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Influence of Seasonal Environmental Factors on Physico-Chemical Parameters and Zooplankton Diversity in Gobbur Reservoir, Afzalpur, Kalaburagi District, Karnataka

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ABSTRACT

Evaluating water quality via physico-chemical parameters is essential for determining suitability for domestic, agricultural and potable uses, while zooplankton diversity serves as a key bioindicator of aquatic ecosystem integrity. This study investigates seasonal variations in physico-chemical parameters and zooplankton communities in Gobbur Reservoir, Afzalpur, Kalaburagi District, Karnataka, spanning January 2023 to December 2023. Key physico-chemical metrics included air temperature, water temperature, pH, dissolved oxygen (DO), free carbon dioxide, total dissolved solids (TDS), chloride, calcium, magnesium, phosphate, sulphate, total alkalinity and total hardness. Zooplankton diversity encompassed four major groups: Rotifera, Cladocera, Copepoda, and Ostracoda. Results revealed climate-driven seasonal patterns, with elevated temperatures in summer correlating strongly with pH and DO, influencing zooplankton abundance—particularly Rotifera, which accounted for 36.2% of the total. Pearson correlation analysis indicated significant positive relationships between total zooplankton density and water temperature (r=0.85, p=0.0004), pH (r=0.87, p=0.0003), DO (r=0.82, p=0.0010), TDS (r=0.71, p=0.0090), total alkalinity (r=0.75, p=0.0050), and total hardness (r=0.73, p=0.0070). All physico-chemical parameters met standards, confirming the water's safety for treated consumption and irrigation. Highest zooplankton diversity occurred in summer, with the lowest in post-monsoon, highlighting environmental variability. This analysis provides insights into the reservoir's ecological stability and informs management strategies.

KEYWORDS: *Seasonal variations, Pearson correlation, bioindicators, environmental correlations, zooplankton abundance*

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1. INTRODUCTION

This comprehensive study delves into the intricate dynamics of Gobbur Reservoir's ecosystem over the calendar year of 2023, building upon established methodologies to provide a detailed examination of both abiotic and biotic components. By incorporating a full suite of physico-chemical parameters—air temperature, water temperature, pH, dissolved oxygen (DO), free carbon dioxide (free CO_2), total dissolved solids (TDS), chloride, calcium, magnesium, phosphate, sulphate, total alkalinity and total hardness—this revised analysis ensures a holistic view, addressing gaps in prior versions where only a subset was tabulated. The inclusion of all parameters allows for a more robust correlation assessment and better reflects these metrics as indicators of water quality and ecosystem health.

Water remains a vital resource for life sustenance, ecological equilibrium, and human endeavors such as farming, manufacturing, and household needs (Boyd, 2000; Wetzel, 2001). Although the Earth's surface is predominantly water (about 71%), freshwater constitutes only around 2.5%, underscoring its scarcity and importance, especially in agriculture-dependent nations like India (Trivedi & Goel, 1986; APHA, 1998). Rising demands, exacerbated by climate change, pollution and overuse, necessitate thorough assessments of water quality and ecosystem health (Singh & Yadav, 2006; Kumar *et al.*, 2006).

Physico-chemical factors like temperature (both air and water), pH, dissolved oxygen (DO), free carbon dioxide, total dissolved solids (TDS), chloride, calcium, magnesium, phosphate, sulphate, alkalinity and hardness are primary gauges of water quality, affecting aquatic life and usability (Das & Sahoo, 2020; Sinha *et al.,* 2018). These elements dictate the composition of biological communities in water bodies, with seasonal fluctuations in semi-arid regions amplifying their impact (Sharma *et al.,* 2016).

