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Study of Zooplankton Diversity in Relation to Physico-Chemical Parameters of Ghodazari Lake, Nagbhid, Dist. Chandrapur

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ABSTRACT

Zooplankton, being sensitive to environmental changes, serve as reliable indicators of water quality and ecological status. The present study investigates the diversity and distribution of zooplankton in relation to selected physico-chemical parameters of Ghodazari Lake, located at Nagbhid, District Chandrapur, Maharashtra, India. The study was carried out over a period of six months to assess the interrelationship between biological and physicochemical components of the lake ecosystem. Physico-chemical parameters such as atmospheric and water temperature, chloride, alkalinity, pH, total hardness, dissolved oxygen, free carbon dioxide, bicarbonate, phosphate-P, ammonium-N, nitrite-N, conductivity, and total dissolved solids (TDS) were analyzed. Zooplankton diversity was studied as a biological parameter. The findings highlight the impact of water quality parameters on zooplankton composition and distribution, providing precious knowledge into the trophic dynamics & ecological health of the lake.

Keywords: *Zooplankton diversity, Physico-chemical parameters, Water quality, Ghodazari Lake, Ecological health.*

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Introduction

Water is chief source of life for all forms and bodies of water rears life. Water consumption in large quantity across the globe for bathing, drinking, irrigation, washing, and also for aquaculture needs and functions. Whether natural or man-made – Ponds, reservoirs, lakes, rivers and underground storages are the chief aqua sources. The working and operational parameters of an ecosystem are linked to its ecological importance and arise from the interactions among its physical, biological, and chemical elements. These interfaces lead to the formation of numerous positions and roles assumed by different organisms, thereby offering plant habitat, animals, and microorganisms within an ecosystem and influencing the trophic dynamics of the aquatic environment. Water, being main driving force, is the essential source of any Economy in the 22nd century. [1]

The examination of freshwater fauna, particularly Zooplankton, within a specific region is a broad and complex phenomenon because of biological, physical, geographical, environmental, and chemical variations that include both external and internal ecological factors. The scattering of zooplankton and their variants across various zones of a water body are recognized to be affected by the physico-chemical conditions of the water.

Over the past few decades, the quality of Indian water bodies particularly has been on decline due to the ongoing release of industrial effluents and domestic sewage. [2] Freshwater ecosystems are influenced by physical and chemical factors in multiple direct and indirect manners. Understanding the physicochemical characteristics of water bodies is essential for examining fish rearing practices within them. [3] The ecological research conducted on Ghodazari Lake in the Nagbhid tehsil of Chandrapur district, Maharashtra, India (Figure 1) has examined the physico-chemical and biological factors, focusing on the diversity and distribution of Zooplankton over six months. The gathered data are analyzed for their significance and the interconnections between the parameters. The physico-chemical parameters examined include atmospheric temperature, water temperature, pH, alkalinity, total hardness, chloride ions, dissolved oxygen, free carbon dioxide, bicarbonate, phosphate-P, ammonium-N, nitrite-N, conductivity, TDS (total dissolved solids), and zooplankton as the biological parameter.

Materials and Methods

Sampling Program & Procedure:

The investigation was carried out continuously over a period of six months, from January to June 2024, at three selected sampling stations of Ghodazari Lake. The primary objective of the study was to assess the physico-chemical properties and biological features of the lake. Water samples were collected from three distinct locations: Site S1, an area influenced by tourism and boating activities; Site S2, where fish farming practices are carried out; and Site S3, located near Ghodazari village, which is frequently used by residents for routine activities such as washing, bathing, and fishing.

Samples for dissolved oxygen (DO) analysis were collected from the surface water between 6:00 a.m. and 8:00 a.m. Various physico-chemical parameters, including DO, pH, soil organic carbon, free carbon dioxide (CO_2), nitrite-N, ammonium-N, phosphate-P, electrical conductivity, alkalinity, total dissolved solids (TDS), hardness, and chloride ions, were analyzed using standard procedures outlined by APHA (2005). [4] The comparison of the obtained results with the prescribed standards of the Bureau of Indian Standards (BIS, 2003). [5] Air and surface water temperatures were measured using a Celsius thermometer (0°C–100°C range), while pH was determined using a digital electrode pH meter (Systronics, Model SYS-335). All reagents used in the analysis were of analytical reagent (AR) grade.

