

ECOLOGY, DIVERSITY AND WATER-QUALITY RELATIONSHIPS OF ZOOPLANKTON IN THE GANGA RIVER AT BHOJPUR, INDIA

Abhilasha Kumari¹, Punam Kumari², Mohita Sardana^{3*}, Neha Singh⁴

^{1,2}Department of Zoology, Veer Kunwar Singh University, Bhojpur – 802 301, India

^{3*}Department of Zoology, Veer Kunwar Singh University, Bhojpur – 802 301, India,

Department of Zoology, A. N. College, Patna – 800 013, India.

⁴Department of Zoology, A. N. College, Patna – 800 013, India.

*Corresponding author: Mohita Sardana, email: mohita.sardana23@gmail.com

ABSTRACT

This study evaluated the limnology and zooplankton of the Ganga River at Bhojpur, Bihar, India, from August 2024 to July 2026. We measured limnological parameters and corresponding biodiversity indices. Water temperature showed a negative relationship with pH, dissolved oxygen, total alkalinity, and hardness, while a direct relationship with electrical conductivity, total dissolved solids, chloride, nitrate, and phosphate. We identified 24 genera of zooplankton, including 7 Rotifera, 5 Protozoa, 5 Cladocera, 4 Copepoda, and 3 Ostracoda, ranging from 05 to 247 ind./L. The analysis showed that zooplankton density declined in post-monsoon and remained highest in summer due to the water body's environmental and inflow characteristics. Density also showed a positive relationship with electrical conductivity, total dissolved solids, chloride, nitrate, and phosphate, but a negative correlation with water pH, dissolved oxygen, total alkalinity, and hardness. The Shannon-Wiener index, Simpson indices, Pielou's evenness index, Menhinick's index, and Margalef richness index assess zooplankton and the limnological profile. The diversity indices indicated moderate to high diversity and moderately polluted conditions.

KEYWORDS: Bhojpur; Biodiversity Indices; Physicochemical Parameters; River Ganga; Zooplankton.

INTRODUCTION

The physicochemical parameters are affected by variations in water distribution, abundance, and diversity of plankton.¹ The assessment of the diversity and abundance of the community structure of the plankton is necessary to assess the potential fishery resource of an aquatic body.^{2,3} Plankton diversity is therefore considered an important ecological parameter because of its fundamental role in aquatic food chains and energy transfer.

Among plankton, zooplankton have several advantages as indicators of environmental quality in water bodies.⁴ Zooplankton distribution shows wide spatio-temporal variations because of the various limnological factors affecting individual species. They act as indicators, as shown by studies on zooplankton from the River Ganga and River Tons.^{5,6} Zooplankton convert plant protein into animal protein in aquatic bodies.⁷

Zooplankton diversity refers to variety within the community and is one of the most important ecological parameters for phytoplankton and fish. Generally, species/genera richness indices are considered the best indicator of biodiversity.⁸⁻¹⁰ Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda dominate freshwater zooplankton. Protozoans generally possess limited locomotory ability, although their mobility varies among taxa; however, others move in quiescent water.

Despite the ecological importance of zooplankton, information on its quantitative characteristics in relation to physicochemical parameters and biodiversity remains scarce in the Bhojpur region.¹¹ Hence, an attempt has been made to study ecology, diversity, and water quality relationships of zooplankton of the Ganga River, Bhojpur. The study is expected to provide baseline information on the ecological status, seasonal dynamics, and condition of the river ecosystem, thereby providing an understanding of its biological productivity and potential fishery resources.

MATERIALS AND METHODS

Three replicates of water samples were collected fortnightly from three sampling stations: Mahuli, Shivpur and Sinha along the Ganga River from August 2024 to July 2026. Water runoff and sewage from the surrounding catchment area enter the river and degrade its quality. The climate of Bhojpur (25033'21.7584" N and 84039'37.1952" E) district is healthy; the district is in a drier part of India, with annual rainfall of 1155.00 mm.

