Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2025; Vol 24: Issue 9s, https://carcinogenesis.com/

Seasonal Dynamics of Water Quality and Zooplankton Diversity in Tripuranth Lake, Basvakalyan, Karnataka: A Year-Long Assessment of Ecosystem Health and Environmental Drivers

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ABSTRACT

Tripuranth Lake serves as a vital freshwater ecosystem in Basavakalyan, Bidar District, Karnataka, providing essential services for irrigation, fisheries and biodiversity conservation. This investigation evaluated the seasonal dynamics of water quality and zooplankton communities through comprehensive monthly monitoring from January to December 2023. Ten key physico-chemical parameters were analyzed, including atmospheric temperature (21.5-36.8°C), water temperature (18.25-28.50°C), pH (6.45-9.35), dissolved oxygen (6.18-9.25 mg/L), total dissolved solids (120.50-210.80 mg/L), conductivity (158.50-315.80 µS/cm), total alkalinity (88.50-248.60 mg/L), total hardness (58.20-208.50 mg/L), calcium (13.80-28.50 mg/L), and magnesium (6.20-32.80 mg/L). Zooplankton diversity assessment revealed 28 species distributed among Rotifera (11 species, 39.3%), Cladocera (8 species, 28.6%), Copepoda (6 species, 21.4%), and Ostracoda (3 species, 10.7%). Maximum parameter values occurred during pre-monsoon months (April-May), with water temperature peaking at 28.50°C, pH at 9.35, and conductivity reaching 315.80 µS/cm. Zooplankton abundance exhibited strong positive correlations with temperature ($r = 0.82$) and dissolved oxygen ($r = 0.73$), indicating temperature-driven productivity patterns. The lake demonstrated good water quality standards suitable for multiple uses, while zooplankton diversity indicated a healthy, functioning ecosystem with seasonal adaptation strategies.

KEYWORDS: *Freshwater ecology, Water quality assessment, Seasonal variations, Biodiversity monitoring, Aquatic ecosystems*

How to Cite: Shilpa Kalyanrao, Nagbhushan Reddy., (2025) Seasonal Dynamics of Water Quality and Zooplankton Diversity in Tripuranth Lake, Basvakalyan, Karnataka: A Year-Long Assessment of Ecosystem Health and Environmental Drivers, *Journal of Carcinogenesis, Vol.24, No.9s*, 402-409.

1. INTRODUCTION

Freshwater ecosystems represent critical components of global biodiversity, serving multiple ecological and socioeconomic functions including water supply, flood control, nutrient cycling, and habitat provision for diverse biological communities. In semi-arid regions of India, artificial lakes and reservoirs have become increasingly important as they provide water security for agriculture, domestic consumption, and ecological sustainability. The assessment of freshwater quality through physico-chemical parameter monitoring has gained significant importance in environmental management, particularly as anthropogenic pressures intensify across Indian landscapes. Parameters such as temperature, pH, dissolved oxygen, conductivity, and nutrient concentrations provide quantitative indicators of ecosystem health and water suitability for various uses. These measurements reflect complex interactions between climatic conditions, geological influences, biological processes, and human activities within the watershed.

Zooplankton communities serve as particularly valuable bioindicators in aquatic ecosystem assessment due to their sensitivity to environmental changes, rapid generation times, and integral role in food web dynamics. These microscopic organisms respond quickly to alterations in water quality, making them effective early warning indicators of ecosystem stress or recovery. The taxonomic composition, abundance patterns and diversity indices of zooplankton assemblages provide insights into trophic status, pollution levels and overall ecological integrity of freshwater systems.

The seasonal dynamics of tropical freshwater ecosystems are strongly influenced by monsoon patterns, which create distinct wet and dry periods that drive cyclical changes in water chemistry and biological communities. Pre-monsoon periods typically exhibit concentrated nutrients, elevated temperatures and enhanced primary productivity, while monsoon seasons bring dilution effects, temperature moderation and potential disturbance from increased inflows. Understanding these patterns is essential for effective water resource management and conservation planning.

This research investigates the temporal variations in physico-chemical parameters and zooplankton diversity in Tripuranth Lake throughout 2023, with the objective of establishing baseline ecological conditions and identifying key environmental drivers of community structure. The study contributes to regional freshwater ecology knowledge and provides scientific foundation for sustainable management practices in similar semi-arid aquatic systems.

