Current Environment
ISSN: 2789-7982 (Online)
Volume- 01 (2021)

Journal updates

REVIEW ARTICLE

https://doi.org/10.54479/ce.v1i01.6659

Responses of Freshwater Zooplankton as Biological Indicators to the Aquatic Chemical Properties

JABER BIN ABDUL BARI[1] | **MD. SAIFUL ISLAM**[1] | **SANJIDA AKTER NISA**[1] | **NAZNIN AKTER TISHA**[2] | **IRINA MASHKOVA**[3] | **NAJMUS SAKIB KHAN**[1]

1. Department of Oceanography, Noakhali Science & Technology University, Bangladesh.
2. Department of Fisheries Biology & Genetics, Bangladesh Agricultural University.
3. Department of Chemistry, South Ural State University, Russia.

Article History
Received: 02 July 2021
Revised: 25 August 2021
Accepted: 30 August 2021
Published: 24 October 2021

Corresponding Author
Najmus Sakib Khan
Contact:
nsakib.ocn@nstu.edu.bd
nsakib.iium@gmail.com

ABSTRACT: Zooplankton are found very sensitive to even slight aquatic pollution due to a number of chemical imbalances in freshwater bodies. As an amazing tiny creature zooplankton play a very crucial role in the aquatic food chain by transferring energy from primary levels to tertiary organisms. For many years it has been well established that zooplankton act as promising biological indicators to continuously fluctuating aquatic environments and subsequently to global warming. While reacting to these aquatic environmental fluctuations, zooplankton population growth can either be stimulated or inhibited. The presence or absence of particular zooplankton species can reveal the trophic status of the water body. Moreover, in a harsh environment, algal toxins may have drastic effects on the behavioral characteristics of zooplankton.

Keywords: Zooplankton, Bioindicator, Trophic status, Allelochemicals, Chemical fluctuations.

Zooplankton are microscopic organisms which float freely in water and have a limited capacity to swim against currents. Therefore, it provides an essential relationship between primary producers and tertiary organisms (1). In the freshwater aquatic bodies, rotifera, cladocera, and copepod are studied intensively on the other hand protozoans are rarely researched (2-4).

Chemical or biological approaches can be used to analyze water quality, but both have limits. Inorganic and organic chemicals which enter water bodies by surface runoff are either consumed by primary producers or deposited in the sediments (5,6). Water parameters such as pH, Dissolved oxygen (DO), nutrients (phosphorus and nitrogen), temperature, salinity, total alkalinity, and free CO_2 influence the abundance of phytoplankton, zooplankton, fish, and other aquatic organisms in the ecosystem and act as the limiting elements for their growth and survival (7-18).

A group of zooplankton species whose function, population, or status can reveal the condition of water quality is referred to as bio-indicator. Rotifers, copepods, and cladocerans are examined for biochemical, physiological, or behavioral changes that could suggest an opportunity in their ecology as bio-indicator. The biological indicators are given us the following benefits to estimate biological impact, to examine the synergetic and antagonistic effect of different contaminants on organisms, to monitor toxicity, and to use as a cost-effective alternative for biomonitoring (19). Eutrophication is caused by excessive nutrients mainly nitrogen and phosphorus which causes an increase in primary production in aquatic ecosystems (2).

Zooplankton play an important role in nutrient and energy recycling in their particular ecosystem. Zooplankton act as bioindicators as supportive in the assessment of water contamination intensity. They are thought to have a key role in determining freshwater eutrophication and primary production (20). This study is conducted to evaluate the response of freshwater zooplankton as a bioindicator to the chemical properties of the water bodies.