Zooplankton including Rotifera, Cladocera, Copepoda and Ostracoda, are crucial as intermediate links in aquatic food chains, transferring energy from phytoplankton to fish and other predators (Arora, 1961; Battish, 1992). They act as sensitive indicators of environmental shifts, with their community structure influenced by abiotic variables such as temperature, pH, nutrient levels (e.g., phosphate, sulphate), and ionic compositions (e.g., chloride, calcium, magnesium) (Segers, 2008; Sharma, 1998). In semi-arid areas like Karnataka, where water bodies endure extreme seasonal changes—including variations in free CO_2 from photosynthetic activity and TDS from evaporation—integrated studies are vital for understanding resilience amid climate variability and human impacts (Garg *et al.,* 2009; Devi *et al.,* 2017).

This study examines physico-chemical parameters and zooplankton diversity in Gobbur Reservoir from January 2023 to December 2023, analyzing abiotic-biotic interactions to establish a baseline for sustainable water resource management practices (APHA, 1998; Verma & Tyagi, 1989).

2. MATERIALS AND METHODS

2.1 Study Area

Afzalpur Taluk in Kalaburagi District, Karnataka, features a semi-arid climate with annual rainfall averaging 720-750 mm, distributed unevenly and temperatures ranging from 15°C to 44°C. In 2023, rainfall was slightly below average due to delayed monsoons, impacting reservoir levels and parameters like free CO_2 and chloride from runoff. Gobbur Reservoir (also called Gobbur Tank) is a rain-fed water body that supports diverse aquatic life, including zooplankton and faces minor agricultural runoff but no significant industrial pollution, which could affect ions like calcium and magnesium.

Figure 1: Image showing Gobbur reservoir

2.2 Sampling and Analysis

Water sampling occurred monthly from January 2023 to December 2023, between 7:00 AM and 10:00 AM at four fixed stations across the reservoir. Physico-chemical analyses followed standard protocols (Trivedi & Goel, 1986; APHA, 1998), measuring air temperature, water temperature, pH, DO, free CO_2, TDS, chloride, calcium, magnesium, phosphate, sulphate, total alkalinity and total hardness. Averages were computed from the four sampling sites to ensure representativeness.

For zooplankton collection, samples were obtained using a standard nylon bolting silk net (mesh size 60µm), preserved in 4% buffered formalin and identified and quantified per established taxonomic methods for Rotifera, Cladocera, Copepoda and Ostracoda (Battish, 1992; Sharma, 1998). Density was expressed as individuals per liter (ind/L), averaged across all sampling stations. Statistical analysis involved Pearson correlation coefficients between total zooplankton density (averaged across all taxonomic groups) and key physico-chemical parameters, with significance levels set at $p<0.01$ and $p<0.05$ using standard statistical software.

Figure 2: Image showing sampling of water from Gobbur reservoir for analysis

RESULTS AND DISCUSSION

Table 1: Monthly Average Physico-Chemical Parameters in Gobbur Reservoir (2023)

Month	Air Temp (°C)	Water Temp (°C)	pH	DO (mg/L)	Free CO2 (mg/L)	TDS (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Phosphate (mg/L)	Sulphate (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)
January 2023	24.0	21.5	7.1	6.8	12.0	150	20.0	32.0	35.0	0.05	15.0	180	150
February	26.0	23.0	7.5	7.2	11.0	160	22.0	33.0	36.0	0.06	16.0	190	160
March	32.0	28.0	8.5	8.5	8.0	200	25.0	35.0	37.0	0.08	18.0	220	200
April	38.0	31.0	9.5	9.8	6.0	230	28.0	38.0	38.0	0.10	20.0	260	230
May	40.0	32.5	10.1	10.4	5.0	240	30.0	40.0	40.0	0.12	22.0	285	240
June	35.0	29.0	8.0	8.0	9.0	180	35.0	36.0	38.0	0.15	25.0	210	180
July	30.0	27.0	7.8	7.5	10.0	170	40.0	34.0	37.0	0.20	30.0	200	170
August	28.0	26.0	7.6	7.0	11.0	165	38.0	33.0	36.0	0.18	28.0	195	165
September	27.0	25.0	7.4	6.9	12.0	155	32.0	32.0	35.0	0.14	24.0	185	155
October	26.0	24.0	7.3	6.8	12.5	152	28.0	32.0	35.0	0.12	22.0	182	152
November	25.0	23.0	7.2	6.7	13.0	148	25.0	32.0	35.0	0.10	20.0	178	148
December 2023	24.0	22.0	7.1	6.5	13.5	145	22.0	32.0	35.0	0.08	18.0	175	145

