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Reassessment of zooplankton diversity of Lake *Gyekar Syinik* of Itanagar, Arunachal Pradesh, India

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Abstract
An assessment of the distribution of zooplankton in Lake *Geykar Sinyik* was carried during 2019 and reported 16 genera. The same wetland was again surveyed throughout the year 2024 where 16 number of genera with 25 species of zooplankton were recorded. 11 genera were found to be common when compared with both the year. There were four groups of zooplankton like copepoda, cladocera, rotifera and protozoa observed. The group rotifera represented with maximum number (13) of species. The distribution trends were Rotifera>Copepoda>Cladocera=Protozoa. Genus *Trichocerca* and *Asplancha* were dominant with three species each. Physio-chemical parameters of water indicating low oxygen level along with negative oxidation reduction potential.

Keywords: Arunachal Pradesh, Ganga Lake, limnology, wetland, zooplankton

1. Introduction

The rapid growth of population, urbanization, and industrialization has significantly increased the water demand while the availability of water resources continues to shrink. Lakes, which are shallow bodies of still water rich in flora and fauna, are vital in supporting humans and animals. Assessing water quality requires examining its physical, chemical, and biological characteristics, including plankton. The relationship between plankton diversity and these factors provides insights into the ecosystem's functioning (Rajagopal *et al*., 2010 [10]; Sunkad & Patil, 2004) [16]. Observations on the diurnal, monthly, and seasonal variations in freshwater systems' biotic and abiotic components can reveal crucial interdependencies. Changes in water quality directly impact aquatic life, reducing primary productivity. Research on various lake systems collectively advances our understanding of their functionality and responses to environmental changes. Zooplankton likes Rotifera and Crustaceans exhibit wide adaptability and play significant ecological roles, including filtering and feeding on algal cells. The Rotifers and the two Crustacean groups, namely Cladocera and Copepoda, share a significant part of the freshwater zooplankton. Lake water quality is determined by a range of physicochemical parameters, including temperature, pH, transparency, electrical conductivity, total dissolved solids (TDS), and dissolved oxygen (DO). The physico-chemical analysis of the lake *Geykar Sinyik* indicating lower oxygen has earlier been reported (Muthu and Mitra, 2024) [7]. These factors influence aquatic life and provide insight into the ecosystem's health. For instance, transparency affects light penetration, influencing photosynthesis and oxygen levels. Analyzing these parameters alongside biological indicators like zooplankton offers a comprehensive picture of a water body's status. The study aims to re-assess zooplankton diversity of Lake *Geykar Sinyik* after five years. During 2019 the lake was assessed for the zooplankton diversity by Foldscope techniques (Nanda *et al*., 2020) [6]. Total of 16 genera was reported during the survey. Furthermore, again in 2024 the same lake was re-assessed to study the zooplankton diversity and presented herein. This research will contribute to understanding the lake's ecological health and the extent of eutrophication impacting its aquatic ecosystem.

2. Methods

2.1 Study Area

The Lake is locally known as *Geykar Sinyik* meaning ‘Confined Water’ in the local Nyishi (Tribe) dialect. The lake is a natural freshwater lake in the western part of the capital city of

Itanagar. It is located about 6 km away from the capital region of Itanagar and situated at altitude of 330-350 MSL above sea level and coordinates 93° 34' 4.58’’E longitude and 27° 04' 30.35"N (Plate-1). An aerial view of lake gives a pistol-shaped morphology (plate-2). The lake has an area of about 70,000m^2 or nearly 7 hectares, though the lake's total area, including the banks and embankments, is about 4 km^2 and is located very close to the Pachin and Pam watersheds. The lake is at threat from a geological point of view because of its location on the top of a hill and weakened banks on the western side. Anthropogenic activities also pose a threat to the previously undisturbed lake. The lake is one of the city's chief tourist attractions, as it enchants visitors with its peaceful environment surrounded by green mountains.

