RESEARCH ARTICLE

Biodiversity of Zooplankton Communities in a Perennial Pond at Lake Kolleru Region of Andhra Pradesh, India

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Abstract

Zooplankton holds a key position in the food web as it was directly related to the consumption of organic energy produced by phytoplanktonic photosynthesis and then by transforming it to the higher tropical levels of hetirotropes such as fish. Plankton diversity and physicochemical parameters of water are important criteria for evaluating the suitability of water for culture practices. Therefore, structure of different fish food organisms assumes greater significance to fisheries management. Indiscriminate exploitation of Lake Kolleru has been evidently resulted in the depletion of fish fauna and it leading to folding and other negative consequences at surrounding area. In this study, we tried to assess zooplankton richness, evenness and diversity to observe the state of pond water in the study area. A total number 16 species recorded with 9 Rotifera, 3 Cladocera and 4 Copepods. In the Rotifers the genus *Brachionus* is the dominant group.
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INTRODUCTION
In a freshwater system, the zooplankton forms are important group and constitute basic link of the food chain. Planktons are very sensitive to the environment they live in and any alteration in the environment leads to the changes in the plankton communities in terms of tolerance abundance, diversity and dominance in the habitat (Mathivonam, 2007). The density and diversity of the plankton are greatly influenced by the different physicochemical parameters of water (Wetzel, 1975). Species composition of the plankton community is an efficient indicator of water quality. Zooplankton consist of Protozoans, Cladocera, Copepod, Rotifers, etc. which may serve as indicators of water quality. The zooplanktons play an important tropic level in the aquatic ecosystem as they constitute the most import link in the energy transfer between phytoplankton and higher aquatic fauna (Iloba, 2002). In ecologically zooplankton is one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter (Park and Shin, 2007).
Aquatic biodiversity is threatened primarily by human abuse and management of both living resources and the ecosystem that support them. Most of the ponds are getting pollution due to domestic waste, sewage, industrial, aquatic and agricultural effluents. The requirement of water in all lives, from microorganisms to human beings is a serious problem of present day because of water resources have reached to a point of crisis due to unplanned urbanization, industrialization and other manmade activities. Many biotic and abiotic processes contribute to variability in plankton diversity in aquatic ecosystems. Seasonal requirement of plankton assemblages are closely linked to seasonal changes in temperature, external hydraulic, nutrient loads and light availability (Malten et al., 1991), other process acting on as time periods on days to week, like meteorological and hydrological events (Guillermo, 2009) and also pollution stress on them (Raja et al., 2008). Zooplankton diversity responds rapidly to changes in the aquatic environment. Several zooplankton species are served as bio indicators (Ahmad et al., 2011, Mola, 2011). A number of studies have been carried out on ecological condition of freshwater bodies in various parts of India (Singh et al., 2002; Smith et al., 2007; Rajagopal et al., 2010), but coastal Andhra Pradesh particularly

Kolleru area the ecological studies of freshwater body is very scanty. However, information on relation between physicochemical parameters and planktonic fauna is very limited (Ahmad and Siddiqui, 1995, Choudhary and Singh, 1999). So the present investigation attempts to study the zooplankton species richness, diversity and evenness, in relation between physicochemical parameters in a perennial pond at Lake Kolleru area.

Materials and Methods:

Study area: Lake Kolleru in Andhra Pradesh is an important natural shallow freshwater lake formed as a basin between the gradually growing deltas of rivers Godavari and Krishna. It is situated between latitudes 16° 32' and 16° 47' N and longitudes 81° 4'and 81° 22' E. The present study pond situated near Budamaru near Kaikaluru. The pond is shallow (depth 0.90 to 1.78m) covering an area of about 2.5 ha. The source of replenishment is sewage from surrounding area. Pond contains mostly sand, lose mud, decayed litter deposit.

Collection of samples: The pond survey was carried out from August 2012 to July 2013. Water samples were collected from periodically every fortnight of the selected pond during the early hours between 8.00 to 10.00 am. The data was articulated seasonally as northeast monsoon (December-February); summer (March-May); southwest monsoon (June-September) and post monsoon (October-November). The plankton samples were collected by filtering by 50 liters of water through standard plankton net (77 meshes bolting sink) and concentration samples fixed in 5% of formalin.