2. MATERIALS AND METHODS

2.1 Study Area and Site Selection

Tripuranth Lake is an ancient reservoir located in Basavakalyan, Bidar District, Karnataka, covering approximately 45 hectares with a maximum depth of 8.5 meters. The lake serves as a primary water source for surrounding agricultural lands and domestic use. The regional climate is classified as semi-arid tropical with an average annual rainfall of 750-850 mm, concentrated primarily during the southwest monsoon (June-September).

Four sampling stations were strategically established to represent different ecological zones: Station 1 (littoral zone with emergent vegetation), Station 2 (shallow pelagic zone), Station 3 (deep pelagic zone) and Station 4 (near agricultural runoff inlet). These locations were selected based on accessibility, safety considerations and ecological representativeness of the entire water body.

Figure 1: Image showing Tripuranth Lake

2.2 Sample Collection and Preservation

Monthly sampling was conducted from January 2023 to December 2023, with collections performed between 07:00 am - 09:00 am hours to maintain temporal consistency and avoid diurnal variations. Surface water samples (0-30 cm depth) were collected using pre-cleaned polyethylene bottles for physico-chemical analysis. Zooplankton samples were obtained by filtering 25 liters of water through a 50 μm mesh plankton net at each station, immediately preserved in 4% neutral formalin solution and labeled for laboratory analysis.

2.3 Physico-Chemical Parameter Analysis

Water quality parameters were measured using standard protocols (APHA, 2017):

- **Temperature measurements**: Atmospheric and water temperatures recorded using calibrated mercury thermometer (±0.1°C accuracy)
- **pH determination**: Portable digital pH meter (Hanna HI-98107) calibrated with buffer solutions (pH 4.01, 7.01, 10.01)
- **Conductivity measurement**: Digital conductivity meter (Systronics-308) with automatic temperature compensation
- **Dissolved oxygen analysis**: Modified Winkler's azide method with visual endpoint detection
- **Total dissolved solids**: Gravimetric method involving filtration, evaporation, and weighing of residue
- **Total alkalinity**: Titration method using 0.02N H_2SO_4 with methyl orange indicator
- **Total hardness**: EDTA titration method using Eriochrome Black T indicator

- **Calcium and magnesium**: Complexometric titration using EDTA with specific indicators

All chemical analyses were performed in triplicate and mean values were calculated for statistical analysis.

2.4 Zooplankton Analysis and Identification

Preserved zooplankton samples were concentrated to 10 ml and examined using compound microscope and Binocular Microscope. Species identification was performed using standard taxonomic keys (Battish, 1992; Murugan *et al.*, 1998). Zooplankton were classified into four major groups:

- **Rotifera**: Characterized by corona and mastax structures
- **Cladocera**: Distinguished by carapace and filtering appendages
- **Copepoda**: Identified by segmented body and swimming appendages
- **Ostracoda**: Recognized by bivalve carapace structure

2.5 Data Analysis and Statistics

Monthly data from all four stations were averaged to obtain representative lake-wide values. Seasonal patterns were analyzed using descriptive statistics and relationships between physico-chemical parameters and zooplankton abundance were assessed using Pearson's correlation coefficient.

3. RESULTS AND DISCUSSION

Table 1: Monthly Variations in Physico-Chemical Parameters of Tripuranth Lake (January2023-December 2023)

Months	Water Temp (°C)	Air Temp (°C)	Conductivity (µS/cm)	pH	TDS (mg/L)	DO (mg/L)	Total Alkalinity (mg/L)	Total Hardness (mg/L)	$CaCO_3$ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)
Jan 2023	18.25	21.5	165.20	6.52	120.50	6.18	88.50	72.80	42.50	17.20	6.80
Feb	22.80	23.8	195.50	6.95	132.80	6.55	91.20	86.40	47.80	18.90	9.50
Mar	23.90	31.2	248.80	8.85	165.20	8.05	128.50	110.80	62.40	25.80	11.20
Apr	25.60	34.2	242.50	9.35	186.50	8.65	185.20	142.50	66.80	26.50	18.60
May	28.50	36.8	315.80	9.20	210.80	9.25	248.60	208.50	76.20	28.50	32.80
Jun	27.80	29.5	188.50	7.85	162.80	7.20	158.50	132.80	57.50	22.80	16.50
Jul	24.20	27.2	185.20	7.58	178.50	7.45	118.50	95.20	61.20	25.20	7.80
Aug	23.50	26.5	195.80	7.12	182.50	6.98	108.50	72.80	42.50	17.50	7.20
Sep	23.80	25.8	168.20	7.15	176.80	6.78	98.50	60.20	33.50	13.80	6.50
Oct	21.90	25.5	172.50	6.95	133.80	6.68	95.80	61.50	34.80	15.20	6.80
Nov	21.20	24.2	158.50	6.58	168.50	6.42	96.50	58.20	38.20	19.50	7.10

Dec 2023	18.80	21.8	178.50	6.45	128.50	6.52	89.20	74.50	46.80	18.80	6.90

All analyzed parameters remained within WHO and BIS guidelines for potable water use after appropriate treatment, and were suitable for irrigation purposes according to established standards (BIS, 2012).