2.2 Sample Collection

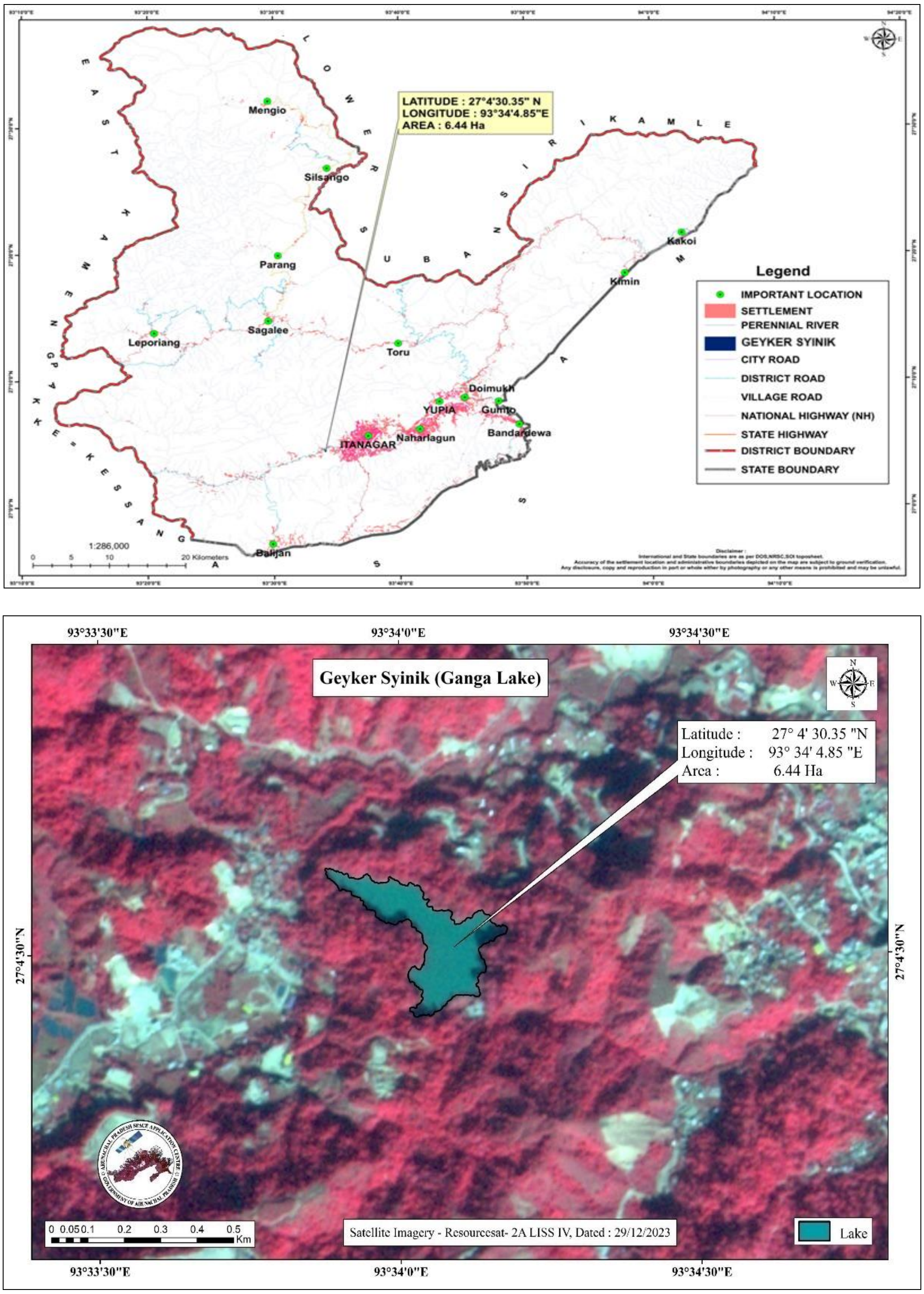
Plankton samples were collected from the site (Plate-2) on the third week of every month, starting from January to December 2024, for one year. Plankton net Collection tube, Sampling bottles, and Formalin solution (5%) were used for the procedures. Samples were collected in the morning hours, between 8.00-9.00 hours, and evening hours between 16.00-17.00 hours when the water temperature is not that high, as plankton are reported to be sensitive to temperature and move downwards or take refuge as the heat increases. Plankton samples were collected from different places and depths of the lake for qualitative analysis. The surface samples were collected by filtering 100 liters of surface water through a bolting silken net with a mesh size of 50 µm for a quality collection of all the major plankton groups. Samples were collected from five different locations around the perimeter of the lake. Aquatic vegetation in the sampling site was disturbed prior to plankton sampling to dislodge the associated plankton. The bottom samples are collected using Mayer’s water sampler to prepare a typical sample by mixing it with surface samples. Then, 50ml surface and 50ml bottom samples are mixed to pull over to make a 100ml plankton sample. The samples were then sieved through a specially designed net of appropriate size to sieve off the larger debris, if any, and fixed immediately in the field in 5% formalin. The sample is preserved in a 5% aqueous formalin solution. In the laboratory, the samples were processed again to clear the debris by sieving through another net of relatively smaller mesh size and allowed to settle overnight. The next day, the supernatant was removed carefully with a dropper, and the plankton samples were preserved in 5% formalin prepared freshly from reagent-grade formalin.

