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Zooplankton Diversity and its Indices in Relation to Physico-Chemical Parameters of Fresh Water Lake at Karimnagar District, Telangana State, India.

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Abstract: *The present study of diversity indices of zooplankton and physico-chemical parameters were studied during June 2020 to May 2021. The sample was analyzed qualitatively as well as quantitatively for distribution of zooplankton. The physico-chemical parameters such as Water Temperature, Transparency(TRS),Total Dissolved Solid (TDS),PH, Dissolve Oxygen (DO),Carbon di Oxide (CO_2), Total Hardness (TH),Total Alkalinity(TA),Chloride(Cl), Phosphate(Po_4), Nitrate(No_3) and Biological Oxygen Demand (BOD)were analyzed during the study period. The relationship between zooplankton and physico-chemical parameter were also calculated statistically. A total of 20 zooplankton species were identified qualitatively, which includes 10 species of Rotifer, 5 species of Cladocera, 3 species of Copepoda and 2 species of Ostracoda. The composition of zooplankton rotifers was dominant (58%) followed by cladocera (26%), copepod (13%) and ostracoda (3%).The mean population of each zooplankton groups from all the seasons recorded was in the following order, Rotifers > Cladocerans > Copepods > Ostracods.Shannon-Wiener index and Simpson's diversity index results were calculated for zooplankton diversity inthis lake.It showed As the productivity of zooplankton was good, it could be continuously utilized for aquaculture, if proper water quality management measures were adopted.*

Key Words: *Physico-Chemical parameters, Seasonal Variation, Zooplankton Diversity Indices, Shannon-Wiener index, Simpson's diversity index.*

1. INTRODUCTION:

The zooplankton is fundamental character in the significance of an aquatic ecosystem and plays a key role in the energy transfer. Freshwater zooplankton plays an important role in ponds, lakes and reservoirs ecosystem and food chain [24]. Zooplankton feed on phytoplankton. They are responsible for eating millions of little algae that may otherwise grow to an out-of-control state.Aquatic ecosystem is affected by several health stressors that significantly deplete biodiversity. In future, the loss of biodiversity and its effects are predicted to be greater in aquatic ecosystem than terrestrial ecosystem [15].Zooplankton species have different types of life histories influenced by seasonal variations of biotic factors, feeding ecology and predation pressure.The zooplankton community is composed of both primary consumers (which eat phytoplankton) and secondary consumers (which feed on the other zooplankton). They provide a direct link between primary producers and higher tropic levels such as fish. Nearly all fish depend on zooplankton for food during their larval phases, and some fish continue to eat zooplankton for their entire lives [21].The distribution and diversity of zooplankton in aquatic ecosystem depend mainly on the physico-chemical properties of water [14].

The zooplankton is fundamental character in the significance of an aquatic ecosystem and plays a key role in the energy transfer. Freshwater zooplankton plays an important role in ponds, lakes and reservoirs ecosystem and food chain [24]. Zooplankton feed on phytoplankton. They are responsible for eating millions of little algae that may otherwise grow to an out-of-control state.Aquatic ecosystem is affected by several health stressors that significantly deplete biodiversity. In future, the loss of biodiversity and its effects are predicted to be greater in aquatic ecosystem than terrestrial ecosystem [15].Zooplankton species have different types of life histories influenced by seasonal variations of biotic factors, feeding ecology and predation pressure.The zooplankton community is composed of both primary consumers (which eat phytoplankton) and secondary consumers (which feed on the other zooplankton). They provide a direct link between primary producers and higher tropic levels such as fish. Nearly all fish depend on zooplankton for food during their larval phases, and some fish continue to eat zooplankton for their entire lives [21].The distribution and diversity of zooplankton in aquatic ecosystem depend mainly on the physico-chemical properties of water [14].

2. MATERIALS AND METHODS:

2.1. STUDY AREA: Pedda cheruvu is located in Manakondur village, Karimnagar district, Telangana. This lake is located in longitude79º13'30"E and latitude 18º23'53"N. In the present study period temperature range a minimum 19.0ºC and maximum of 31.0ºC.The water is used for drinking, agriculture and supports fish culture.

Figure1: *Satilite image of Pedda Cheruvu (Manakondur)*

2.2. Analysis of physico-chemical characteristics of lake water:

During the study period of one year from June 2020 to May 2021.Water Temperature, Transparency, Total Dissolved Solids, PH, Dissolved Solids, Carbon Di Oxide, Total Hardness, Total Alkalinity, Chlorides, Phosphates and Nitrates were determined. Physical and chemical parameters had been expected within the laboratory by means of preferred techniques prescribed by using [1];[40].

