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Short Communication

SEASONAL DYNAMIC IN ALGAL DIVERSITY AND PRIMARY PRODUCTIVITY OF WETLAND IN GAROBADHA MEGHALAYA, INDIA

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ABSTRACT

Wetland undergoes significant changes with changes in the season; it is a habitat for diverse form of microorganism and macrophytes. Therefore, the investigation of the algal diversity and primary productivity was very important. A total of 134 algal species was recorded spreading over 8 classes in Garobadha wetland. *Bacillariophyceae*, *Cyanobacteria* and *Euglenophyceae* were dominant groups and their species diversity was high during spring and monsoon seasons. The wetland was acidic in nature with low dissolved oxygen and high temperature. Many pollution tolerant species (*Navicula radiosa, Nitzschia palea, Anabaena subcylindrica, Merismopedia glauca, Microcystis aeruginosa, Euglena acus, Trachelomonas volvocina* and *Phacus* spp.) were recorded from this wetland. Primary productivity and chlorophyll 'a' was at peak during spring and minimum during monsoon season.

Keywords: Wetland, Algae, Diversity, Productivity, Chlorophyll a.

1. INTRODUCTION

Wetland is a dynamic lentic ecosystem that undergoes seasonal fluctuation in the water level unlike lake and ponds. Wetland is a transitional stage between terrestrial and aquatic ecosystem that support diverse group of macrophytes and animals along with algal community [1]. Wetlands are easily affected by the changes that occur in the water level [2]. Change in algal composition with seasonal water fluctuation is one of the characteristic features of wetland. They can regulate dissolved oxygen concentration, sediment formation, nutrient uptake and retention and can account for a significant amount of primary production and decomposition [3-6]. Changes in water depth even for a few millimeters can expose algal taxa to variation in nutrient concentration and dissolved gases which in turn induce significant changes in community metabolism [7]. Flooding is another phenomenon that occurs in wetland; flooding reduces abundance of macrophytes releases nutrients from dead vegetation, litter and sediments that subsequently shift the algal species composition; pollution sensitive species get replaced by pollution tolerant species [8, 9]. Light incident in wetland is extremely dynamic. Macrophytes are the primary substrate for benthic algae in wetland. Due to over growing of macrophytes, light attenuation varies hence light limitation reduces algal productivity [10]. Diversity of species in any ecosystem is considered as the reflection of the physical and chemical status of the system. High algal diversity usually indicated diverse and well balanced community in water body whereas low diversity values indicated stressed environment [11, 12]. Wetlands are the areas which are covered partly or fully by water at varying periods of time during the year, including the growing season [13]. They are dynamic aquatic ecosystems continuously undergoing changes due to deposition of sediments, nutrients and many non biodegradable wastes that are carried by heavy floods. They support many life forms and carry out many functions in the maintenance of overall balance of nature. Due to fast degradation of wetland, they are considered as endangered habitat where its quality and quantity is getting declined due to urbanization and various anthropogenic activities [14]. The present study was conducted to analyze the role of seasonal effect on algal diversity and productivity in Garobadha wetland.

2. MATERIAL AND METHODS

2.1. Study site

Meghalaya one of the states in India, is situated in North East India with geographical coordination of 20.1° to 26.5° N latitudes and 85.49° to 92.52° E longitudes. It has 11 districts; the study was conducted in one of the district, West Garo Hills. The wetland is located at Garobadha and recently named as Singiram bil. It covers an area of 2,428 square meters with the depth of 20-30cm in the periphery whereas in the centre it is 50-80cm. At an altitude of 33.53m asl, with the geographical coordinates at 25°34'86"N latitude and 90°01'27"E longitude. It is about 30 km away from Tura on the Western side of the West Garo Hills District, a cross junction of Phulbari, Mankachar, and Ampati. Most part of the wetland is covered with macrophytes like *Eicchornia crassipes, Lugwigia adscendans, Marsilea quadrifolia, Nymphaea* sp. and *Salvinia* sp (Fig 1). One side of the wetland is surrounded by paddy field and other side by resident area.

