PAKISTAN JOURNAL OF EMERGING SCIENCE AND TECHNOLOGIES (PJEST)

December, 2022, 3(2) ISSN 2788-8630 (On-Line)

IMPACTS OF PHYSICOCHEMICAL PARAMETERS ON ZOOPLANKTON BIODIVERSITY RECORDED FROM SAFARI ZOO LAKE LAHORE, PUNJAB, PAKISTAN

NAVEED AKHTAR[1], SARA HAYEE[2], FAHEEM NAWAZ[3], AMIR NADEEM[4]*, ABDUL QAYYUM KHAN SULEHRIA[5], FARAH ASHFAQ[6]

[1]Department of Zoology, Government Graduate College for Boys, Pattoki, Kasur.

[2&6] Department of Zoology, Government Graduate College for Women, Samanabad, Lahore.

[3] Department of Zoology, Government Khawaja Rafique Shaheed College for Boys, Lahore.

[4&5] Department of Zoology, Government College University, Lahore.

*Correspondence: amir679@yahoo.com

ARTICLE INFORMATION

Crossref DOI: https://doi.org/10.56819/pjest.v3i2.75

Received: 24th-Dec-2022

Revised and Accepted: 20th -January-2023

Published On-Line 21th-January-2022

***Corresponding Author:**
amir679@yahoo.com

Original Research Article

ABSTRACT

Zooplanktons are an integral part of any water reservoir, whether freshwater or marine. They are linked in food chains and the food web of a water ecosystem. Some zooplanktons are food for other zooplankton types. The diversity and density of these creatures are affected by eutrophication and changes in Physico-chemical parameters. Some species of zooplanktons are found in eutrophic water bodies. They are important bio-indicators, and their presence reflects the eutrophic condition of any water body. These organisms have a worldwide distribution, playing a pivotal role in shaping the whole community structure of any water reservoir and unfolding the close connections of various trophic levels. The present study explores the density and diversity of various types of zooplankton found in Safari Zoo Lake, Lahore. The study on an artificial lake with lesser water replacement pictured different zooplankton groups, including copepod, tintinnids, cladoceran and rotifers with many larger animals, which affected the overall zooplankton population. Since Physico-chemical parameters also affect the density and diversity of zooplankton, water samples were collected to measure various parameters every month. A very low density and diversity of zooplanktons were recorded during this study, where rotifers were the most abundant. The lake condition showed eutrophication getting support from bio-indicator species like *Brachionus calyciflorus*.

Keywords: Eutrophication, Physico-chemical parameters, Bio-indicator

Introduction:

Zooplanktons are water-floating microorganisms and are also known as drifters [1]. The Zooplankton community is cosmopolitan. They are present in all freshwater habitats, and their density and diversity show variety in the whole community [2]. Zooplanktons are essential in preserving aquatic ecological units [3]. In aquatic habitats, zooplanktons play a vital role in energy transfer among different trophic levels [4]. Zooplanktons can be studied for their species composition, and their pattern of changes in species composition explores the relationship between micro-invertebrate and fish in a water body. They act as bio-indicators, are the markers

to determine water quality, and are an integral part of the carbon cycle. They are the foundation of aquatic food chains [5 & 6]. All biotic factors shape a community's vibrant nature [7].

Three main groups usually found in water bodies include Copepods, Rotifers and Cladocerans. Among these groups, rotifers are mainly the more diverse, abundant and rich group [8]. Zooplanktons have hundreds of types; the members of phylum Rotifera are cosmopolitan in distribution and reported from all significant freshwater reservoirs [9]. Copepods are one of the representative zooplankton groups, which are primary consumer playing a crucial role in cycling energy and nutrients [10]. Copepods are the bio-indicators of water quality and are essential to water communities [11]. Cladocerans are the meso-zooplanktons like copepods. These organisms have about 700 species [12]. Cladocera belongs to a group of crustaceans which are worldwide in their distribution. Cladocera show sensitivity to pH changes and also indicate eutrophication [13]. Tintinnids are ciliated micro-zooplanktons also covered with a specific shell called lorica, which may be of many shapes [14]. Tintinnids are tiny organisms that link nano and micro-planktons [15]. Our study aims to explore the types, density and diversity of zooplanktons found in an artificial lake. For this purpose, the Safari Zoo Lake of Lahore city was selected. Correlating and analysing main zooplankton groups and artificial lake physico-chemical factors made this study relevant.