Water temperature and pH were assessed at the time of sampling using digital pH meter. Electrical conductivity, total dissolved solids, dissolved oxygen, total alkalinity, hardness, chloride, nitrate and phosphate were determined following standard methods.¹² Seasonal variations were observed during summer (March to May), monsoon (June to August), post-monsoon (September to November) and winter (December to February).

Zooplankton were collected by horizontal hauls at a depth of about 1.00 m for 5-10 minutes using a silk net with a mouth area of 0.0855 m² and mesh size 0.02 mm. Zooplankton were transferred to 100 mL plastic bottles and fixed with 10% formalin. A stereoscopic microscope and an Olympus FX 100 microscope were used to observe plankton, and standard keys were used for identification.¹³ Sedgwick rafter was used for cell counting.¹⁴

Data were analyzed for correlation in Microsoft Excel 2007, while Diversity indices were calculated using Prism 5.

RESULTS AND DISCUSSION

Indian freshwater rivers are increasingly affected by contamination resulting from pollution, industrial effluents, and toxic substances, posing serious threats to the aquatic life and ecological integrity that these rivers once sustained. In this context, the physicochemical parameters of the Ganga River at Bhojpur exhibited marked spatial and temporal variations, reflecting changes in environmental conditions and the influence of anthropogenic activities.

Table 1: Physicochemical parameters of water of Ganga River, Ara during 2024-2026

Month	Water Temperature (°C)	pH	Electrical Conductivity (µs/cm)	Total Dissolved Solids (mg/l)	Dissolved oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)
Summer (March-May)	30.5±2.05	7.5±0.15	1326.6±37	663.3±21.5	7.47±0.21	387.2±29.68	397±8.54	45.35±1.77	3.0±0.28	6.33±0.57
Monsoon (June-August)	32.6±2.16	7.27±0.14	1349.33±82.59	664.67±24.19	7.43±0.42	354.33±20.50	354±58.92	23.3±12.80	2.7±0.58	6.67±0.25
Post-Monsoon (Sept.-Nov.)	27.3±2.36	7.6±0.11	1255.3±15.01	524.6±33.31	8.2±0.21	409.67±18.90	429±10.0	14.15±4.48	2.18±0.70	6.0±0.2
Winter (Dec.-Feb.)	22.9±1.80	7.83±0.06	1185±35.59	521±72.27	8.57±0.25	487±57.86	498.67±90.89	34.46±8.86	2.11±0.78	5.3±0.17
Average	28.3417±3.72	7.56±0.23	1279.08±79.32	593.417±82.33	7.925±0.56	409.583±59.26	419.667±72.16	29.3217±14.08	2.5225±0.66	6.075±0.60

The water temperature was higher in summer and lower in winter because of seasonal changes in river-water temperature (Table 1). The observed mean water temperature of 28.3417±3.720°C. The lower temperature may be associated with strong winds and reduced solar heating, and the highest value could be attributed to high solar radiation.¹⁵ An increase in water temperature decreases dissolved oxygen.¹⁶

Water temperature showed significant correlations with pH (-0.895***, p<0.001), electrical conductivity (0.946***, p<0.001), total dissolved solids (0.870***, p<0.001), dissolved oxygen (-0.950***, p<0.001), total alkalinity (-0.947***, p<0.001), hardness (-0.803***, p<0.001), nitrate (-0.895*, p<0.05), and phosphate (0.926***, p<0.001).

pH remained alkaline throughout the study period, with carbonate and bicarbonate originating from the alkaline earth metals. pH was lowest in summer and highest in winter (Table 1). The water pH ranged from 7.27 to 7.83, indicating metabolic activities are pH-dependent.¹⁷

Table 2 Correlation analysis of physicochemical parameters of water of Ganga River, Ara during 2024-2026

