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Study of Zooplankton Diversity of Ganga Lake (GyakarSinyik) of Itanagar, Eastern Himalayas, India, using Foldscope

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Abstract:
The state of Arunachal Pradesh, in the extreme north-east of India is located within one of the global biodiversity hotspots of the world-the Eastern Himalayas. The state is blessed with variety of aquatic resources in the forms of streams, falls, rivers and lakes. Amongst the various freshwater lakes within the state, Ganga Lake (GyakarSinyik) is the only lake, a major wetland in the Papum Pare district and in the Itanagar Wildlife Sanctuary as well. An attempt has been made here to prepare a brief account on the zooplanktons found in the only natural lake near the capital city of Itanagar.The lake is at threat from geological point of view because of its location on the top of a hill and weakened banks on the western side and anthropogenic activities. An assessment of the physicochemical characteristics and zooplankton diversity study was done in order to understand and document the present status of the lake. Foldscope is used to identify the various species of zooplanktons found in the lake. The foldscope is aultra-low-cost origami-based portable microscope, and it was used effectively to identify the various zooplankton species. A total of 16 genuses of zooplanktons comprising of 16 species belonging to 3 genera of protozoa, 6 genera of rotifera, 3 genera of cladocera and 4 genera of copepoda were observed during the present study. Physicochemical studies showed that the pH, temperature, DO and other parameters were favourable for biotic sustainability. The conductivity, transparency and turbidity levels observed during the study indicate that the quality of water is fit for aquatic life. The present study provided valuable information on water quality and distribution of various zooplankton communities of the lake.

Keywords: Zooplankton, GyakarSinyik, Limnology, Foldscope, Eastern Himalayas

INTRODUCTION

The state of Arunachal Pradesh, in the extreme north-east of India is located within one of the global biodiversity hotspots of the world-the Eastern Himalayas (Sharma, H, 2020). With an area of 83,743 km^2, this state is blessed with variety of aquatic resources in the forms of streams, falls, rivers and lakes. Amongst the various freshwater lakes within the state, Ganga Lake (GyakarSinyik) is the only

lake, a major wetland in the Papum Pare district and in the Itanagar Wildlife Sanctuary as well (Sharma D, 2012).

Limnology is an interdisciplinary science which involves various qualitative and quantitative aspects of the water bodies. The overall parameters decide the extent of sustainability of organisms in such environment (Adoni *et. al.*, 1985). An assessment of the physiochemical characteristics and zooplankton diversity study of the lake was done in order to understand and document the present status of the lake. Zooplankton diversity is an important parameter and indicator of water quality which indicates the productivity and overall health of the lake (Datta Munshi, 1995). Primary productivity of a water body and plankton growth is determined by the physicochemical parameters of water, i.e. light, nutrients and oxygen (Gang *et. al.,* 2006, Khwaja *et. al.,* 2014, Zaher *et. al.,* 2018).

Physicochemical studies of pH, temperature, DO and other parameters are done to ascertain the favourability for biotic sustainability. The conductivity, transparency and turbidity levels observed during the study indicate that the quality of water is fit for aquatic life. Foldscope, an origami based microscope, is used to identify the various species of zooplanktons found in the lake. As the present study has limited observations, further studies are required for overall assessment of the status of the lake. The embankments on the north-western direction need to be strengthened in order to overcome the threatened status of the lake. Only such timely steps can help in the protection and conservation of this rich and unique Eastern Himalayan Lake.Not many scientific publications are available on the Ganga Lake, apart from the ones by few authors (Sinha and Tamang, 2012, Dutta *et. al.*, 2015). Therefore, an attempt has been made here to prepare a brief account on the zooplanktons found in the only natural lake near the capital city of Itanagar.