2.3 Plankton analysis

Slides of each sample were prepared in duplicate, where the sample was placed on a slide observed under the microscope. The zooplanktons were identified by using a research Thermo Fisher EVOS XL at a magnification of 1000X. Micro-photographs of each plankton were taken with the highest magnification. The zooplankton species were identified with the help of standard works (Ward & Whiple, 1945; Battish, 1992) [2]. The micro-measure of planktons was done using the software ImageJ (https://imagej.net/ij).

2.4 Physicochemical analysis: The physico-chemical analysis of water was done as per the standard methods of American Public Health Association (APHA, 2005) [1]. A water analysis kit, Secchi Disc, and BOD bottles were used for the procedures. Samples were collected from different locations around the perimeter of the Lake. The locations were recorded using a GPS application. Water transparency was measured by a 20cm diameter Secchi disc. The water sample was carefully collected from five selected study sites in a BOD bottle. Fixation was done on the spot using standard chemicals and brought to determine dissolved oxygen content using Winkler’s method. The parameters like pH, temperature, Oxidation Redux Potential (ORP), turbidity, and conductivity were determined with the help of a probe following standard procedures.

Plate 1: Map of India showing Arunachal Pradesh



Source: State Remote Sensing Application Centre (SRSAC), Itanagar

Plate 2: Map of Arunachal Pradesh showing location (GPS) of Lake *Geykar Sinyik*

3. Results

The result obtained is presented in Table-1. The physico-chemical characteristics of lake water is presented as a data range observed throughout the year with minimum and maximum (Table-1). Physico-chemical factors like pH, temperature, TDS regulate the growth of plankton in the wetlands.Temperature in the wetland varies with season with lowest (22.3$\pm$0.6) recorded in the month of November and highest in August (31.98$\pm$1.22). All life processes, such as distribution of organisms are influenced by water temperature. Wetlands are in general alkaline in nature due to the presence of carbonates and bicarbonates. The pH is influenced due to their presence. The higher pH is also attributed to different anthropogenic activities. Here, results observed depict a range of 6.66-9.31 with high during monsoon. The dissolved oxygen content is one of the limiting factors of any wetland. It is also dependent upon photosynthesis, temperature and salinity of the water and varies in accordance with different seasons. The DO level was observed highest during September (7.8 ppm) whereas lowest in February with 5.24ppm. The availability of oxygen decreased with the decrease in temperature. The minimum DO record in post monsoon was due to its utilization for decomposition of organic matter and respiration of zooplanktons. The variation is due to the rainwater and evaporation in response to seasonal variation. The increase of TDS is mainly due to inflow of drainage water containing large quantity of silt from the surrounding hills which is very often facing landslides during rainy season. An increase in TDS always corresponds to Electrical Conductivity (EC) increase. Zooplanktons are the primary consumers in aquatic ecosystem and are sensitive to environmental changes. They also play an important role in the food web in the trophic structure. Due to their sensitivity to physico-chemical factors they are also often considered as bio indicators of lake health. The presence of abundant zooplankton also indicates better qualities of water. The zooplankton species collected and identified during the study are listed in Table-2 and plate-3. A total of 16 genera of zooplankton comprising 25 species were observed during the study. The sequences (in order) among different groups were Rotifera>Copepoda>Protozoa=Cladocera. The highest number of 13 species is represented by Rotifera. Copepod is represented by six species, followed by three species each by Cladocera and Protozoan. Under the phylum rotifer, 13 species identified were *Lecane quadridentate, Keratella cochlearis, Testudinella patina, Brachionus forficula, Brachionus quadrata, Trichocerca bicristata, Trichocerca elongate, Trichocerca similis, Asplancha brightwelli, Asplancha priodonta, Asplancha herricki, Filina terminalis* and *Filina longiceta*. Genus *Asplancha* and *Trichocerca* were dominant with three species, followed by two species of genus *Filina and Brachionus*. From protozoan, the three genera with each species were identified as *Ceratium hirudinella, Euglena viridis, and Arcella vulgaris.* Under the sub-phylum Crustacea, six species of Copepoda were identified, which include *Heliodiaptomus viduus, Mesocyclops edax, Sinodiaptomus indicus, Mesocyclops hyalinus, Sinodiaptomus indicus, Mesocyclops pehpeiensis.* Different stages of *Nauplius sp.* were observed during the study. At the same time, three species from Cladocera, namely *Bosmina longirostris, Diphanosoma brachyurum*, and *Diphanosoma sarsi*, were observed during this investigation.

