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Phytoplankton diversity of lake, Gyakar Sinyik (Ganga Lake), eastern Himalayas, India

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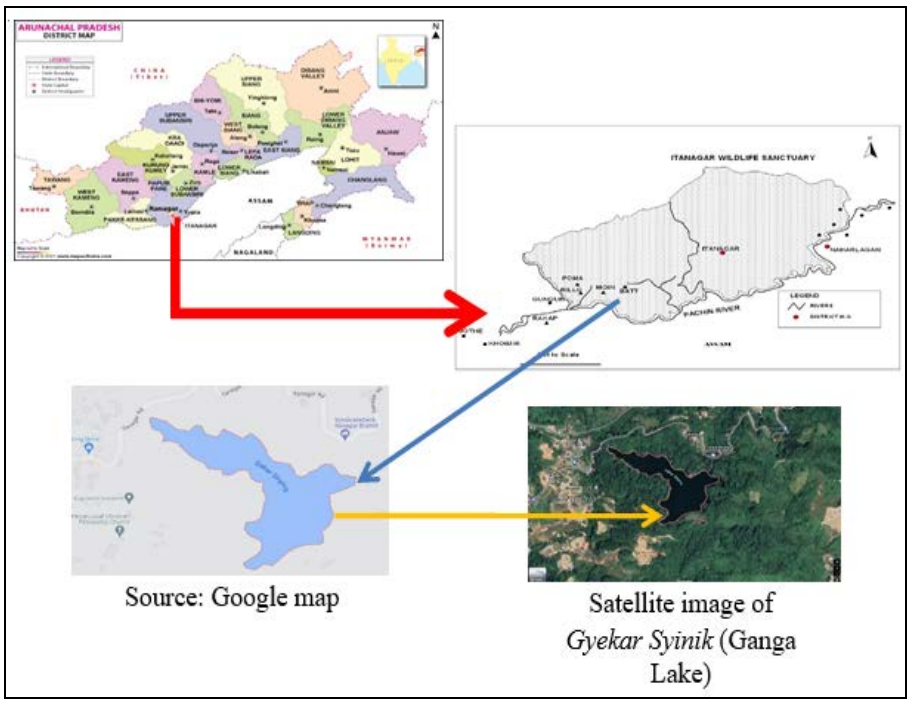
Abstract
Among the major biodiversity hotspots of the world, Eastern Himalaya is known for its species richness and endemism located in the state of Arunachal Pradesh in north-east India. Apart from the terrestrial biodiversity, there are so many aquatic bio-resources like rivers, streams and lakes in Arunachal Pradesh. *Gyakar Sinyik* (Ganga Lake) is one such wetland located at Itanagar in the Papum Pare district. Preliminary study on the distribution of phytoplankton in the lake was studied during the year 2023.All the parameters were found to be within the permissible limit. A total of 41 genuscomprising of 57 species were observed during the study of phytoplanktons. They belong to 20family under 8 major classes. The number of sequences in order among different classes were Bacillariophyceae>Zygnematophyceae> Chlorophyceae>Euglenophyceae>Cyanophyceae>Dinophyceae>Chrysophyceae>Eumastigmatophyceae. ClassDinophyceae, Chrysophyceae and Eumastigmatophyceae were represented by one species each whereas Cyanophyceae with two species. The present study provides a valuable insight of the wetland in relation to water quality with the phytoplankton diversity.

