



Role of Zooplankton as a Bioindicator in Assessing Physico-Chemical Changes in the Son River

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Abstract: The Son River, an important water body in India, plays a crucial role in sustaining its surrounding ecosystems and communities. This review examines the physicochemical factors present in the river and their implications for aquatic biodiversity, with a particular focus on zooplankton communities. Zooplankton, as important primary consumers and bioindicators, provide crucial information about water quality and ecosystem health. The study explores various factors affecting their density, diversity, and role in energy transfer within aquatic food webs. Key parameters such as temperature, dissolved oxygen, and organic matter are discussed as important determinants of zooplankton dynamics. The review further highlights the interconnectedness between zooplankton populations and larger ecological and environmental changes. This underscores the importance of maintaining a balanced aquatic ecosystem to support biodiversity and ensure the sustainability of dependent communities.

Keywords: Zooplankton diversity, Physico-chemical parameters, Son River, Aquatic biodiversity, Bioindicators

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INTRODUCTION

Ecosystems are the functional and structural units of ecology that allow living things to interact with one another and their environment. The sum of all the ways in which living things in an area interact with one another and with their environment is called an ecosystem. Born in 1935, the English botanist A.G. Tansley was the one who first used the phrase "ecosystem". [1]

A desert oasis is one kind of ecosystem, whereas a vast ocean covering hundreds of kilometers is another. There are two main types of ecosystems: A. terrestrial and B. aquatic. Terrestrial ecosystems are those that do not extend beyond the surface of the earth. Various geological zones are home to a wide variety of terrestrial ecosystems.

Ecosystems in water, whether freshwater or saltwater, make up the vast majority of the biosphere.

THE IMPORTANCE OF ZOOPLANKTON IN AQUATIC ECOSYSTEMS

When zooplankton feed on economically significant fish, they indirectly transform the energy in food into energy, which is why they are so vital to freshwater ecosystems. They mostly devour aquatic plants and animals found in freshwater environments. There would be no herbivores or other food chains if these main consumers didn't exist. Their quantitative and qualitative estimations provide a fair picture of the water's

condition. The sensitivity and rapidity with which zooplankton adapt to their environments make them a reliable barometer of water quality. [2]

Importantly, they show if certain fish are there or not, and they also tell us a lot about the ecosystem as a whole and the water's current condition. A wide range of complicated elements, such as weather, physical and chemical parameters, and vegetation fluctuations, influence the aquatic zooplankton ecosystem. Zooplankton densities and diversity in freshwater habitats are regulated by a multitude of variables. An essential set of variables that regulate zooplankton development include organic matter, temperature, and dissolved oxygen.

As they consume phytoplankton, they aid in the transformation of plant materials into animal tissues, which are the staple diet of fish and other higher animals. Zooplankton are crucial to the recycling of nutrients and the flow of energy in aquatic ecosystems, and they impact every functioning element of these systems. A vital cog in the wheel of aquatic nutrition are zooplankton. Zooplankton are an essential food source for a wide variety of fish, including both omnivores and carnivores.

In the natural world, zooplankton distribution and abundance are regulated by light and predation. It is widely acknowledged that zooplankton, due to their size and ease of identification, are the most important indication of tropical conditions. They are also useful for gauging acidity, nutrient loading, fish presence or absence, pollutants, and sediment input. Zooplankton are microscopic creatures that live in water and can detect and react to drastic changes in water quality with minimal effort and power. [3]

GROUPS OF ZOOPLANKTON

Rotifers

The name is derived from the Latin *rota*, "wheel"; *phero*, "bear," so they are commonly called "wheel-animacules." They are also called "Rotatoria." Rotifers are a highly diverse group of microscopic aquatic organisms. Rotifers are an important group with approximately 2,000 species. Rotifers are ubiquitous, found in almost all types of water bodies. In freshwater habitats, rotifers are the most diverse group of organisms among other zooplanktonic groups.