2.3. Qualitative and quantitative analysis of zooplankton:

During the study period of investigation monthly samples were collected by a plankton net made of silk bolting cloth silk no. 25 (Mesh size 56 µm). Water sample (50 liter) was filtered through the net from littoral and open water zones and carefully transferred to 50 ml bottle and preserved in 4% formalin. Preserved samples were examined under a binocular microscope with different magnification. Quantitative analysis was done on a Sedgwick Rafter Counter cell by taking 1 ml sample. Taxonomic identification was carried out with the help of standard literature by [28];[30];[29];[9] and [4].

2.4. Statistical Analysis:

The Statistical calculation on biodiversity of zooplankton was studied using the formula of Shannon-Wiener Diversity Index (Williams & Feltmate, 1992) and Simpson's diversity index [18] which was calculated as follows.

2.5. Shannon –Wiener Index (Williams & Feltmate, 1992)

This is a widely used method of calculating biotic diversity in aquatic and terrestrial ecosystems and is expressed as:

$$H' = -\sum_{i=1}^{s}\left[\left(\frac{n_i}{n}\right)\ln\left(\frac{n_i}{n}\right)\right]$$

Where H= index of species diversity s= number of species *ni*= proportion of total sample belonging to the *i th* species. Large H value indicates greater diversity, as influenced by a greater number and/or a more equitable distribution of species.

2.6. Simpson's diversity index (Krebs, 1994)

The Simpson's diversity index (D) is calculated using the following equation:

$$D = \sum_{i=1}^{S}\frac{n_i(n_i-1)}{N(N-1)}$$

D = Where '*ni*' is the proportion of individuals of the *i th* taxon in the community. Simpson's index gives relatively little weight to the rare species and more weight to the common species. It ranges in value from 0 (low diversity) to a maximum of (1-1/s), where "*s"* is the number of taxa. "N" is the total number of species in community.

3. RESULTS & DISCUSSION:

In the present study physic-chmical parameters variations were found during the study period four selected stations at different seasons of Manakondur Lake. Physico chemical parameters and plankton population density have been reported by [22];[17]. Physico-chemical parameters and quantity of nutrients in water play a significant role in the distribution patterns and species composition of plankton [15]; [35]; [24]; [20].All the metabolic, physiological activities and life processes, such as feeding, reproduction, movements and distribution of organisms are greatly influenced by water temperature. A rise in the temperature leads to the fast chemical and biochemical reactions. In the present study attempts on the water quality parameters, diversity of zooplankton and its seasonal fluctuations in the

lake were summerised. The seasonal variations of average physic-chemical parameters i.e water temperature ranges from 19.0ºC to 31.0ºC.Highest Mean value of the temperature in summer season (28.50±2.08) while the lowest values of winter season (23.75±3.79) were recorded. In the present study transparency ranges from 18.50cm to 44.30cm. Highest Mean value of the transparency in winter season (36.35±8.01) while the lowest values of Rainy season (19.85±1.27), were recorded. In the present study TDS ranges from 200(mg/l) to 350(mg/l). Highest Mean value of the TDS in summer season (327.50±22.17) while the lowest value of winter season (221.25±15.47) were recorded. In the present study PH ranges from 7.5 to 8.3. Highest mean value of the PH in Rainy season (8.00±0.35) while the lowest values of summer season (7.62±0.09) were recorded. The DO content in water is most important parameter in water quality assessment and reflects the physical and biological process prevailing water quality. High DO content is an indication of healthy system in a water body [5];[10].The present study In the present study DO ranges from 5.2(mg/l) to 12.0(mg/l).Highest Mean value of the DO in Rainy season (10.22±1.75) while the lowest values of summer season (6.10±0.73) were recorded.**CO2:** In the present study CO2 ranges from 3.0(mg/l) to 9.2(mg/l). Highest Mean value of the CO2 in winter season (7.95±0.88) while the lowest values of Rainy season (4.87±2.42), were recorded. In the present study Total Hardness ranges from 110(mg/l) to 210(mg/l). Highest Mean value of the Total Hardness in summer season (183.75±11.08) while the lowest values of winter season (125.25±12.78) were recorded. In the present study Total Alkalinity ranges from 165(mg/l) to 300(mg/l). Highest Mean value of the Total Alkalinity in winter season (266.75±31.23) while the lowest values of summer season (183.75±14.93) were recorded. In the present study Chlorides ranges from 35.00(mg/l) to 50.20(mg/l). Highest Mean value of the Chlorides in summer season (43.57±6.69) while the lowest values of Rainy season (33.27±2.53), were recorded. In the present study Phosphates ranges from 0.02(mg/l) to 0.16(mg/l). Highest Mean value of the Phosphates in summer season (0.097±0.067) while the lowest values of winter season (0.035±0.012) and were recorded. In the present study Nitrates ranges from 0.02(mg/l) to 0.14(mg/l). Highest Mean value of the Nitrates in summer season (0.10±0.042) while the lowest values of winter season (0.027±0.009) were recorded. In the present study BOD ranges from 2.5(mg/l) to 7.0(mg/l). Highest Mean value of the BOD in summer season (5.37±1.37) while the lowest values of winter season (3.37±0.47) and were recorded.