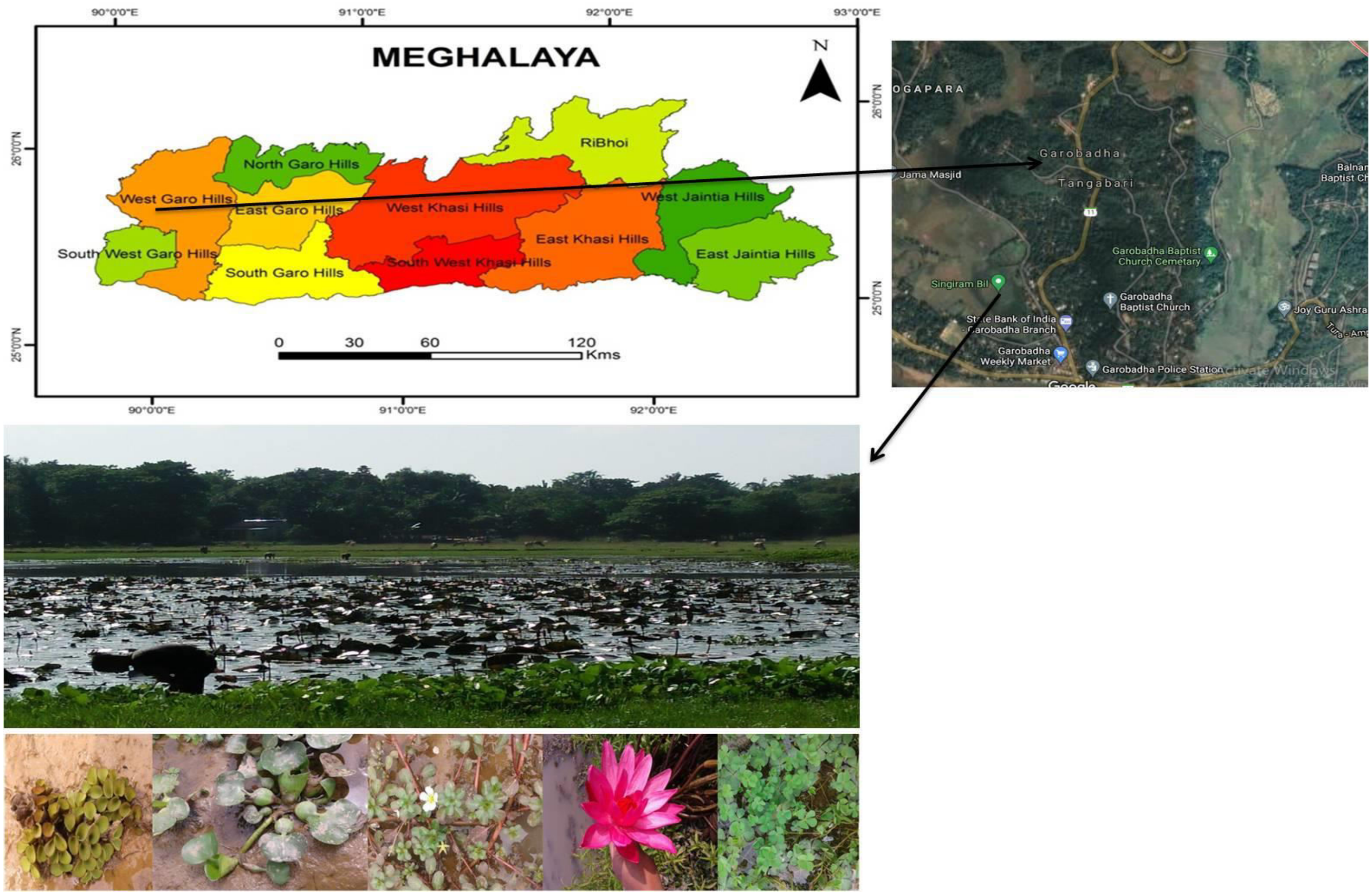


Fig. 1: Map of the study site

2.2. Sample collection and analysis

Water and algal samples were collected monthly from September 2015 to August 2016. Water temperature, pH, turbidity, conductivity, transparency were measured at the spot. Dissolved oxygen, phosphate, nitrate and nitrite were estimated following standard methods [15]. Primary productivity was analyzed by dark and light bottles method and by estimating Chlorophyll 'a' by spectrophotometer method [16].

Phytoplankton was collected from surface water by using plankton net (45 μm). Periphytic algae were collected from different substrata like stones, rocks, pebbles, dead leaves and sediments with help of scalpel and tooth brush. The algal samples were preserved in 4% formaldehyde and brought to the laboratory for further study. Algal samples were observed under a trinocular microscope and photographed (using Olympus B41 microscope). Taxonomic identification up to species level was carried out with the help of standard books and Monographs [17-20] and taxonomy was updated using the online database Algae Base [21].

