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ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES WITH ZOOPLANKTON OF MAREHALLI LAKE, MANDYA, KARNATAKA, INDIA

M. P. DHARMA GURU PRASAD [a] AND SHIVABASAVAIAH [a*]

[a] Department of Studies in Zoology, University of Mysore, Karnataka, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Human activities have made a big impact on Marehalli Lake, Karnataka, India. This study was carried out during August 2018 to July 2020 to cover all seasons in rendemly selected 04 sampling plots. The study examined the level of pollutions by observing the zooplanktons in quantitative method which includes diversity, distribution and physico-chemical factors for consecutive 24 months.

Sample analysis elucidated the existence of zooplankton species including Rotifers, Cladocera, Copepods, and Ostracods. Rotifera dominated the average for the entire group. The summer season had the largest diversity of rotifers, cladocera, copepods, and ostracods, while the winter season had the lowest. The summer season also had the highest density. It's worth noting that the Marehalli lake is slowly transitioning into a mesotrophic environment.

Keywords: Marehalli lake; physico-chemical parameter; seasonal variation; zooplankton.

1. INTRODUCTION

"Zooplankton biodiversity is one of the most important biological markers of the aquatic environment" [1,2,3]. "Zooplankton biodiversity is vital for maintaining the health of our environment since each species plays a unique role in recycling nutrients and food for other species in the ecosystem, and certain species can help the natural ecosystem work properly" [1,4,5,6]. "Zooplankton is an essential component of freshwater lake ecosystems because it occupies the centre of the aquatic food web at some time throughout its life cycle and provides food for practically all freshwater fish species" [1,7,8,9,10]. "Furthermore, since zooplankton populations are very sensitive to environmental oscillations and are vulnerable to human effects, their research might be beneficial in anticipating long-term changes in lake ecosystems" [1,11,12,13].

**Corresponding author: Email: shivabasavaiahuom@gmail.com;*

"Changes in physico-chemical conditions in aquatic systems cause changes in the relative composition and amount of species that survive in the water, making them valuable as a monitoring tool for aquatic ecosystems" [1,14,15,16,17]. "As a consequence, zooplankton is a vital component of the ecosystem. The expanding population of India is driving a rise in industry, which is producing sewage disposal issues. Surface runoff regularly introduces an undesired substance into the lake water, resulting in deterioration of the water quality" [1,18-20].

"Many studies have shown that changes in zooplankton abundance, species diversity, and community composition are indicators of environmental change or disturbance, and that zooplankton can serve as an indicator of changes in lake trophic dynamics and ecological state due to changes in nutrient loading and climate" [1,21,22,23,24,3]. "The eutrophic status of a lake's zooplankton filtration capability has major effects, anthropogenic alterations to lakes and watersheds may have an impact on zooplankton community structure (species density and composition), as can natural lake water chemistry and lake topography" [1,25,26,27]. "When the physico-chemical conditions in aquatic systems change, the relative composition and quantity of creatures living in the water also vary; as a result, they may be used to monitor aquatic ecosystems, and hence zooplankton is regarded as an ecologically important organism" [28,29,30].

"As India's population grows, so does industry, and this in turn generates disposal issues for waste water products. Surface runoff periodically introduces a harmful material to the lake's water, causing the quality to deteriorate" [28,27,30].

Freshwater and marine plankton diversity were the most relevant ecological parameters. Each community's species diversity is made up of a diverse range of taxa and physically distinct species. When we talk about species diversity, we mean the variety of species found in a given area, including both common and unusual ones. "Species diversity is quite high in tropical and subtropical natural communities, whereas it is extremely low in communities that are mostly man-made" [1,22,23,31,32]. There are two aspects to species diversity: the richness of species and the evenness of species distribution" [33]. "Species richness may be defined as the number of distinct species and the size of those species' populations" [33,34,35,36,2]. "This really relates to the ratio of one species (S) to the total number of all species in the world (N)" [1,21]. To gauge how evenly distributed species are, the phrase "species evenness" is used".

