International Journal of Agricultural and Natural Sciences
E-ISSN: 2651-3617 15(1): 1-14, 2022
Research Article

IDENTIFICATION OF FRESHWATER ZOOPLANKTON IN GODAVARI RIVER CONCERNING FOOD CHAIN IN AQUATIC ECOSYSTEM OF NANDED, MAHARASHTRA, INDIA

Sonali Yannawar[1] Rani Akkewar[2], Vyankatesh Yannawar[3*], Sujit Pedewad[4]

[1]*School of Chemical Sciences, S.R.T.M. University, Nanded, Maharashtra, India*
[2]*School of Earth Sciences, S.R.T.M. University, Nanded, Maharashtra, India*

**Corresponding Author:*
E-mail: vyanky@hotmail.com

(Received 14th September 2021; accepted 10th March 2022)

ABSTRACT. Plankton occupies the first link in the food chain of the aquatic ecosystem and considers as an important source of food for fish and other aquatic organisms in which zooplankton is the secondary producer of the aquatic ecosystem. It always survives near the surface area of the fresh water and sea because; it requires a food nutrient which is near sea and river banks. Zooplankton is the fauna for the food it depends on phytoplankton. The growth of these organisms' other aquatic life depends. Most changes in the diversity of this organism are due to seasonal wise and with some abiotic factors. Hence the study of zooplankton undertaken with some physicochemical characteristics of this water body needs to be monitored. The present study is aimed to study zooplankton and its diversity along with composition relationships among different zooplankton groups and abiotic factors during the period January 2020 to December 2020 of a Godavari River from Nanded city, Maharashtra. Samplings were carried out seasonally like summer, winter, and monsoon nearly four sampling sites in this reservoir were selected. In study showed that the Rotifera group was the most dominant among all three groups and having Positive correlation was found between zooplankton growth with water temperature and pH while their growth was a negative correlation with increasing dissolved oxygen. are mostly affected with seasonal basis observed the period of this winter is highly suitable for Cladocera genera and Rotifera genera summer season and Copepoda, Protozoa and Ostracoda monsoon respectively highly suitable.

Keywords: *Physico-chemical parameter, Zooplankton, Godavari River, Rotifera, Dominant*

INTRODUCTION

Plankton plays an important role in a freshwater ecosystem which acts as a basic food source of any aquatic ecosystem [1]. The planktonic plants are known as phytoplankton and planktonic animals are called zooplankton [13] For the food purpose Phytoplankton trapped solar energy latter producers are consumed by the zooplankton, which is primarily consumer and secondary consumers are the macroinvertebrates and planktivorous fish, which are consumed by large fishes hence zooplankton are the central trophic link between primary producers and higher trophic levels. Thus, the transfer of food energy from producer to consumer and is consumed is called a food chain [2]. In the lake, ecosystem zooplankton occupies an important position structure and plays an essential role in energy transfer [5].

Zooplanktons are microscopic and heterogeneous free-floating organism is an intermediate between phytoplankton and fish for food purposes. These are good indicators of water quality they are very sensitively affected with the environmental condition because of their short life cycle, which changes water quality [3]. In an aquatic ecosystem 90% of zooplankton species are herbivorous and 10% are carnivorous. The zooplankton has a role in converting phytoplankton into food, suitable for fish and aquatic animals have an important position in fishery research. Zooplanktons feed during the night when the protein content of the algae is highest, predation least, and temperature is high allowing rapid feeding while spending the rest of the day in water lower temperature allowing more efficient growth [4].

Zooplankton constitutes the basic food for higher invertebrates like fishes and especially their larvae and energy transfer in the aquatic ecosystem and are also a good indicator of water quality they feed on phytoplankton [11]. The higher level of zooplankton species density and physicochemical parameters may depend upon the levels of organic enrichment.[6],[14]. Due to anthropogenic activity nutrients, eutrophication enrichment in water bodies hence highly undesirable changes in the freshwater and marine ecosystem.

Freshwater zooplankton is a microscopic animal and feeds on a primary producer and acts as a primary consumer and produces food for tertiary consumers [7]. For the maintenance of healthy aquatic ecosystem abiotic properties of water and the biological diversity of the ecosystem are responsible [8]. Quantitative variation of zooplankton is mostly due to seasonal changes and responds quickly to water qualitative changes as well as it acts as a biological indicator of water pollution. [9] For the water quality assessment, zooplankton diversity has the most important role to use as an indicator of eutrophication. Hence studies of zooplankton with qualitative and quantitative have great importance in Reservoir water body [10], [12]. Studied that the temperature changes affect the production of Zooplankton. He observed the production of zooplankton increased during the period of low temperature and decreased when the temperature was considerably high.

The water of this Godavari River water is primarily used for washing, bathing fishing activities, agriculture, and other domestic purpose but recently it is at a transitional state concerning degradation. The present study is based on monthly variation in the physicochemical parameters and correlates with zooplankton population diversity. Phytoplankton plays a role in the biology of the aquatic environment. The natural existence of the wall provides all the living things of the spiritual body with proper food or other supplies. Actual data on implementation numbers is important for fishing. According to the study, the purpose of this study is to better understand the characteristics of organic water algae. The purpose of this study was to identify the species of aquariums and plankton from the river. An investigation is underway because the charges are not known. Notwithstanding this, not all data is available on local data.

The Godavari River is known as the Dakshin Ganga, behind the skull, it is the largest river in India and has a great history, history, and culture. Godavari river originated in the Trimbakshwar mountain in Nashik district of Maharashtra and its length is about 500 km. In Maharashtra, two dams on the Godavari River are built one is the Jaikwadi at Paithan in Aurangabad District and another is the Vishnupuri dam at Nanded. It is necessary to develop a floristic chart and database of the present-day freshwater macroalgal flora of the Godavari River and surrounding areas.

MATERIALS AND METHODS

Study Area

For the present study, the path of the Godavari River in the Nanded district is selected. The stretch of Godavari River from Rahati to Sangam which is about 150 km in length is taken for present investigations. To see the impact of the city as well as of the other locations on the quality of river water this stretch of the river is chosen. (Fig.1) Nanded district is situated in the Godavari basin. Towards the north-western side Parbhani district and Hingoli districts are located and towards the southwest side of Nanded, Latur district is located while Yeotmal district is located towards the northern side of the Nanded District. The state of Andhra Pradesh lies to the east and Karnataka state to the southern side of the Nanded District. The study area is bounded by latitude $18^{o}15'$ to $19^{o}55'$ N and $77^{o}7'$ to $78^{o}15'$ E longitude. The Nanded district covers an area of 10528.00 sq. km. It contributes 3.42 % area of Maharashtra state. Among the 38 districts in the state, it ranks 14^{th} in its area [25].