Month	Water Temperature (°C)	pH	Electrical Conductivity (µs/cm)	Total Dissolved Solids (mg/l)	Dissolved oxygen (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)
Water Temperature (°C)	1.0	-0.895**	0.946***	0.870**	-0.950**	-0.947**	-0.803**	0.063 NS	0.644*	0.926**
pH		1.0	-0.774**	-0.709*	0.834**	0.802**	0.734**	0.103 NS	-0.524 NS	-0.926**
Electrical Conductivity			1.0	0.835**	-0.935*	-0.900**	-0.691*	0.193 NS	0.643*	0.880**

vity ($\mu\text{s/cm}$)					**	*	*			
Total Dissolved Solids (mg/l)				1.0	- 0.933* **	- 0.791**	0.753* *	0.414 NS	0.703 **	0.710**
Dissolved oxygen (mg/l)					1.0	0.874** *	0.791* *	-0.316 NS	- 0.676 *	- 0.863** *
Total Alkalinit y (mg/l)						1.0	0.892* **	0.094 NS	-0.470 NS	- 0.851** *
Total Hardness (mg/l)							1.0	0.062 NS	-0.319 NS	-0.655*
Chloride (mg/l)								1.0	0.575 *	- 0.052N S
Nitrate (mg/l)									1.0	0.554*
Phosphat e (mg/l)										1.0

(NS = Not significant, * = significant at 5%, ** = significant at 1% and *** = significant at 0.1% level; df = 11)

Dissolved oxygen in water ≥ 5.0 mg/L is desirable for good biota. The reduction in dissolved oxygen during summer may be associated with increased water temperature, which reduces oxygen solubility, as well as enhanced microbial respiration and decomposition of organic matter. These dissolved oxygen levels supported the earlier finding. It has been explained that at low dissolved oxygen in water, organic matter started decomposing.¹⁸

pH and dissolved oxygen in water showed significant negative correlations with total alkalinity, hardness, nitrate and phosphate (Table 2).

Table 3. Seasonal variation of zooplankton density (unit/Litre) from Ganga River, Ara during the period of August 2024 to July 2026

	No. of genera	Names and densities	Summer	Monsoon	Post- Monsoon	Winter	Total
Protozoa	05	<i>Amoeba</i> (58), <i>Arcella</i> (35), <i>Diffugia</i> (49), <i>Euglena</i> (51), <i>Paramoecium</i> (52)	99 (40.41%)	76 (31.02%)	30 (12.24%)	40 (16.33%)	245 (18.92%)
Rotifera	07	<i>Asplanchna</i> (49), <i>Brachionus</i> (247), <i>Cephalodella</i> (50), <i>Filinia</i> (53), <i>Keratella</i> (93), <i>Lecane</i> (70), <i>Testudinella</i> (51)	344 (56.12%)	192 (31.32%)	33 (5.38%)	44 (7.18%)	613 (47.34%)
Cladocera	05	<i>Bosmina</i> (33), <i>Chydorus</i> (76), <i>Daphnia</i> (42), <i>Daphniosoma</i> (37), <i>Monia</i> (76)	127 (48.11%)	77 (50.89%)	25 (9.47%)	35 (13.26%)	264 (20.39%)
Copepoda	04	<i>Heliodiaptomous</i> (38), <i>Mesocyclops</i> (33), <i>Nauplius</i> (42), <i>Thermocyclops</i> (38)	81 (53.64%)	42 (27.81%)	12 (7.95%)	16 (10.60%)	151 (11.66%)
Ostracoda	03	<i>Cypris</i> (9), <i>Stenocypris</i> (8), <i>Lothonura</i> (5)	8 (36.36%)	4 (18.18%)	5 (22.72%)	5 (22.72%)	22 (1.7%)
	24		659 (50.89%)	391 (30.19%)	105 (8.11%)	140 (10.81%)	1295

ANOVA = 2.477NS (p>0.05)

Table 4. Correlation-coefficient of physicochemical parameters of water and zooplankton of Ganga River, Ara during the period of August 2024 to July 2026.