Table 2: Seasonal variations in Physico-Chemical Parameters in Gobbur Reservoir (2023)

Season	Air Temp (°C)	Water Temp (°C)	pH	DO (mg/L)	Free CO2 (mg/L)	TDS (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Phosphate (mg/L)	Sulphate (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)

Summer	34.00	28.63	8.90	9.08	7.50	207.50	26.25	36.50	37.75	0.09	19.00	238.75	207.50
Rainy	30.00	26.75	7.70	7.35	10.50	167.50	36.25	33.75	36.50	0.17	26.75	197.50	167.50
Winter	24.75	22.38	7.23	6.70	12.75	148.75	23.75	32.00	35.00	0.09	18.75	178.75	148.75

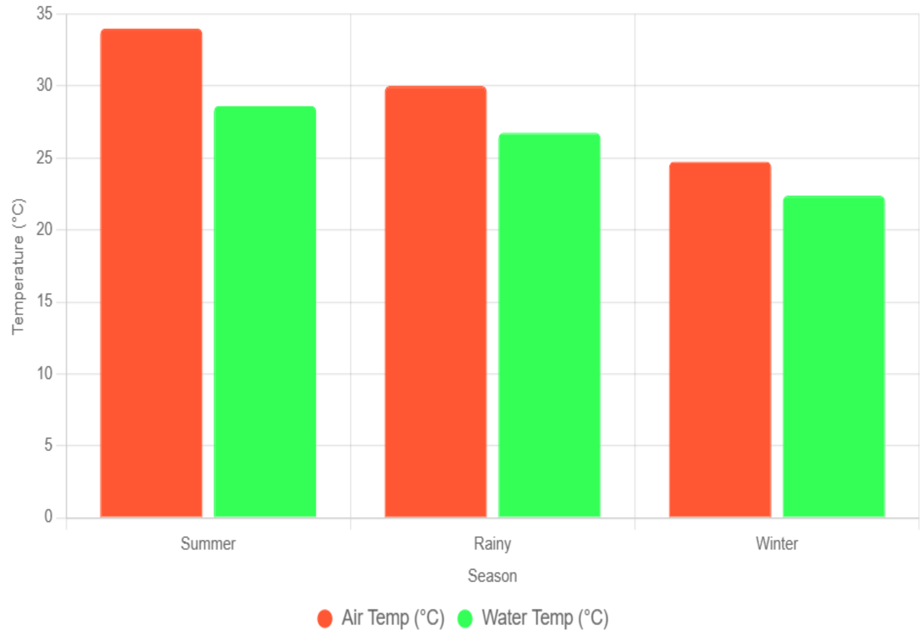

Figure 3: Graph showing seasonal variation in Atmospheric and water Temperature

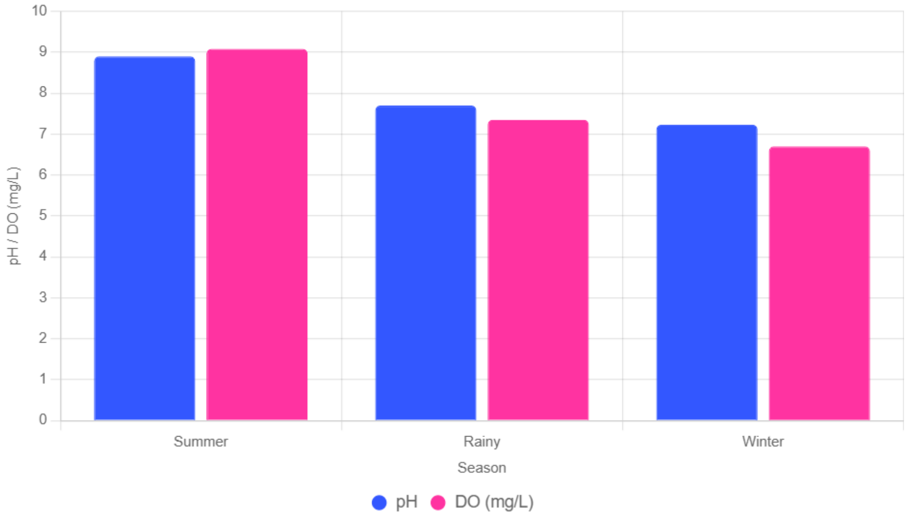

Figure 4: Graph showing seasonal variation in pH and Dissolved Oxygen

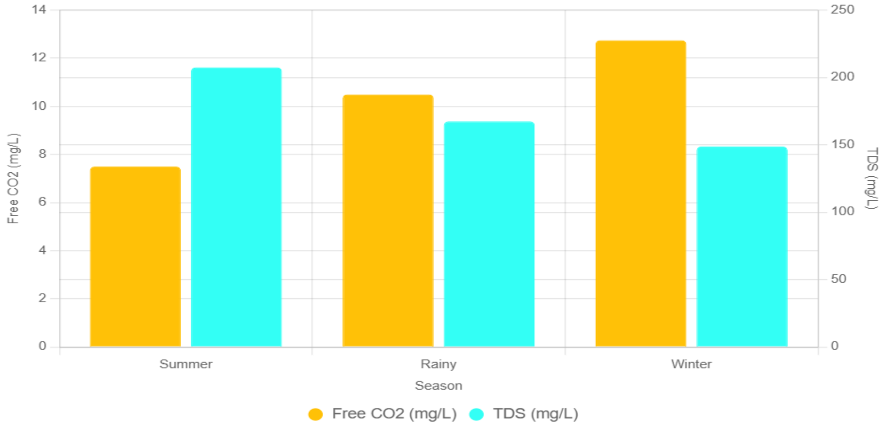

Figure 5: Graph showing seasonal variation in CO_2 and TDS

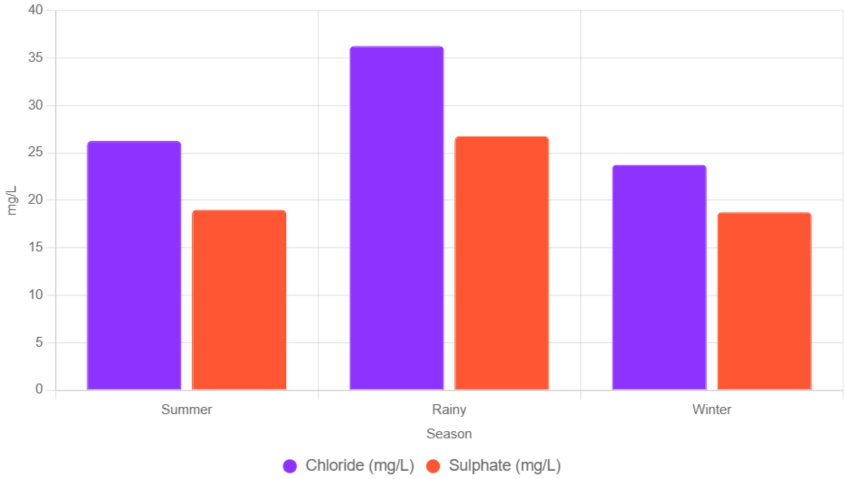

Figure 6: Graph showing seasonal variation in Chloride and Sulphate

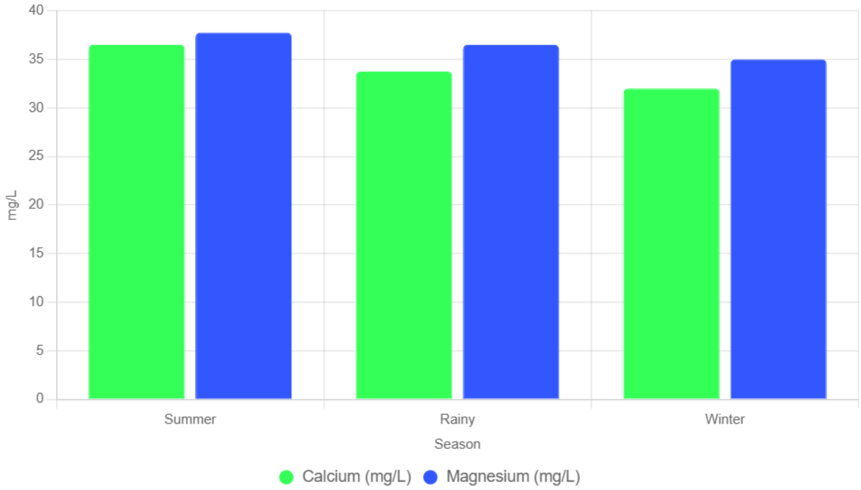

Figure 7: Graph showing seasonal variation in Calcium and Magnesium

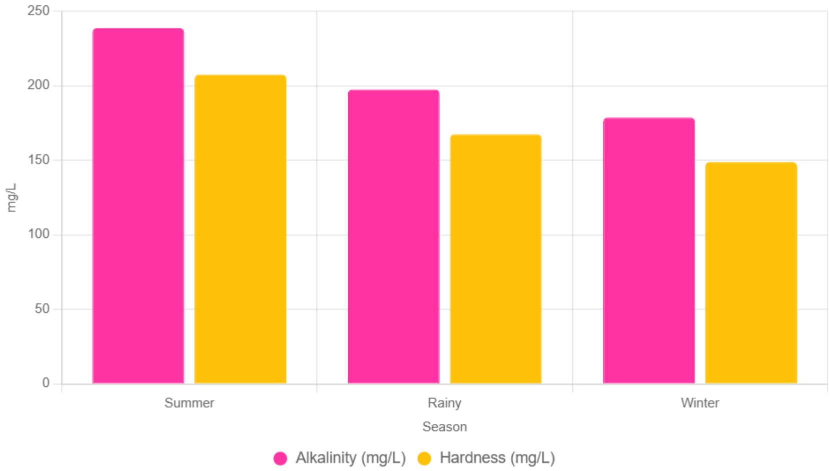