The plankton is heterogeneous assemblage of minute organism which occurs in natural water and float about by wave action and movement of water [26].Zooplankton study provides a relevant and convenient point focus for research on the mechanism of eutrophication and its adverse impact on an aquatic ecosystem. Zooplankton are an important components in aquatic ecosystems, whose main function is to act as primary secondary links in the food chain[16].Zooplankton diversity rapidly to changes in the aquatic environment. Several zooplankton species are served as bio indicators [3]; [27];[11].In the present investigation 20 species of zooplankton belonging to 4 groups were recorded manakondur fresh water lake. Out of 20 species 10 species of Rotifera,5 species of cladocera,3 species of copepod and 2 species of ostracoda. Rotifers are microscopic soft bodies' fresh water invertebrates. Their distribution and ecology have interesting evolutionary implications[19].The rotiferans exhibit a very wide range of morphological variations and adaptations. Among the zooplankton rotifers respond more quickly to the environmental changes and used as a change in water quality [12]. Rotifers are regarded as Bioindicators of water quality. Rotifers play a vital role in the trophic tiers of freshwater impoundments and serve as living capsule of nutrition [39]. The monthly variation of zooplankton density (nos/lit) at four stations found that minimum number of rotifera observed in monsoon season and maximum in summer season.Maximum Cladocera population observed in summer season and minimum in monsoon season. The Cladocerans also prefer to live in clear waters. Copepods are considered as important food item for various kinds of fish, play a key role in the energy transformation at different trophic levels. As a nature of copepod they prefer Eutrophication environment. Maximum copepod population observed in summer season and minimum in monsoon season. Similar observation was made by [7]. Ostracoda observed maximum population in winter season and minimum in monsoon season.The seasonal wise zooplankton analysis showed that the number of population was highest during summer, followed by monsoon and lowest during winter. In the present investigation, the group wise seasonal mean and standard value of zooplankton is represented as the maximum number of rotifer (75.75±20.48) recorded during summer season, minimum during (32.50±6.80) monsoon season. Followed by maximum number of cladocera (31.25±13.59) recorded in summer season, minimum during (13.50±3.10) monsoon season. The maximum number of copepoda (15.75±1.70) recorded in summer season, minimum during (7.00±1.41) monsoon season. Similar results observed by [42]. The maximum number of ostracoda(5.25±0.50) recorded in winter season, minimum during(1.25±0.95)monsoon season. The percentage of zooplankton rotifer was dominant (58%) followed by cladocera (26%),copepod(13%) and ostracoda (3%). Maximum abundance of zooplankton during the summer season was primarily contributed by Rotifera, Cladocera and Copepoda which may be due to favourable environmental conditions[8], maximum temperature during summer stimulates the rate of decomposition of organic matter [25], availability of more food due to decomposition of organic matter, less predation pressure[38], Similar observation made by [37];[32],[41] and[13].The moderate abundance of zooplankton fauna observed during winter season may be due to high nutrient flow during this season, maximum abundance in food supply in the form of

bacteria, suspended detritus and senescenced macrophytes with withered leaves floating on the surface of water may provide more space and shelter to the zooplankton population [2]; [33].

