UTTAR PRADESH JOURNAL OF ZOOLOGY

41(7): 1-6, 2020
*ISSN: 0256-971X (P)*

# DIVERSITY OF CHLOROPHYCEAE IN THE MIRIK LAKE OF THE DARJEELING HIMALAYAN REGION

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**AUTHOR'S CONTRIBUTION**

The sole author designed, analysed, interpreted and prepared the manuscript.

***Received: 22 March 2020***
***Accepted: 28 May 2020***
***Published: 05 June 2020***

***Original Research Article***

## ABSTRACT

"Mirik Lake" is an artificial reservoir of Mirik town of the Darjeeling Himalayan region of West Bengal, India at an altitude of 1767 meters above mean sea level. This Lake was constructed in 1979 primarily for the facilitation of commercial tourism in Darjeeling and is fed by both perennial streams and rain water. The Lake is not only used for different recreational activities but also supplies drinking water to the local people of the Mirik Town. The Chlorophyceae constitute a large and diverse group of fresh water algae including members that are important ecologically and scientifically. Chlorophyceae are the photosynthetic organisms and one of the pioneer species in aquatic food web. Diversity of Chlorophyceae was studied in the Mirik Lake of Darjeeling Himalayan region for a period of two years at monthly basis from the surface water samples of seven selected sampling locations. A total of twenty five varieties of Chlorophyceae were recorded during the whole study period, of which *Ankistrodesmus* sp., *Cosmarium* sp., *Chlorella* sp. and *Chlorococcum* sp. were the most common species found throughout the year. Some pollution tolerant genera of Chlorophyceae were also observed during the investigation period among which *Chlamydomonas* sp., *Scenedesmus* sp. and *Chlorella* sp. were the most common indicator of anthropogenic pollution of the lake. The density of Chlorophyceae varied from 445 to 4596/ml and the highest diversity was recorded at sampling location 3 and 4. Highest density was observed at Site 3 and lowest density and diversity recorded in case of Site 2 might be due to greater anthropogenic activities of the site.

**Keywords:** Chlorophyceae; water; Mirik Lake; density; diversity; pollution.

## 1. INTRODUCTION

The Chlorophyceae or green algae are a large and important group of algae which may vary from small, single-celled forms to complex multicellular forms. These are cosmopolitan in distribution found everywhere like sea, rivers , lakes, on soil and walls, in animals and plants, in fact just about everywhere where there is a light to carry out photosynthesis [1]. This group forms an important component of aquatic flora and plays a vital role in maintaining proper equilibrium of abiotic and biotic components of aquatic ecosystem. The members of this group form the base of the food chain and are directly or indirectly a good source of food for various animal groups [2]. These are also a good source of oxygen for the aquatic life. This group has vast industrial and economic potential as valuable sources in pharmaceuticals, health foods and in bioremediation of industrial effluent. These are also used as biological indicators of water pollution [3,4]. The use of density and diversity of phytoplankton and their association as biological indicators for the assessment of water quality or

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trophic status have been done by several workers [5,6,7,8,9].

Diversity of Chlorophyceae has also been studied by various workers in different freshwater bodies of India [10,11,12]. However, study on density and diversity of phytoplankton population in the freshwater bodies of Darjeeling Himalaya is scanty [13,14]. Till now there is no report found on Chlorophyceae diversity in the Mirik Lake of Darjeeling Himalayan region. Therefore the present investigation was aimed at finding out the diversity of Chlorophyceae population in the Mirik Lake of Darjeeling Himalayan region.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

"Sumendu Lake" popularly known as"Mirik Lake" is situated at Mirik, the famous hill resort in the Kurseung subdivision of Darjeeling District, West Bengal at an altitude of 1767 meters. It is an artificial reservoir of Mirik Town and extends between $26^0$ 53'N and $88^0$10'E. The lake was constructed in 1979 under "Mirik Tourist Project" for the facilitation of commercial tourism. The area is under the jurisdiction of Mirik Municipal Corporation and overall controlled by Darjeeling Gorkha Hill Council (DGHC). This lake has been included under National Lake Conservation Programme, formulated by the Ministry of Environment and Forests, Government of India.

