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Zooplankton Diversity and Water Quality Assessment of the River Godavari, India

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Name of author	Contribution
Madasamy Karuthapandi	Conceptualization; Methodology; Sampling; Investigation; Data generation; Writing original draft
Shrikant Jadhav	Sampling; Data generation; Manuscript revision
Rehanuma Sulthana sk	Sampling; Data generation; Manuscript revision
Arunkumar S	Conceptualization; Sampling; Data generation; Data analysis
Shiva Shankar C	Sampling; Data generation
Deepa Jaiswal	Overall guidance; supervision; validation

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Data availability

The data generated in the present study has been submitted to Freshwater Biology Regional centre Hyderabad and it can be obtained from the Institute.

Declarations

Competing interests

Authors declare no conflicts of interest in the research activity and in data presented in the manuscript.

Ethical approval

No ethical approval required.

Ethical responsibilities of Authors

All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors.

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Abstract

The present investigation assessed the composition and diversity of zooplankton in the River Godavari, along with selected physicochemical parameters. It reveals that 78 species of zooplankton, comprising 44 species of rotifera, 27 cladocera, and seven copepoda. Among these, *Brachionus caudatus*, *Brachionus calyciflorus*, *Keratella tropica*, and *Lecane bulla* were the most abundant, collectively accounting for 70-80% of occurrences throughout the river stretch. The overall zooplankton density was 64.80±11 Ind./L, with the highest value noted in the summer, primarily due to more abundance of rotifers. Diversity analysis indicates the overall river diversity (H') was 1.95 ± 0.15, with maximum diversity observed in summer (H' = 2.12 ± 0.50). A similar seasonal trend was observed for species richness and abundance, both higher in summer and lower during the monsoon season, whereas evenness peaked during the monsoon. Dominance (40±13%) was mainly attributed to *Brachionus calyciflorus*, *Brachionus caudatus*, *Keratella tropica*, and *Lecane bulla*, which exhibited strong dominance in the winter season. spatial assessment on physicochemical parameters reveals that a few sampling stations were hotspots for pollution are characterized by elevated total dissolved solids, major ions and nutrient loads linked to agricultural runoff, domestic wastewater, and industrial effluent. Pearson's correlation and principal component analysis indicate that zooplankton diversity, abundance, species richness and its community balance are strongly shaped by physicochemical parameters like nutrient load, mineral content and oxygen availability. This emphasizes the crucial role of water quality in maintaining a healthy zooplankton population, which ultimately reflects the ecological stability and function of the river ecosystem. The overall physicochemical parameters and zooplankton diversity indices suggest that the River Godavari exhibits the health and stability of the zooplankton community with mesotrophic conditions and fair water quality.

Keywords: Zooplankton, Seasonal, Spatial variation, Physiochemical, River Godavari

Introduction

Freshwater ecosystems are most diverse and supporting nearly 10% of all known species despite occurring less than 1% of the Earth's surface. These ecosystems facing significant threat worldwide, primarily due to adverse climatic changes, overexploitation of resources, and habitat degradation. They offer a wide variety of goods, services, and essential benefits that support human wellbeing and livelihoods (Dudgeon et al., 2006; Acero Triana et al., 2021). Despite their importance, human civilization has often developed close to rivers and lakes, resulting in high population pressure, intensive resource use, and pollution hotspots in surrounding areas. Further, it is increasingly threatened by both climate and human driven factors, including nutrient loading, hydrological alteration, morphological changes, thermal stress, and other toxic or chemical stressors (Birk et al., 2020). These factors have led to the ongoing degradation of freshwater ecosystems and loss of species (Weijters et al., 2009). Urbanization and modern agricultural practices particularly intensive forms of land use, strongly affect biotic communities and reduce water quality. These changes alter both the physical and chemical characteristics of the rivers (Feld 2013; Gutierrez-Rial 2023), leading to negative impact on aquatic life and overall ecosystem health.

Among the freshwater faunal groups, zooplankton occupy an intermediate trophic position as consumers of phytoplankton and as prey for macroinvertebrates and fish. They also respond rapidly to changes in environmental conditions and predation pressure (Li and Chen 2020; Espinosa-Rodriguez et al., 2025). The community structure of these organisms in relation to environmental heterogeneity, characterized by composition, abundance and diversity Eskinazi-Sant'Anna et al., 2020; Simoes et al., 2022). They have short generation times and high reproductive rates (Beisner and Thackeray 2023), characteristics that make them excellent indicators for detecting environmental change (Michaloudi et al., 2024). Among metazooplankton, rotifers, cladocerans, and copepods are primary groups used in monitoring and restoring aquatic ecosystems (Jeppesen et al., 2011). They have proven effective as bioindicators of water quality (Jeppesen et al., 2007, 2012). Monitoring aquatic ecosystems using biological indicators and indices offers a practical and economical tool for assessing water quality (Chandel et al., 2024; Michaloudi et al., 2024). Zooplankton respond strongly to physical and chemical conditions, which affect their community structure, composition, density, species richness, and diversity (Dodson et al., 2009; Bonecker et al., 2013; Razak and Shairp 2019). They can reflect the state of the ecosystem and water quality (Barnett et al., 2007; Brito et al., 2011; Heberman and Haldna 2014; Ismail et al., 2022). These characteristics make zooplankton suitable bioindicators for evaluating and managing water quality and for assessing the trophic status of aquatic ecosystems (Anas et al., 2013; Munoz-Colmenares et al., 2021).

The Godavari River is the second largest river in India and the longest in Peninsular India, extending approximately 1,465 kilometres (910 miles) and draining a basin of 312,812 square kilometres. The river originates in Trimbakeshwar, Nashik District, Maharashtra and flows eastward across the Deccan Plateau through the states of Maharashtra, Telangana, Chhattisgarh, and Andhra Pradesh, finally it enters into the Bay of Bengal. Its major tributaries include the Purna, Pranhita, Indravati, Sabari, Pravara, Manjira, and Manair rivers. The Godavari serves as a vital lifeline for central and southern India, supporting agricultural, economic, ecological, cultural, and religious activities. It is a primary source of water for irrigation, contributing to food security and sustaining millions of livelihoods across the basin. Numerous dams and barrages, such as the Jayakwadi Dam, the Sriram Sagar Project, and the Sir Arthur Cotton Barrage have been constructed to regulate water flow and support regional development. The basin also contains economically significant deposits of oil, natural gas, and coal. Ecologically, the Godavari River supports several important wildlife habitats, including the Coringa Mangrove Forests and Papikonda National Park. Its riverine and deltaic environments host diverse fish species, migratory birds, and vulnerable species. The river system also encompasses notable bird sanctuaries, including the Jayakwadi Bird Sanctuary and the Nandurmadhmeshwar Bird Sanctuary, which serve as key nesting and feeding grounds for both resident and migratory bird species.

River pollution is causing an unpredicted shift in the ecosystem (Bowes et al., 2020; Lokhande and Tare 2021) and degrading water quality. Most of the rivers in India are extremely polluted, including Ganga, Yamuna, Sabarmati, Coum (Kazmi and Hansen 1997; Khna et al., 2016). Despite its ecological richness and biodiversity, the river Godavari is also increasingly threatened by human activities. Pollution from domestic waste, industrial effluents, and dam construction. The excessive water extraction has significantly altered the river's natural flow regime, disrupted fish migration pathways, and contributed to habitat loss associated with rapid urban development and

agricultural expansion. Navasakthi et al., (2023) highlighted the deuteriation of water quality over time in the river Godavari due to increasing degradation of organic matter by aerobic microorganisms. Given these pressures, it is crucial to regularly monitor biological changes in the river in relation to its physicochemical conditions. Several studies recommend the use of zooplankton communities as effective bioindicators, noting that their diversity indices can provide valuable insights into trophic status and water quality. However, existing research on zooplankton in the Godavari River remains limited, with studies largely confined to specific localities (Patil and Ghorade 2013; Totawar 2019; Bhavare and Andhale 2014; Kasab 2024). Consequently, there is still a substantial gap in knowledge regarding zooplankton diversity along the entire stretch of the River Godavari. The primary aim of this study is to assess the composition and diversity of zooplankton in relation to selected water quality parameters across the river Godavari continuum. Additionally, the study seeks to analyse the relationships between environmental variables and zooplankton diversity indices using a range of statistical techniques.

Materials and Methods

The current study was conducted from April 2022 to March 2025, involving seasonal sampling at 21 stations of the River Godavari (Fig. 1). The qualitative and quantitative zooplankton collections were made from the littoral surface of the water column at different sampling stations. Qualitative collections were collected by zooplankton net (> 62µm) towing the surface of the water column, while quantitative samples were collected by filtering 50 L of water through a zooplankton net. Collected samples were transferred into clean plastic containers and preserved in 4% neutralized formaldehyde solution. The specimens were examined using a Nikon light microscope. Zooplankton species were identified with reference to the established literature (Koste 1978; Michael and Sharma 1988; Reddy 1994; Segers 1995; Sharma 1992; Sharma and Sharma 2008).

Physical parameters like water temperature, pH, total dissolved solids, and electrical conductivity were measured at the sampling sites using digital electronic test meters (Orlab). Water samples for chemical parameters were collected in a pre-cleaned 1liter plastic container. Samples were transported to the laboratory in ice-packed conditions, parameters including total hardness, total alkalinity, calcium, magnesium, chloride, nitrate, nitrite, Phosphate, and ammonia were analyzed following standard protocol of APHA (1989), Wetzel and Likens (2000). Dissolved oxygen was determined by Winkler's method.

The Shannon Diversity Index (H′) for species diversity; Hill Numbers Index for species richness and abundance; Pielou Index for evenness; and the Berger-Parker Dominance Index for dominance (Hayek and Buzas, 1997) were used with the Biodiversity pro and Past version 4.03 software.

$$\text{Shannon Diversity Index } H' = -\Sigma_i\, p_i \ln (p_i) \qquad (1)$$

where pi = proportion of the number of individuals of a species to the total number of individuals (pi = ni /N), where n = total number of species and N = total number of individuals.

$$\text{Evenness } J' = H'_{max} / \text{Log}^2 S, \qquad (2)$$

where H′ max = Shannon maximum diversity index, and S = total number of species in the sample.

Hill Numbers: H0 = S (species richness); H1 = exp H′ exponential of Shannon diversity indices (abundance)

$$\text{Berger-Parker Dominance index } d = N_{max} / N \qquad (3)$$

where N_{max} = number of individuals of most abundant species; N = total number of individuals in sample.

The species frequency, expressed as a percentage was calculated as the number of times a zooplankton species was present at a given number of sample sites.

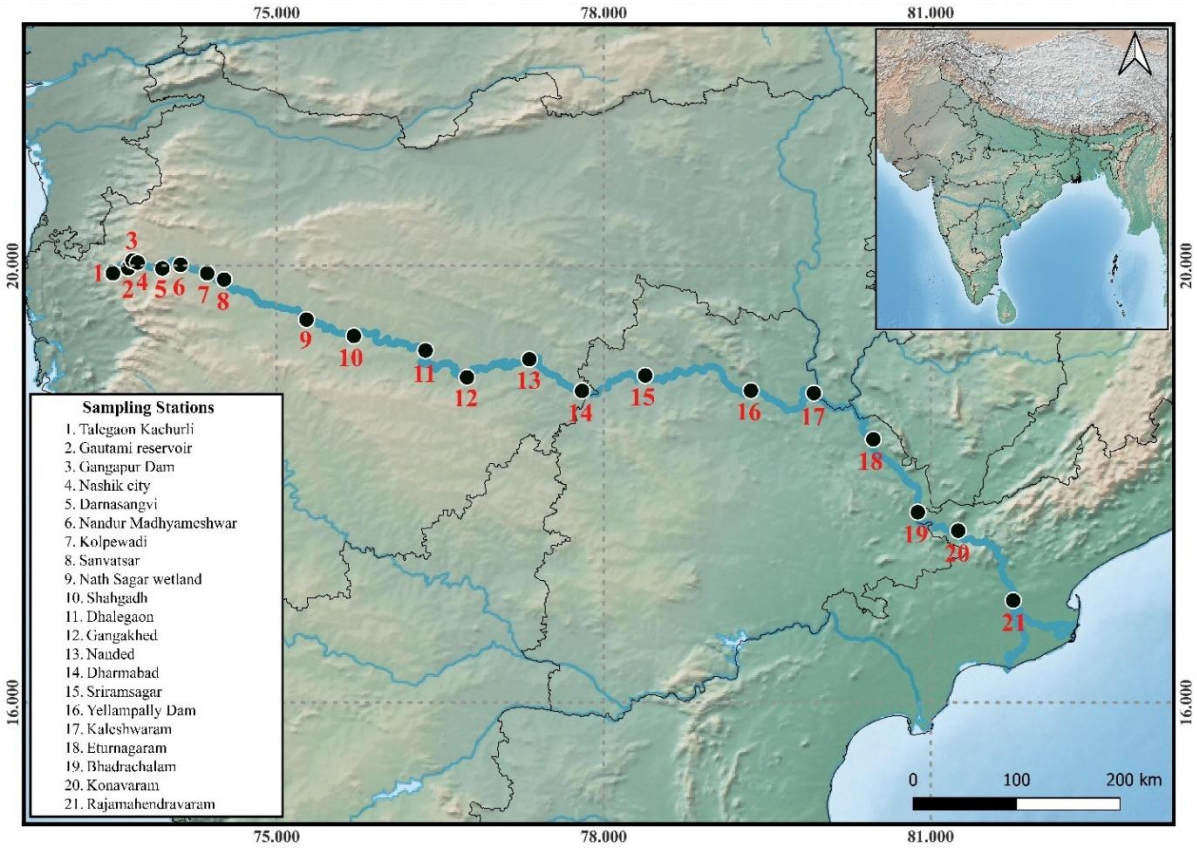


Fig. 1 Map showing sampling station in River Godavari, India

Multivariant analysis

Principal component analysis was performed with Jolliffe, 2002 method using XLSTAT software. Correlation coefficient analysis followed the Karl Pearson Correlation coefficient method.

