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Zooplankton as bio-indicator of aquatic ecosystem: A review

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Abstract

In the present study, the role of zooplankton in monitoring the health of aquatic ecosystem has been reviewed. The present study revealed that the zooplankton community exhibit notable monthly fluctuation depending on water quality and seasonal variation. The winter months shows comparatively significant diversities. zooplankton serves as a regional bioindicator of lake eutrophication. The soil-water chemistry, food chain, alkalinity, DO, pH, DO and nutritional status of the water body affect the diversity and density of zooplankton. Rotifers are a type of zooplankton that reacts more quickly to environmental changes and uses.

Keywords: Bioindicator, Water quality, Wetland, Zooplankton.

Introduction

Plankton encompasses tiny aquatic organisms that lack sufficient mobility to resist the movement of water currents and exist by floating within open or marine water. Phytoplankton refers to planktonic plants, while zooplankton refers to planktonic animals. Zooplankton serve as the vital trophic link connecting primary producers to higher trophic levels. Freshwater zooplankton include Protozoa, Rotifers, Cladocerans, Copepods and Ostracods with many relying heavily on bacterioplankton and phytoplankton as their primary food sources. Larger zooplankton species often prey on smaller zooplankton and some also feed as detritivores. Organism in the plankton community play a crucial role in aquatic ecosystems, serving as a pivotal component in the food web and exerting influence over the entire aquatic environment. Plankton has been employed as an indicator to monitor and gain insights into ecosystem changes, largely driven by its responsiveness to climatic factors (Beaugrand *et al.,* 2000). The variations in zooplankton distribution arise from abiotic factors such as climate and hydrology (including temperature, salinity, advection and stratification), biotic factors like food availability, predation and competition or a blend of these influences (Christou, 1998 and Beyst *et al*., 2001). Plankton contributes not just to enhance fish production but also plays a role in the removal of heavy metals and other harmful substances through bioremediation. There are five groups of fresh water zooplankton as follows-

Protozoans (First Animal)

Protozoans, a significant part of this group, often go unsampled because of their tiny size. Planktonic protozoans mainly consist of ciliates and flagelletes. Within the protozoans, there are two orders of amoebae primarily linked to sediment and littoral aquatic vegetation, along with a substantial number meroplanktonic species (Edmonson, 1959; Battish, 1992).

Rotifers (Wheel bearers)

Rotifers are approximately less abundant than protozoans among the planktons and are considered the primary soft bodied invertebrates. They are named after their distinctive rotating wheel of cilia, known as the corona, which they use for movement and to sweep food particles into their anterior mouth. Their digestive tract is equipped with a set of jaws to seize and break down food particles.

Crustaceans

All members of this group belong to the widely recognized phylum Arthopoda which holds the distinction of being the largest phylum both in terms of the number of species it encompasses.

Cladocerans (Branched Horn)

Cladocerans, a vital zooplankton group, stand out as a nutritious crustacean subgroup essential for sustaining higher level fish species in the food chain. These organisms typically possess a protective chitinous shell known as a carapace. Cladocerans exhibit filter-feeding behavior, where they shift water to capture organisms within it. They display a remarkable sensitivity to even trace amounts of pollutants.

Copepods (Oar Foot)

Copepods distinguish themselves as hardier and more robust zooplankton due their durable exoskeleton and longer, more powerful appendages. Their diet primarily consists of smaller zooplankton, making them largely carnivorous.

Ostracods (Shell Like)

Ostracods, classified as bivalve organisms within the Phylum Arthopoda, primarily reside in lake bottoms, often among macrophytes. They sustain themselves by feeding on detritus and deceased plankton. Furthermore, ostracods serve as a food source for fishes and benthic macro-invertebrates (Chakrapani, 1996).

The present study aims to review the role of zooplankton as a bioindicator of pollution in aquatic environment.

Zooplankton as a Bio-indicators of Aquatic Ecosystem

Kolkwitz and Marsson coined the term "Bioindicator Species" in 1908 and 1909 to assess the effects of organic pollution, such as sewage, on aquatic organisms. Many conservationists including organizations like the World Conservation Union World Conservation Monitoring Center, the U.S. Environmental Protection Agency, and the Nature Conservancy, actively advocate for the use of biological indicators to monitor and assess human impacts on the environment. Zooplankton have been recommended as regional bioindicators for assessing lake eutrophication. They play a crucial role as bioindicators and are well suited for understanding the status of water pollution.

Plankton has emerged as a valuable indicator for monitoring and comprehending ecosystem changes, largely due to its susceptibility to the influences of climate factors (Beaugrand *et al*., 2000) The variability in the distribution of zooplankton can be attributed to a combination of abiotic parameters such as climatic and hydrological factors (temperature, stratification, advection, salinity) as well as biotic factors like food availability, competition, and predation (Escribano and Hidalgo, 2000; Beyst *et al*., 2001). While zooplankton can thrive in various environmental conditions, numerous species face limitations due to factors such as dissolved oxygen levels, temperature, salinity, and other physicochemical parameters. Utilizing zooplankton for environmental lake characterization offers significant benefits. They are relatively straightforward to identify, making them particularly valuable when assessing community sensitivity based on zooplankton body sizes.