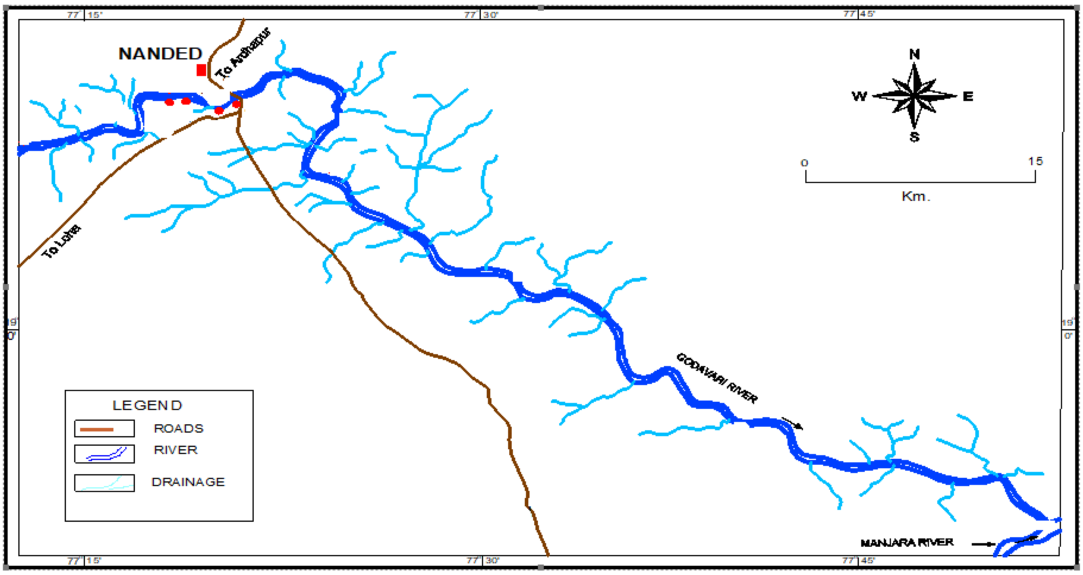

Fig.1. *Showing selected sampling locations in Godavari River of Nanded City, [MH]*

Sample Collection Site

We collected the water sample of Godavari River and analysis of physicochemical parameters with plankton (i.e., zooplankton) sp. identification. We selected three points for the water sample collection of Godavari River and collect a water sample in 3 liters. Water cane made up of plastic, the sample was once in month collected at morning 9 to 10 AM during the period January 2020 to December 2020.

Zooplankton collection and identification

We used a Planktonic net at the end of this glass bottle for the collection of Plankton samples. Zooplankton samples were preserved by 4% formalin added in the collected sample. The samples were analyzed qualitatively with the help of a microscope and quantitative estimation was carried out by using the Sedgwick-Rafter Cell method which is expressed as numbers per liter and identification of zooplanktons done by using keys and published literature.

For the diversity find out we used Shannon's and Weaver (1949) formula

$$H = - \Sigma (ni/N) \log (ni/N)$$

Whereas,

H = Shannon's – Wiener's index of species diversity in individuals.
ni= Total number of individuals
N= Total number of individuals of all species
Pi= Importance of probability for each species (ni/Ni)

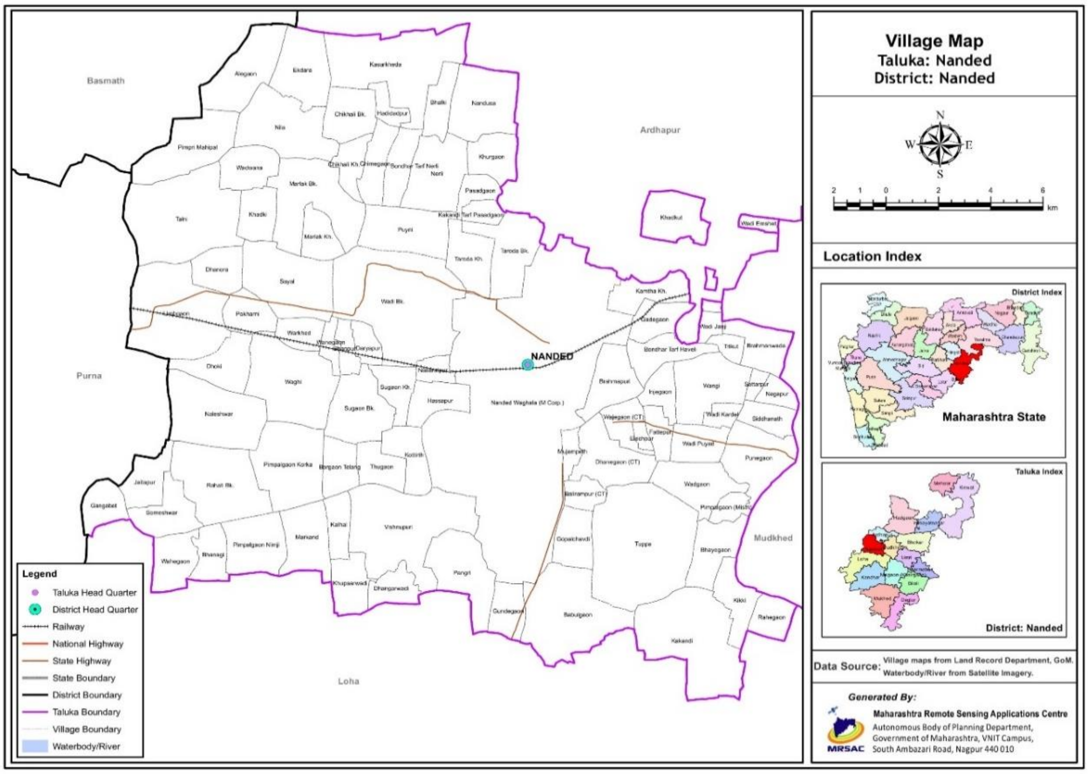

Fig. 2. *Showing the location of Nanded Taluka in Nanded district, Maharashtra, India*

Physico-Chemical Parameters

The samples were collected from January 2020 to December 2020 of each month between 9 to 10 AM. Collected samples physicochemical parameters like PH, Temperature (T.,°C) were recorded at the sampling site and other physicochemical parameters likewise Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chloride (Cl), Phosphate (PO_4), Sulphate (SO_4) analyzed in the laboratory of School of Earth Sciences, Swami Ramanand Teerth Marathwada University Nanded as per standard methods for examinations of water sample given by APHA [15], [16] and Nitrite (NO_2-N) by [17].