Zooplankton abundance and diversity are influenced by aquatic chemical properties

The chemical properties of aquatic bodies have a strong influence on the density and diversity of zooplankton. The quantitative changes of the zooplankton population might be led by a close interaction between them and aquatic physico-chemical parameters. The growth of zooplankton is regulated by inorganic and organic substances such as carbon dioxide, dissolved oxygen, nitrogen, and phosphorus as well as amino acid and humic acid (21). The most sensitive demand for zooplankton is dissolved oxygen which is produced by aquatic algae and plants (22). The dissolved oxygen decreasing level in a water body is directly or indirectly responsible for the death of organisms. However, atmospheric air pressure, photosynthesis, temperature, salinity and turbulence all affect the DO level in natural water which is inversely related to temperature. An increase in temperature can result in a decrease in DO level thus endangering the organisms of an aquatic ecosystem (23). Alam et al., (1987), Roy et al., (2010) and Shayestehfar et al., (2010) stated that zooplankton abundance shows a negative relation with dissolved oxygen. Therefore, among the zooplankton groups, rotifers and copepods show a significant inverse relation with dissolved oxygen (24-26). Furthermore, Sinha and Sinha (1993) observed a positive correlation of total zooplankton with DO and temperature (27). A high level of total suspended solids is a critical factor that can affect the temperature of the water body (22). Echaniz et al., (2012) have observed that the concentration of dissolved solid had no effect on zooplankton biomass, while the concentration of chlorophyll-a, and inorganic suspended solid had a positive effect (28). A similar result has also been reported showing a strong relation between rotifers and total suspended solids (22,29,30). Numerous nutrients (ammonia, nitrite, nitrate, and phosphate) play a significant role in determining the assemblages of zooplankton. Hence the decrease of zooplankton density might be a result of the decline of these essential nutrients which subsequently affect the algal population. However, excessive growth of algae may cause an algal bloom thus result in the release of several harmful toxins such as cyanotoxin, anatoxin-a, microcystin, domoic acid, etc, which inhibit zooplankton growth and reproduction (31). Phosphates and nitrates are found in low amounts in the aquatic environment and these are necessary for zooplankton's growth and metabolism. Additionally, a high level of phosphate and nitrate may cause eutrophication and subsequently decline the water quality. Therefore, a positive correlation between total zooplankton with phosphate and nitrate was observed (27,32,33), while an inverse relation was reported (34). Khan and Bari, (2019) noted that, among the dominated zooplankton groups, cladocera and copepod showed a positive relation with ammonia (35). Similarly, rotifers showed a positive relation with ammonia (30). Moreover, rotifers had a negative relation with alkalinity which is referred to as the buffering capacity of water (33,35). In contrast, copepods showed a positive relation with alkalinity (22). The pH range in water between 7.4 to 8.2 indicates well-buffered water that initiates zooplankton growth (32). Moreover, Joseph and Yamakanamardi, (2011) reported a significant positive correlation between pH and total zooplankton (34). The decomposition of organic matter releases CO_2 which reduces alkalinity and lowers pH in water bodies. Therefore, free CO_2 is required for photosynthesis and its presence has an impact on zooplankton and productivity. A positive correlation between zooplankton and free CO_2 was reported (36). In the temperate lakes and reservoirs, zooplankton displays a bimodal oscillation with spring and fall (37). Temperature and nutrition seem to have the biggest impact on zooplankton periodicity (38). Through seasonal fluctuation, the primary environmental element temperature starts zooplankton development and survival (32).

Roles of zooplankton as biological indicator

Aquatic creatures, especially plankton, have long been recognized for a diverse distribution. Moreover, studying freshwater fauna particularly zooplankton even of a single location is large and complex due to their temporal and spatial fluctuations as well as ecological, extrinsic, and intrinsic variables. Extrinsic factors can influence the diversity of zooplankton and remain one of the most significant intellectual challenges for ecologists (39,40). Only a few environmental factors may be responsible for building aquatic ecosystems that reflect the environment's trophic level (20,40). Among all the freshwater aquatic biota, the zoo-plankton population can reflect the nature and potentiality of any aquatic system (42). Carnivorous zooplankton grazes on other zooplankton, while herbivorous zooplankton consumes phytoplankton. Without these important consumers, herbivorous and other levels of the food chain would collapse (43). Zooplankton species are utilized as bio-indicators of aquatic ecosystem's health because they are sensitive to specific physical and chemical conditions (44). Many rotifer species are used as good indicators of water quality and ecological monitors of water bodies due to their tolerant ability of a large variety of environmental circumstances (45,46). In addition, the Wetland Zooplankton Index (WZI) was approached to assess the quality of lake water in North America based on zooplankton assemblages (41).