2.3. Data Analysis

Species diversity Index was calculated by using Shannon-Wiener diversity index following the formula:

$$H' = \sum_{i=1}^{s} Pi \ln Pi$$

Where; s = total number of species, Pi is ni/N, ln Pi is normal log of Pi, ni = Number of individuals belonging to the i^{th} species, N = total number of individual of all the species.

3. RESULTS

3.1. Physico-chemical parameters

In Wetland, water temperature fluctuated throughout the seasons, ranged from 18°C in winter to 31°C in monsoon. Water pH was acidic to slightly alkaline in nature and ranged from 5.2 in winter to 7.1 in autumn season. Electrical conductivity ranged from 0.04 mS/cm in winter to 0.18 mS/cm in spring. Turbidity ranged from 25.26 NTU in winter to 44.0 NTU in spring. Parameters like temperature, pH, electrical conductivity and turbidity varied significantly among the seasons.

Dissolved oxygen ranged from 4.20 mg/l in spring to 6.74 mg/l in autumn and there was no significant variation among the seasons. Nitrate concentration ranged from 0.7 mg/l in autumn to 3.75 mg/l in monsoon. Nitrite concentration ranged from 0.18 mg/l in autumn to 0.48 mg/l in spring. Phosphate concentration ranged from 0.22 mg/l in winter to 0.76 mg/l in spring (late spring). Nitrate, nitrite and phosphate varied significantly among the seasons (Table 1).

Table 1: Seasonal variations with range in physico-chemical parameters of Wetland (Mean values with standard deviation are given in parenthesis)

Parameters	Autumn	Winter	Spring	Monsoon	P-value
Temperature (^{O}C)	24-26 (25±1.21)	18-19 (18±0.57)	22-27 (27±1.52)	27-31 (29±1.52)	0.002*
pH	6.2-7.1 (6.6±0.45)	5.2-6.5 (5.10±0.15)	6.2-6.8 (6.6±.32)	5.4-6.5 (5.4±0.34)	0.01*
Turbidity (NTU)	32.1-33.12 (32.49±0.66)	25.26-27.10 (26.16±0.47)	34.22-44.0 (41.22±3.54)	38.32-42.0 (35.88±2.20)	0.001*
Electrical conductivity (mS/cm)	0.06-0.14 (0.1±0.02)	0.04-0.09 (0.07±0.004)	0.14-0.18 (0.16±0.005)	0.08-0.17 (0.14±0.04)	0.02*
Dissolved oxygen (mg/l)	4.72-6.74 (5.21±1.34)	5.20-6.40 (5.76±0.1)	4.20-6.30 (4.57±0.1)	4.50-5.50 (4.86±0.26)	0.11
Nitrate (mg/l)	0.7-1.86 (1.65±0.05)	1.30-2.67 (2.35±0.1)	1.75-2.82 (2.78±0.05)	2.22-3.75 (3.65±0.04)	0.001*
Nitrite (mg/l)	0.18-0.28 (0.26±0.05)	0.20-0.32 (0.28±0.05)	0.31-0.48 (0.46±0.01)	0.27-0.36 (0.32±0.01)	0.01*
Phosphate (mg/l)	0.31-0.40 (0.38±0.01)	0.22-0.39 (0.34±0.14)	0.55-0.76 (0.61±0.1)	0.38-0.59 (0.46±0.12)	0.001*

**Significant different at $p<0.05$*

3.2. Seasonal dynamic of algal community

Wetland is a transition zone between land and aquatic system, the water in this habitat changes drastically with changes in seasons. This habitat is dominated by many hydrophytes and microorganism. A total of 134 algal species were recorded from Wetland belonging to 8 classes. In Wetland, maximum species were recorded from the class Bacillariophyceae with 43 species followed by Cyanobacteria with 28 species, Euglenophyceae with 23 species, Chlorophyceae with 18 species, Zygnematophyceae with 16 species, Trebouxiophyceae with 3 species, Ulvophyceae with 2 species and Charophyceae with 1 species (Table 2).