	Water Temperature (0C)	pH	Electrical Conductivity	Total Dissolved Solid	Dissolved Oxygen (mg/L)	Total Alkalinity (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
Protozoa	0.7036**	- 0.6047*	0.7800**	0.9429**	- 0.8690**	- 0.6169*	- 0.6484*	0.6782*	0.9809**	0.6632*
Rotifera	0.6884**	- 0.5525*	0.7628**	0.9016**	- 0.8507**	- 0.6006*	- 0.6207*	0.6875**	0.9846**	0.6442*
Cladocera	0.6492*	- 0.5205 NS	0.7289**	0.8893**	- 0.8243**	- 0.5562*	- 0.5805*	0.7278**	0.9746**	0.6034*
Copepoda	0.6284*	- 0.4850 NS	0.7072**	0.8591**	- 0.8029**	-0.5376 NS	- 0.5540*	0.7340**	0.9659**	0.5808*
Ostracoda	0.1123NS	- 0.1077 NS	0.1871 NS	0.3268 NS	-0.2934 NS	-0.4035 NS	-0.0074 NS	0.7694**	0.5895*	0.0559 NS

(NS = Not significant, * = significant at 5%, ** = significant at 1% and *** = significant at 0.1% level; df = 11)

Table 5. Biodiversity indices of Zooplankton in Ganga River, Ara during August 2024 to July 2026.

Phylum/Group	Shannon-Weinner Index	Evenness Index	Simpson Dominance Index	Simpson Diversity Index	Simpson Reciprocal Index	Menhennick's Index	Margalef species Richness Index
Protozoa	1.597	0.992	0.205	0.795	4.882	0.319	0.727
Rotifera	1.725	0.887	0.226	0.774	4.428	0.283	0.935
Cladocera	1.545	0.960	0.226	0.774	4.418	0.308	0.717
Copepoda	1.383	0.997	0.252	0.748	3.972	0.326	0.598
Ostracoda	1.070	0.974	0.351	0.649	2.847	0.640	0.647
Average	1.464	0.962	0.252	0.748	4.1094	0.3752	0.7248

Electrical conductivity ranged between 1185 ± 35.59 and 1349.33 ± 82.59 $\mu\text{mhoS/cm}$ with an average value of 1279.08 ± 79.32 $\mu\text{mhoS/cm}$. The highest value of electrical conductivity (1349.33 ± 82.59) was recorded during the monsoon and the lowest (1185 ± 35.59) during post-monsoon. Electrical conductivity had significant positive correlations with total dissolved solids, nitrate, and phosphate.

Total dissolved solids varied between 521 ± 72.27 and 664.67 ± 24.19 mg/L with an average value of 593.417 ± 82.33 mg/L. Highest TDS of 664.67 ± 24.19 mg/L was observed in the monsoon and lowest (521 ± 72.27 mg/L) during post-monsoon. Total dissolved solids had a significant positive correlation with nitrate and phosphate.

Maximum total alkalinity during summer may be due to increased photosynthesis, carbon dioxide, and the disposal of debris and urban discharge through open drains into the river. Highest total alkalinity of water during summer and the lowest during winter has also been reported earlier.¹⁹ Total alkalinity is related to fluctuations in photosynthesis. Water with alkalinity greater than 100 mg/L is productive and ideal for fish culture.²⁰ In this work, total alkalinity of water was found 409.583 ± 59.26 mg/L. Total alkalinity and hardness of water also showed significant positive relationships with phosphate (Table 2)

The chloride value varied from 14.15 ± 4.48 to 45.35 ± 1.77 mg/L. Maximum of 45.35 ± 1.77 mg/L chloride was recorded during the summer and minimum of 14.15 ± 4.48 mg/L chloride was recorded in the post-monsoon with an average of 29.3217 ± 14.08 mg/L. Chloride was significantly positively correlated with free nitrate.²¹ But, a chloride level of more than 100mg/L can burn the edges of the gills of fishes.

Nitrate (2.5225 ± 0.66 mg/L) in the water was highest during the monsoon season. This is due to excess from agricultural fields, decayed vegetables, animal matter, etc. The high nitrate detected in the river can be attributed to fertilizers, which enter river bodies. Such findings on nitrate in water have also been reported.²²

Phosphate levels ranged from 5.3 ± 0.17 to 6.67 ± 0.25 mg/L with an average value of 6.075 ± 0.60 mg/L. The highest value of 6.67 ± 0.25 mg/L was recorded during monsoon and the lowest (5.3 ± 0.17 mg/L) was in winter.