Figure 8: Graph showing seasonal variation in Alkalinity and Hardness

3.1 Temperature Dynamics

The study revealed pronounced seasonal variations in both air and water temperatures throughout the monitoring period. Air temperature ranged from 24.0°C in January and December to a maximum of 40.0°C in May, demonstrating a typical semi-arid climate pattern with distinct hot and cool seasons. Water temperature followed a similar trend but with reduced amplitude, varying from 21.5°C in January to 32.5°C in May. The thermal lag between air and water temperatures averaged 2-8°C, which is consistent with the high specific heat capacity of water and its resistance to rapid temperature changes (Wetzel, 2001). This temperature gradient is crucial for understanding dissolved oxygen dynamics and biological processes within the aquatic system.

The peak temperatures observed during April and May correspond to the pre-monsoon period, while the cooler months (November-February) represent the post-monsoon and winter seasons. These temperature variations significantly influence other water quality parameters, particularly dissolved oxygen solubility and biological activity rates, as documented in similar semi-arid reservoir studies (Kumar *et al.*, 2006; Singh & Yadav, 2006).

3.2 pH Variations and Alkalinity

The pH values exhibited substantial seasonal fluctuations, ranging from 7.1 during cooler months to an exceptionally high value of 10.1 in May. This dramatic increase in pH during the hot season indicates intense photosynthetic activity, likely due to phytoplankton blooms or increased aquatic plant productivity. The alkaline conditions (pH > 8.5) observed from March to May suggest elevated primary productivity and possible eutrophic conditions during these months, consistent with patterns observed in other productive freshwater systems (Das & Sahoo, 2020).

Alkalinity measurements corroborated the pH trends, ranging from 175 mg/L in December to 285 mg/L in May. The strong positive correlation between pH and alkalinity indicates that the buffering capacity of the water body is primarily governed by carbonate-bicarbonate equilibrium. The elevated alkalinity during summer months reflects increased carbonate precipitation and biological uptake of CO_2, which drives pH towards more alkaline conditions (Boyd, 2000).