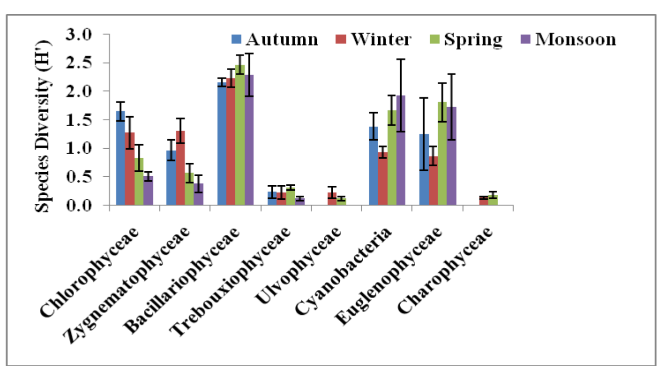


Fig. 2: Seasonal variation in species diversity of different algal groups in Wetland. Standard deviation represented by Error bars.

There was seasonal variation in species diversity. The maximum species diversity was recorded in Bacillariophyceae with 2.46 during spring season, followed by Cyanobacteria with 1.93 during monsoon, Euglenophyceae with 1.81 during spring season and Chlorophyceae with 1.65 during autumn. The species diversity of other classes like Zygnematophyceae, Trebouxiophyceae, Ulvophyceae and Charophyceae ranged from 0.11 to 1.30 (Fig. 2).

Table 2: List of algal species recorded from Wetland

Chlorophyceae	Autumn	Winter	Spring	Monsoon
Ankistrodesmus falcatus (Corda) Ralfs	+	-	+	
Ankistrodesmus spiralis (W.B.Turner) Lemmermann	+	+	-	-
Characium pringsheimii A.Braun	+	+	+	-
Coelastrum astroideum De Notaris	+	-	-	+
Coelastrum cambricum W.Archer	+	-	-	-
Golenkinia radiata Chodat	+	+	-	-
Oedogonium capillare f.Staggnale Hirn	-	+	+	+
Oedogonium globosum Nordstedt ex Hirn	-	-	-	+
Oedogonium hispidum Nordstedt ex Hirn	+	-	-	-
Oedogonium porrectum Nordstedt and Hirn	+	+	-	-
Oedogonium sp	+	-	-	+
Palmodictyon viride Kutzing	-	-	-	+
Pediastrum duplex Meyen	+	-	+	-
Pediastrum tetras (Ehrenberg) Ralfs	+	+	-	-
Scenedesmus acutus Meyen	+	+	-	-
Scenedesmus obliquus (Turpin) Kutzing	+	-	+	-
Scenedesmus denticulatus Lagerheim	-	-	+	-
Scenedesmus dimorphus (Turpin) Kutzing	+	+	-	-
Zygnematophyceae				
Closterium dianae Ehrenberg ex Ralfs	-	+	+	-
Closterium leibleinii Kutzing ex Ralfs	+	+	-	-
Closterium navicula (Brebisson) Lutkemuller	+	-	-	+
Closterium strigosum Brebisson	+	+	-	-
Closterium venus Kutzing ex Ralfs	-	+	+	-
Cosmarium jaoi Kouwets	+	+	-	+
Cosmarium leave Rabenhorst	-	+	-	-
Cosmarium lundellii Delponte	+	-	+	-
Cosmarium meneghinii var.boldtii West	-	+	-	+
Cosmarium subcostatum Nordstedt	-	+	-	-
Euastrum binale Ehrenberg ex Ralfs	+	-	+	-
Spirogyra crassa (Kutzing) Kutzing	-	+	-	-
Spirogyra punctiformis Transeau	-	-	-	-
Staurastrum connatum (P.Lundell) J.Roy and Bisset	-	+	+	-
Staurastrum gracile Ralfs ex Ralfs	+	+	-	-
Staurastrum muticumm Brebisson ex Ralfs	-	+	-	-
Bacilariophyceae				
Amphora coffeaeformis (C.Agardh) Kutzing	-	+	+	-
Amphora veneta Kutzing	+	-	+	+
Caloneis alpestris (Grunow)Cleve	+	+	+	-
Cyclotella bodanica Eulenstein ex Grunow	+	-	+	+
Cyclotella melosiroides (Kirchner) Lemmermann	-	+	+	+
Cymbella affinis Kutzing	+	+	+	-
Cymbella aspera (Ehrenberg) Cleve	-	+	+	+
Cymbella ventricosa (C.Agardh) C.Agardh	+	+	+	+
Eunotia lunaris (Ehrenberg) Grunow	-	+	+	+