"Varieties of diversity indices—mathematical formulae built from information on species abundance—can be used to quantify the variety of species on Earth" [37]. "Species richness, evenness, and overall diversity may all be used to calculate the diversity of a population's species" [37,38,31,39,40]. Marehalli Lake serves as a natural environment in this investigation. This lake's freshwater supply is critical since it employs local fishermen and serves as the primary source of income for some of the region's most marginalised residents. This research was done to see how seasonal fluctuations in zooplankton biodiversity affect the lake's biodiversity, therefore it was carried out.

1.1 Objectives

1. To study the seasonal variations, for 2 consecutive years in Physico-Chemical parameters of Marehalli lake.
2. To study the seasonal variations in the Diversity of Rotifer, Cladocera, Copepod and Ostracod Zooplankton groups.

2. MATERIALS AND METHODS

2.1 Study Area

Mandya district is in Karnataka state's southern region, between 12°31'20.28" N latitude and 76°53'50.86" E longitude. The average annual rainfall is roughly 680nm, and the majority of the area is irrigated by massive canals. The Marehalli Lake ecosystem is found in Mandya, Karnataka, India (latitude 12° 31' 25.4316" N, longitude 76° 53' 40.8624" E) (Fig. 1). The water in this lake covers an area of 2245351 meters^2, and it fills up when the city is flooded. Local fishermen fish in the lake on a regular basis [41,42].

2.2 Water Sample Collection and Analysis

"Water and plankton samples were collected at four distinct locations during a two-year period, from August 2018 to July 2020 with the monthly interval of one month. According to its geographical location, the lake can be divided into four zones (Fig. 1)".

2.3 Parameters

"The water samples were collected in sterile screw-capped wide-mouth vials. During the early morning hours (6:00 a.m. to 8:00 a.m.)" [43-46,27,47,48]. Samples from the lake were obtained vertically between 1 and 4 m depth with a few metres between the samples from the surface and the bottom, transferred to the laboratory, and examined on the

same day" [1]. The dissolved oxygen (DO) was fixed in the same place at the same time, the pH, the atmosphere, and the surface water temperature were also measured. Surface water samples are taken from the Marehalli lakes to determine Physico-chemical parameters [1].

"Surface water samples will be collected in 5-liter plastic canisters early in the morning (6:00 a.m. - 8:00 a.m.)" [43,44,45,46,27,47,48]. In the field, the temperature of the air, water, pH of the soil, and DO of the soil were all measured. "Conductivity, turbidity, total suspended solids (TSS), dissolved oxygen (DO), carbon dioxide (CO2), biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, hardness, alkalinity, phosphate, nitrate, sulphate, and calcium were all measured separately in the laboratory" [1].

Fig. 1 Geographical map location showing sampling sites at the Marehalli lake.