### 2.2 Area and Surroundings of Mirik Lake

The total lake area is about 16.19 ha with approximate length of 1.25 km and the peripheral road is about 3.5 km. The arch-type over bridge across the lake is 24.38 m long. Initially maximum depth of the lake was 7.92 m while minimum was 1.83 m [15]. While eastern bank of the lake is flat at ground level, the western bank, having hill slopes, is covered by a rich forest of about ten thousand *Cryptomaria japonica* trees.

The lake is fed by both perennial streams and rainwater. Since the lake is situated in a valley encircled by hill ridges with extensive natural drainage network, it receives wastewater from human settlements through numerous inlets. There is one out-fall point through which the spillover water of the lake is discharged into the river Mechi, situated to the Western side of the lake. The catchment area consists of residential areas, vacant lands and commercial centers comprising of hotels, restaurants and other shops.

Mirik Lake and its surroundings, as a whole, contain multifarious recreational features like boating, jogging, organizing fair, picnic and many others. This is the most beautiful lake of Darjeeling district where visitors come from different parts of the world. Besides attracting tourists, the lake water also serves as a major source of drinking water to the local people.

### 2.3 Sampling Sites

To study the diversity of Chlorophyceae in the Mirik Lake water, seven sampling sites were identified in the Lake (Fig. 1) considering the length of the lake as well as point and non-point sources of pollution, The water samples were collected every month at regular intervals from these locations with the help of paddle-boat for two years. The brief descriptions of the sites are as follows:

**Site 1** ($26^0$53'08.49" N and $88^0$11'08.32" E) is 250 m away from DGHC Nursery toward North- West. This site is located at the point where wastes from hotels and residential area join into the lake. Car washing also takes place at this site.

**Site 2 (**$26^0$53'16.80" N and $88^0$11'14.95" E) is situated at the flank of the lake where tourists assemble to observe the fishes that agglomerate specifically here for consuming various food items thrown by the visitors. Wastes from hotels and residential areas also join at this site.

**Site 3** ($26^0$53'.20" N and $88^0$11'01" E) is located at 100 m away from the concrete bridge of the lake towards South East. This site is situated near the children park area. Human activity is comparatively lesser at this site.

**Site 4 (**$26^0$53'.017" N and $88^0$10'.927" E) is located at the centre of concrete bridge over the lake. Some amount of surface runoff joins here.

**Site 5** ($26^0$53'38.40" N and $88^0$10'55.11" E) is situated at 90 m away from the water intake point towards North East. This water intake well is used for water treatment plant under PHED having a capacity of 1MGD (Million Gallon per Day) to cater the water supply for the people of Mirik Municipality area.

**Site 6** ($26^0$53'27.99" N and $88^0$10'56.53" E) is the area where waste water is discharged primarily from Mirik market. Bathing and washing of clothes take place at this site.

**Site 7** ($26^0$53'34.53" N and $88^0$10'51.89" E) is situated near the outlet of Mirik Lake which joins to the Mechi River through weirs. Washing of clothes and bathing take place near this site.

