Nepalese Journal of Zoology
Special Issue: International Conference on Zoology 2021

ISSN: 2705-4403 (Print) & 2705-4411 (Online)
www.cdztu.edu.np/njz

Volume 6 | Issue S1 | December 2022

https://doi.org/10.3126/njz.v6iS1.50528

Research Article

Phytoplankton and zooplankton abundance and distribution: a case of Ghodaghodi Lake, Sudurpaschim Province, Nepal

Melina DC [1*] | Archana Prasad [1] | Smriti Gurung [2] | Rita Bhatta [3] | Dikshya Regmi [4] | Shrija Tuladhar [2] | Chhatra Mani Sharma [4]

[1] Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal
[2] Department of Environmental Science and Engineering, Kathmandu University, Nepal
[3] Department of Chemical Science and Engineering, Kathmandu University, Nepal
[4] Central Department of Environmental Science, Tribhuvan University, Nepal
*** Correspondence:** dcmelina1723@gmail.com

Suggested citation: DC, M., Prasad, A., Gurung, S., Bhatta, R., Regmi, D., Tuladhar, S. and Sharma, C. M. 2022. Phytoplankton and zooplankton abundance and distribution: a case of Ghodaghodi Lake, Sudurpaschim Province, Nepal. Nepalese Journal of Zoology **6**(S1):35–41. https://doi.org/10.3126/njz.v6iS1.50528

Article History:
Received: 22 January 2022
Revised: 28 October 2022
Accepted: 10 November 2022

Publisher's note: The editorial board and the publisher of the NJZ remain neutral to the opinions expressed and are not responsible for the accuracy of the results and maps presented by the authors.

Abstract

Planktons are the community of pelagic organisms, composed of different groups, which are in suspension in water and hence restricted mobility, often less than that of the water which carries them. The study was carried out during the winter of 2019 to observe the phytoplankton and zooplankton abundance and distribution in Ghodaghodi Lake, Nepal. Temperature, pH, electrical conductivity, dissolved oxygen, Secchi disc transparency, total dissolved solids, and turbidity were analyzed during the study. Collection of plankton samples were made by conical-shaped monofilament nylon plankton net of 90 µm mesh net size from approximately 10 - 12 cm depth from six different sites. A total of 58 individuals of zooplankton were enumerated during the present investigation. The maximum number was counted for *Mesocyclops* sp. (n = 18) and minimum for *Diaptomus* (n = 1). The highest zooplanktons were reported from site I (n = 12) and the lowest were reported from site II (n = 7). Cladocera was the most dominating zooplankton group. A total of 85 individuals of phytoplankton were enumerated during the present investigation. The maximum number was counted for Spirogyra sp (30) and the minimum for *Lamena* sp. (1). The most leading group of the phytoplankton was Chlorophyceae (30), followed by Cyanophyceae (13), Bacillariophyceae (7) and group Zygnematophyceae (6). Thus, these resources are also favorable for flourishing fish diversity in a lake ecosystem.

Keywords: Chlorophyceae; Phytoplanktons; Zooplanktons; Mesocyclops; Zygnematophyceae

1 | Introduction

Since Plankton can be defined as the community of pelagic organisms, composed of different groups, which are in suspension in water and hence restricted mobility, often less than that of the water which carries them (Delincé 1992). Plankton is categorized into phytoplankton and zooplankton. Zooplanktons are identified as important components of water ecosystems. They help in regulating algal and microbial productivity through grazing and in the transfer of primary productivity to fish and other consumers (Dejen et al. 2004). Phytoplankton are minute microscopic chlorophyll bearing organisms or non-photosynthetic plants or saproplanktons passively floating in the water and multiply rapidly, which includes diatoms (Bacillariophyceae), blue-green algae (mixophyceae), green algae (Chlorophyceae) and Desmidaceae (Kushwaha 2012). These are at the base of aquatic food webs and of global importance for ecosystem functioning and services (Kumari et al. 2018). Plankton forms also provide information on the environmental and physiological conditions of lakes. The water quality factors that include water temperature, pH, transparency, turbidity and