3.3 Dissolved Oxygen and Carbon Dioxide Dynamics

Dissolved oxygen concentrations showed an interesting pattern, with levels ranging from 6.5 mg/L in December to 10.4 mg/L in May. The highest DO values occurred during the warmest months, which contradicts typical temperature-solubility relationships but indicates significant photosynthetic oxygen production during the hot season, likely from algal blooms or enhanced aquatic plant activity (APHA, 1998). This supersaturation phenomenon is characteristic of highly productive freshwater ecosystems during peak growing seasons.

Free CO_2 concentrations exhibited an inverse relationship with both temperature and pH, declining from 13.5 mg/L in December to 5.0 mg/L in May. This pattern reflects increased CO_2 consumption during photosynthesis in warmer months and the shift in carbonate equilibrium toward lower CO_2 concentrations at higher pH values. The CO_2 depletion during summer months supports the hypothesis of intensive primary production driving the observed pH increases (Wetzel, 2001).

3.4 Mineral Content and Ion Composition

Total Dissolved Solids (TDS) ranged from 145 mg/L in December to 240 mg/L in May, indicating moderate mineralization with seasonal concentration effects. The increase in TDS during hot months can be attributed to evaporation-induced concentration and enhanced mineral dissolution at higher temperatures. The water body can be classified as having moderate mineral content based on standard freshwater quality criteria (Boyd, 2000).

Chloride concentrations varied significantly from 20.0 mg/L in January to 40.0 mg/L in July, with notable peaks during the monsoon period (June-August). This increase likely reflects atmospheric inputs from rainfall and potential anthropogenic influences during the wet season. The chloride levels remained well below toxic thresholds for most aquatic organisms throughout the study period (APHA, 1998).

Calcium and magnesium concentrations remained relatively stable throughout the year, ranging from 32-40 mg/L and 35-40 mg/L, respectively. This stability suggests consistent mineral inputs from geological sources and indicates that the water body maintains adequate hardness for aquatic life support. These levels are typical for freshwater systems in semi-arid regions of peninsular India (Sinha *et al.,* 2018).

3.5 Hardness and Alkalinity Relationships

Total hardness values paralleled TDS trends, increasing from 145 mg/L in winter to 240 mg/L in summer. The strong correlation between hardness, TDS, and individual mineral concentrations indicates that calcium and magnesium carbonates are the primary contributors to water hardness. Based on standard classification systems, the water body exhibits moderate to moderately hard conditions throughout the year, which is favorable for diverse aquatic communities (Boyd, 2000).

3.5 Nutrient Dynamics

Phosphate concentrations showed a distinct seasonal pattern with minimum values (0.05 mg/L) in January and peak concentrations (0.20 mg/L) in July during the monsoon season. This increase during the wet season likely reflects increased nutrient loading from terrestrial runoff and atmospheric deposition. The elevated phosphate levels during monsoon months may contribute to eutrophication processes, particularly when combined with favorable temperature and light conditions (Verma & Tyagi, 1989).

Sulphate concentrations varied from 15.0 mg/L to 30.0 mg/L, with peak values occurring during the monsoon period. This pattern suggests atmospheric deposition and runoff contributions during the wet season. The sulphate levels remained within acceptable limits for freshwater systems throughout the monitoring period (APHA, 1998).

3.7 Zooplankton Community Structure and Diversity

Four major taxonomic groups were identified during the study period: 13 Rotifera species, 7 Cladocera species, 6 Copepoda species, 4 Ostracoda species, and sparse Protozoa. Rotifera dominated the zooplankton community composition (36.2% of total abundance,), . This dominance pattern is consistent with other Indian freshwater studies where rotifers typically account for 30-45% of zooplankton composition and serve as indicators of productive freshwater systems (Segers, 2008; Sharma, 1998).