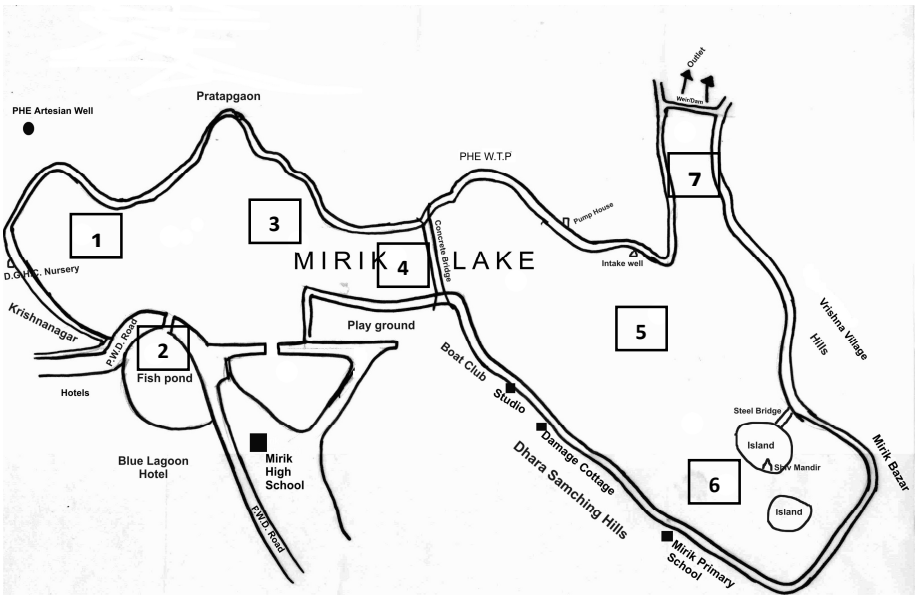


**Fig. 1. Location of sampling sites at Mirik Lake, Darjeeling**

## 2.4 Methodology

Chlorophyceae samples were collected without filtering the surface water. To preserve, 0.3 mL. Lugol's Iodine solution was added to 100 mL. sample. In the Laboratory, water samples were centrifuged at 1500 r.p.m. for 15 minutes and then studied under microscope (Olympus CK2, Japan). Identification of Chlorophyceae was done using Standard books [16,17,18,19,20].

## 3. RESULTS AND DISCUSSION

A total of twenty five Chlorophyceae species were recorded from seven sampling sites of Mirik Lake during the whole study period (Table 1). *Ankistrodesmus* sp., *Cosmarium* sp., *Chlorella* sp. and *Chlorococcum* sp. were the most common genera of Chlorophyceae in the lake. The highest diversity of Chlorophyceae was found at Site 3 and Site 4 having twenty three Chlorophyceae species while lowest diversity was recorded at Site 2 where only seventeen Chlorophyceae species were recorded. The higher Chlorophyceae diversity of Site 3 and 4 was probably due to lesser human activities and lowest diversity in case of Site 2 might be due to greater anthropogenic activities.

The highest density of Chlorophyceae (4596/ml) was observed at Site 3 during summer in the second year, while lowest density was recorded at Site 2 during monsoon of the second year (445/ml) of study period (Fig. 2). In general, Chlorophyceae density was relatively higher during summer months. Higher population density of Chlorophyceae in summer were also reported by Padma Priya et al. [11] in Saroornagar Lake, Hyderabad.

*Ankistrodesmus* sp., *Cosmarium* sp., *Chlorella* sp. and *Chlorococcum* sp. were the most common species found throughout the year. *Ankistrodesmus* sp. was the dominant species which was represented throughout the investigation period at all stations.

Palmer [21] has listed Chlorophyceae taxa in decreasing order of emphasis with reference to pollution index. With reference to this, in the Mirik Lake water the pollution tolerant species in decreasing order of emphasis were *Chlamydomonas, Scenedesmus, Chlorella, Stigeoclonium, Ankistrodesmus, Closterium, Spirogyra, Pediastrum, Ulothrix, Oocystis, Chlorococcum, Cosmarium* and *Crucigenia*. During the whole study period presence of *Ankistrodesmus sp* was recorded which was reported to be present in organically polluted water [22] and sewage polluted urban eutrophic lakes [23]. According to Verma et al. [24] *Scenedesmus* sp. and *Chlorella* sp. are considered as indicators of highly organic polluted waters and represent eutrophic nature of the lake. Presence of these two species in the water of Mirik Lake in numerically good numbers at all stations throughout the year indicate high organic pollution and rich nutrient status of the lake. C*rucegenia sp.* were also recorded from the Mirik Lake. Their presence in nutrient rich water is supported by Ansari [25]. Species of *Mougeotia, Oocystis, Euastrum, Scenedesmus, Pediastrum, Zygnema, Chlamydomonas, Chlorella, Spirogyra,*

*Tetraedron, Stigeoclonium, Staurastrum* were found in the Mirik Lake which according to Standards IS 10500: 2012- Annexture-I, are found in polluted waters.

