



Exploring Intricate Interplay between Water Quality Dynamics and Zooplankton Diversity in Chikkere Water Body, Karnataka, India

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Abstract: The study investigates the zooplankton diversity and water quality of Chikkere Waterbody in Sira town, located at 13°75'25" N latitude and 76°90'70" E longitude, covering an area of 10.54 hectares. Water samples were collected from February 2020 to January 2022 across four strategically selected stations. Physico-chemical analysis of the water indicated that all parameters fell within permissible limits, though the pH was slightly alkaline. Zooplankton diversity included groups such as protozoa, rotifers, cladocerans, and copepods, with rotifers being the most dominant, comprising 47.82% of the total zooplankton population, followed by cladocerans (26.1%) and copepods (17.39%). The diversity of fish species was notable, with 23 species belonging to five genera and five families, and the highest species dominance recorded during the summer season. The Shannon diversity index ranged from 2.918 to 3.098, peaking at 3.081 during the northeast monsoon season. The findings stress the importance of long-term conservation strategies to ensure the preservation and ecological health of Chikkere waterbody.

Keywords: Physico-chemical, Water quality, Zooplankton, Diversity, Chikkere water body

Freshwater ecosystems have a vital role in providing essential resources and services to human beings. These include the provision of drinking and irrigation water, food, as well as the creation and regulation of micro-climate (Vörösmarty et al., 2010, Green et al., 2015). However, it is alarming to note that freshwater ecosystems, such as rivers and inland lakes, are facing significant threats (Vörösmarty et al., 2010, Alahuhta et al., 2019). The rate of biodiversity loss in freshwater ecosystems surpasses that of terrestrial ecosystems (Geist 2011) and loss of biodiversity shows no signs of slowing down in recent years (Butchart et al., 2010). The severity of biodiversity loss in freshwater ecosystems may be much greater than particularly when comes to the response of hidden microscopic taxa like zooplankton to disturbances (Cazolla 2016).

Zooplankton have been recognized as organisms of ecological importance (Smitha et al., Jose et al., 2015), making them a vital and paramount role in the maintenance of ecosystems. Murulidhar and Yogananda Murthy (2014) utilized the Lange-Bertteart method to study the distribution and ecology of diatom communities in Tumkur's lakes, identifying a total of 46 species. Murulidhar and Yogananda Murthy (2015) investigated the seasonal variations in hydrography and phytoplankton diversity in the Teeta wetland of Tumkur district, discovering 66 species of phytoplankton across different groups. Shalini et al. (2018) focused on the limnological profile of the Gottla Gollahalli wetland in Tumkur district, reporting 45 species of phytoplankton. The water body is

located near the city of Sira; nevertheless, remains unusable due to various pollutants. However, no reports were published on the Chikkere water body with regard to water quality and zooplankton studies. Consequently, the current study aims to explore the abundance and seasonal diversity of zooplankton specifically in the Chikkere water body.

MATERIAL AND METHODS

Sira, a taluk headquarter, is situated approximately 50 kilometers away from Tumkur, a district headquarter. It is located along National Highway No. 4. The coordinates of water body fall under 13° 75' 25" N latitude and 76° 09' 70" E longitude at about 662 meters above mean sea level (MSL). Every month water samples collected for the period from February 2020 to January 2022. The physical parameters, including air and water temperature, as well as pH, were recorded on-site during the collection of samples. Enumeration of phytoplankton and zooplankton were done with separately collected as per APHA (2005).

Modified Haron-Trantor net with a square metallic frame measuring 0.0625 m² was used for collecting zooplankton samples. The filtering cone consisted of a nylon bolting silk plankton net (No. 25 mesh size 50 μ) for zooplankton collection. With the help of Needham and Needham (1962), Tonopi (1980) and Battish (1992) identification process was done and same was confirmed by Zoological Survey of India.

Statistical analysis: The data was analyzed using the Past software 4.0.