Results

Zooplankton community composition

A total of 78 zooplankton species were recorded during the sampling period in the River Godavari, comprising 44 rotifers, 27 cladocerans, and 7 species of copepods (Table 1). Among these, rotifers comprised the highest number of species, mainly due to the families Brachionidae (17 species) and Lecanidae (8 species), especially the genera *Brachionus* and *Lecane* having a greater number of species. The relative abundance of rotifers accounts for 64.29% in summer, 54.9% in monsoon, and 38.41% in winter. Among cladocerans, the family Chydoridae contributed the maximum number of 17 species, and their abundance was highest in winter (32.59%), followed by summer (21.31%) and monsoon (17.41%) (Table 1). The highest frequency of occurrence was recorded for *Brachionus calyciflorus* (84%) and *Keratella tropica* (80%), followed by *Asplanchna brightwellii, Brachionus angularis, Brachionus forficula, Euchlanis dilatata,* and *Chydorus sphaericus* (each 56%), and *Ceriodaphnia cornuta* (52%). In contrast, species such as *Keratella lenzi, Platyias quadricornis, Lecane ludwigi, Trichocerca bicristata, Trichocerca*

194 *pusilla, Hexarthra mira, Daphnia lumholtzi, Moinadaphnia macleayai, Camptocercus rectirostris, Kurzia*
195 *longirostris,* and *Pseudochydorus globosus* showed only 4% occurrence (Table 2).
196 **Density of Zooplankton**
197 The mean overall zooplankton density in the Godavari River was 64.8±11 ind./L, with the highest density
198 during summer (78.26±80 ind./L), followed by monsoon (59.83±60 ind./L) and winter (56.3±68 ind./L) (Table 3).
199 Rotifers showed the more density in summer (50±55 ind./L), whereas microcrustaceans particularly cladocerans
200 (27±27 ind./L) and copepods (17.53±14 ind./L) were more abundant during the monsoon. A similar trend was
201 observed in winter, with rotifers recording 21.6±29 ind./L (Table 3). Among the sampling stations, Nathsagar
202 exhibited the highest zooplankton density (142±76 ind./L), followed by Talegaon Kachurli (124±170ind./L),
203 Yellampally Dam (117±73 ind./L), and Kolpewadi (109±107 ind./L) (Table 4). The lowest densities were found in
204 Gautami reservoir (15±2 ind./L), Eturnagaram (15±12 ind./L), and Konavaram (28±14ind./L) (Fig. 2). The overall
205 increase in density at several stations was primarily driven by rotifer abundance, notably in Kolpewadi (66±100
206 ind./L), Nathsagar (90±93 ind./L), and Yellampally Dam (77±70 ind./L) (Fig. 3). In contrast, cladocera contributed
207 increased densities at Talegaon Kachurli (67±100 ind./L), Nandurmadhmeshwar (33±34 ind./L), Nanded (65±0.1
208 ind./L), and Sanvastar (43±50 ind./L) (Fig. 4). Copepods showed higher densities in Yellampally Dam (34±30.4
209 ind./L), Sanvatsar (32±17 ind./L), and Kolpewadi (30±23 ind./L). Whereas copepods contributed more noticeable
210 density in Dhalegaon (19±8 ind./L) and Gangakhed (18±4 ind./L) than other zooplankton communities (Table 4 &
211 Fig. 5). Zooplankton communities exhibited clear seasonal and site-specific variation like *Brachionus calyciflorus*
212 dominated in Kolpewadi and Shahgadh, whereas *Mesocyclops* sp. predominated in Dhalegaon during summer,
213 similarly *Lecane bulla* and *Lecane papuana* were dominant in Nathsagar, while *Brachionus falcatus* and *Mesocyclops*
214 sp. were abundant in the Yellampally Dam. During the monsoon, *Mesocyclops* sp. dominated in Sanvatsar. In the
215 post-monsoon period, *Brachionus rubens* was predominant in Dhalegaon, *Simocephalus expinosus* in
216 Nandurmadhmeshwar, and *Ceriodaphnia cornuta* along with *Mesocyclops* sp. in Nanded.
217

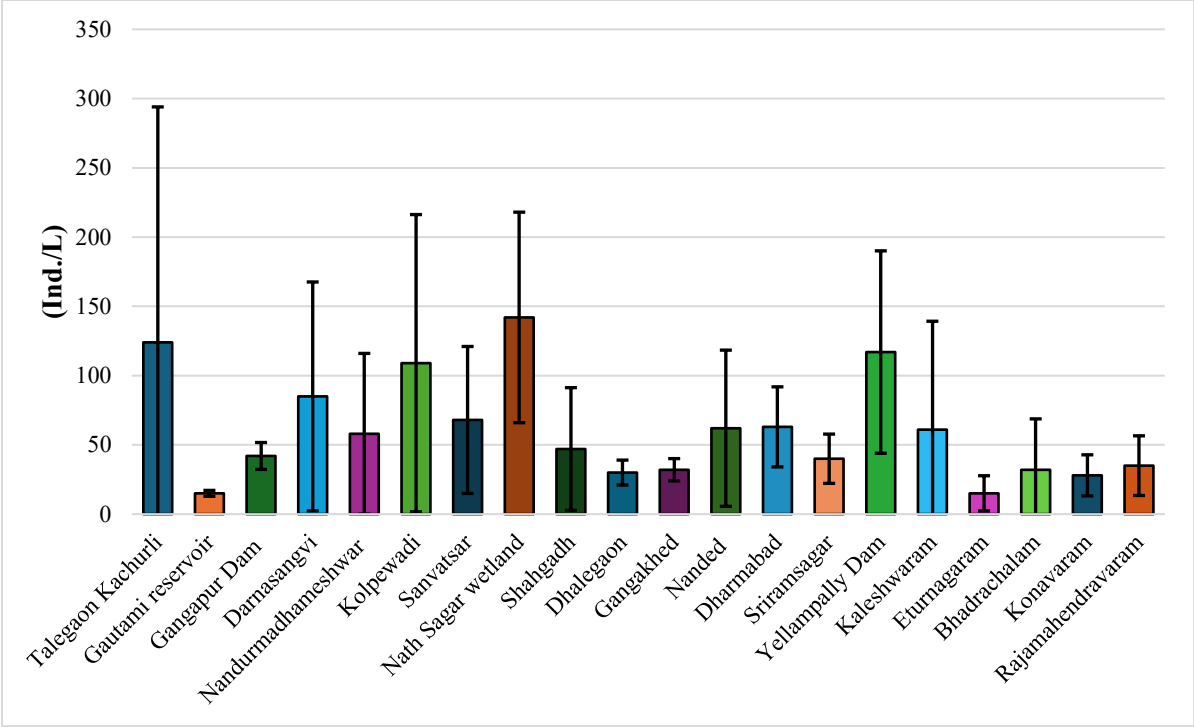


Fig. 2 Density of Zooplankton from River Godavari

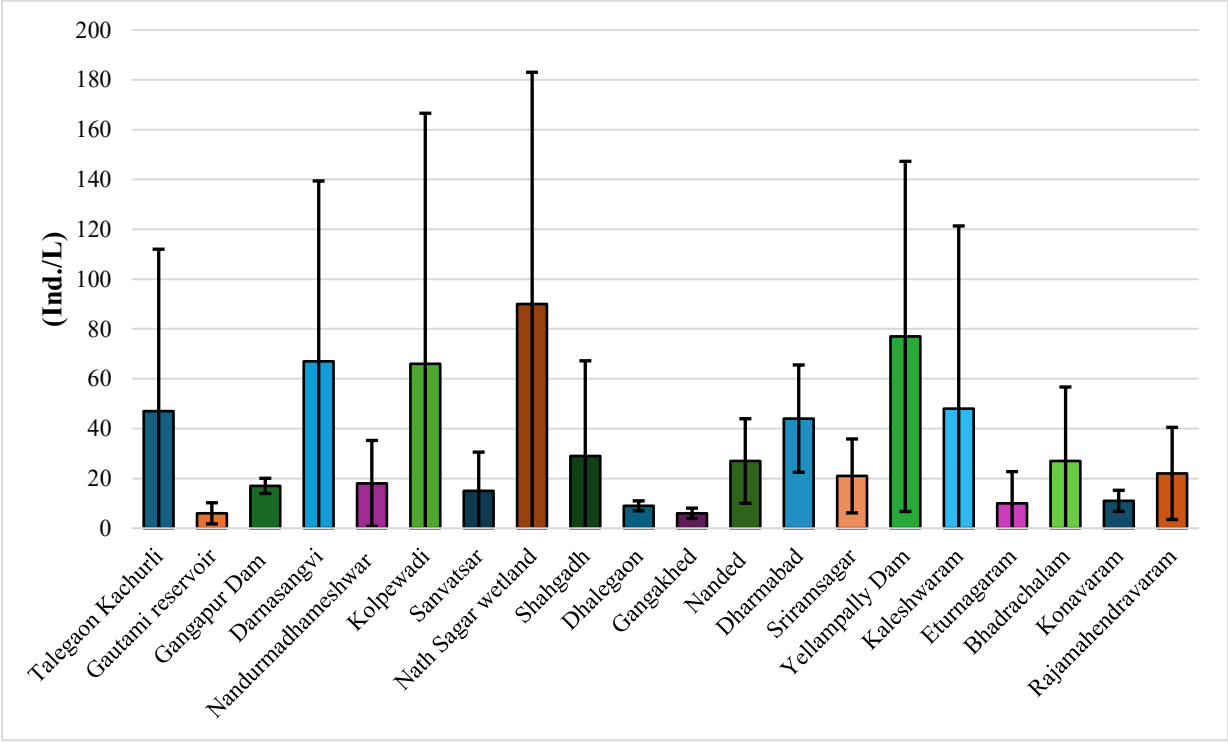
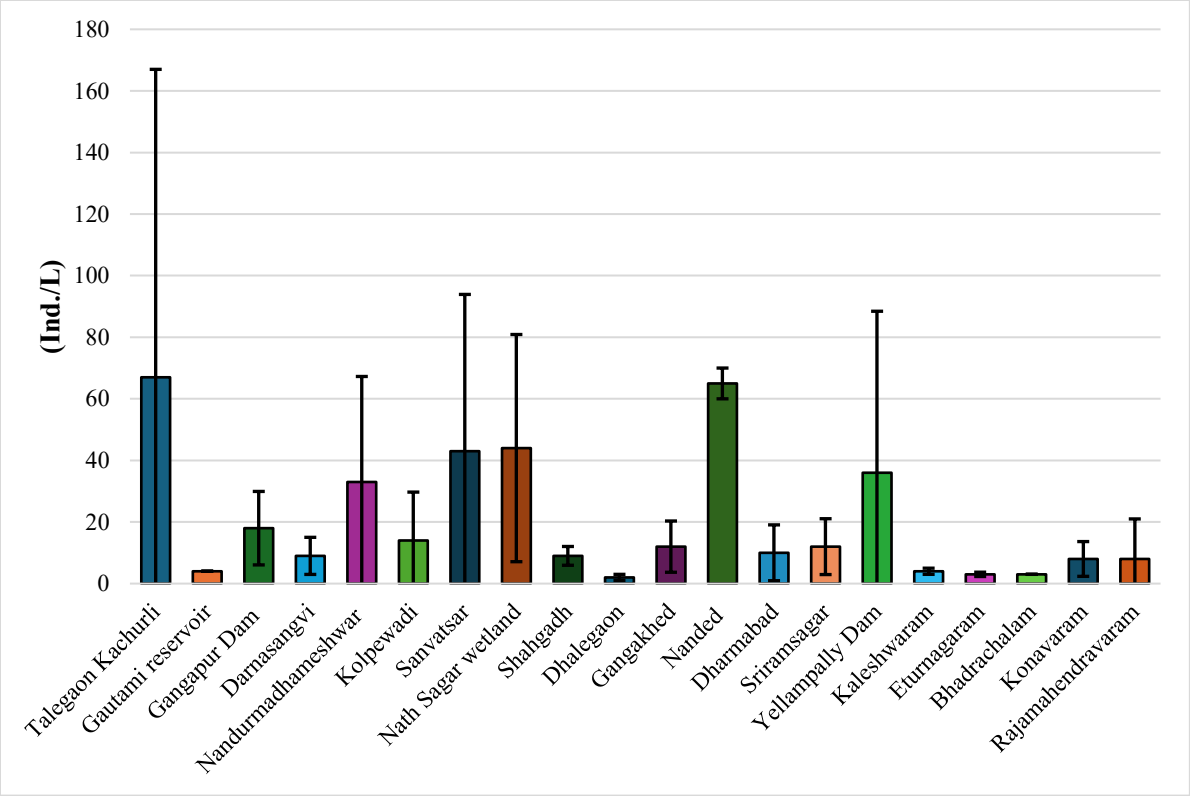
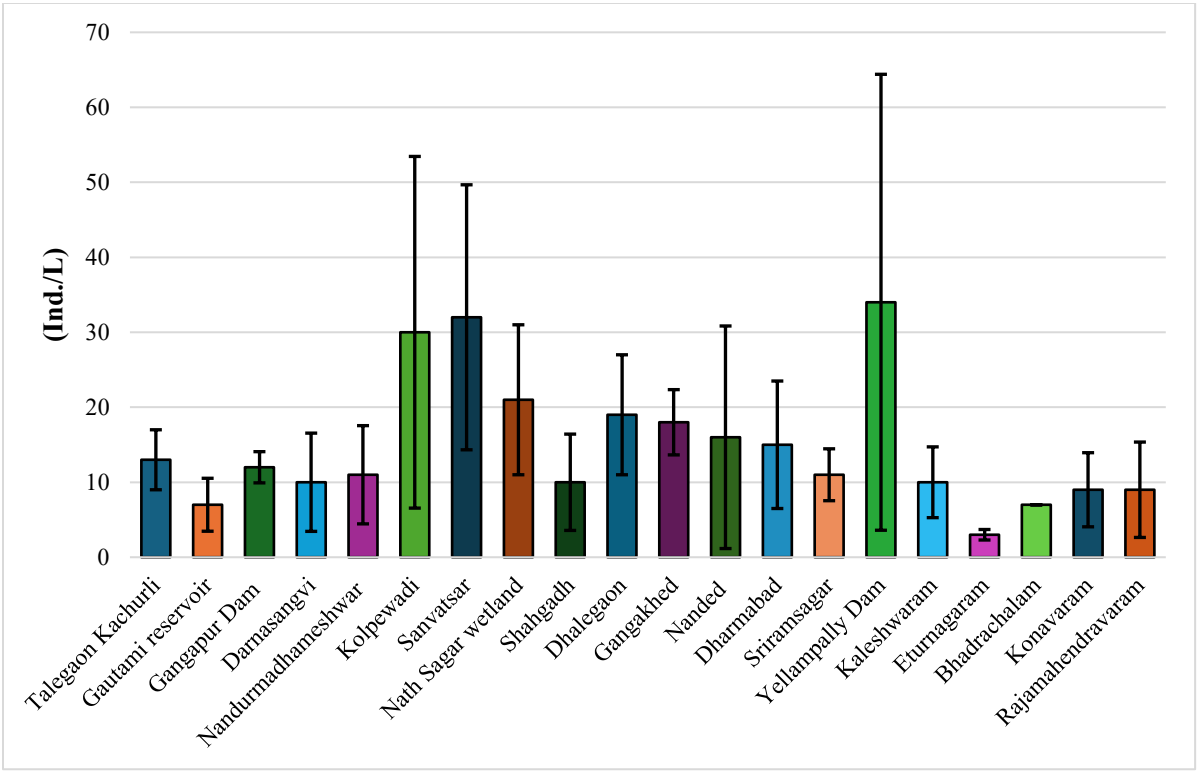