RESULTS AND DISCUSSION

The consequences received from the water quality examination and identification of zooplankton and their statistics are perceived in detail are described below in tables and summarized below iubsequently are as follows. Respectively Table 1, 2, and 3 showed that among all classes of zooplankton Rotifera population was the highest amount and the Ostracoda population has been found a lower amount.

Zooplankton Species

In the class of Rotifera at the three sites of Godavari River *Brachionus falcatus sp.* had the highest amount of population and *Keratella chochlearis sp.* in lower amount of population was observed. Likewise, the class of Copepoda *Macrobrachium sp. population* was highest and *Thermocyclops sp.* population in lower amount observed. In the class of Cladocera *Moina micrura sp.* population was highest and *Moina Brachiata sp.* population in lower amount observed and a class of protozoa *A. discoides sp.* population larger amount and *Caculeate sp.* population lower amount found compared to other species of protozoa. As well as the class of Ostracoda *Stenocypris sp.* population was dominated compared to *Heterocypris sp.* population.

Table 1. *Study area site 1 of Godavari River*

Zooplankton species	Monsoon			Winter			Summer		
	(ni)	(ni/N)	Log ni/N	(ni)	(ni/N)	Log ni/N	(ni)	(ni/N)	Log ni/N
Rotifers									
Brachionus falcatus	102	0.18378378	-0.73569281	68	0.15077605	-0.82166763	120	0.19672131	-0.70614859
B. forficula	60	0.10810811	-0.96614173	56	0.12416851	-0.90598851	80	0.13114754	-0.88223985
B. caudatus	92	0.16576577	-0.78050516	85	0.18847007	-0.72475762	93	0.15245902	-0.81684689
B. Calyciflorus	80	0.14414414	-0.841203	65	0.14412417	-0.84126319	85	0.13934426	-0.85591091
Filinia longiseta	71	0.12792793	-0.89303463	55	0.12195122	-0.91381385	70	0.1147541	-0.94023179
diversicornis	30	0.05405405	-1.26717173	26	0.05764967	-1.23920319	34	0.0557377	-1.25385092
Keratella tropica	85	0.15315315	-0.81487406	75	0.16629712	-0.77911528	88	0.1442623	-0.84084716
Keratella chochlearis	35	0.06306306	-1.20022494	21	0.04656319	-1.33195725	40	0.06557377	-1.18326984
Total	**555**			**451**			**610**		
Copepoda									
Mesocyclops sp.	56	0.18006431	-0.74457236	44	0.18565401	-0.73129567	46	0.17293233	-0.7621238
Microcyclops sp.	66	0.21221865	-0.67321645	58	0.24472574	-0.61132035	62	0.23308271	-0.63248995
Macrocyclops sp.	55	0.17684887	-0.7523977	48	0.20253165	-0.69350711	51	0.19172932	-0.71731146
Macrobrachium	68	0.21864952	-0.66025148	45	0.18987342	-0.72153583	56	0.21052632	-0.67669361
Thermocyclops	30	0.09646302	-1.01563913	22	0.092827	-1.03232567	26	0.09774436	-1.00990829
Undinula valgaris	36	0.11575563	-0.93645789	20	0.57142857	-0.24303805	25	0.09398496	-1.02694163
Total	**311**			**237**			**266**		
Cladocera									
Moina micrura	65	0.26530612	-0.57625273	70	0.25641026	-0.59106461	60	0.26315789	-0.5797836
Moina Brachiata	56	0.22857143	-0.64097806	60	0.21978022	-0.6580114	52	0.22807018	-0.6419315
Damphinea sp.	63	0.25714286	-0.58982553	74	0.27106227	-0.56693093	58	0.25438596	-0.59450685
Macrothrix sp.	61	0.24897959	-0.60383625	69	0.25274725	-0.59731356	58	0.25438596	-0.59450685
Total	**245**			**273**			**228**		
Protozoa									
A.discoides	30	0.23809524	-0.62324929	28	0.25925926	-0.58626572	25	0.26595745	-0.57518784
Caculeate	26	0.20634921	-0.6853972	24	0.22222222	-0.65321251	20	0.21276596	-0.67209786
Paramecium sp.	30	0.23809524	-0.62324929	26	0.24074074	-0.61845041	22	0.23404255	-0.63070517
Vorticella sp.	40	0.31746032	-0.49831055	30	0.27777778	-0.5563025	27	0.28723404	-0.54176409
Total	**126**			**108**			**94**		
Ostracoda									
Stenocypris	30	0.51724138	-0.28630674	25	0.53191489	-0.27415785	21	0.53846154	-0.26884531
Heterocypris	28	0.48275862	-0.31626996	22	0.46808511	-0.32967518	18	0.46153846	-0.3357921
Total	**58**			**47**			**39**		