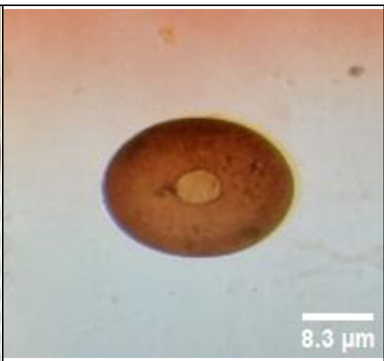
Table 1: Physico-chemical characteristics of water of *Geykar Sinyik* Lake

SL. No.	Parameters	Values
1	Temperature ^{0} C	22.3-31.98
2	pH	6.66-9.31
3	Transparency (cm)	95.2-118.5
4	DO ppm	5.24-7.8
5	TDS (ppm)	13.31-98.5
6	Electrical Conductivity (µs/cm)	20-166.4
7	ORP	-67.9 to -12.3

Table 2: Zooplankton diversity of Geykar Sinyik

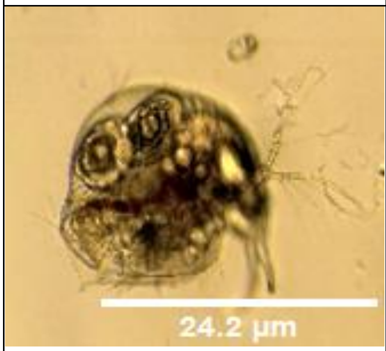
SL. No.	Species	Group
1	*Ceratium hirudinella* (O.F.Müller) Dujardin.	Protozoa
2	*Euglena viridis* (O.F.Müller) Ehrenberg.	Protozoa
3	*Arcella vulgaris* Ehrenberg.	Protozoa
4	*Bosmina longirostris* O. F. Müller.	Cladocera
5	*Diphanosoma brachyurum* Liévin.	Cladocera
6	*Diphanosoma sarsi* Richard.	Cladocera
7	*Nauplius sp.*Otto F. Müller.	Copepoda
8	*Heliodiaptomus viduus* Gurnee.	Copepoda
9	*Mesocyclops hyalinus* Moriarty *et al*.	Copepoda
10	*Mesocyclops edax* Forbes.	Copepoda
11	*Mesocyclops pehpeiensis* Hu.	Copepoda
12	*Sinodiaptomus indicus* Kiefer.	Copepoda
13	*Lecane quadridentata* Ehrenberg.	Rotifer
14	*Keratella cochlearis* Gosse.	Rotifer
15	*Testudinella patina* Hermann.	Rotifer
16	*Brachionus forficula* Wierzejski.	Rotifer
17	*Brachionus quadrata* O.F. Muller.	Rotifer
18	*Trichocerca bicristata* Gosse.	Rotifer
19	*Trichocerca elongate* Gosse.	Rotifer
20	*Trichocerca similis*Wierzejski.	Rotifer
21	*Asplancha brightwelli* Gosse.	Rotifer
22	*Asplancha priodonta Gosse*.	Rotifer
23	*Asplancha herrickii De Guerne.*	Rotifer
24	*Filina terminalis* Plate	Rotifer
25	*Filina longiceta* Ehrenberg.	Rotifer