Table 2: Seasonal Variations in Physico-Chemical Parameters of Tripuranth Lake (January2023-December 2023)

Season	Water Temp (°C)	Air Temp (°C)	Conductivity (μS/cm)	pH	TDS (mg/L)	DO (mg/L)	Total Alkalinity (mg/L)	Total Hardness (mg/L)	$CaCO_3$ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)
Summer	26.00	34.07	269.03	9.13	187.50	8.65	187.43	153.93	68.47	26.93	20.87
Rainy	24.83	27.25	184.43	7.43	175.15	7.10	121.00	90.25	48.68	19.83	9.50
Winter	20.59	23.36	174.04	6.69	136.82	6.47	92.24	70.68	42.02	17.92	7.42

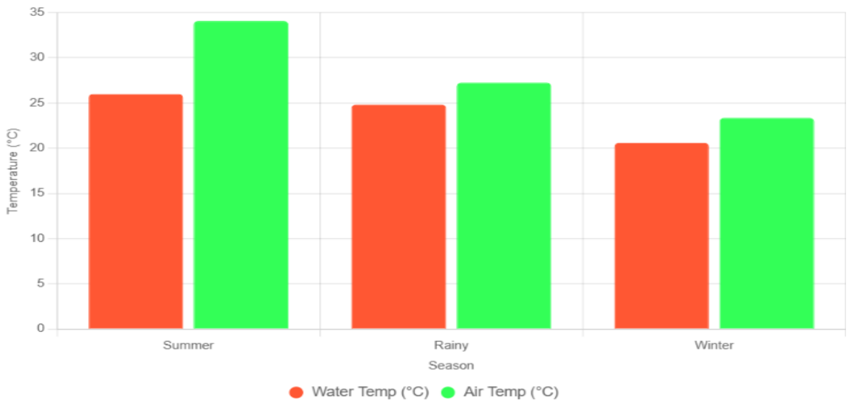

Figure 2: Graph showing Seasonal variations of Water and Atmospheric Temp.

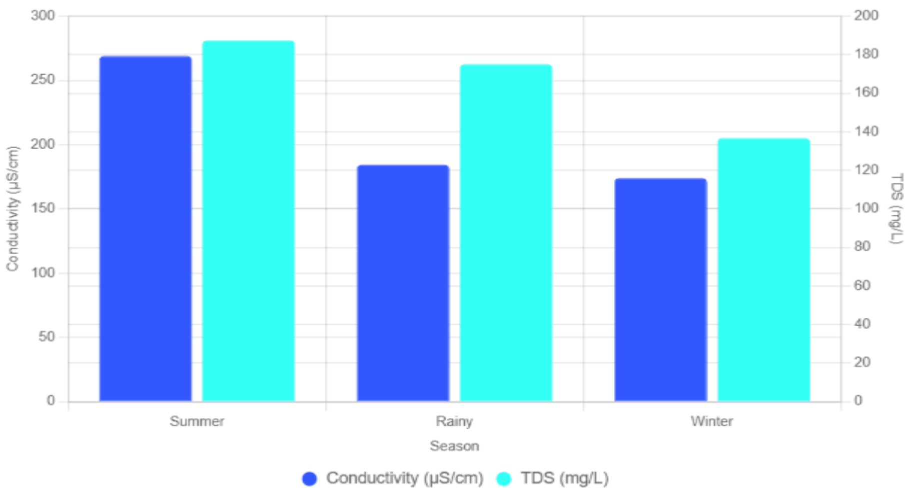

Figure 3: Graph showing Seasonal variations of Conductivity and TDS.