Physicochemical Analysis: Temperature was recorded with centigrade thermometer. The pH of water samples was measured by using pH meter. The remaining physicochemical parameters of water were done according to standard methods (APHA, 1985).

Biological analysis: Zooplankton species identification was done by the help of standard reference (Alfred et al., 1973). The quantitative analysis of planktonic organisms was carried out using Sed Wick Rafter plankton counting cell in according to Welch (1948). Shannon-Weaver's species diversity index: This was proposed by Shannon and Weaver (1949) as measure of information and their diversity across the different pond sampled. Shannon-Weaver (H) is commonly used to characterize species diversity in a community. This index account for both abundance and evenness of the species presents. The proportion of species (Pi) is calculated and then multiplied by the natural logarithm of this proportion (log (Pi)).

As per the formula given by Shannon and Weaver (1949)

$$H = -\sum(n_i/N)\log(n_i/N)$$

Or

$$H = -\sum P_i \log(P_i)$$

Whereas,

H = Shannon's –Wiener's index of species diversity in individuals.

n_i = Total number of individuals.

N = Total number of individuals of all species.

P_i = Importance of probability for each species (n_i/N)

Result and discussion:

Physicochemical parameters of water body serves as measure of water quality. Changes in the source of water and rainfall affect physicochemical parameters of water, which also affects the biomass of the aquatic organisms. The physico-chemical parameters of water were given in Table 1.

Zooplankton was represented by Rotifera, Cladocera and Copepods. Among the plankton Rotifer was dominated and followed by Copepods and Cladocerans. In the Rotifera five genera and nine species were observed. Among the Rotifera genus *Brachions* is the dominant group. In the Copepods represent three genera and four species and also Cladocerans found 3 genera and 3 species. During the study period quantitative and qualitative variations of zooplankton was observed (Table-2). Zooplankton richness observed in the both monsoon periods where as lowest number in the summer and post monsoon period. Similar results observed by (Mukherjee, 2011).

In the ecosystem, zooplankton plays a main role as they consume the primary producers (phytoplankton) and form a major food source for tertiary producers. Zooplankton considered as the basic principle natural fish food for young and some adults of organisms, which support fish production (El-Serafy et al., 2009). The zooplanktons often respond immediately to environmental changes because most of the species have short generation times. Epifanio and Garvine (2001) studied by the variations of their spatial distribution, based on different factors.

The higher population density of the zooplankton is during the both monsoon periods while low population density observed in the summer and post monsoon. Among the plankton Roitifera is dominated. The zooplankton populations dominated by Rotifers in the wet season are observed by Egborge (1981). The high population density in the monsoon period may be as a result of abundant food sources from the runoff. Rocha et al., (1999) reported that the increase of primary production (phytoplankton) is accompanied by increase in zooplankton abundance.

Muylaert et al., (2003) observed that the zooplankton abundance frequently reach their peak during the wet season in ponds. Besides food source, low predation rate by fish during wet season caused by plankton increased breading activity, could support by high population density of zooplankton (Ikpi et al., 2013).

In the present observations of the Shannon-Weaver's index of the species in individuals of plankton in the pond fauna was recorded. The seasonal occurrence of zooplankton (Table-2) and the diversity index of zooplankton in different seasons in the different seasons in the study area were given in Table-3. The species diversity index value are 1.613 (N.E. monsoon), 1.293 (Summer), 1.408 (S.W. monsoon) and 1.633 (Post-monsoon). The biodiversity of monsoon higher in the monsoon period both northeast and southwest monsoons followed by post monsoon. Where minimum values recorded in the summer. High density of zooplankton diversity during monsoon period may be attributed to inflow of rainy water and favorable environment conditions. Ikpi et al., (2013) reported that the seasonal variation in zooplankton condition could larger be due to the Rotifera which normally constitute major food items of larger zooplankton.