Euglena viridis

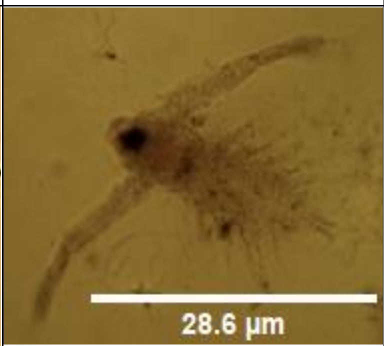


Arcella vulgaris


Ceratium hirudinella

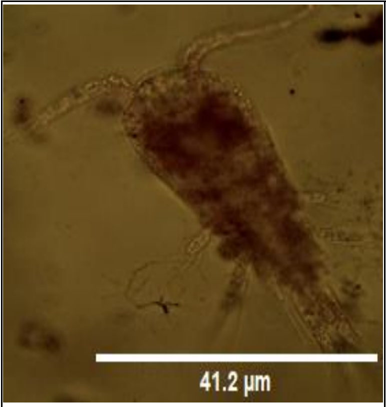


Bosmina longirostris

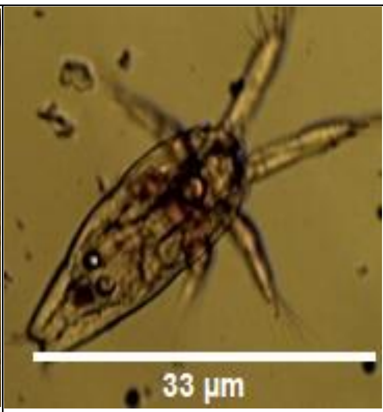


Diphanosoma brachyrum

Diphanosoma sarsi



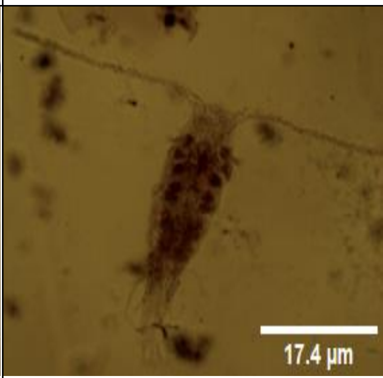
Mesocyclops pehpeiensis



Nauplius sp.