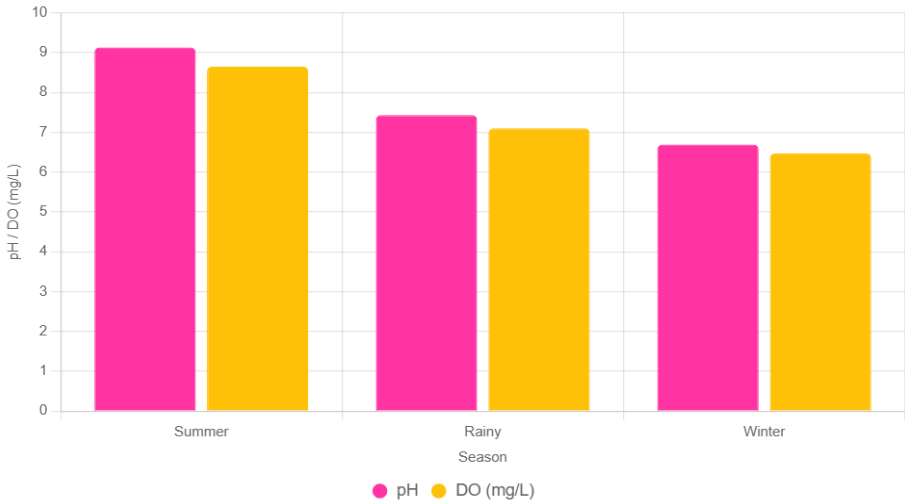

Figure 4: Graph showing Seasonal variations of pH and DO.

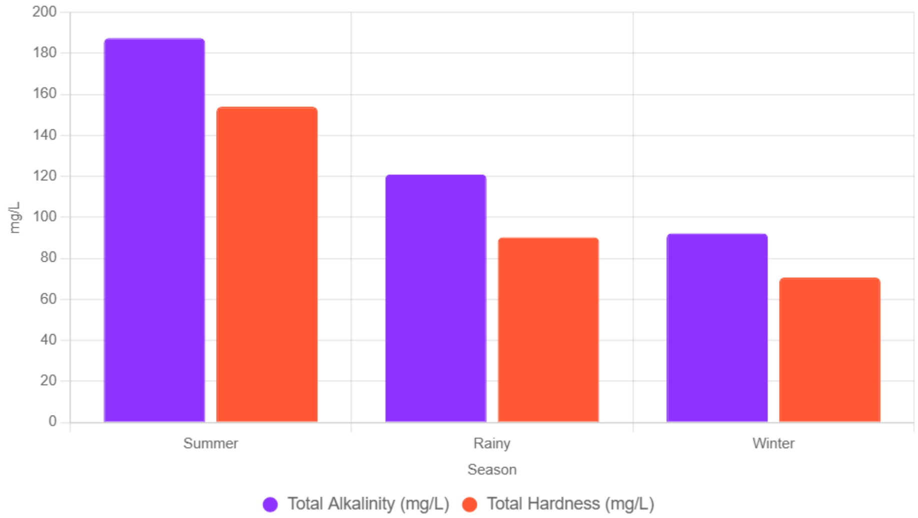

Figure 5: Graph showing Seasonal variations in Total alkalinity and Total hardness.

