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Assessing Zooplankton Communities as Bioindicators in an Urban Freshwater System Near Bhubaneswar Odisha

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ABSTRACT: Urban pond ecosystems are critical ecological assets that provide essential services such as groundwater recharge, flood mitigation, microclimate regulation, and biodiversity support. Plankton communities—particularly zooplankton—are integral to the ecological functioning of these freshwater systems, serving both as bioindicators of water quality and as key players in nutrient cycling and energy transfer. This study focuses on Nuapokhari, an artificial pond located near Bhubaneswar, Odisha, and aims to assess the diversity, abundance, and ecological role of zooplankton within this urban aquatic environment. The pond, situated in Matiapara village, expands seasonally during heavy rainfall, exhibiting dynamic hydrological characteristics that influence its biotic communities. Zooplankton taxa such as Rotifera, and Copepoda were examined due to their sensitivity to environmental changes and their functional significance in aquatic food webs. Findings from this study contribute to understanding how urbanization impacts freshwater biodiversity and highlight the importance of zooplankton monitoring in ecological assessment and sustainable water management practices.

Keywords: Nuapokhari, Urban pond, Rotifera, and Copepoda.

INTRODUCTION

Pond ecosystems within urban landscapes serve as vital ecological units, offering a range of ecosystem services such as groundwater recharge, flood control, microclimate regulation, and biodiversity conservation. Among the most fundamental components of these aquatic systems are plankton—microscopic organisms that include both phytoplankton (plant-like) and zooplankton (animal-like). Despite their small size, plankton plays a crucial role in maintaining the ecological balance and productivity of freshwater bodies.

In an urban context, where ponds are often subjected to anthropogenic pressures such as sewage inflow, agricultural runoff, and industrial discharge, the study of plankton becomes especially important. Plankton is highly sensitive to changes in water quality and act as reliable bioindicators of environmental health. Their diversity, abundance, and community structure reflect the trophic status of the water body and help in assessing the impacts of urbanization on aquatic ecosystems.

Furthermore, plankton forms the base of the aquatic food web, supporting higher trophic levels including commercially and ecologically important fish species. Understanding their dynamics provides insights into nutrient cycling, energy transfer, and potential for sustainable fisheries in urban ponds.

Hence, a systematic study of plankton not only aids in ecological monitoring and conservation but also informs urban water management and restoration strategies.

Nuapokhari, the focal point of this study, is a large, artificial pond located near Bhubaneswar in Odisha. It is locally known by the residents of Matiapara village and lies approximately 16 km southeast of Bhubaneswar. It has a defined catchment area, which expands during heavy rainfall, transforming the pond into a lake-like structure

Zooplankton (from Greek: *zoon* = animal, *planktos* = drifting) are a diverse group of small, delicate, and often visually striking aquatic animals that drift with water currents (Molly Varghese *et al*., 2015). Most are microscopic, ranging from unicellular to multicellular organisms, with sizes from a few microns to several millimeters. These organisms vary widely in form, function, and taxonomy and are essential indicators of aquatic biodiversity.

Zooplankton plays a pivotal role in aquatic food webs. They consist of both permanent members of the plankton community (*holoplankton*) and temporary members like eggs and larvae (*meroplankton*). Their abundance and distribution help gauge energy transfer at the secondary trophic level, as they primarily feed on phytoplankton, converting plant biomass into animal matter. This conversion makes them a crucial food source for many higher-level consumers, especially fish and their larvae.

Freshwater zooplankton communities mainly include Rotifera, Cladocera, Copepoda, and Ostracoda (Dhanasekaran *et al.*, 2017). These organisms drift with currents and lack the ability to move independently against them. Many consume bacterioplankton and phytoplankton, while some larger species feed on smaller zooplankton, functioning as secondary consumers. Others are detritivores, feeding on organic matter either suspended in the water column or attached to substrates.

Zooplankton populations are sensitive to disturbances such as nutrient influx, acidification, and sedimentation. Their response to these changes makes them essential for studying aquatic ecosystem health. Furthermore, they are a vital food source for fish and other macrofauna. Their spatial distribution is influenced by both biological and physical factors, creating heterogeneity within aquatic environments (Dede and Deshmukh 2015).