RESULTS AND DISCUSSION

The highest temperatures were 25.1°C and 25.3°C in May 2020 and 2021, respectively, while the lowest was 22.1°C in October 2021. Turbidity was maximum of in May 2021 (90 NTU) and minimum in October 2021 (14 NTU). Total dissolved solids were maximum in April 2020, with the lowest of 406 mg/L in December 2021. Electrical conductivity values ranged from 616 µS/cm in November 2021 to 2290 µS/cm in April 2020.

pH values ranged from 7.2 (January 2022) to 9.3 (September 2021). Dissolved oxygen (DO) concentrations varied between 1.8 mg/L in March 2021 and 6.5 mg/L in December 2021. Total alkalinity ranged from 181 mg/L in December 2021 to 512 mg/L in May 2021. Total hardness fluctuated from 154 mg/L in December 2021 to 420 mg/L.

Calcium hardness was maximum of in May 2020 (262 mg/L) and minimum in December 2021*154 mg/L), while magnesium hardness varied from 162 mg/L in April 2020 to 92 mg/L in December 2021. Chloride concentrations ranged from 65 mg/L in December 2021 to 310 mg/L in February 2020. Biochemical oxygen demand (BOD) ranged from 3 mg/L in November 2021 to 38 mg/L in February 2020. Nitrate (NO₃⁻) concentrations varied from 2.9 mg/L in November 2020 to 21.7 mg/L in September 2021. Sulfate (SO₄²⁻) concentrations peaked at 145 mg/L in January 2021 and dropped to a minimum of 45 mg/L in October 2020. Phosphate levels ranged between 0.1 mg/L in July 2021 and 0.7 mg/L in December 2021.

All physicochemical parameters were within the permissible limits. However, during the summer and southwest monsoon (SWM) seasons, electrical conductivity, turbidity, total dissolved solids, and chloride levels exceeded BIS limits, while dissolved oxygen was lower than the recommended 5 mg/L. Overall, the water samples fall within the BIS standards, corroborated by the findings of Meride and Ayenew (2016). Among the four groups of zooplankton, rotifers were the most dominant, representing 41%, followed by Cladocera, protozoa (Fig. 1). The highest 2167 individuals/liter of zooplankton was in December 2020, and 1922 ind/liter in December 2021. Conversely, the lowest of 555 ind/liter were in June 2020 and 653 ind/liter in June 2021. The highest number of protozoa, *Centropyxis spinosa*, was 661 ind/liter (Fig. 2).

Rotifer was identified as the predominant group within the zooplankton community. Rotifers with maximum density 6312 ind./liter are considered the most considerable. The peak seasonal diversity was observed during the northeast monsoon (NEM) (15201 ind/liter), followed by summer (8939 individuals per liter) and southwest monsoon (7169 individuals/liter) seasons, respectively (Fig. 3). The

dominancy and composition of 41 % of rotifers indicate the eutrophication (Jagadeeshawara et al., 2015, Sulata and Devashish 2016). Turbulent and excess flow of water in the rainy period leads to environmental stress, resulting in low density of rotifers (Edward and Ugwumba 2010). Similar findings were also reported by Anita et al. (2019). *Brachionus calyciflorus*, a pollutant-tolerant species and an indicator of

