Rotifers and Their Role in Water Health: A Review

Shweta Sao[1], Deepak Kumar Soni[2], R. K. Singh[3] and Pratibha Pandey[4]

[1]Professor (Biotechnology), Department of Life Science, Dr. C. V. Raman University, Kargi Road Kota, Bilaspur, Chhattisgarh
[2]Assistant Professor (Botany), Department of Life Science, Dr. C. V. Raman University, Kargi Road Kota, Bilaspur, Chhattisgarh
[3]Professor (Zoology), Department of Life Science, Dr. C. V. Raman University, Kargi Road Kota, Bilaspur, Chhattisgarh
[4]Associate Professor (Zoology), Department of Life Science, Dr. C. V. Raman University, Kargi Road Kota, Bilaspur, Chhattisgarh

Abstract

Rotifers are microscopic, aquatic organisms known for their resilience and adaptability. This paper explores the biology, ecology, and significance of rotifers in freshwater ecosystems. It highlights their use as bioindicators in assessing water health, emphasizing their sensitivity to environmental changes and pollutants. By understanding the role of rotifers in aquatic ecosystems, we can better monitor and manage water quality, ensuring the sustainability of these vital resources. Rotifers, belonging to the phylum Rotifera, are microscopic metazoans found in various aquatic environments. They are an essential component of the freshwater plankton community, playing crucial roles in nutrient cycling, energy flow, and as prey for higher trophic levels. Their sensitivity to environmental changes makes them valuable indicators of water quality and ecosystem health. This paper aims to review the biology of rotifers, their ecological roles, and their application in monitoring water health.

Keywords: Rotifer, Bioindicator, Water health.

Introduction

Rotifers, belonging to the phylum Rotifera, are microscopic metazoans found in a variety of aquatic environments, including freshwater, brackish, and marine habitats. These organisms are an essential component of the freshwater plankton community, playing crucial roles in nutrient cycling, energy flow, and as prey for higher trophic levels (Wallace & Snell, 2010). The phylum Rotifera comprises over 2,000 species, with a wide range of morphological and ecological diversity. Rotifers can be found in diverse environments such as lakes, rivers, ponds, and even in moist terrestrial habitats like soil and leaf litter (Pourriot & Degrange, 1990). Rotifers are known for their resilience and adaptability, which enable them to thrive in various environmental conditions. They possess unique features such as the wheel-like corona, which is used for locomotion and feeding. This distinctive characteristic, along with their simple body structure, makes them a fascinating subject of study in aquatic biology (Wallace & Snell, 2010). One of the most significant aspects of rotifers is their sensitivity to environmental changes. This sensitivity makes them valuable bioindicators for assessing water quality and ecosystem health. Rotifers respond rapidly to alterations in water chemistry, temperature, and pollution levels, providing early warning signs of environmental degradation (Radix et al., 2000). Their use as bioindicators is particularly important in the context of increasing anthropogenic pressures on aquatic ecosystems, such as industrial pollution, agricultural runoff, and climate change (Bielańska-Grajner & Gawrońska, 2011). In addition to their role as bioindicators, rotifers also play a crucial role in the aquatic food web. They feed on a variety of microorganisms, including algae, bacteria, and detritus, converting these materials into biomass that is accessible to higher trophic levels. This process helps maintain the balance of nutrient availability in aquatic systems and supports the overall health of the ecosystem (Dumont & Segers, 1996). Moreover, rotifers serve as a vital food source for numerous invertebrates and fish larvae, highlighting their importance in sustaining biodiversity and ecosystem stability (Pourriot & Degrange, 1990). This paper aims to provide a comprehensive review of the biology of rotifers, their ecological roles, and their application in monitoring water health. By understanding the intricate relationships between rotifers and their environment, we can better appreciate their significance in freshwater ecosystems and leverage their potential in water quality management.