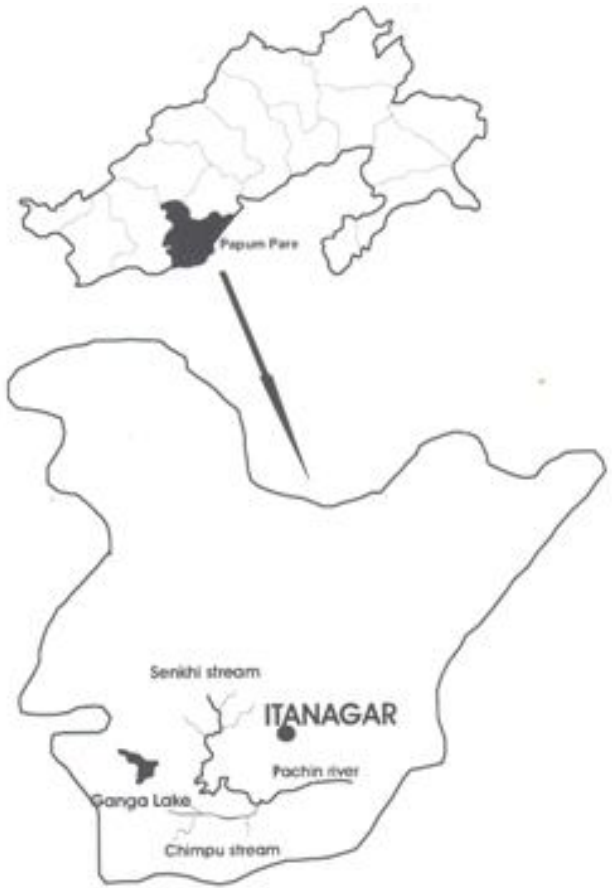

Figure 1: Location map of Ganga Lake

MATERIALS AND METHODS

Study Area

The Ganga Lake, locally known as GyakarSinyi, Or GyakarSinyik, literally meaning 'CONFINED WATER' in local Nyishi dialect, is a natural, freshwater lake in the western part of the capital city of Itanagar. It is located about 6 km away from Ganga market (capital complex) at Itanagar and situated at altitude of 330-350 m above sea level and coordinates 93° 34' 04.58"E longitude and 27° 04' 28.52"N. However, an aerial view gives a pistol-shaped morphology of the lake. The lake has an area of about 70,000 m^2 though the total area of the lake including the banks and embankments is about 4Km^2 and is located very close to Pachin and Pam watersheds. Anthropogenic activities along with weak banks on the western side pose a threat to the previously undisturbed lake. The lake is one of the chief tourist attractions of the city, as it enchants visitors with its peaceful environment, surrounded by green mountains. The Lake is likely to be formed from a tributary of the Budhibeta stream due to neotectonic activity. Deflection in the pathway of Chimpu and Senkhi streams, presence of numerous vertical faults, tri-angular facets and uplifted river terraces in the Itanagar area indicate neotectonism which created the Lake (Devi and Singh, 2006).

Sample Collection and analysis

Zooplankton samples were collected on the 3rd week of every month starting March 2019 for 1 year. Plankton net, Collection tube, Sampling bottles, 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 zooplankton are reported to be sensitive to temperature and move downwards or take refuge as the heat increases. Water sample for qualitative analysis of zooplankton fauna of Ganga Lake were collected by towing plankton net made of nylobolt silk having a mesh size of 50 µm for a quality collection of all the major groups of zooplankton. Samples were collected from five different locations around the perimeter of the Lake. Samples were collected both from littoral and limnetic zones of the lake. Aquatic vegetation in the sampling site was disturbed prior to plankton sampling to dislodge the associated planktons. 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 4-5% formalin. 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. 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. Then the plankton samples were studied with the help of foldscope for identification of different species of zooplanktons in the laboratory. The foldscope is an ultra-low-cost origami-based portable microscope, and it was used effectively to identify the various zooplankton species (Cybulski, Clements and Manu Prakash, 2014). The foldscope, developed by Cybulski, Clements and Manu Prakash at Stanford University can generate image with 2 µ resolution and 140X magnification. Zooplankton taxa were identified with the help of standard literature and other guides available on the internet (Edmondson, 1959, Tonapi, 1980 and Battish, 1992).

For the physicochemical analysis of water, chemicals as per American Public Health Association (APHA, 2005), Soil & Water analysis kit, Secchi disc, infrared thermometer, 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. Dissolved Oxygen (DO), transparency, pH, temperature, Turbidity, and conductivity for the samples were determined using water analysis kit and equipment's following standard procedures. The water sample was collected in BOD bottle carefully from five different selected study sites. Fixation was done on the spot using standard chemicals and Dissolved Oxygen content was determined by Winkler's method.