Keywords: Phytoplankton, Ganga Lake, limnology, Eastern Himalayas

Introduction
Arunachal Pradesh, one amongst of the North-East State of India, is located within Eastern Himalayas-one of the biodiversity hotspots of the world. Ganga Lake (Gyakar Sinyik) is one of the lakes of the state of Arunachal Pradesh is located in Itanagar town situated at an altitude of 330-350 MSL and coordinates 93° 34' 04.58"E longitude and 27° 04' 28.52"N. Water quality of any wetland has an impact on the distribution as well as diversity of planktons in any ecosystem [1]. Fluctuation in the physico-chemical characteristics of the wetland also has an impact on the distribution, richness and abundance of phytoplankton [2]. Limnological studies with special reference to phytoplankton also indicate the quality of wetland [3]. Few authors have done some study on the phytoplankton diversity of Eastern Himalaya with special reference to Arunachal Pradesh [4-6]. 86 freshwater algal species were documented from different locations of Arunachal Pradesh in 2012 [4]. A recent work in the year 2021 on random floristic survey on various locations, a checklist of the phytoplankton flora in the foot hill belt of Arunachal Himalayas was compiled which reported 116 phytoplankton taxa representing 6 algal phyla, 35 families and 55 genera [6]. However, no comprehensive studies were done on the phytoplankton distribution at species level from the Gyakar Sinyik lake. Presently, an attempt was made to study phytoplankton diversity along with physico-chemical characteristics of water of the Gyakar Sinyik Lake.

Materials and Methods
The above work was carried in the lake, locally known as Gyakar Sinyik which means 'confined water' in *Nyishi* tribe dialect. It is a natural, freshwater wetland located near the capital city of Itanagar. The lake, is the main tourist attractions of the city (Map-1), which has an area of about 70,000m^2 though the total area of the lake including the banks and embankments is about 4 km^2 and is located very close to *Pachin* and *Pam* watersheds.
Standard methods were followed for the analysis of physico-chemical characteristics of water [7]. Water analysis kit with probes was used the study the temperature, pH, oxidation reduction potential (ORP), electrical conductivity (EC), total dissolved solid (TDS) and salinity.

For transparency study Secchi disc was used. Water samples were collected throughout the year in 2023 from different locations around the perimeter of the Lake for the estimation of dissolved oxygen content. Fixation was done on the spot using standard chemicals as per the Winkler's method. The locations were recorded using a GPS application. Phytoplankton samples were collected during the year 2023. Plankton-net, Collection tube, Sampling bottles, Formalin solution (5%) were used for the procedures. Samples were collected in the morning hours around 9.30 am as phytoplankton are sensitive to temperature. Phytoplankton flora was collected by towing plankton net made of nylon-bolt silk having a mesh size of 50 µm. Samples were collected from different locations of the Lake, both from littoral and limnetic zones of the lake. The samples were then fixed immediately in the field in 5% formalin and brought to laboratory and allowed to settle overnight. Next day after the phytoplankton had settled down, the supernatant was removed with a dropper and the plankton samples were preserved in 5% formalin. Then the plankton samples were observed under the microscope for species identification. Standard available literature was used for the identification of up to species level [8].



Map 1: Showing the study site of lake *Gyaker Siniyik* (Ganga Lake)

Results

The results obtained is presented in Table 1&2. The physico-chemical characteristics of lake water is presented as data range observed throughout the year with minimum and maximum. The temperature range was found to be 21-31 ℃ which is well within the range for the aquatic organisms. pH also follows the same pattern with a range of 7.1-9.8. The permissible limit of pH recommended by WHO is from 6.5 to 9.2. The pH of the Lake being within the range is suitable for sustaining aquatic life in it. The transparency during the period of study was recorded with an annual range of 91-115 cm. However, seasonal fluctuation with insignificant difference was observed during the study. The total dissolved solid (TDS) was within the permissible limit as estimated range was 35-55 ppm. However, the oxygen stress was quite evident within an annual average, dissolved oxygen content was found to be range 5.5-7.4 ppm with a negative oxidation reduction potential (-47-24 µv). Moreover, less electrical conductivity (52-74 µs/cm) and salinity (20-38 ppm) makes the quality of water fit for aquatic life.