Fig. 3 Density of Rotifers from River Godavari



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223 **Fig. 4** Density of Cladocera from River Godavari



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225 **Fig. 5** Density of Copepoda from River Godavari

Diversity indices of Zooplankton

The overall mean value of the diversity index was H' = 1.95±0.15, with an evenness of 0.68±0.03, species richness of 12.6±1.5, abundance of 30.4±6.8%, and dominance of 36.5±3%. Seasonal analysis revealed that diversity was highest in the summer (H' = 2.12±0.5), followed by winter (H' = 1.89±0.52) and monsoon (H' = 1.84±0.43). Species richness and abundance were also highest in the summer, with values of 14±5 species and 38.02±23%, respectively, while dominance peaked during the winter (40.3±13%) as shown in Table 3. Station-wise analysis highlighted Gangapur Dam as the most diverse station (H' = 2.56±0.13), followed by Nathsagar (H' = 2.50±0.56), Nandurmadhmeshwar (H' = 2.37±0.61), and Konavaram (H' = 2.35±0.24). In contrast, lower diversity was recorded at Gautami reservoir (H' = 1.34±0.18), Dhalegaon (H' = 1.51±0.29), and Bhadrachalam (H' = 1.45±0.16) (Fig. 6). Evenness was higher at Gangapur Dam (J'= 0.71±0.04), Nandurmadhmeshwar (J'= 0.70±0.13), Dharmabad (J'= 0.73±0.1), Eturnagaram (J'= 0.89±0.03), and Konavaram (J'= 0.81±0.1), while lower evenness values were observed at stations like Kolpewadi (J'= 0.53±0.31), Sanvatsar (J'= 0.55±0.05), Nathsagar (J'= 0.52±0.16), Dhalegaon (J'= 0.55±0.13), and Gangakhed (J'= 0.52±0.09) (Fig. 7). Species richness was highest in Nathsagar (25±6.8), followed by Nandurmadhmeshwar (18±10), Gangapur Dam (18±1.5), and Konavaram (14±4.9). In contrast, Gautami reservoir (5±1.4), Bhadrachalam (8±4.9), and Dhalegaon (9±0.5) exhibited lower species richness (Fig. 8). A similar trend was seen in species abundance, with Nathsagar (63.6±39%), Gangapur Dam (58.8±12.1%), and Nandurmadhmeshwar (54.5±33%) showing the highest abundance, while Gautami Dam, Bhadrachalam, and Dhalegaon had lower abundance values (Fig. 9). Dominance showed an inverse relationship with other indices, with high values at Gangakhed (54.0±17%), Dhalegaon (53.4±10%), Gautami reservoir (48.07±2.7%), and Bhadrachalam (45±16.6%). On the other hand, lower dominance was noted at Konavaram (20.9±3%), Sriramsagar (23.6±6.1%), Yellampally Dam (29.2±5.1%), Gangapur Dam (26.1±3%), and Nathsagar Wetland (26.7±13%). (Table 4 & Fig. 10).

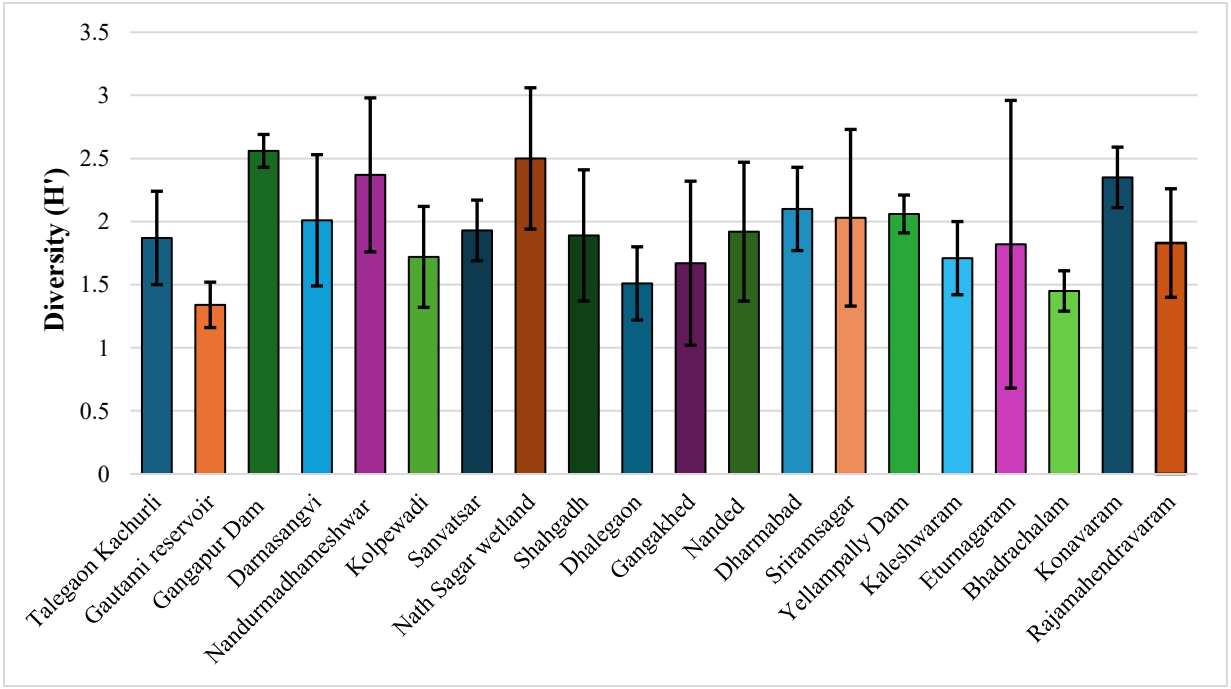


Fig. 6 Diversity of Zooplankton from River Godavari

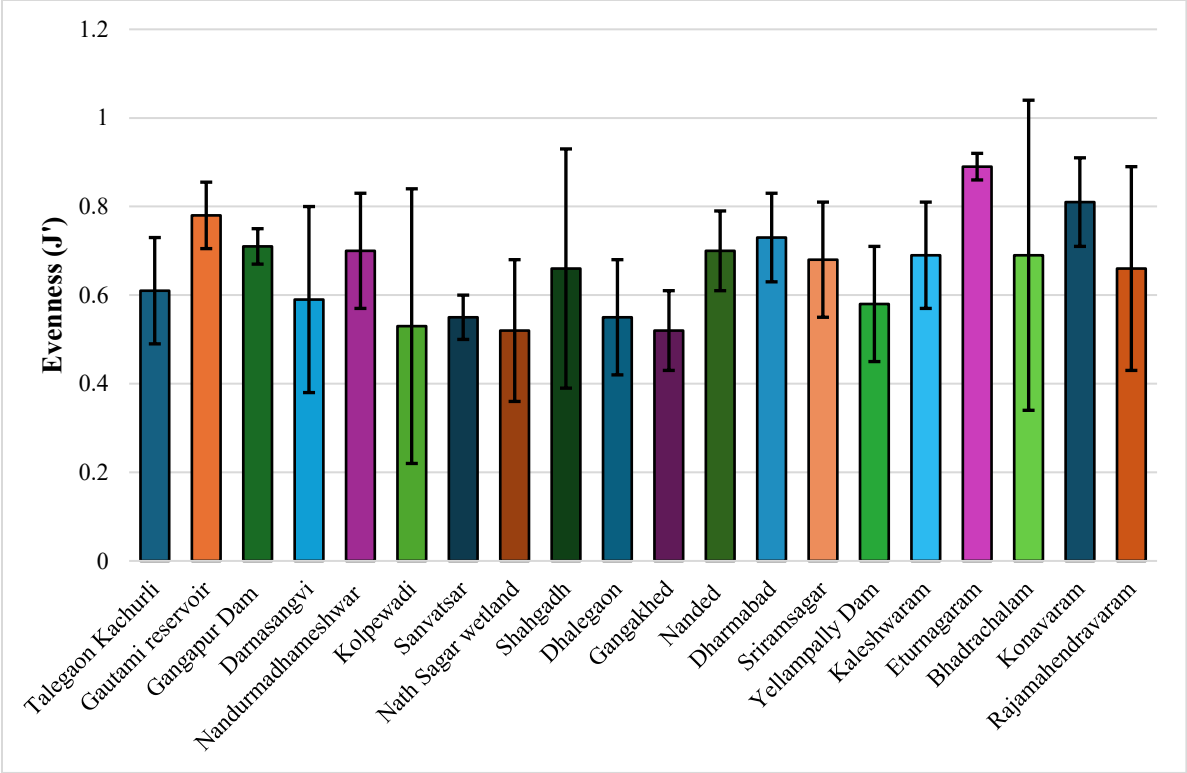


Fig. 7 Evenness of Zooplankton from River Godavari

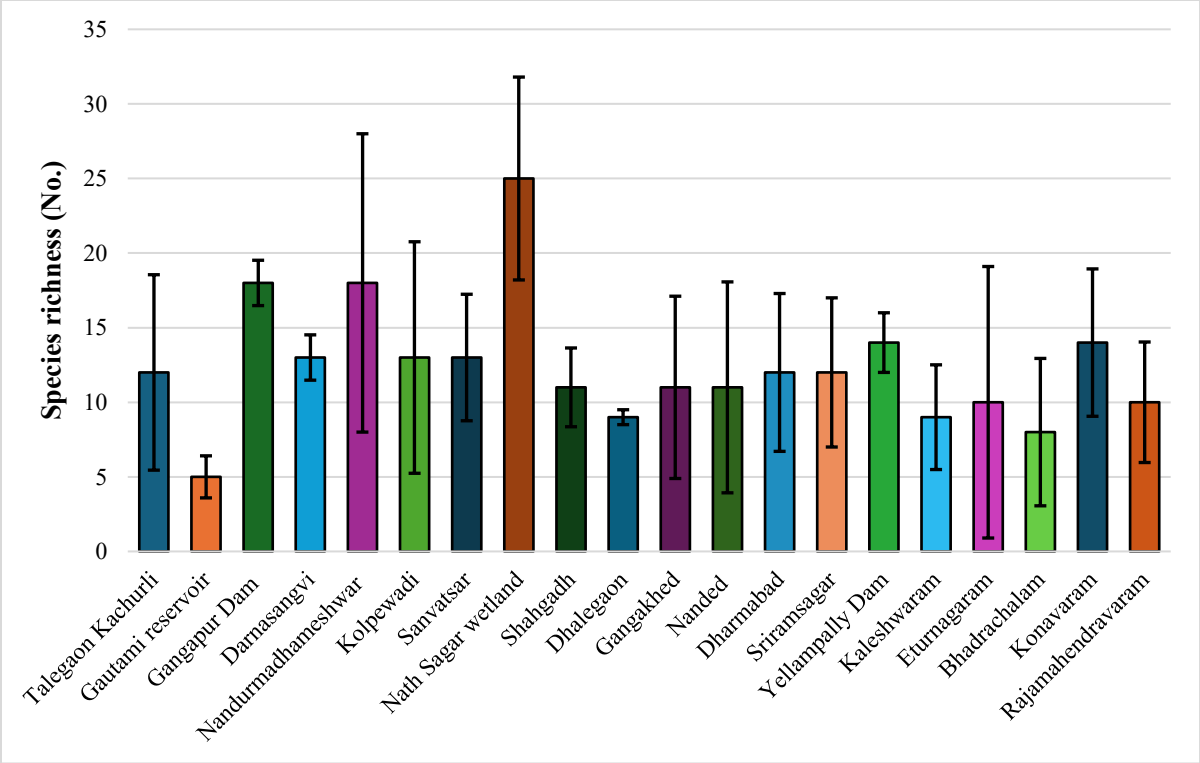
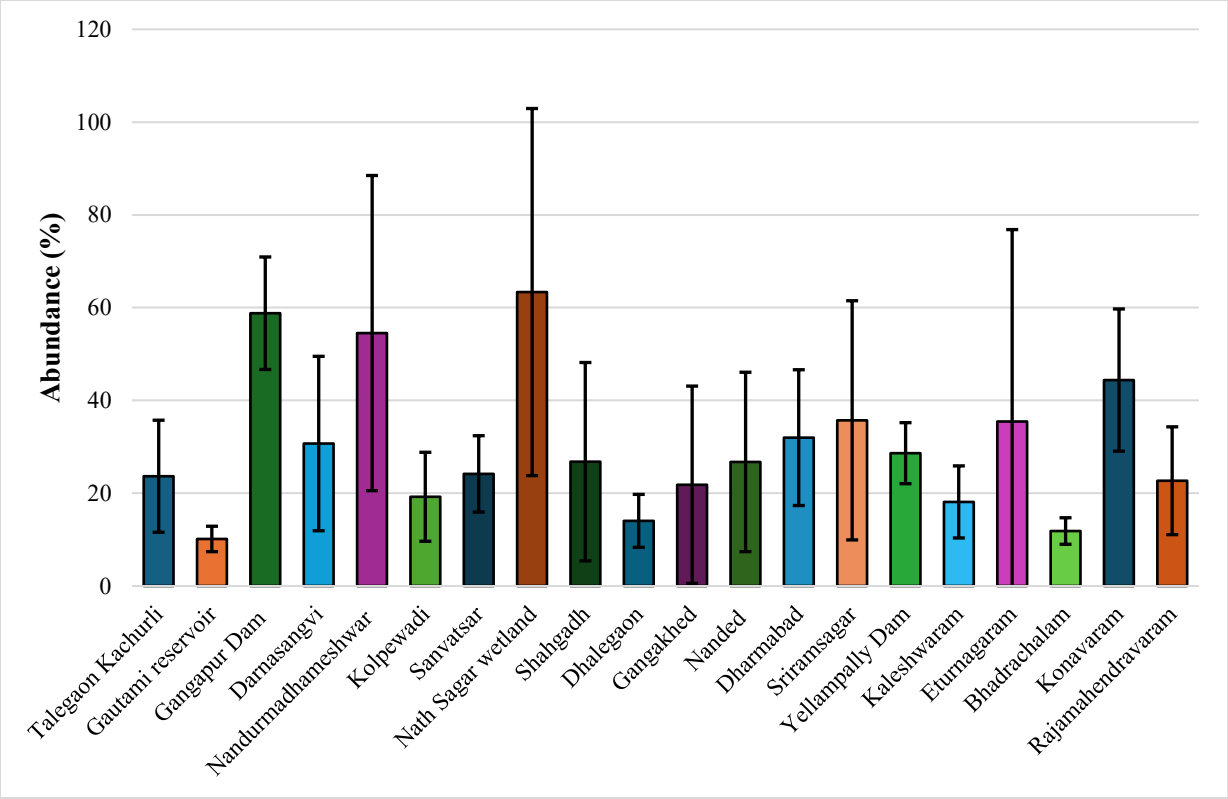
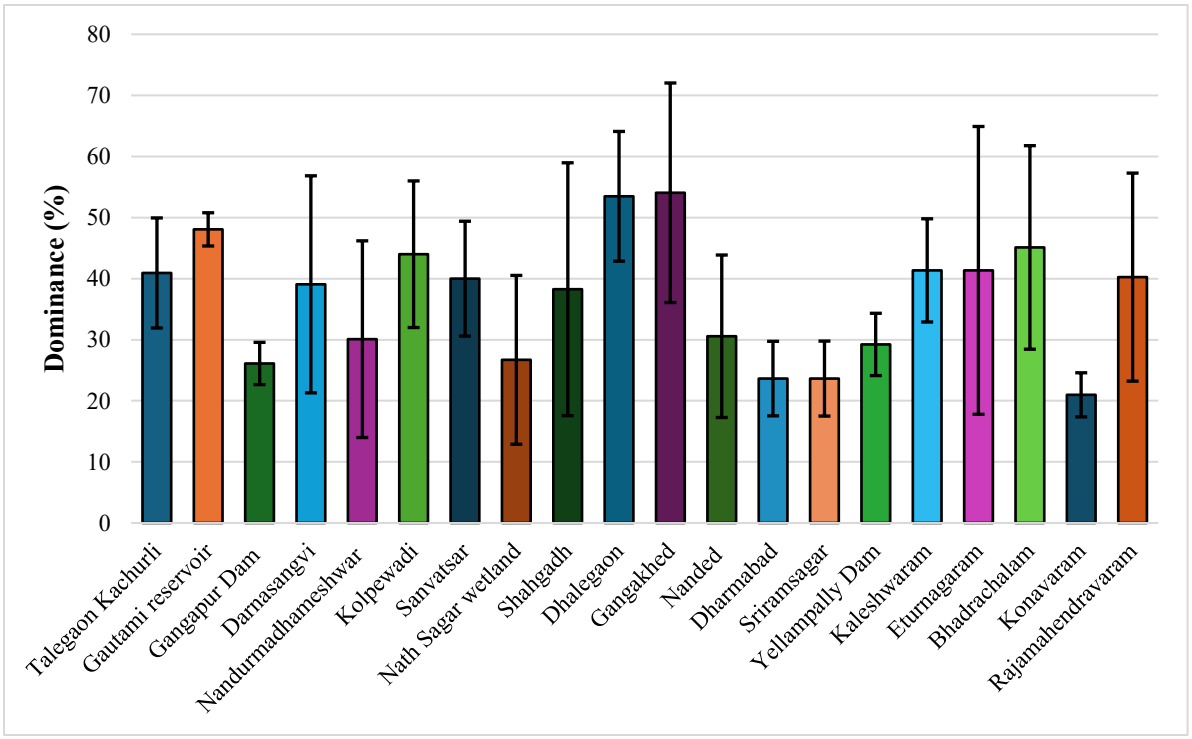