conductivity have significant correlation with pankton growth. The number, type and heterogeneity of zooplanktons present in any aquatic habitat help to determine the biological condition existing in that particular habitat (Khanna et al. 2009). It is seen that many environmental factors interact to provide conditions for the development of plankton, both spatially and temporally (Khanna et al. 2009). Similarly, phytoplanktons have been identified as important bio-indicator of water quality (Jakhar 2013) as they portray the pollution status of aquatic ecosystem. Some members of Rotifera and Cladocera are reported as pollution indicators (Mallik et al. 2011; Virani & Makode 2011). According to Gupta and Shukla (1990); Adesalu and Nwankwo (2008); Chellappa et al. (2008) and Rajagopal et al. (2010), pollution indicator algal forms have been reported from Cyanophyceae, Bacillariophyceae, and Chlorophyceae.

Studies in the past have been made by several researchers (e.g., Bista & Shah 2010; Lamsal et al. 2014; Joshi & KC 2017) on water quality and fish diversity in Ghodaghodi Lake but the study on abundance and distribution of phytoplankton and zooplankton still remain lacking. Evaluation of water quality helps to know the condition of Lake. This can further assist in management of lake, restoration projects and conservation of wetland ecosystem. Hence, this study aims to identify the physico-chemical properties of water and abundance and distribution of planktons (phytoplankton and zooplankton).

2 | Materials and methods

2.1 | Study area

The study was conducted in Ghodaghodi Lake, a Ramsar Site, in the Kailali District, Sudurpachim Province of Nepal (28°41′17″ N; 80°56′47″E). It covers an area of 2,563 hectares including a cluster of nine lakes. It is a large and shallow lake, having finger-like projections, with associated marshes and meadows surrounded by tropical deciduous forest. The lake is fed by direct precipitation during the monsoon season and by surface flows from the watershed area, groundwater springs and small streams. Water depth varies from 1-4 m. Low secchi depth transparency and high phosphorus levels indicate the lake as hypertrophic, the nitrogen level as eutrophic, and low Chlorophyll "A" level (due to the rich growth of macrophytes) as oligo to mesotrophic. Dissolved oxygen has been reported low, ranging between 5.27-6.56 mg/l (Diwakar et al. 2009). A total of 45 species of aquatic macrophytes, 54 species of terrestrial/riparian vegetation, 19 fish species, 41 bird species, 17 mammals (endangered and vulnerable), and five reptiles were recorded at the lake complex (Lamsal et al. 2014).

The study area was divided into six sampling sites based on different features such as human intervention, cattle grazing, settlement area, religious spot, disturbed and undisturbed area, etc.
Site I: 28 º41′19.9′′N 080º56′50.5′′E - It is near the old view tower that is dense forest area.
Site II: 28 º41′29.6′′N 80º56′36.9′′ E- It is a portion of the lake consisting of shallow water.
Site III: 28 º41′13.1 ′′N 80º56′45.7′′E -It is below Temple where Indigenous Tharu people celebrate a traditional festival Agan Panchami during December worshipping, offering animals and taking holy bath in the lake.
Site IV- 28 º41′01.0′′N 080º56′47.4 ′′E -It is an outlet human influence area along the Mahendra high way.
Site V- 28 º41′06.4′′N 80º56′53.7′′E- It is just opposite of crocodile breeding area.
Site VI-28 º41′81.6′′N 80º56′02.5′′E- It is the outlet between two statues of horses from where water is passed for irrigation to nearby villages.