The physicochemical and biological characteristics of water directly impact zooplankton productivity and, by extension, aquaculture yields. In freshwater systems, zooplankton is crucial for maintaining ecological balance. Despite their significance, detailed studies on their dynamics are still lacking and urgently needed. Biological productivity in any aquatic ecosystem is directly linked to its physicochemical conditions, which serve as indicators of its trophic status and potential for fisheries development. Life within aquatic environments is largely influenced by these physicochemical properties, which have driven aquatic organisms to evolve various adaptations that enhance sustained productivity and regulate the overall metabolic functions of lakes.

Typical water quality criteria for aquaculture systems include parameters such as temperature, dissolved oxygen, pH, conductivity, and alkalinity. Most existing guidelines have been developed to protect a wide range of aquatic species across various life stages, but they may not be suitable for specific species or life stages, especially under commercial farming conditions. The relevance of a particular water quality standard often depends on the species being cultured, their size, and the specific objectives of the aquaculture operation.

In water reuse systems, additional factors such as suspended solids, refractory organic compounds, surface-active agents, metals, and nitrate levels may become significant. The limiting factors in high-intensity, water reuse-based aquaculture systems are still not fully understood. Therefore, developing more appropriate and species-specific water quality standards for such systems will require trials conducted at production scale.

MATERIALS AND METHODS

Study Area: Nuapokhari is a large, manmade pond located approximately 16 km southeast of Bhubaneswar, Odisha. The pond is situated at 20°15’N latitude and 85°85’E longitude, at an elevation of around 54 meters above sea level. Covering an area of 46,114.01 m² (or 496,367.09 ft²), it has a perimeter of 827.02 m (2,713.31 ft).It is sustained year-round by a natural underground spring, ensuring sufficient water levels even in the dry summer months. However, two inlets from nearby villages introduce sewage, polluting the pond, while a single outlet discharges excess water into adjacent fields. Two sides of the pond are flanked by agricultural lands. Dense clusters of jackfruit, fig, mango, and other fruit-bearing trees grow sporadically along its boundary. One side borders a village, while the opposite side is lined with a fruit orchard. An adjacent smaller nursery pond is also present.

During the summer, the pond’s depth reaches about 10 feet at its centre, increasing to around 18 feet during the rainy season. According to local residents, the pond was originally constructed by Mukundadev Maharaja, a Gajapati ruler of Odisha. It was later renovated in 1897 by the local Zamindar and, after India’s independence, was entrusted to the care of three nearby villages, who continue to maintain it.

A unique feature of this pond is its perennial underground water source, which ensures sufficient water even during summer. However, the pond is also subject to pollution due to the inflow of sewage from nearby villages through two inlets, while one outlet discharges excess water into nearby agricultural fields. Agricultural lands flank two sides of the pond.

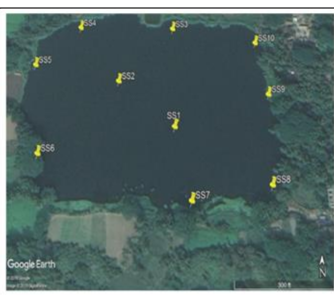

Fig. 1. Satellite picture of the pond with sampling sites.

Fig. 2. Sampling site 6 in Nupokhari.

Fig. 3. Sampling site 7 in Nupokhari.

Specimen Collection: Zooplankton was sampled from multiple locations within Nuapokhari. Collection methods followed standard practices using water bottles, plankton nets, and pumps. Van Dorn bottles, specifically designed for sampling water from specific depths with minimal disturbance, were employed to collect microzooplankton from various layers of the water column (Goswami, 2014). These bottles enable the collection of composite or pooled samples for horizontal and vertical sampling and are particularly effective for collecting samples across stratified layers (Dhanasekaran *et al*., 2017).

For surface sampling, water was collected using 1-liter bottles by gently scooping to avoid disturbing the water and triggering avoidance reactions in plankton. For mid-depth sampling, a water pump was used to collect samples from depths of 10 cm and 20 cm below the surface. Each of these processes was repeated 50 times to ensure a representative and diverse sample set. Collected water was then filtered through plankton nets of 0.2 mm mesh size (typically monofilament nylon) to concentrate the zooplankton.