RESULTS

Along with zooplankton identification, a clear assessment of the quality of water in the lake was done during the study. The foldscope is found to be efficient in the identification of zooplanktons, at least

upto the genus level, though higher magnifications are required to look into minute details of the organisms. The following table shows the physico-chemical conditions of water in the lake:

Table 1: Physicochemical characteristics of water of Ganga Lake

Sl. No.	Parameters	Value
1.	Dissolved Oxygen Content (ppm)	11.2±2.81
2.	Transparency (cm)	104±5.3
3.	pH	7.5±0.35
4.	Temperature (^{0}C)	26.2±1.86
5.	Turbidity (NTU)	55±3.52
6.	Conductivity (mS)	0.06±0.01

The WHO has recommended maximum permissible limit of pH from 6.5 to 9.2. Thus, the pH of Ganga Lake being around 7.5 is found to be suitable for sustaining life in it. The DO content of Ganga Lake is found to be quite favourable for the aquatic organisms of the lake. Moreover, better conductivity, transparency and turbidity makes the quality of water fit for aquatic life. The lake water is reported to be alkaline and the littoral zone of the lake contains a plenty of aquatic macrophytes. Among the planktonic form phytoplankton has dominance. However, as the present study is primarily aimed at assessing the zooplankton population, the zooplankton species are taken into consideration.

Presence of abundant amount of zooplanktons as well as phytoplanktons also proves the better quality of water. The following species of zooplanktons were identified in our collection as listed in Table 2 below.

Table 2: List of Zooplankton species present in Ganga lake.

Sl. No.	Zooplankton Sp.	Group
1	*Amoeba sp*	***Protozoa***
2	*Arcella sp*	
3	*Ceratium sp*	
4	*Lecane sp*	***Rotifera***
5	*Keratella sp*	
6	*Testudinella sp*	
7	*Asplancha sp*	
8	*Trichocerca sp*	
9	*Brachionus sp*	
10	*Bosmina sp*	***Cladocera***
11	*Sida sp*	
12	*Ceriodaphnia sp*	
13	*Diaptomus sp*	***Copepoda***
14	*Neodiaptomus sp*	
15	*Nauplius sp*	
16	*Cyclops sp*	

A total of 16 genuses of zooplanktons comprising of 16 species belonging to 3 genera of protozoa, 6 genera of rotifera, 3 genera of cladocera and 4 genera of copepoda were observed during the present study. Various other minor populations of larval forms like larvae of may fly, dragon fly, stone fly, alder fly, chironomids, hemipteran bugs and water scorpions, whirling beetles, oligochaets and mollusks are the common macro invertebrates found in Ganga Lake.