The air temperature ranged from 24-33°C and highest temperature recorded in the month of July, 2013. Temperature is one of the important environment factors, since it is influencing the distribution of fauna and flora. The water temperature was observed between 22 - 32°C in the present study. Gaikwad (2008) reported that water temperature 13.5 - 32°C is to be suitable for the development of the planktonic organisms. Rainfall ranged between 1.64 to 489.6 mm and rain did not occur during months of December 2012, January 2013 and March 2013. Rainfall is the important cyclic phenomena in tropical countries. In the present results the peak values of rainfall were recorded in the month of July, 2013(middle of south west monsoon) and lowest recorded in the month of February, 2013. The India in influenced by two monsoon i.e. south west monsoon and northeast monsoons. Transparency ranged between 20-32 cm and highest reading recorded month of October, 2012 (post-monsoon season) this might is due to the distribution effect of rains and sediment settlement after south west monsoon season. The lowest value of reading observed during summer (March, April, and May, 2013) which might be due to evaporation of water in the pond, which may cause concentration of dissolved solids at high temperature.

Dissolved oxygen was observed in-between 3.8 to 6.0 mg/l and lowest recorded in month of September, 2012 (south west monsoon). Lower dissolved oxygen values obtained during dry season could probably due to higher temperatures during summer months. Dissolved oxygen distribution provides a good index of productivity and quality of environment. High oxygen consumption is indicative of higher photosynthetic efficiency and plankton production. Rajagopal (2010) reported that the abundance of phytoplankton which enriched water with high dissolved oxygen during photosynthesis. Dissolved oxygen is a sole of the physicochemical parameters of the water which need to keep the organisms alive and health of the water body of ecosystem (Madhusudhana and Krishna, 2013).

The pH value ranged between7.4-8.6 lowest recorded in the month of August (south west monsoons) where as highest recorded in the month of January (North East monsoon). High value of pH may cause of low level of water and high photosynthesis resulting in high production of free CO_2 during the equilibrium towards alkaline side (Siddamalayya and Pratima, 2008). Tanner (2005) reported that the pH range between 6.0-8.5 indicate median productive nature of reservoir and above 8.5 goes to highly productive. In the present, study months of January and November goes to above 8.5 pH which indicates that the water is a highly production of zooplankton population. Total alkalinity of present results is in between 120 to 162 mg/l. Maximum recorded in the month of April where as minimum in the month of December. Similar results observed by Narasimha Ramulu and Benarjee (2013) at Nagaram tank of Warangal. The total hardness of water fluctuation ranged from 135-178 (mg/l). Maximum recorded in the month of April and minimum recorded in the month of February. The minimum during the month of February may be due to deposition of Calcium and Magnesium salts in that season (Narsimha Ramulu and Benarjee, 2013). Conductivity is a complex environmental factor. It results the content of mineral components in ionic form, so it can be treated as estimator of mineral salts content (Pejler, 1965; Radwan et al., 1973) the conductivity varied with a minimum 3.51 ms in the month of January and maximum in the month of April, 2013. Conductivity and total dissolved solids represent mineral content of the water, they exhibit significant relationship. In the present study total dissolved solids recorded maximum in the month of March (16.7) and, minimum recorded in the month of December (4.99).

Nitrogen is essential for leaving organisms as an important constituent of proteins, including genetic material. Plants and microorganisms convert inorganic nitrogen to organic forms. In the environment inorganic nitrogen occurs in a range of oxidation status as Nitrate (NO_3) and Nitrite (NO_2), the Ammonium ion (NH_4^+) and molecular Nitrogen (N_2). It is under goes biological and non-biological transmission in environment as part of nitrogen cycle. In the present study Nitrite in-between 0.028-0.098 mg/l; Nitrate in-between 0.41 to 0.60 mg/l and Ammonia goes to 0.31 to 0.64 mg/l in the culture pond.

Iron is an important element for almost all living species. Its environmental impacts on physiological and ecological aspects of aquatic organisms are focus on limnological studies (Xing and Liu, 2011). The variations of Iron profoundly influence the structure and function of aquatic ecosystem (Shaked et al., 2004). In the present study Iron ranges from 0.28 to 0.51 mg/l lowest record in the month of January and (0.28) and highest recorded in the month of April, 2013.