Zooplankton are biotic components of food chains, energy flow, and cycling in aquatic ecosystems as secondary consumers. Zooplankton from 24 genera: 7 of Rotifera, 5 of Protozoa, 5 of Cladocera, 4 of Copepoda, and 3 of Ostracods, were identified from the Ganga River (Table 3). These results were similar to earlier observations.²³ 21 zooplankton belonging to 5 major groups, viz. Protozoa (7), Cladocera (5), Copepoda (1), Rotifera (7), and Ostracoda

(1) have been reported from Tons in Dehradun.²⁴ Earlier, out of 46 genera of zooplankton, 19 rotifera, 6 protozoa, 9 cladocera, 9 copepoda, and only 3 ostracoda were identified at Shersha Suri pond, Bihar, India.¹ Besides, 38 genera of zooplankton, having Copepoda with 17, Protozoa and larval forms of animals consisted of 5 genera, and Ostracoda with 3 species at River Kali at Karwar, have been reported.²⁵

Rotifers indicate eutrophication and are used to assess and minimize aquatic pollution.²⁶ In this study also, the maximum share in zooplankton composition was shown by Rotifers (47.34%), followed by cladocerans (20.39%), protozoans (18.92), Copepods (11.66), and least by Ostracods (1.7%). Among these, Cladocerans and Copepods can be used as indicators of freshwater aquatic environments.²⁷ Abundance and dominance of rotifera are reported in several water bodies.^{28,29} This pattern is common in many freshwater bodies: lakes, ponds, reservoirs, rivers, and streams.³⁰

In this study, the density showed temporal variation. Zooplankton determine the nature of the aquatic environment. The density fluctuated from 05 to 247 ind./L (Table 3). In a study, the numerical density of 1 zooplankton at Vasishti estuary ranged from 10845/100 m³ to 23308/100 m³.³¹ The maximum was recorded during the summer season and the minimum during post-monsoon. While analyzing seasonal dynamics of Rotifers in relation to physicochemical conditions of the River Yamuna, similar observations were made: higher densities in summer and lower during the winter season.³² The highest count of Rotifers was recorded in the northeast monsoon season, followed by winter and summer seasons at Yadigir, Karnataka.³³ According to an earlier report, ostracods and protozoans are maximum in summer months and minimum in monsoon months.³⁴ Higher numerical density of zooplankton, more during summer and lowest during winter months, was also reported.³⁵ Regular flash floods, rainfall, and perhaps cloudy skies during the monsoon are major causes of lower plankton diversity because zooplankton prefer either steady or low water current.^{26,36} The present study supports these observations.

Distribution depends on a complex of factors, including climatic conditions and physicochemical parameters such as water temperature, pH, dissolved oxygen, and nitrate.³⁷ Water quality can affect aquatic biodiversity, biological productivity, and mineral cycling in the ecosystem. Density was negatively correlated with pH, dissolved oxygen, total alkalinity, and hardness. It was positively correlated with water temperature, electrical conductivity, total dissolved solids, chloride, nitrate, and phosphate (Table 4).³⁸ A positive correlation between water temperature and zooplankton has also been reported.³⁹

The value of the Shannon-Wiener index in the present observation ($H' = 1.464$, range = 1.070 to 1.725) indicates moderate variation in diversity of zooplankton density. The values of the Shannon-Wiener index (H') <1.0 indicate heavy pollution, 1.0 to 3.0 moderate pollution, and >3.0 non-polluted water.⁴⁰ Although these values provide useful information on community structure, they should not be used to classify the pollution status (Table 5). However, H' alone is insufficient to establish the pollution status of the river.

Pielou evenness index (J') is a function of some diversity measure and the number of individuals in a sample collection. Its value of 1 indicates perfect evenness, but 0 indicates no evenness and high dominance.⁴¹ Pielou evenness index (J') permits considerable refinement in diversity studies. 0.887 to 0.997 for this index were observed in this work.