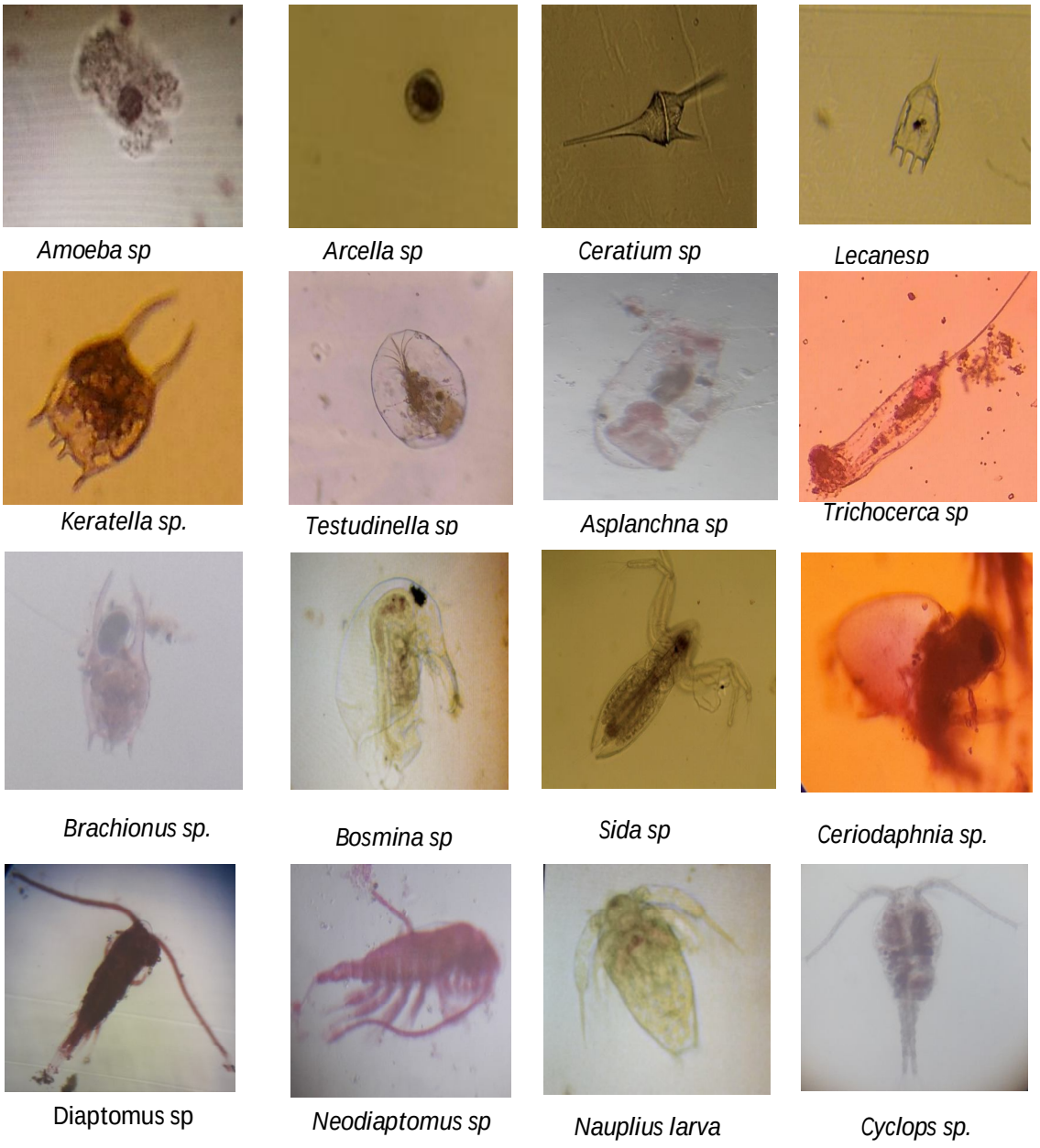

Figure 2: Photomicrograph of zooplankton species of Ganga Lake.

The following species of zooplanktons were identified during our research study in the Ganga Lake, amongst these 3 protozoans (*Amoeba sp., Arcella sp. and Ceratium sp.*), 6 rotifers (*Lecane sp. Keratella sp., Testudinella sp., Asplanchna sp., Trichocerca sp. And Branchionus sp.*), 3 cladocerans (*Bosmina sp., Sida sp. and Ceriodaphania sp.*) and 4 copepods (*Diaptomus sp., Neodiaptomus sp., nauplius larva and Cyclops sp.*

DISCUSSION

Favourable temperature and associated factors seem to be contributing to the healthy population of zooplanktons in the lake (Sinha and Islam, 2003, Rajagopal *et. al*., 2010). The DO content is found to be favourable when we correlate to certain studies in moderately polluted ponds in some other regions of India (Kumar, 2020). According to our study, Rotifera were found to be dominant followed by the other groups of zooplankton i.e., cladocerans and copepods. Though the rotifers, a minor phylum, constitute a very small group of animal kingdom, they are qualitatively and quantitatively the most abundant metazoans in inland waters. Also, the rotifers are widely available world-wide, occurring from the Arctic and the Antarctic regions to the Tropics (Sharma, 2001, Sunkad and Patil, 2004). The occurrence of Rotifers at higher species number and abundance indicatesbetter quality of the lake from limnological point of view. Rotifers comprise the vital part of an aquatic food chain and play a noteworthy role being a significant link between the nanoplankton and carnivorous zooplankton. They also play a significant role in cycling of organic material and form a significant component of diet of larval fish (Somani, Quadros and Pejaver, 2012). Rotifers usually feed on particulate organic matter, in addition to assimilating the dissolved nutrient substances from the adjacent water (Dhanpati, 2000). Their food consists of algae, dinoflagellates, bacteria and diatoms. Various previous studies also indicated the significance of rotifers as they are quantitatively dominant in many Indian Lakes (Somani, 2002). A previous study from the state of Arunachal Pradesh also showed rotifers to be the dominant group among zooplanktons of river Siang (Das and Kar, 2016). The copepod species were second highest in abundance, which indicates its moderately dominant status in the lake. The copepods by virtue of their predatory roles keep the population of large phytoplankton in check and release small phytoplankton from grazing pressure by protozoans and other competitors (Sommer and Sommer, 2006). The copepods structure the aquatic community by predation upon microzooplankton, resulting in a top-down effect of copepods on microzooplankton (Armengol, Franchy and Ojeda, 2017). The presence of second most dominant group in the lake, i.e., the copepods may be a significant factor contributing to the healthy status of this lentic ecosystem.