**Table 1. Chlorophyceae species recorded from the surface water samples of seven sampling sites of Mirik Lake during the whole study period (two years)**

| Rotifers | Sampling stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 |
| *Ankistridesmus* sp. | + | + | + | + | + | + | + |
| *Cosmarium pygmaeum* | + | + | + | + | + | + | + |
| *Chlamydomonas* sp. | + | + | + | + | + | + | + |
| *Chlorococcum* sp. | + | + | + | + | + | + | + |
| *Chlorella* sp. | + | + | + | + | + | + | + |
| *Closteridium* sp. | + | - | + | + | - | + | + |
| *Closteriopsis* sp. | + | + | + | + | + | + | + |
| *Closterium* sp. | + | + | + | + | + | + | + |
| *Crucigenia* sp. | + | + | + | + | + | + | + |
| *Eustrum pectinatum* | - | - | + | + | + | + | - |
| *Gleocystis* sp. | - | + | + | + | + | + | - |
| *Microspora* sp. | - | - | + | + | - | - | - |
| *Mougeotia* sp. | + | - | + | + | + | + | - |
| *Myrmecia* sp. | + | - | + | + | - | - | - |
| *Oocystis* sp. | + | + | + | + | - | + | + |
| *Pediastrum* sp. | + | + | + | + | + | + | + |
| *Scenedesmus* sp. | + | + | + | + | + | + | + |
| *Schroderia* sp. | + | + | - | + | + | + | + |
| *Spirogyra* sp. | - | - | - | + | - | + | + |
| *Staurastrum* sp. | + | - | + | + | + | + | - |
| *Stigeoclonium* sp. | + | + | + | + | + | + | + |
| *Tetraedron minimum* | + | + | + | + | + | + | + |
| *Tetrastrum* sp. | + | - | + | - | + | + | - |
| *Ulothrix* sp. | + | + | + | + | - | + | + |
| *Zygnema* sp. | + | + | + | - | + | - | + |
| ***Total no.*** | **21** | **17** | **23** | **23** | **19** | **22** | **18** |

*+ Present, -Absent*

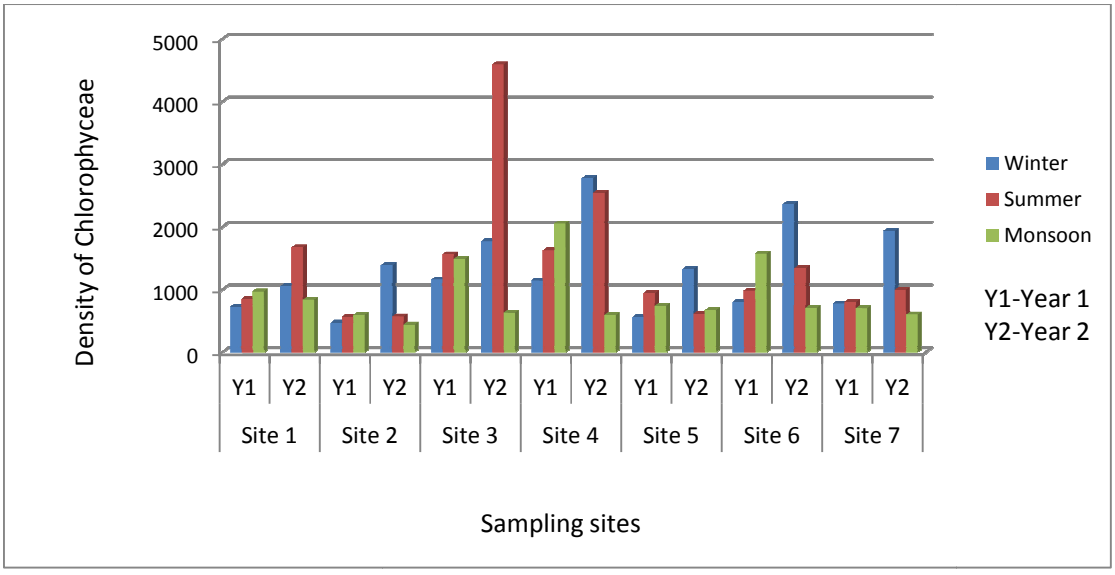


**Fig. 2. Seasonal variations in population density of Chlorophyceae in Mirik Lake during the whole study period (two years)**

## 4. CONCLUSIONS

From the present study it is revealed that Mirik Lake supports the growth of a large number of Chlorophyceae population. Some pollution tolerant genera of Chlorophyceae were also found during the investigation period which proves the eutrophic condition of the lake. Therefore, regular monitoring of the lake water is essential before consumption and the water of the Mirik Lake should be properly maintained for the conservation of its Chlorophyceae population.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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