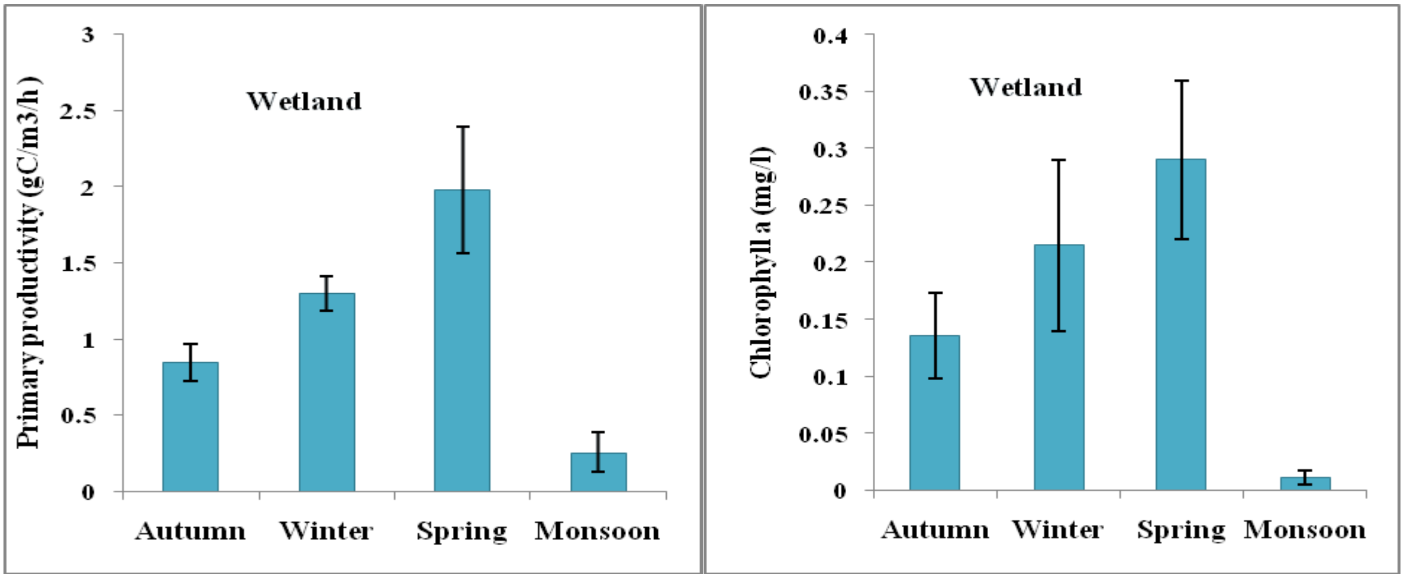
Eunotia minor (Kutzing) Grunow	+	-	+	+
Fragillaria capucina Desmazieres	+	+	+	-
Frustulia vulgari s(Thwaites) De Toni	+	+	+	+
Gomphonema clevatum Ehrenberg	-	-	+	+
Gomphonema gracile Ehrenberg	+	+	+	-
Gomphonema angustatum (Kutzing) Rabenhorst	+	+	+	+
Gomphonema cristatum Ralfs	-	+	+	+
Gomphonema olivaceum (Hornemann) Ehrenberg	+	-	+	+
Gomphonema parvulum (Kutzing) Kutzing	-	-	+	+
Gomphonema sphaerophorum Ehrenberg	+	-	-	+
Gyrosigma scalproides (Rabenhorst) Cleve	+	+	+	+
Gyrosigma spenceri (Bailey ex Quekete) Griffith and Henfrey	-	+	-	-
Mastogloia braunii Grunow	+	+	+	+
Melosira varians C.Agardh	+	+	+	+
Navicula capitatoradiata H.Germain ex Gasse	-	-	+	+
Navicula cincta (Ehrenberg) Ralfs	-	-	+	-
Navicula cryptocephala Kutzing	+	+	+	+
Navicula *cuspidata* (Kutzing) Kutzing	+	+	-	+
Navicula lanceolata Ehrenberg	+	-	+	+
Navicula protracta Grunow	-	-	-	+
Navicula radiosa kutzing	+	+	+	-
Navicula rhyncocephala Kutzing	-	+	+	+
Navicula seminulum Grunow	+	+	+	+
Neidium hitchcockii (Ehrenberg) Cleve	+	+	+	+
Nitzschia acicularis (Kutzing) W.Smith	+	+	+	+
Nitzschia amphibian Grunow	-	+	+	+
Nitzschia obtuse W.Smith	+	+	+	-
Nitzschia palea (Kutzing) W.Smith	+	+	-	+
Pinnularia braunii Cleve,nom.illeg	-	+	+	+
Pinnularia cardinalis f.angustior Skvortzow (Skvortzov)	+	-	+	-
Pinnularia interrupta W.Smith	-	+	-	-
Pinnularia viridis (Nitzsch) Ehrenberg	-	-	+	+
Stauroneis anceps Ehrenberg	+	-	+	+
Stauroneis phyllodes Ehrenberg	+	-	+	+
Trebouxiophyceae				
Crucigenia tetrapedia(Kirchner) Kuntze	+	-	+	-
Chlorella vulgaris Beyerinck (Beijerinck)	-	+	+	-
Chlorella pyrenoidosa H.Chick	-	-	-	+
Ulvophyceae				
Cladophora glomerata (Linnaeus) Kutzing	-	+	-	-
Ulothrix sp	-	-	+	-
Charophyceae				
Chara fragilis Desvaux	-	+	+	-
Cyanobacteria				
Anabaena subcylindrica Borge	+	-	+	+
Anabaena constricta (Szafer) Geitler	+	+	-	+
Arthrospira sp	-	-	+	+
Calothrix marchica Lemmermann	+	-	+	+
Chroococcus dispersus (Keissler) Lemmermann	+	+	-	-
Chroococcus sp	-	-	+	+
Coelosphaerium kuetzingianum Nageli	+	-	+	+
Fischerella sp	+	-	-	+
Gloeocapsa sp	-	-	+	+

