Journal of Advances and Scholarly Researches in Allied Education
Vol. 19, Issue No. 5, October-2022, ISSN 2230-7540

A Study on Physico-Chemical Characteristics and Zooplankton Diversity

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Abstract - This study was done over a year (March 2015–February 2016) and four seasons (post-monsoon, summer, pre-monsoon, and monsoon) to see if Hale Dharmapuri Lake in Dharmapuri Town is good for inland aquaculture. Quantitative identifications were made for 29 different zooplankton species, including 10 different rotifers, 8 different cladocerans, 6 different copepods, and 5 different ostracods. Rotifers had the highest average population out of all the zooplankton categories, followed by Cladocerans, Copepods, and Ostracods. According to this research, zooplankton production is highest in the summer, then in the pre-monsoon, post-monsoon, and monsoon periods. Many physical and chemical factors, such as the temperature, pH, salinity, dissolved oxygen, total dissolved solids, and electrical conductivity of lake water, were found to be linked to the number of zooplankton. All of the zooplankton species were seen in all four seasons, which suggests that the diversity index values didn't change much from season to season. Seasonal changes in the index value are caused by changes in the number of species in each group of zooplankton. There is a promise for the lake to be used for inland aquaculture of fish and prawns since a substantial number of zooplankton species variety was observed.

Keywords - Physico-chemical, Zooplankton, Diversity

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1. INTRODUCTION

Each species of zooplankton has a distinct function in nutrient recycling and supplying food for other species in an ecosystem, and certain creatures may assist ecological systems to work more effectively, thus it's crucial to have a diverse zooplankton population. Being the primary food source for the vast majority of freshwater fish species at some point in their life cycles, zooplankton is an essential part of the ecosystems of freshwater lakes. As zooplankton populations are responsive to environmental variations and human impacts, studying them may aid in the prediction of long-term changes in lake ecosystems.[1-3]

Alterations in water physicochemical parameters may be used to track the health of aquatic ecosystems, providing insight into the types and numbers of creatures that can survive there. Zooplankton plays an important role in maintaining a balanced ecosystem. Growth in manufacturing is causing sewage disposal issues in India, which is exacerbated by the country's rapidly expanding population. The lake's water quality has decreased because of the regular addition of an undesirable chemicals through surface runoff.

There are issues with wastewater disposal as India's population rises as a consequence of more factories opening. Surface runoff is a major contributor to the worsening water quality in the lake since it carries with it a wide variety of hazardous chemicals and other contaminants. The chemical, physical, and biological components of water are the main criteria by which we evaluate it. It is crucial to any management strategy to understand the state of water quality and the well-being of the species that inhabit there.[4]

The variety of plankton found in both marine and freshwater environments was the single most influential biological component. Each ecosystem has a unique collection of taxa and morphologically distinct species. Species diversity is the range of different kinds of species that may be found in a given area, including both widespread and rare varieties. Natural ecosystems in the tropics and temperate zones have a greater variety of species than their artificial counterparts. Diversity in species is characterized by a high number of species and an even distribution of those species. Species richness may be defined as the number of distinct species present in an area and the size of their combined populations. The term "species evenness" is used as a measure of how equally dispersed species are.

Richness in species, evenness of species distribution, and overall diversity are three ways to measure the species diversity of a population. This lake's freshwater supply is crucial since it offers jobs for local fishermen and a substantial source of income for some of the poorest residents of the area. The purpose of this research was to learn how the lake's biodiversity responds to seasonal shifts in zooplankton abundance.[5-8]

1.1 Zooplankton

A wide variety of plant and animal life may be found in an environment with fresh water. These organisms may be found in a wide variety of freshwater habitats and have complex social structures.[9]

In the same way, as zooplankton floats passively on water currents, plankton floats or swims weakly. These are tiny aquatic plants or animals that may float freely in broad oceans and resist water currents very little if at all. The two types of planktonic organisms are phytoplankton and zooplankton. Phytoplankton (microalgae) come in a variety of forms, including unicellular, colonial, and filamentous algae. Several of these species have unique light, temperature, and nutrient-needs responses.