Materials and Method:

The research was carried out in a freshwater lake in Safari Park, Lahore. The study was carried out to obtain all possible types of zooplanktons.

Study Area:

Woodland Wildlife Park, also known as Lahore Zoo Safari, opened to the public in 1982 for entertainment. In 1996, it first welcomed visitors for recreational use. The park's location is at Raiwind Road in the Lahore district, and it spans an expansive 242 acres. Geographically, the park is situated at a latitude 31°22′57″ N and a longitude of 74°12′51″ E. Our study site is an artificial oval-shaped lake biggest in size among all lakes in the whole city. It has five islands. It was 7 feet (2.134 m) deep, covering an area of 5 acres (20234 sq. meters). The average temperature of the park was 29.40 ˚C. The average rainfall of this region was 838.8 millimetres (33.02 inches) (Fig. 1).

Fig. 1: Map of Safari Zoo Lake (Aerial View), Lahore. Courtesy: Google Maps

Sampling Sides, Duration and Time:

The whole lake was divided into four sampling sides named Eastern Side (E.S.), Western Side (W.S.), Southern Side (S.S.) and Northern Side (N.S.). The sampling duration was about one year, i.e. from 2020 to 2021. The samples were taken once from all sides between 09:00 am to 11:00 pm per month.

Zooplankton Sample Collection, Counting and Identification:

In the present study, zooplanktons were collected by using two different methods. While rowing a boat in the lake water, a zooplankton net was dipped horizontally for about five minutes. Zooplankton net was used for the Zooplankton collection. This net was made of a fine mesh size of 37µm and was fixed on a circular framework of 30 cm diameter. Zooplankton samples were kept safe in 4 % formalin solution and Tarson 100 ml plankton tubes [16, 17 &18]. Quantitative analysis was done by using the Sedgewick-Rafter chamber. For the identification of diverse zooplankton fauna, different available keys were followed [19, 20, 21, 22 and 23]. LEICA HC 50/50 microscope with a 5.0- megapixel Cannon camera was used to take up photographs of collected zooplankton for the record. The total count of each group of zooplankton was done by using the formula given below:

$$\text{Number/ml} = C \times 1000\ mm / L \times D \times W \times S$$

C = Number of organisms counted

L = Length of the strip (Sedgwick- Rafter cell length) mm

D = Depth of the strip (S-R cell length) mm

W = Width of a strip in mm

S = Number of strips counted

$$V1 = (50)\ (1)\ (W) = mm^3$$

Water Sampling and Physico-chemical Parameters:

Physico-chemical parameters were also studied, and water samples for this purpose were collected separately [24]. The sampling bottles were dipped in dilute acid (HCl), washed with distilled water and dried in air. Before sample collection, collectors rinsed all bottles with lake water. The following physicochemical parameters were recorded with the respective meters on the spot (Table 1).

Table 1: Meters used to observe physic-chemical parameters.

Parameters Observed	**Meter Used**
Temperature (Air and water)	Thermometer (Hanna HI98501)
Dissolved Oxygen (Water)	Oxygen Meter (Hanna HI98193)
Oxygen Saturation (Air)	Oxygen Meter (Hanna HI98193)
Electrical Conductivity (water)	EcoSense (EC300A)
pH of water	Potentiometric pH meter (Hanna HI8424)
Salinity (Water)	Salinity Meter (Hanna HI98319)
Water transparency	Measurement tape with Secchi disc
Water turbidity	Turbidity Portable Meter (Hanna HI-98703)

Statistical Analysis:

ANOVA was used in Minitab 13 to evaluate physico-chemical parameters. Graphs were plotted using OriginPro (8.5) 2018. Abundance curves were plotted for species of all the groups separately using Past Software.