Gomphosphaeria sp	-	+	-	+
Hapalosiphon sp	+	+	+	-
Leptolyngbya boryana (Gomont) Anagnostidis and Komarek	-	-	+	+
Lyngbya limnetica Lemmermann	-	-	+	-
Lyngbya sp	+	-	+	+
Merismopedia glauca (Ehrenberg) Kutzing	+	-	-	+
Microcoleus lacustris f. minor. Desikachary	-	+	-	+
Microcystis aeruginosa (Kutzing) Kutzing	+	-	+	-
Microcystis botrys Teiling	-	-	-	+
Nostoc sp	-	-	+	+
Nostoc spongiaeforme C.Agardh ex Bornet and Flahault	-	-	-	+
Oscillatoria curviceps C.Agardh ex Gomont	+	-	+	+
Oscillatoria Formosa Bory ex Gomont	+	-	-	-
Oscillatoria sp	-	-	+	+
Oscillatoria subbrevis Schmidle	+	+	+	-
Oscillatoria tenuis C.Agardh ex Gomont	-	-	+	+
Phormidium sp	+	+	-	-
Phormidium tenue Gomont	-	-	+	+
Spirulina nordstedtii Gomont	-	+	+	+
Euglenophyceae				
Euglena acus (O.F.Muller) Ehrenberg	+	-	+	+
Euglena agilis H.J. Carter	-	+	-	+
Euglena anabaena Mainx	+	-	+	-
Euglena clara Skuja	-	+	+	+
Euglena convolute Korshikov	+	-	+	-
Euglena gracilis G.A.Klebs	-	+	-	+
Euglena limnophila Lemmermann	-	-	+	-
Euglena oxyuris Schmarda	+	-	+	-
Euglena polymorpha P.A.Dangeard	-	+	-	+
Lepocinclis ovum (Ehrenberg) Lemmermann	+	-	-	+
Lepocinclis playfairiana (Deflandre) Deflandre	-	-	+	-
Lepocinclis steinii (Lemmermann) Lermmermann	+	-	-	+
Phacus acuminatus Stokes	+	-	+	+
Phacus agilis Skuja	-	-	+	-
*Phacus alatus*var.latviensis Skvortzov	+	-	-	+
Phacus anomalus F.E.Fritsch and M.F.Rich	-	+	-	+
Phacus caudatus Hubner	-	-	+	-
Phacus curvicauda Svirenko	+	-	-	+
Phacus mariae Deflandre	-	-	+	-
Phacus nordstedtii Lemmermann	-	-	+	+
Phacus striatus France	-	-	+	+
Trachelomonas sp	+	-	+	
Trachelomonas volvocina (Ehrenberg) Ehrenberg	+	-	-	+

(+ indicate present; - indicate absent)

3.3. Primary productivity and Chlorophyll a content in phytoplankton

There was significant seasonal variation in the net primary productivity and phytoplankton chlorophyll a content in all the study sites. Maximum primary productivity and Chlorophyll a in wetland were observed during spring with 1.97 $gC/m^3/h$ and 0.29 mg/l respectively and minimum during monsoon with 0.25 $gC/m^3/h$ and 0.01 mg/l respectively (Fig. 3).



