Original Article

Zooplanktons As Bioindicators Of Water Pollution From Vikram Tearth Sarovar Ujjain (M.P)

Haroon Rashid[1]*, M.M.Prakash[2]

*[1,2]Department of Zoology, Government Holkar (Model, Autonomous) Science College, Indore, Madhya Pradesh, India
Email: haroonrashidkhan89@gmail.com
Doi: 10.47750/pnr.2022.13. S05.140

Abstract

Freshwater ecosystems harbor a vast diversity of Zooplanktons, and such diverse taxonomic groups play important roles in ecosystem functioning and services. Bioindicators are living organisms such as plants, planktons, animals, and microbes, which are utilized to screen the health of the natural ecosystem in the environment. They are used for assessing environmental health and biogeographic changes taking place in the environment. Each organic entity inside a biological system provides an indication regarding the health of its surroundings such as zooplankton responding rapidly to changes taking place in the surrounding environment and serving as an important biomarker for assessing the quality of water as well as an indicator of water pollution. Some species of Zooplanktons are sensitive to water quality oscillations from natural or anthropogenic causes. Information on basic ecological attributes such as abundance or absence can be helpful in the context of hydric resource monitoring. In the present study Zooplankton communities from Vikram Tearth Sarovar (Ujjain) of Madhya Pradesh (India) were sampled from (Jan. 2018- Dec.2018) in order to ascertain the trophic status of these freshwater bodies of Madhya Pradesh using Zooplankton as indicators. The present study discusses *Brachionus: Trichocerca* ratio for the evaluation of the nature of the recognized Site. Our aim was to identify and understand the abundance of species with potential to monitor water quality in large scale assessments. The selected water body suggested that there was a tremendous anthropogenic pressure on the freshwater bodies of Madhya Pradesh. Different species of plankters have wide as well as narrow range of tolerance towards the fluctuating environmental conditions. It can be inferred from the study that the Vikram Tearth Sarovar is under the tremendous pressures of anthropogenic activities as was reflected by high B/T values. During the present study a total of 53 taxa of zooplankton comprising 24 Rotifers, 15 Cladocerans, 12 Copepods and only 2 Ostracods were found to inhabit the Vikram Tearth Sarovar. The presence of organic pollution indicators *Brachionus calyciflorus, Keretella Tropica, Keretella priodonta, Chydorous Sphaericus, Moina sp, Lapdella patella, B. caudatus, B.falactus, Asplanchana brightweli, Asplanchana priodonta, Ceriodaphnia reticulate, Ceriodaphnia sps. etc.* is a warning sign of the deteriorating condition of the water quality in the reservoir. Measures need to be enforced to reduce the rate of pollution of the selected water body arising from the human activities in the catchment of the reservoir.

Keywords: Bioindicators; Zooplanktons; Pollution; Vikram Tearth Sarovar.

INTRODUCTION

All living organisms on this planet need water for their growth and survival thus water is an essential ingredient of life. It has been rightly described as the “Elixir of Life”. The civilized world depends largely upon water for its domestic, irrigational, industrial requirements and many other purposes besides potable water. Since the quality of water affects our lives in many ways, it must be of good quality (Kapoor and Kumar, 2006). The degradation of freshwater resource and water quality is speeding up, posing a global challenge (Mahananda *et al.*, 2005). Planktons have recently been used as bio-indicators for monitoring aquatic ecosystems and water integrity. In order to identify the health of water bodies, quick and reliable monitoring systems are essential. In an ideal situation the quality of water should be evaluated by the use of physical, chemical and biological parameters in order to obtain a complete spectrum of information for appropriate water management. However, such study requires more time and expenditure than the study of biological parameters, which is widely accepted and reliable (Iliopoulou Georgudaki *et al.*, 2003).The potential for freshwater organisms to reflect changes in aquatic environmental conditions dates back to the middle of the 19th century and was first reported by Kolenati, (1848) and Cohn (1853).A bioindicator can be defined as ‘‘a species or group of species that readily reflects the abiotic or biotic state of an environment, represents the impact of environmental change on a habitat, community, or ecosystem, or is indicative of the diversity of a subset of taxa, or of the wholesale diversity, within an area’’ (M. McGeoch, 1998).Zooplanktons are our aquatic “Canaries-in-a-Cage” (Suthers and Rissik, 2009). Different zooplankton behaves differently in responses to eutrophication as changes in reproductive rates Fielto *et al*,(2004) filtering capacities Xie, *et al.*, (1998) and specializations in acquiring food Schriver *at al.*, (1995) and Shah and Pandit (2014). Therefore, it is imperative to study the zooplankton as bioindicator particularly with reference to Fresh water bodies of Ujjain (M.P).