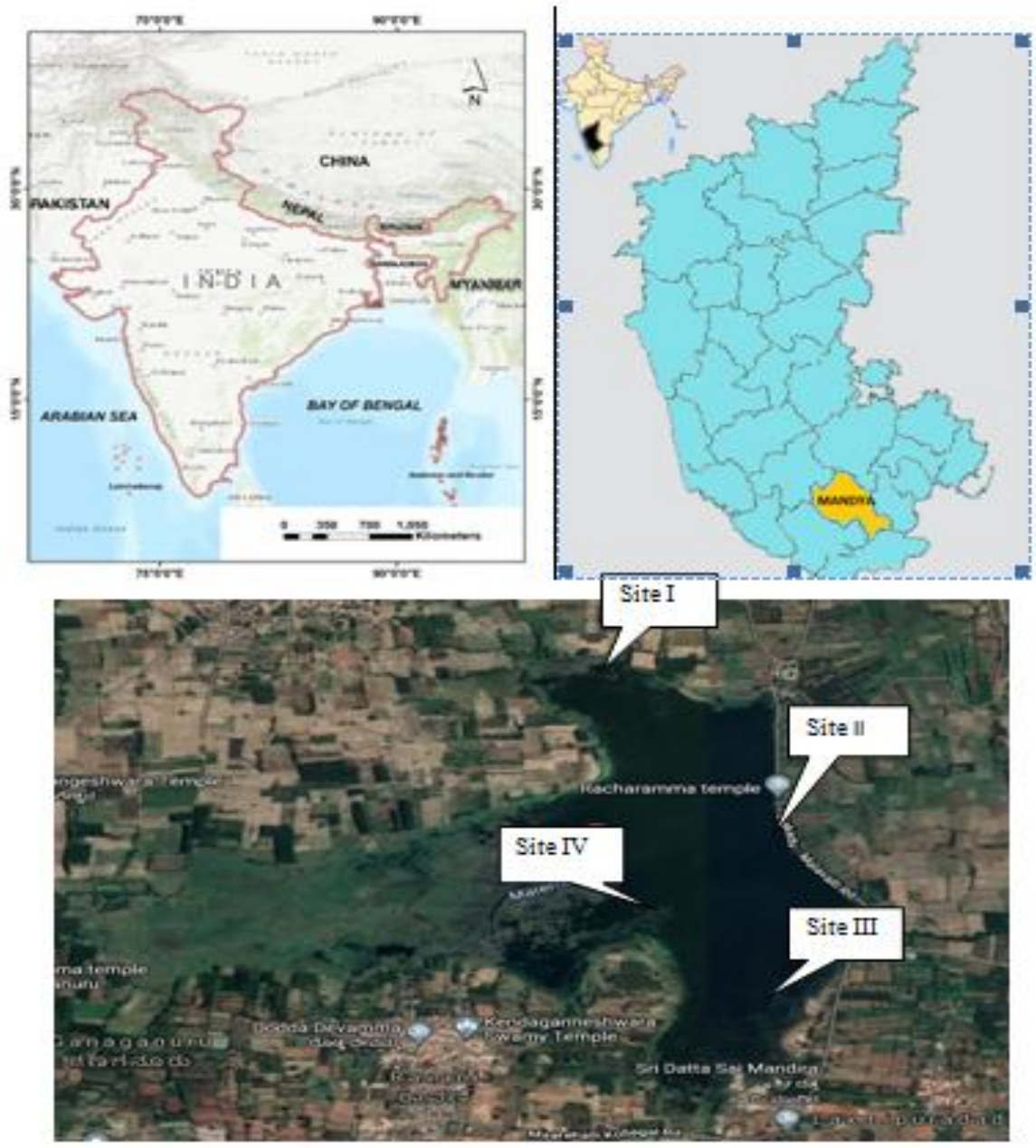

Fig. 1. Geographical map location showing samping sites at the Marehalli lake, Mandya, Karnataka, India

2.4 Zooplankton Quantitative Analyses

"100 l of water was filtered through a plankton net made of bolting silk (No: 05; mesh size 50 micron) for quantitative zooplankton studies, and the plankton was placed into sample vials (pre-filled with 4 percent formalin) and put through a microscopic examination (Olympus Microscope)" [49]. "They were separated with a thin needle and brush under a binocular stereo zoom dissection microscope (Magnus, Technology)" [1]. "On microscopic slides, each plankton species were stained with eosin or rose bengal on a drop of 20% glycerine" [1]. Zooplanktons were identified using textbooks and standard guides.

"A 1 ml zooplankton sample was taken using a wide neck pipette and deposited into the Sedgewick Rafters counting cell, where it was allowed to settle for a while before being counted" [1]. For each plankton sample, the counting procedure was repeated three times. "The total number of plankton in a litre of water was determined using the formula: N = n v / V, where N is the total number of plankton per litre of filtered water, n is the average number of plankton in a 1 ml plankton sample, v is the concentrated plankton volume (ml), and V is the total filtered water volume (liters)" [50,51]. The statistical analysis are been calculated by using the GraphPad Prism software program (8.0.2).