Zooplankton samples were collected using a modified Heron–Tranter plankton net with a circular metal frame having an area of 0.625 m^2. The conical filtering net of nylon bolting silk measured No. 25 mesh, 50 µm. The collected plankton samples were preserved in labeled vials containing 5% formalin. Quantitative analysis was carried out using a Sedgwick–Rafter counting chamber by examining 1 ml of the sample. Microscopic observation and photographic documentation were performed using a Magnus trinocular microscope (Model MLX-TR) fitted with a Nikon Coolpix camera. Taxonomic identification of zooplankton was done following standard references. [6-9] Every chemical utilized in this investigation was as pure as possible.

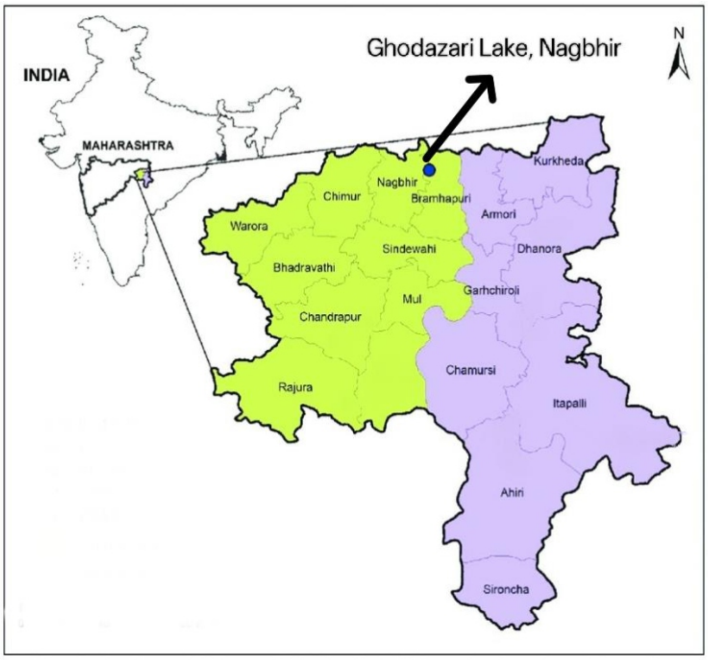


Figure 1: Study Area Map

Figure 2: Aerial picture of the Sites of Ghodazari Lake

Result and Discussion

The physico-chemical parameters of three different sites of Ghodazari lake from January -June 2024 are summarily presented in Table 1. The readings of different hydro biological parameters are Mean ± S.E. Some noticeable variations in hydro biological parameters were noted.

Table-1: Summary of physico-chemical and biological parameters Mean ± S.E. of different sites of Ghodazari lake during January to June, 2024

Parameters	S-1	S-2	S-3	BIS standard
AirTemp. (0C)	35.1 ± 2.9	34.5 ± 3.5	35.6 ± 2.8	--
Water Temp. (0C)	24.1 ± 2.3	23.7 ± 2.1	23.2 ± 1.9	--
pH	7.79 ± 0.72	7.80 ± 0.70	7.8 ± 0.62	6.5 – 8.5
DO (mg/L)	4.46 ± 0.02	4.52 ± 0.03	4.06 ± 0.01	Upto 6.0
Free CO_2 (mg/L)	33.2 ± 0.19	47.0 ± 1.00	57 ± 3.02	--
Chloride ions (mg/L)	35.0 ± 0.36	37.0 ± 0.93	40.2 ± 0.15	Upto 250
Alkalinity (mg/L)	114.2± 0.56	115.01 ± 5.6	238.2 ± 3.5	50 – 200
Total hardness (mg/L)	208.0 ± 5.6	216.25 ± 9.5	244.3 ± 6.9	Upto 300
Nitrite-N (mg/L)	1.401	1.41	1.4	--
Conductivity (µS/cm)	750±8.1	720±7.8	780±8.0	--
TDS (ppm)	470±5.3	436±4.7	470±5.8	Upto 500

Water temperature during the study period showed seasonal variation, ranging from 22.2 °C to 24.0 °C, while air temperature fluctuated between a minimum of 33.8 °C and a maximum of 35.6 °C (Table 1). Variations in water temperature significantly influence primary productivity, particularly creating differences between temperate and tropical aquatic ecosystems. [10,11]

Hydrogen ion concentration (pH) is an important parameter affecting both biological processes and chemical reactions in aquatic environments. Since most metabolic activities of aquatic organisms are pH-dependent, variations in pH can directly influence their survival. [12] During the six-month study period, the average pH values ranged from 7.75 to 8.02 (Table 1), which aligns with other's findings. [13] The lowest pH was recorded at Site S1. Overall, the pH values (7.65–8.02) indicated slightly acidic to mildly alkaline conditions. It was also observed that polluted waters generally show pH fluctuations between 8 and 9. [14] Elevated pH values above 9 are often caused by intense algal photosynthesis in nutrient-rich waters, leading to eutrophication. [15] As per BIS report in 2003, the acceptable pH range for drinking water is 6.5–8.5; thus, the lake water falls within permissible limits and may be suitable for fishing and drinking after appropriate treatment.