Fig. 8 Species richness of Zooplankton from River Godavari



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254 **Fig. 9** Abundance of Zooplankton from River Godavari



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256 **Fig. 10** Dominance of Zooplankton from River Godavari

Water quality parameters

The physicochemical parameters of the River Godavari, represented on a seasonal basis are shown in Table 3. The maximum average surface water temperature recorded during the study period was 27.3±2.4°C, with higher values of 30.0±2.33°C observed during the summer seasons. The mean pH was 8.4±0.3, higher value was in the monsoon (8.74±0.31), and the lower in winter (8.27±0.28). The mean electrical conductivity was 0.7±0.1 mS/cm, with a higher value in summer (0.86±0.84 mS/cm) and a lower value in winter (0.65±0.43 mS/cm). The average total dissolved solids concentration was 379±45.7 mg/L, with higher values during the summer (431.8±425.4mg/L). The mean dissolved oxygen was 6.8±1.5 mg/L, relatively higher in the monsoon season (7.95 ±1.7mg/L) and lower during summer (5.04±1.42 mg/L). The average total hardness for the entire river stretch was 234.3±26.6mg/L, showing higher values in monsoon (261.8±266 mg/L) and lower in winter (208.6±96 mg/L). A similar trend was observed in total alkalinity (196.5±20.1mg/L) and calcium (91.6±43.4 mg/L), showing elevated concentrations during the monsoon and summer season respectively. The mean chloride concentration was 110.5±30.4 mg/L, with higher levels in summer (144.9±148 mg/L) and lower levels recorded in winter (99.06±48 mg/L). The average nitrate value was 29.6±28.1 mg/L, with higher concentrations during the monsoon (61.82±59 mg/L) and lower in winter (17.08±26.32 mg/L). Nitrite levels followed a similar trend, being higher in summer (1.82±1.23 mg/L) and lower during winter (0.28±0.81 mg/L). The mean total phosphate concentration was 1.3±1.7 mg/L, with higher values in winter (3.20±2.21 mg/L) and lower concentrations during the monsoon (0.13±0.06 mg/L). Ammonia levels averaged 2.1±1.5 mg/L, showing higher concentrations in the summer (2.16±2.51 mg/L) and lower levels in the monsoon (0.58±0.91 mg/L) as shown in Table 3.

The sampling station wise water quality analysis showed that surface water temperature varied from 23.9°C to 30.4°C. pH values were lowest at Talegaon Kachurli (8.03 ± 0.59) and highest at Sanvatsar (8.03 ± 0.59). Electrical conductivity was low value at Talegaon Kachurli (0.12±0.01 mS/cm), Konavaram (0.19±0.09 mS/cm), Rajamahendravaram (0.31±0.14 mS/cm), Bhadrachalam (0.38±0.09 mS/cm), Eturnagaram (0.41±0.10 mS/cm), and Kaleshwaram (0.45±0.06 mS/cm), whereas high values were recorded at Sanvatsar (2.13±1.33 mS/cm) and Shahgadh (2.32±1.18 mS/cm). TDS levels were lowest at Talegaon Kachurli (60.5±4.5 mg/L) and Gautami Reservoir (88.9±4.7 mg/L), while higher concentrations occurred at Sanvatsar (1081±678 mg/L), Shahgadh (1209.1±528 mg/L), Kolpewadi (628.1±291 mg/L), and Nandurmadhmeshwar (521.5±195 mg/L). Dissolved oxygen was lowest at Kolpewadi (4.53 ±1.17 mg/L) and highest in Gautami Reservoir (7.81±1.23 mg/L). Total hardness was lowest at Talegaon Kachurli (65±38.68 mg/L), while the maximum was found at Sanvatsar (515±305 mg/L). Calcium concentration was highest at Shahgadh (267.5±152 mg/L) and Darnasangavi (125±96 mg/L), lowest at Talegaon Kachurli (17.08±24 mg/L). Magnesium levels were elevated at Sanvatsar (119±90 mg/L) and Shahgadh (105±103 mg/L) lowest at Konavaram (6.8±7.53 mg/L). Nitrate concentration was highest at Darnasangavi (72.85±68 mg/L), while nitrite levels were elevated at Dhalegaon (3.30±0.17 mg/L), Darnasangavi (3.05±0.57 mg/L), and Shahgadh (1.73±1.5 mg/L). Phosphate levels were also high in Nandurmadhmeshwar (1.98±1.5 mg/L), and Sanvatsar (1.76±0.03 mg/L). Ammonia concentration was highest at Darnasangavi (3.99±1.85 mg/L) and Yellampally Dam (1.94±1.8 mg/L) (Table 4).

Correlation coefficient

Season based Pearson's correlation coefficient analysis between biological and physicochemical parameters revealed strong associations between zooplankton communities and key water quality variables in the Godavari River. Overall zooplankton density, including rotifers and cladocerans, showed a significant positive correlation with pH (r = 0.84-0.98), dissolved oxygen (r = 0.97-0.99), magnesium (r = 0.96-1.00), and phosphate (r = 0.55-0.81), while ammonia (r = 0.43-0.73) and electrical conductivity (r = 0.35-0.67) exhibited moderate positive correlations. Copepod density showed moderate correlations with magnesium (r = 0.72), nitrate (r = 0.74), nitrite (r = 0.85), and dissolved oxygen (r = 0.69). Zooplankton density was negatively correlated with the Shannon diversity index (r = –0.67). This similar pattern was also observed for evenness. Shannon diversity exhibited strong positive correlations with temperature (r = 0.90), total dissolved solids (r = 0.99), total hardness (r = 0.79), total alkalinity (r = 0.97), and nitrite (r = 0.77), while showing highly negative correlations with phosphate (r = –0.98), ammonia (r = –1.00), electrical conductivity (r = –1.00), zooplankton and rotifer densities (r = –0.67 and –0.59), and dominance (r = –0.70). Evenness was strongly positively associated with dominance (r = 0.98) and zooplankton communities (r = 0.98–1.00) and had a moderate correlation with copepods (r = 0.64). Abundance showed a strong positive correlation only with calcium (r = 0.82), displaying negative associations with all other parameters. In contrast, the dominance index correlated positively with pH (r = 0.99), dissolved oxygen (r = 0.96), chloride (r = 0.92), magnesium (r = 0.95), nitrate (r = 0.94), phosphate (r = 0.83), ammonia (r = 0.75) and moderately with electrical conductivity (r = 0.69), but negatively with total alkalinity (r = –0.85), total hardness (r = –0.99), total dissolved solids (r = –0.77), Shannon diversity (r = –0.70), and abundance (r = –0.52) (Fig. 11).

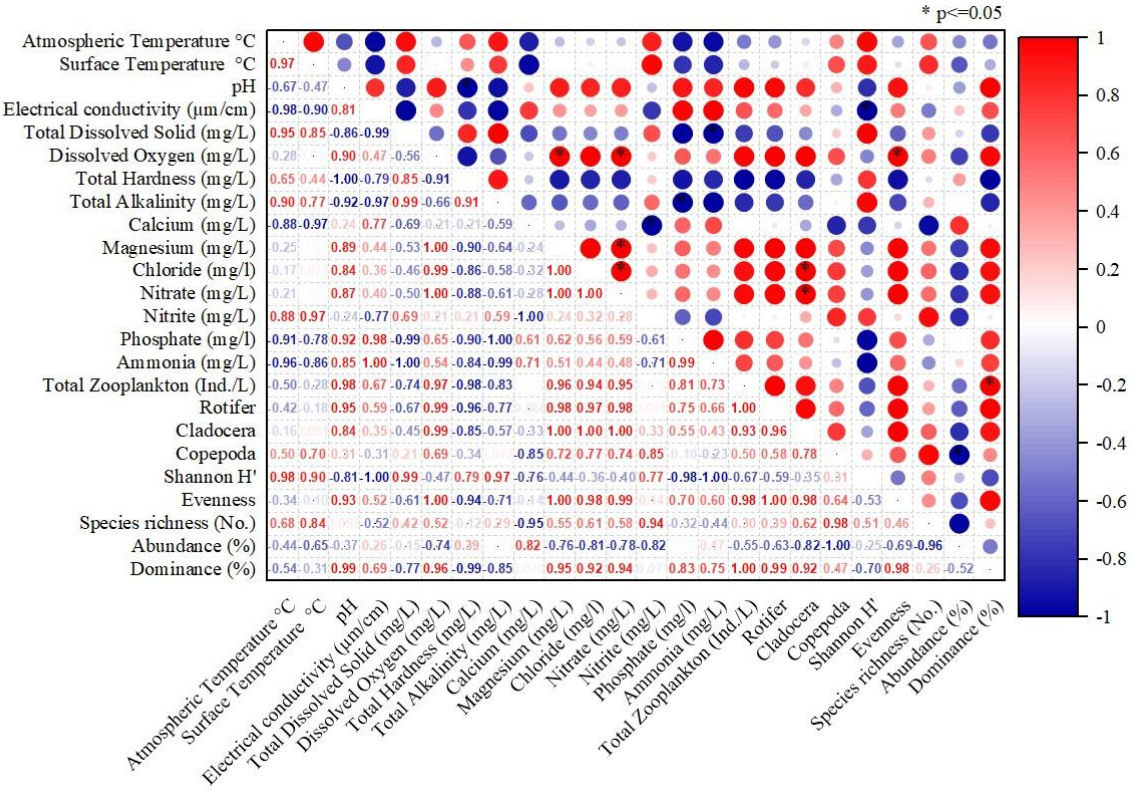


Fig. 11 Correlation coefficient analysis of seasonal basis biological and water quality parameters.

Principal Component Analysis (PCA)

The principal component analysis conducted on seasonal water quality and biological parameters revealed distinct environmental factors influencing zooplankton community structure in the Godavari River. During the monsoon season, zooplankton density, including rotifers and cladocerans showed a strong positive relationship with dissolved oxygen, chloride, magnesium, nitrate, and pH, indicating that these variables were the primary drivers of community abundance. Phosphate, ammonia, and electrical conductivity exhibited moderate loadings, suggesting a secondary but noticeable influence on zooplankton distribution during this period. In winter, zooplankton abundance demonstrated the highest association with calcium, reflecting the influence of geochemical parameters under low-flow conditions. Conversely, the Shannon diversity index was strongly supported during summer, particularly by temperature, total dissolved solids, total alkalinity, and total hardness, while phosphate, ammonia, and electrical conductivity contributed negatively, indicating that elevated nutrient and ionic concentrations were unfavourable for maintaining diversity in summer (Fig. 12).