MATERAILS AND METHODS

Vikram Tearth sarovar also known as Vikram Man sarovar is placed in Vikram University campus, Ujjain. It is also fed by seasonal rains. Vikram Tearth sarovar is located at Latitude 23°16′43″N and Longitude 75°80′53″ E, with an average elevation of 489 m. The depth of the pond is 3.50 meter 0.45 m. The average length and width of the pond is 140 and 62 meters respectively. The pond receives huge amount of domestic sewage from government quarters located nearby to the pond.

Google map of Ujjain (M.P)

Google Map of Vikram Tearth Sarovar

Study period: -The survey was conducted for of one year (Jan 2018- Dec 18) in the following seasons:-

- Winter - December to February,
- Summer - March to June,
- Monsoon - July to September,
- Post Monsoon- October to November,

METHODS

Zooplankton Studies

Collection and preservation of zooplankton

For the quantitative studies of zooplankton, 50 liters of water, procured from 4 study sites, were sieved through standard plankton net of bolting silk having 25 meshes/ cm. The content collected in a plankton tube attached to the lower end of the plankton net, were transferred to well marked separate polyethylene bottles. The zooplankton organisms were preserved in 4% formalin, added with 4-5 drops of glycerin (for keeping the organisms flexible), and 5% sucrose (for retaining eggs in their broad chamber).

Qualitative analysis

Identification of the preserved samples was carried out with the help of standard taxonomic works of Koste (1978), Pennak (1978), Amoros (1984), Adoni (1985), Defaye and Dussart (1991*etc*.

Quantitative estimation

The quantitative enumeration of zooplankton was carried out in a Sedge-wick rafter counting chamber of 1mL capacity by counting the number of individuals in 1mL of plankton sample from each polyethylene bottle. Binocular microscope was used for identifying the specimens. The abundance of zooplankton was calculated in accordance with Welch (1952) and the results were expressed in terms of organisms per litre (org. /L).

Zooplankton as bioindicators

The zooplankton, encountered in the present study, were classified into the indicators of eutrophy, mesotrophy and oligotrophy as per the works of Jarnefelt (1952,),), Sladecek, (1983), Balkhi, (1989), Sampaio*et al*.,(2002) andShah and Pandit, (2014).

*Brachionus: Trichocerca*ratio ($Q_{B/T}$)

Brachionus: Trichocerca ratio called as Sladecek's $Q_{B/T}$ quotient was also used in the present study to find out the trophic state of the ponds. It is represented as:

$$Q_{B/T} = \frac{\text{Number of species of } Brachionus}{\text{Number of species of } Trichocerca}$$

If the value of this quotient is less than 1.0 it means oligotrophic condition, values between 1.0 and 2.0 reflect mesotrophic and values over 2.0 indicate eutrophic conditions.

Diversity Index

The Shannon and Weaver (1963) diversity index (H) was calculated by diversity calculator software (PAST).

RESULTS

Biological communities in general and plankton communities in particular are not random aggregations of the species thrown together by the whims of nature, but rather organized communities with numerous interlocking cause-effect pathways. It is clear that the needs of biological species and communities are nearly as complicated as those of taxonomically higher organisms and that disruption of these communities by pollution can affect the entire aquatic food web (Unni, 1993, Pai, 2002).

In recent years, there has been a widespread acceptance that chemical monitoring alone is insufficient. Pollution brings many biological changes and its impact is on living organisms. As a result, chemical and biological approaches are complementary and it is appropriate to detect and assess impacts through an examination of the biota. Biological organisms are diagnostic in determining the health of aquatic environment (Loeb, 1994) since they are the primary sensors responding to stress affecting these biotopes. Any stress imposed in these environs manifests its impact on inhabitant communities and results in restructuring and re-arrangement of originally present biotic components. In Vikram Tearth Sarovar during the year 2018 (Jan-Dec), a total of 53 taxa of zooplankton comprising 24 Rotifers belonging to eight families (Brachionidae 14species, Asplanchnidae,Lepadellidae and Notommatidae with 2 species each. Lecanidae, Filiniidae, Trichocercidae and Hexathridae, with 01 species each), 15 Cladocerans belonging to five families(Chydoridae 7 species, Daphniidae with 05 species, Bosminidae, Moinoidae and Macrothricidae with 01 species each), 12 Copepods belonging to three families (Cyclopoidae 10, Canthocamptidae and Diaptomidae 1 species each) and only 02 Ostracods belonging to family Cyprididae were recorded.