Results

The present study recorded four zooplankton groups from various lake sites, including rotifers, copepods, cladocerans and tintinnids. A total of twenty-nine species were obtained, belonging to sixteen different genera. A pie chart has been plotted to show the abundance of each group. There were fourteen rotifers species contributing 51.16 % of the total collection. Copepoda was of eight other species, contributing 27.91 %. The number of species of Cladocera

and tintinnids was four and three, respectively. Both these groups counted 13.95 % and 6.98 % of zooplankton, respectively (Fig. 2). Species of phylum Rotifera are the most abundant zooplankton in the present study. *Brachionus calyciflorus* is the most abundant species among all rotifers. *Lecane luna*, a rotifer, is the least available species in lake water. Among cladocera, the most richly found species was *Daphnia longispina*. *Moina micrura* was the least available species. *Tintinnopsis sinensis* was the most, and *Tintinnopsis subpstilum* was the least abundant tintinnid. For copepods, *Dicyclops thomasi* showed the highest, while *Calanus austrilis* showed the lowest numbers (Table 2). All species were photographed (Fig. 3). The species abundance curves explored different species of each group according to their quantity. The abundant specie of each group was on top, while the least in number were on the lowest sides of the curves. The remaining species lie in between (Fig. 5).

Table 2: Zooplankton Species obtained from Safari Zoo Lake Lahore.

Species of Cladocera	**Species of Copepoda**	**Species of Rotifera**	**Species of Rotifera**	**Species of Tintinnids**
Bosima longirostris	*Acanthocyclops virdis*	*Brachionus angularis*	*Cephalodella exhigua*	*Tintinnopsis sinensis*
Chydorus reticulatus	*Calanus austrilis*	*Brachionus bidentatus*	*Cephalodella gibba*	*Tintinnopsis subpstilum*
Daphnia longispina	*Dicyclops bicuspidatus*	*Brachionus calyciflorus*	*Keratella cochlerais*	*Tintinnopsis wangi*
Moina micrura	*Dicyclops namus*	*Brachionus diversicornis*	*Keratella valga*	
	Dicyclops thomasi	*Brachionus forficula*	*Lecane luna*	
	Eucyclops pheleratus	*Brachionus quadridentatus*	*Polyarthra dolicoptera*	
	Macrocyclops fuscus	*Brachionus sericus*		
	Mesocyclops vericans	*Brachionus urceus*		

Variations were observed among all measured parameters during the study period. Although one parameter, i.e. salinity, was unchanged. It showed a mean value of 0.18. No significant change in any parameter was observed. The water was turbid. Electrical conductivity was much elevated. For each parameter, mean and standard error mean values were calculated (Table 3) (Fig. 4).

Table 3: Mean ± SEM of various physico-chemical parameters recorded from the Safari Zoo Lake, Lahore.

Physico-chemical Parameters	**Mean± Standard Error Mean**	**Analysis of Variance (ANOVA)**	
Temperature (Air) (˚C)	29.40±1.73	F=45.27,	P=0.000
Temperature (water) (˚C)	25.51±1.73	F=28.43,	P=0.000
Dissolved Oxygen (Water)(mg/dl)	12.34±0.58	F=3.40,	P=0.050
Electrical Conductivity (µs/cm)	535.7±3.79	F=8877.43,	P=0.000
Oxygen Saturation (Air)(mg/l)	4.12±0.65	F=2.10,	P=0.490
pH of water	7.56±0.22	F=0.40.28,	P=0.000
Salinity (water) (ppt)	0.18±0.01	F=16.13,	P=0.001
Water transparency (Inches)	2.37±0.14	F=8.71.27,	P=0.005
Water turbidity (FTU)	290.5±9.13	F=43.30,	P=0.001

Along with zooplankton species, non-zooplankton organisms were also observed on various sides of the lake. Fish and macrophytes were numerous. Phytoplanktons and mosquito larvae were abundant. Tadpole larvae, fish fry, frogs and freshwater mussels were present to a lesser extent. Water fowls like ducks were also observed on different sides (table 4).

Table 4: Biotic Components (non-zooplankton) of Safari Zoo Lake Lahore.