Acts of zooplankton as monitoring of trophic status

The trophic state of aquatic habitats is one of the most significant characteristics. Robert Carlson's Trophic State Index (TSI) is used to determine the trophic condition of the aquatic body based on its index value between 01 (one) to 05 (five) (47). Trophic status is a helpful way to categorize freshwater bodies and describe their activities in terms of the system's productivity. Nutrients (such as nitrogen, phosphorus, etc.) availability in the particular aquatic environment can indicate the trophic status in oligotrophic, mesotrophic to eutrophic (even hyper-eutrophic) and can moderate the abundance and diversity of plankton communities. Where zooplankton is the most sensitive community to the changeable trophic status of any aquatic body and having the potentiality to act as an effective biological instrument for evaluating and monitoring the ecological condition of water bodies (48,49). The zooplankton community may alter completely or partially in aquatic bodies as a result of the shift in trophic status (48, 50). Micro-eukaryotes (rotifers, copepods, and cladocerans) are abundant in freshwater environments, and their varied taxonomic groupings play significant roles in the ecosystem. Unfortunately, numerous environmental stresses endanger freshwater ecosystems and biodiversity, especially those resulting from intense anthropogenic activities including household activities, industrial by-products, agricultural runoff, etc. Several pollutants have negative impacts on many species, including those which are part of the food chain and are sensitive to environmental changes (51). The community size of specific major zooplankton can indicate the trophic status of lakes and also can help to understand the shifts in the trophic state and might be used as bioindicators of environmental changes as they are composed of organisms with high environmental sensitivity (52,53). Significant efforts have been made in recent decades to control biodiversity loss and restore the functions and services of aquatic ecosystems. The most important reason for assessing pollution's effects on ecosystems is monitoring biodiversity and developing conservation strategies. Bio-monitoring of ubiquitous micro-eukaryotes is exceedingly difficult due to numerous technical difficulties connected with micro-zooplankton, such as tiny size, fuzzy morphological characteristics, and very rich diversity. Studies indicate that existing techniques for monitoring zooplankton biodiversity improve the management of freshwater ecosystems. Rotifers are considered one of the most useful water quality bioindicators and, eutrophic lakes have been described as having a high rotifer density (20,51,54). In a case study, *Conochilus dossuarius* and *Synchaeta longipes* were two rotifer species found in oligotrophic to mesotrophic environments (55). However, the most dominant species in the Southern region of Bangladesh's freshwater ecosystems are *Keratella* sp., *Brachionus* sp., *Anuraepsis* sp., *Trichocerca* sp., *Ascomorpha* sp., *Filinia* sp., etc, which indicates a eutrophic environment condition (22,32). Furthermore, according to the Wetland Zooplankton Index (WZI), research shows that the majority of rotifer species indicate moderate to poor water quality, owing to rotifer's ability to adapt to extreme conditions of the water body (20). On the other hand, copepods and cladocerans are the most susceptible to environmental changes. Their high abundance in particular water bodies implies that the ecosystem's water quality is eco-friendly (4,32).