Microscopic creatures that float freely in the water column are called zooplankton. To avoid sinking to the bottom of the ocean, these animals have evolved body forms that increase drag and the active flipping of appendages like antennae or spines, as is the case with phytoplankton. While zooplankton has an advantage in terms of feeding by remaining in the water column, they are very susceptible to predators due to the absence of refuges in this area. Hence, certain species, especially Daphnia sp., move vertically in the water column every day, sinking passively to the darker lower levels during the day and actively migrating towards the top during the night. Because of the low levels of oxygen and cold temperatures, only a select few invertebrate species can make it to the deep sea. Those that can be red have higher than average quantities of hemoglobin in their blood, which significantly increases the amount of oxygen given to cells. Size isn't the only variable; physical characteristics and taxonomic status also fluctuate across species.[10]

1.2 Importance of Zooplankton in Aquatic Ecosystem

Due to their status as the prey of commercially valuable fishes, zooplankton plays an indirect but crucial role in the conversion of food energy in the freshwater environment. In the freshwater aquatic ecology, they are often the dominant consumers. Without these key consumers, food webs supporting herbivores and other species would quickly unravel. We can gauge water quality based on their qualitative and quantitative assessment.[11]

Because of its sensitivity to and rapid response to environmental changes, zooplankton provides useful information on the state of the water supply. They provide fundamental details about the ecosystem and the present state of the water body, and they serve as crucial indicators of the existence or absence of certain species. Changes in climate, physical and chemical characteristics, and vegetation all play important roles in shaping aquatic zooplankton ecosystems. Several variables regulate the abundance and variety of zooplankton in freshwater ecosystems. Important elements that regulate zooplankton development include temperature, dissolved oxygen, and organic matter. They are the primary source of nutrition for higher organisms like fish because they consume phytoplankton and catalyze the transformation of plant matter into animal tissue. One of the most influential biotic components, zooplankton plays a crucial part in the aquatic ecosystem's nutrient recycling and energy flow.[12]

2. METHODOLOGY

2.1 Analysis of physicochemical characteristics of lake water

Samples of surface water were collected in clean plastic bottles, frozen, and sent to a facility for physicochemical examination. In the first week of every month from March 2015 through February 2016, samples of water and plankton were taken between 6:00 and 7:00 in the morning. The "P Based Water & Soil Analysis Kit" was used to calculate the air and water temperature, pH, salinity, dissolved oxygen (DO), total dissolved solids (TDS), and electrical conductivity (EC) (Model 1160).

2.2 Qualitative and quantitative analysis of zooplankton

To collect water samples for zooplankton qualitative analysis, we towed a Henson's standard plankton net (150 m mesh) in a zigzag pattern for around 10 minutes at a consistent boat speed, from a depth of 50 to 100 cm. One hundred liters of water was filtered through a plankton net of bolting silk (No: 10, mesh size: 150 m) utilizing a plastic container with a ten-liter capacity for quantitative examination of zooplankton. When the water was removed using a filter, the plankton biomasses were placed in plastic specimen bottles (100 ml) containing 5% formalin (10 ml), an aqueous solution of formaldehyde. Each kind of zooplankton (Rotifer, Cladocera, Copepoda, and Ostracoda) was carefully separated using a small needle and brush and a binocular stereo zoom dissection microscope. Staining with eosin and rose Bengal, several plankton species were then placed on microscope slides with a drop of 20% glycerin. To identify zooplankton, we used a compound microscope and took photos using an inverted biological microscope (Model Number INVERSO 3000 (TC-100) CETI) equipped with a camera (Model IS 300).

Using a large-mouthed pipette, 1 ml of material was drawn and deposited into the Sedgwick Rafter's counting cell. They were counted after a period of resting to ensure accuracy. For each set, there were at least 5 separate counts taken. We took into account species, sex, and plankton growth stage. Values were averaged out. The formula below was used to determine the total number of plankton in a 1-liter water sample:

N = n × v / V Where,

N = Total number of plankton per liter of water filtered

n = Average number of plankton in 1 ml of plankton sample v = Volume of plankton concentrated (ml) and

V = Volume of total water filtered (liter)

The population of each group of zooplankton was expressed in the average, number of individuals per liter (ind./l).

3. RESULT

3.1 Physico-chemical characteristics of the lake water

Summer has the highest average air and water temperatures, followed by spring and fall before the monsoons, and then the monsoon itself. Summer has the highest average values for pH, salinity, and total dissolved solids, followed by spring, fall, and winter. The results showed that the mean value of DO was highest during the monsoon season, followed by the post-monsoon period, the pre-monsoon period, and the summer. It was determined that summer had the highest average EC value, followed by spring, fall, and winter (Table 1).