Cladocerans

Cladocerans are microcrustaceans commonly known as "water fleas" that belong to the subclass Branchiopoda (Class: Crustacea). They are divided into four suborders: Anomopoda, Ctenopoda, Onychopoda, and Haplopoda. Cladocera is an ancient group that originated in both fresh and salt water, but their fossil remains are known from the Mesozoic era. Cladocerans have a typical body size of 0.2–6.0 mm, but some can reach up to 18 mm. The body and limbs are covered by a bivalve carapace composed of a single piece. They exhibit high variability due to alternating parthenogenetic and amphimixis reproductive modes.[4]

They mostly range in size from 0.2–6.0 mm. The body is not clearly segmented. The trunk and appendages of most cladocerans are enclosed in a bivalve carapace. Usually, an eye and an ocellus are present. Antennules are univalves, while antennae are mostly bivalves. The first antenna bears olfactory setae, while the second is used for swimming. Four to six pairs of trunk limbs are present.

The pattern of setae on the second antennae is a useful character for identification. All antennae are mostly similar in shape or sometimes slightly modified. The mouthparts are small, consisting of an unpaired labrum, a pair of mandibles and maxillae each, and an unpaired labium. Under favorable environmental conditions, their numbers are low. When food is scarce, smaller body sizes are preferred. Furthermore, when fish are present, larger cladocerans appear to be rare, as fish are visual predators and can easily consume them.

Copepoda

Worldwide, you may find copepod populations in every kind of body of freshwater, making them a significant and prolific category of zooplankton. Diverse organisms, including as bacteria, phytoplankton, and debris, make up their diet. Their function in aquatic environments is essential for the transmission of energy from sources of production to those that use it later on. A naupliar stage is unique to copepods, which means that they reproduce sexually only, in contrast to rotifers and cladocerans. [5]

A variety of environmental factors, including temperature, food availability, and predators, may greatly impact their mating habits and population sizes (Reed and Williamson, 2010). One of their most distinctive features is the remarkable degree to which they can adapt to harsh environments. Their body reacts by going through menopause and reducing its metabolic rate. When it comes to productivity and biomass in freshwater environments, copepods are king.

Because of this, their omnivorous diet makes them an essential part of aquatic food webs. Copepods are a common kind of fish food. The intermediary hosts for flukes, tapeworms, and germs like *Vibrio cholerae* are copepods. It is possible for people to become very sick if they consume water contaminated with copepods. Both marine and freshwater environments are home to copepods, the largest planktonic group. Included in this category are the Calanoida, Cyclopoida, and Harpacticoida free-living groups.

Over 1,200 marine and freshwater species of Calanoida, 1,000 Cyclopoida, and 1,200 Harpacticoida have been recorded. About 120 species of freshwater free-living copepods are known from India (Uttangi, 2001). Copepods of Cyclopoida are both free-living and parasitic. Harpacticoida mostly consists of free-living and benthic forms. Among planktonic microcrustaceans, Cyclopoida and Calanoida are among the most abundant, constituting the largest biomass in the plankton community.

Copepods have short, segmented cylindrical bodies. They have rounded heads and long, erect antennae, which are visible when held away from the body. They typically have nine trunk segments. The anterior segments bear appendages for swimming, while the posterior segments terminate at the base of the abdomen.[6]

The amount of segmentation on the endopods, the presence of spines on the metasome, and the quantity of setae on the caudal rami are all important taxonomic features. The sexes are distinct in many of these respects. During mating, males utilize their modified antennules to grip the female, and they are somewhat smaller than females overall.

Mating necessitates the adaptation of the fifth pereopod so that it can transport spermatophores, or packets

of sperm. A enlarged vaginal region is a telltale sign of a mature female. The initial antennae of calanoids are biramous and at least half the length of the body, setting them apart from other planktonic copepods (Mauchline, 1998). They abound in oceans and seas. Even in high-quality water, the presence of calanoid copepods is a strong sign of contamination. A thorax with six pairs of swimming legs and a head with five pairs of appendages representing mouthparts and antennae make up the body. A lot of fish naturally eat calanoids and their larvae.

Ostracods

Ostracods, commonly known as "seed shrimp," are small crustaceans, typically less than a millimeter long. They are one of the most diverse groups of crustaceans, living in all aquatic ecosystems—marine, brackish, and freshwater. They are cosmopolitan in distribution and play an important role in the food chain and energy flow in aquatic habitats. 2,000 species have been reported so far. Ostracods can reproduce both sexually and parthenogenetically. [7]

Ostracoda is a class within the Crustacea and is divided into the subclasses Myodocopa and Podocopa (Martin and Davis, 2001). The subclass Podocopa contains three orders: Platycopida, Podocopida, and Palaeocopida. Platycopida includes marine and some brackish forms. Podocopida exists in both freshwater and marine environments, and Palaeocopida is known only from the fossil record.