Table 2. *Study Area of Site 2 of Godavari River*

Zooplankton species	Monsoon			Winter			Summer		
	(ni)	**(ni/N)**	**Log ni/N**	**(ni)**	**(ni/N)**	**Log ni/N**	**(ni)**	**(ni/N)**	**Log ni/N**
Rotifers									
Brachionus falcatus	108	0.18848168	-0.72473087	69	0.15098468	-0.82106711	125	0.19872814	-0.70174063
B. forficula	62	0.10820244	-0.96576293	55	0.12035011	-0.91955351	85	0.13513514	-0.86923172
B. caudatus	94	0.16404887	-0.78502677	86	0.18818381	-0.72541775	95	0.15103339	-0.82092704
B. Calyciflorus	82	0.14310646	-0.84434077	64	0.14004376	-0.85373623	86	0.13672496	-0.86415219
Filinia longiseta	72	0.12565445	-0.90082213	56	0.12253829	-0.91172817	72	0.11446741	-0.94131815
diversicornis	33	0.05759162	-1.23964068	28	0.06126915	-1.21275817	36	0.0572337	-1.24234814
Keratella tropica	88	0.15357766	-0.81367195	78	0.17067834	-0.7678216	90	0.14308426	-0.84440814
Keratella chochlearis	34	0.05933682	-1.2266757	21	0.04595186	-1.33769691	40	0.063593	-1.19659065
Total	**573**			**457**			**629**		
Copepoda									
Mesocyclops sp.	56	0.17445483	-0.75831701	48	0.19753086	-0.70436504	47	0.16845878	-0.77350635
Microcyclops sp.	68	0.21183801	-0.67399612	60	0.24691358	-0.60745502	64	0.22939068	-0.63942423
Macrocyclops sp.	58	0.18068536	-0.74307704	50	0.20576132	-0.68663627	54	0.19354839	-0.71321044
Macrobrachium	69	0.21495327	-0.66765594	44	0.18106996	-0.7421536	58	0.2078853	-0.68217621
Thermocyclops	32	0.09968847	-1.00135505	21	0.08641975	-1.06338698	28	0.10035842	-0.99844617
Undinula valgaris	38	0.11838006	-0.92672144	20	0.08230453	-1.08457628	28	0.10035842	-0.99844617
Total	**321**			**243**			**279**		
Cladocera									
Moina micrura	69	0.27380952	-0.56255145	73	0.25795053	-0.58846358	59	0.26818182	-0.57157067
Moina Brachiata	55	0.21825397	-0.66103785	64	0.22614841	-0.64560646	50	0.22727273	-0.64345268
Damphinea sp.	66	0.26190476	-0.58185661	74	0.2614841	-0.58255472	55	0.25	-0.60205999
Macrothrix sp.	62	0.24603175	-0.60900885	72	0.25441696	-0.59445394	56	0.25454545	-0.59423465
Total	**252**			**283**			**220**		
Protozoa									
A.discoides	34	0.24817518	-0.60524165	29	0.25438596	-0.59450685	24	0.26086957	-0.58357659
Caculeate	27	0.19708029	-0.7053568	26	0.22807018	-0.6419315	19	0.20652174	-0.68503423
Paramecium sp.	32	0.23357664	-0.63157059	25	0.21929825	-0.65896484	21	0.22826087	-0.64156853
Vorticella sp.	44	0.32116788	-0.49326789	34	0.29824561	-0.52542593	28	0.30434783	-0.5166298
Total	**137**			**114**			**92**		
Ostracoda									
Stenocypris	32	0.56140351	-0.25072488	22	0.48888889	-0.31078983	23	0.47916667	-0.3195134
Heterocypris	25	0.43859649	-0.35793485	23	0.51111111	-0.29148468	25	0.52083333	-0.28330123
Total	**57**			**45**			**48**		

We also observed that the class of *Copepoda* and *Ostracoda* sp. population was the highest growth in the monsoon season followed by the summer and winter seasons. The class of Rotifera has the summer season highest population growth followed by the monsoon and winter season and the class of Cladocera has the highest population growth in the winter season then the monsoon and summer season and class of Protozoa has monsoon season highest population growth followed by winter and summer season were observed.

Table 3. *Study Area of Site 3 of Godavari River*

Zooplankton species	**Monsoon**			**Winter**			**Summer**		
	(ni)	**(ni/N)**	**Log ni/N**	**(ni)**	**(ni/N)**	**Log ni/N**	**(ni)**	**(ni/N)**	**Log ni/N**
Rotifers									
Brachionus falcatus	112	0.18791946	-0.72602824	68	0.14782609	-0.83024892	126	0.196875	-0.70580943
B. forficula	64	0.10738255	-0.96906629	58	0.12608696	-0.89932984	86	0.134375	-0.87168152
B. caudatus	99	0.16610738	-0.77961107	88	0.19130435	-0.71827516	96	0.15	-0.82390874
B. Calyciflorus	84	0.1409396	-0.85096697	66	0.14347826	-0.8432139	88	0.1375	-0.8616973
Filinia longiseta	76	0.12751678	-0.89443267	58	0.12608696	-0.89932984	74	0.115625	-0.93694825
diversicornis	35	0.05872483	-1.23117822	24	0.05217391	-1.28254659	40	0.0625	-1.20411998
Keratella tropica	90	0.15100671	-0.82100375	76	0.16521739	-0.78194424	92	0.14375	-0.84239215
Keratella chochlearis	36	0.06040268	-1.21894376	22	0.04782609	-1.32033515	38	0.059375	-1.22639638
Total	**596**			**460**			**640**		
Copepoda									
Mesocyclops sp.	54	0.16875	-0.77275622	50	0.19607843	-0.70757018	52	0.17808219	-0.74937951
Microcyclops sp.	65	0.203125	-0.69223662	62	0.24313725	-0.61414849	65	0.22260274	-0.65246949
Macrocyclops sp.	59	0.184375	-0.73429797	50	0.19607843	-0.70757018	58	0.19863014	-0.70195486
Macrobrachium	68	0.2125	-0.67264107	48	0.18823529	-0.72529894	60	0.20547945	-0.6872316
Thermocyclops	35	0.109375	-0.96108193	24	0.19512195	-0.70969387	27	0.09246575	-1.03401909
Undinula valgaris	39	0.121875	-0.91408537	21	0.08235294	-1.08432089	30	0.10273973	-0.9882616
Total	**320**			**255**			**292**		
Cladocera									
Moina micrura	68	0.26356589	-0.57911079	76	0.2585034	-0.58753374	61	0.28110599	-0.5511299
Moina Brachiata	56	0.43410853	-0.36240168	70	0.23809524	-0.62324929	48	0.22119816	-0.6552185
Damphinea sp.	68	0.26356589	-0.57911079	76	0.2585034	-0.58753374	58	0.26728111	-0.57303174
Macrothrix sp.	66	0.25581395	-0.59207577	72	0.24489796	-0.61101483	50	0.23041475	-0.63748973
Total	**258**			**294**			**217**		
Protozoa									
A.discoides	36	0.24657534	-0.60805036	29	0.25	-0.60205999	22	0.25287356	-0.59709657
Caculeate	30	0.20547945	-0.6872316	26	0.22413793	-0.64948464	18	0.20689655	-0.68424675
Paramecium sp.	33	0.10610932	-0.97424645	25	0.21551724	-0.66651798	21	0.24137931	-0.61729996
Vorticella sp.	47	0.32191781	-0.492255	36	0.31034483	-0.50815549	26	0.29885057	-0.5245459
Total	**146**			**116**			**87**		
Ostracoda									
Stenocypris	34	0.47222222	-0.32585358	20	0.48780488	-0.31175386	22	0.48888889	-0.31078983
Heterocypris	38	0.52777778	-0.2775489	21	0.51219512	-0.29056456	23	0.51111111	-0.29148468
Total	**72**			**41**			**45**		