3.1. Shannon –Wiener diversity index (H^-):

Zooplankton Shannon –Wiener diversity index presented in table-5.Shannon –Wiener index (H^-) of highest rotifer diversity value (2.107) were recorded in winter season while the lowest rotifer diversity value (1.808) were recorded in summer season.Similar results were observed by [36]; [31].The highest cladocera diversity index (H^-) values (1.566) were recorded in winter season while the lowest cladocera diversity index (H^-) values (1.514) were recorded in monsoon season. The highest copepoda diversity index (H^-) values (1.095) were recorded in winter season while the lowest copepoda diversity index (H^-) values (1.089) were recorded in summer season. The highest ostracoda diversity index (H^-) values (0.693) were recorded in summer season while the lowest ostracoda diversity index (H^-) values (0.673) were recorded in monsoon season.

3.2. Simpson's diversity index:

Zooplankton Simpson's diversity index presented in table-5. Simpson's diversity index of highest rotifer diversity value (0.863) were recorded in winter season while the lowest rotifer diversity value were (0.782) were recorded in summer season. Similar results were observed by [36]; [31].Simpson's diversity index of highest cladocera diversity value (0.783) were recorded in winter season while the lowest cladocera diversity value were (0.763) were recorded in summer season. The highest copepod Simpson's diversity index values (0.664) were recorded in winter season while the lowest copepod Simpson's diversity index values (0.660) were recorded in summer season. The highest ostracoda Simpson's diversity index values (0.50) were recorded in summer season while the lowest ostracoda Simpson's diversity index values (0.480) were recorded in monsoon season.

Table-1: Seasonal Variations in Physico-chemical Parameters (Mean Values) of Manakondur Fresh water lake from 2020-2021

Parameters	TEM	TRS	TDS	PH	DO	CO2	TH	TA	CL	Po_4	No_3	BOD
Rainy Season	26.12 ±0.85	19.85 ±1.27	258.00 ±16.41	8.00 ±0.35	10.22 ±1.75	4.87 ±2.42	160.50 ±33.28	190.00 ±15.81	33.27 ±2.53	0.050 ±0.18	0.042 ±0.017	2.67 ±0.69
Winter Season	23.75 ±3.79	36.35 ±8.01	221.25 ±15.47	7.85 ±0.31	7.60 ±0.14	7.95 ±0.88	125.25 ±12.78	266.75 ±31.23	36.55 ±0.26	0.035 ±0.012	0.027 ±0.009	3.37 ±0.47
SummerSeason	28.50 ±2.08	29.90 ±1.86	327.50 ±22.17	7.62 ±0.09	6.10 ±0.73	4.95 ±1.33	183.75 ±11.08	183.75 ±14.93	43.57 ±6.69	0.097 ±0.06	0.10 ±0.042	5.37 ±1.37

Table-1.1: Monthly variation of individual zooplankton species in Manakondur Fresh water lake from 2020-2021

ROTIFERA															
Seasons	**Monsoon**					**Winter**					**Summer**				
Species	**Jun**	**Jul**	**Aug**	**Sep**	**Tot**	**Oct**	**Nov**	**Dec**	**Jan**	**Tot**	**Feb**	**Mar**	**Apr**	**May**	**Tot**
Brachionusangularis	6	12	2	2	**22**	8	5	4	1	**18**	1	5	4	8	**18**
Brachionuscaudatus	2	3	3	2	**10**	8	4	4	6	**22**	5	6	2	3	**16**
Brachionusdiversicornis	1	2	3	1	**7**	2	8	3	3	**16**	3	5	3	1	**12**
Cephalodella sp	3	1	2	1	**7**	2	4	2	2	**10**	3	2	2	0	**7**
Edilatata	2	1	0	1	**4**	4	3	2	6	**1**	0	2	1	3	**6**
keratellacochlerias	8	9	4	12	**33**	11	10	9	10	**40**	41	22	15	20	**98**
Keratella tropica	7	6	5	9	**27**	12	8	15	12	**47**	39	24	17	26	**106**
Lechane lunaris	5	3	2	2	**12**	9	4	5	3	**21**	8	5	6	4	**23**
Filinalongisepta	1	1	2	3	**7**	1	2	4	3	**10**	3	2	5	6	**16**
P.rsoeola	1	0	0	0	**1**	1	0	2	3	**6**	1	0	0	0	**1**
TOTAL	**35**	**39**	**23**	**33**	**130**	**58**	**48**	**50**	**49**	**191**	**104**	**73**	**55**	**71**	**303**
CLADOCERA															
Seasons	**Monsoon**					**Winter**					**Summer**				
Species	**Jun**	**Jul**	**Aug**	**Sep**	**Tot**	**Oct**	**Nov**	**Dec**	**Jan**	**Tot**	**Feb**	**Mar**	**Apr**	**May**	**Tot**
Alona rectangular	2	0	1	2	**5**	3	2	1	3	**9**	4	3	5	7	**18**
Bosminalongirostriss	0	1	1	1	**3**	1	2	5	8	**16**	2	3	2	4	**11**
Daphniacorunata	8	4	3	3	**18**	15	8	9	4	**36**	20	16	4	7	**47**
Daphnia pulex	4	5	6	4	**19**	7	6	3	2	**18**	11	4	6	3	**24**
Moinabrachiata	4	3	0	2	**9**	11	2	7	5	**25**	13	6	2	3	**24**
TOTAL	**18**	**13**	**11**	**12**	**54**	**37**	**20**	**25**	**22**	**104**	**50**	**32**	**19**	**24**	**124**
COPEPODA															
Seasons	**Monsoon**					**Winter**					**Summer**				
Species	**Jun**	**Jul**	**Aug**	**Sep**	**Tot**	**Oct**	**Nov**	**Dec**	**Jan**	**Tot**	**Feb**	**Mar**	**Apr**	**May**	**Tot**
Diaptomus sp	1	2	1	1	**5**	3	2	1	3	**9**	4	3	5	2	**14**
Mesocyclopshyailmus	6	2	4	2	**14**	4	2	5	4	**15**	2	4	7	5	**18**
Mesocyclopsleukarti	2	3	1	3	**9**	5	6	7	2	**20**	10	7	6	8	**31**