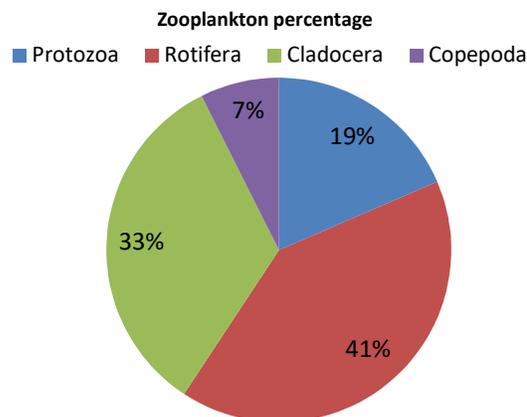


Fig. 1. Percentage of Zooplankton groups

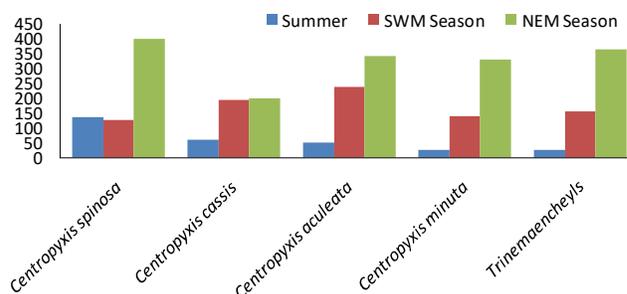


Fig. 2. Seasonal variation of protozoa of Chikkere water body (Number of individuals/lit)

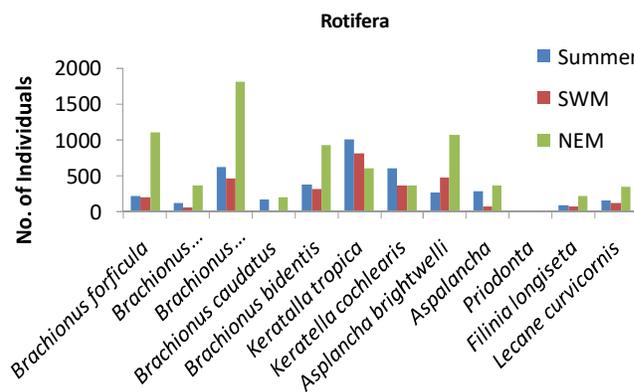


Fig. 3. Seasonal variation of Rotifera of Chikkere water body (Number of individuals/lit)

organic pollution (Pandey et al., 2014, Fatibi et al., 2017), emerged as the dominant species during the NEM and in the annual average, with counts of 1,810 and 2,888 individuals per liter, respectively. Species from the Brachionidae family, along with *Keratella tropica*, *Filinia longiseta*, *Filinia caudata*, and *Filinia diversicornis*, are recognized indicators of eutrophication (Pal et al., 2015, Somani et al., 2012, Bera 2021) and were dominant during the summer and NEM seasons.

The zooplankton community structure displays a mixture of mesotrophic to eutrophic species, with *Brachionus* species commonly found in eutrophic environments, as documented by various studies (Baloch et al., 2004). The presence of *Keratella cochlearis*, an indicator species for eutrophication, suggests a transition from mesotrophic to eutrophic conditions. Paulose and Maheshwar (2008), as well as Ezhili et al. (2013), observed a higher abundance of rotifers in correlation with elevated water temperatures, nutrient levels, and pH. Rotifers exhibit adaptability by rapidly appearing and disappearing in response to environmental conditions

The higher number of cladocerans were in the northeast monsoon season due to congenial conditions and sufficient food. The dominant species among Cladocera were *Daphnia pulex* (3178 individuals) followed by *Daphnia carinata*, *Diaphanosoma excism*, and *Macrothrix goelidii* (Fig. 4). *Daphnia* species are indicators of organic pollution (Vijayapriya et al. 2019, Shashikanth 2013). The dominance of *D. pulex* and the low relative abundance of other *Daphnia* species in ponds with fish presence imply ineffective fish predation. This leads to the dominance of large cladocerans, possibly due to the competitive superiority of larger species. Rotifers are the predominant species within the zooplankton community (Ezhili et al., 2013, Sivakami et al., 2014, Basawarajeshwari Indur et al., 2015), due to their feeding, parthenogenetic reproduction, and fecundity rates (Sampio et al., 2002). Water temperature, ranging from 20.2°C to 23.1°C, regulated the density and diversity of the dominant zooplankton population in the freshwater, moderate warming can enhance the growth and feeding rates of certain filter-feeding zooplankton species, such as some *Daphnia sp.*. Warmer temperatures can also favor smaller zooplankton during their developmental stages. Water temperature, DO, and r magnesium hardness are seasonally the most influential parameters (Vikaskumar et al., 2024).