Biotic Components	**Sides**			
	E.S.	**W.S.**	**N.S.**	**S.S.**
Adult Fish	+	+	++	+
Fish Fry	+	+	+	+
Frog	+	+	+	+
Freshwater Mussel	+	+	+	+
Macrophytes	++	+	+	+
Mosquito Larvae	+	++	++	++
Phyto-planktons	+++	++	+++	++
Tadpole Larvae	+	+	+	+
Ducks	++	++	+	++

Key= Eastern Side (E.S.); Western Side (W.S.); Southern Side (S.S.); Northern Side (N.S.); Abundant (+++); Numerous (++); Lesser (+)

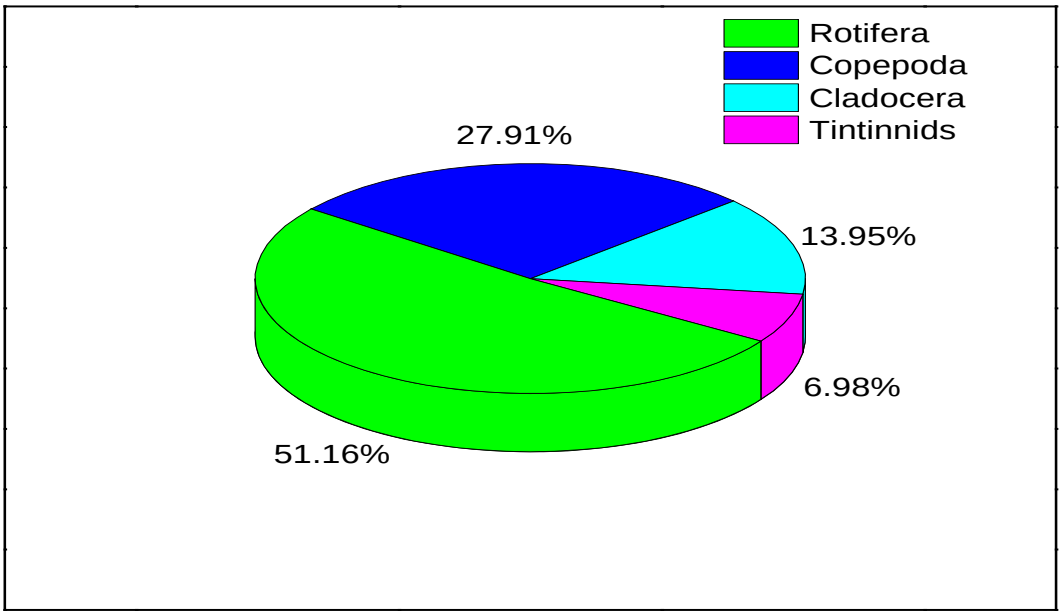
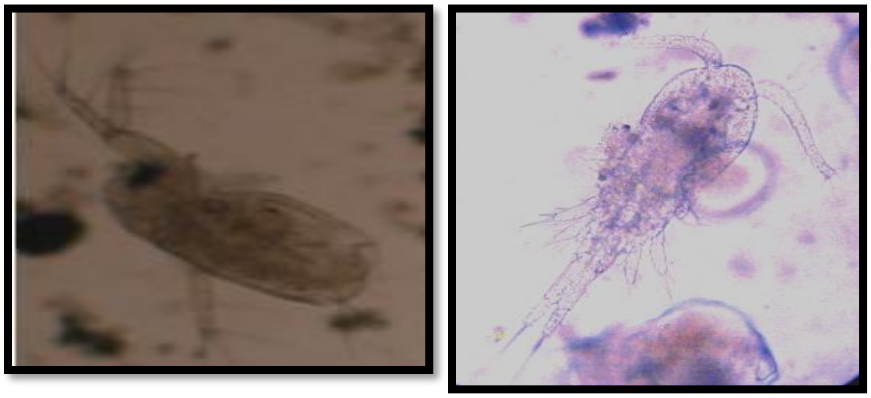
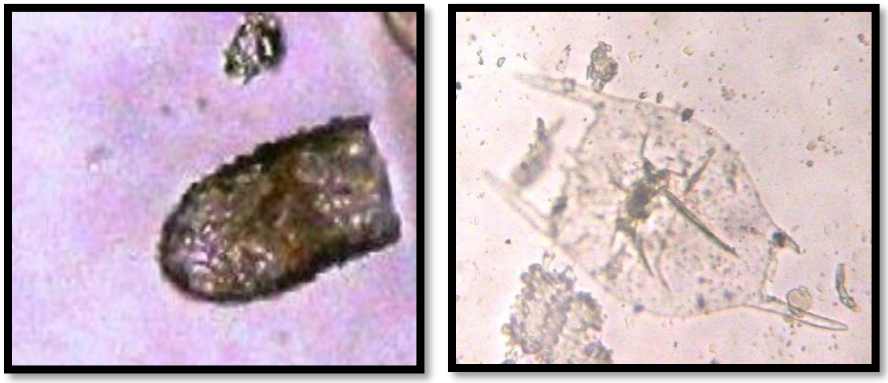