2.5 Species Diversity Indices

"Diversity indices such as Dominance, Shannon-Wiener index [52], Simpson [53], and Evenness are calculated using the PAST software tool" [53,52].

3. RESULTS

The air temperature was highest in the summer season (30.83) and lowest in the winter season, according to the findings of this study (24.99). Water temperature was greatest in the summer season (28.03) and lowest in the winter season (22.64), PH was highest in the summer season (8.29) and lowest in the rainy season (8.03), and conductivity was highest (2309.50) in the rainy season and lowest (1361.78) in the winter season. TSS showed the highest (36.34) in the summer season and the lowest (35.13) in the winter season, while DO showed the highest (8.10) in the rainy season and the lowest (7.14) in the summer season. Co2 showed the highest (0.04) in the summer season and the lowest (0.0) in the rainy season and winter season. BOD was highest (7.78) in the summer season and lowest (4.38) in the winter season, COD was highest (10.53) in the summer season and lowest (7.50) in the winter season, Hardness was highest (206.47) in the summer season and lowest (167.06) in the winter season, Rainy Chloride was highest (32.81) in the summer season and lowest (31.47) in the winter season, and alkalinity was highest (32.81) in the summer season and lowest (31.47) in the winter season (Table 1). The water parameters were also subjected to a statistical analysis (Table 2).

3.1 Zooplankton Species Composition and Species Diversity

In this study, the collected zooplanktons were examined using a compound microscope (Fig. 1). According to the findings, Rotifera is at the top of the composition, followed by Copepoda, Cladocera, and Ostracoda (Table 3). "According to observations, the highest density of zooplankton was detected in the summer and the lowest in the winter (Fig. 3)". Rotifera was observed to be more plentiful throughout the year, while ostracod had the lowest population (Table 3 and Fig. 4 respectively).

3.2 Canonical Correspondence Analysis (CCA)

"The Canonical Correspondence Analysis (CCA) ordination revealed a strong link between the distribution of zooplanktons and environmental variables" [1]. Zooplankton ostracods, copepods, had the strongest explanatory negative correlation with water temperature, conductivity, calcium, dissolved oxygen and nitrate. Zooplankton cladoceras had the strongest negative correlation with alkalinity, P^H, air temperature, TSS and Sulphate. Zooplankton rotifers had the strongest positive correlation with chloride, phosphate, turbidity, hardness, BOD and carbon dioxide (Fig. 5).

3.3 Species Diversity Indices

"In Tables 4 for zooplankton, a summary of the Taxa S, Individuals, Dominance D, Simpson 1-D, Shannon H, and Evenness eH/S is shown" [54]. In terms of zooplankton, site I (6627.00) had the most taxonomic individuals while site IV had the least (6485.00). In all of the locations, the dominance index and Simpson index were 0.34 and 0.66, respectively. The Shannon index indicated the highest value in site II (1.17) and a constant value of 1.16 in all the other locations. The evenness index was found to be higher in site II (0.81) than in the other sampling sites (0.80).

4. DISCUSSION

"The distribution patterns and species composition of plankton are influenced by physico-chemical factors and the amount of nutrients in lake water" [1,55,56,29,57]. "Environmental factors such as

water's physical (gases and solids solubility, light penetration, temperature, and density) and chemical (pH, hardness, phosphates, and nitrates) properties are critical for phytoplankton growth and distribution in aquatic habitats, which zooplankton rely on for survival" [1].

"The development and dispersion of flora and fauna in the lake ecosystem are influenced by surface water temperature, which is one of the most significant and dynamic environmental elements" [1,58,18,59]. "Surface water has been shown to impact limnological phenomena such as stratification, gas solubility, pH value, conductivity, and planktonic dispersion" [1]. When the temperature rises, chemical and biological processes speed up [60, 17,61].