2.2 | Analysis of environmental variables

Water quality parameters were measured by using digital probes such as:

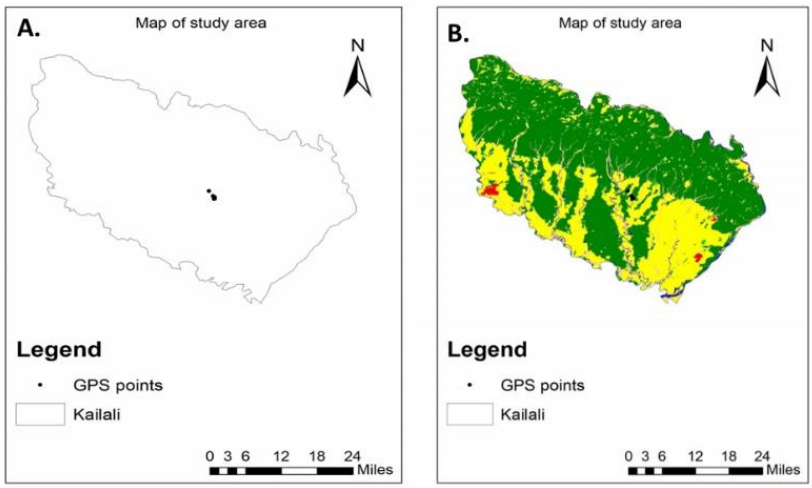

Figure 1. Map of the study area (Ghodaghodi Lake)

Water pH: calibrated pH meter (HI 98107, HANNA Instrument).

Temperature: Temperature was measured in (temperature, ^{o}C).

Dissolved oxygen: DO meter (DO, mg/L). DO meter was put on, the reading zeroed and then the electrode dipped into the water sample and the reading taken.

Transparency: Transparency of the water was measured with Secchi Disc and recorded in centimeters. For taking the transparency of water in different places of lake, the Secchi disc was dipped in water and the depth was noted at which it just disappeared.

Electrical conductivity: Conductivity was recorded by a conductivity meter (EC, μS/cm), adjusting the reading portion and dipping the meter into the water sample and approximate reading taken.

Total dissolved solids: Total dissolved solid (ppm) was measured by TDS meter.

Turbidity: Turbidity (NTU) was recorded by a Turbidity meter.

2.3 | Plankton sampling

Collection of plankton samples were made by conical-shaped monofilament nylon plankton net of 90 μm mesh net size from approximately 10 - 12 cm depth, and the collected samples from six different sites were transferred to one litre capacity plastic bottles and immediately preserved in 5 % formaldehyde-labelled and then transferred to the Central Department of Zoology laboratory at Tribhuvan University for further analysis. The abundance of plankton was estimated by counting their presence per focus of the microscopic field under 10X and 40X magnifications. Each sample was stirred smoothly just before microscopic examination for qualitative analysis. 10 ml of water from each site was observed under a microscope in the laboratory, making five slides for each one ml. Plankton was identified by using the standard keys following APHA (American Public Health Association 1998).

2.4 | Statistical analysis

The Data obtained were compiled, tabulated, and analysed for the descriptive statistics such as in mean values and standard deviation, particularly for water samples.

The catch compositions of individual organisms were determined using the following formula:

$$\text{Catch composition by number (\%)} = \frac{\text{Total catch of an individual}}{\text{Total catch of all species}} \times 100$$

A diversity index is a quantitative measure that reflects the number of different species and how evenly the individuals are distributed among those species. Typically, the value of a diversity index increases when the number of types increases, and the evenness increases.

Zooplankton and phytoplankton species diversity were subjected to the analysis using the Shannon-Weiner diversity index.

All The diversity of species was calculated by using the Shannon-Weiner diversity index (Shannon & Weaver 1949). The Shannon-Weiner diversity index is designated as H', which is calculated as:

$H' = -\Sigma (Pi) \log (Pi)$

Where, Pi = ni/N Ni = number of all individuals in the species

N = Total number of all individuals in the sample

Log = Logarithm of base e11

Figure 2. Plankton sample collection with the help of local fisherwomen

3 | Results

3.1 | Water quality parameters

The mean value of temperature was 19.75±1.60 °C. The highest was recorded in site VI (22.4 °C) and the lowest in the site I (17.9 °C). The average pH was 7.65±0.7. The highest pH value was obtained in site VI (9.1) and the lowest in the site I (7.21). The highest value of electrical conductivity was found in the site I (139.9 µS/cm) and the lowest in site II (122 µS/cm) with an average value of 134.15±7.01 µS/cm. The mean value of dissolved oxygen was 7.17±12.18 mg/L; the highest was obtained in the site I (9.4 mg/L) and the lowest in site VI (5.4 mg/L). The average value of Secchi disc was 27±8.52 cm, with. The maximum value in site I (38 cm) and the minimum in site VI (16 cm). The mean value of total dissolved solids was 69.1±6.55 ppm. The highest was found in the site I (79.6 ppm) and low in site II (60 ppm). The average value of turbidity was 2.29±0.74 NTU. The highest was recorded in site III (3.19 NTU) and the lowest in site V (1.21 NTU).

3.2 | Zooplankton abundance and distribution

Among A total of 58 individuals were enumerated during the present investigation, which comprised of 8 genera of zooplankton belonging to Cladocera, copepods and rotifers. The maximum number was counted for Mesocyclops sp (18 individuals) and minimum for Diaptomus (one individual), which contributes to 31.04% and 1.7%, respectively. The highest numbers (12 individuals) were recorded in the site I throughout the study period, whereas the lowest numbers (7 individuals) were found in site II. The most dominating group Cladocera (31 individuals), consisted of *Daphnia* sp, *Bosomina* sp, *Alona*, and crustacean larvae, followed by copepods (24 individuals) that constituted Mesocyclops, *Trichocera* sp, and Diaptomus followed by rotifers (3 individuals) constituted of Synchaeta. During the present investigation, the percentage abundance of zooplankton was in the order of Cladocera (53.45%), copepods (41.38%) and rotifers (5.17%).

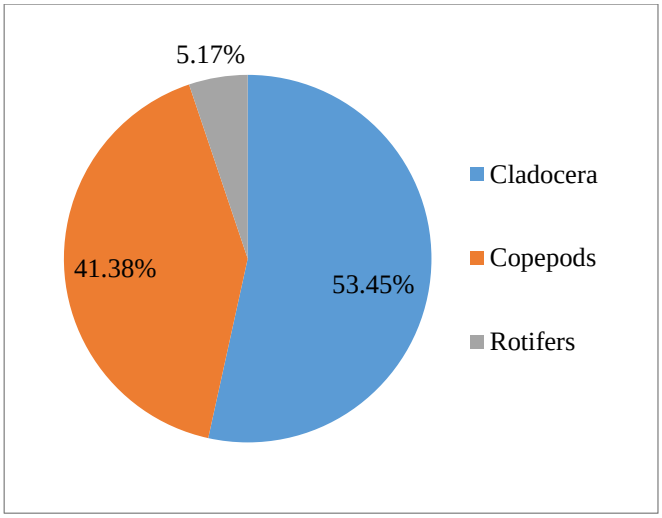

Figure 3. Percentage composition of zooplankton in Ghodaghodi Lake during December 2019

3.3 | Phytoplankton abundance and distribution

A total of 85 individuals of phytoplankton were enumerated, which comprised of 12 genera of phytoplankton belonging to 4 groups (i.e., Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Zygnematophyceae). The maximum number was counted for *spirogyra* sp (30 individuals) and minimum for *Lamena* sp (one individual), which are 35.3% and 1.2%, respectively. The highest number (19 individuals) was recorded in site II throughout the study period, whereas a poor number (4 individuals) were found in site VI. The most dominating group was Chlorophyceae (30 individuals), consists of *Spirogyra* sp, *Selenastrum* sp, *Ankistrodesmus* sp, *Closterium* sp, *Elakatothrix* sp, *Lamanea* sp, and *Schizomeris* sp followed by Cyanophyceae (13 individuals), comprising of *Microcystis* sp, *Oscillatoria* sp, *Gloeotrichia* sp and by Bacillariophyceae (7 individuals) consists *Melosira* sp and group Zygnematophyceae (6 individuals) consisting of *Zygnema* sp. During the present investigation, the percentage abundance of phytoplankton was in the order of Chlorophyceae (69.41%), Cyanophyceae (15.3%), Bacillariophyceae (8.2%), and Zygnematophyceae (7.1%).