Among the planktonic form phytoplankton has dominance. The present study is primarily aimed at assessing the phytoplankton diversity at species level. The presence of abundant number of phytoplanktons also proves the better quality of water. The phytoplanktons species identified in our collection is listed in Table 2. A total of 41 genus of phytoplanktons comprising of 57 species were observed during the study. They are classified under 20 family belonging to 8 major classes (Figure 1). Class Bacillariophyceae is represented by maximum number (19) of species (Figure 2) followed by Zygnematophyceae (14) (Figure 3) and Chlorophyceae (11) as shown in Figure 4. Eight species were reported from the class Euglenophyceae. Class Dinophyceae, Chrysophyceae and Eumastigmatophyceae were represented by one species each whereas Cyanophyceae with two species. They are order of diversity is as Bacillariophyceae> Zygnematophyceae> Chlorophyceae>Euglenophyceae>Cyanophyceae>Dinophyceae>Chrysophyceae>Eumastigmatophyceae (Figure5). Among the family desmidiacae is most abundant whereas Pinnularia genus is the dominant one representing 6 species.

Table 1: Physico-chemical parameters of lake *Gyaker Siniyik* (Ganga Lake)

Sl. No.	Parameters	Range
1.	Temperature (°C)	21-31
2.	pH	7.1-9.8
3.	Transparency(cm)	91-115
4.	TDS (ppm)	35-55
5.	EC (µs/cm)	52-74
6.	ORP(µv)	-47-24
7.	Salinity(ppm)	20-38
8.	Dissolved Oxygen Content (ppm)	5.5-7.4

Table 2: Phytoplankton diversity of lake *Gyaker siniyik* (Ganga Lake)

Sl. No	Genus (41) Species (46+11)	Family (20)	Class (8)
1.	*Synedra linearis*	Fragilariaceae	Bacillariophyceae
2.	*Cymbella sps*	Cymbellaceae	Bacillariophyceae
3.	*Epithemia gibba*	Rhopalodiaceae	Bacillariophyceae
4.	*Pinnularia subsimilis*	Pinnulariaceae	Bacillariophyceae
5.	*Pinnularia viridis*	Pinnulariaceae	Bacillariophyceae
6.	*Pinnularia acrosphaeria*	Pinnulariaceae	Bacillariophyceae
7.	*Pinnularia brevicostata*	Pinnulariaceae	Bacillariophyceae
8.	*Pinnularia joculata*	Pinnulariaceae	Bacillariophyceae
9.	*Pinnularia sps*	Pinnulariaceae	Bacillariophyceae
10.	*Navicula radiosa*	Naviculaceae	Bacillariophyceae
11.	*Navicula pupula*	Naviculaceae	Bacillariophyceae
12.	*Nitzschia palea*	Bacillariaceae	Bacillariophyceae
13.	*Achnantes longipes*	Achnanthaceae	Bacillariophyceae
14.	*Melosira granulata*	Melosiraceae	Bacillariophyceae
15.	*Discostella stelligera*	Stephanodiscaceae	Bacillariophyceae
16.	*Amphipleura sps*	Amphipleuraceae	Bacillariophyceae
17.	*Rhopalodia gibberula*	Rhopalodiaceae	Bacillariophyceae
18.	*Rhopalodia sps*	Rhopalodiaceae	Bacillariophyceae
19.	*Ditylum brightwellii*	Lithodesmiaceae	Bacillariophyceae
20.	*Tetraedron incus*	Chlorococcaceae	Chlorophyceae
21.	*Tetraedron trigonum*	Chlorococcaceae	Chlorophyceae
22.	*Asterococcus limnetics*	Palmellopsidaceae	Chlorophyceae
23.	*Chlorella vulgaris*	Chlorellaceae	Chlorophyceae
24.	*Selenastrum bibraianum*	Selenastraceae	Chlorophyceae
25.	*Oocystis sps*	Oocystaceae	Chlorophyceae
26.	*Ankistrodesmus densus*	Oocystaceae	Chlorophyceae
27.	*Coelastrum indicum*	Scenedesmaceae	Chlorophyceae
28.	*Tetrastrum glabrum*	Scenedesmaceae	Chlorophyceae
29.	*Desmodesmus abundans*	Scenedesmaceae	Chlorophyceae
30.	*Dimorphococcus lunatus*	Scenedesmaceae	Chlorophyceae
31.	*Phacus elegans*	Euglenaceae	Euglenophyceae
32.	*Phacus rotundus*	Euglenaceae	Euglenophyceae
33.	*Euglena viridis*	Euglenaceae	Euglenophyceae
34.	*Trachelomonas sps*	Euglenaceae	Euglenophyceae
35.	*Lepocinclis sps*	Euglenaceae	Euglenophyceae
36.	*Closterium submoniliform*	Closteriaceae	Euglenophyceae
37.	*Closterium acerosum*	Closteriaceae	Euglenophyceae
38.	*Closterium rostratum*	Closteriaceae	Euglenophyceae
39.	*Nostoc carneum*	Nostocaceae	Cyanophyceae
40.	*Chroococcus minutes*	Chroococcaceae	Cyanophyceae
41.	*Ceratium hirudinella*	Ceratiaceae	Dinophyceae
42.	*Cosmarium subcostatum*	Desmidiaceae	Zygnematophyceae
43.	*Cosmarium forceps*	Desmidiaceae	Zygnematophyceae
44.	*Cosmarium sps*	Desmidiaceae	Zygnematophyceae
45.	*Cosmarium sps*	Desmidiaceae	Zygnematophyceae
46.	*Staurastrum tetracerum*	Desmidiaceae	Zygnematophyceae
47.	*Staurastrum convergens*	Desmidiaceae	Zygnematophyceae
48.	*Staurastrum lunatum*	Desmidiaceae	Zygnematophyceae
49.	*Euastrum luetkemulleri*	Desmidiaceae	Zygnematophyceae
50.	*Micrasterias radiosa*	Desmidiaceae	Zygnematophyceae
51.	*Groenbladia sps*	Desmidiaceae	Zygnematophyceae
52.	*Pediastrum duplex*	Hydrodictyaceae	Zygnematophyceae
53.	*Gonatozygon sps*	Gonatozygaceae	Zygnematophyceae
54.	*Spirogyra hyaline*	Zygnemataceae	Zygnematophyceae
55.	*Pleurotaenium trabecula*	Zygnemataceae	Zygnematophyceae
56.	*Dinobryon sertularia*	Dinobryaceae	Chrysophyceae
57.	*Pseudostaurastrum limneticum*	Eustigmataceae	Eumastigmatophyceae