Rotifers and Their Role in Water Health

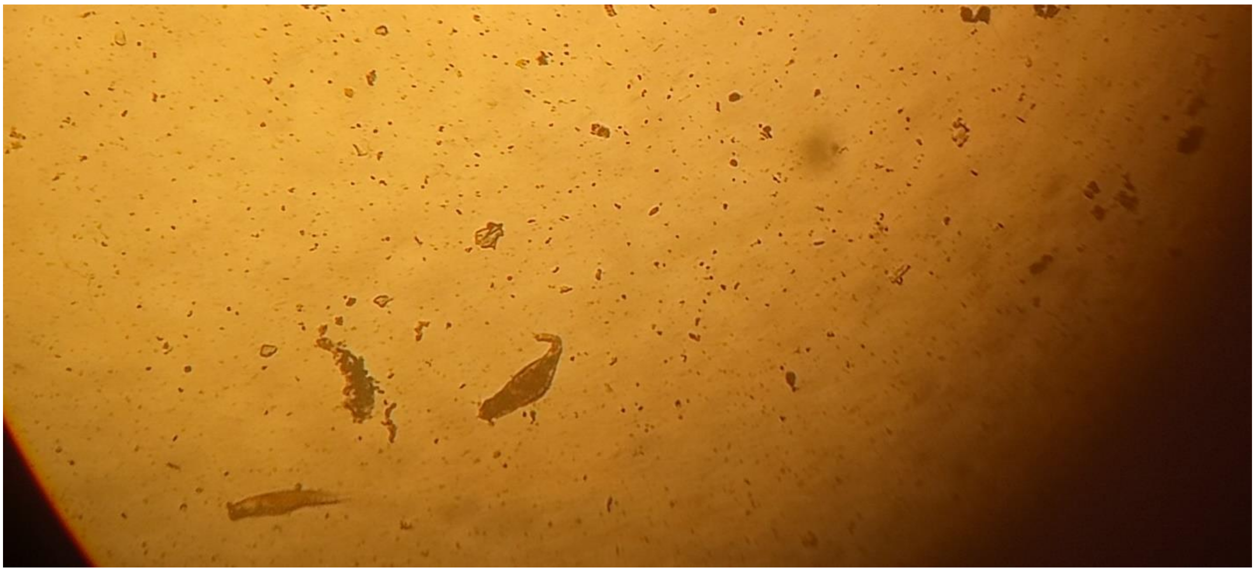

Fig. 10X x 4X Microscopic structure of Rotifers in rain water source from Dr. C.V. Raman University Campus, Kargi Road Kota, Bilaspur, Chhattisgarh.

Biology of Rotifers

Morphology and Physiology

Rotifers are characterized by their wheel-like corona, used for locomotion and feeding. They possess a simple body structure, including a head, trunk, and foot, with variations across different species. Despite their microscopic size, rotifers have complex organ systems, including a digestive tract, nervous system, and reproductive organs (Wallace & Snell, 2010).

Reproduction

Rotifers exhibit diverse reproductive strategies, including sexual and asexual reproduction. Parthenogenesis, a form of asexual reproduction, is common, allowing rapid population growth under favorable conditions. Sexual reproduction occurs under environmental stress, producing resting eggs that withstand adverse conditions (Pourriot & Degrange, 1990).

Ecological Role of Rotifers

Nutrient Cycling

Rotifers contribute significantly to nutrient cycling in freshwater ecosystems. They feed on algae, bacteria, and detritus, converting these materials into biomass that is accessible to higher trophic levels. This process helps maintain the balance of nutrient availability in aquatic systems (Dumont & Segers, 1996).

Food Web Dynamics

As primary consumers, rotifers are a crucial link in aquatic food webs. They are preyed upon by a variety of organisms, including small fish, crustaceans, and other invertebrates. The abundance and diversity of rotifers can influence the population dynamics of their predators and the overall health of the ecosystem (Pourriot & Degrange, 1990).

Rotifers as Bioindicators

Sensitivity to Environmental Changes

Rotifers are sensitive to changes in water quality, including alterations in temperature, pH, dissolved oxygen, and the presence of pollutants. Their rapid response to environmental stressors makes them effective bioindicators for monitoring water health (Radix et al., 2000).

Rotifers exhibit high sensitivity to a wide range of environmental changes, making them valuable indicators for assessing the health of aquatic ecosystems. Their responses to pollutants, nutrient loading, and other stressors provide critical information for water quality management and conservation efforts.

Pollutants such as heavy metals, pesticides, and pharmaceuticals can have detrimental effects on rotifer populations. These substances can reduce rotifer reproduction rates, alter community composition, and decrease overall population abundance. Studies have demonstrated that rotifers are particularly sensitive to changes in water chemistry caused by industrial and agricultural activities (Devetter & Frouz, 2011).

Nutrient loading, particularly from agricultural runoff and wastewater discharge, can lead to eutrophication, which significantly impacts rotifer communities. Elevated nutrient levels can cause algal blooms, reducing water clarity and oxygen levels, and subsequently affecting rotifer populations. Monitoring rotifer responses to nutrient changes helps in assessing the extent and impact of eutrophication on freshwater ecosystems (Gophen, 2005).