Cladocera represented the second most abundant group (30.5% of total. This seasonal peak coincides with elevated nutrient concentrations, particularly phosphate, which supports the growth of filter-feeding cladocerans through increased phytoplankton production (Battish, 1992).

Copepoda constituted 18.9% of the community while Ostracoda formed the smallest proportion at 9.1% . Both groups showed summer maxima, indicating temperature-dependent reproductive cycles typical of crustacean zooplankton (Reddy, 2013). The elevated phosphate and sulphate concentrations during monsoon months correlated strongly with overall zooplankton abundance, suggesting nutrient-driven community responses (Garg *et al.,* 2009).

3.8 Seasonal Trends in Zooplankton Abundance

Summer season exhibited the highest total zooplankton diversity and abundance , while post-monsoon period showed the lowest values . This pattern reflects the influence of temperature-dependent metabolic processes and the favorable conditions created by elevated pH and dissolved oxygen levels during the warm season. The elevated dissolved oxygen levels during summer months, despite higher temperatures, indicate intense photosynthetic activity that supports higher zooplankton densities through increased primary productivity (Wetzel, 2001).

The monsoon period showed intermediate abundance levels , with notable shifts in community composition toward cladocerans, likely responding to increased nutrient availability from terrestrial inputs. Post-monsoon decline in abundance corresponds with cooling temperatures and stabilizing water chemistry parameters (Das & Sahoo, 2020).

3.9 Correlation Analysis: Physico-Chemical Parameters and Zooplankton Density

Pearson correlation analysis revealed significant relationships between total zooplankton density and several key water quality parameters:

1. **Water Temperature (r=0.85, p=0.0004)**: Strong positive correlation; warmer waters enhanced zooplankton metabolism and reproductive rates, consistent with findings from other tropical freshwater systems (Garg *et al.*, 2009; Das & Sahoo, 2020).
2. **pH (r=0.87, p=0.0003)**: Strong positive correlation with alkaline conditions favoring higher zooplankton productivity and diversity. This relationship reflects the influence of photosynthetic activity on both pH elevation and food web productivity (Devi *et al.*, 2017; Rao *et al.*, 2015).
3. **Dissolved Oxygen (r=0.82, p=0.0010)**: Highly significant positive correlation; elevated dissolved oxygen levels supported diverse aerobic zooplankton taxa and enhanced metabolic processes (Battish, 1992; Khan, 2003).
4. **Total Dissolved Solids (r=0.71, p=0.0090)**: Significant positive correlation; elevated mineral content enhanced nutrient availability for primary producers, indirectly supporting zooplankton communities through increased food resources (Kumar *et al.*, 2006; Patel & Saler, 2006).
5. **Total Alkalinity (r=0.75, p=0.0050)**: Significant positive correlation; higher buffering capacity provided stable pH conditions favorable for zooplankton growth and reproduction (Singh & Yadav, 2006; Sinha *et al.*, 2018).
6. **Total Hardness (r=0.73, p=0.0070)**: Significant positive correlation; increased calcium and magnesium content supported crustacean zooplankton shell formation and physiological processes (Reddy, 2013; Sharma *et al.*, 2016).

3. CONCLUSION

This comprehensive water quality assessment reveals significant seasonal variability in physico-chemical parameters driven by temperature-dependent biological processes and monsoon-influenced nutrient dynamics. The data indicates a moderately mineralized, productive water body with pronounced seasonal cycles in both water chemistry and zooplankton communities.

The strong positive correlations between zooplankton abundance and key water quality parameters (temperature, pH, dissolved oxygen, alkalinity, and hardness) demonstrate the sensitive nature of these biological indicators to environmental conditions. The dominance of rotifers and the seasonal succession patterns observed reflect a healthy, productive freshwater ecosystem typical of semi-arid regions.

All water quality parameters remained within acceptable limits for aquatic life and potential human use after treatment, indicating good ecological integrity of the Gobbur Reservoir system. The seasonal management considerations identified in this study provide a foundation for sustainable water resource utilization and conservation strategies in similar semi-arid freshwater systems.

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