Plankton nets—both open-type (for horizontal and oblique hauls) and closed-type with messenger systems (for vertical hauls)—were also utilized. These nets, typically conical and made from bolting silk or synthetic materials, consist of a rigid or flexible ring, filtering cone, and a detachable collecting bottle. The sampling efficiency depends on several factors such as mesh size, towing speed, net design, and haul duration.

The collected zooplankton samples were stored in plastic containers, sealed, and labelled for subsequent analysis.

Fixation and Preservation: Zooplankton samples were immediately fixed and preserved post-collection to prevent decomposition due to bacterial activity, cannibalism, or chemical degradation. Fixation ensures structural preservation, while preservation maintains these conditions over time. A 10% formaldehyde solution was used, as recommended by Leakey *et al.* (1994), allowing long-term storage without compromising sample integrity.

Observation of Zooplankton: A few drops from the preserved samples were placed on a Petridis using an eye dropper and initially examined under a dissecting microscope (Bhat *et al*., 2014). For smaller and more detailed observations, slides were prepared and analyzed under a compound microscope using different magnification objectives.

Physico-Chemical Study: Sampling sites were selected to reflect diverse conditions within the pond, including shallow and deep zones, points of inflow and outflow, and areas affected by human activity. Grab samples were collected monthly during February, March, and April from ten representative sites.

Water samples were collected in 1-liter clean, inert plastic containers and 1-liter BOD bottles, thoroughly rinsed with distilled water beforehand. To minimize contamination, bottles were submerged approximately 10 cm below the surface, then opened underwater and re-sealed before retrieval. Each container was properly sealed and labelled with relevant sampling information including site name, date, time, and sampling conditions.

To prevent chemical changes in the samples between collection and analysis, samples were preserved immediately upon collection (Abbasi, 1998). The temperature was recorded using a digital thermometer. pH and Conductivity was measured with digital pH meter and conductivity meter (Spectronic India). Dissolved Oxygen (DO) was analyzed using the Winkler's titration method. Chloride content was measured following standard chemical procedures. These parameters were chosen for their relevance in evaluating water quality and ecological status of the pond system.

RESULT AND DISCUSSION

The zooplankton species collected during the study period were used to estimate the zooplankton diversity in the Nuapokhari pond. A total of eight species were recorded, comprising four species of Rotifers and four species of Copepods. All the Rotifer species belonged to the same genus, whereas the Copepod species belonged to different genera.

Rotifers: From the above identification, it was found that the rotifers belonged to the genus *Brachionus*. Rotifers (Phylum Rotifera), commonly known as wheel animals, are microscopic and near-microscopic pseudocoelomate animals. They were first described by John Harris in 1696, with additional forms later described by Antonie van Leeuwenhoek in 1703. Most rotifers range in size from 0.1 to 0.5 mm, though some species can be as small as 50 µm or as large as over 2 mm. They are commonly found in freshwater environments.

Rotifers exhibit a variety of lifestyles: some are free-swimming and planktonic, others move by inch-worming along substrates, and some are sessile, living inside tubes or gelatinous holdfasts attached to a surface. They play a vital role in freshwater ecosystems, serving as a major food source for larger organisms and contributing to the decomposition of organic matter in the soil. While many rotifer species are cosmopolitan in distribution, some are known to be endemic.

***Brachionus diversicornis* (Daday, 1883)**: Brachionus is a genus of planktonic rotifers occurring in fresh water. One anterior flagella is slightly longer than other one.

***Brachionu srubens**:* Juncture between anteromedian and anteromediate spines acutely notched.

Brachionu sfalcatus: The body structure is nearly similar with *B. diversocornis*. Anterior flagella are same in length.

Brachionus budapestinesis var. punctatus : It is fresh water zooplankton belongs to group brachionus.

Copepods: From the above identification, it was found that the copepods belonged to the genera *Cyclops* and *Sinodiaptomus*. Copepods (meaning "oar-feet") are a group of small crustaceans found in the sea as well as in nearly all freshwater habitats. Depending on the species, copepods can be planktonic (free-swimming in the water column) or benthic (living on or near the bottom). Some continental species inhabit limno-terrestrial environments and other moist terrestrial habitats such as swamps, leaf litter in wet forests, bogs, springs, ephemeral ponds, puddles, damp moss, or water-filled plant cavities (phytotelmata) like those found in bromeliads and pitcher plants.