***Table 4**. Comparison of one-year data of two selected sampling sites of Godavari River*

	Study area site 1 of Godavari River			Study area site 2 of Godavari River		
Zooplankton species	**Monsoon (ni/N) Log ni/N**	**Winter (ni/N) Log ni/N**	**Summer (ni/N) Log ni/N**	**Monsoon (ni/N) Log ni/N**	**Winter (ni/N) Log ni/N**	**Summer (ni/N) Log ni/N**
Rotifers						
Brachionus falcatus	-0.13521	-0.12389	-0.13891	-0.1366	-0.12397	-0.13946
B. forficula	-0.10445	-0.1125	-0.1157	-0.1045	-0.11067	-0.11746
B. caudatus	-0.12938	-0.1366	-0.12454	-0.12878	-0.13651	-0.12399
B. Calyciflorus	-0.12125	-0.12125	-0.11927	-0.12083	-0.11956	-0.11815
Filinia longiseta	-0.11424	-0.11144	-0.1079	-0.11319	-0.11172	-0.10775
diversicornis	-0.0685	-0.07144	-0.06989	-0.07139	-0.0743	-0.0711
Keratella tropica	-0.1248	-0.12956	-0.1213	-0.12496	-0.13105	-0.12082
Keratella chochlearis	-0.07569	-0.06202	-0.07759	-0.07279	-0.06147	-0.07609
Total	**-0.87352**	**-0.86869**	**-0.8751**	**-0.87304**	**-0.86926**	**-0.87483**
Copepoda						
Mesocyclops sp.	-0.13407	-0.13577	-0.1318	-0.13229	-0.13913	-0.1303
Microcyclops sp.	-0.14287	-0.14961	-0.14742	-0.14278	-0.14999	-0.14668
Macrocyclops sp.	-0.13306	-0.14046	-0.13753	-0.13426	-0.14128	-0.13804
Macrobrachium	-0.14436	-0.137	-0.14246	-0.14351	-0.13438	-0.14181
Thermocyclops	-0.09797	-0.09583	-0.09871	-0.09982	-0.0919	-0.1002
Undinula valgaris	-0.1084	-0.13888	-0.09652	-0.10971	-0.08927	-0.1002
Total	**-0.76074**	**-0.79754**	**-0.75444**	**-0.76238**	**-0.74595**	**-0.75724**
Cladocera						
Moina micrura	-0.15288	-0.15156	-0.15257	-0.15403	-0.15179	-0.15328
Moina Brachiata	-0.14651	-0.14462	-0.14641	-0.14427	-0.146	-0.14624
Damphinea sp.	-0.15167	-0.15367	-0.15123	-0.15239	-0.15233	-0.15051
Macrothrix sp.	-0.15034	-0.15097	-0.15123	-0.14984	-0.15124	-0.15126
Total	**-0.6014**	**-0.60082**	**-0.60145**	**-0.60053**	**-0.60137**	**-0.6013**
Protozoa						
A.discoides	-0.14839	-0.15199	-0.15298	-0.15021	-0.15123	-0.15224
Caculeate	-0.14143	-0.14516	-0.143	-0.13901	-0.14641	-0.14147
Paramecium sp.	-0.14839	-0.14889	-0.14761	-0.14752	-0.14451	-0.14644
Vorticella sp.	-0.15819	-0.15453	-0.15561	-0.15842	-0.15671	-0.15724
Total	**-0.59641**	**-0.60057**	**-0.5992**	**-0.59516**	**-0.59886**	**-1.2026**
Ostracoda						
Stenocypris	-0.14809	-0.14583	-0.14476	-0.14076	-0.15194	-0.1531
Heterocypris	-0.15268	-0.15432	-0.15498	-0.15699	-0.14898	-0.14755
Total	**-0.30077**	**-0.30014**	**-0.29974**	**-0.29775**	**-0.30092**	**-0.30065**
H=-Σ(ni/N) Log ni/N	**3.13285**	**3.16776**	**3.12993**	**3.12886**	**3.11635**	**3.73662**

The availability of the high population density of the zooplankton more during the wet season than the dry may be as a result of seasonal variation in the physicochemical parameters and attributed to the inflow of rainy water with favorable environment conditions. [18]. The high population density in the monsoon period may be as a result of abundant food sources from the runoff and low predation rate by fish during wet season caused by plankton increased breading activity which is support to the high population density of zooplankton. [19], [20]. Studied that class of Rotifera was the most dominant group having positively influenced by BOD, Cl, and PO_4. etc.

Table 5. *One-year data of third selected sampling site of Godavari River*

Zooplankton species	Monsoon (ni/N) Log ni/N	Winter (ni/N) Log ni/N	Summer (ni/N) Log ni/N
Rotifers			
Brachionus falcatus	-0.13643	-0.12273	-0.13896
B. forficula	-0.10406	-0.11339	-0.11713
B. caudatus	-0.1295	-0.13741	-0.12359
B. Calyciflorus	-0.11993	-0.12098	-0.11848
Filinia longiseta	-0.11406	-0.11339	-0.10833
diversicornis	-0.0723	-0.06692	-0.07526
Keratella tropica	-0.12398	-0.12919	-0.12109
Keratella chochlearis	-0.07363	-0.06315	-0.07282
Total	**-0.87389**	**-0.86716**	**-0.87566**
Copepoda			
Mesocyclops sp.	-0.1304	-0.13874	-0.13345
Microcyclops sp.	-0.14061	-0.14932	-0.14524
Macrocyclops sp.	-0.13539	-0.13874	-0.13943
Macrobrachium	-0.14294	-0.13653	-0.14121
Thermocyclops	-0.10512	-0.13848	-0.09561
Undinula valgaris	-0.1114	-0.0893	-0.10153
Total	**-0.76586**	**-0.7911**	**-0.87566**
Cladocera			
Moina micrura	-0.15263	-0.15188	-0.15493
Moina Brachiata	-0.15732	-0.14839	-0.14493
Damphinea sp.	-0.15263	-0.15188	-0.15316
Macrothrix sp.	-0.15146	-0.14964	-0.14689
Total	**-0.61405**	**-0.60179**	**-0.59991**
Protozoa			
A.discoides	-0.14993	-0.15051	-0.15099
Caculeate	-0.14121	-0.14557	-0.14157
Paramecium sp.	-0.10338	-0.14365	-0.149
Vorticella sp.	-0.15847	-0.1577	-0.15676
Total	**-0.55298**	**-0.59744**	**-0.59832**
Ostracoda			
Stenocypris	-0.15388	-0.15208	-0.15194
Heterocypris	-0.14648	-0.14883	-0.14898
Total	**-0.30036**	**-0.3009**	**-0.30092**
H=-Σ(ni/N) Log ni/N	**3.10714**	**3.15839**	**3.25047**

The biodiversity of zooplankton taxa was studied with various population densities of the zooplankton groups, and it was found to be in like this order Rotifera > Copepoda > Cladocera > Ostracoda. The high and low population densities were obtained in the summer and early monsoon season respectively. This higher zooplankton population density in summer might be the reason for the temperature [21]. Researched that zooplankton population was dominated by Rotifera (39%), cladocera (33%), copepoda (19%), and ostracoda (9%) respectively where the number of Rotifers increased in summer which may be due to the higher amount of chloride and levels showed greater periodicity being higher during summer, which may be due to high rate of evaporation during hotter months [22]. The presence of phosphate and temperature in water helpful for the growth of zooplankton and their maximum population density is due to available source of food viz. phytoplankton for these dissolved oxygen and temperature factors were played an important role to maintain diversity and population of zooplankton showed by [23].

