico-chemical changes in freshwater bodies Saha *et al*. (2000). Thus, algae are important indicators of freshwater ecosystem conditions since they respond promptly to changes both in species composition and density, in water bodies (Karr *et al.,* 2000).

Algae dominant in all the freshwater bodies including lakes, ponds, river and streams. Algae are important bio-indicators of environmental conditions for a variety of reasons (Stevenson and Smol, 2003). Algae are considered as an important component of any freshwater ecosystem and are responsible the primary productivity. Pramila *et al*. (2008) assessed water quality of lakes by using Palmer's pollution index. Kshirsagar (2013) investigated water quality Mula river in Pune city and have recorded a total of 162 algal species and employed Palmer's Genus and Species Pollution Index. Hosmani (2013) studied twenty freshwater lakes of state Karnataka using palmer's index.

The ability of algae to tolerate in versatile environments gained attention from phycologists over generations. Documentation on diversity of algae in lentic habitatssituated around Chennai city has been carried out by many researchers, including Ganapathi (1940); Periyasamy (2006); Murugesan and Sivasubramanian (2008); Arulmurugan *et al.* (2011); Anuja and Chandra (2012) Altaff *et al.* (2016); Uma Rani *et al.* (2017); Sonic and Martin (2017) and Palanivel *et al.* (2018).

Although Indian subcontinent found to be natural reservoir for variety of algal flora but still there is a paucity for exploration of the algal resources from all possible habitats. Literature revealed that most of the water bodies in India is on the verge of eutrophication. It is therefore essential to take positive step towards water management. Keeping in view, the present study was carried out to evaluate the algal diversity of ariyalur pond, Tiruvallur district. This study would also be helpful in evaluating the algal flora and the trophic status of the study area.

Materials and Methods

Study Area

Ariyalur pond is a freshwater reservoir located in Tiruvallur district of Tamil Nadu, India (Plate I). The pond is named as "*AriyalurPo*Seenayya*nd*" because of nearest village ariyalur. This village is a recent developing residential area near Manali town, an extension of North Chennai – capital of the state. This lentic ecosystem measures 63.5 acres of land with perimeter of 2789m. The study area is completely surrounded by agricultural field and connected by state highways where movements of heavy vehicles are often. This aquatic ecosystem supports biodiversity by providing shelter to many organisms. No wonder this place provides suitable environment for the luxuriant growth of algae.

The location map (Map 1) of the study area was created using the software ArcGIS 10.3 Version 10.3.0.4322 © 1999 – 2012 Esri Inc

Collection, Observation & Identification of Sample:

Algal samples from the study area were collected randomly in sterile plastic bottles from the pond covering various habitats such as planktonic, benthic, epiphytic and terrestrial algae. The collection of algal samples from *Ariyalur pond* was carried out in two different seasons *viz.* Monsoon (October 2021 to December 2021) and Post-Monsoon season (January 2022 to March 2022). All the collected samples were brought to the laboratory. The samples were first studied under the light microscope for morphological features. Color, size, shape of the cell, nature of the filament, branching pattern were recorded. Photomicrographs were taken in HOVERLABS Research Microscopic Unit with varying magnification.

All the algae were identified up to species level with the help of monographs such as Anand (1998); Desikachary (1959 & 1986); Geitler (1932); Krishnamurthy (1954 & 2000); Philipose (1967 & 1988); Ramanathan (1964); Randhawa (1959); Singh (1961) and Venkataraman (1961 & 1969).

Diversity Analysis

To analyze and evaluate the level of diversity from study area, the diversity indices such as Simpson's Diversity index; Wiener index and Evenness were derived. Simpson's index (D) - species abundance; Shannon's Wiener Index (H) – species richness and Evenness (E_H) – measurement of evenness was calculated.

The formulas are used as follows,

$$\text{Simpson's Index}(D) = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

$$\text{Shannon's Index}(H) = -\sum_{i=1}^{S} \text{pi In pi}$$

Evenness (**E_H**) **= H / H_{max}**

Palmer Pollution Index (1969)

Palmer (1969) prepared a list of genera and species of algae tolerant to organic pollution of freshwater. He developed pollution index based on the presence of algal species. The Palmer Algal Pollution Index was employed in the present study to measure the pollution level of each study area. Palmer (1969) has listed out twenty algal genera with ratings to evaluate the pollution level of the water bodies (Table 1). Presence of 50 or more individuals per millilitre may conform the alga (Palmer, 1969). Based on the number of genera with their ratings the pollution levels were measured (Table 2).