Dissolved oxygen (DO) is a vital parameter for sustaining aquatic fauna. Among the three sites, Site S2 recorded the highest DO concentration. Oxygen diffusion from the atmosphere into surface water plays a major role in maintaining DO levels. [16] Additionally, photosynthetic activity of algae and other autotrophs contributes oxygen to the water. Ponds with abundant aquatic vegetation generally exhibit higher DO compared to those with limited flora. However, excessive growth of algae can form surface mats, restricting gas exchange and leading to oxygen depletion, which may cause mortality of aquatic organisms under anoxic conditions. Increased algal blooms can reduce DO levels. [17] In the present study, Site S3 exhibited very low DO, possibly due to heavy anthropogenic use and pollutant input, while Site S2 showed the highest DO value (4.59 mg/L) due to a dense phytoplankton population. Despite low oxygen levels, rotifers were abundant at Site S2, indicating their tolerance to reduced DO conditions. Organisms such as *Paramecium*, *Euglena*, *Chlamydomonas*, *Keratella cochlearis*, *Brachionus urceolaris*, and *Monostyla bulla* were observed in well-lit zones of the water body. Similar associations between algal abundance and hydrophyte-rich areas were reported. [18]

Decomposition of aquatic plants under anaerobic conditions can release harmful compounds such as strychnine, which negatively affect aquatic life.[19] DO concentration is directly related to surface exposure to air and inversely related to water temperature, while plankton density also influences oxygen levels, as noted by Ahmad and Krishnamurthy (1990) and Singh and Singh (1993). [20,21]

Dissolved carbon dioxide plays an important role in sustaining aquatic ecosystems. Its primary sources include respiration by aquatic organisms and exchange with atmospheric air. Due to its high solubility, CO_2 readily dissolves in water, forming carbonic acid and carbonate compounds that influence pH. In the present study, Site S3 recorded the highest free CO_2 concentration (57 mg/L), whereas Site S1 showed the lowest (33.2 mg/L), likely due to greater human activity at Site S3. However, free CO_2 rarely acts as a limiting factor for phytoplankton growth [22]

Alkalinity represents the water's capacity to neutralize acids. Dissolved CO_2 forms bicarbonate and carbonate ions, which reduce hydrogen ion concentration and stabilize pH. Significant variation in alkalinity was observed, with Site S3 recording the highest value (238 mg/L), exceeding the BIS limit of 200 mg/L. Sites S1 (114.6 mg/L) and S2 (115.2 mg/L) remained within acceptable ranges. Elevated alkalinity at Site S3 may be attributed to intensive domestic activities such as washing and cleaning. Similar increases in alkalinity due to detergent use were reported. [23]

Chloride occurs in water mainly as sodium, potassium, and calcium chlorides. Its sources include rock weathering, pollution, and animal waste. In this study, chloride concentration ranged from 35 to 40 mg/L, with the lowest value recorded at Site S1 (35 mg/L). Higher chloride levels generally indicate increased pollution from organic waste. Seasonal variations have been noted and observed that higher chloride concentrations are found during summer due to evaporation and reduced water volume. [24] Elevated chloride levels can adversely affect osmoregulation in aquatic organisms. Species such as *Lepadella ovalis*, *Heliodiaptomus*, *Cypris*, *Heterocypris*, and *Paramecium vulgaris* were found in waters with low chloride levels, while *Lecane luna* tolerated concentrations between 25–60 mg/L. *Hexarthra fennica*, *Cypris* sp., and *Brachionus plicatilis* exhibited higher tolerance to chloride.

Water hardness is an important quality parameter, although it does not directly indicate pollution. Based on hardness classification, values between 150–300 mg/L are considered hard water. In the present investigation, total hardness ranged from 208 mg/L at Site S1 to 244.65 mg/L at Site S3, likely due to the presence of calcium, magnesium, sulphate, and nitrate ions. [25] Reportedly, hardness typically increases during summer because of evaporation and reduced water volume. [26] Site S1 showed the lowest hardness and was also observed to be eutrophic.

Nitrate and nitrite are essential components of the nitrogen cycle. Nitrate (NO_3^-) is the most stable nitrogen form in oxygen-rich environments, whereas nitrite (NO_2^-) is relatively unstable and can be transformed through biological and chemical processes (ICAIR Life Systems, Inc., 1987). Nitrite contamination may result from agricultural runoff containing fertilizers and oxidation of animal waste (WHO, 2007). The acceptable nitrite concentration in water is approximately 1 mg/L. In the present study, nitrite levels were low, ranging from 0.8 mg/L at Site S1 to 1.4 mg/L at Site S3.