Responses of zooplankton to allelochemicals

Allelochemicals are produced by micro and macro algae and may interact synergistically, resulting in greater plankton growth inhibition. In a competitive setting, the algae are recognized as self-defensive which release phycotoxins (allelochemicals) to limit other algal development and challenge predator capabilities. Algal allelopathic abilities empower their long-term prehistoric survival (31). The inhibition of phytoplankton growth can reduce zooplankton survival. *Elodea*, *Stratiotes*, *Chara*, and *Myriophyllum* are examples of macrophytes that produce chemical compounds that affect phytoplankton abundance and have an impact on the behavior of zooplankton such as cladocerans and copepods life-table factors (56-59). On the other hand, a greater temperature may increase the disruption of the food gathering process induced by filamentous cyanobacteria that generate cyanotoxin, resulting in a reduction of *Daphnia* (60,61). Because of a large variety of periphytic zooplankton, such as rotifers and cladocerans, which are specialize in living in macrophyte-dominated settings, an unfavorable allelopathic impact does not harshly occur (59). Furthermore, the embryos of cladocerans are infected by cyanotoxins from cyanophyta and egg hatching rates of copepods are inhibited by domoic acid from diatoms (61,62). As selective feeder, copepods are able to differentiate between toxic and non-toxic algae for feeding and filter feeder cladocerans are capable of reducing their filtering rate when toxic algal species are dominant (31,60,61, 63,64).

CONCLUSION

Zooplankton have highly dynamic life strategies to survive in a constantly changing aquatic environment caused by climatic and anthropogenic stressors. As a result, the sensitivity of different zooplankton to various forms of aquatic chemical pollution demonstrates their potentiality to serve as biological indicators.

CONFLICT OF INTEREST

The authors have no conflict of interest.

REFERENCES

1. Alcaraz M, Calbet A. Zoplankton ecology in marine ecology. Encyclopedia of Life Support Systems (EOLSS), eds. Duarte C, Lott A., Helgueras (Oxford: Developed under the Auspices of the UNESCO, Eolss Publishers), 2003;295–318.
2. Alprol AE, Heneash AMM, Soliman AM. Assessment of water quality, eutrophication, and zooplankton community in lake Burullus, Egypt Diversity. 2021;13(6):1-23.
3. Khan NS, Uddin A, Bari JBA, Tisha NA. Evaluation the potentiality of ancient ponds by Palmer's algal pollution. International Journal of Fisheries and Aquatic Research. 2019;4(4):28-31.
4. Khan NS, Islam S. State the organic pollution level in rain fed ponds, Noakhali, Bangladesh. Int J Fish Aquat Stud. 2020;7:438–41.
5. Singh WR, Kalamdhad AS. Transformation of nutrients and heavy metals during vermicomposting of the invasive green weed *Salvinia natans* using *Eisenia fetida.* Int J Recycl Org Waste Agric. 2016;5:205–20.
6. Kowalczewska-Madura K, Kozak A, Dera M, Gołdyn R. Internal loading of phosphorus from bottom sediments of two meso-eutrophic lakes. Int J Environ Res. 2019; 13:235–51.
7. Sarker MM, Hossain MB, Islam MM, Mustafa Kamal AH, Idris MH. Unravelling the diversity and assemblage of phytoplankton in homestead ponds of central coastal belt, Bangladesh. Aquac Res. 2021;52:167–84.
8. Mustafa MG, Parvez MS, Hossain MA, Ahmed S. Fisheries diversity around Nijhum Dwip Island of Bangladesh in relation to some environmental parameters. The Journal of NOAMI. 2018;35:77–91.
9. Amira FS, Rahman MM, Kamaruzzaman BY, Jalal KCA, Hossain MY, Khan NS. Relative abundance and growth of male and female *Nemipterus furcosus* population. Sains Malaysiana. 2016;45:79–86.
10. Rahman MM, Ali MR, Sarder MRI, Mollah MFA, Khan NS. Development of sperm cryopreservation protocol of endangered spiny eel, *Mastacembelus armatus* (Lacepede 1800) for ex-situ conservation. Cryobiology. 2016;73:316–23.
11. Khan NS, Sarder MRI, Al-Faroque MA, Mollah MFA. Standardization of sperm cryopreservation techniques of Indian major carp Rohu (*Labeo rohita*, Hamilton 1822). Int J Fish Aquat Stud. 2015;175–81.
12. Siddique MAM, Rahman M, Khan NS, Islam MM. Size frequency, length-weight, and length-length relationship of bearded worm Goby *Taenioides cirratus* (Blyth, 1860) from the Noakhali Coast, Bay of Bengal. Thalassas. 2021;37:347–51.
13. Rahman KMM, Nahar M, Adhikary RK, Khan NS, Rahman MM, Asadujjaman M, Rahman MA. Socio-economic condition and occupation migration of fisherman of the Jamuna River under Shirajgonj District in Bangladesh. Middle-East J Sci Res. 2014;22: 633–38.