Results and Discussions

A total number of fort one algal species belonging to four classes namely Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae were recorded in *Ariyalur* pond located in Tiruvallur district of Tamil Nadu, India (Table 3). Most abundant algal species from the study area was represented in Plate II. It has been reported that Cyanophyceae, Chlorophyceae, Bacillariophyceae, and Euglenophyceae were the four classes commonly found in most of the freshwater environments (Mahendra Perumal and Anand, 2008). Out of the eleven classes of algae (Fritsch, 1935), four are represented in the present study area. Class Phaeophyceae are universally not represented in freshwaters. The order of dominance is,

Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae.

Maximum representation was from the members of Chlorophyceae which had twentythree species accounting 56.10% of the total species. Class Bacillariophyceae was second dominant comprised of eleven species forming 26.83% followed by Cyanophyceae representing five species with 12.19%. Two species belonging to class Euglenophyceae forming 4.88% were also reported from the study area (Fig. 1). The highest diversity of Chlorophycean algae directly related to good health of water (Descy, 1987). They play significant role in freshwater ecosystem as most of the members are found to be ecologically important (Palmer, 1980).

Further, the taxonomic categories from the study area were illustrated in Fig. 2. Itreveals that the species of four classes includes ten orders. They are Volvocales, *Chlorococcales, Cladophorales, Oedogoniales* and *Conjugales*, of Chlorophyceae; *Centrales* and *Pennales* of Bacillariophyceae; *Euglenales* of Euglenophyceae and *Chroococcales* and *Nostocales* of Cyanophyceae. Among that Chlorococcales was found to be dominant order with 11 species followed by order Penales with 10 species. Members of chlorophyceae and bacillariophyceaeare considered fundamental in the food chain due to which they form direct or indirect food sources for various heterotrophic groups (Rao, 1975).

Generally about 90% of the members of Chlorophyceae grow in fresh water whereas only 10% are in marine or terrestrial habitat. (Smith, 1955). Among the Chlorophycean members the genus *Scenedesmus* was found dominant with 4 species followed by *Closterium* and *Cosmarium* each with 3 species (Fig. 3a). Chlorophycean species can be found mainly in unpolluted water (Bisht, 1993). Similarly, in class Bacillariophyceae genus *Synedra* was found with 4 species. Rest of genera from the class Bacillariophyceae was recorded with single species each (Fig. 3b). Diatoms form the most diverse photosynthetic and ecologically significant organisms in aquatic ecology and play important role in food chain (Urban *et al.,* 1992); biogeochemical cycle (Tréguer *et al.,* 1995) and global carbon fixation (Battarbee *et al.,* 2001).

Many of the BGA species are capable of living in the soil and other terrestrial habitats, where they play an important role in the functional processes of ecosystems (Whitton, 1992). Genera such as *Aphanocapsa, Merismopedia, Lyngbya* and *Oscillatoria* were reported from class Cyanophyceae (Fig. 3c). Whereas two species including *Euglena proxima* and *Euglena sanguine* were reported from class Euglenophyceae. Hosmani and Bharathi (1983) documented diversity of Euglenoids of polluted and unpolluted waters.

Biological indices are a useful way to summarize data even for the people with little biological information and expertise (Norris, 1995). In the present study the value of Simpson's Diversity Index is 0.659. The results showed that the study area has greater level of diversity (Fig. 4). Shannon's Wiener Index is calculated to find out the species richness and species evenness as overall index of diversity.The value of Shannon's Wiener index also ranges between 0 and 1. Higher the value greater the species diversity. In this study the Shannon Wiener Index and evenness index is 1.078 and 0.778 respectively were derived (Fig. 4). The present study divulges that diversity indices such as Simpson, Shannon – Wiener and Evenness showed moderate level of species abundance, richness and evenness in study area.