Rotifers are also affected by temperature fluctuations and climate change. Increased temperatures can accelerate rotifer metabolism and reproduction, leading to shifts in population dynamics. Additionally, climate change can alter the timing and intensity of seasonal events, affecting rotifer life cycles and interactions with other aquatic organisms (Dokulil & Herzig, 2009).

The sensitivity of rotifers to various environmental factors underscores their importance as bioindicators. Their responses provide valuable data for understanding the impacts of environmental changes on aquatic ecosystems and for developing strategies to mitigate these effects.

Monitoring Pollutants

Research has demonstrated that rotifers can be used to detect various pollutants, such as heavy metals, pesticides, and pharmaceuticals. Changes in rotifer population dynamics, morphology, and behavior can indicate the presence and impact of these contaminants, providing valuable information for water quality management (Radix et al., 2000).

Table 1.1:

S.No.	Name of Rotifers	Used to Monitor	References
1	*Brachionus calyciflorus*	Water quality in dam reservoirs with different trophic statuses	Bielańska-Grajner & Gawrońska (2011)
2	*Brachionus plicatilis, Rotaria rotatoria*	Environmental toxicity (heavy metals, pesticides, pharmaceuticals)	Radix et al. (2000)
3	*Keratella cochlearis, Asplanchna priodonta*	Seasonal changes and long-term environmental conditions	Gophen (2005)
4	*Monogononta*	Global patterns of species richness and environmental changes	Fontaneto et al. (2012)

Case Studies

Several studies have utilized rotifers to assess water health in different aquatic environments. For example, changes in rotifer communities have been used to monitor the effects of agricultural runoff, industrial discharges, and urbanization on freshwater ecosystems. These studies underscore the utility of rotifers as bioindicators in diverse contexts (Bielańska-Grajner & Gawrońska, 2011).

Table. 1. 2. Showing some studies carried out on Rotifers during different timelines.

S. No.	studies carried out on Rotifers	Citation
1	The Plankton of the Lakes	(Geelen, 1955)
2	The uses of ecology: Lake Washington and beyond	(Edmondson, 1991)
3	Seasonal rotifer dynamics in Lake Kinneret (Israel)	(Gophen, 2005)
4	The global abundance and size distribution of lakes, ponds, and impoundments	(Downing et al., 2006)
5	Long-term stability of the seasonal succession of different zooplankton species	(Feike & Heerkloss, 2008)
6	Analysis of long-term winter data on phytoplankton and zooplankton in Neusiedler See	(Dokulil & Herzig, 2009)
7	Influence of wastewater on zooplankton communities in the Daugava River	(Deksne, 2011)
8	Primary succession of soil rotifers in clays of brown coal post-mining dumps	(Devetter & Frouz, 2011)
9	The 'rotiferologist' effect and global correlates of species richness in monogonont rotifers	(Fontaneto et al., 2012)
10	Microbial food web structure in a hypertrophic warm-temperate shallow lake	(Fermani et al., 2013)
11	Zooplankton and their driving factors in a large subtropical river	(de Paggi et al., 2014)
12	The Swedish monitoring of surface waters: 50 years of adaptive monitoring	(Folster et al., 2014)

Challenges and Future Directions

Methodological Challenges

While rotifers are valuable bioindicators, there are challenges associated with their use. Accurate identification and quantification of rotifer species require specialized knowledge and techniques. Additionally, understanding the specific responses of different rotifer species to various pollutants is crucial for accurate water quality assessment (Wallace & Snell, 2010).

Research Needs

Future research should focus on developing standardized protocols for using rotifers in water quality monitoring. Investigating the responses of rotifers to emerging contaminants, such as microplastics and nanomaterials, is also essential. Integrating rotifer-based assessments with other bioindicator methods can provide a comprehensive understanding of aquatic ecosystem health (Radix et al., 2000).

Conclusion

Rotifers play a vital role in freshwater ecosystems, contributing to nutrient cycling, food web dynamics, and overall ecosystem health. Their sensitivity to environmental changes makes them valuable bioindicators for monitoring water quality. By leveraging the ecological and biological characteristics of rotifers, we can enhance our ability to detect and mitigate pollution, ensuring the sustainability of freshwater resources. The extensive study of rotifers over several decades has significantly enhanced our understanding of their ecological importance, environmental responses, and adaptability. These microscopic organisms play critical roles in aquatic ecosystems, serving as indicators of environmental health and contributing to the balance of microbial food webs. In future, Rotifers may play in water filter, so more research is needed to uncover their possibilities to contribute in nature welfare.

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