Fig. 2: The percentage share of all major zooplankton groups recovered from Safari Zoo Lake, Lahore.



Moina micrura *Diacyclops bicuspidatus*



Tintinnopsis sinensis *Brachionus diversicornis*

Fig. 3: Pictures of some zooplankton species obtained from the lake.

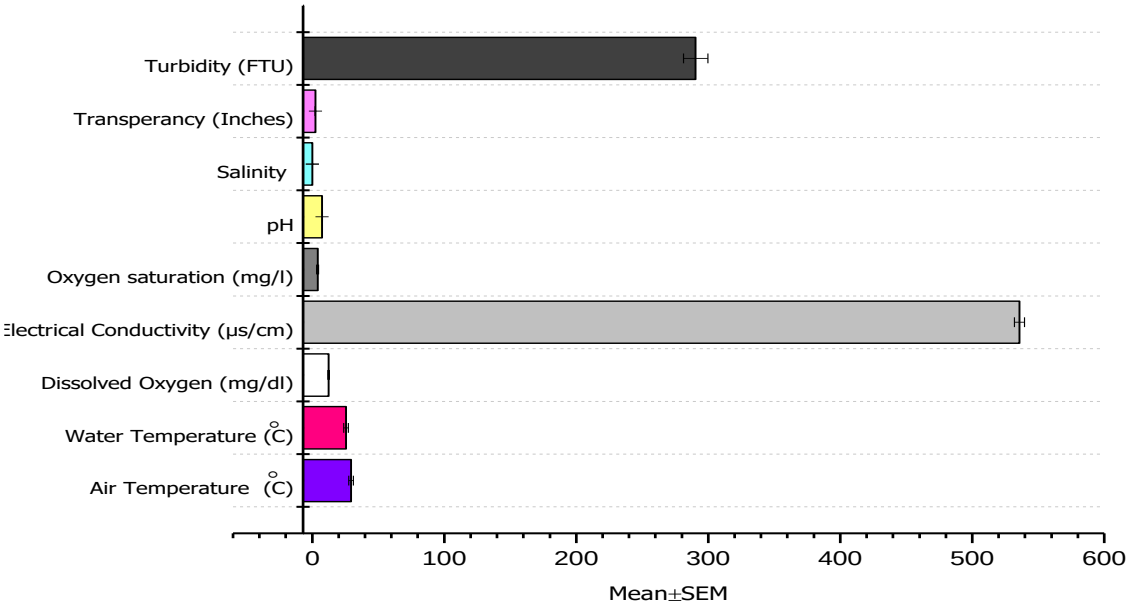


Fig. 4: Mean ± SEM of physicochemical parameters.