The seasonal variation (Monsoon and Post Monsoon season) of algae documentedfrom the study area was given in Table 3. Maximum number of 28 species were reported during Monsoon season (October 2021 to December 2021). Similarly, 26 species were found in Post Monsoon season (January 2022 to March 2022). Further, Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were recorded in Post Monsoon season, Whereas class Euglenophyceae was not reported during Monsoon season. Both the season was dominated by class Chlorophyceae (Fig. 5 & 6). Similarly, dominance of Chlorophycean algae during monsoon season was previously reported by Prathap and Balasingh (2011), Shakila and Natarajan (2012) and Shashank and Vaishali (2015). Chlorophycean algae improves water quality and influence biodiversity of aquatic ecosystems (Cardinale, 2011).

A total number of ten pollution tolerant genera was reported from the study area. They are *Pandorina, Ankistrodesmus, Scenedesmus, Cyclotella, Synedra, Gomphonema, Navicula, Nitzschia, Euglena* and *Oscillatoria.* The seasonal-wise Palmer's Pollution Index of the study area is given in Table 4. It is elucidated that maximum pollution index of the study area was reported during post monsoon season. Further it indicates the study area was found high organic pollution during post monsoon season and light organic pollution during monsoon season. Exactly the same amount of pollution index (22 PPI score) was reported in Gandhisagar lake, Maharashtra (Pramila *et al*., 2008) and Arulmigu Vadapalani Andavar Temple Tank, Chennai (Karthikeyan, 2020) during post monsoon study. This increase of organic pollution during post monsoon is due to high anthropogenic activities including cleaning of heavy vehicles, agricultural runoff, bathing and so on.

Biomonitoring is considered to be a key process that employs biological indicators to survey the ecological health of the habitat.The number of species recorded from the study area was indicating the algal wealthiness as well as quality of the habitat. Moreover, studies on biodiversity and its pattern, provides us an opportunity to know the different species in their natural habitat. Considering the fact only very few genera from the nature have so far been used for industrial application. These studies give a wide scope for the choice of other potential species which are available in plenty.

Conclusion

Studies on algal diversity of *Ariyalur* pond a freshwater reservoir located in Tiruvallur district was explored for the first time. The investigation resulted with a total of forty-one species belonging to twenty seven genera and four classes of freshwater algae was documented during the study period. The study was conducted to explore the diversity of algae along with seasonal variation and biomonitoring status of the study area. The seasonality studies shows that 28 species and 26 species were reported during Monsoon and Post Monsoon season respectively. A total number of ten pollution tolerant genera was reported from the study area. The Palmer Pollution Index 13 and 22 was calculated during Monsoon and Post Monsoon season respectively. Further it indicates the study area was found high organic pollution during post monsoon season and light organic pollution during monsoon season. This increase of organic pollution is due to anthropogenic. Documentation of many algae and study of their utility appears to be a promising area for future research.

PLATE I

a&c– Ariyalur Pond – Study area; **b**– Satellite Image of the Study area (Source: Google Earth)