Presence copepods are the signs of availability of diatoms and blue-green algae, as they are the food sources for all the developmental stages of cyclopoid copepods (Pandit et al., 2020). Even feeds on rotifers and cladocera (Mathur et al., 2008). The northeast monsoon season exhibited the highest density of copepoda, with *Mesocyclops*

leukarti species reaching its peak at 1668 ind/l because of abiotic conditions and abundant food availability (Fig. 5). The lower copepod population indicates a food-rich environment, favoring Cladocera. Majagi and Vijaykumar (2009) observed lower abundance of copepods in monsoon season.

Highest zooplankton were in summer and lowest in the northeast monsoon season (Fig. 6), indicating the significant role of temperature in their distribution). The correlation between zooplankton groups and different physico-chemical parameters showed both positive and negative relationships

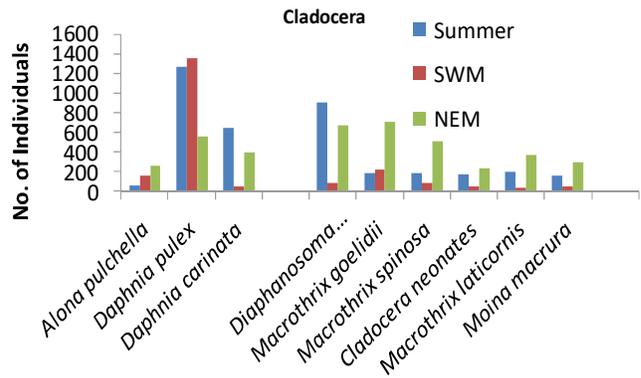


Fig. 4. Seasonal variation of Cladocera of Chikkere water body (Number of individuals/lit)

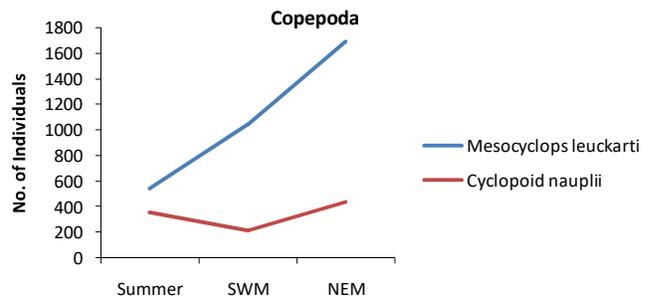


Fig. 5. Seasonal variation of Copepoda of Chikkere water body (Number of individuals/lit)

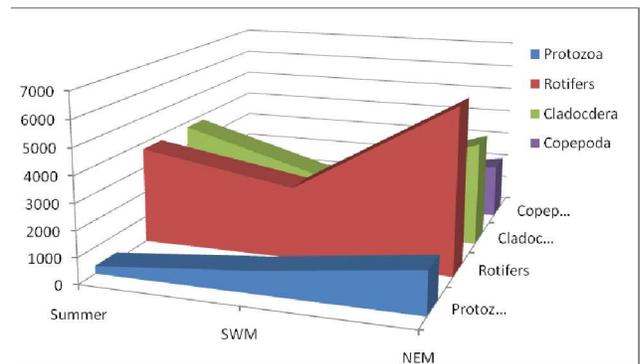


Fig. 6. Seasonal variation of Zooplankton groups (Number of individuals/lit)

Table 1. Diversity indices of zooplankton in different seasons

Diversity indices	NEM	Summer	SWM
Taxa_S	27	27	27
Individuals	8939	7169	15201
Dominance_D	0.07071	0.08958	0.05697
Simpson_1-D	0.9293	0.9104	0.943
Shannon_H	2.903	2.778	3.081
Evenness_e^H/S	0.675	0.5956	0.8064
Brillouin	2.893	2.765	3.074
Menhinick	0.2856	0.3189	0.219
Margalef	2.858	2.929	2.7
Equitability_J	0.8807	0.8428	0.9347
Fisher_alpha	3.433	3.547	3.188
Berger-Parker	0.1413	0.189	0.1191
Chao-1	27	27	27