The Indian water bodies host a diverse array of zooplankton comprising various major taxonomic groups, each with distinct environmental and physiological characteristics. The presence, variety, and distribution of these organisms within aquatic habitats offer insights into the prevailing environmental conditions. It is evident that multiple environmental factors interact, influencing the spatial and seasonal dynamics of zooplankton growth (Khanna *et al*., 2009). Trivedy and Goel (1984) highlighted that an excessive presence of Total Dissolved Solids (TDS) in water can disrupt the ecological equilibrium leading to suffocation among aquatic fauna, even when a sufficient amount of Dissolved Oxygen (DO) is present. Mustapha (2010) established a positive correlation between total zooplankton and phosphate, nitrate, DO, conductivity and TDS while a negative correlation between total zooplankton and carbon dioxide, water transparency, temperature and total alkalinity. The production of zooplankton is favored by a gradual increase in alkalinity, especially when there is a simultaneous presence of dissolved oxygen (DO) and hard water (Bhati and Rana, 1987; Kumar and Dutta, 1994; Joshi, 2011). Ostracod abundance demonstrates a significant positive correlation with pH but a negative correlation with water hardness. Total zooplankton abundance is positively correlated with pH but negatively correlated with turbidity, phosphate, and nitrate levels (Joseph and Yamakanamardi, 2011). The diversity and density of zooplankton depend on various factors, including nutrient levels in the water, abiotic conditions, DO levels, the food chain, soil-water chemistry. It has been emphasized that zooplankton serve as valuable bioindicators for monitoring aquatic ecosystems and water integrity (Dhembare, 2011). The distribution and abundance of zooplankton are influenced by various factors including water temperature, turbidity, transparency, and dissolved oxygen, (Chandraseker, 1996). Additionally, both interspecific and intraspecific factors play a role in shaping zooplankton populations. Furthermore, the availability of phytoplankton can impact zooplankton by affecting female fertility (Ahmad *et al*., 2011). Notably, the highest concentrations of zooplankton were observed during the winter months likely due to the combination of lower temperatures, elevated dissolved oxygen levels, and reduced water velocity (Khanna *et al*., 2000; Khanna and Bhutiani, 2003, and Purushothama *et al*., 2011).

Zooplankton, particularly rotifers, have been recommended as regional bioindicators for assessing various environmental factors in lakes, such as eutrophication (Burns and Galbraith, 2007), acidification and disturbances caused by agriculture (Pinto-Coelho *et al*., 2005). Rotifers, in particular, exhibit rapid responses to environmental changes and are commonly utilized to gauge shifts in water quality (Gannon and Stemberger, 1978). Moreover, high rotifer density is often associated with eutrophic lakes, making them valuable bioindicators of water quality (Balakrishna *et al*., 2013). In their respective studies, Shayestehfar *et al*. (2010) observed a negative correlation between air and water temperature and dissolved oxygen (DO)along with an inverse relationship between DO and Cladocera, Ostracoda, Copepoda and Rotifera. Conversely, Sinha and Sinha (1993) reported positive correlations of total zooplankton with temperature, DO, chloride, and phosphate. In contrast, Salaskar and Yeragi (2003) found inverse relationships between total zooplankton and temperature, while noting positive correlations with free CO2 and DO, and negative correlations with total hardness, phosphate, and nitrate. Additionally, Jhingran (1992) recorded positive correlations between total zooplankton and potassium, total hardness, and iron. These findings collectively underline the importance of zooplanktons as valuable bioindicators for assessing anthropogenic contamination patterns and the dynamics of waste nitrogen in both pelagic and benthic food chains (Xu and Zhang, 2012). Pollution has a harmful impact on numerous organisms within the food chain that are highly sensitive to environmental changes. The degree of pollution is not solely determined by physicochemical parameters but is also influenced by aquatic organisms. Recently, plankton has emerged as a valuable bio-indicator for monitoring aquatic ecosystems and assessing water quality integrity. The community size of key zooplankton species can provide insights into the trophic status of lakes and facilitate an understanding of shifts in their trophic state (Ferdous and Muktadir, 2009). Additionally, these zooplankton species, composed of environmentally-sensitive organisms, serve as reliable bioindicators of environmental changes (Pinto-Coelho *et al*., 2005). Diatoms are employed in environmental assessment and monitoring due to their specific pH, nutrient concentration and suspended sediment tolerances making them excellent indicators of water pollution (Laskar and Gupta, 2009). Certain Ostracod species can thrive in heavily polluted lakes demonstrating superior adaptability and facing reduced competition from other species, thereby serving as reliable biological indicators (Padmanabha and Belagali, 2008). As stated by Kumar *et al*. (2011), rotifers are known for their tolerance to nutrients, their presence and diversity often characterize highly productive and eutrophic wetlands. Additionally, several species of Rotifera and Cladocera have been identified as pollution indicators (Mallik *et al*., 2011; Patrick *et al*., 2012; Ekhande *et al*., 2013).

Conclusion

The study highlights the ecological role of zooplankton and diversity in the Deepor Beel site, with 171 species known. Strong links have been found in all of these published studies between the biotic and abiotic elements of freshwater ecosystems, as well as the function of phytoplanktons and zooplanktons as bio-indicators in determining the trophic status and general health of aquatic bodies. Certain species have a high tolerance level because they can thrive in highly contaminated environments and resist extreme abiotic circumstances, whereas sensitive species are absent, suggesting a low tolerance.

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