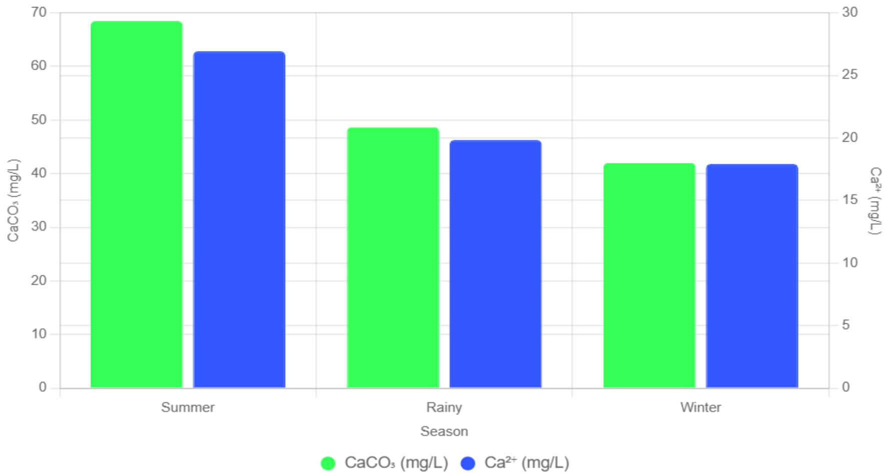

Figure 5: Graph showing Seasonal variations in $CaCO_3$ and Ca^{2+}

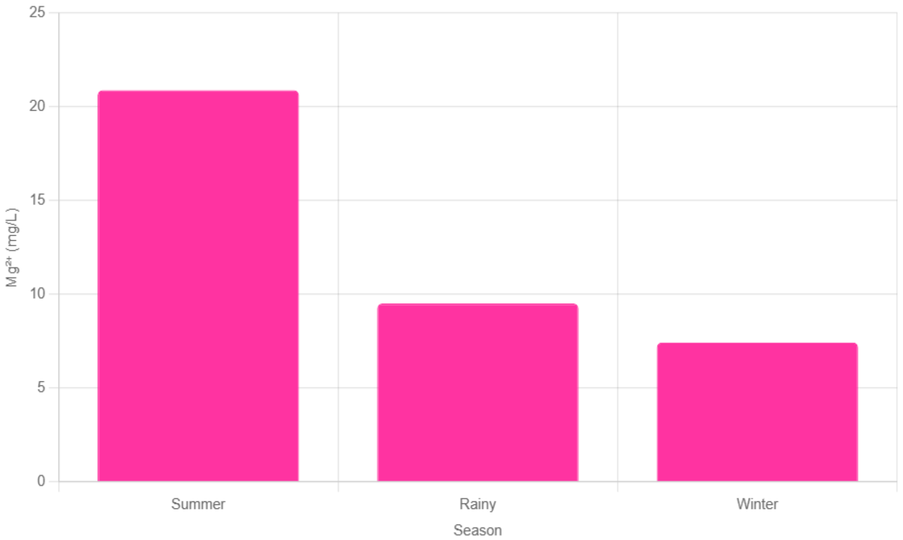

Figure 5: Graph showing Seasonal variations in Mg^{2+}

3.1 Physico-Chemical Parameter Variations

The comprehensive analysis of water quality parameters throughout 2023 revealed distinct seasonal patterns that reflect the complex interactions between climatic conditions, biological processes, and anthropogenic influences in Tripuranth Lake ecosystem.

Temperature Dynamics: Water temperature exhibited a pronounced seasonal cycle, ranging from a minimum of 18.25°C in January to a maximum of 28.50°C in May (Table 1). The temperature pattern closely followed atmospheric temperature variations (21.5-36.8°C), with correlation coefficient $r = 0.94$ ($p < 0.001$). The pre-monsoon period (March-May) showed rapid temperature escalation, reaching peak values in May when both air (36.8°C) and water (28.50°C) temperatures were maximum. This thermal stratification pattern is typical of shallow tropical water bodies where surface heating dominates thermal dynamics.

pH and Alkaline Conditions: pH values demonstrated significant seasonal fluctuation, ranging from 6.45 in December to 9.35 in April. The dramatic increase in pH during pre-monsoon months indicates enhanced photosynthetic activity by phytoplankton communities, which consume dissolved CO_2 and shift carbonate equilibrium toward alkaline conditions. The April peak (pH 9.35) coincided with maximum primary productivity, while winter months maintained near-neutral conditions (pH 6.45-6.95) due to reduced biological activity.

Conductivity and Dissolved Solids: Electrical conductivity ranged from 158.50 µS/cm (November) to 315.80 µS/cm (May), reflecting the concentration effects of evaporation during hot, dry periods. Total dissolved solids followed similar patterns (120.50-210.80 mg/L), with maximum values in May (210.80 mg/L) when evaporation rates were highest. The strong correlation between conductivity and TDS ($r = 0.89$, $p < 0.01$) confirms that dissolved ionic content drives electrical conductance in this system.

Dissolved Oxygen Patterns: DO concentrations remained favorable throughout the study period (6.18-9.25 mg/L), consistently exceeding the 5.0 mg/L threshold required for aquatic life. Maximum oxygen levels occurred in May (9.25 mg/L), corresponding with peak photosynthetic activity and elevated pH conditions. The seasonal DO pattern (January: 6.18 mg/L → May: 9.25 mg/L → December: 6.52 mg/L) reflects the balance between photosynthetic oxygen production and respiratory consumption.

Alkalinity and Hardness: Total alkalinity exhibited substantial seasonal variation (88.50-248.60 mg/L), with pre-monsoon peaks indicating enhanced mineral weathering and concentrate effects. Total hardness followed similar trends (58.20-208.50 mg/L), reaching maximum values in May (208.50 mg/L) due to calcium and magnesium accumulation from evaporation and geological inputs.