Primary productivity represents the rate of biological production in an aquatic ecosystem and forms the foundation of ecosystem functioning. [27] In freshwater systems, photosynthetic carbon fixation occurs through phytoplankton, periphyton, benthic algae, and macrophytes. Among these, phytoplankton productivity is the most significant indicator of ecosystem productivity. Electrical conductivity counts the potential property of water to conduct electrical current and is absolutely related to the concentration of dissolved ions such as chlorides, sulphates, carbonates, and other electrolytes derived from dissolved salts and inorganic substances.

Table 2: Abundance of Zooplankton of study sites

Sr.No.	Genera	S-1	S-2	S-3
	Cladocera			
1	*Daphnia sp.*	40	170	280
2	*Bosmina sp.*	-	-	50
3	*Moina sp.*	10	50	100
	Total	**50±7**	**220±5**	**430±20**
	Copepoda			
5	*Cyclops sp.*	110	250	600
6	*Mesocyclops sp.*	40	70	210
7	*Diaptomus sp.*		30	15
	Total	**75±4**	**50±3**	**825±30**
	Rotifera			
8	*Brachionus bidentata*	75	25	25
9	*Brachionus quadridentata*	-		25
10	*Keratella tropica*	-	25	
11	*Asplanchna sp.*	-	-	-
	Total	**75±6**	**50±3**	**50±3**
	Ostracoda			
12	*Cypris sp.*	50	-	175
13	*Stenocypris sp.*	25	-	75
	Total	**75±4**	**0**	**250±15**
	Larva And Protozoa			
14	Nauplius larva	100	75	125
15	Zoea	-	25	25
16	*Paramoecium sp.*	50	50	50
17	*Euglena sp.*	25	-	50
	Total	**175±9**	**150±8**	**250±15**
	Grand Total	350	450	1905

The electrical conductivity of water increases with a rise in the concentration of dissolved ions. Total dissolved solids (TDS) refer to the combined amount of inorganic salts and minerals present in water and are expressed in parts per million (ppm), indicating the number of impurity units per million units of water. Studies on inland freshwater systems suggest that streams capable of supporting diverse fish populations typically exhibit conductivity values between 150 and 500 µS/cm. Values beyond this range may indicate inappropriate conditions for specific fish species and macroinvertebrates. In the present investigation, conductivity values across the study sites (S1 to S3) ranged from 720 to 800 µS/cm, which remained within acceptable limits. The highest conductivity was recorded at Site S3 (800 µS/cm), likely due to intensive domestic use by nearby residents, while the lowest value was observed at Site S2, which experiences relatively minimal anthropogenic disturbance.

Total dissolved solids (TDS) levels at all three sites exceeded the permissible limits, indicating that the lake water is unsuitable for drinking and other domestic uses without treatment. TDS concentrations varied from 432 to 470 ppm, with the highest value recorded at Site S3 (740 ppm) and the lowest at Site S2 (432 ppm), reflecting differences in human activity and pollutant input.

Zooplankton are small, animal-like organisms that drift or weakly swim in aquatic environments. Their size ranges from approximately 5 mm in larger forms to microscopic dimensions in smaller species. The term “plankton” is coined from the Greek term *planktos*, denoting drifter or wanderer.

In lentic (standing water) ecosystems, zooplankton communities primarily consist of members of the groups Rotifera, Cladocera, Copepoda, and Ostracoda, with rotifers forming the second most plentiful group.

Rotifers are soft-bodied, multicellular invertebrates characterized by rapid reproduction and short life cycles. In the present study, rotifers were represented by six genera, with *Brachionus* being the dominant genus, including *B. diversicornis*, *B. bidentata*, and *B. quadridentata*. Other recorded genera included *Keratella tropica*, *Asplanchna*, *Filinia*, and *Lecane*. Rotifers are highly sensitive to environmental fluctuations and are widely recognized as reliable indicators of water quality. [28] The occurrence of *Brachionus* species is often associated with organic pollution. [29-31] Additionally, *Brachionus calyciflorus* is considered a strong indicator of eutrophic conditions (Manickam et al., 2012). [32] Previous studies have documented the effects of toxic substances such as lead and pesticides on rotifer survival and reproduction. [33,34] The present study recorded a lower rotifer population than expected (Fig. 9), although it was reported that rotifers can rapidly increase under favorable environmental conditions. [35]

Cladocerans form one of the most important and nutritionally valuable zooplankton groups, serving as a key food source for fish larvae, juveniles, and adults. In this study, Cladocera emerged as the dominant zooplankton group and was represented by *Daphnia*, *Moina*, *Ceriodaphnia*, and *Bosmina* species. These organisms feed on algae, bacteria, and smaller zooplankton and are highly sensitive to pollutants, responding even to low concentrations of contaminants. [36] Site S3 exhibited the highest cladoceran abundance, indicating altered water quality conditions.