Table 1. Physico-chemical parameters of lake water in different seasons

Parameters	Marehalli lake							
	Rainy		Winter		Summer		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Air Temp. (°C)	27.05	0.03	24.99	0.02	30.83	0.06	27.62	2.52
Water Temp. (°C)	24.78	0.01	22.64	0.05	28.03	0.04	25.15	2.32
P^H	8.03	0.01	8.08	0.02	8.29	0.02	8.13	0.12
Conductivity (μS^{-cm})	1919.28	37.73	1361.78	30.37	2309.50	32.59	1863.52	407.34
Turbidity(NTU)	31.84	0.19	26.84	0.26	29.13	0.77	29.27	2.18
TSS(mg/L)	35.41	0.52	35.13	1.28	36.34	0.50	35.63	0.94
DO(mg/L)	8.10	0.03	7.75	0.04	7.14	0.05	7.66	0.42
Co_2(mg/L)	0.00	0.00	0.00	0.00	0.04	0.02	0.01	0.02
BOD(mg/L)	5.59	0.06	4.38	0.10	7.78	0.19	5.92	1.48
COD(mg/L)	8.25	0.23	7.50	0.18	10.53	0.28	8.76	1.36
Hardness(mg/L)	167.06	2.82	170.44	3.25	206.47	3.77	181.32	18.87
Chloride(mg/L)	31.84	0.50	31.47	0.26	32.81	0.38	32.04	0.69
Alkalinity(mg/L)	209.50	1.88	171.69	2.14	236.78	4.28	205.99	28.01
Phosphate(mg/L)	0.05	0.00	0.04	0.00	0.06	0.00	0.05	0.01
Nitrate(mg/L)	0.25	0.00	0.18	0.01	0.27	0.01	0.24	0.04
Sulphate(mg/L)	24.81	0.48	24.66	0.49	31.19	1.95	26.89	3.36
Calcium(mg/L)	25.66	0.43	23.25	0.68	27.00	0.14	25.30	1.68

Table 2. Physico-chemical parameters of lake water and its statistical analysis

Parameters	Marehalli lake				
	Total Mean	SD	CV	Upper limits	Lower limits
Air Temp. (°C)	27.62	0.02	0.07	27.62	27.65
Water Temp. (°C)	25.15	0.02	0.06	25.15	25.17
P^H	8.13	0.01	0.10	8.13	8.14
Conductivity (μS^{-cm})	1863.52	31.01	1.66	1863.52	1912.87
Turbidity(NTU)	29.27	0.23	0.78	29.27	29.63
TSS(mg/L)	35.63	0.60	1.69	35.63	36.58
DO(mg/L)	7.66	0.02	0.28	7.66	7.70
Co_2(mg/L)	0.01	0.01	60.86	0.01	0.02
BOD(mg/L)	5.92	0.10	1.72	5.92	6.08
COD(mg/L)	8.76	0.09	1.05	8.76	8.91
Hardness(mg/L)	181.32	2.02	1.11	181.32	184.54
Chloride(mg/L)	32.04	0.26	0.82	32.04	32.46
Alkalinity(mg/L)	205.99	1.64	0.80	205.99	208.61
Phosphate(mg/L)	0.05	0.00	1.59	0.05	0.05
Nitrate(mg/L)	0.24	0.00	1.84	0.24	0.24
Sulphate(mg/L)	26.89	0.63	2.36	26.89	27.89
Calcium(mg/L)	25.30	0.34	1.36	25.30	25.85