(Fig. 7). Dominance was high during the summer season (0.0895) and low in the southwest monsoon season (0.056) Similarly, the highest is 0.062471 in the protozoa group and the lowest is 0.04843 in the cladocera. With regard to dominance index, the aquatic environment is classified as very good when $H > 4$, good when 4-3, moderate when 3-2, and poor when < 1 . The Shannon index ranged from 2.918 to 3.098 in the Chikkere water body, and the maximum dicates the stability of the water body. The northeast monsoon season recorded a Shannon index of 3.081, while the summer and southwest monsoon seasons recorded 2.778 and 2.903, respectively (Tables 1, 2 Fig 7). Among these groups, cladocera exhibited the highest (3.098) diversity index, while protozoa had the lowest (2.918) Highest was in the southwest monsoon season (3.081) and lowest in the summer (2.77). The population of zooplankton showed an

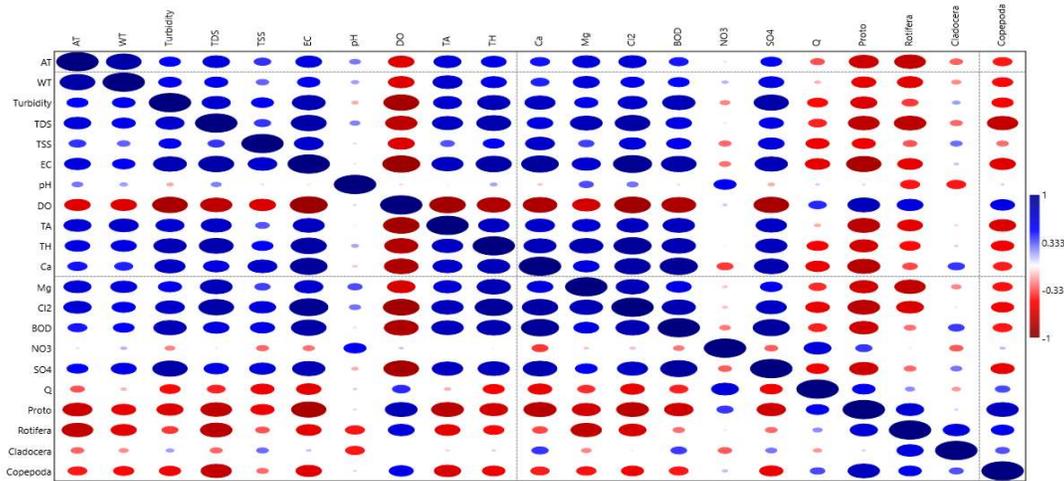


Fig. 7. Correlation between the physicochemical parameters and zooplankton groups

Table 2. Diversity indices among the different groups of Zooplankton

Indices	Protozoa	Rotifera	Cladocera	Copepoda
Taxa_S	24	24	24	24
Individuals	2780	14367	9902	4260
Dominance_D	0.06271	0.04988	0.04843	0.05722
Simpson_1-D	0.9373	0.9501	0.9516	0.9428
Shannon_H	2.918	3.079	3.098	2.979
Evenness_e^H/S	0.7712	0.9058	0.9233	0.8192
Brillouin	2.893	3.073	3.089	2.961
Menhinick	0.4552	0.2002	0.2412	0.3677
Margalef	2.9	2.403	2.5	2.752
Equitability_J	0.9182	0.9689	0.9749	0.9372
Fisher_alpha	3.61	2.81	2.957	3.358
Berger-Parker	0.1004	0.0774	0.07352	0.09272