Table 1: Physico-chemical characteristics of the Hale Dharmapuri lake during the study period

Parameter	Summer (Mar' 2015-May' 2015)	Pre-Monsoon (Jun' 2015-Aug' 2015)	Monsoon (Sep' 2015-Nov' 2015)	Post-Monsoon (Dec 2015-Feb' 2016)	Overall average	F-value
AT (°C)	26.07±0.63^{a}	24.85±0.75^{ab}	24.20±0.85^{c}	24.75±0.57^{ab}	24.97±0.79	3.71
WT (°C)	27.38±0.75^{a}	27.05±1.54^{a}	25.22±0.78^{a}	26.37±1.08^{a}	26.51±0.95	2.32
pH	8.02±0.28^{a}	7.45±0.26^{ab}	6.12±0.60^{c}	6.85±0.67^{bc}	7.11±0.82	8.34
Salinity (ppt)	1.958±0.225^{a}	1.185±0.208^{b}	0.751±0.074^{c}	0.928±0.060^{bc}	1.206±0.532	33.03
DO (mg/l)	6.28±0.14^{b}	6.43±0.61^{b}	7.78±0.46^{a}	7.08±0.56^{ab}	6.89±0.69	6.08
TDS (mg/l)	176.93±15.20^{a}	156.88±24.06^{ab}	111.88±13.98^{b}	120.31±35.33^{b}	141.50±30.65	5.00
EC (µS cm^{-1})	2.038±0.229^{a}	1.685±0.186^{b}	0.747±0.100^{c}	1.041±0.176^{c}	1.378±0.589	32.54

DO stands for dissolved oxygen; TDS for total dissolved solids; EC for electrical conductivity; AT for air temperature; WT for water temperature.

The values for each season are the overall mean SD (n=15; 5 locations 3 months).

The means of the numbers in adjacent rows with the same superscript deviate by a statistically (P0.05).

3.2 Quality of zooplankton

Qualitative identifications were made of 29 different zooplankton species in this research, including 10 species of rotifers, 8 species of cladocerans, 6 species of copepods, and 5 species of ostracods (Table 3.2; Figs. 3.2-3.5). Brachionus budapestinesis var. punctatus, Brachionus calyciflorus, Brachionus caudatus personatus, Brachionus diversions, Brachionus falcatus, Brachionus quadridentatus, Brachionus rubens, Asplanchna Brightwell, Asplanchna intermedia, Filinia longiseta, and Asplanchna nana were (Table 3.2; Fig. 3.2). Eight species of Cladocerans, six species of Copepods, and five species of Ostracods were found to belong to the subphylum crustacea (Table 3.2; Figs. 3.3-3.5). Diaphanosoma sarsi, D. excisum, D. carinata, D. magna, C. cornuta, M. brachiata, M. micrura, and M. macleayi were the Cladocerans found (Table 3.2; Fig. 3.3). Heliodiaptomus viduus, Sinodiptomus (Rhinediaptomus) indicus, Eucyclops speratus, Mesocyclops hyalinus, Mesocyclops leuckarti, and Thermocyclops hyalinus were all named as species of Copepods (Table 2; Fig. 3.4). Cyprinus nudus, Cypris protubera, Eucypris bispinosa, Strandesia elongata, and Heterocypris dentatomarginatus were the Ostracods recognized (Table 2; Fig. 5).

Table 2: List of zooplankton species recorded in the Hale Dharmapuri Lake during the study period

Group	Family	Genus	Species
Rotifer (10)	Brachionidae (Ehrenberg, 1838)	*Brachionus* Pallas, 1776	*Brachionus budapestinesis var punctatus* Hempel, 1896
			Brachionus calyciflorus Pallas, 1776
			Brachionus caudatus personatus Ahlstrom, 1940
			Brachionus diversicornis Daday, 1883
			Brachionus falcatus Zacharias, 1898
			Brachionus quadridentatus Hermann, 1783
			Brachionus rubens Ehrenberg, 1838
	Asplanchnidae (Harring and Myers, 1933)	*Asplanchna* Gosse, 1850	*Asplanchna brightwelli* Gosse, 1850
			Asplanchna intermedia Hudson, 1886
	Filinidae (Bartos, 1959)	*Filinia* Bory and Vincent, 1824	*Filinia longiseta* Ehrenberg, 1834
Cladocera(8)	Sididae (Baird, 1850)	*Diaphanosoma* Fischer, 1850	*Diaphanosoma sarsi* Richard, 1895
			Diaphanosoma excisum Sars, 1885
		Daphnia Muller, 1785	*Daphnia carinata* King, 1853
			Daphnia magna Straus, 1820
	Daphnidae (Straus, 1850)	*Ceriodaphnia* Dana, 1853	*Ceriodaphnia cornuta* Sars, 1853
	Moinidae (Goulden, 1968)	*Moina* Baird, 1850	*Moina brachiata* Jurine, 1820
			Moina micrura Kurz, 1874
		Moinodaphnia Herrick, 1887	*Moinodaphnia macleayi* King, 1853