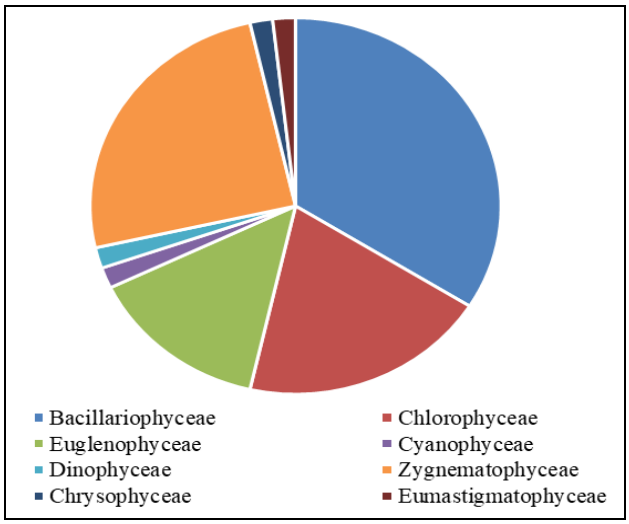


Fig 1: Species distribution among different class

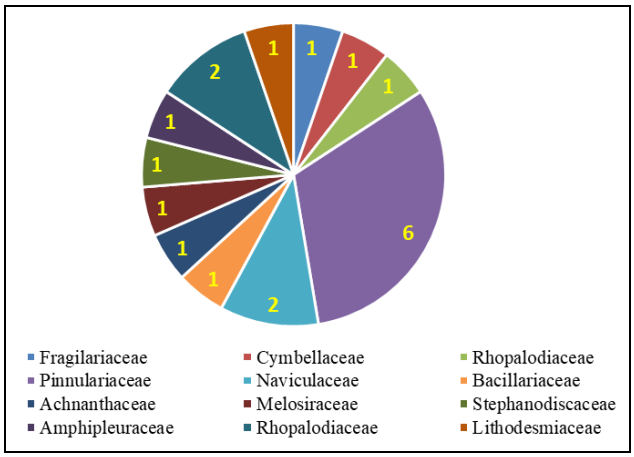


Fig 2: Distribution of number of species within the family of Class Bacillariophyceae