Simpson diversity index (D') ranges from 0 to 1. 0 represents numerous genera/species and infinite diversity, and 1 represents no diversity.⁷ Therefore, the present observation ($D' = 0.649$ to 0.793) showed moderate dominance. It follows the probability of picking the same genus.

Simpson dominance index ($1-D'$) also ranges from 0 to 1. Simpson indices represent diversity. Simpson dominance index ($1-D'$) values of 0.205 to 0.351 observed in this work showed similarities and indicate moderate diversity. It follows the probability of picking different genera.

The Simpson reciprocal index ($1/D'$) begins at 1 for only one genus/species. Its value increases with diversity and is influenced by the equitability of each genus/species present and richness. If there are five genera/species, its maximum value will be five. The value of the Simpson reciprocal index ($1/D'$) of 2.847 to 4.882 shows conformity with the number of genera (3 to 7) observed in this study and indicates moderate diversity. It follows the effective number of abundant genera.

Menhinick's Index is based on the ratio of the number of genera/species and the square root of the total number of individuals. A higher value of Menhinick's Index indicates greater species richness, and lower values indicate lower species richness. The Menhinick's Index is used for samples of different sizes. Earlier, this index ranged from 0.870 to 0.942 at Rameswaram. 0.283 to 0.640 featured lower generic richness.⁴²

Further, Margalef's richness index ($d' = 0.7248$, range = 0.598 to 0.935) showed high pollution of this river. Margalef's richness index (d') <1 indicates heavy pollution, 1 to 3 moderately polluted conditions, and >3 no pollution.⁴³ Margalef (d') Index provides an understandable and instantaneous expression of diversity. The mean values of $H' > 2$ and $D' > 0.9$ indicate the healthy diversity of the ecosystem.⁴⁴ Therefore, the present work probably indicates unhealthy diversity in this water body.

The value of d' is strongly influenced by sampling and highlighted genera/species richness of 2 to 3. The values of H' ranged from 0.44 to 3.4 and d' from 0.35 to 2.09 at Mumbai harbour.³ The maximum values of H' and d' were also calculated at Dhaula and Baigul.⁴⁵

Margalef's Richness of 5, Pielou Evenness of 0.90, the Shannon-Weiner Index of 1.42, Simpson Diversity Index of 0.72, and Simpson Dominance Index of 0.28 for different zooplankton were observed in the Ganga-derived Chhariganga Oxbow Lake in West Bengal.³⁷ It describes low taxonomic richness. Thus, the present work corroborates the earlier findings.⁴⁶

CONCLUSION

The study revealed seasonal variation in the physicochemical characteristics and zooplankton community of the Ganga River at Bhojpur, Bihar. 24 zooplankton genera and five major taxonomic groups were recorded. Zooplankton abundance was generally higher during summer and lower during the post-monsoon season. Abundance showed positive relationships with temperature, electrical conductivity, total dissolved solids, chloride, nitrate, and phosphate, and negative associations with pH, dissolved oxygen, alkalinity, and hardness. The diversity indices indicated variation in community structure across sampling periods. Overall, the findings provide baseline information on zooplankton composition and its relationship with physicochemical conditions in the studied river stretch.