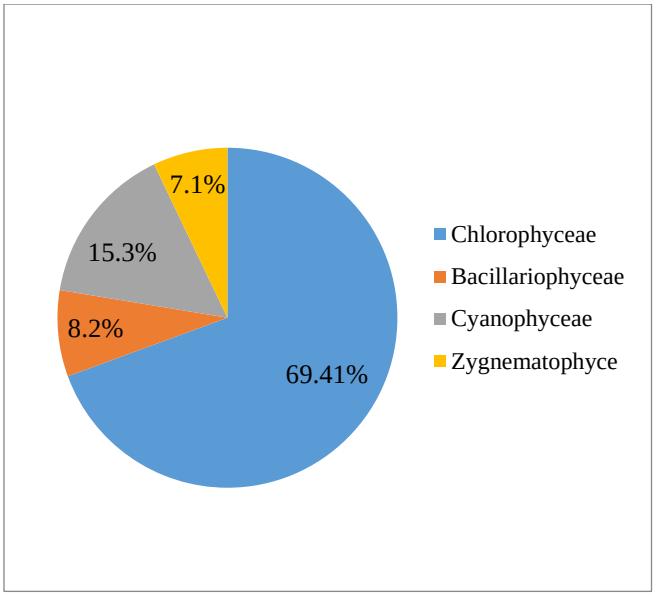

Figure 4. Percentage composition of phytoplankton species in Ghodaghodi Lake

3.4 | Diversity status

Altogether Among sites, the value of the Shannon-Weiner diversity index for zooplankton was found highest at the site I (1.52) and lowest at site II (1.1). The value of the Shannon-Weiner diversity index for Phytoplankton was highest at site V (1.72) and lowest at site IV (1.35). The sites wise values of the Shannon-Weiner diversity index for zooplankton and phytoplankton are given in the figures 6 and 7, respectively.

4 | Discussion

4.1 | Water quality parameters

The highest value of temperature was recorded in site VI (22.4 °C) and the lowest in the site I (17.9 °C), and nearly the same value was also reported by Gautam (2016) from Rupa Lake. pH has a major role in both lentic and lotic environments for determining the speciation of inorganic chemicals and influencing biotic life. Generally, pH value 6.5 to 8.5 is suitable for the growth and development of aquatic organisms (King 1970), and the pH value of the present study exceeds this range (i.e., pH = 9.1). The electrical conductivity value was found to be higher in site I (139.9 µS/cm) compared to site II (122 µS/cm) because of groundwater and surface runoff from the grounding farmlands that might have increased ionic substances such as nitrate, chloride and phosphate from fertilizers as stated by Enrique (1992). During the previous phase of studies in Ghodaghodi Lake, dissolved oxygen ranged between 5.27–6.56 mg/L (Diwakar 2009) and 6.42–8.09 mg/L (Bhatta et al. 2018) around winter seasons, which contradicts with the present study (DO = 9.4 mg/L). The maximum value of the Secchi disc was found in the site I (38 cm) and the minimum in site VI (16 cm). The minimum transparency at Site VI could be due to its proximity to the water channel, which is opened only for irrigation, otherwise it is closed. This has caused a massive growth of algae blocking the light penetrate in deeper areas, which is similar to the findings of Gautam et al. (2016). The value of total dissolved solids was highest at the site I (79.6 ppm) and minimum at site II (60 ppm). TDS values in lakes and streams are typically found to be in the range of 50 to 250 mg/L (Bhateria & Jain 2016). The high turbidity at Site III, situated just below the Ghodaghodi temple, could be due to the fact that it has the passage of some particles and debris along organic matters which supports the growth of plankton.