TOTAL	9	7	6	6	28	12	10	13	9	44	16	14	18	15	63
OSTRACODA															
Seasons	Monsoon					Winter					Summer				
Species	Jun	Jul	Aug	Sep	Tot	Oct	Nov	Dec	Jan	Tot	Feb	Mar	Apr	May	Tot
Cypris sp	0	2	0	2	**4**	2	4	2	4	**12**	1	0	1	1	**3**
Hemicypris fossulata	0	0	1	0	**1**	4	1	3	1	**9**	0	2	1	2	**5**
TOTAL	**0**	**2**	**1**	**2**	**5**	**6**	**5**	**5**	**5**	**21**	**1**	**2**	**2**	**3**	**8**

Table-2: Group wise percentage of zooplankton diversity in Manakondur Lake during 2020-2021

Seasons	Monsoon	Winter	Summer	Total	Percentage
Rotifera	130	191	303	624	58%
Cladocera	54	104	124	282	26%
Copepoda	28	44	63	135	13%
Ostracoda	5	21	8	34	3%
Total	217	360	498	1075	100%

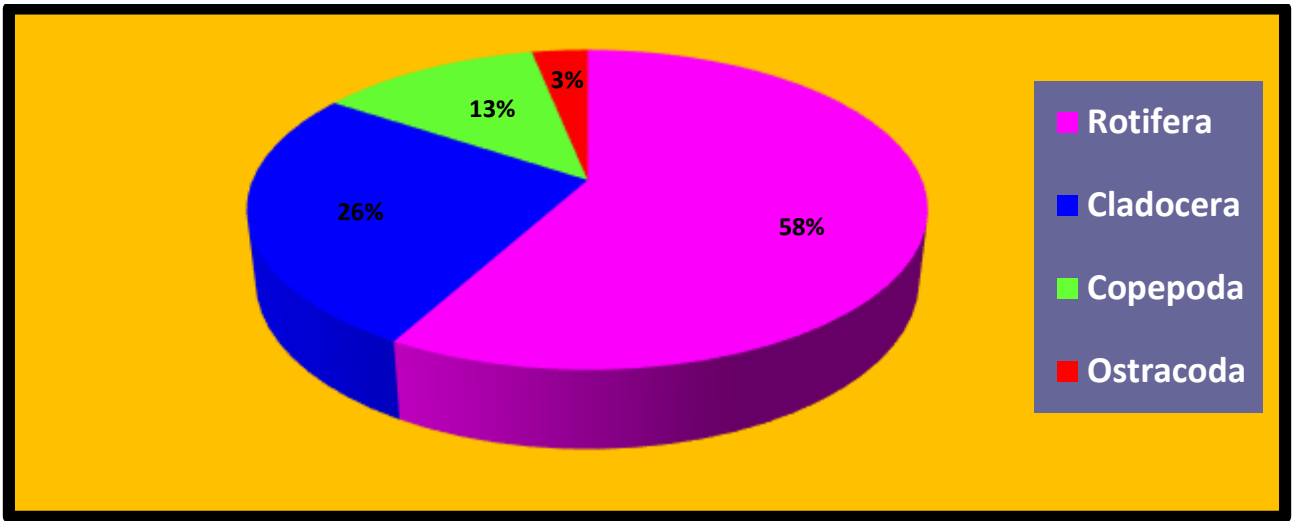

Figure 2: *Percentage of different zooplankton groups in Manakondur Lake*

Table-2.1: Seasonal mean diversity of zooplankton in Manakondur Lake during 2020-2021