Map 1

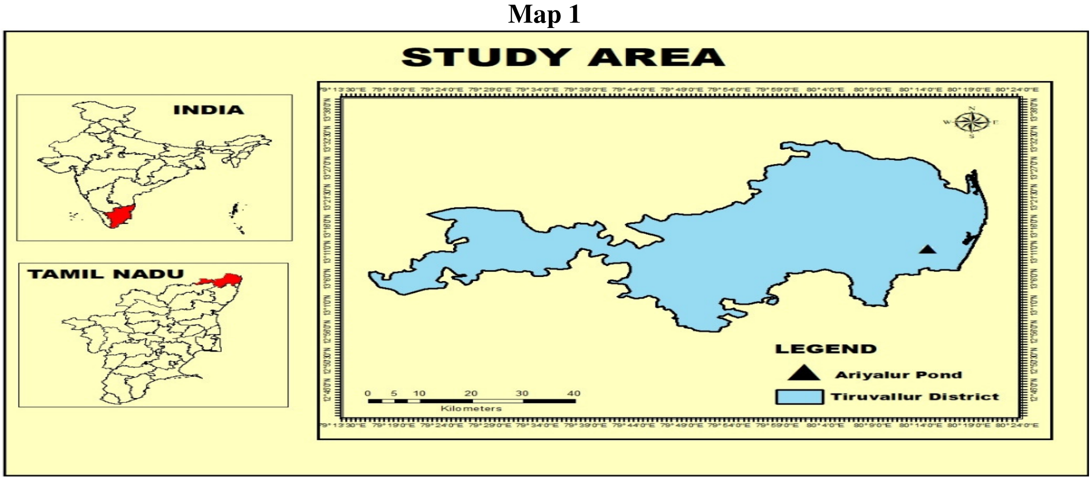


Table 1 : Palmer (1969) has listed out twenty algal genus with ratings

S. No	Genus	Pollution Index	S.No	Genus	Pollution Index
1	*Anacystis*	1	11	*Micractinium*	1
2	*Ankistrodesmus*	2	12	*Navicula*	3
3	*Chlamydomonas*	4	13	*Nitzschia*	3
4	*Chlorella*	3	14	*Oscillatoria*	4
5	*Closterium*	1	15	*Pandorina*	1
6	*Cyclotella*	1	16	*Phacus*	2
7	*Euglena*	5	17	*Phormidium*	1
8	*Gomphonema*	1	18	*Scenedesmus*	4
9	*Lepocinclis*	1	19	*Stigeoclonium*	2
10	*Melosira*	1	20	*Synedra*	2

Table 2 : Palmer rating of pollution index

Pollution Index	Status of Pollution
<15	Light organic pollution
15 to 20	Organic pollution
>20	High organic pollution

Fig. 1 - Class wise distribution of Algae

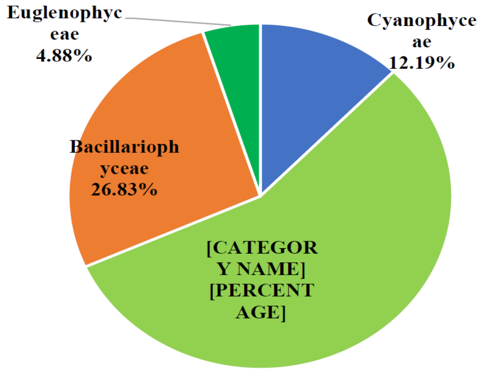
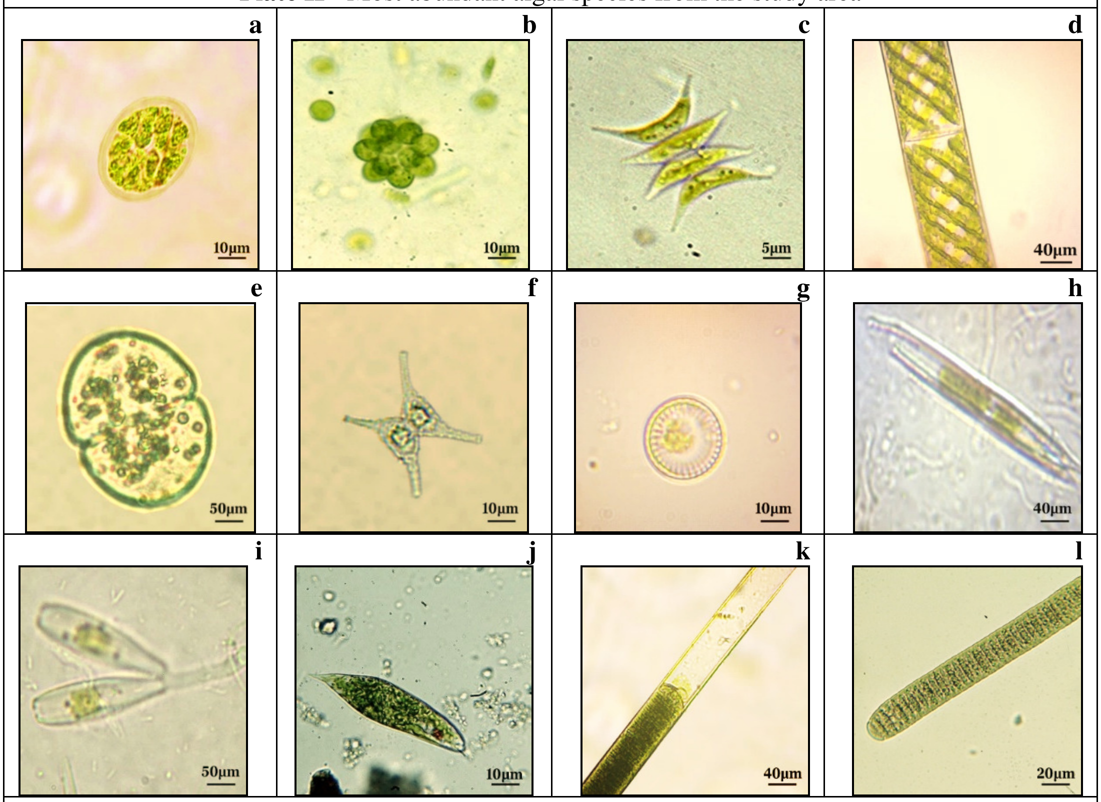


Table 3 : Diversity of algae from the study area with Seasonal Variation.