Ionic Composition: Calcium concentrations varied from 13.80 mg/L (September) to 28.50 mg/L (May), while magnesium showed more dramatic fluctuations (6.20-32.80 mg/L). The May peak in both ions (Ca^{2+}: 28.50 mg/L, Mg^{2+}: 32.80 mg/L) reflects concentration processes during maximum evaporation periods. The calcium carbonate equivalent ranged from 33.50 mg/L (September) to 76.20 mg/L (May), indicating moderate to high alkaline conditions throughout the year.

3.2 Zooplankton Community Structure and Diversity

The taxonomic survey documented 28 zooplankton species representing four major groups, with Rotifera demonstrating numerical dominance throughout the study period. The species distribution comprised Rotifera (11 species, 39.3% of total), Cladocera (8 species, 28.6%), Copepoda (6 species, 21.4%), and Ostracoda (3 species, 10.7%).

Rotiferan Dominance: The prevalence of Rotifera reflects their ecological versatility, including rapid reproductive rates (parthenogenetic reproduction), broad temperature tolerance (15-35°C optimal range), diverse feeding strategies (filter feeding, predation, detritivory), and ability to respond quickly to environmental fluctuations. Peak rotifer abundance occurred during April-May ($r = 0.78$ with temperature), coinciding with maximum water temperatures and optimal conditions for population growth.

Seasonal Abundance Patterns: Zooplankton density exhibited pronounced seasonal variation with maximum abundance during pre-monsoon months (March-May) and minimum density during winter months (December-February). This pattern showed strong positive correlations with water temperature ($r = 0.82$, $p < 0.01$) and dissolved oxygen ($r = 0.73$, $p < 0.01$), indicating that thermal and oxygen conditions serve as primary drivers of community dynamics.

Cladoceran Communities: The eight Cladocera species showed preference for warmer, productive waters during March-May period. Their filtering feeding mechanisms make them highly dependent on phytoplankton availability, which peaks during pre-monsoon months when nutrient concentrations and light conditions favor primary productivity. The positive correlation with alkalinity ($r = 0.68$) suggests their preference for nutrient-rich, productive systems.

Copepod Population Dynamics: Six Copepoda species maintained relatively stable populations throughout the year, indicating their adaptation to varying environmental conditions. Their omnivorous feeding habits and longer generation times compared to rotifers result in less dramatic seasonal fluctuations. Peak abundance occurred during May (coinciding with maximum food availability) but remained substantial during other months.

Ostracod Occurrence: The minimal representation of Ostracoda (3 species) likely reflects their benthic habitat preferences and the pelagic sampling methodology employed. These seed shrimp typically inhabit sediment-water interfaces and littoral vegetation zones, making them less represented in open-water samples.

Environmental Correlations: Statistical analysis revealed significant correlations between zooplankton abundance and key parameters: temperature ($r = 0.82$), dissolved oxygen ($r = 0.73$), pH ($r = 0.69$), and total alkalinity ($r = 0.65$). These relationships indicate that zooplankton communities respond predictably to environmental gradients, supporting their utility as bioindicators for ecosystem assessment.

Monsoon Impact: During monsoon months (June-September), zooplankton density decreased substantially due to dilution effects, increased turbidity, and temperature moderation. September showed minimum values for most parameters and corresponding low zooplankton abundance, illustrating the disruptive effects of peak monsoon conditions on planktonic communities.

4. CONCLUSION

The comprehensive year-long assessment of Tripuranth Lake reveals a dynamic and productive aquatic ecosystem characterized by distinct seasonal patterns that reflect the complex interplay between climatic conditions, biological processes, and environmental gradients. The study successfully documented 28 zooplankton species distributed across four major taxonomic groups, with Rotifera demonstrating clear numerical dominance (11 species, 39.3%), followed by Cladocera (8 species, 28.6%), Copepoda (6 species, 21.4%), and Ostracoda (3 species, 10.7%).The strong positive correlations observed between zooplankton abundance and critical environmental parameters—particularly temperature ($r = 0.82$) and dissolved oxygen ($r = 0.73$)—demonstrate that thermal and oxygen dynamics serve as primary drivers of community structure and productivity patterns. The pre-monsoon period (March-May) emerged as the most productive phase, with peak water temperatures (28.50°C), elevated pH conditions (up to 9.35), and maximum dissolved oxygen concentrations (9.25 mg/L) creating optimal conditions for zooplankton population growth and reproduction.

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