Seasonal variations (based on population density) of zooplankton

A perusal of the data revealed that the populations of zooplankton were at their lowest ebb during winter and Monsoon season for the year 2018. After winter, when the populations remained modest, sudden upsurge took place till the populations reached the maximum of its growth and development in summer, thus producing the greatest summer peak in the site under study.

In general, the population density of wheel animalcules showed bimodal growth curve with a prominent summer peak in selected biotope (Vikram Tearth Sarovar). A decline of rotifer population was observed in winter and monsoon season throughout the study. In Vikram Tearth sarovar summer peak of rotifers was mainly contributed by species namely *Anuraeopsis fissa, Brachionus calyciflorus, B. caudatus, Keratella tropica, K. valga, Asplanchana brightweli, Lapdella patella, Lapdella ovalis, Cephalodella sp., Platyias patulus, Hexthra mira etc.*The density of rotifers for the year 2018 in Vikram Tearth sarovar, varied between a minimum of 380 ind./L and 465 ind./L (each for September and December months of 2018) and a maximum of 3879 ind./L in the month of May 2018.

The population density of water fleas (Cladocerans) at Vikram Tearth Sarovar varied from minimum 294 ind./L ind. /L in winter season (December 2018 to a maximum of 2517 ind./L (May 2018).Summer peak of water fleas at Vikram Tearth sarovar were due to species like *Alona costata, , A.monocantha, A. rectangula, Bosmina longirostris, Ceriodaphnia dubia, C. reticulata, Chydorus ovalis, C. sphaericus, Daphnia pulex, Simocephalus vetulus, , Moina sp.,. etc.*

The density of Copepods for the year 2018 Vikram Tearth Sarovar, varied between a minimum of 317 ind. /L and 418 ind./L (each for September and December months 2018) and a maximum of 1323 ind./L in the month of April 2018. The copepods were mainly contributed by species namely *Mesocyclops hyalinus, Paracyclops fimbriatus, Cyclops bicolor, Mesocyclops leuckarti, C.virdis, Mesocyclops fimbriatus , etc*

Ostracoda, being least represented, was sparsely distributed during the entire period of study and no definite trend was observed in all the selected water bodies. The group, as a whole, made a small contribution to overall zooplankton density throughout study. Ostracods were represented by only three species viz., *Cypris sps.*,and *Ilyocypris* species.

Table Monthly variations in the population density of Zooplankton (ind. /L) at (Vikram Tearth Sarovar) from JAN.2018 to DEC.2018