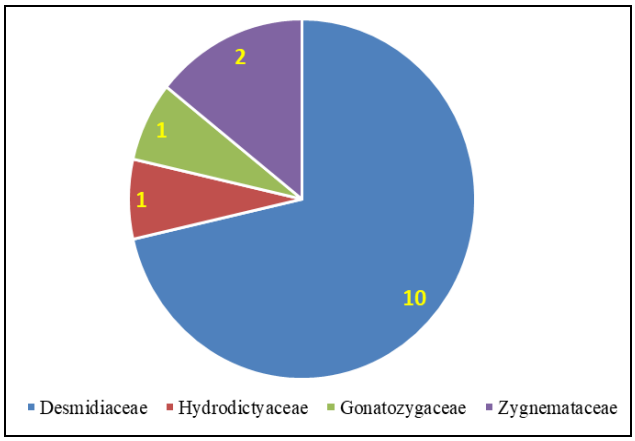


Fig 3: Distribution of number of species within the family of Class Zygnematophyceae

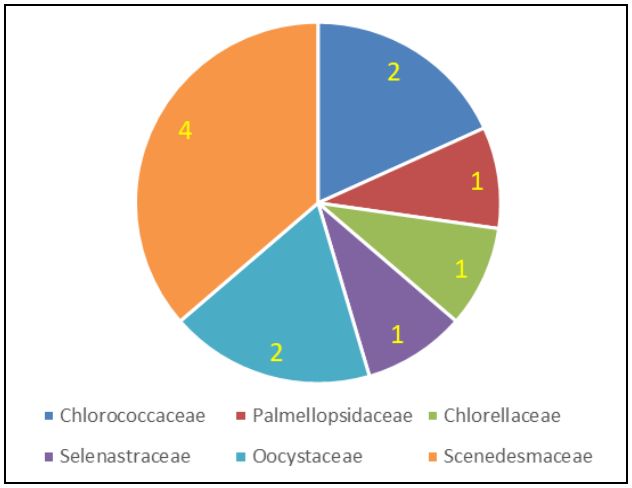


Fig 4: Distribution of number of species within the family of Class Chlorophyceae