Many copepods also inhabit subterranean environments such as marine and freshwater caves, sinkholes, or streambeds. Due to their sensitivity to environmental changes, copepods are sometimes used as indicators of biodiversity and ecological health.

One of the commonly observed developmental stages in copepods is the **nauplius**, especially in species like *Cyclops*, which is often found in freshwater ecosystems.

Cyclops nauplii: It is the most common genera of fresh water copepods having the single large eye which may be either red or black in Cyclops.

Mesoocyclops leukarti (Claus 1857): It is easily distinguished from other copepods by the last pair of legs. It is mainly found in fresh water bodies.

Eucyclops speratus (Lill Jeborg1901): Its taxonomy is based on latest scientific consensus and the organism mainly found in freshwater bodies and also in brackish water

Thermocyclops hyalinus:

It is a genus of crustaceans in family cyclopidae. It was first described by F.Kiefer. This species are found in both brackish and fresh water

The results are in accordance with the diversity study on zooplankton conducted in relation to water quality parameters in Ambe Ghosle Lake, Thane city in by Nimbalkar *et al.* (2013).

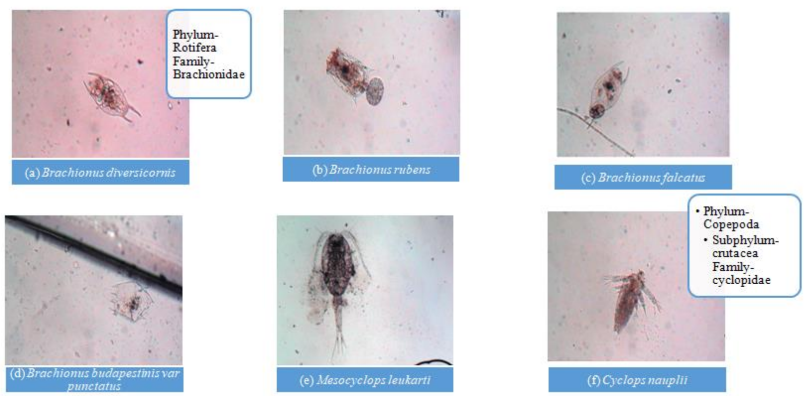

Fig. 4. Microphotographs of plankton specimen collected from the Nuapokhari pond.

Diversity in zooplankton was observed in Tulshi Reservoir (Koli and Muley 2012) and Perennial Reservoir at Thoppaiyar (Manickam *et al.*, 2014) as found in a stagnant pond in case of our study.

Water Quality parameters: The water quality parameters measured during the study period showed slight variations across different sampling sites in the Nuapokhari pond. The pH of the water ranged from 7.1 to 7.5, indicating a neutral to slightly alkaline nature. Similar results were obtained in Cauvery river by Kalavathy *et al.* (2013). Dissolved oxygen (DO) levels varied between 3.4 mg/L and 5.4 mg/L (Fig. 5), suggesting varying degrees of organic pollution across the sites. Specifically, Site 8 exhibited the lowest DO concentration, indicating a higher level of organic pollution, while Site 1 (Table 1) showed the highest DO value, reflecting minimal organic contamination. The temperature of the water ranged from 24°C to 30.3°C during the sampling period. Alkalinity was found to be relatively high, ranging between 480.1 mg/L and 486.2 mg/L, which may be indicative of significant buffering capacity in the pond water. The water quality parameters show a seasonal variation in accordance with the work (Jose and Sunalkumar 2012). Electrical conductivity (Table 2) values ranged from 331 µS to 383 µS, reflecting moderate levels of dissolved ionic substances (Kumar and Dua 2009). Chloride concentrations varied from 71.3 mg/L to 95.5 mg/L (Table 3), which falls within the typical range for freshwater bodies but may point to some degree of anthropogenic influence. These findings collectively offer valuable insight into the physico-chemical status of the pond and help in understanding the ecological conditions influencing zooplankton diversity (Mia *et al.*, 2009).