14. Waseeh MA, Rahman AAFM, Khan NS. Effects of artificial food additives in Vietnam Koi, *Anabas Testudineus* (Bloch, 1792) pond culture system. Int J Fish Aquatic Res. 2020;5(3):50-4.
15. Khan NS, Islam MR, Hossain MB, Quaiyum MA, Shamsuddin M, Karmaker JK. Comparative analysis of microbial status of raw and frozen freshwater prawn (*Macrobrachium rosenbergii*). Middle East J Sci Res. 2012;12:1026–30.
16. Quaiyum MA, Rahman MM, Sarker SB, Alam MM, Khan NS, Rahman MS, Siddiqui R. Microbiological quality assessment of Chapila (*Gudusia chapra*) and Tengra (*Mystus vittatus*) in Bangladesh. Stamford J Microbiol. 2013;2: 6–9.
17. Krupa E, Romanova S, Berkinbaev G, Yakovleva N, Sadvakasov E. Zooplankton as indicator of the ecological state of protected aquatic ecosystems (Lake Borovoe, Burabay National Nature Park, Northern Kazakhstan); 2020.
18. Khan NS. Microbial water quality of freshwater prawn. Lambert academic publishing; 2012, pp.19-22.
19. Parmar TK, Rawtani D, Agrawal YK. Bioindicators: the natural indicator of environmental pollution. Front Life Sci. 2016;9(2):110-18.
20. Sladecek V. Hydrobiologia. 1983;100:169-201.
21. Roy U, Shaha BK, Mazhabuddin KH, Haque MF, Sarower G. Study on the diversity and seasonal variation of zooplankton in a brood pond, Bangladesh. Mar Res Aquac. 2010;1(1):30-7.
22. Khan NS, Islam S, Bari JBA, Kamal MM. Monsoonal plankton distribution and physico-chemical water qualities in a rain-fed lake in Noakhali, Bangladesh. Bangladesh J Fish. 2020;32(1):179-84.
23. Singh CS, Sharma AP, Deorani BP. Limnological studies for bioenergetic transformation in a Tarai reservoir, Nanak Sagar (UP). In: Singh HR. (Ed.). Adv Limnol. 1990;356-62.
24. Alam MJ, Habib MAB, Begum M. Effects of water properties and dominant genera of phytoplankton on the abundance of available genera of zooplankton. Pakistan journal of Scientific and Industrial Research. 1989;32(3):194-200.
25. Alam AKMN, Islam MA, Mollah MFA, Haque MS. States of zooplankton newly constructed pond and their relation to some mereorological and limnological factor. Bangladesh Journal of Fisheries. 1987;10(1): 83-8.
26. Shayestehfar A, Noori M, Shirazi F. Environmental factor effects on the seasonally changes of zooplankton density in Parishan Lake (Khajoo Spring Site), Iran. Asian J Exp Biol Sci. 2010;1(4):840-44.
27. Sinha KK, Sinha DK. Seasonal trends in physico-chemical factors and zooplankton in a fresh water pond of Munger, Bihar. J Ecobiol. 1993;5(4):299-302.
28. Echaniz SA, Vignatti AM, Cabrera GC, Paggi SBJ. Zooplankton richness, abundance and biomass of two hypertrophic shallow lakes with different salinity in central Argentina. Biota Neotrop. 2012;12(1):41-48.