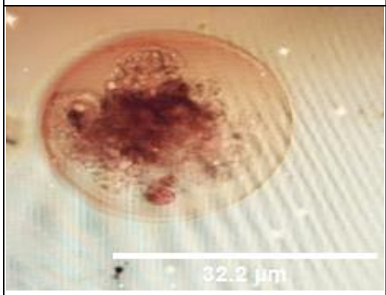
Mesocyclops edax

Mesocyclops hyalinus



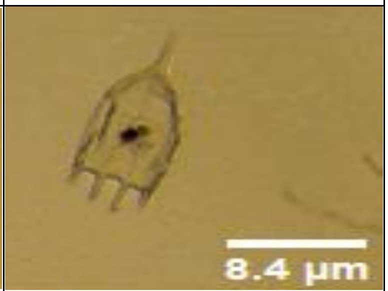
Heliodiaptomus viduus

Sinodiaptomus indicus

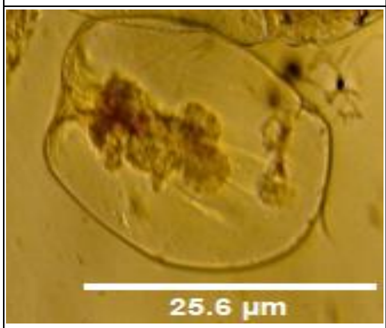


Testudinella patina

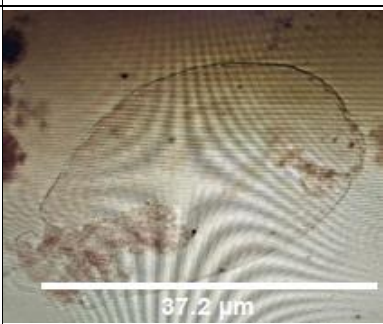
Keratella cochlearis



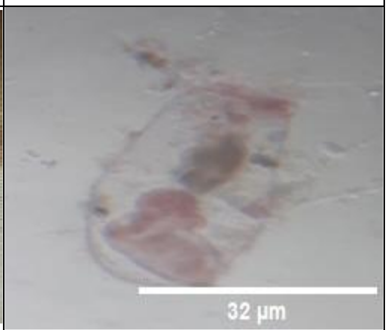
Lecane quadridentata



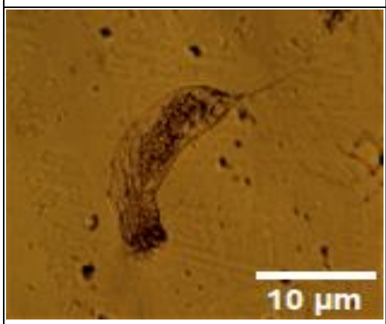
Asplancha priodonta



Asplancha herrickii

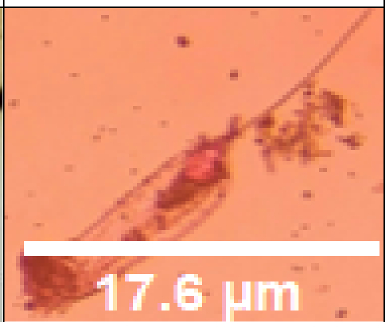


Asplancha brightwelli



Trichocerca similis

Trichocerca bicristata



Trichocerca elongate

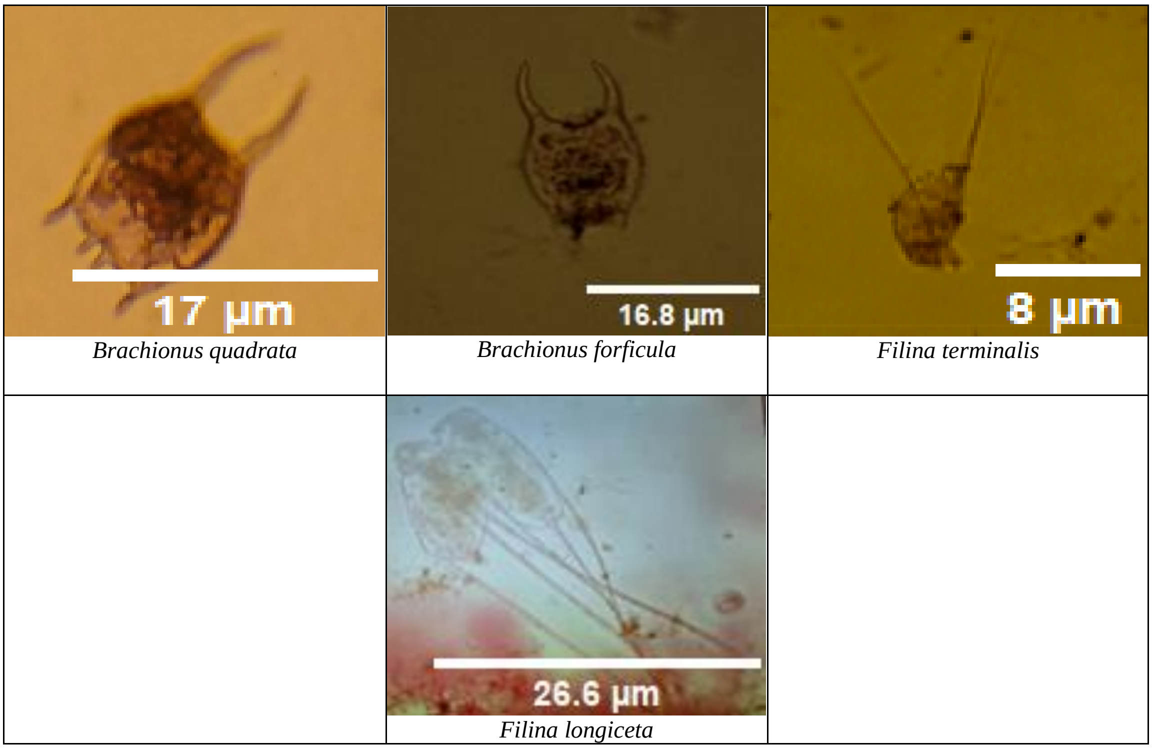


Plate 3: Zooplankton diversity of Lake *Geykar Sinyik*

4. Discussion

There is an intrinsic connection between physico-chemical parameters and plankton diversity as parameters such as temperature, pH, EC, DO, BOD, COD, free carbon dioxide, total alkalinity, hardness, chloride, phosphate, sulfate and nitrate does have an impact on distribution on plankton in wetlands which also coincide with rainwater influx and seasonal variations (Jagadeeshappa *et al*., 2013) [5]. Physico-chemical factors contribute to the healthy population of zooplankton in the lake (Sinha& Islam, 2003 [14]; Rajagopal *et al*., 2010 [10]; Sunkad and Patil, 2004) [16]. In our study, Rotifera was dominant, followed by the other groups of zooplankton, i.e., Copepods, Protozoans, and Cladocerans. Though the rotifers constitute a small group of animal kingdoms, they are qualitatively and quantitatively the most abundant metazoans in wetlands (Nanda *et al*., 2020) [6]. Also, rotifers are widely distributed worldwide, occurring from the Arctic and the Antarctic regions to the Tropics (Sinha, 2023 [13]; Somani *et al*., 2012) [15]. From a limnological point of view, the abundance of Rotifers indicates a better quality of the lake. Rotifers play a vital part in an aquatic food chain as they link the nanoplankton and carnivorous zooplankton. They also form a significant component of the diet of fish larvae. Previous studies also indicated the significance of rotifers in many Indian lakes (Shegal *et al*., 2013 [11], Pokale, 2018 [9] and Singh *et al*., 2021) [12]. The previous