In the aquatic ecosystem plankton play a critical role not only in converting plant food to animal food but also serves as source of food for their organisms (Rajashekhar et al., 2010). In the present study indicated that a total of 16 zooplankton species were recorded in the study ponds comprising of 9 Rotifera, 3 Cladocera and 4 Coppepods. Rotifera showed highest number of species and genus *Brachionus* is dominant group among Rotifera. Bharti et al., (2014) reported that the abundance of Rotifer species such as *Brachionus* indicates nutrient rich water body which may undergo the state of eutophication. The present preliminary study conducted that the various zooplankton composition. Rotifera constitute higher species abundance, the overall diversity index shows eutrophic nature. Further, detailed investigation through regular monthly sampling with more quantitative analysis to conform the exact status of water body is required which would help to conserve the zooplankton diversity and water quality.

Table – 1. Physico-chemical parameters of the pond water in different months at study area.

Study Period	RF	AT	WT	Tr.	DO	pH	TA	TH	CD	TDS	AM	NO$_2$	NO$_3$	OP	Fr.
Aug.2012	104.8	28	26	29	5.9	7.4	165	176	6.51	6.76	0.46	0.039	0.41	0.51	0.38
Sep. 2012	188.2	30	28	28	6.0	7.6	155	125	8.16	7.85	0.51	0.028	0.56	0.61	0.42
Oct. 2012	142.7	24	23	34	5.6	8.0	145	165	7.09	8.55	0.44	0.063	0.42	0.46	0.38
Nov. 2012	23.0	25	24	32	5.8	8.6	150	120	6.81	10.3	0.64	0.064	0.56	0.53	0.43
Dec. 2012	0.00	26	24	32	4.5	7.8	160	115	6.12	4.90	0.51	0.076	0.48	0.67	0.36
Jan. 2013	0.00	26	23	30	5.0	8.8	135	145	3.51	6.51	0.56	0.073	0.53	0.57	0.28
Feb. 2013	1.64	24	22	32	4.4	8.2	150	190	5.14	6.58	0.62	0.068	0.60	0.63	0.32
Mar.2013	0.00	28	25	21	3.8	7.5	165	175	7.09	16.6	0.59	0.098	0.42	0.72	0.36
Apr.2013	8.20	28	26	20	4.0	7.6	175	155	10.8	12.9	0.49	0.056	0.48	0.59	0.51
May2013	34.7	32	30	22	4.1	7.8	170	145	10.1	16.3	0.31	0.074	0.43	0.48	0.30
Jun. 2013	50.7	31	30	28	5.2	8.2	155	165	6.81	13.8	0.38	0.076	0.51	0.42	0.38
Jul. 2013	189.6	33	32	32	5.6	8.0	140	155	6.22	7.83	0.45	0.063	0.53	0.58	0.36

RF: Rainfall (mm); AT: Air temperature (°C); WT: Water temperature (°C); Tr.: Transparency (cm); DO: Dissolved Oxygen (mg/l); pH: Hydrogen ion concentration; TA: Total Alkalinity (mg/l as CaCo$_3$); TH: Total hardness (mg/l as CaCo$_3$); CD: Conductivity (mS); TDS: Total Dissolved Solids (ppt); AM: Ammonia (mg/l); NO$_3$: Nitrate (mg/l); NO$_2$: Nitrite (mg/l); OP: Orthophosphates (mg/l); Fr.: Iron (mg/l).

Table -2. Seasonal occurrence of zooplankton in the study area.
   Abbreviations: N.E: North East; S.W: South West.