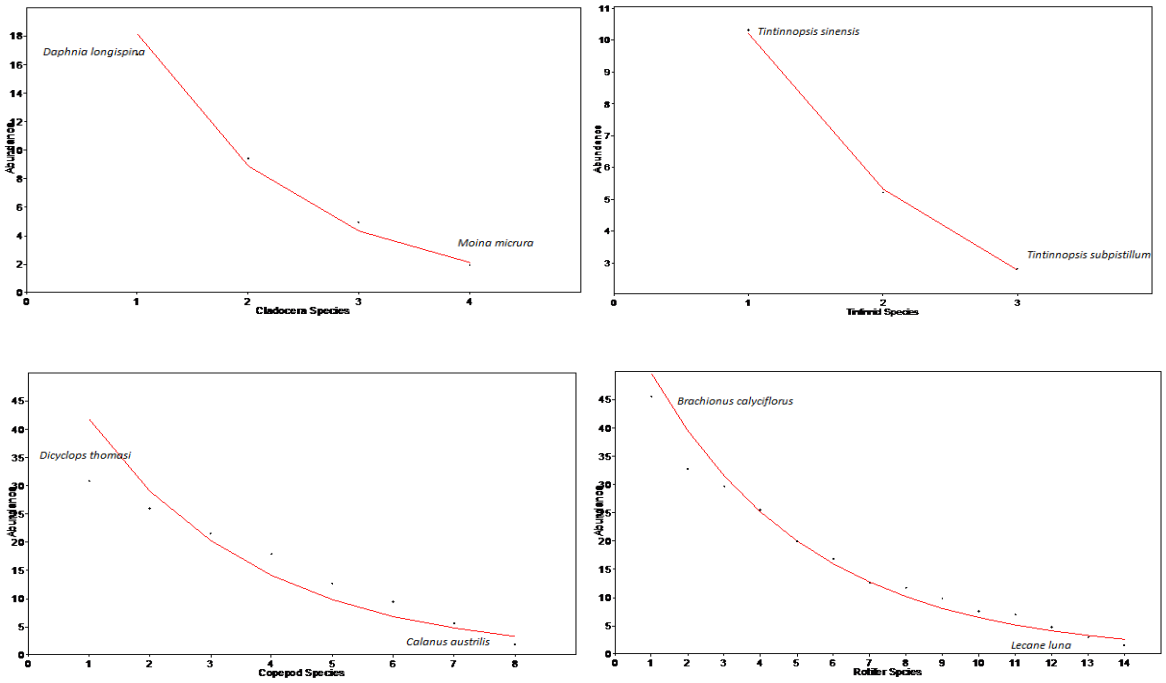


Fig. 5: Species abundance curves of zooplankton Groups (Cladocera, tintinnds, copepoda and rotifera showing the number of most and least abundant species).

Discussion

The present study reveals the eutrophic condition of Safari Zoo Lake. It is because of the presence of zooplankton species which are bio-indicator of eutrophication, like *Brachionus calyciflorus*, *Daphnia longispina* and *Dicyclops thomasi* etc. In a previous publication, *Brachionus calyciflorus* and *Daphnia longispina* have been reported as preferring eutrophic conditions species [25]. Overall, moderate abundance was observed for different zooplankton species. Among all types, rotifers were the most abundant (51.16%). The second most abundant species were from copepoda. This result gets support from a study showing that rotifers were 41% of the total zooplankton community [26]. Tintinnids are delicate ciliated organisms which contain a thick lorica. They were observed from December to February. They were obtained only in three months, which shows their seasonal presence. It indicates that this group of organisms prefers low temperatures [18]. Therefore, these were the least abundant organisms and only three species were obtained in our study.

The water added to the lake was only through rainwater or a small tube well. So, the addition of fresh water was a slow process. The temperature usually affects other properties of water. The mean values were 29.40 ˚C (air) and 25.51 ˚C (water). The increase in the temperature of waterbody favours the zooplankton community to achieve higher metabolic rates, which in turn helps them activate their reproductive behaviour. Lower dissolved oxygen levels lead to hypoxic conditions, affecting the abundance of zooplanktons. Lake water usually has electrical conductivity between 0-200 (µs/cm). Electrical conductivity was much high in the present study (535.7 µs/cm). The pH value was alkaline in most of the months. Increased turbidity and salinity in water negatively affect zooplanktons, especially copepods [27]. It increases the death rate of copepods. The lake was also a habitat of biotic components, including fish, fish fry, frogs, mosquito larvae, and water-fowls. The presence of some reptiles was also observed on the islands of the lake. Many of these organisms were contributing faecal waste to lake water. Solid waste was also noticed in the lake water, like wrappers, shopping bags, bottles and leftover eatables etc., thrown by the general public coming to this lake for boating.