The presence of comparatively less number of cladoceran species indicates that the lake is still a long way away from acquiring dystrophic characteristics. It thus reinforces the status of fair ecological health of Ganga Lake. In certain studies, abundance of cladocerans has been used to study community structure to variable environments, especially dystrophic lakes in central Europe (Zawisza, Zawisza and Correa-Metrio, 2016).

CONCLUSION

This study was an attempt to identify the zooplanktons found in the Ganga Lake, and we were quite successful in identifying a few of them. Along with zooplanktons identification we could very well determine the quality of water in the lake. The DO content is quite favourable which indicates a healthy environment for the aquatic organisms of the lake. The permissible limit of pH from is also favourable as per recommendations of WHO. The pH of Ganga Lake is found to be suitable for sustaining life being around 7-8.

Moreover, the transparency of the lake is found to be favourable, which indicates the better quality of the water and hence fit for aquatic life. Presence of abundant amount of zooplanktons as well as phytoplanktons also proves the better quality of water.Still more information on the physico-chemical and biological characteristics of the lake are necessary for proper understanding and better management of the Ganga Lake which is not only beautiful but also has a great biodiversity. Identification of zooplankton species by origami based microscope, the foldscope showed presence of 16 genuses of zooplanktons. The organisms consisted of 3 genera of protozoa, 6 genera of rotifera, 3 genera of cladocera and 4 genera of copepoda were observed during the present study. Presence of more rotiferan species and comparative lesser cladocerans indicates the healthy status of the lake. Various other minor populations of larval forms, oligochaets and mollusks are the common macro invertebrates found in Ganga Lake. The study indicates that it is a self-sustained ecosystem with zooplanktons being one of the vital links in its food chain.The embankments on the north-eastern

direction of the lake need to be strengthened in order to overcome the threatened status of the lake. Further studies will help substantiate the present work on this elegant and ecologically significant lake of Itanagar.

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Conflict of Interest

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

REFERENCES

1. APHA, (2005). Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.
2. Adoni, A.D., Joshi, D.G., Chourasia, S.K., Vaishya, A.K., Yadav, M. and Verma, H.G., (1985). A workbook on limnology published by department of botany, Dr.Hari Singh Gaur Vishwavidyalaya, Sagar, M.P., India, pp.1–216.
3. Armengol, L., Franchy, G., Ojeda, A. et al. (2017). Effects of copepods on natural microplankton communities: do they exert top-down control? Mar Biol, 164: 136. https://doi.org/10.1007/s00227-017-3165-2.
4. Battish, S.K. (1992). Freshwater Zooplankton of India. Oxford and IBH Publishing Co., New Delhi, pp.1-233.
5. Cybulski, JS, Clements J, Prakash, M. (2014). Foldscope: Origami-Based Paper Microscope. PLoS ONE 9(6): e98781. https://doi.org/10.1371/journal. pone. 0098781
6. Das, B.K. and Kar, D. (2016). Diversity of Zooplankton in River Siang of Arunachal Pradesh, India, Fisheries and Oceanography Open Access Journal, 1(2): 001-005.
7. Datta Munshi, Jayashree & Datta Munshi, J.S., 1995. Fundamentals of Freshwater Biology; Narendra Publishing House, Delhi.
8. Devi, R.K.M., Singh, T., (2006). Morphotectonic setting of the Ganga Lake, Itanagar capital complex, Arunachal Himalaya,Geomorphology, 76(1-2): 1-11.
9. Dhanapati, M.V.S.S.S. (2000). Taxonomic notes on the Rotifers from India – FAAB Publication, Hyderabad, 175.
10. Dutta, Debajit&Sarma, Hari. P., (2015). Hydro Chemical Analysis of Surface Water Quality of Ganga Lake at Itanagar, Arunachal Pradesh; International Journal of Advance Research, IJOAR, 3(3): 1-8.
11. Edmondson, W., (1959). Rotifera. In W. T. Edmondson (ed.), Ward and Whipple's Freshwater Biology, 2nd ed. John Wiley and Sons, N.Y. pp.420–494.
12. Gang, R. K., Saksena, D. N., and Rao, R. J., (2006). Assessment of physicochemical water quality of Harsi reservoir, District Gwalior, Madhya Pradesh. Journal of Ecophysiology and Occupational Health, 6: 33–40.
13. Khwaja, S, Manish, V., Suresh, G., Chirag, G., Virendra, K. S., and Mohammad, D. H., (2014). Diel variations in limnological characteristics of Omkareshwar reservoir of Narmada River, India. Journal of Ecology and the Natural Environment, 6: 12–24. doi:10.5897/JENE2013.0371.
14. Kumar, V., (2020). Physico-chemical Analysis of Two Fresh Water Ponds of Hajipur, Vaishali District of Bihar.Bulletin of Pure and Applied Sciences. 39A (1): 137-142.
15. Rajagopal, T., Thangamani, A., Sevarkodiyone, S. P., Sekar, M., & Archunan, G. (2010). Zooplankton diversity and physico-chemical conditions in three perennial ponds of Virudhunagar district, Tamilnadu. Journal of environmental biology/Academy of Environmental Biology, India. 31: 265-72.