study from the state of Arunachal Pradesh also showed rotifers to be the dominant group among zooplanktons in river Siang (Das and Kar, 2016) [4]. In the present study, the copepod represents the second-highest abundance, indicating its moderately dominant status in the lake. The copepod's structure in the aquatic community by predation results in a top-down effect. The presence of copepods in the lake may be a significant factor contributing to the healthy status of this lentic ecosystem. The study also indicates fewer Cladoceran and protozoan members, saying that the lake is still far from acquiring dystrophic characteristics. In some studies, an abundance of Cladocerans has been used to study community structure in relation to environments, especially dystrophic lakes in central Europe (Zawisza *et al*., 2016) [18]. Thus, it reinforces the status of fair ecological health at *Geykar Syinik* Lake.

Very often has been reported deteriorating condition of wetlands due to the changes in physico-chemical parameters affected by pollution (Bhusal & Devkota, 2020) [3]. Even though, the physico-chemical parameters are within the permissible limit, oxygen stress is visible. Lake *Gyekar Sinyik* is known for its low transparency and oxygen content due to high phytoplankton density (Muthu and Mitra, 2024) [7]. As it is a closed lake with much decomposition taking place. Thus, it reinforces the perception of threat to the ecological health of *Geykar Sinyik* Lake.

5. Conclusion

The above work found that most of the water parameters are suitable for aquatic biodiversity. Less dissolved oxygen, along with negative ORP, is indicative of stress leading towards nitrate reduction. Wetlands with more nutrients reduce the transparency there by becoming sunlight deficient. Transparency was found to be within the range of 1 meter or 100 cm, less than the normal range of more than 1.5 meters of a typical quality wetland. This may lead to eutrophication in days to come, which is a matter of concern. An abundance of Cladocera is also an indicator that the wetland is under stress and not in a balanced trophic structure.

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