29. Iqbal J, Mumtaz M, Iqbal I, Mahmood J, Razaq A. Particle size distribution analysis and physicochemical characterization of Chenab river water at Marala Headworks. Pak J Bot. 2010;42(2):1153-61.
30. George A, Getabu A, James N. Effect of pond type on physicochemical parameters, phytoplankton diversity and primary production in kissi, Kenya. Int J Fish Aquatic Stud. 2018;8(6);125-30.
31. Khan NS, Tisha NA. Freshwater algal tolerance to organic pollution: A review. Pollution Research. 2020;39(4):1297-301.
32. Khan NS, Islam MS, Bari JBA, Tisha NA. Water quality evaluation by monitoring zooplankton distribution in wild ponds, Noakhali, Bangladesh. Nature Environment Pollution Technology. 2020;19(4):1767-70.
33. Mustapha MK. Seasonal influence of limnological variables on plankton dynamics of a small, shallow, tropical African reservoir. Asian j exp Biol Sci. 2010; 1(1):60-79.
34. Joseph B, Yamakanamardi SM. Monthly changes in the abundance and biomass of zooplankton and water quality parameters in Kukkarahalli lake of Mysore, India. Journal of Environment Biology. 2011;32:551-57.
35. Khan NS, Bari JBA. The effects of physico-chemical parameters on plankton distribution in poultry manure and artificial formulated feed treated fish ponds, Noakhali, Bangladesh. Int J Fish Aquat Stud. 2019;7(5):1-7.
36. Salaskar PB, Yeragi SG. Seasonal fluctuations of plankton population correlated with physico-chemical factors in Powai Lake, Mumbai, Maharashtra. J Aqua Biol. 2003;18(1):19-22.
37. Wetzel RG. Limnology: Lakes and reservoir ecosystem, (3rd edn). Burlington: Academic. 2001; pp 1005-1006..
38. Prasad BB, Singh RB. Composition, abundance and distribution of phytoplankton and Zoo benthos in a tropical water body. Nat Environ & amp Poll Tech. 2003;2:255-58.
39. Pinel-Alloul P. Spatial heterogeneity as a multiscale characteristic of zooplankton community. Hydrobiologia. 1995;300:17–42.
40. Gaston K. Global patterns in biodiversity. Nature. 2000;405:220–27.
41. Lougheed V, Chow-Fraser P. Development and use of a Zooplankton Index of Wetland Quality in the Laurentian Great Lakes basin. Ecological Applications. 2002;12(2):474-86.
42. Kumar KS. Studies on freshwater Copepods and Cladocerans of Dharmapuri district Tamil Nadu. J Aqua.Biol. 2001;16(1&2):5-10.
43. Magurran AE. Ecological diversity and its measurement. New Jersey, Princeton University Press. 1988, pp.197.
44. Sládeček V. System of water quality from the biological point of view. Arch Biol Beih Ergeb Limnol. 1973;7:1-218.