CULTIVATION OF ZOOPLANKTON AS LIVE FOOD FOR FISH LARVAE

The growth of aquaculture has far-reaching consequences on the dynamics and structure of aquatic ecosystems. In addition, establishing and maintaining stable and beneficial zooplankton populations is a top priority for pond fish producers.

Most aquatic animals, especially those in their larval stages, depend on zooplankton for survival. Some zooplankton are used specifically to feed young fish species that typically do not accept artificial feed. This importance stems from the fact that most fish rely on it as a source of nutrition after the yolk sac is digested. The importance of zooplankton as a primary food supply for marine fish larvae has long been recognized.

Scientists believe that increased zooplankton populations will lead to increased fish populations. Variations in zooplankton production between estuarine, coastal, and oceanic environments have been linked to an area's fisheries potential. Zooplankton are the primary link in energy transfer to the secondary level, and they play a crucial role in the production capacity of any aquatic ecosystem.

Estimating the standing crop of zooplankton provides an index for quantifying ocean fertility. Plankton availability has been proven to play a role in the success and failure of fisheries, especially pelagic fisheries. High fish populations are found in areas with high plankton biomass, also known as enrichment zones. The ecological efficiency of transfer from one trophic level to another is estimated to be approximately 10%. Plankton has a significant impact on the natural survival rates of fish juveniles and larvae, as well as on the outcomes of adult fish stocks.

In other words, these tiny organisms are responsible for the development of future fish stocks.

As larvae grow larger, they become less dependent on plankton, leading to reduced mortality. Under normal conditions, fish growth and mortality can vary dramatically. A common strategy is to lay a large number of eggs, of which only a few will survive and become adults. Surrounding environmental conditions and plankton abundance, not the number of parents, determine the success of the larvae. [8]

Although a variety of organisms provide sustenance for larval fish, zooplankton is the most common food source. Rotifers, copepods, and *Artemia* are the most common zooplankton used in aquaculture. Rotifers are microscopic aquatic invertebrates belonging to the phylum Rotifera. Copepods, a subclass of Crustacea, are a more diverse group. These two categories are used by fish farmers to feed a variety of fish and shrimp species. To properly raise large numbers of fish and shrimp, the ability to maintain a large culture of these live feeds is crucial. In fish farming, rotifers of the genus *Brachionus* are used as live feed.

With the right water and nutrition, super-intensive batch cultures can achieve rotifer densities exceeding 1,000 per milliliter. Since the establishment of the *Brachionus plicatilis* culture system in the 1950s, significant advances have been made in cultivating many different species of rotifers. The nutritional value of rotifers depends on the food source they are fed. Larval fish require highly unsaturated fatty acids (HUFAs) for proper survival and growth. Rotifers are enriched with feed containing docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which helps increase the HUFA content in rotifers. [9]

Depending on the food source, rotifers can contain approximately 52 to 59 percent protein and 13 percent fat. Because no single food source supplies all the nutrients required by rotifers, multiple food sources are recommended to maintain high densities. When larval fish are fed a mixture of copepod nauplii and rotifers, they consume more copepods than rotifers. Another advantage of using copepods as live feed is the ability to feed larval fish either nauplii or copepodites. More than 50 species of copepods have already been successfully cultured. Copepods have the unique ability to develop a resting egg-like *Artemia* under the right conditions, which can be kept for months.

Copepods are much more difficult and expensive to cultivate commercially than rotifers. Because most copepods have different food preferences, specific studies on each copepod species are essential for effective culture. Live feeds include harpacticoids, calanoids, and cyclopoids. Calanoids regularly produce a reasonable number of prey, while harpacticoids and cyclopoids can produce large quantities of prey at any given time. Calanoids is the most studied and widely used culture system. [10]

CONCLUSION

The review highlights the crucial role of zooplankton in the aquatic ecosystem of the Son River, serving as indicators of water quality and a vital link in the aquatic food chain. The presence of physicochemical contaminants significantly impacts their diversity and abundance, directly affecting the broader ecological balance. Sustainable management practices combined with regular monitoring of physicochemical parameters are essential to preserve the health of the river and its ecosystem. Future research should focus on developing strategies to mitigate pollution and enhance the resilience of aquatic biodiversity. These efforts will ensure the long-term sustainability of the river and its essential contribution to both ecology and

human well-being.

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