REFERENCES

1. Ezra AG, Nwankwo DI. Composition of phytoplankton algae in Gubi Reservoir, Bauchi, Nigeria. *J Aquat Sci*. 2001;16(2):115-118.
2. Varadharajan D, Soundarapandian P, Dinakaran GK, Vijaykumar G. Crab fishery resources from Arukkattuthurai to Aiyampattinam, southeast coast of India. *Curr Res J Biol Sci*. 2009;1:118-122.
3. Jose EC, Furio EF, Borja VM, Gatdula NC, Santos DM. Zooplankton composition and abundance and its relationship with physico-chemical parameters in Manila Bay. *Oceanography*. 2015;3(1):1-6.
4. Saha LC, Pandit B. Limnological variations in pond and riverine ecosystem. *Pro Nat Sym Pure Appl Limn Bot Soc Sagar*. 1985;32:124-130.
5. Adhikari S, Goswami AR, Mukhopadhyay SK. Diversity of zooplankton in municipal wastewater-contaminated urban pond ecosystems of the lower Gangetic plains. *Turk J Zool*. 2017;41:464-475. doi:10.3906/zoo-1601-12.
6. Sivakumar K, Sujatha P, Albaff K. Studies on the freshwater copepods and cladocerans of Dharmapuri District, Tamil Nadu. *J Aqua Biol*. 2001;16(1-2):5-10.
7. Terbiyik KT, Polat S. Seasonal distribution of coastal mesozooplankton community in relation to the environmental factors in İskenderun Bay (northeast Levantine, Mediterranean Sea). *J Mar Biol Assoc UK*. 2013;93:1163-1174.
8. Shannon CE, Weaver W. The mathematical theory of communication. Urbana (IL): University of Illinois Press; 1949.
9. Simpson EH. Measurement of diversity. *Nature*. 1949;163:688.
10. Margalef R. Perspectives in ecological theory. Chicago (IL): University of Chicago Press; 1958. p. 122.
11. Kumar P, Sonallah F, Wanganeo A. A preliminary limnological study on Shershah Suri Pond, Sasaram, Bihar. *Asian J Exp Sci*. 2011;24(2):219-226.
12. American Public Health Association. Standard methods for the examination of water and wastewater. 21st ed. Washington (DC): American Public Health Association; 2005.
13. Needham JG, Needham PR. A guide to the study of freshwater biology. Holden-Day; 1972.
14. Lackey JB. Study of some ecologic factors affecting the distribution of protozoa. *Ecol Monogr*. 1938;8(4). doi:10.2307/1943082.
15. Santhanam P, Perumal P. Diversity of zooplankton in Parangipettai coastal water, southeast coast of India. *J Mar Biol Assoc India*. 2003;45(2):144-151.
16. Perlman H. Water density. In: The USGS Water Science School [Internet]. 2013 [cited 2026 Sep 16]. Available from: <https://ga.water.usgs.gov/edu/density.html>
17. Balakrishna D, Reddy TR, Reddy KV, Samatha D. Physico-chemical parameters and plankton diversity of Ghanpur Lake, Warangal, A.P., India. *Int J Zool Res*. 2013;3:44-48.
18. Mahobe H, Mishra P. Study of physico-chemical characteristics of water ponds of Rajnandgaon Town, Chhattisgarh. *Int J Sci Eng Res*. 2013;4(8):738-748.
19. Ghosh BB. Physicochemical analysis of pond water in Purba Bardhaman, West Bengal, India. *Res J Environ Sci*. 2018;7(2):54-59.
20. Alikunhi KH. Fish culture in India. *Bull Indian Counc Agric Res*. 1957;20:1-150.
21. Arya S, Kumar V, Raikwar M, Dhaka A. Physico-chemical analysis of selected surface water samples of Laxmi Tal (pond) in Jhansi City, UP, Bundelkhand region, Central India. *J Exp Sci*. 2011;2(8):1-6.
22. Kadam MS, Nanware SS, Ambhore JS. Physicochemical status of water in Asana River, District Nanded. *J Comp Toxicol Physiol*. 2005;2(1-2):13-17.
23. Bhavan PS, Selvi A, Manickam N, Srinivasan V, Santhanam P, Vijayan P. Diversity of zooplankton in a perennial lake at Suler, Coimbatore, India. *Int J Educ Res*. 2015;5:31-44.
24. Negi RK, Mamgain S. Zooplankton diversity of Tons River of Uttarakhand State, India. *Int J Zool Res*. 2013;3(2):1-8.
25. Shaikh N, Rathod JL, Durgekar R. Zooplankton diversity in River Kali, Karwar, west coast of India. *Int J Eng Dev Res*. 2017;5(3):495-500.
26. Manickam N, Bhavan PS, Santhanam P, Muralisankar T, Srinivasan V, Vijayadevan K, et al. Biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake, Krishnagiri District, Tamil Nadu, India. *Malaya J Biosci*. 2015;2(1):1-12.
27. Saldeek V. Rotifers as indicators of water quality. *Hydrobiologia*. 1983;100:167-201.
28. Nogueira MG. Zooplankton composition, dominance and abundance as indicators of environmental compartmentalization in Jaramirim Reservoir (Paranapanema River), São Paulo, Brazil. *Hydrobiologia*. 2001;455:1-18.
29. Kudari VA, Kadadevaru GG, Kanamadi D. Zooplankton composition in some ponds of Haveri District, Karnataka. *Zoo's Print J*. 2005;20(12):2094-2099.