4.2 | Zooplankton diversity and distribution

Copepoda and Rotifera are common zooplankton groups in many water bodies and a number of studies reveal Cladocera as the most dominant group of zooplanktons (Dorlikar 2018). Similar findings have also been reported by Akther (2015) from Bangladesh. However, Rotifers were dominating over the other zooplankton in Turkaulia Lake, Motijheel Lake, Kararia Lake, and Suraha Lake (Prasad et al. 2009).

During the present investigation, the most leading group was Chlorophyceae (69.41%), followed by Cyanophyceae (15.3%), Bacillariophyceae (8.2%) and Zygnematophyceae (7.1%). This is similar to the study made by Bharati (2015) and Kumari et al. (2018).

5 | Conclusions

Cladocera and Chlorophyceae were the dominating groups of zooplankton and phytoplankton respectively. The species diversity of zooplankton and phytoplankton was found to be higher in the site I and V. In the present study, phytoplanktons were dominant over zooplankton. Therefore, we can conclude that the abundance of phytoplanktons portrays the increasing pollution status of Lake. However, these resources are also favourable for flourishing fish diversity in a lake ecosystem.

Acknowledgements

We are thankful to Ghodaghodi Municipality and Ghodaghodi Conservation Committee for providing permits for this research and fisherwomen of the study area who helped in sample collection. This study was financially supported by the University Grants Commission of Nepal (Grant # CRG-73/74-S&T-04). Central Department of Environmental Science provided essential support for the completion of this research work.

Conflicts of interest

Authors declare no conflict of interest.

References

Adesalu, T. A. and Nwankwo, D. I. 2008. Effect of water quality indices on phytoplankton of a sluggish Tidel Creek in Lagos, Nigeria. Pakistan Journal of Biological Science **11**:836–844. https://doi.org/10.3923/pjbs.2008.836.844

APHA, 1998. Standard methods for examination of water and wastewater. 20th Edition, American Public Health Association, American Water Works Association and Water Environmental Federation, Washington DC

Akther, S., Ashaduzzaman and Hossain, J. 2015. Abundance of zooplankton in Ramsagar-Dighi, Dinajpur, Bangladesh. Journal of Zoology **43**(2):303–312. https://doi.org/10.3329/bjz.v43i2.27400

Bhateria, R. and Jain, D. 2016. Water quality assessment of lake water: a review. Sustainable Water Resources Management **2**(2):161–173. https://doi.org/10.1007/s40899-015-0014-7

Bharti, P. K. and Niyogi, U. K. 2015. Plankton diversity and aquatic ecology of a freshwater lake (L3) at Bharti Island, Larsemann Hills, east Antarctica. Global Journal of Environment Science and Management **1**(2):137–144. https://doi.org/10.7508/gjesm.2015.02.005

Bhatta, J., Bohara, R., Bhatta, B. R. and Joshi, T. R. 2018. Limnological study of the Ghodaghodi Wetland in Kailali District. Proceedings of the Seminar on "NATURE FOR WATER". Nepal Academy of Science and Technology, Khumaltar, Lalitpur.

Bista, D. and Shah, K. 2010. Assessment of the status of herpetofauna especially focusing on the turtles in Ghodaghodi Lake, Kailali a Ramsar Site of Nepal. Masters Dissertation submitted to the Central Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal.

Chellappa, N. T., Borba, J. M. and Rocha, O. 2008. Phytoplankton community and physicochemical characteristics of water in the public reservoir of Cruzeta, RN, Brazil. Brazilian Journal of Biology **68**:477–494. https://doi.org/10.1590/s1519-69842008000300004

Delincé, G. 1992. The ecology of the fish pond ecosystem. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-3292-5

Dejen, E., Vijverberg, J., Nagelkerke, L. A. J. and Sibbing, F. A. 2004. Temporal and spatial distribution of microcrustacean zooplankton in relation to turbidity and other environmental factors in large tropical lake (L. Tana, Ethiopia). Hydrobiologia **513**:39–49. https://doi.org/10.1023/B:hydr.0000018163.60503.b8

Diwakar, J., Barjracharya, S. and Yadav, U. 2009. Ecological study of Ghodaghodi Lake. Banko Janakari **19**(3):18–23. https://doi.org/10.3126/banko.v19i3.2207

Dorlikar, A. V. 2018. Studies on composition and population density of zooplanktons in Koradi Power Plant Lake, Maharashtra, India. International Journal of Researches in Biosciences, Agriculture and Technology **6**(1):153–158.