Copepoda(6)	Diaptomidae(Baird, 1850)	*Heliodiaptomus* Kiefer, 1932	*Heliodiaptomus viduus* Gurney, 1916
		Sinediaptomus Kiefer, 1937	*Sinodiptomus (Rhinediaptomus) indicus* Sewell, 1934
	Cyclopoidae(Dana, 1853)	*Eucyclops* Claus, 1893	*Eucyclops speratus* Lilljeborg, 1901
		Mesocyclops Claus, 1893	*Mesocyclops hyalinus* Rehberg, 1880
			Mesocyclops leuckarti Claus, 1857
		Thermocyclops Kiefer, 1927	*Thermocyclops hyalinus* Rehberg, 1880
Ostracoda(5)	Cyprididae (Baird, 1845)	*Cypris* Muller, 1776	*Cypris protubera* Muller, 1776
		Eucypris Vavra, 1891	*Eucypris bispinosa* Victor and Michael, 1975
		Strandesia Stuhlmann, 1888	*Strandesia elongate* Stuhlmann, 1888
		Cyprinotus Brady, 1886	*Cyprinus nudus* Brady, 1885
		Heterocypris Claus, 1892	*Heterocypris dentatomarginatus* Baird, 1859

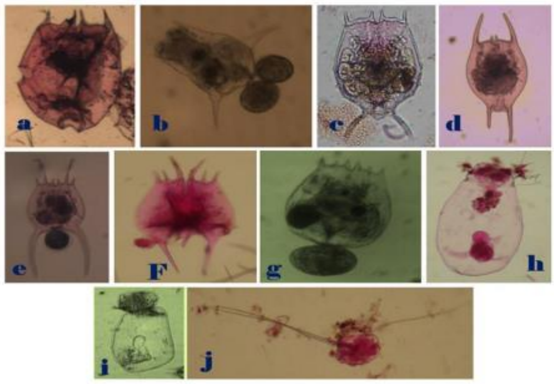

Fig 1: Group of Rotifers observed in the Hale Dharmapuri lake during the study period (a. Brachionus budapestinesis var punctatus; b. Brachionus calyciflorus; c. Brachionus caudatus personatus; d. Brachionus diversicornis; e. Brachionus falcatus; f. Brachionus quadridentatus; g. Brachionus rubens; h. Asplanchna Brightwell; i. Asplanchna intermedia; j. Filinia longest)

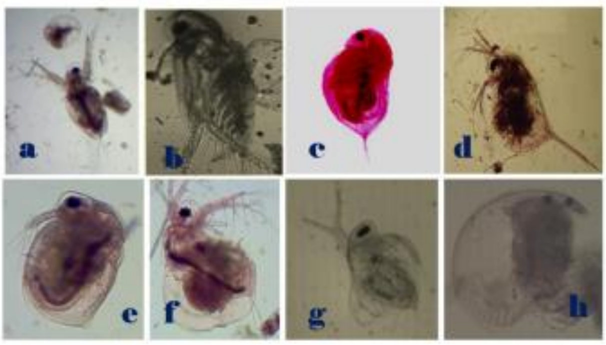

Fig 2: Group of Cladocerans observed in the Hale Dharmapuri lake during the study period (a. Diaphanosoma sarsi; b. Diaphanosoma excised; c. Daphnia carinata; d. Daphnia magna; e. Ceriodaphnia cornuta; f. Moina brachiata; g. Moina micrura; h. Moinodaphnia macleayi)

Fig 3: Group of Copepods observed in the Hale Dharmapuri lake during the study period (a. Heliodiaptomus viduus; b. Sinodiptomus (Rhinediaptomus) indicus; c. Eucyclops speratus; d. Mesocyclops hyalinus; e. Mesocyclops leuckarti; f. Thermocyclops hyalinus)