Physico-chemical Parameters

Table 6. *Physico-chemical Parameters of sampling site 1*

Study Period		Temp °C	pH	DO	BOD	Cl	PO_4	SO_4	NO_2-N
Summer	Jun.2017	24	8.3	2.6	1.56	30.2	0.021	3.6	0.005
	May-18	26	8.6	2.86	1.74	32.1	0.028	3.7	0.007
	Apr.2018	28	8.4	2.74	1.6	33.12	0.035	4.8	0.011
	Mar.2018	24	8.4	2.52	1.2	33.36	0.018	7.25	0.012
Winter	Feb.2018	24	8.4	2.64	0.66	28.3	0.033	7.85	0.01
	Jan 2018	23	8.3	2.62	0.94	27.3	0.069	8.4	0.0144
	Dec.2017	23	8.3	2.34	0.86	24.34	0.072	8.2	0.021
	Nov.2017	22	8.3	2.62	1.18	24.38	0.047	8.7	0.028
Monsoon	Oct.2017	20	8.2	2.8	0.9	26.32	0.038	8.9	0.034
	Sep.2017	21	8.3	2.88	0.94	24.22	0.45	9.4	0.036
	Aug.2017	18	8.2	2.86	0.94	26.24	0.049	9.2	0.04
	July.2017	15	8.2	2.78	0.98	22.34	0.05	9.5	0.045
	Mean	16.7	8.17	2.77	0.71	21.97	0.156	11.03	0.046

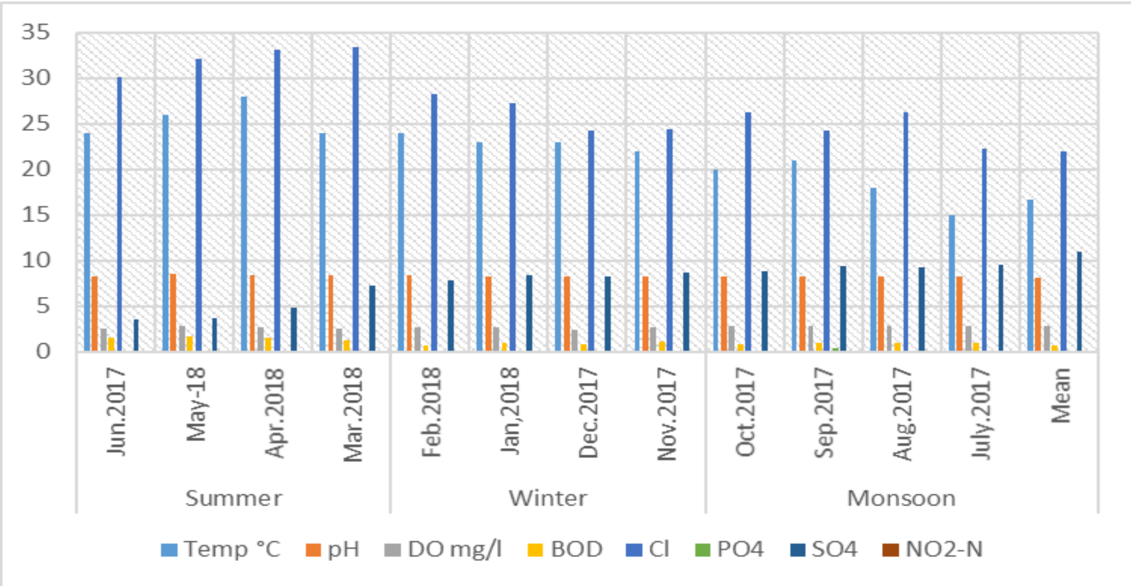

Fig. 3. *showing Physico-chemical Parameters of sampling site 1 of the Godavari River*

(Table 1) The quantity of zooplankton in all three studied areas was richness observed in monsoon periods whereas the lowest number in the summer and medium quantity in the winter period [24]. Obtained that class of rotifers were dominant in summers and winter season and low in the rainy season. Where he also analyzed that concentration of DO was low recorded during summer. This may be related to low solubility at high temperatures and high degradation of organic substances. In the present study of the Godavari River class of Rotifera was dominant in summer and monsoon and low in winter found. It may be due to irregular rainfall and little amount increasing temperature hence aquatic climate changes in the reservoir.

Table 7. *Physico-chemical Parameters of Sampling site 2*

Study Period		Temp °C	pH	DO	BOD	Cl	PO_4	SO_4	NO_2-N
Summer	Jun.2017	24	8.6	2.58	1.55	28.22	0.023	4	0.004
	May-18	26	8.4	2.84	1.7	30.06	0.033	4.2	0.006
	Apr.2018	26	8.3	2.76	1.6	32.28	0.016	5.1	0.021
	Mar.2018	24	8.4	2.54	1.34	33.42	0.025	7.8	0.016
Winter	Feb.2018	23	8.3	2.62	0.68	30.2	0.045	7.25	0.024
	Jan 2018	22	8.4	2.64	0.96	26.06	0.05	9.2	0.027
	Dec.2017	21	8.2	2.44	0.9	24.44	0.025	8.9	0.021
	Nov.2017	22	8.3	2.64	1.16	26.38	0.033	9.6	0.03
Monsoon	Oct.2017	19	8.3	2.9	1	26.28	0.037	9.2	0.031
	Sep.2017	20	8.2	2.96	0.98	28.22	0.038	9.4	0.041
	Aug.2017	18	8.2	2.88	0.96	28.26	0.04	9.3	0.043
	July.2017	19	8.1	2.88	1.08	24.32	0.042	9.5	0.045
	Mean	18	8.1	2.87	0.78	25	0.04	11.2	0.048