Enrique, V. 1992. Temperature and dissolved oxygen in Lake of the Lower River Floodplain (Venezuela). Hydrobiologia **25**:23–33.

Joshi, D. and KC, B. 2017. Fish diversity of Ghodaghodi Lake in Kailali, Far-West Nepal. Journal of Institute of Science and Technology **22**(1):120–126. https://doi.org/10.3126/jist.v22i1.17762

Gautam, G., Paudel, A., Poudel, A. and Shrestha, M. 2016. An investigation on the diversity of limnoplankton along with habitat parameters in a shallow Rupa Lake. International Journal of Advanced Research in Biological Sciences **3**(7):131–139.

Gupta, P., and Shukla, A. C. 1990. Cyanophyceae and pollution interwebs in Ganga water at Bithoor. In R.K. Trivedi (Ed.) River pollution in India . Ashish Publishing House pp. 228.

Jakhar, A. 2013. Role of phytoplankton and zooplankton as health indicators of aquatic ecosystem: a review. International Journal of Innovative Research and Studies **2**(12):490–500.

Khanna, D. R., Bhutiani, R., Gagan Matta., Singh, V., Kumar, D., and Ahraf, J. 2009. A study of zooplankton diversity with special reference to their concentration in River Ganga at Haridwar. Environment Conservation Journal **10**(3):15–20.

King, B. L. 1970. The role of carbon in eutrophication. Journal of Water Pollution Control Fed **42**:2035–2051.

Kushwaha, P. K. (2012). Biodiversity and density of phytoplankton in pond of Kirtipur. Academic Voices: A Multidisciplinary Journal **2**(1):43–47.

Kumari, S., Gayathri, S. and Mohan, R. M. 2018. Phytoplankton diversity in Bangalore lakes, importance of climate change and nature's benefits to people. Journal of Ecology and Natural Resources **2**(1):1–8. https://doi.org/10.23880/jenr-16000118

Lamsal, P., Pant, K. P., Kumar, L. and Atreya, K. 2014. Diversity, uses, and threats in the Ghodaghodi Lake Complex, a Ramsar Site in Western lowland Nepal. ISRN Biodiversity, 680102 https://doi.org/10.1155/2014/680102

Mallik, R., Sinha, S. K. and Abhishek 2011. Zooplankton biodiversity and pollution indicator species in Damodar river of Jharia coalfield, Dhanbad (Jharkhand). The Ecoscan **1**:329–334.

Prasad, S., Ranjan, R., Singh, R. B. and Singh, N. P. 2009. Studies on phytoplankton-zooplankton relationship in some lentic water bodies of east Champaran Bihar. Nature Environment and Pollution Technology **8**(3):571–574.

Rajagopal, T., Thangamani, A., Sevakodiyone, S. P., Sekar, M. and Archunan, G. 2010. Zooplankton diversity and physico-chemical conditions in three perennial ponds of Virudhunagar, Tamilnadu. Journal of Environmental Biology **31**:265–272.

Sharma, C. M. 2008. Freshwater fishes, fisheries, and habitat prospects of Nepal. Aquatic Ecosystem Health and Management **11**(3):289–297.

Shannon, C. E. and Weaver, W. 1949. The mathematical theory of communication. Urbana, University of Illinois Press.

Virani, R. S. and Makode, P. M. 2011. Role of rotifer diversity in a tropical lentic ecosystem with reference to eutrophication. Bioscience Biotechnology Research Communications **4**(1):55–64.