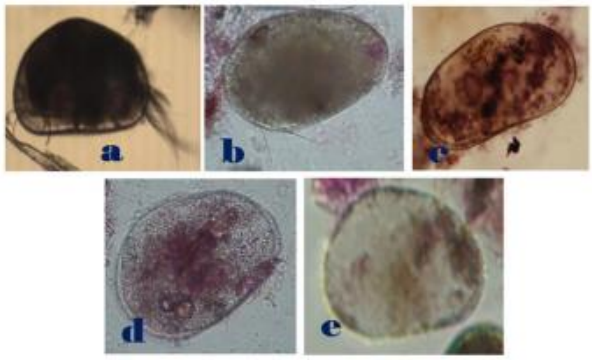

Fig 4: Group of Ostracods observed in the Hale Dharmapuri lake during the study period (a. Cypris protubera; b. Eucypris bispinosa; c. Strandesia elongata; d. Cyprinus nudus; e. Heterocypris dentatomarginatus)

3.3 Quantity of zooplankton

For all documented seasons, the following is the order of zooplankton population density: There are more rotifers (7066 ind./l) than any other kind of animal, including clams (5532/l), crabs (4553/l), and ostracods (1958/l). We discovered that the total productivity of zooplankton (across all four classes) was highest in the summer (25080 ind./l), then lowest in the pre-monsoon (20825 ind./l), highest in the post-monsoon (17445 ind./l), and lowest in the monsoon (13092 ind./l) (Table 3). The mean population density of zooplankton observed in this research was 19110 ind./liter, and it was discovered that summer is the most productive season, both in terms of individual group production (Rotifer, Cladocera, Copepoda, and Ostracoda) and overall productivity (Table 3). In this research, the zooplankton groups with the lowest species diversity were the Rotifer and the Ostracoda, with the former ranking first and the latter fourth in terms of both the number of species and the total numbers present throughout the summer months. The genus Cladocera came in at number two, followed by the genus Copepod in third (Tables 2 and 3). Several physicochemical lake water factors were shown to have a favorable correlation with the zooplankton population measured (Table 3.4).

Table 3: Zooplankton population density with percentage composition in the Hale Dharmapuri lake during the study period

Plankton group	Population density of zooplankton (ind./l)				Mean (ind./l) & %	F-value
	Summer (Mar' 2015- May' 2015)	Pre-Monsoon (Jun' 2015- Aug' 2015)	Monsoon (Sep' 2015- Nov' 2015)	Post-Monsoon (Dec' 2015- Feb' 2016)		
Rotifer	9675±264^{a}	7762±326^{b}	4389±138^{d}	6441±412^{c}	7066.7 (36.9%)	162.82
Cladocera	6710±253^{a}	5947±174^{b}	4255±265^{d}	5216±215^{c}	5532.0 (28.9%)	62.45
Copepoda	6163±179^{a}	5077±310^{b}	3061±152^{d}	3912±130^{c}	4553.2 (23.8%)	130.92
Ostracoda	2532±197^{a}	2039±132^{b}	1387±78^{c}	1876±129^{b}	1958.5 (10.2%)	33.81
Total	25080	20825	13092	17445	19110	--

Table 4: The relationship between physico-chemical parameters and zooplankton population in the Hale Dharmapuri lake during the study

Physico-chemical parameters Vs. Zooplankton population	'y' – Value (Linear Type)	R	R^2	Correlation
Atmospheric Temperature	y=2029.873x-44310.593	0.944	0.892	Positive
Water Temperature	y=1718.25x-39170.759	0.970	0.941	Positive
pH	y=1008.723x-801.767	0.485	0.235	Positive
Salinity	y=2694.466x+3116.683	0.848	0.718	Positive
Dissolved oxygen	y=1854.115x-6407.38	0.752	0.565	Positive
Total Dissolved Solids	y=53.399x-1185.826	0.966	0.932	Positive
Electrical Conductivity	y=2414.826x+3043.224	0.839	0.705	Positive

Table 5: Diversity indices of zooplankton in the Hale Dharmapuri lake during the study period