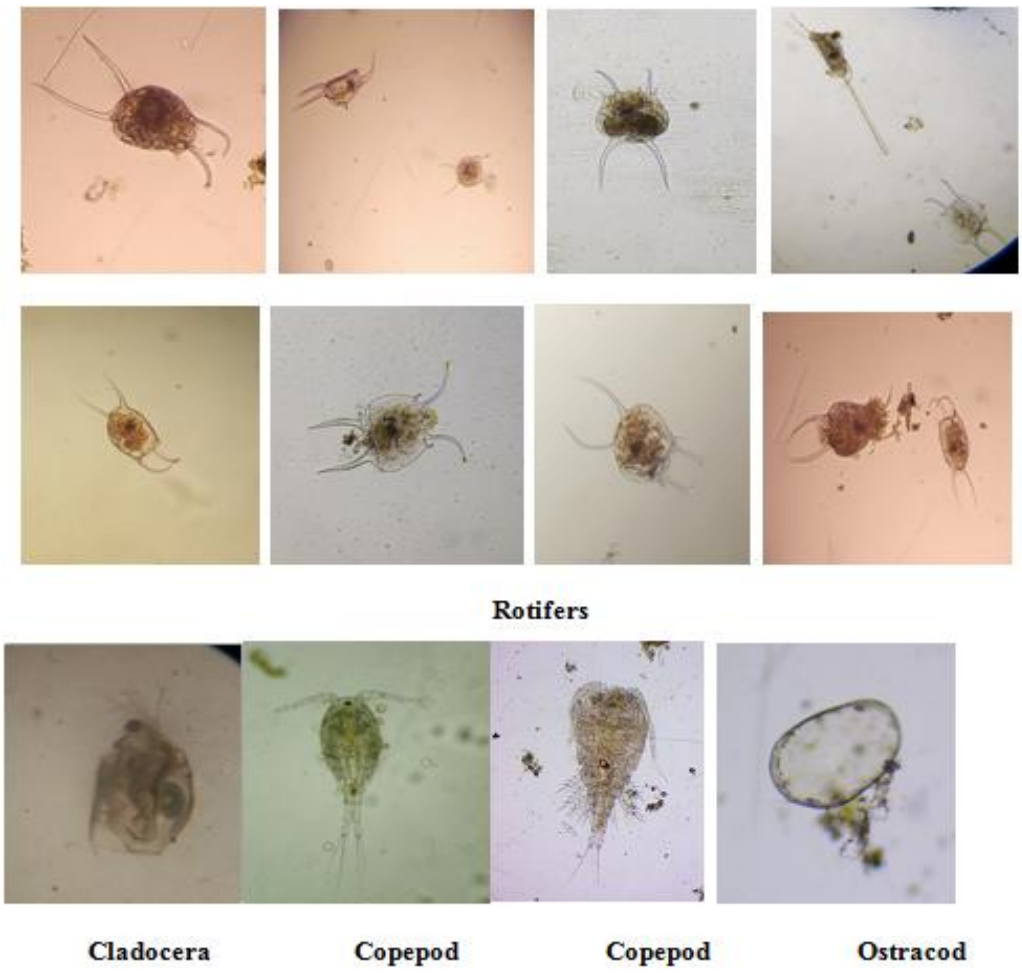

Fig. 2. Zooplanktons observed under compound microscope

Rotifers - Brachionus
Cladocera - Daphnia
Copepod - Mesocyclops, Paracyclops
Ostacod – Cyclocypris

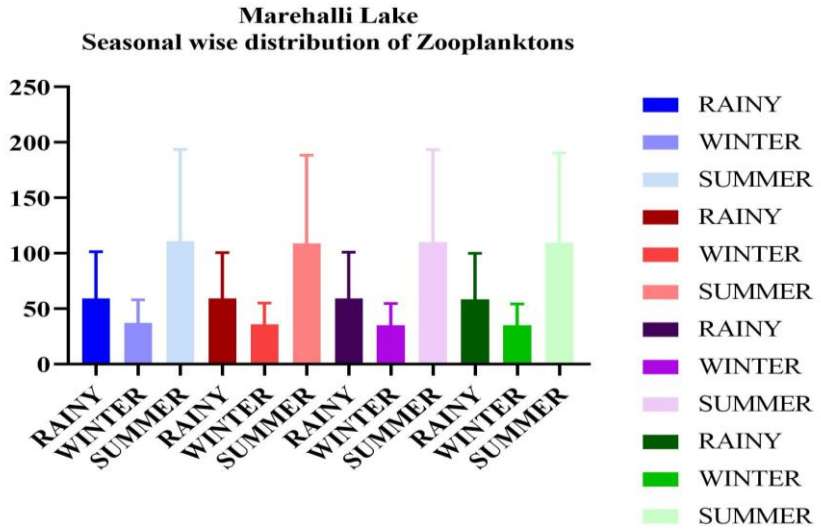

Fig. 3. Seasonal wise distribution of zooplanktons in Marehalli Lake in different sampling sites