Conclusion

The zooplanktons obtained in the present study are rotifers, cladocera, copepods and tintinnids. Except for tintinids which prefer the winter season, all zooplanktons were obtained each month. Rotifers, copepods and cladocera are more interlinked with one another as they compete for common food sources. It is concluded that the presence of zooplankton in the Safari Zoo Lake was affected by physico-chemical parameters, which resulted in lower diversity. The lake was in a eutrophic state. Solid waste contributed by people coming for boating was a major reason for the eutrophic condition of lake water. Lake water was affected by public use because of improper waste dumping. Water replacement depended on rainwater and a small tube well which was not enough for this purpose. Many water bodies that are aquatic life habitats are being used for recreational purposes. These water bodies should be studied to explore more about human impact. The present study is a step towards exploring water bodies with recreational values.

Author's Contribution:

A.Q.K.S. conceived the idea and designed the research work; N.A. & S.H. performed the lab work, made all collections, acquired data and wrote the basic draft; F.N. & F.A. executed data analysis and interpretation of data; A.N. did the language and grammatical edits or Critical revision. A.N. did all the correspondence.

Funding: The publication of this article was funded by no one.

Author's Conflict: Authors declare no conflict of interest.

Acknowledgement: The authors of this study are thankful to the Chairperson of the Zoology Department, Government College University, Lahore.

REFERENCES

[1] H. Song et al., "Classification of freshwater zooplankton by pre-trained convolutional neural network in underwater microscopy," International Journal of Advanced Computer Science Applications, vol. 11, no. 7, pp. 252-258, 2020.

[2] D. Golmarvi, M. F. Kapourchali, A. M. Moradi, M. Fatemi, and R. M. Nadoshan, "Study of Zooplankton Species Structure and Dominance in Anzali International Wetland," Open Journal of Marine Science, vol. 8, no. 2, pp. 215-222, 2018, doi: 10.4236/ojms.2018.82011

[3] P. Lertvilai, "The In situ Plankton Assemblage eXplorer (IPAX): An inexpensive underwater imaging system for zooplankton study," Methods in Ecology and Evolution, vol. 11, no. 9, pp. 1042-1048, 2020, doi: 10.1111/2041-210X.13441

[4] S. M. Pawar and V. B. Supugade, "Zooplankton Diversity and Density in Some Freshwater Bodies around Satara (MS) India," International Journal of Researches in Biosciences, Agriculture and Technology, vol. 5, no. 3, pp. 49-51, 2017.

[5] J. Dai, R. Wang, H. Zheng, G. Ji, and X. Qiao, "ZooplanktoNet: Deep convolutional network for zooplankton classification," in OCEANS 2016-Shanghai, 2016, pp. 1-6: IEEE, doi: 10.1109/OCEANSAP.2016.7485680

[6] H. Zheng, R. Wang, Z. Yu, N. Wang, Z. Gu, and B. Zheng, "Automatic plankton image classification combining multiple view features via multiple kernel learning," BMC Bioinformatics, vol. 18, no. 16, p. 570, 2017, doi: 10.1186/s12859-017-1954-8

[7] P. Das, S. Kar, U. Das, M. Bimola, D. Kar, and G. Aditya, "Day time variations of zooplankton species composition: observations from the wetlands of Assam, India," Acta Limnologica Brasiliensia, vol. 32, p. e10, 2020, doi: 10.1590/S2179-975X1418

[8] B. Hu et al., "Seasonal and inter-annual community structure characteristics of zooplankton driven by water environment factors in a sub-lake of Lake Poyang, China," PeerJ Life & Environment, vol. 7, p. e7590, 2019, doi: 10.7717/peerj.7590

[9] F. Leasi and W. H. De Smet, "Thalassic rotifers from the United States: descriptions of two new species and notes on the effect of salinity and ecosystem on biodiversity," Diversity, vol. 12, no. 1, p. 28, 2020, doi: 10.3390/d12010028

[10] J. Ismail et al., "Zooplankton species composition and diversity in the seagrass habitat of Lawas, Sarawak, Malaysia," Biodiversity Data Journal, vol. 9, p. e67449, 2021, doi: 10.3897/BDJ.9.e67449

[11] A. Maqbool, A. Q. K. Sulehria, M. Ejaz, and A. Hussain, "Density, diversity and abundance of copepods in a pond," Biologia, vol. 60, no. 1, pp. 57-62, 2014.