16. Sharma, B.K. (2001). Zooplankton diversity: Freshwater Planktonic and Semi-planktonic Rotifera. In: Water quality assessment, Biomonitoring and Zooplankton diversity (Ed. B. K. Sharma). 190-215. Department of Zoology, North-Eastern Hill University, Shillong.
17. Sharma, D., Das, D.N., Dutta, R., Baruah, D., Kumar, P., Tyagi, B.C. & Mahanta, P.C., (2012). Coldwater Lakes and Rivers of Arunachal Pradesh, India; Directorate of Coldwater Fisheries Research (Indian Council of Agricultural Research).
18. Sharma, H. Traditional beliefs as conservation tools: The Galo's of Arunachal Pradesh, Eastern Himalayas, India, (2020). Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences, 6(2): 73-83.
19. Sinha, B. & Islam, M.R., (2003). Seasonal Variation in Zooplankton Population of two Lentic Bodies at Assam State Zoo cum Botanical Garden, Guwahati, Assam; Eco., Env. & Cons. 9 (3): 391-397.
20. Sinha, B &Tamang, L, (2012). Fish Diversity of Ganga Lake in Itanagar, Arunachal Pradesh; bulletin of Arunachal Forest Research, Vol. 28 & 29 Nos. 1& 2: 7-11.
21. Somani, V.U. (2002). Ecological Studies on Kacharali and Masunda Lakes of Thane city with reference to bacterial treatment of Kacharali for Lake Beautification., Ph.D. Thesis University of Mumbai., 242.
22. Somani, V., Quadros, G. & Pejaver, M. (2012). Occurrence of Rotifers and its Relation to the Water Quality during the Bioremediation process in Lake Kacharali, Thane, MS, India. ISCA Journal of Biological Sciences. 1: 2278-3202.
23. Sommer, U and Sommer, F. (2006). Cladocerans versus copepods: the cause of contrasting top–down controls on freshwater and marine phytoplankton. Oecologia, 147: 183-194.
24. Sunkad B.N. and Patil H.S. (2004). Water quality assessment of Fort lake of Belgaum (Karnataka) with special reference to Zooplankton, J. Environ. Biol., 25(1): 99–10.
25. Tonapi, G. T., (1980). Fresh water animals of India an ecological approach.Oxford and I BH Publ. Co. New Delhi, 314-315.
26. Zaher, D, Salma K.M., Houda, S., Marc Pagano, Marc Tedetti, *et al*., (2018). Water quality affects the structure of copepod assemblages along the Sfax southern coast (Tunisia, southern Mediterranean Sea). Marine and Freshwater Research, CSIRO Publishing, 69 (2): 220-231.
27. Zawisza, E, Zawiska I, Correa-Metrio, A. (2016). Cladocera community composition as a function of physicochemical and morphological parameters of dystrophic lakes in NE Poland. Wetlands, 36: 1131–1142.