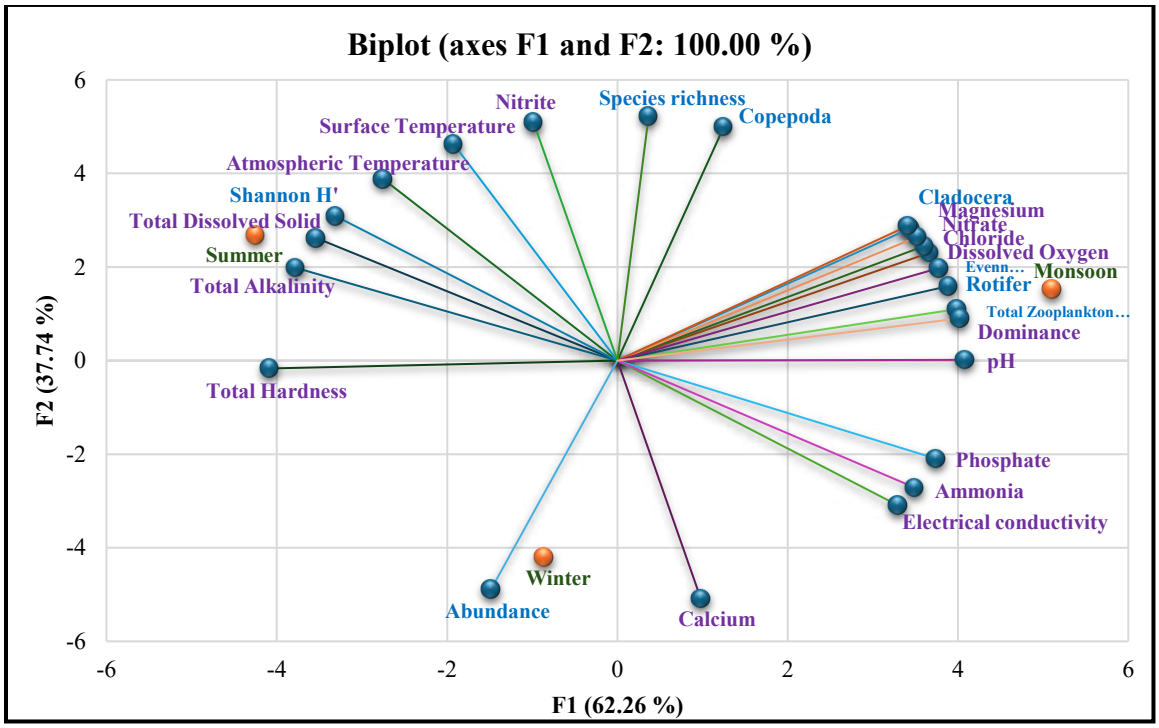


Fig. 12 Principal component analysis on seasonal wise biological and water quality variables.

Station-wise PCA further revealed clear spatial patterns. Zooplankton density, diversity, abundance, species richness, and total zooplankton were strongly associated with each other and were notably higher at Nathsagar wetland, Gangapur Dam, Talegaon Kachurli, and Yellampally Dam, indicating favourable environmental conditions at these locations. In contrast, stations such as Nandurmadhmeshwar, Darnasangvi, and Nanded were strongly influenced by nutrient parameters, including phosphate, nitrate, and ammonia, demonstrating the impact of nutrient enrichment on zooplankton dynamics. Higher impacts of electrical conductivity, total dissolved solids, total hardness, alkalinity, magnesium, and chloride were observed at Kolpewadi, Sanvatsar, and Shahgadh, which contributed to reduced zooplankton diversity observed at these stations. Elevated dominance values at Dhalegaon and Gangakhed

were primarily associated with nitrite and calcium, indicating skewed community composition toward a few tolerant species. Evenness was positively associated with dissolved oxygen, pH, and temperature, with higher values observed at Sriramsagar, Rajamahendravaram, Eturnagaram, Kaleshwaram, Gautami Dam, and Bhadrachalam (Fig. 13).

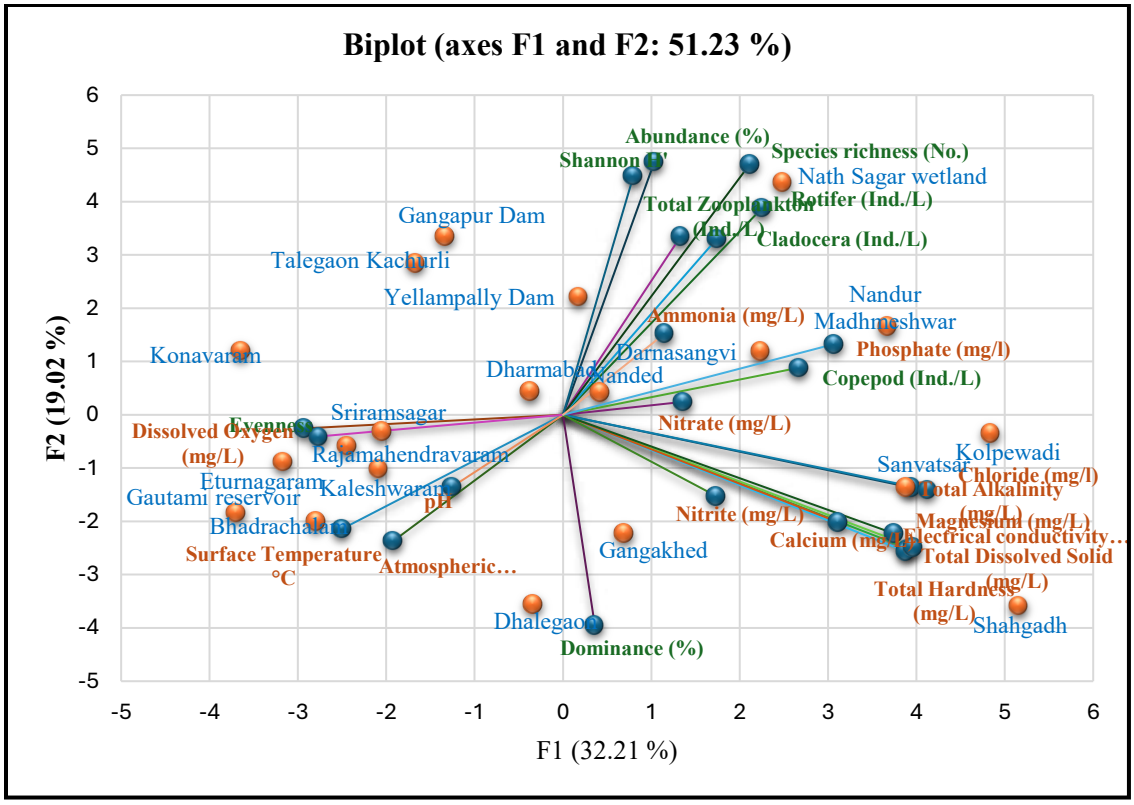


Fig. 13 Principal component analysis on sampling station wise biological and water quality variables.

Discussion

Zooplankton composition

The River Godavari exhibits high zooplankton species richness, with rotifers constituting the most diverse in species number and relative abundance. Rotifers are the most diverse group within the zooplankton community (Chen et al., 2020; Qin et al., 2020; Lu et al., 2021). The abundance of rotifers could be primarily driven by seasonal changes and environmental factors (Jafari et al., 2011; Phan et al., 2021) such as temperature fluctuations, nutrient availability, and water quality, which influence their reproductive cycles and community dynamics. This may be attributed to the high tolerance of rotifers to varying environmental conditions in large river systems (Serna and Casper 2021). Among the rotifers, the families Branchionidae and Leccanidae are the most dominant groups, especially the genera *Brachionus* and *Lecane* exhibited more number of species. Their tropical character, predominantly consisting of cosmopolitan species, represented this richness (Segers 1996; Karuthapandi et al., 2018; Sharma and Sharma 2019; Karuthapandi and Jaiswal, 2021; Phan et al., 2021; Enawgaw et al., 2023). The significant frequency of occurrence of key species such as *Brachionus calyciflorus* and *Keratella tropica* suggests these taxa may be particularly well suited to the tropical river's ecological conditions. Sharma (1996) reported that the abundance of *Brachionus* species and *Keratella tropica* is associated with alkaline, hardwater conditions in different parts of tropical India. Similar

observations were also made by Karuthapandi et al., (2018) and Karuthapandi and Jaiswal (2021). In general, the rotifers are highly diverse and exhibit a wide range of ecological tolerance, enabling them to withstand varying environmental conditions. They are widely recognized as important bioindicators assessing water quality and the ecological health of aquatic ecosystems (Oh et al., 2017). Among the cladoceran family Chydoridae, represented a greater number of species were represented and showed higher relative abundance during winter season. In many temperate and subtropical systems, certain cladoceran taxa, including chydorids and other benthic species, exhibit higher species richness under specific seasonal conditions and littoral habitat resources are comparatively more stable (Basile et al., 2020; Agarwal et al., 2026). The occurrence of cladocerans is also influenced by food availability, abundance of macrophytes, and there is a strong relationship between macrophytes and zooplankton occurrence (Bomfim et al., 2025). The changes in the zooplankton taxonomic composition can also lead to changes in functional group density and diversity (Shen et al., 2021).

Density

The zooplankton density of the River Godavari reveals notable seasonal and spatial variations in zooplankton populations, reflecting the influence of environmental factors on their distribution (Li et al., 2022). The overall zooplankton density was highest during the summer, followed by the monsoon and winter, with rotifers showing more abundance in summer. These findings are consistent with the observations made by Manickam et al., (2018) and the similar density values were noted from tropical river system of Dakatia river (Rahman et al., 2025). Among the zooplankton, rotifers generally represent the main contributors to the zooplankton density and diversity in the freshwater ecosystem (Makwinja et al., 2021; Umi et al., 2018, 2024). Whereas cladocerans and copepods were more prevalent during the monsoon. Muthuraja, et al. (2021) suggest that monsoon driven changes in environmental parameters affect the zooplankton communities and composition. Spatially, Nathsagar exhibited the highest zooplankton density, likely due to favorable conditions such as nutrient rich water, while Gautami reservoir, Eturnagaram, and Konavaram had the lowest densities could be due to variance in the water quality and seasonal zooplankton distribution. The overall density increase at several stations was primarily driven by rotifers, especially in Kolpewadi, Nathsagar, and Yellampally Dam, whereas certain stations like Sanvatsar showed increased densities due to cladocerans, and Dhalegaon and Gangakhed were more influenced by copepods. The high density of microcrustaceans reflects that eutrophic conditions were probably due to high nutrient concentrations that favour the growth of phytoplankton as a food source for them (Umi et al., 2020). These patterns highlight the ecological complexity of the system, with different zooplankton groups thriving under varying environmental conditions. This emphasizes the role of zooplankton as indicators of ecosystem health and trophic dynamics in freshwater habitats. Serna and Casper (2021) noted that zooplankton communities are highly structured in space, with their distribution driven by spatial, temporal, chemical and biological factors. Species level dominance patterns further demonstrated the ecological gradients across the river. The dominance of *Lecane bulla* and *L. papuana* in Nathsagar indicates habitat conditions conducive to littoral rotifer species (Segers 1996). The prevalence of *Mesocyclops* sp. at several stations across seasons suggests that this genus is particularly well adapted to a wide range of environmental conditions and enrichment of nutrients at the specific location of the Godavari River, possibly due to its opportunistic feeding and

reproductive strategies and density of cyclopoids. *Mesocyclops* reparents in high nutrient rich environments and significantly lowers the biodiversity (Picapedra et al., 2020; Umi et al., 2020, 2024).

Diversity

The River Godavari supports a moderately diverse zooplankton community, while seasonal patterns show that diversity, richness, and abundance were highest in the summer. A similar observation was made by Li et al., (2024). Geng et al., (2022) also reported that diversity increased significantly in summer with seasonal fluctuation and was lowest in winter. It indicates favorable environmental conditions and seasonal variation in diversity, abundance, and dominance. This highlights the dynamic nature of the river ecosystem, with higher species richness and abundance observed during the summer season, which is consistent with earlier findings (Manickam et al., 2014; Qiu et al., 2022; Jamwal and Sharma 2025). Whereas dominance peaked during winter, suggesting changes in community structure and reduced evenness. Similar observations were made by Sharma and Hatimuria (2017), Karuthapandi and Jaiswal (2021), Dubey and Pathak (2025). The sampling station wise analysis highlighted that Gangapur Dam, Nathsagar, Nandurmadhmeshwar, and Konavaram had more diversity, evenness, and richness, while Gautami reservoir, Dhalegaon, and Bhadrachalam exhibited low diversity and high dominance, indicating ecological stress or poorer habitat quality. Pinto et al., (2023) reported that diversity values decrease with the increase of trophic status. Overall, the biological indices suggest that while several stretches of the river support stable and diverse zooplankton communities, others show signs of imbalance, reflecting spatial variation in environmental conditions and ecosystem health across the Godavari River. The diversity index value (H' = 1-2) indicates a eutrophic condition, with a value above (H' = 2.1-2.5) showing a mesotrophic condition (Habrmon and Haldna 2014).