30. Neves IF, Rocha O, Roche KF, Pinto AA. Zooplankton community structure of two marginal lakes of the River Cuiabá (Mato Grosso, Brazil) with analysis of rotifera and cladocera diversity. *Braz J Biol.* 2003;63(3):329-343.
31. Nair NB, Kumar KK, Arunachalam M, Azis PA, Dharmaraj K. Ecology of Indian estuaries: studies on the zooplankton ecology of Kadinamkulam Backwater. *Proc Indian Acad Sci.* 1998;93(6):573-584.
32. Arora J, Mehra N. Seasonal dynamics of rotifers to physical and chemical conditions of River Yamuna (Delhi), India. *Hydrobiologia.* 2003;491:101-109.
33. Basawarajeshwari I, Reddy R, Vijaykumar K. Zooplankton diversity in freshwater reservoir of Yadgir District, Karnataka State. *Int J CurrInnov Res.* 2015;1(1):19-22.
34. Mahor RK. Diversity and seasonal fluctuation of zooplankton in freshwater reservoir Tighra, Gwalior (M.P.). *Int Res J.* 2011;2(19):24-25.
35. Sadasivan S, Gurjar UR, Shukla SP, Jaiswar AK, Shenoy L, Dashmukhe G. Zooplankton abundance and its seasonal distribution in Patalganga Estuary, Maharashtra, India. *J EntomolZool Stud.* 2019;7(1):1156-1160.
36. Bonner LA, Walter WJ, Altiz R. Physical, chemical and biological dynamics of five temporary dystrophic forest pools in central Mississippi. *Hydrobiologia.* 1997;357:77-89.
37. Mahar MA, Baloch WA, Jafri SIH. Diversity and seasonal occurrence of planktonic rotifers in Manchhar Lake, Sindh, Pakistan. *Pak J Fish.* 2000;1(1):25-32.
38. Sen S, Paul MK, Borah M. Study of some physico-chemical parameters of pond and river water with reference to correlation study. *Int J ChemTech Res.* 2011;3(4):1802-1807.
39. Varadharajan D, Soundarapandian P. Distribution and abundance of zooplankton along Tamil Nadu coastal water, India. *EcosystEcogr.* 2013;3(4):1-4.
40. Wilhm RL, Dorris TC. The biological parameters for water quality criteria. *BioScience.* 1968;18:477-481.
41. Pielou EC. Ecological diversity. New York: John Wiley; 1975. p. 165.
42. Davari N, Jouri MH, Ariapour AH. Comparison of measurement indices of diversity, richness, dominance and evenness in rangeland ecosystem (case study: Jvaherdeh-Ramesar). *J Rangeland Sci.* 2011;2:389-398.
43. Lenat DR, Smock LA, Penrose DL. Biological monitoring for environmental effects. In: Douglass LW, editor. [Book title not provided]. 1980. p. 97-114.
44. Srichandan S, Panda CR, Rout NC. Seasonal distribution of zooplankton in Mahanadi Estuary (Odisha), east coast of India: a taxonomical approach. *Int J Zool Res.* 2012;9:17-31.
45. Gholap AB. Species diversity indices of zooplankton from Sadatpur Reservoir, Ahmednagar, Maharashtra. *Ann Biol Res.* 2014;5(4):58-61.
46. Rahman MM, Hasan MR, Sarker MM, Faraji MS, Hasan MM, Jaman A, et al. Zooplankton diversity patterns, assemblage, and environmental determinants in a seasonally dynamic tropical river. *Sci Prog.* 2025;108(4):1-21.