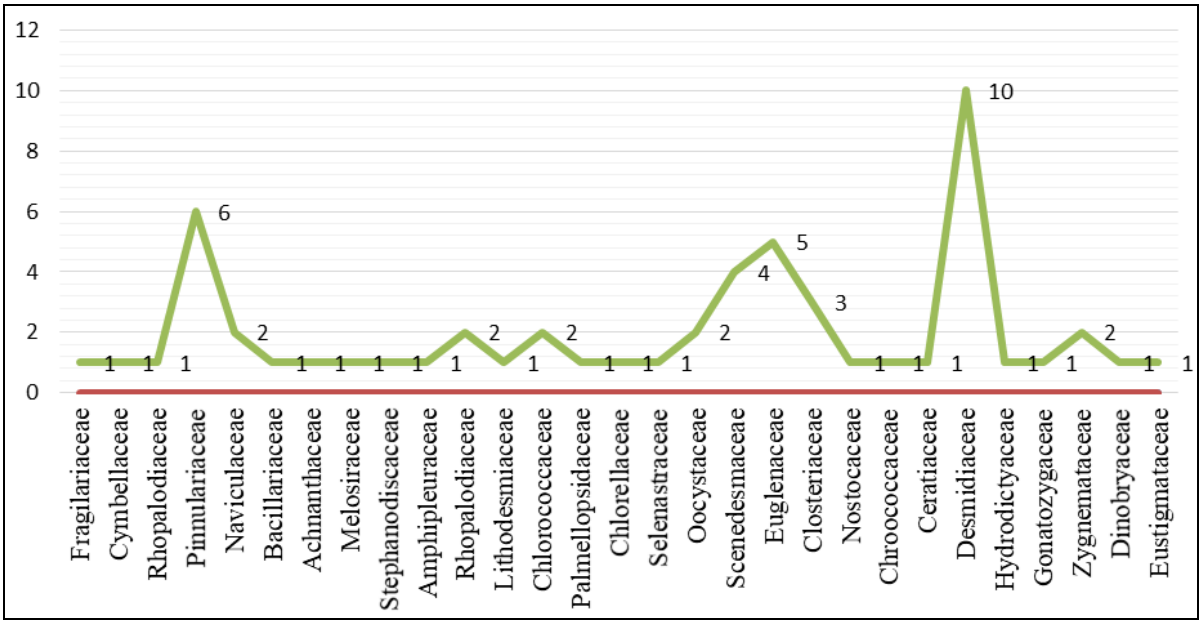


Fig 5: Species distribution among different family

Discussion

Very often it has been reported deteriorating condtion of wetland due to change in physico-chemical parameters effected by pollution [9]. Physico-chemical factors contribute to the healthy population of phytoplanktons in the lake. It has been reported that physico-chemical characteristics like TDS, pH, and chlorides have negative correlation with the abundance of phytoplanktons [3]. It has been observed that anthropogenic habitat alteration in the wetland leads to increase nutrient loads which helps species from

Bacillariophyceae thrives [10]. In our study there was abundance of phytoplankton from Bacillariophyceae. It has already been reported in other high-altitude lakes like Wular lake of Kashmir with the dominance of Bacillariophyceae with more Navicula population. However in our studies we found the diminace of genus Pinnularia [11]. In another lake of Himalaya named Gangabal study reveals 45 number species under Bacillariophyceae out of 61 species recorded [12]. In north east also, Halflong lake of Assam is having 13 species of Bacillariophyceae out of 27 species reported by worker [13]While working on the phytoplankton diversity of another Himalayan lake of Garhwal region named Dodi tal, authors have also reported dominance of Bacillariophyceae with 20 genera[4].So all the above works corroborates with our findings that in Himalayan Lakes Bacillariophyceae groups are mostly dominant. However, in plain land wetland like Hadhinaru lake, Shetty lake from Karnataka as well as Sulur and Ukkadam lake of Tamil Nadu showed dominance of Chlorophyceae [14, 15] A recent report on phytoplankton of the foot hill belt of Arunachal Himalaya depicted Desmidiceae family with highest number (19) of species [6]. In our findings also, same results obtained with 10 numbers of species representing Desmidiceae. Even though the physico-chemical parameters are within the permissible limit but oxygen stress is clearly visible. As it is a closed lake with lot of decomposition taking place, the presence of more number (5) Euglenaceae family is believed to be an indicator eutrophication. Thus, it reinforces the threat perception to the ecological health of *Gyakar Synik* Lake.

Conclusion

This study was to identify the phytoplanktons species of Gyaker Synik lake, and it was a successful attempt in identifying up to species level. Along with phytoplankton identification the physico-chemical parameters of the lake were also done. The pH and temperature were quite favourable for a healthy environment for the aquatic organisms of the lake. Moreover, the transparency of the lake, which was found to be favourable, indicates the better marker for photosynthesis leading to oxygen balance in the lake for aquatic life. Presence of abundant number of phytoplanktons specially Bacillariophyceae, Zygnematophyceae and Chlorophyceae is a good indicator of the wetland. However, with less dissolved oxygen along with negative ORP is indicative of stress. The study indicates that it is a self-sustained ecosystem with phyto plankton being one of the vital links in its food chain. During the study it is found that the embankments of the lake at north-western end need to be strengthened in order to overcome the possible threat of landslides to the lake. Further studies will help substantiate the present work on this elegant and ecologically significant lake of the Eastern Himalaya.

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Conflict of Interest: The authors declare that they do not have any conflict of interest.

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