Water quality parameters

The physicochemical environment plays a vital role for the growth and reproduction of zooplankton as well as the structure of the zooplankton communities, which responds to changes in the conditions (Pinto et al., 2023). The ambient temperature range has significantly changed over the time frame from 25°C to 41°C, with changes in the pH value between 7.5 to 9 which fall under the alkaline nature of the river Godavari. Navasakthi et al., (2023) also reported similar corroborating findings from the river Godavari. Seasonal and spatial variations in the physicochemical characteristics of the river Godavari indicate strong influences from hydrological conditions and anthropogenic pressures, consistent with patterns reported in other major Indian rivers (Singh et al., 2018; Gupta et al., 2020; Kirkels et al., 2020). Water temperature is an important environmental factor that affects the composition of the zooplankton community (Kagalou et al., 2010). Monsoon linked increases in pH, dissolved oxygen, hardness, alkalinity, calcium, and nitrate suggest substantial inputs from surface runoff carrying agricultural fertilizers, soil minerals, and organic matter. It is aligned with earlier findings from studies on the Ganga and Narmada, where monsoonal runoff significantly elevates ionic and nutrient loads (Singh et al., 2018; Matta et al., 2020; Gupta et al., 2020). Hu et al., (2019) found that pH had a significant effect on season variation of the zooplankton community. Spatial disparities, particularly the elevated electrical conductivity, total dissolved solids, major ions, and nutrient concentrations at Sanvatsar, Shahgadh, Kolpewadi, and Darnasangavi, correspond with earlier reports suggesting that elevated values are due to agricultural and domestic pollution (Khan and Parveen 2024), electrical conductivity was increased with pollution (Liu et al., 2012) and increasing concentration of nutrients results in water quality deterioration (Liu et al.,

2020; Lu et al., 2021). Some stations have higher conductivity, and alkalinity can be due to the release of untreated effluents from industrial and agricultural runoff entering the river Godavari (Navasakthi et al., 2023). The observed low dissolved oxygen at Kolpewadi, coupled with high nutrient loads at several stations, mirrors concern raised in studies linking eutrophication risk to elevated nitrate and phosphate levels in Indian rivers (Rao et al., 2017). It is further supported by Navashakthi et al., (2023) who reported that utilization of dissolved oxygen is at a higher rate due to increasing degradation of organic matter by microorganisms in the River Godavari. The present study aligns with broader evidence that unregulated nutrient inflow, wastewater discharge, and seasonal hydrological extremes can significantly impair riverine ecological health.

Correlation

Seasonal correlation analysis between biological and physicochemical parameters in the Godavari River provides key insights into the ecological processes governing zooplankton community dynamics. Li et al., (2024) suggesting that seasonal variations are crucial drivers of environmental changes. Strong positive associations of total zooplankton, rotifers, and cladocerans with pH, dissolved oxygen, magnesium, and phosphate indicate their preference for well oxygenated, moderately alkaline, and nutrient enriched conditions. Elevated phosphate levels likely enhance primary productivity and reduce the functional diversity of planktonic animals by altering their community structure (Chen et al., 2025). The enhanced nutrients and stable water body provide a good habitat for the growth of the zooplankton (Liu et al., 2020). In contrast, the negative relationship between zooplankton density and Shannon diversity reflects dominance by a few tolerant taxa under high density conditions, typical of nutrient rich environments (Rahman et al., 2025). Positive correlations of diversity with temperature, total dissolved solids, hardness, alkalinity, and nitrite indicate that diverse communities are associated with relatively stable and moderately mineralized conditions. Conversely, strong negative associations with phosphate, ammonia, and conductivity suggest that excessive nutrient loading and ionic concentration reduce community complexity (Dorak et al., 2025).

Diversity and abundance showed strong positive interrelationships, while both were negatively associated with dominance. It indicates that ecologically balanced communities occur under conditions of low dominance. Copepods exhibited sensitivity to ionic composition, showing moderate associations with conductivity, TDS, hardness, alkalinity, magnesium, and chloride, consistent with their preference for stable, mineral rich environments and often reflecting alteration in nutrient status, contaminant exposure and climatic conditions (Dehingia et al., 2026). Overall, zooplankton communities were strongly regulated by nutrient dynamics, ionic composition, and oxygen availability in the river Godavari. A similar positive correlation of zooplankton community and oxygen was observed by (Geng et al., 2022). Elevated nutrient levels enhance zooplankton abundance but reduce diversity, favouring opportunistic species and eutrophic conditions, whereas higher diversity is associated with moderate nutrient levels and stable physicochemical conditions, reflecting healthier ecosystem states (Havens and Beaver 2011; Qiu et al., 2022). The greater diversity is alien to plankton stability and better water quality. The overall diversity and stability controlled by multiple physicochemical parameters and the influences of nutrients also play a significant role (Geng et al., 2022). Increasing conductivity reduces zooplankton species diversity and leads to homogenistation of the assemblage (Tavsanoglu et al., 2015).

Principal Component Analysis

Principal component analysis highlights the key seasonal and spatial drivers shaping zooplankton community structure in the Godavari River, consistent with a recent study (Qiu et al., 2022; Li et al., 2024). Seasonally, monsoon conditions showed strong associations of zooplankton density, particularly rotifers and cladocerans with dissolved oxygen, nutrients, and ionic factors, indicating that runoff driven nutrient enrichment and improved oxygenation enhance productivity (Gillooly et al. 2001, 2002; Spaolijar et al., 2011). These are responsible for biological processes such as metabolic rate, developmental time and healthy growth of microcrustaceans and rotifers. In winter, zooplankton abundance was linked to calcium, reflecting geochemical control under low flow conditions (Godfrey et al., 2021). In contrast, higher diversity during the summer was associated with warm, stable, and moderately mineralized conditions, although excessive nutrients reduced community evenness. Seasonal changes could be the main driving factor for the variation of the zooplankton community (Qiu et al., 2022).

Spatial PCA revealed strong interlinkages among zooplankton density, diversity, and richness, with higher values at relatively stable sites such as Nathsagar, Gangapur, Talegaon, and Yellampally, indicating favorable environmental conditions. In contrast, nutrient enriched locations such as Nandurmadhmeshwar, Darnasangvi, and Nanded showed shifts toward tolerant taxa, while sites influenced by high ionic content, such as Kolpewadi, Sanvatsar, and Shahgadh exhibited reduced diversity. Elevated dominance at Dhalegaon and Gangakhed reflects stress driven community imbalance, whereas sites with better oxygenation and physicochemical stability in Sriramsagar, Rajamahendravaram, and Bhadrachalam supported more even communities. Overall, PCA underscores that nutrient loading, ionic composition, hydrological variation, and anthropogenic influences are primary drivers for changing the composition and community structure of zooplankton along with their spatiotemporal and physicochemical factors (Wagaw et al. 2023). This reaffirms the importance of zooplankton as sensitive indicators for riverine ecosystem assessment, such as such as climate change, habitat degradation, and organic pollution. Further, it leads to increasing demand for biodiversity monitoring used in conservation and management decisions (Stefanni et al., 2018; Qiu et al., 2022). Hence, zooplankton communities are an effective tool for biomonitoring, have become a widely accepted and preserving structure and function of zooplankton assemblages, and are thus critical for both biodiversity conservation and management of aquatic ecosystems (Xiong et al., 2020; Bomfim et al., 2025; Karpowicz et al., 2025). Therefore, this study further emphasizes that the major rivers of India need to assess their ecological status through monitoring of zooplankton communities, which can provide a potential strategy for conservation and management of the riverine ecosystem of the country, maintaining its stability and biodiversity.

Conclusion

This study reveals that the Godavari River supports a moderately diverse and dynamic zooplankton community, whose composition, abundance, and distribution are strongly governed by seasonal hydrological variations and spatial differences in water quality. Overall, the river reflects mesotrophic conditions with moderate levels of pollution, though several locations show pronounced ecological stress linked to agricultural runoff, domestic sewage, and other anthropogenic actives. Seasonal patterns highlight increases in temperature, conductivity, and chlorides during the summer favours peak rotifer diversity, whereas monsoon driven nutrient enrichment enhance microcrustaceans populations. In contrast, winter conditions are associated with reduced nutrient levels and high community dominance. Spatial analyses identified high diversity zones at Nathsagar, Gangapur, Talegaon Kachurli,

and Yellampally Dam, while lower diversity was observed at Gautami Dam, Dhalegaon, and Bhadrachalam, indicating poorer habitat quality and localized environmental degradation. Correlation and PCA results emphasize that nutrient concentrations, mineral content, and dissolved oxygen are key determinants of zooplankton community structure, whereas excessive nutrient and ionic loads negatively affecting diversity and stability. Overall, these findings reinforce the role of zooplankton as sensitive bioindicators of aquatic ecosystem health and underscore the importance of long term, continuous monitoring of both biological and physicochemical parameters. Hence, strengthening wastewater management, regulating nutrient inputs, and implement targeted conservation measures are essential to protect the ecological integrity, biodiversity and ensure the sustainable functioning of the Godavari River.

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819 **Table 1** List of Zooplankton species, relative abundance and frequency of occurrence from River
820 Godavari

S. No	Zooplankton Species	Abundance (Ind./L) and percentage of relative abundance (%)			Frequency of occurrence (%) (n=21)
		Winter	Summer	Monsoon	
	Phylum: Rotifera Cuvier, 1817	**38.41**	**64.29**	**54.9**	
	Class: Eurotatoria De Riddler, 1957				
	Subclass: Monogononta Plate, 1889				
	Order: Ploima Hudson & Gosse, 1886				
	Asplanchnidae Harring & Myers, 1926				
1	*Asplanchna brightwellii* Gosse, 1850	0.71	0.81	0.37	56
	Brachionidae Ehrenberg, 1838				
2	*Anuraeopsis fissa* (Gosse, 1851)	0.18	0.20	0.28	28
3	*Brachionus angularis* Gosse, 1851	0.36	3.03	2.04	56

4	*Brachionus bidentatus* Anderson, 1889	0.27	0.27	0.09	20
5	*Brachionus calyciflorus* Pallas, 1776	3.55	16.01	4.35	84
6	*Brachionus caudatus* Barrios &Daday, 1894	1.07	2.42	1.11	76
7	*Brachionus diversicornis* (Daday, 1883)	1.24	3.63	0.37	48
8	*Brachionus durgae* Dhanapathi, 1974	0.09	0.47	0.46	24
9	*Brachionus falcatus* Zacharias, 1898	0.27	4.10	0.65	48
10	*Brachionus forficula* Wierzejski, 1891	3.64	6.32	9.25	56
11	*Brachionus quadridentatus melhemi* Barrios and Daday 1894		0.20	0.19	8
12	*Brachionus quadridentatus quadridentatus* Hermann, 1783	4.00	1.61	0.09	40
13	*Brachionus rubens* Ehrenberg, 1838	10.04	3.97	0.19	40
14	*Keratella cochlearis* (Gosse, 1851)	0.89	1.75	0.65	44
15	*Keratella lenzi* Hauer, 1953	0.09			4
16	*Keratella procurva* (Thorpe, 1891)			0.46	8
17	*Keratella tropica* (Apstein, 1907)	2.75	8.81	7.96	80
18	*Platyias quadricornis* (Ehrenberg, 1832)			0.09	4
	Euchlanidae Bartos, 1959				
19	*Euchlanis dilatata* Ehrenberg, 1832	1.15	1.41	1.20	56
20	*Sinantherina socialis* (Linnaeus, 1758)	0.36	0.27		28
	Lecanidae Bartos, 1959				
21	*Lecane bulla* (Gosse, 1851)	2.40	1.88	10.27	76
22	*Lecane closterocerca* (Harring and Myers, 1926)	0.27	0.07	0.19	12
23	*Lecane crepida* Harring 1914		0.07	0.09	8
24	*Lecane leontina* (Turner, 1892)	0.18	0.13	0.19	20
25	*Lecane ludwigi* (Eckstein 1883)		0.07		4
26	*Lecane luna* (Muller, 1776)	0.18	0.47	2.04	24
27	*Lecane lunaris* (Ehrenberg, 1832)	0.62	0.13	0.65	20
28	*Lecane papuana* (Murray, 1913)	0.18	0.07	3.79	20
	Lepadellidae Harring, 1913				
29	*Lepadella biloba* Hauer, 1958	0.09	0.13	0.28	20
30	*Lepadella triba* Myers, 1934	0.62			12
	Mytilinidae Bartos, 1959				
31	*Mytilina ventralis* (Ehrenberg, 1832)	0.09	0.27	0.46	24
	Notommatidae Remane 1933				
32	*Cephalodella gibba* (Ehrenberg, 1830)		0.20		12
	Trichocercidae Remane, 1933				
33	*Trichocerca bicristata* (Gosse, 1887)			0.09	4
34	*Trichocerca pusilla* (Jennings, 1903)		0.27		8
35	*Trichocerca rattus* O.F.Mueller 1776	0.18	2.96	3.89	32
	Trichotridae Bartos, 1959				

36	*Trichotria tetractis* (Ehrenberg, 1830)	0.18	0.13		16
	Order: Flosculariidae				
	Synchaetidae Remane, 1933				
37	*Hexarthra mira* (Hudson, 1871)		0.07		4
38	*Polyarthra indica* Segers and Babu, 1999	0.80	0.34	0.93	28
	Testudinellidae Bartos, 1959				
39	*Pompholyx complana* (Gosse, 1851)	1.07	0.67		44
40	*Testudinella parva* (Ternetz, 1892)	0.18	0.20	1.48	16
	Trochosphaeridae Bartos, 1959				
41	*Filinia longiseta* (Ehrenberg, 1834)	0.27	0.34	0.19	24
42	*Filinia opoliensis* (Zacharias, 1898)		0.27	0.28	12
	Subclass: Bdelloidea Hudson, 1884				
	Order: Philodonida Melone & Ricci, 1995				
	Philodinidae Remane, 1933				
43	*Rotaria neptunia* Ehrenberg, 1832	0.44			20
44	*Rotaria rotatoria* (Pallas, 1766)		0.27	0.28	20
	Phylum: Arthropoda				
	Subphylum: Crustacea				
	Class: Branchiopoda				
	Subclass: Cladocera	**32.59**	**21.31**	**17.41**	
	Order: Ctenopoda Sars, 1865				
	Sididae Baird 1850				
45	*Diaphanosoma excisum* G. O. Sars 1885	0.71	0.47	4.44	48
	Order: Anomopoda Sars, 1865				
	Daphniidae O. F. MULLER, 1785				
46	*Ceriodaphnia cornuta* Sars, 1885	9.06	1.68	1.76	52
47	*Daphnia lumholtzi* Sars, 1885	0.89			4
48	*Scapholeberis kingi* Sars, 1903	1.95	0.40	1.94	40
49	*Simocephalus (Echinocaudus) exspinosus (*De Geer, 1778)	3.82	0.34		40
	Macrothricidae Norman and Brady, 1867				
50	*Macrothrix spinosa* King, 1853	0.44	0.54		24
51	*Macrothrix triserialis* (Brady, 1886)	1.24	1.34	0.28	28
	Moinidae Goulden, 1968				
52	*Moina micrura* Kurz, 1874	0.36	0.07	0.93	28
53	*Moinadaphnia macleayi* (King, 1853**)**	0.18			4
	Bosminidae Baird, 1845				
54	*Bosmina longirostris* (O.F. Muller, 1776)	0.09	2.96	0.93	32
	Chydoridae Dybowski and Grochowski 1894				
55	*Camptocercus rectirostris* Schoedler, 1862	0.62			4
56	*Camptocercus uncinatus* Smirnov, 1971		0.20		12