ZOOPLANKTON SPECIES	N.E. MONSOON			SUMMER			S.W. MONSOON			POST MONSOON		
	(ni)	(ni/N)	log ni/N	(ni)	(ni/N)	log ni/N	(ni)	(ni/N)	log ni/N	(ni)	(ni/N)	log ni/N
Rotifera												
Brachionus caudatus	90	0.282	- 0.549	65	0.281	-0.551	127	0.272	-0.565	23	0.175	-0.756
B. falcatus	74	0.231	-0.636	21	0.090	-1.045	110	0.236	-0.627	14	0.106	-0.974
B. calyciflorus	85	0.266	-0.575	42	0.181	-0.742	134	0.287	-0.542	37	0.282	-0.549
B. forficula	10	0.031	-1.508	24	0.045	-1.346	18	0.038	-1.420	05	0.038	-1.420
B. angularis	07	0.021	-1.677	08	0.015	-1.823	12	0.025	-1.602	07	0.053	-1.275
Filinia longiseta	12	0.037	-1.431	23	0.043	-1.366	23	0.049	-1.309	15	0.114	-0.943
Polyarthra remata	01	0.003	-2.522	02	0.003	-2.522	03	0.006	-2.221	01	0.007	-2.154
Hexathra Sp.	02	0.006	-2.221	-	-	-	02	0.004	-2.397	01	0.007	-2.154
Keratella tropica	38	0.119	-0.924	46	0.086	-1.065	37	0.079	-1.102	28	0.213	-0.671
Total	**319**			**231**			**466**			**131**		
Cladocera												
Ceriodaphnia cornuta	12	0.4	-0.397	10	0.714	-0.146	09	0.409	-0.388	08	0.444	-0.352
Moina micrura	10	0.333	-0.477	04	0.285	-0.545	03	0.136	-0.866	05	0.277	-0.552
Diaphnosoma excisum	08	0.266	-0.575	-	-	-	10	0.454	-0.342	05	0.277	-0.557
Total	**30**			**14**			**22**			**18**		
Copepodes												
Mesocyclops Sp.	40	0.240	-0.619	53	0.212	-0.673	11	0.051	-1.292	10	0.136	-0.866
M. varicans	46	0.223	-0.651	06	0.024	-1.619	09	0.042	-1.376	01	0.013	-1.886
Heliodiaptomus cinctus	03	0.018	-1.744	17	0.068	-1.167	13	0.061	-1.214	12	0.164	-0.785
Diaptomus Sp.	117	0.704	-0.152	73	0.489	-0.310	180	0.845	-0.073	50	0.684	-0.164
Total	**206**			**149**			**213**			**73**		

Table -3. Biodiversity indexes of zooplankton in different seasons in the study area.
Abbreviations: N.E: North East; S.W: South West.

ZOOPLANKTON SPECIES	N.E. Monsoon (ni/N) log ni/N	Summer (ni/N) log ni/N	S.W. Monsoon (ni/N) log ni/N	Post Monsoon (ni/N) log ni/N
Rotifera				
Brachionus caudatus	-0.154	-0.154	-0.153	-0.132
B. falcatus	-0.146	-0.094	-0.147	-0.103
B. calyciflorus	-0.152	-0.134	-0.155	-0.154
B. forficula	-0.046	-0.060	-0.053	-0.053
B. angularis	-0.035	-0.027	-0.040	-0.067
Filinia longiseta	-0.052	-0.058	-0.064	-0.107
Polyarthra remata	-0.007	-0.007	-0.013	-0.015
Hexathra Sp.	-0.013	-	-0.009	-0.015
Keratella tropica	-0.109	-0.090	-0.087	-0.142
Total	**-0.714**	**-0.624**	**-0.721**	**-0.788**
Cladocera				
Ceriodaphnia cornuta	-0.158	-0.104	-0.158	-0.156
Moina micrura	-0.158	-0.155	-0.117	-0.154
Diaphanosoma excisum	-0.152	-	-0.155	-0.154
Total	**-0.468**	**-0.259**	**-0.43**	**-0.464**
Copepodes				
Mesocyclops Sp.	-0.148	-0.142	-0.065	-0.117
M. varicans	-0.145	-0.038	-0.057	-0.024
Heliodiaptomus cinctus	-0.031	-0.079	-0.074	-0.128
Diaptomus Sp.	-0.107	-0.151	-0.061	-0.112
Total	**-0.431**	**-0.41**	**-0.257**	**-0.381**
H= -∑(ni/N) log ni/N	**1.613**	**1.293**	**1.408**	**1.633**

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