Table 3. Overall distribution of zooplankton in Marehalli lake

Zooplankton	Marehalli lake				
	Total Mean	SD	CV	Upper limits	Lower limits
Rotifers	122.82	67.17	54.68	165.50	80.15
Cladoceras	59.94	25.70	42.87	76.26	43.61
Copepods	80.92	35.82	44.27	103.67	58.16
Ostracods	8.95	1.41	15.78	9.84	8.05

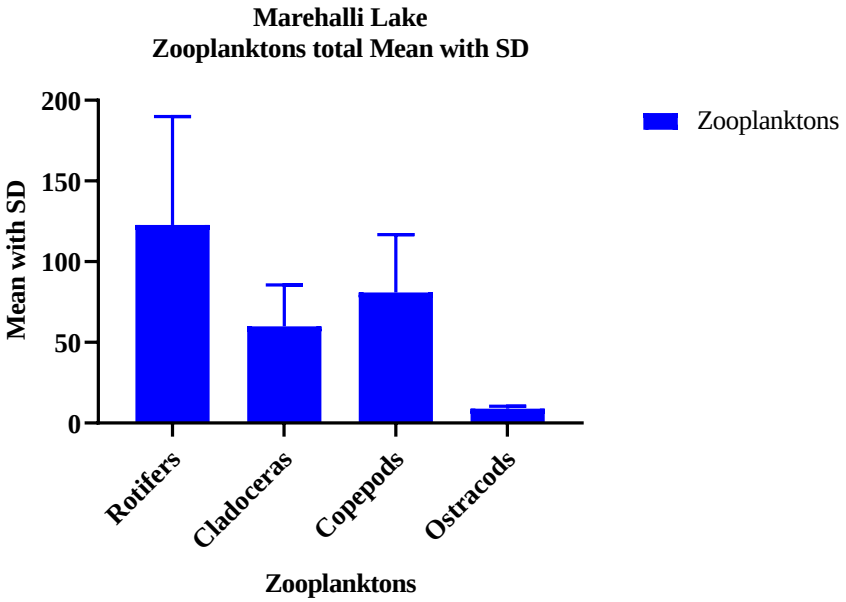

Fig. 4. Distribution of zooplanktons in Marehalli lake

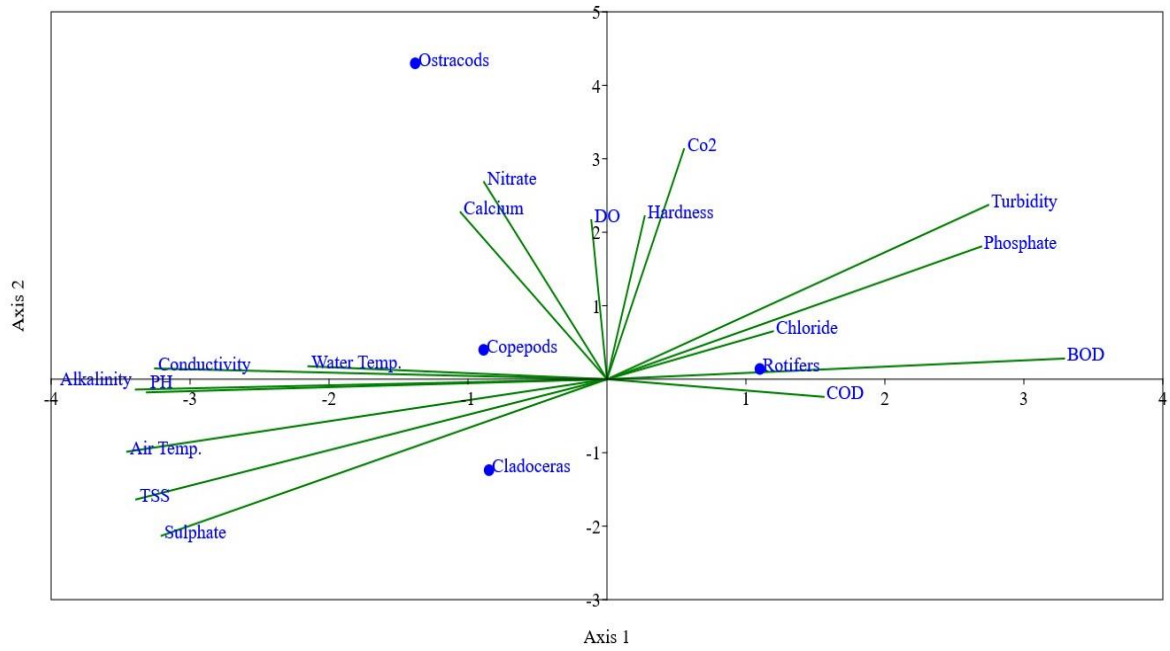

Fig. 5. The canonical correspondence analysis (CCA) association between zooplankton and water quality variables for the first two axis

Table 4. Species diversity indices of Marehalli lake for different sampling sites

Species Diversity indices	Site I	Site II	Site III	Site IV
Taxa_S	4.00	4.00	4.00	4.00
Individuals	6627	6516	6544	6485
Dominance_D	0.34	0.34	0.34	0.34
Simpson_1-D	0.66	0.66	0.66	0.66
Shannon_H	1.16	1.17	1.16	1.16
Evenness_e^H/S	0.80	0.81	0.80	0.80

"The pH scale measures the concentration of hydrogen ions in water and is used to assess the severity of acidity and alkalinity". In the summer, a high rate of photosynthesis in bodies of water suggests an increased pH value. "In this study, the greatest pH was discovered in the summer and the lowest in the rainy season" [51,62,63].

"The highest pH value with enhanced photosynthesis resulted in increased carbon dioxide consumption in the aquatic environment as a consequence of the high temperatures in the summer" [1,64,65,66]. According to the results of the present research, the summer season has the greatest average, while the rainy season has the lowest. The use of DO and the decomposition of organic material, as well as the respiration of micro and macroorganisms, resulted in an increase in DO content during the rainy season due to increased mixing of water with the atmospheric air, and a decrease in DO content during the summer season due to increased BOD and COD content due to the use of DO and the decomposition of organic material [67,37,68,69].

"In this study, the maximum electrical conductivity was found in the summer months and the lowest in the winter months" [1,70,71,72]. Increased temperature produced by the discharge of residential waste, according to existing statistics, may exacerbate pollutant levels. As a consequence, it's been shown that in certain circumstances, higher water temperatures paired with toxins might assist zooplankton populations thrive [28,49,73].

A high nutrient load may also promote high phytoplankton production, which in turn can sustain zooplankton abundance or population in the long term. According to the results of this research, the overall population density of zooplankton is modest in the winter season, possibly owing to lower light intensity. Similar results have been discovered in previous studies [74,75,76,61,77].

In terms of zooplankton with species diversity indices, the Dominance indices and Simpson indices remained constant in all the sites [24,3,78].

5. CONCLUSION

The results of numerous experiments led to the conclusion that the largest density of zooplanktons was observed in the summer season due to the high rate of evaporation, and the lowest density was found in the winter season due to the low rate of evaporation. The water concentration will dilute as a result of the rain, lowering the density of zooplankton, therefore it may be stated that water temperature can favourably support zooplankton population diversification. As a result, to ensure that these are correctly understood, they are continually investigated in more depth to better understand the future implications of climate change on zooplankton diversity.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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