57	*Chydorus sphaericus* (O. F. Muller, 1776)	2.04	2.08	3.89	56
58	*Chydorus sp.*		0.20		12
59	*Coronatella rectangula* (Sars, 1862)	1.15	1.28	0.65	52
60	*Dunhevedia crassa* King, 1853	0.89	0.13	0.74	32
61	*Flavalona cheni* (Sinev, 1999)	2.04	0.47	0.46	48
62	*Indialona ganapati* Petkovski, 1966		8.54	0.09	20
63	*Karualona karua* (King, 1853)	0.18		0.56	16
64	*Kurzia longirostris* (Daday,1898	0.44			4
65	*Leydigia (Neoleydigia) ciliata* Gauthier, 1939	0.09	0.07		8
66	*Oxyurella singalensis* (Daday, 1898)	0.80	0.07	0.46	28
67	*Pleuroxus aduncus* (Jurine, 1820)	0.71	0.20		12
68	*Pleuroxus denticulatus* Birge, 1879	0.98	0.07	0.09	24
69	*Pleuroxus laevis* Sars, 1862a	0.53		0.19	16
70	*Pleuroxus similis* Vavra, 1900	3.29	0.20		28
71	*Pseudochydorus globosus* (Baird, 1843)	0.09			4
	Class **Hexanauplia** Oakley, T.H., J.M. Wolfe, A.R. Lindgren & A.K. Zaharoff, 2013 Subclass **Copepoda** H. Milne Edwards, 1840	**29.03**	**14.39**	**27.76**	
72 73 74	Order **Cyclopoida** Burmeister, 1834 *Mesocyclops sp.* *Eucyclops sp.* *Thermocyclops sp.*	24.69	13.11	21.28	92
75 76 77 78	Order **Calanoida** G. O. Sars, 1903 *Heliodiaptomus viduus* (Gurney, 1907) *Neodiaptomus sp.* *Phyllodiaptomus blanci* (Guerne and Richard, 1896) *Sinodiaptomus indicus* (Sewell, 1934)	4.34	1.28	6.48	88

821 **Table 2** Composition of frequency of occurrence in River Godavari

Frequency	Zooplankton species
80-100%	*Brachionus calyciflorus, Cyclops, Calanoids*
60-80%	*Brachionus caudatus, Keratella tropica, Lecane bulla*
40-60%	*Asplanchna brightwellii, Brachionus angularis, Brachionus diversicornis, Brachionus falcatus, Brachionus forficula, Keratella cochlearis, Euchlanis dilatata, Pompholyx complanata, Diaphanosoma excisum, Ceriodaphnia cornuta, Chydorus sphaericus, Coronatella rectangula, Flavalona cheni.*
10-40%	*Anuraeopsis fissa, Brachionus bidentatus, Brachionus durgae, Brachionus quadridentatus quadridentatus, Brachionus rubens, Sinantherina socialis, Lecane closterocerca, Lecane leontina, Lecane luna, Lecane lunaris, Lecane papuana, Lepadella biloba, Lepadella triba, Mytilina ventralis, Cephalodella gibba, Trichocerca rattus, Trichotria tetractys, Polyarthra indica, Testudinella parva, Filinia longiseta, Filinia opoliensis, Rotaria Neptunia, Rotaria rotatoria, Scapholeberis kingi, Simocephalus (Echinocaudus) exspinosus, Macrothrix spinosa, Macrothrix triserialis, Moina micrura, Bosmina longirostris, Camptocercus uncinatus, Chydorus pubescens, Dunhevedia crassa, Indialona ganapati, Karualona karua, Oxyurella singalensis, Pleuroxus aduncus, Pleuroxus denticulatus, Pleuroxus laevis, Pleuroxus similis.*

0-10%	*Platyias quadricornis, Lecane crepida, Lecane ludwigi, Trichocerca bicristata, Trichocerca pusilla, Hexarthra mira, Daphnia lumholtzi, Moinadaphnia macleayai, Camptocercus rectirostris, Kurzia longirostris, Leydigia (Neoleydigia) ciliata, Pseudochydorus globosus.*

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845 **Table 3** Seasonal variance of physicochemical and Zooplankton diversity indices and of River
846 Godavari
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Parameters	**Winter**		**Summer**		**Monsoon**		**Godavari**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Atmospheric Temperature °C	27.47	3.97	31.17	3.64	28.26	4.24	29.0	1.9
Surface Temperature °C	25.50	2.53	30.00	2.23	26.54	3.28	27.3	2.4
pH	8.27	0.28	8.31	0.57	8.74	0.31	8.4	0.3
Electrical conductivity (mS/cm)	0.65	0.43	0.86	0.84	0.71	0.73	0.7	0.1
Total Dissolved Solid (mg/L)	353.7	227.8	431.8	425.4	351.5	367.4	379.0	45.7
Dissolved Oxygen (mg/L)	7.39	1.17	5.04	1.42	7.95	1.79	6.8	1.5
Total Hardness (mg/L)	208.6	96.5	232.3	162.1	261.8	266.1	234.3	26.6
Total Alkalinity (mg/L)	178.2	56.85	193.23	101.66	218.06	99.07	196.5	20.1

Calcium (mg/L)	77.50	0.00	57.06	72.85	140.28	85.82	91.6	43.4
Magnesium (mg/L)	15.69	20.80	42.57	33.71	30.88	46.81	29.7	13.5
Chloride (mg/L)	99.06	48.16	144.9	148.3	87.43	89.40	110.5	30.4
Nitrate (mg/L)	17.08	26.32	10.00	0.00	61.82	59.94	29.6	28.1
Nitrite (mg/L)	0.28	0.81	1.82	1.23	1.39	1.45	1.2	0.8
Phosphate (mg/l)	3.20	2.21	0.54	0.55	0.13	0.06	1.3	1.7
Ammonia (mg/L)	3.62	1.88	2.16	2.51	0.58	0.91	2.1	1.5
Diversity Indices								
Total Zooplankton (Ind./L)	56.30	50.33	78.26	80.56	59.83	60.43	64.80	11.79
Rotifer (Ind./L)	21.60	32.68	50.32	55.37	32.83	45.71	34.92	14.47
Cladocera (Ind./L)	20.39	29.33	16.68	40.73	27.00	27.17	21.36	5.23
Copepoda (Ind./L)	17.21	12.31	11.89	8.74	17.53	14.79	15.54	3.17
Diversity (H')	1.89	0.52	2.12	0.50	1.84	0.43	1.95	0.15
Evenness (J')	0.63	0.18	0.63	0.16	0.68	0.16	0.65	0.03
Species richness (No.)	13.00	7.00	14.00	5.00	11.00	5.00	12.67	1.53
Abundance (%)	28.60	22.08	38.02	23.47	24.61	16.58	30.41	6.88
Dominance (%)	40.30	13.20	33.30	16.01	36.05	13.70	36.55	3.53

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850 **Table 4** Sampling station wise physicochemical parameters and zooplankton diversity indices of River Godavari
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Parameters	Talegaon Kachurli		Gautami reservoir		Gangapur Dam		Darnasangvi		Nandurmadhyameshwar	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Atmospheric Temperature °C	21-30.5	25.19 ±3.27	26.55-33.26	28.4 ±2.67	22.73-30.3	26.7 ±3.5	23-32.83	28.05 ±3.72	23.04-29.7	26.99 ±2.63
Surface Temperature °C	22.1-29.8	24.02 ± 2.72	22.7-30.5	25.06 ± 3.14	22.73-27.2	24.48 ± 2.06	23.7-29.4	25.6 ± 2.28	20.8-26.94	24.4 ± 2.48
pH	6.96-8.66	8.03 ± 0.59	7.50-9.62	8.56 ± 0.74	7.92-9.16	8.45 ± 0.46	7.58-8.8	8.17 ± 0.54	7.88-8.26	8.09 ± 0.12
Electrical conductivity (/cm)	0.11-0.13	0.12 ± 0.01	0.15-0.2	0.17 ± 0.01	0.18-0.22	0.2 ± 0.01	0.27-0.82	0.51 ± 0.22	0.36-1.47	1.03 ± 0.39
Total Dissolved Solid (mg/L)	54.5-68	60.54 ± 4.53	84.33-97	88.9 ± 4.75	92.6-220	121.3 ± 55	128-405	249.9 ± 114.7	190-746	521.5 ± 195
Dissolved Oxygen (mg/L)	5.49-8.04	7.05 ± 0.85	6.43-9.95	7.81 ± 1.23	5.49-8.86	7.31 ± 1.5	3.62-7.35	5.68 ± 1.79	2.4-5.89	4.68 ± 1.2
Total Hardness (mg/L)	50-150	65 ± 38.68	75-175	112.5 ± 41.0	90-200	129 ± 43.06	120-225	172.33 ± 49.3	196-700	410.1 ± 172
Total Alkalinity (mg/L)	50-100	82.5 ± 17.44	75-120	100.2 ± 16.7	80-137.5	113.8 ± 21.5	75-358	199.6 ± 109	185-400	280.3 ± 94.1
Calcium (mg/L)	0-75	17.08 ± 24.84	26.66-75	46.33 ± 19.3	20-175	77.5 ± 68.8	46.66-266	125.8 ± 96.7	34-220	101.6 ± 72.75
Magnesium (mg/L)	6.07-19.4	12.45 ± 6.39	6.07-36.4	17.9 ± 10.9	6.07-20.65	12.45 ± 7.5	8.50-18.22	14.17 ± 4.68	39.3-142.7	76.44 ± 42.57
Chloride (mg/l)	34.3-50	38.95 ± 6	35-70.9	46.3 ± 14.22	34.3-50	38.02 ± 6.7	34.34-584	237.2 ± 160.3	60.1-272.6	170.4 ± 83.9
Nitrate (mg/L)	0-0	0 ± 0	15-15	15 ± 0	10-10	10 ± 0	10-150	72.85 ± 68.3	10-27.5	18 ± 6.47
Nitrite (mg/L)	0-0.13	0.05 ± 0	0.13-0.13	0.13 ± 0	0.01-0.68	0.345 ± 0.47	2.64-3.46	3.05 ± 0.57	0.05-3.43	1.36 ± 1.25
Phosphate (mg/l)	0-0.30	0.1 ± 0.11	0.01-0.61	0.28 ± 0.24	0.15-1.83	0.79 ± 0.76	0.15-1.63	0.95 ± 0.73	0.16-5	1.98 ± 1.51
Ammonia (mg/L)	0.61-0.61	0.61 ± 0	0.036-2.44	1.24 ± 1.07	1.22-2.44	1.83 ± 0.86	2.44-6.1	3.99 ± 1.85	0.06-2.196	1.013 ± 1
Total Zooplankton (Ind./L)	24-321	124±170	13-16	15±2.12	34-53	42±9.71	30-180	85±82.61	24-125	58±58.02
Rotifer (Ind./L)	7-122	47±65	3-9	6±4.24	14-20	17±3.05	11-149	67±72.4	3-37	18±17.24
Cladocera (Ind./L)	7-183	67±100	4-4	4±0	4.0-26.0	18±11.93	3-15	9±6.027	5-71	33±34.26
Copepod (Ind./L)	8.0-16.0	13±4	4-9	7±3.53	10-14	12±2.08	3-16	10±6.55	4-17	11±6.55
Diversity (H')	1.49-2.24	1.87±0.37	1.20-1.47	1.34±0.18	2.47-2.7	2.56±0.13	1.42-2.44	2.01±0.52	1.67-2.78	2.37±0.61
Evenness (J')	0.49-0.74	0.61±0.12	0.72-0.83	0.78±0.07	0.65-0.75	0.71±0.04	0.34-0.76	0.59±0.21	0.58-0.83	0.70±0.13
Species richness (No.)	6.0-19.0	12±6.55	4-6	5±1.41	17-20	18±1.52	12.0-15.0	13±1.52	8-28	18±10
Abundance (%)	12.40-36.4	23.66±12.0	8.20-12.0	10.14±2.74	51.05-72	58.80±12.1	11.33-48.8	30.71±18.8	16.1-80.6	54.52±33.9
Dominance (%)	30.53-46.4	40.93±9.01	46.15-50.0	48.07±2.72	22.5-29.4	26.11±3.46	26.6-59.4	39.07±17.7	16.6-48.0	30.09±16.1

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853 **Table 4** continue….