JAN.2018 to DEC.2018												
Seasons	**Winter**			**Summer**				**Monsoon**			**Post-Monsoon**	
Zooplankton	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**
ROTIFERA (a)												
Anuraeopsis fissa	16	29	56	112	129	131	141	88	36	15	75	68
Brachionus calyciflorus (Ehrenberg, 1838)	23	30	77	167	185	257	245	71	44	18	145	112
B. quadridentata (Hermann, 1783	19	32	58	91	136	156	137	79	38	16	87	71
B. bidentata (Anderson, 1889)	17	29	61	101	126	157	125	60	42	21	80	81
Brachionus caudatus	19	32	55	91	145	191	177	72	37	19	72	83
Brachionus angularis	11	21	40	88	101	148	145	71	31	14	72	61
Brachionus sp.	13	19	24	70	88	111	137	68	41	6	68	55
Brachionus rubens	11	29	61	98	147	177	141	69	39	19	88	83
Keratella cochlearis (Gosse, 1851)	9	19	30	45	65	77	85	40	19	8	40	33
Keratella tropica	19	39	81	171	181	235	257	81	46	30	138	91
Keratella valga (Ehrenberg, 1834	17	25	44	141	153	201	170	55	49	18	122	77
Monostyla bulla (Gosse, 1867)	15	19	55	91	111	170	135	62	36	21	82	81
Monostyla deprsessa	11	25	62	85	121	155	110	55	22	11	69	60
Platyias patulus (O. F. Muller, 1786)	17	36	25	77	177	200	197	67	28	16	88	77
Lecane flexilis (Gosse, 1886)	18	31	44	82	155	177	162	77	25	13	97	81
Asplanchana brightweli	12	25	44	97	153	164	189	68	49	15	91	88
Asplanchana priodonta	91	188	161	91	61	18	24	17	15	11	76	102
Filinia longiseta (Ehrenberg, 1834)	15	22	41	88	177	168	181	54	38	18	99	82
Trichocerca cylindrical	18	14	26	32	41	25	12	31	19	11	66	71
Cephalodella sp	17	25	51	100	121	180	175	61	50	18	122	77
Cephalodella megacephalla	18	22	51	142	171	201	244	76	38	15	110	88
Lapdella patella	23	28	77	164	185	233	223	76	38	15	121	111
Lapdella ovalis (O.F.Muller, 1773)	14	21	46	78	110	148	155	76	38	17	74	66
Hexathra mira	22	31	55	177	279	199	177	76	38	15	102	92
TOTAL= 24	465	791	1325	2479	3318	3879	3744	1550	856	380	2184	1891
(B) CLADOCERA												
Alona affinis (Leydig, 1860)	11	42	36	49	31	44	10	15	11	19	44	48
A.costata (Sars, 1862)	17	19	36	99	181	191	145	48	25	21	88	85
A. monacantha (Sars, 1901)	22	19	29	85	150	171	155	56	38	18	65	71
A. rectangula (Sars, 1861)	8	21	31	88	152	160	147	51	25	22	71	59
Ceriodaphnia dubia (Richard, 1894)	15	30	91	238	201	155	137	76	38	24	88	101
C. reticulata (Jurine, 1820)	21	31	55	160	188	181	170	76	38	20	71	52
Chydorus ovalis (Kurz, 1875)	19	31	81	165	181	211	227	72	38	25	125	91
C. sphaericus (O. F.Muller, 1785)	23	34	77	191	187	260	211	75	41	19	126	106
D. magna (Straus, 1820)	24	39	62	81	117	151	159	78	43	22	94	74
D. pulex (Leyig, 1860)	19	31	55	88	111	144	133	68	45	21	88	78
D.catwaba	27	44	52	92	121	155	129	55	39	25	79	83
Simocephalus vetulus	23	34	81	201	229	198	177	76	38	11	135	198
Bosmania longirostris	15	34	77	188	210	251	184	71	29	21	129	153
Macrothrix rosea (Jurine,1820)	23	67	99	166	95	44	29	44	25	19	136	132
Moina sp.	27	36	65	199	250	201	191	88	33	18	112	177
TOTAL= 15	294	512	927	2090	2404	2517	2204	949	506	306	1451	1508
(C) COPEPODA												
C.viridis (Jurine, 1820)	12	22	37	81	132	97	131	46	31	17	71	68
C. insignis (Claus, 1857)	196	145	78	17	12	0	0	6	19	9	51	92
C. bicolor (Sars G.O, 1863)	15	22	35	77	124	115	119	40	29	11	56	59
Mesocyclops leuckarti	0	9	21	81	141	126	155	51	25	19	65	41
Mesocyclops hyalinus	11	26	41	79	131	124	119	45	31	11	61	51
Mesocyclops sp.	15	28	47	71	118	104	119	33	24	8	58	57
Paracyclops fimbriatus	18	39	55	97	145	171	155	48	34	18	70	75
Paracyclops affinis (Sars, 1863)	22	44	52	78	177	176	159	51	34	18	65	81
Macrocyclops sp.	19	31	44	69	125	103	98	48	25	12	54	65
Eucyclops sp	15	19	40	77	90	107	123	40	29	11	44	50
Diaptomus sp	78	65	17	12	0	0	0	8	9	5	35	48
Eucyclops macrurus (Sars, 1863)	17	35	48	72	128	112	133	40	27	10	37	46
TOTAL= 12	418	485	515	811	1323	1235	1311	456	317	149	667	773
(d) OSTRACODA												
Cypris sp.	17	29	51	79	93	145	152	67	35	11	59	71
Ilyocypris sp.	21	25	64	78	97	151	147	69	32	9	47	75
TOTAL= 02	38	54	115	157	190	296	299	136	67	20	106	146
Grand Total= 53	1215	1842	2882	5537	7235	7927	7558	3091	1746	855	4408	4318

Seasonal succession (based on relative density) of zooplankton

The seasonal succession of zooplankton gives an idea of the dominance pattern of different groups in different seasons based on the relative density (% density values). During the entire study period for the year 2018, the Rotifera dominated followed by Cladocera, Copepoda and Ostracoda.