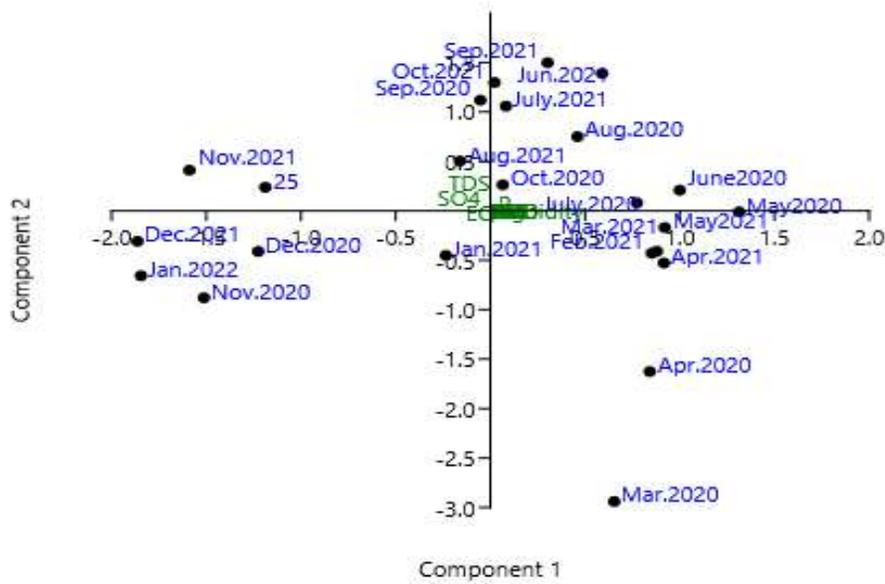


Fig. 8. PCA analysis

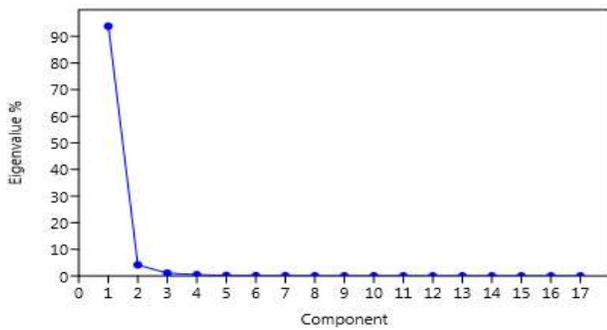


Fig. 9. Scree plot of the eigen values

components (PCs), their eigenvalues, and the percentage of variance attributed to each PC 9 (Fig. 8). The scree plot illustrates the eigenvalues for each component, with 14 PCs having eigenvalues greater than 1, collectively accounting for 72% of the total variance in the dataset (Fig. 9). The change in slope is observed in the scree plot between the first and second eigenvalues. PC1 accounts for 93.9% of the variation in water quality in Chikkere, while PC2 explains 4.1%. PC3 contributes 1.4%, with the remaining PCs each contributing less than 1%.

upward trend during the northeast monsoon season due to favorable environmental conditions such as temperature, dissolved oxygen levels, and the availability of nutrient-rich sources like bacteria, nano-plankton, and suspended detritus. Salve and Hiware (2010) reported a higher number of zooplankton during the winter season due to favorable environmental factors. The evenness during the southwest monsoon was 0.804, indicating a moderate level of evenness. The higher value, 0.9233 was a cladocera and a lower 0.7712, in the protozoa group.

PCA has proven to be a valuable tool in explaining the variance of interrelated variables using a smaller set of independent variables. This analysis helps in accurately assessing the water quality. Although many parameters fall within permissible limits, by and large, the water quality of the Chikkere waterbody indicates that it is unsuitable for drinking or domestic purposes. Further studies are needed continuously to monitor this waterbody. The principal

CONCLUSIONS

The water quality was not detrimental to the survival of zooplankton rather significantly contributed to the enhancement of productivity. The concentrations of all the physicochemical parameters were within acceptable limits. The Chikkere water body indicated the presence of zooplankton groups of protozoa, rotifera, cladocera, and copepoda. Zooplankton abundance and diversity play an important role in the freshwater ecosystem. The plankton density in the water body influenced the stocking rate of commercially important fishes and contributed to the growth of the inland fishery sector.

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