Plankton group	Diversity indices	Summer (Mar' 2015- May' 2015)	Pre-Monsoon(Jun' 2015- Aug' 2015)	Monsoon (Sep' 2015- Nov' 2015)	Post-Monsoon (Dec' 2015- Feb' 2016)	Overall average	F-Value
Rotifer (10 species)	Dominance (D)	0.111±0.005^{c}	0.121±0.006^{c}	0.127±0.008^{a}	0.105±0.003^{ab}	0.116±0.010	8.71
	Shannon (H)	2.305±0.042^{ab}	2.268±0.041^{a}	2.237±0.036^{b}	2.354±0.046^{b}	2.291±0.050	4.43
	Evenness_e^H/S	0.835±0.031^{ab}	0.805±0.023^{a}	0.781±0.017^{c}	0.877±0.034^{bc}	0.825±0.041	7.00
	Margalef (R1)	1.362±0.028^{c}	1.401±0.016^{b}	1.511±0.031^{a}	1.437±0.053^{bc}	1.428±0.063	10.02
Cladocera (8 species)	Dominance (D)	0.156±0.003^{a}	0.157±0.006^{a}	0.158±0.004^{a}	0.154±0.002^{a}	0.156±0.002	0.53
	Shannon (H)	1.954±0.032^{a}	1.953±0.029^{a}	1.945±0.036^{a}	1.961±0.045^{a}	1.952±0.007	0.10
	Evenness_e^H/S	0.882±0.031^{a}	0.881±0.035^{a}	0.875±0.032^{a}	0.888±0.037^{a}	0.882±0.005	0.07
	Margalef (R1)	0.908±0.052^{a}	0.922±0.054^{a}	0.966±0.058^{a}	0.939±0.056^{a}	0.934±0.025	0.61
Copepoda(6 species)	Dominance (D)	0.178±0.002^{c}	0.192±0.006^{a}	0.202±0.008^{bc}	0.186±0.004^{b}	0.190±0.010	10.23
	Shannon (H)	1.756±0.043^{a}	1.722±0.041^{a}	1.699±0.035^{a}	1.737±0.042^{a}	1.729±0.024	1.06
	Evenness_e^H/S	0.965±0.035^{a}	0.933±0.037^{a}	0.912±0.036^{a}	0.947±0.032^{a}	0.939±0.022	1.22
	Margalef (R1)	0.656±0.054^{a}	0.674±0.057^{a}	0.723±0.066^{a}	0.697±0.062^{a}	0.688±0.029	0.70
Ostracoda(5 species)	Dominance (D)	0.222±0.001^{b}	0.228±0.004^{a}	0.222±0.001^{b}	0.216±0.003^{c}	0.222±0.005	10.66
	Shannon (H)	1.552±0.045^{a}	1.541±0.043^{a}	1.554±0.046^{a}	1.562±0.048^{a}	1.552±0.009	0.10
	Evenness_e^H/S	0.944±0.034^{a}	0.953±0.037^{a}	0.946±0.035^{a}	0.953±0.037^{a}	0.949±0.005	0.05
	Margalef (R1)	0.595±0.052^{a}	0.615±0.053^{a}	0.653±0.051^{a}	0.623±0.056^{a}	0.622±0.024	0.61

The values for each season are the overall mean SD (n=15; 5 locations 3 months).

The means of the numbers in adjacent rows with the same superscript deviate by a statistically (P0.05).

Dominance (D), Shannon (H), Evenness (eH/S), and Margalef (R1) richness values determined seasonally for each group of zooplankton in this investigation indicated no significant degree of variation (

D: Rotifer, 0.105-0.127; Cladocera, 0.154-0.158; Copepod, 0.178-0.202; Ostracoda, 0.216-0.228; H: Rotifer, 2.237-2.354; Cladocera, 1.945-1.961; Copepod, 1.699-1.756; Ostracoda, 1.541-1.562; e^H/S: Rotifer, 0.781-0.877; Cladocera,0.875- 0.888; Copepod, 0.912-0.965; Ostracoda, 0.944-0.953; R1: Rotifer, 1.362-1.511; Cladocera, 0.908-0.966; Copepod, 0.656-0.723; Ostracoda, 0.595-0.653), as all the species was recorded in all the four seasons. The Shannon (H) diversity index for rotifers, cladocerans, copepods, and ostracods in summer were 2.305, 1.954, 1.756, and 1.552 correspondingly; this variation was due to the varying numbers of species present in each season's zooplankton groups. This kind of variation in group composition was also seen across all analyzed diversity indices, and throughout all four seasons (Table 3.5).

4. CONCLUSION

This lentic lake was getting close to eutrophication and being organically contaminated because the species in it didn't change with the seasons and all of them were there all year long. However, the lake's nutritional state ensures plankton production. The summertime, just before the monsoon, was when the symptoms of this instance were at their worst. Overfishing may have increased the zooplankton population at these times. Water temperature, pH, salinity, and total dissolved solids (TDS) were all less favorable for zooplankton development during the monsoon because of the dilution effect. Over-predation of zooplankton by higher trophic members, such as planktivorous fishes, occurs during the post-monsoon because there is an excess of food in the form of bacteria, nano-plankton, and suspended detritus, allowing for a larger fish population and faster development. There is a promise for the lake to be used for inland aquaculture of fish and prawns since a substantial number of zooplankton species variety was observed.

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