45. Hellawell JM. Biological indicators of freshwater pollution and environmental management. Elsevier Appl Sci Publ. London. 1986, pp.546.
46. Nikleka E, Shumka S, Mali S. Zooplankton species as biological indicators of the water of Bovilla reservoir. Natura Montenegrina, Podgorica. 2015;7(2):253-59.
47. Carlson RE. A trophic state index for lakes. Limnol Oceanog. 1977;22(2):361-69.
48. Mashkova IV, Kostriykova AM, Trofimenko VV, Slavnaya AI. Study of the zooplankton community as an indicator of the trophic status of reservoirs of the Chelyabinsk region, Russia. IOP Conf Series: Earth and Environmental Science. 2019;344.
49. Jekatierynczuk-Rudczyk E, Zieliński P, Grabowska M, Ejsmont-Karabin J, Karpowicz M, Więcko A. The trophic status of suwałki landscape park lakes based on selected parameters (NE Poland). Environ Monit Assess. 2014;186:5101-21.
50. Moss B, Stephen D, Alvarez C, et al. The determination of ecological status in shallow lakes- a tested system (ECOFRAME) for implementation of the European Water Framework Directive. Aquatic Conservation: Marine and Freshwater Ecosystems. 2003;13(6):507–49.
51. Pooja J. Role of phytoplankton and zooplankton as health indicators of aquatic ecosystem: A review. International Journal of Innovative Research & Studies. 2013;2(12).
52. Ferdous Z, Muktadir AKM. A review: Potentiality of zooplankton as bioindicator. American Journal of Applied Science. 2009;6(10):1815-19.
53. Pinto-Coelho RM, Bezerra-Neto JF, Morais CA. Effects of eutrophication on size and biomass of crustacean zooplankton in a tropical reservoir. Braz J Biol. 2005;65:325-38.
54. Balakrishana D, Reddy TR, Reddy KV, Warangal AP. Samatha D. Physico-chemical parameters and plankton diversity of Ghanpur lake, India. International Journal of Zoology Research. 2013;3(1):44-8.
55. Imoobe TOT, Adeyinka ML. Zooplankto based assessment of the trophic state of a tropical forest river in Nigeria. Arch Biol Sci Belgrade. 2009;61(4):733-40.
56. Korner S, Nicklisch A. Allelopathic growth inhibition of selected phytoplankton species by submerged macrophytes. J Phycology. 2002;38(5):862–71.
57. Gross EM. Allelopathy of aquatic autotrophs. Crit Rev Plant Sci. 2003;22:313-39.
58. Meerhoff M, Fosalba C, Bruzzone C, et al. An experimental study of habitat choice by *Daphnia*; plants signal danger more than refuge in subtropical lakes. Freshwater Biol. 2006;51:1320-30.
59. Burks RL, Jeppesen E, Lodge DM. Macrophyte and fish chemicals suppress Daphnia growth and alter life-history traits. Oikos. 2000;88:139-47.
60. Barreiro A, Guisande C, Maneiro I, et al. Zooplankton interactions with toxic phytoplankton: Some implications for food web studies and algal defence strategies of feeding selectivity behaviour, toxin dilution and phytoplankton population diversity. Acta Oecologica. 2017;32:279–90.
61. Bednarska A, Slusarczyk M. Effect of non-toxic, filamentous cyanobacteria on egg abortion in *Daphnia* under various thermal conditions. Hydrobiologia. 2013;715:151-57.
62. Miralto A, Barone G, Romano G, et al. The insidious effect of diatoms on Copepod reproduction. Nature. 1999;402:173-6.
63. Forsyth DJ, James MR, Cryer M. Alteration of seasonal and diet patterns in vertical migration of zooplankton by *Anabaena* and planktivorous fish. Archiv fu¨r Hydrobiologie. 1990;117:385–404.
64. Haney JF, Forsyth DJ, James MR. Inhibition of zooplankton filtering rates by dissolved inhibitors produced by naturally occurring cyanobacteria. Archiv fur Hydrobiologie. 1994;132:1–13.

Author's contributions

Najmus Sakib Khan planned, designed, and guided this review manuscript. Jaber Bin Abdul Bari, Md. Saiful Islam and Sanjida Akter Nisa performed in the entire manuscript. Naznin Akter Tisha and Irina Mashkova thoroughly revised the manuscript and participated in the correction. The first and second authors mainly drafted the manuscript and all authors equally contributed to edit the language.

To cite the article

Bari JBA, Islam MS, Nisa SA, Tisha NA, Mashkova I, Khan NS. Responses of Freshwater Zooplankton as Biological Indicators to the Aquatic Chemical Properties. Current Environment. 2021;1:9-14.