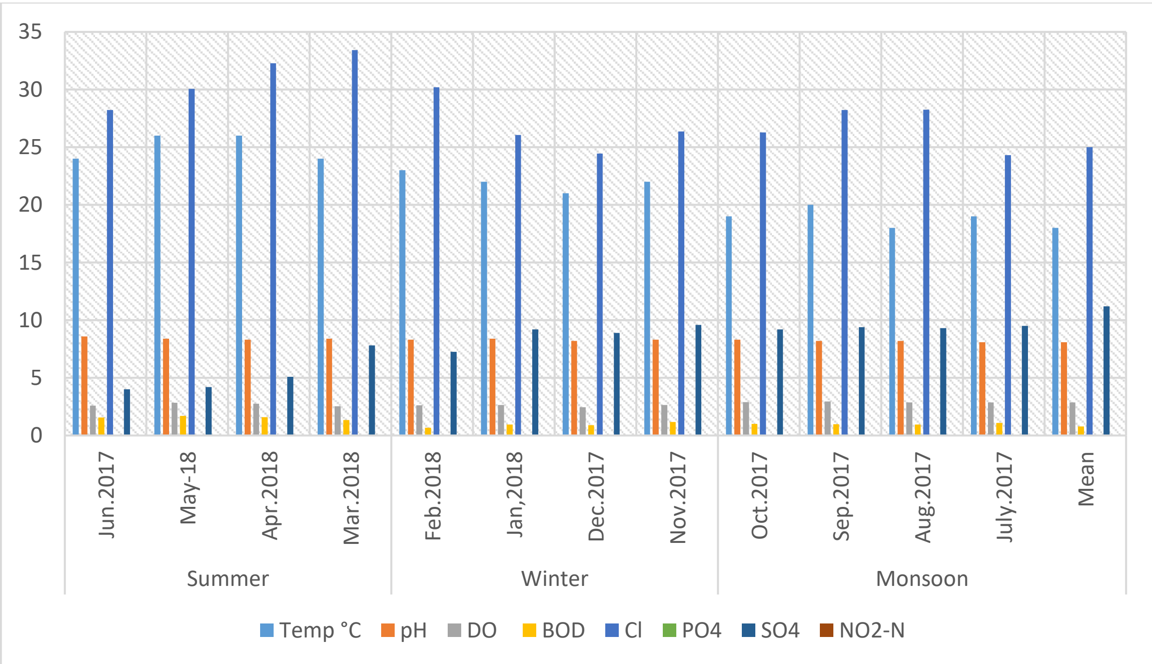

Fig. 4. *Showing Physico-chemical Parameters of sampling site 2 of the Godavari River*

Table 8. *Physico-chemical Parameters of Sampling site 3*

Study Period		Temp °C	pH	DO mg/l	BOD	Cl	PO_4	SO_4	NO_2-N
Summer	Jun.2017	24	8.3	2.66	1.6	33.22	0.03	4.2	0.011
	May-18	26	8.8	2.88	1.79	35.04	0.033	4	0.0144
	Apr.2018	28	8.6	2.74	1.64	34.66	0.04	5.3	0.016
	Mar.2018	24	8.4	2.5	1.18	33.44	0.047	5.8	0.016
Winter	Feb.2018	24	8.4	2.64	0.7	30.22	0.044	5.4	0.027
	Jan 2018	24	8.6	2.66	0.96	28.06	0.059	7.85	0.031
	Dec.2017	22	8.3	2.36	0.92	26.54	0.082	8.9	0.037
	Nov.2017	23	8.2	2.64	1.22	24.38	0.059	9.6	0.051
Monsoon	Oct.2017	22	8.4	2.8	0.94	26.28	0.077	9.9	0.06
	Sep.2017	21	8.3	2.86	0.9	28.22	0.068	10	0.064
	Aug.2017	20	8.1	2.86	0.88	28.24	0.072	9.6	0.067
	July.2017	22	8.2	2.76	0.96	24.04	0.0785	9.9	0.07
	Mean	20	8.14	2.76	0.68	23.4	0.086	11.6	0.07

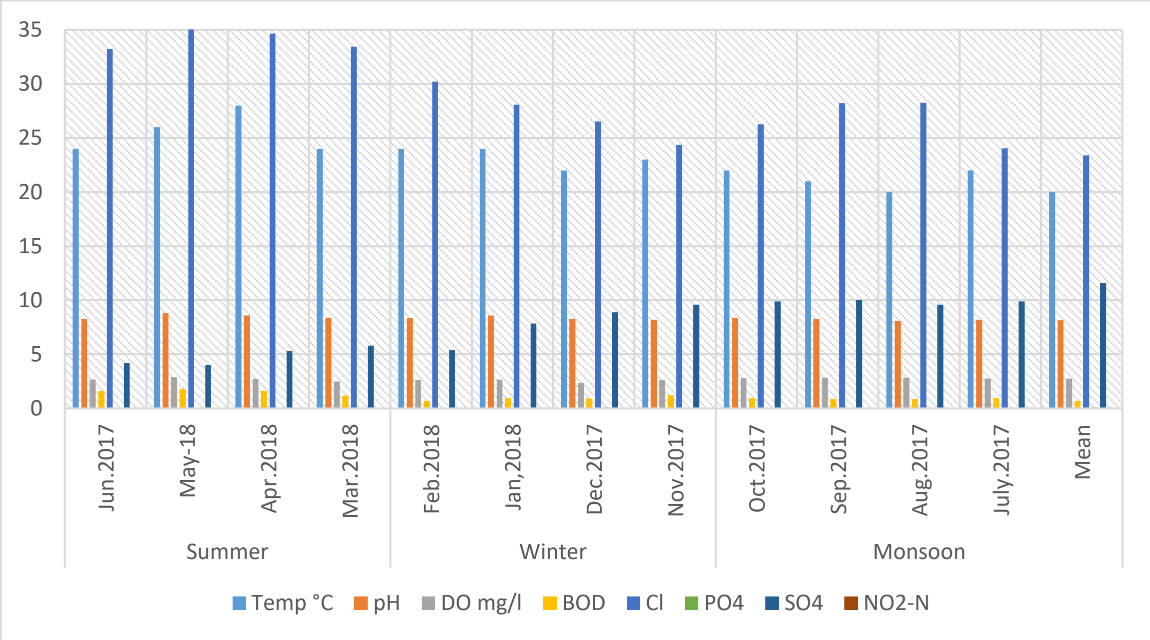

Fig. 5. *Showing Physico-chemical Parameters of sampling site 3 of the Godavari River*

CONCLUSION

The presence of zooplankton is directly or indirectly influenced by seasonal variation with complex limnological factors and due to richness and reduction in several nutrients with a suitable environment to maintain diversity and population of zooplankton. Where class belonging to Rotifera is dominant followed by Cladocera > Copepoda > Protozoa and the class of Ostracoda has lower the quantity throughout the study period. We also found that the class of Copepoda and Ostracoda sp. has monsoon season is highest suitable for growth followed by summer and winter season. Especially class of Rotifera has summer season highest suitable followed by monsoon and winter season and class of Cladocera has highest in winter season then monsoon and summer season and class of Protozoa has monsoon season suitable followed by winter and summer season. Records of various species of zooplankton in this reservoir are some pollution indicators.