Standard deviation represented by Error bars

Fig. 3: Seasonal variation in primary productivity and chlorophyll a of Garobadha Wetland

4. DISCUSSION

The water temperature showed seasonal fluctuation, maximum temperature was recorded in monsoon (31°C). The possible reason could be low altitude, low water level, negligible rate of water current, sediment deposition and discharge of household waste. The increase in temperature during monsoon (summer) in lake of Bhopal could be due to rise in atmospheric temperature as well as due to anthropogenic activites going around that region [22]. The pH was acidic throughout the study periods, acidic nature or low pH of Garobadha wetland could be due to deposition of waste entering from surrounding areas which might have resulted in higher respiration and decomposition rate and in turn lower the pH (acidic) level. In addition, luxuriant growth of macrophytes and their high decomposition rate could be another reason which led to low pH value. Turbidity and electrical conductivity of the wetland was high during spring season before the onset of monsoon. Factors responsible for increase in turbidity and electrical conductivity in the wetland are the drainage system one side of the wetland and other side by the paddy field, which cause deposition of increased domestic and agricultural waste in the water body which result into suspension of sediment. Increase in turbidity and electrical conductivity as results of urbanization, anthropogenic activities, deposition of organic and inorganic waste, leaching of fertilizer and pesticides from different sources had been reported by many authors [23-25]. In our present work, we observed that low dissolved oxygen in the Garobadha wetland indicated a poor ecosystem; warmer water can dissolve less oxygen. In lakes and rivers in Uttar Pradesh, the dissolved oxygen reduced drastically due to the high temperature, biological and anthropogenic activities [26]. Nitrate, nitrite and phosphate content were high in wetland during spring and monsoon seasons due to extensive decomposition of wastes as well as decayed plant (macrophytes), animals' bodies, runoff of agricultural as well as domestic wastes and no proper drainage system. The concentrations of these nutrients were exceeding the permissible limit. Rapid increase in nutrient concentration has been reported due to excessive pollution caused by anthropogenic activities as well as agricultural runoff [27, 28].

The wetland is dominated by Bacillariophyceae followed by Cyanobacteria and Euglenophyceae, these classes were very competitive and could adopt fast in polluted water and grew rapidly unlike members of Zygnematophyceae and Chlorophyceae. High nutrient concentration, high temperature, low dissolved oxygen and turbid water in wetland might had accelerated the growth of pollution indicators genus like *Oscillatoria*, *Microcystis*, *Merismopedia*, *Anabaena, Euglena*, *Phacus* and *Trachelomonas*. Species diversity showed seasonal variations. High level of nutrient concentration, low amount of dissolved oxygen and high turbidity were the factors responsible for high species diversity in Bacillariophyceae during spring season and Cyanobacteria and Euglenophyceae during monsoon and spring respectively. Whereas species diversity of Zygnematophyceae and Chlorophyceae members are very low, because of poor amount of dissolved oxygen, high temperature and high nutrient does not favour the growth of these classes. High concentration of nutrients and alkaline pH resulted into poor diversity and low concentration of nutrients favoured maximum diversity [29, 30].

Seasonal fluctuation in primary productivity and chlorophyll a were recorded. Primary and chlorophyll a production rate does not remain same during the period of study. Primary productivity and chlorophyll a content showed a trend of fluctuation; gradually increased during winter and peaked during spring and decreased during monsoon. The increase in rate of production during spring indicated the nutrient rich condition and high temperature enhanced the productivity [31]. Other reasons for high productivity in wetland during spring could be high temperature, enrichment of nitrogen and phosphorus which accelerated the extensive growth of filamentous algae. The decline in productivity and chlorophyll a content during monsoon could be due to dilution of water which adversely affected the phytoplankton assemblages [32-33].

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Conflict of interest

None declared

Source of funding

None declared

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