Copepods constituted the third most abundant zooplankton group and included *Cyclops*, *Diaptomus*, and *Mesocyclops* species. Copepods possess a strong exoskeleton and well-developed appendages, enabling efficient swimming. Their feeding behavior varies across groups: cyclopoids are primarily carnivorous, calanoids are omnivorous, and harpacticoids are largely benthic. Such adaptability and structural strength allow copepods to tolerate harsher environmental conditions compared to cladocerans. [37] High copepod densities were recorded at Site S3, followed by Site S2, possibly due to their broad feeding habits and high reproductive capacity. [38]

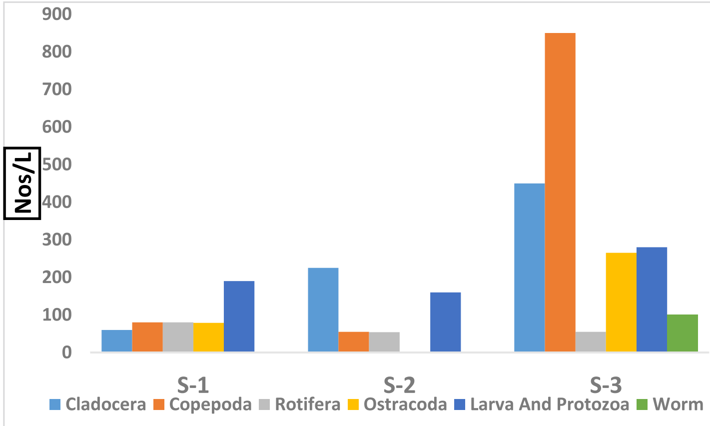
Both cladocerans and copepods are considered tolerant species and are commonly found across a wide range of aquatic environments. [39] In the present study, their dominance at Site S3 suggests eutrophic and polluted conditions, as cladocerans are also recognized indicators of nutrient-rich waters. [40]

Ostracods were the least abundant zooplankton group and were represented by *Cypris* and *Heterocypris* species. These organisms typically inhabit the bottom sediments of lakes, feeding on detritus and decomposed phytoplankton, and serve as food for fish and benthic invertebrates. [41] Their population density remained low throughout the study period.

Protozoans and larval forms exhibited high abundance at Sites S1 and S2, while moderate populations were observed at Site S3. The highest zooplankton species diversity was recorded at Site S2, which is primarily used for fishing activities (Table 2). Greater diversity at this site suggests lower pollution levels and a well-functioning biogeochemical cycle, making it suitable for natural fish and shellfish culture. Species richness was highest at Site S3, indicating the presence of a larger number of species under favorable environmental conditions.

The importance of zooplankton studies in fisheries, aquaculture, and paleolimnology lies in their role as primary food for freshwater fish and their influence on fish productivity. [42] Rotifers, in particular, are globally recognized as biological indicators of aquatic pollution. [43] Zooplankton distribution is typically not even as certain species concentrated in littoral zones and others preferring open water regions, and their abundance is influenced by ecological situations and grazing pressure.

Graphical representation of some biological parameters of Ghodazari Lake from January to June 2024:



Some of the Zooplankton are frequently observed on the sites

Conclusion

Effective management of freshwater bodies such as ponds and lakes requires a comprehensive understanding of their physico-chemical characteristics and biological components. Aquatic ecosystems are strongly influenced by environmental factors, including light availability, temperature, humidity, and the input of various contaminants and effluents. The overall productivity and ecological balance of a water body are therefore governed by the interaction between its chemical properties and biological communities.

Based on the present investigation, it can be concluded that the physico-chemical parameters recorded at all three sampling sites of Ghodazari Lake over the six-month study period remained within the permissible limits prescribed by the Bureau of Indian Standards. A key outcome of the study is the observation of moderate zooplankton diversity across the selected sites. Since rotifers are widely recognized as biological indicators of water quality and fish culture suitability, the findings suggest that, despite regular use by local inhabitants, the lake water is appropriate for fisheries development with minimal management interventions. The results provide a valuable baseline for future monitoring and for strategies aimed at enhancing both the diversity and abundance of zooplankton. Biodiversity serves as an important indicator of ecosystem health and forms a strong foundation for ecological stability and sustainable biological development.

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