S. No	Name of the Species	Monsoon	Post -Monsoon
1	*Pandorina morum*	+	+
2	*Chlorococcum infusionum*	+	-
3	*Golenkinia radiata*	-	+
4	*Tetraedron gracile*	+	+
5	*Tetraedron triangulare*	+	-
6	*Ankistrodesmus falcatus* var. *radiates*	+	+
7	*Pediastrum tetras* var. *apiculatum*	+	+
8	*Coelastrum microporum*	+	-
9	*Scenedesmus armatus*	-	+
10	*Scenedesmus graevenitzii*	-	+
11	*Scenedesmus obliqutis*	+	-
12	*Scenedesmus quadricauda*	+	+
13	*Cladophora glomerata.*	+	-
14	*Oedogonium spheroideum*	-	+
15	*Spirogyra submaxima*	+	-
16	*Closterium acerosum*	+	-
17	*Closterium jenneri*	+	+
18	*Closterium parvulum*	+	+
19	*Cosmarium inane*	+	+
20	*Cosmarium lundellii*	+	+
21	*Cosmarium ovllatum.*	+	-
22	*Staurastrum anatinum*	+	-
23	*Staurastrum recurvatum*	+	-
24	*Cyclotella stelligera*	-	+
25	*Synedra acus*	+	+
26	*Synedra dorsiventralis*	-	+
27	*Synedra gracilis*	-	+
28	*Synedra ulna*	+	+
29	*Achnanthidium exiguum*	-	+
30	*Cocconeis placentula*	+	-
31	*Gomphonema dichotomum*	+	-
32	*Navicular adiosa*	+	-
33	*Pinnularia saprophila*	+	+
34	*Nitzschia filiformis*	-	+
35	*Euglena proxima*	-	+
36	*Euglena sanguinea*	-	+
37	*Aphanocapsa pulchra*	+	-
38	*Merismopedia tenuissima*	+	+
39	*Lyngbya ceylanica*	-	+
40	*Lyngbya majuscula*	+	-
41	*Oscillatoria limosa*	-	+

Plate II - Most abundant algal species from the study area



a– *Pandorina morum;* **b** –*Coelastrummicroporum;* **c** – *Scenedesmus obliquus;***d**– *Spirogyra submaxima;* **e** – *Cosmarium lundellii;* **f** – *Staurastrumanatinum;***g** – *Cyclotella stelligera;* **h** – *Synedra dorsiventralis;* **i** – *Gomphonema dichotomum;***j** – *Euglena proxima;* **k** – *Lyngbya majuscule* and **l** – *Oscillatoria limosa*