Seasons	Monsoon	Winter	Summer
Rotifera	**32.50±6.80**	**51.25±4.57**	**75.75±20.48**
Cladocera	**13.50±3.10**	**26.00±7.61**	**31.25±13.59**
Copepoda	**7.00±1.41**	**11.00±1.82**	**15.75±1.70**
Ostracoda	**1.25±0.95**	**5.25±0.50**	**2.00±0.81**

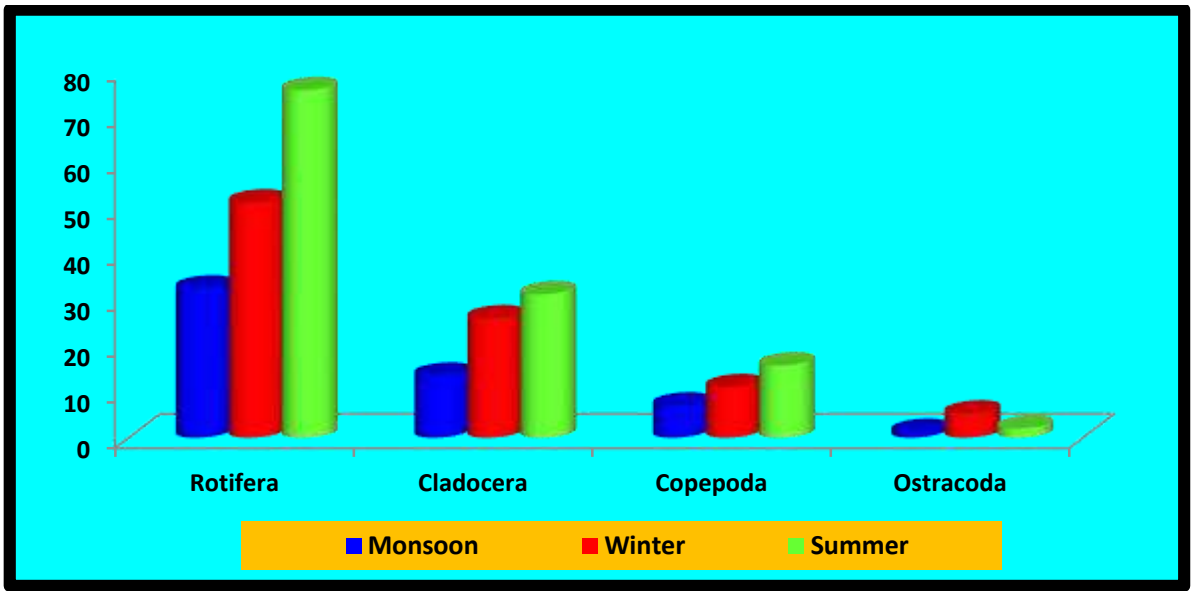

Figure 3: Seasonal mean diversity of zooplankton Manakondur Lake

Table 3:- Showing Diversity indices Seasonal values of Manakondur Lake during the year 2020-2021

Group	Diversity Index	Season		
		Monsoon	Winter	Summer
Rotifera	Simpson_1-D	0.858	0.863	0.782
	Shannon_H	2.089	2.107	1.808
Cladocera	Simpson_1-D	0.763	0.783	0.778
	Shannon_H	1.514	1.566	1.557
Copepoda	Simpson_1-D	0.661	0.664	0.660
	Shannon_H	1.090	1.095	1.089
Ostracoda	Simpson_1-D	0.480	0.498	0.50
	Shannon_H	0.673	0.692	0.693

4. CONCLUSION:

The present study revealed that, the distribution and diversity of zooplankton is depending on the physicochemical parameters prevailing in the environment. Hence measures should be taken to minimize the freshwater pollution by minimizing or preventing washing of clothes, bathing and other human activities. It is understood that the Manakondur fresh water Lake is very good for natural pisciculture practices. In addition, the data generated from this investigation are being useful to the decision maker for the effective conservation and sustainable utilization of this water body.

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