[12] D. Bedikoğlu, I. N. Yilmaz, and N. Demirel, "Reproductive strategies and population characteristics of key Cladocera species in the Sea of Marmara," Regional Studies in Marine Science, vol. 54, p. 102450, 2022, doi: 10.1016/j.rsma.2022.102450

[13] H. J. Dumont, A. Pociecha, E. Zawisza, K. Szeroczyńska, E. Worobiec, and G. Worobiec, "Miocene cladocera from Poland," Scientific Reports, vol. 10, no. 1, p. 12107, 2020, doi: 10.1038/s41598-020-69024-9

[14] M. Monti-Birkenmeier, T. Diociaiuti, P. Castagno, G. Budillon, and S. Fonda Umani, "Pluridecadal Temporal Patterns of Tintinnids (Ciliophora, Spirotrichea) in Terra Nova Bay (Ross Sea, Antarctica)," Diversity, vol. 14, no. 8, p. 604, 2022, doi: 10.3390/d14080604

[15] J. A. Santiago and M. C. Lagman, "Species check-list for Tintinnids of the Philippines Archipelago (Protozoa, ciliophora)," ZooKeys, no. 771, pp. 1-14, 2018, doi: 10.3897/zookeys.771.24806

[16] W. Koste, Rotatoria. Die Radertiere Mittel-europas, 2nd ed. Gebruder Borntraeger, Berlin and Stuttgart: V. 1, text, 673 p.; V. 2, plates, 476 p. DM238., 1978.

[17] A. Q. K. Sulehria, Z. S. Mirza, A. Hussain, M. Faheem, and N. Zafar, "Community structure of epiphytic rotifers of a floodplain," Biologia, vol. 58, no. 1&2, pp. 1-12, 2012.

[18] S. Hayee, N. Akhter, K. Hanif, F. Nawaz, and A. Q. K. Sulehria, "An assessment of zooplankton community and physico-chemical parameters of safari zoo lake, Lahore," FUUAST Journal of Biology, vol. 11, no. 1, pp. 29-35, 2021.

[19] H. B. Ward, G. C. Whipple, and W. T. Edmondson, Fresh-water Biology, 2nd ed. John Wiley and Sons. New York and London, 1959.

[20] R. W. Pennak, Fresh-water invertebrates-of the United States, 2nd ed. John Wiley and Sons, New York, 1978, p. 803.

[21] R. G. Michael and B. K. Sharma, Indian Cladocera (Crustacea: Branchiopoda: Cladocera). Zoological Survey of India. Calcutta, 1988.

[22] K.-I. Yoo, Y.-O. Kim, and D.-Y. Kim, "Taxonomical studies on tintinnids (Protozoa: Ciliata) in Korean coastal waters. 1. Chinhae Bay," Korean Journal of Systematics Zoology, vol. 4, no. 1, pp. 67-90, 1988.

[23] H. Segers, "Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution," Zootaxa, vol. 1564, no. 1, pp. 1–104, 2007, doi: 10.11646/zootaxa.1564.1.1

[24] W. Federation and A. Association, Standard methods for the examination of water and wastewater, 21st ed. (American Public Health Association(APHA)). Washington, DC, USA, 2005.

[25] E. Zawisza, I. Zawiska, and A. Correa-Metrio, "Cladocera Community Composition as a Function of Physicochemical and Morphological Parameters of Dystrophic Lakes in NE Poland," Wetlands, vol. 36, no. 6, pp. 1131-1142, 2016, doi: 10.1007/s13157-016-0832-x

[26] S. S. Abbai and B. N. Sunkad, "Effect of anthropogenic activities on zooplankton population of Sogal pond, Belgaum District, Karnataka, India," Research Journal of Recent Sciences, vol. 2, no. 7, pp. 81-83, 2013.

[27] I. Vuorinen, J. Hänninen, M. Viitasalo, U. Helminen, and H. Kuosa, "Proportion of copepod biomass declines with decreasing salinity in the Baltic Sea," ICES Journal of Marine Science, vol. 55, no. 4, pp. 767-774, 1998, doi: 10.1006/jmsc.1998.0398