Acknowledgment. We are thankful to the Indian Council Social Sciences Research (ICSSR), New Delhi, for financial support to this research and the school of Earth Sciences, Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India for providing laboratory and library facilities which are helping me to carry on with my work in an effective way.

Declaration: The authors of this manuscript do not oppose the interest.

REFERENCES

[1] Ningule K.B. and Ovhal S.D. (2016): Study of Zooplanktons from Sangvi Reservoir, Patoda Dist. Beed. (M.S.) India, World Journal of Pharmacy and Pharmaceutical Sciences, Vol.5, (7) pp 940-947.

[2] Ramachandra T.V., Rishiram R., and Karthick B. (2006): Zooplankton as Bioindicators: Hydro Biological Investigations in Selected Bangalore Lakes, Centre for Ecological Sciences Indian Institute of Science Bangalore 560 012, pp 1-115.

[3] Arjun Shukla and Reeta Solanki (2016): Diversity and Abundance of Zooplankton in River Narmada at Jabalpur Region (M.P.) International Journal of Information Research and Review Vol.3(3), pp 2060-2064.

[4] Raut K.S., Shinde S.E., and Sonawane D.L. (2012): Zooplankton Diversity of Ravivar Peth Lake at Ambajogai District Beed Marathwada Region, India, Bionano Frontier, Eco Revolution 2012 Colombo Srilanka pp 139-141.

[5] Sandhya S. Kadam, S.U. Kadam, and Md. Babar (2014): Zooplankton Diversity of Masooli and Yeldari reservoirs in Parbhani district, Maharashtra, India concerning the Physico-Chemical Parameters, The International Journal Research Publications, Vol.3, (11) pp 1-6.

[6] Rajagopal T., Thangamani A., Sevarkodiyone S.P., Sekar M. and G. Archunan (2010): Zooplankton diversity and physicochemical conditions in three perennial ponds of Virudhunagar district, Tamilnad, Journal of Environmental Biology, Vol.31, pp 265-272.

[7] Pradhan V.P. (2014): Zooplankton Diversity in Fresh Water Wunna Lake, International Journal of Life Sciences, Vol. 2 (3), pp 268-272.

[8] Shaikh P.R, and Bhosle A.B. (2012): Planktonic Biodiversity of Siddhewshwar Dam in Hingoli, Maharashtra, India, Journal of Environmental Research and Development, Vol.7 (2A), pp 905-916.

[9] Sharma C. and Tiwari R.P. (2011): Studies on Zooplanktons of the freshwater reservoir at Lony Dam, International Journal of Pharmacy & Life Sciences, Vol.2 (1), pp 492-495.

[10] Mola HRA (2011): Seasonal and spatial distribution of Brachionus (Pallas, 1966; Eurotatoria: Monogononta: Brachionidae), a bioindicator of eutrophication in lake El-Manzalah, Egypt, Research Article, Biology and Medicine Vol.3(2) pp 60-69.

[11] Kadam CP, Dandolia HS, Kausik S, Saksena DN and Shrotriy VP (2014): Biodiversity of Zooplankton in Pillow Reservoir District Morena Madhya Pradesh, India, International Journal of Life Sciences, Vol. 2(3), pp 263-267.

[12] M. G. George (1962): Diurnal Variations in Two Shallow Ponds in Delhi, India, 18. Hydrobiologia, XVIII, 3. pp 265-273.

[13] Krishna P.V. and Hemanth Kumar (2017): Seasonal Variations of Zooplankton Community in Selected Ponds at Lake Kolleru Region of Andhra Pradesh, India, International Journal of Current Microbiology and Applied Sciences, Vol.6 (8), pp 2962-2970.

[14] Sala OE, Chapin III FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R et al. Global biodiversity scenarios for the year 2100. Science. (2000): Vol. 287 (5459), pp 1770-1774.

[15] APHA (1985): Standard Methods for Examination of Water and Wastewater. 16th Ed. American Public Health Association, Washington, D.C.

[16] Trivedy R.K. and Goel P.K. (1984): Hand Book of Chemical and Biological Methods for Water Pollution Studies, Enviromedia Publications 1-247. Karad.

[17] Diwan A.D., Misra S.M., Dhanpati, Murugan N., Thirumalai G., Altaff K., Sakhre V.B. Methodology For Water Analysis (3rd Ed.2006): (Physico-chemical, Biological and Microbiological) Indian Association of Aquatic Biologists (IAAB) Publication No.2 (ISBN: 81-900595-2-1)

[18] Gabriel Ujong Ikpi, Benedict Obeten Offem and Irom Bassey Okey (2013): Plankton Distribution and Diversity in Tropical Earthen Fish Ponds, Environment and Natural Resources Research; Vol. 3 (3), pp 45-51.

[19] Madhusudhana Rao K., Krishna, P.V., Jyothirmayi V., Hemanth Kumar V. (2014): Biodiversity of Zooplankton Communities in a Perennial Pond at Lake Kolleru Region of Andhra Pradesh, India, International Journal of Advanced Research Vol.2 (7) pp 33-41.

[20] Ashis P., Kalyan B.S., and Chanchal Kumar M. (2011): Ecology and Diversity of Zooplankton about Physico-Chemical Characteristics of Water of Santragachi Jheel, West Bengal, India. Journal of Wert land Ecology, (5), pp 20-39.

[21] Narasimman M., Periyakali S.B., Perumal S., Rajagopal B., Thirunavukkarasu M., Veeran S., Annamalai A., Gopalan R., Rajendaran U., and Madhayan K. (2018): Impact of seasonal changes in zooplankton biodiversity in Ukkadam Lake, Coimbatore, Tamil Nadu, India, and potential future implications of climate change, The Journal of Basic and Applied Zoology, https://doi.org/10.1186/s41936-018-0029-3. pp 1-10.

[22] Shashikanth M., and K. Vijaykumar (2009): Ecology and abundance of zooplankton in Karanja reservoir, Environ. Monit. Asses., pp 451–458.

[23] Najeeb A.B., Ashwani W., and Rajni R. (2014): The composition and net diversity of net zooplankton species in a tropical water body (Bhoj Wetland) of Bhopal, India, International Journal of Biodiversity and Conservation, Vol.6 (5) pp 373-381.

[24] Pramod Kumar Sinha and Ravinder Singh (2016): Seasonal zooplankton diversity about Physico-chemical parameters of the perennial pond of Chaibasa, West Singhbhum, Jharkhand, India. International Journal of Bioassays, http://dx.doi.org/10.21746/ijbio.2016.09.0023, pp 4906-4908.

[25] Yannawar Vyankatesh B, (2015): The Nanded Information System, Lap Lambert Academic publishing, Germany.