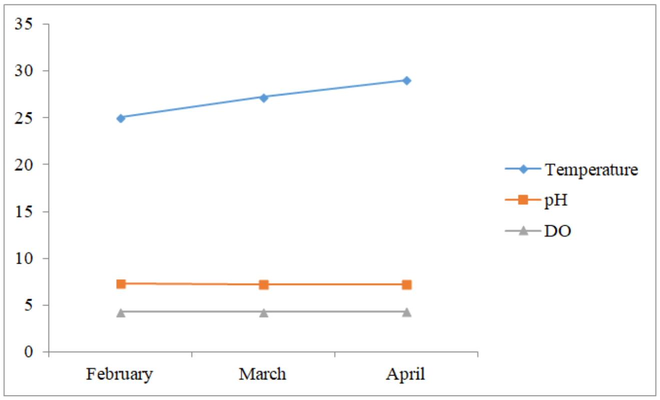

Fig. 5. Variations in temperature, pH, and DO content in the pond across the months. The values are mean of all sampling sites in a particular month.

Table 1: Mean values of water parameters at different sampling sites in the month of February.

Sampling sites (ss)	Temp. (◦c)	ph	Conductivity (μs)	DO (mg/l)	Bi- carbonate (mg/l)	Free co2 (mg/l)	Chloride (mg/l)
1	25	7.27	352	5	246.7	483.3	71.3
2	24.5	7.35	338	4.9	247.1	484.2	74.2
3	27.5	7.28	356	4.2	236.7	482.1	71.4
4	27	7.24	370	4.1	248.7	484.2	72.4
5	24	7.33	343	4.8	239.3	485	79.3
6	24.5	7.2	335	4.8	238.1	484.5	75.1
7	26	7.21	341	4.1	242.2	484	73.2
8	26	7.3	362	3.4	253.3	485.1	91.5
9	27	7.34	357	3.5	251.1	484.9	90.4
10	26.5	7.2	349	3.9	240	483.4	76.4

Table 2: Mean values of water parameters at different sampling sites in the month of March.

SS	Temp. (◦C)	ph	Conductivity (μs)	DO (mg/l)	Bi- carbonate (mg/l)	Free co2 (mg/l)	Chloride (mg/l)
1	27.5	7.1	367	5.2	2445.2	484.2	72.3
2	27	7.3	358	4.9	244.1	483.2	73.2
3	29	7.21	370	4.1	233.7	482.1	71.4
4	30	7.16	383	4.4	245.6	483.2	72
5	27	7.25	349	4.6	238.3	485.1	75.3
6	26.5	7.18	348	4.4	237.1	483.5	74.1
7	27	7.2	356	4	242.4	483.9	81.2
8	28	7.2	370	3.7	254.3	486.2	94.5
9	28.5	7.3	371	3.4	252.2	485.9	92.4
10	27	7.2	356	4	240.3	482.4	76.4

Table 3: Mean values of water parameters at different sampling sites in the month of April.

SS	Temp. (◦C)	pH	Conductivity(μs)	DO (mg/l)	Bi- carbonate (mg/l)	Free co2(mg/l)	Chloride(mg/l)
1	**29.9**	**7.2**	**369**	5.4	245.3	483.2	72.2
2	**27.3**	**7.05**	**359**	4.5	243.9	482.2	72.2
3	**30.1**	**7.1 2**	**371**	4.2	233.6	480.1	73.4
4	**30.3**	**7.33**	**383**	4.1	244.6	483.4	73
5	**28.2**	**7.21**	**355**	4.7	238.5	485.3	76.3
6	**27.5**	**7.1**	**353**	4.5	238.1	484.2	74.2
7	**28.6**	**7.2**	**352**	4.1	242.4	482.8	81.2
8	**29.9**	**7.31**	**373**	3.5	254.5	456.2	95.5
9	**30.1**	**7.3**	**372**	3.6	252.2	484.9	93.4
10	**28.5**	**7.2**	**359**	4.3	241.3	483.4	77.3

CONCLUSIONS

The current investigation revealed that the water quality exhibited only minimal variations across the different sampling points—a uniformity likely stemming from the pervasive presence of both organic and inorganic pollutants throughout the pond. This subtle homogeneity in water chemistry suggests that these contaminants are well-dispersed, exerting a consistent influence on the aquatic environment. Within this ecological framework, the zooplankton community was represented by an equal distribution of diversity, comprising four species of Rotifers and four species of Copepods. This balanced assemblage not only reflects the prevailing environmental conditions but also underscores the resilience and adaptability of these microscopic organisms in the face of continuous pollutant inputs.

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