Parameters	Kolpewadi		Sanvatsar		Nath Sagar wetland		Shahgadh		Dhalegaon	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Atmospheric Temperature °C	20.4-34.66	26.31 ±5.05	22.5-34.8	27.83 ±5.35	24.8-32.38	27.89 ±3.01	23.75-30.9	28.33 ±3.97	26.1-38.5	33.43 ±6.5
Surface Temperature °C	20.86-26.66	23.95 ± 2.55	24.65-31.45	27.46 ± 2.9	22.25-30.2	26.08 ± 2.72	22.65-27.45	25.36 ± 2.46	24.6-33	29.05 ± 4.22
pH	7.88-8.46	8.11 ± 0.22	8.065-9.8	8.8 ± 0.78	8.40-9.11	8.76 ± 0.23	8.33-8.42	8.38 ± 0.047	8.82-8.91	8.85 ± 0.046
Electrical conductivity (/cm)	0.38-2.12	1.36 ± 0.57	0.48-3.63	2.13 ± 1.33	0.59-1.02	0.81 ± 0.15	1.02-3.32	2.32 ± 1.18	0.7-1.21	0.95 ± 0.25
Total Dissolved Solid (mg/L)	190-1079	682.1 ± 291.95	244.5-1840	1081 ± 678	297-519.8	409.5 ± 76.47	628-1662	1209.16 ± 528	353-610	479.6 ± 128.5
Dissolved Oxygen (mg/L)	3.42-6.11	4.53 ± 1.17	2.02-12.08	7.65 ± 4.92	3.27-8.92	6.22 ± 1.86	4.02-7.055	5.9 ± 1.64	5.03-9.04	6.56 ± 2.16
Total Hardness (mg/L)	200-800	421.11 ± 214.3	150-850	515 ± 305.34	225-375	274.16 ± 56.58	330-1225	690 ± 472.46	180-450	290 ± 141.77
Total Alkalinity (mg/L)	200-600	334.4 ± 156.35	137.5-360	234.3 ± 93.77	157.5-362	221.87 ± 81.85	210-450	300.8 ± 130.2	135-200	156.6 ± 37.52
Calcium (mg/L)	30-250	105 ± 84.85	50-75	61.66 ± 12.5	45-187.5	113.75 ± 53.88	160-375	267.5 ± 152.02	30-200	115 ± 120.2
Magnesium (mg/L)	30.4-170.1	78.81 ± 54.26	18.23-191.7	119.38 ± 90.2	24.3-50.11	40.27 ± 9.98	0.06-206.5	105.72 ± 103.3	0.065-60.7	37.28 ± 32.5
Chloride (mg/l)	68.68-413	238.7 ± 142.7	42.25-290	155.83 ± 126.	88.66-150.3	114.66 ± 22.67	100-390	263.33 ± 148.43	100-141.8	121.93 ± 20.97
Nitrate (mg/L)	10-25	17.5 ± 8.66	10-25	17.5 ± 10.6	10-10	10 ± 0	10-10	10 ± 0	0-15.0	15.0 ± 0
Nitrite (mg/L)	0.05-0.28	0.16 ± 0.098	0.343-0.343	0.343 ± 0	0.05-0.445	0.247 ± 0.19	0.5-3.43	1.73 ± 1.517	3.18-3.43	3.305 ± 0.176
Phosphate (mg/l)	0.03-1.53	0.732 ± 0.69	0.153-0.2	1.76 ± 0.033	0.11-1.83	0.7 ± 0.64	0.1-0.3	0.2 ± 0.141	0.1-0.4	0.25 ± 0.21
Ammonia (mg/L)	0.061-2.03	1.03 ± 0.92	1.12-1.56	1.34 ± 0.311	0.061-0.61	0.282 ± 0.25	0.06-0.24	0.15 ± 0.12	1.11-1.11	1.11 ± 0
Total Zooplankton (Ind./L)	10-223	109±107.2	30-105	68±53.03	83-230	142±76	18-98	47±44.3	21-39	30±9
Rotifer (Ind./L)	3-182	66±100.5	4-26	15±15.55	17-195	90±93.04	4-73	29±38.22	7-11	9±2
Cladocera (Ind./L)	3-32	14±15.71	7-79	43±50.91	13-85	44±36.89	6-12	9±3.05	1-3	2±1
Copepod (Ind./L)	4-49	30±23.45	19-44	32±17.67	11-31	21±10	3-15	10±6.42	11-27	19±8
Diversity (H')	1.27-2.06	1.72±0.4	1.76-2.10	1.93±0.24	1.85-2.93	2.50±0.56	1.48-2.47	1.89±0.52	1.21-1.81	1.51±0.29
Evenness (J')	0.32-0.89	0.53±0.31	0.51-0.58	0.55±0.05	0.37-0.69	0.52±0.16	0.36-0.91	0.66±0.27	0.42-0.68	0.55±0.13
Species richness (No.)	7-22	13±7.76	10.0-16.0	13±4.24	17-30	25±6.8	8.0-13.0	11±2.64	8-9	9±0.5
Abundance (%)	9.11-28.21	19.23±9.59	18.35-29.99	24.17±8.23	20.94-99.10	63.63±39.57	12.30-51.36	26.80±21.38	8.33-19.75	14.04±5.71
Dominance (%)	30.00-54.26	44.0±12	33.33-46.67	40±9.4	13.25-40.87	26.71±13.82	16.67-58.16	38.27±20.7	42.86-64.10	53.48±10.62

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855 **Table 4** continue….

Parameters	Gangakhed		Nanded		Dharmabad		Sriramsagar		Yellampally Dam	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Atmospheric Temperature °C	22.5-35.5	26.77 ±5.7	20.5-34	28.09 ±4.9	25-36.5	29.2 ±4.1	31-38.8	35.94 ±3.0	23.4-31.3	27.89 ±2.8
Surface Temperature °C	23.45-32.6	28.3 ± 3.5	22.5-32.6	27.67 ± 4.1	24.7-29.6	27.6 ± 1.95	27.4-31.9	30.04 ± 1.89	25.56-30.9	28.73 ± 2.1
pH	8.41-9.19	8.7 ± 0.306	8.28-8.85	8.61 ± 0.23	8.41-9.02	8.7 ± 0.24	7.97-9	8.59 ± 0.35	8.43-8.96	8.72 ± 0.24
Electrical conductivity (/cm)	0.66-1.08	0.87 ± 0.19	0.535-1.08	0.76 ± 0.23	0.5-0.77	0.7 ± 0.10	0.37-0.6	0.49 ± 0.08	0.39-0.60	0.5 ± 0.08
Total Dissolved Solid (mg/L)	329-636.5	496.1 ± 122.5	268-557	385.1 ± 122	260-379	328.5 ± 42.0	197-347	270.7 ± 51.3	201-305.6	253.7 ± 42.2
Dissolved Oxygen (mg/L)	5-8.245	6.47 ± 1.17	1-9.26	6.68 ± 3.344	3.84-10.5	6.9 ± 2.43	3.84-8.06	6.79 ± 1.69	3.4-9.64	6.65 ± 2.3
Total Hardness (mg/L)	175-450	308 ± 106.8	150-325	247.5 ± 65.8	170-300	261.7 ± 53.5	125-275	187.7 ± 51.0	135-250	176.38 ± 48.6
Total Alkalinity (mg/L)	180-375	262 ± 70.4	172.5-255	228 ± 33.13	182.5-275	219.6 ± 31.5	126.66-225	181.11 ± 34.16	166.6-200	181.66 ± 13.58
Calcium (mg/L)	40-250	147.5 ± 95	40-200	113.75 ± 67.25	40-175	99 ± 60.45	36.66-225	88.33 ± 80.8	30-225	90.66 ± 81.0
Magnesium (mg/L)	18.2-59.5	42.22 ± 17.47	14.58-59.5	33.71 ± 18.7	18.225-63.1	44 ± 18.8	6.075-38.8	25.75 ± 15.5	6.07-42.5	22.84 ± 14.2
Chloride (mg/l)	70.92-177	118 ± 46.2	76-156.5	112.43 ± 34.65	70.9-106.3	93.4 ± 13.57	53.19-100	75.6 ± 16.38	35.46-100	69.91 ± 23.4
Nitrate (mg/L)	10-10	10 ± 0	15-72.5	39.37 ± 25.36	10-45	18.8 ± 17.5	10-45	26.66 ± 17.55	10-10	10 ± 0
Nitrite (mg/L)	0.05-0.16	0.115 ± 0.058	0.274-1.71	0.99 ± 0.71	0.05-0.71	0.3 ± 0.27	0.205-0.71	0.405 ± 0.26	0.034-0.2	0.108 ± 0.07
Phosphate (mg/l)	0.05-0.75	0.506 ± 0.31	0.105-0.75	0.44 ± 0.29	0.2-0.61	0.4 ± 0.21	0.030-0.30	0.15 ± 0.12	0.1-0.30	0.225 ± 0.08
Ammonia (mg/L)	0.06-0.061	0.06 ± 0.0	0.061-2.44	1.3 ± 0.85	0.061-1.2	0.8 ± 0.55	0.06-0.12	0.07 ± 0.03	0.61-3.27	1.94 ± 1.88
Total Zooplankton (Ind./L)	23-39	32±8.08	20-104	62±59.39	30-85	63±28.91	24-59	40±17.78	33-166	117±73.08
Rotifer (Ind./L)	4-8	6±2.08	15-39	27±16.97	22-65	44±21.54	5-34	21±14.84	11-151	77±70.28
Cladocera (Ind./L)	3-19	12±8.32	60-70	65±5	3-20	10±9.07	2-19	12±9.07	1-96	36±52.4
Copepod (Ind./L)	15-23	18±4.35	5-26	16±14.84	5-21	15±8.5	9-15	11±3.46	12-55	34±30.4
Diversity (H')	1.16-2.40	1.67±0.65	1.52-2.31	1.92±0.55	1.74-2.41	2.10±0.33	1.23-2.58	2.03±0.7	1.90-2.22	2.06±0.15
Evenness (J')	0.411-0.61	0.52±0.09	0.62-0.76	0.70±0.09	0.62-0.83	0.73±0.1	0.57-0.82	0.68±0.13	0.41-0.65	0.58±0.13
Species richness (No.)	6-18	11±6.11	6-16	11±7.07	8-18	12±5.29	6-16	12±5	12.0-16.0	14±2
Abundance (%)	7.75-46.2	21.82±21.2	13.06-40.4	26.74±19.3	17.85-47.0	31.98±14.6	8.54-59.8	35.71±25.7	22.41-35.5	28.63±6.5
Dominance (%)	33.33-65.2	54.06±17.9	21.15-40.0	30.57±13.3	16.67-26.0	23.64±6.1	19.44-62.5	23.64±6.14	23.68-33.7	29.23±5.1

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857 **Table 4** continue…..

Parameters	Kaleshwaram		Eturnagaram		Bhadrachalam		Konavaram		Rajamahendravaram	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Atmospheric Temperature °C	24.5-34.6	30.98 ±4.36	24.5-33.2	28.79 ±3.6	25.6-35.8	30.33 ±3.83	29.85-31.53	30.69 ±1.18	27.37-32.8	30.23 ±2.19
Surface Temperature °C	24-32.7	29.66 ± 3.19	28-32.7	30.4 ± 1.72	26.25-32.7	29.57 ± 2.35	29.175-30.15	29.66 ± 0.68	26-31.3	28.92 ± 2.2
pH	8.3-9.1	8.65 ± 0.27	8.35-9.1	8.65 ± 0.29	8.21-8.88	8.54 ± 0.22	8.41-9.14	8.77 ± 0.51	7.57-8.75	8.26 ± 0.46
Electrical conductivity (/cm)	0.38-0.55	0.45 ± 0.06	0.3-0.54	0.41 ± 0.10	0.3-0.56	0.38 ± 0.09	0.13-0.26	0.19 ± 0.09	0.175-0.54	0.31 ± 0.14
Total Dissolved Solid (mg/L)	190-276	229.3 ± 33.77	147-252	189.5 ± 46.81	153-275.5	194 ± 46.67	67-135.5	101.2 ± 48.43	84-273.75	160.2 ± 73.7
Dissolved Oxygen (mg/L)	3.84-9.66	7.21 ± 2.21	4.03-7.85	6.17 ± 1.68	5-7.84	6.56 ± 1.17	6.03-7.24	6.63 ± 0.85	5.5-8.3	6.87 ± 1
Total Hardness (mg/L)	120-350	203.33 ± 89.53	120-250	156.66 ± 50.56	120-250	165.83 ± 50.0	90-112.5	101.25 ± 15.9	90-212.5	154.2± 55.1
Total Alkalinity (mg/L)	123.33-225	181.38 ± 38.79	135-225	171.38 ± 35.42	120-200	159.58 ± 26.9	90-120	105 ± 21.21	62.5-250	166.5 ± 70.8
Calcium (mg/L)	23.33-125	70.66 ± 43.94	30-100	62.66 ± 34.43	20-75	49 ± 25.34	40-40	40 ± 0	20-150	61 ± 54.1
Magnesium (mg/L)	12.15-66.82	34.83 ± 20.42	6.08-36.45	24.62 ± 12.32	12.15-42.52	30.61 ± 11.57	1.5-12.15	6.82 ± 7.53	15.18-27.3	19.92 ± 4.63
Chloride (mg/l)	35.46-100	54.83 ± 24.9	35.46-100	57.98 ± 24.4	35.46-100	62.47 ± 24.5	35-100	67.5 ± 45.9	32.8-100	48.8 ± 26.1
Nitrate (mg/L)	0-0	0 ± 0	10-10	10 ± 0	10-10	10 ± 0	0-0	0 ± 0	5-27.5	14.16 ± 11.8
Nitrite (mg/L)	0.06-0.2	0.13 ± 0.07	0.06-0.27	0.17 ± 0.10	0.034-0.11	0.069 ± 0.04	0-0	0 ± 0	0.03-0.18	0.08 ± 0.08
Phosphate (mg/l)	0.03-0.61	0.25 ± 0.22	0.03-0.2	0.08 ± 0.07	0.03-0.05	0.04 ± 0.01	0-0	0 ± 0	0.03-0.15	0.101 ± 0.05
Ammonia (mg/L)	0.61-2.44	1.22 ± 1.05	0.06-0.06	0.06 ± 0.0	0.061-0.33	0.17 ± 0.14	0-0	0 ± 0	0.12-0.33	0.23 ± 0.15
Total Zooplankton (Ind./L)	9-151	61±78.25	6-24	15±12.72	6-58	32±36.76	17-38	28±14.84	13-56	35±21.54
Rotifer (Ind./L)	4-133	48±73.35	1-19	10±12.72	6-48	27±29.69	8-14	11±4.24	10-43	22±18.5
Cladocera (Ind./L)	3-5	4±1	2-3	3±0.7	3-3	3±0	4-12	8±5.65	0-23	8±13
Copepod (Ind./L)	5-14	10±4.72	2-3	3±0.7	7-7	7±0	5-12	9±4.94	4-13	9±6.36
Diversity (H')	1.42-2.02	1.71±0.29	1.01-2.63	1.82±1.14	1.33-1.56	1.45±0.16	2.181-2.52	2.35±0.24	1.33-2.16	1.83±0.43
Evenness (J')	0.60-0.83	0.69±0.12	0.87-0.91	0.89±0.03	0.43-0.94	0.69±0.35	0.73-0.88	0.81±0.1	0.47-0.91	0.66±0.23
Species richness (No.)	5-12	9±3.51	3-16	10±9.19	4-11	8±4.94	10-17	14±4.94	8.0-15.0	10±4.04
Abundance (%)	11.30-26.6	18.12±7.77	6.20-64.7	35.46±41.4	9.82-13.87	11.85±2.86	33.54-55.2	44.39±15.3	9.91-32.62	22.69±11.62
Dominance (%)	31.79-47.83	41.35±8.45	16.67-50.00	33.33±23.56	33.33-56.90	45.11±16.6	18.42-23.53	20.98±3.61	23.08-57.14	40.25±17.03

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