Fig.2 Taxonomic categorization of algae under each class in the study area

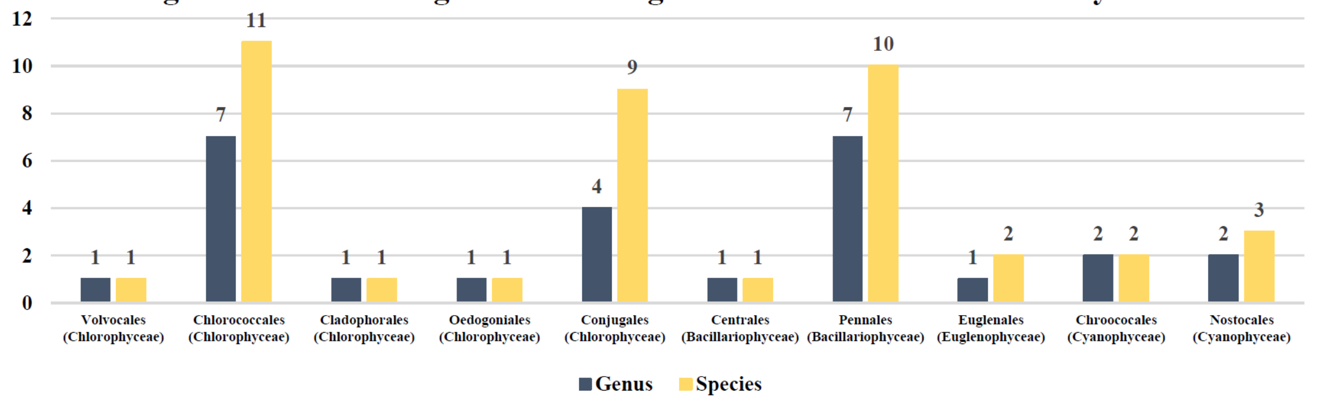


Fig. 3a

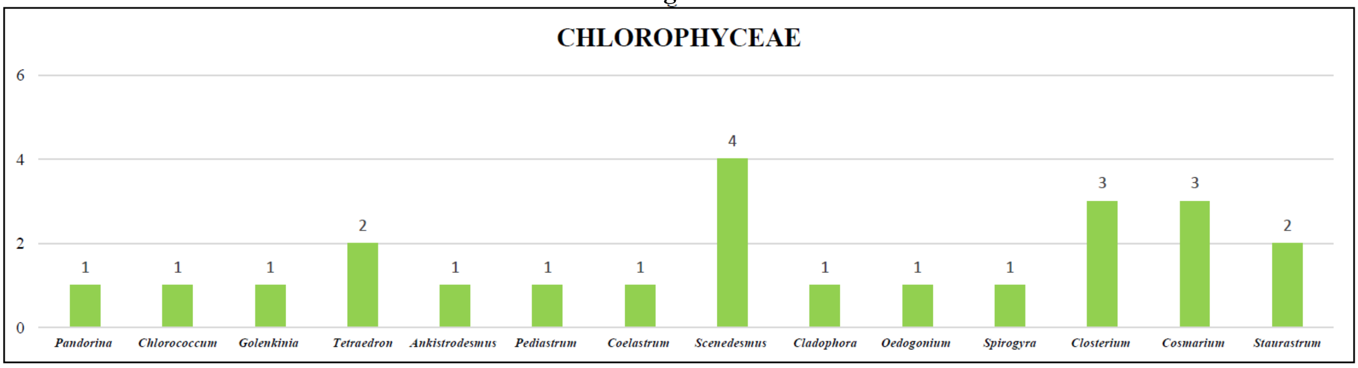


Fig. 3b

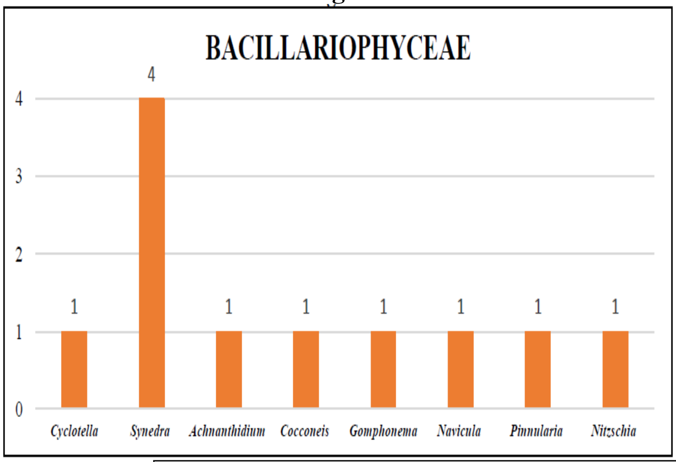


Fig. 3c

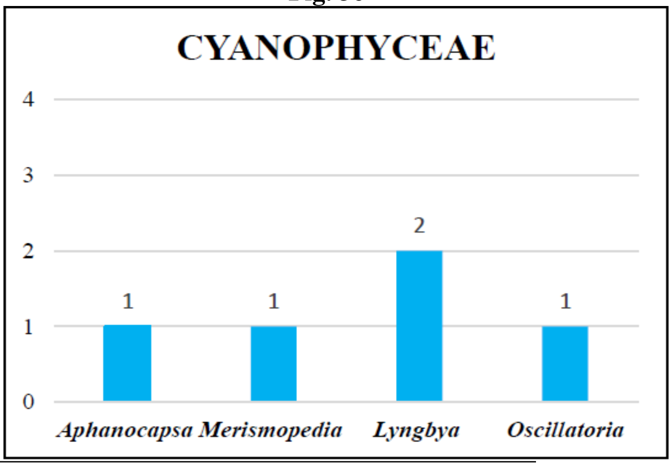
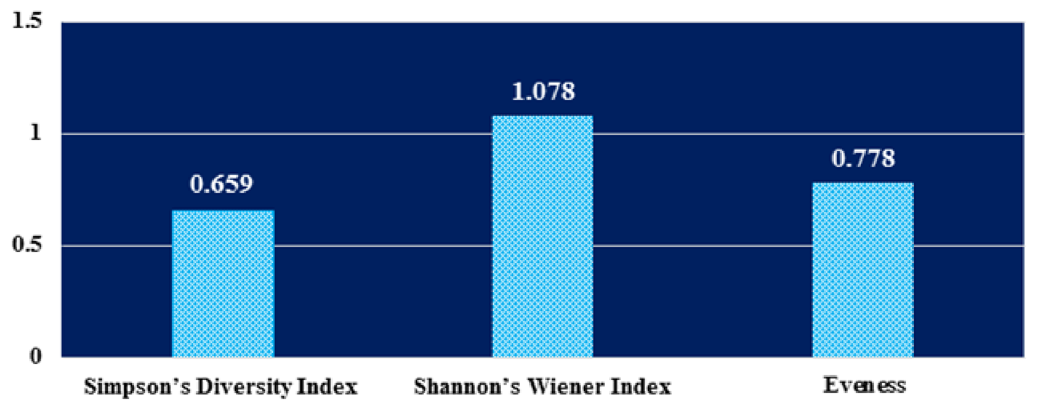
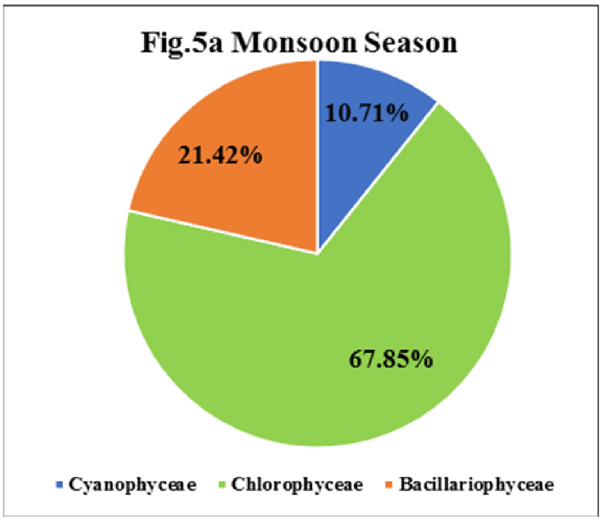


Fig. 4 - Diversity Indices





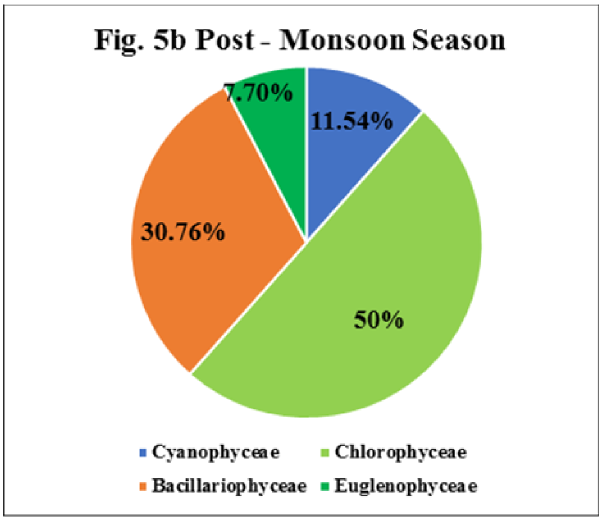


Table 4 : Palmer's Pollution Index of the study area

Monsoon Season		Post Monsoon Season	
Name of the Genus	**Palmer's Pollution Index**	**Name of the Genus**	**Palmer's Pollution Index**
Pandorina	1	*Pandorina*	1
Ankistrodesmus	2	*Ankistrodesmus*	2
Scenedesmus	4	*Scenedesmus*	4
Synedra	2	*Cyclotella*	1
Gomphonema	1	*Synedra*	2
Navicula	3	*Nitzschia*	3
		Euglena	5
		Oscillatoria	4
Total	**13**	**Total**	**22**

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