Rotifera > Cladocera > Copepoda >Ostracoda

Table. Seasonal succession of zooplankton or percentage distribution (based on relative density values of different groups) in Vikram tearth sarovar during the year 2018 (Jan- Dec) .

JAN –DEC 2018				
	Rotifera	**Cladocera**	**Copepoda**	**Ostracoda**
WINTER	**43.45**	**29.17**	**23.27**	**3.40**
SUMMER	**47.49**	**32.61**	**16.56**	**3.33**
MONSOON	**48.94**	**30.93**	**16.19**	**2.14**
POST MONSOON	**46.68**	**33.89**	**16.49**	**2.14**

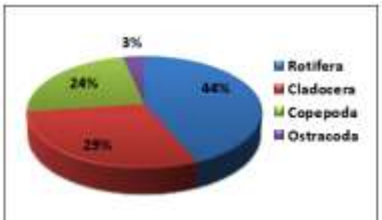

Fig. Relative density of zooplankton in Winter season during 2018 in Vikram Tearth sarovar

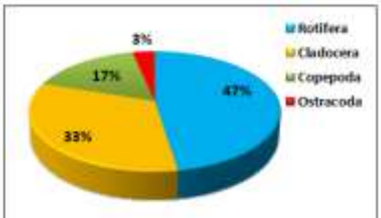

Fig. Relative density of zooplankton in Summer season during 2018 in Vikram Tearth sarovar

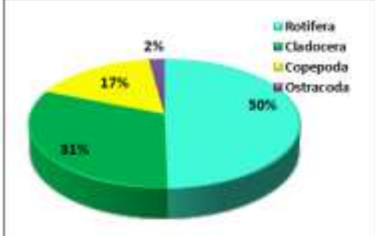

Fig. Relative density of zooplankton in Monsoon season during 2018 in Vikram Tearth Sarovar

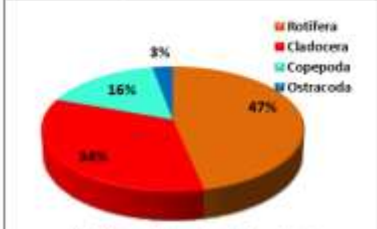

Fig. Relative density of zooplankton in Post Monsoon season during 2018 in Vikram Tearth Sarovar

Shannon- Weiner index

Shannon- Weiner index was used to work out the species diversity of different groups of zooplankton Community.

Shannon- Weiner index (H') for Vikram Tearth Sarovar (Madhya Pradesh)

JAN 2018-DEC2018				
1	**ROTIFERA**	**CLADOCERA**	**COPEPODA**	**OSRACODA**
2	**3.14**	**2.67**	**2.45**	**0.69**

DISCUSSION

Nature has provided different adaptability mechanisms for organisms in response to changing environmental conditions. Monitoring and assessment of the freshwater environment are often based on turbidity, pH, dissolved oxygen, biological oxygen demand and nutrients. Point measurements of these physico- chemical traits can vary over hours to weeks, and from meters to kilometers, where as we need traits that integrate the small scale variation. Zooplanktons have been widely used as bio-indicators to monitor and assess various forms of pollution including acidification, eutrophication and pesticide pollution and algal toxins.

During the entire investigation period for the year 2018 in Vikram Tearth Sarovar Ujjain (M.P), Brachionidae was the most dominant family which may be due of their adaptability to diverse and harsh environmental conditions (Nandini *et al.,* 2007; George *et al.,* 2011). Dominant nature of Rotifers and Cladocerans in freshwater lakes, as in the present study, has been attributed by many workers to eutrophication. Branco *et al.,* (2002) observed that the dominance of wheel animalcules followed by water fleas is sign of accelerated eutrophication in freshwaters (Xiong *et al.,* 2003; Tasevska *et al.,* 2010). Guevare *et al.,* (2009) also observed the same dominance pattern in temperate lakes. Here are some important zooplanktons which were recorded during the study period and are Biomarkers of Polluted or Clean waters.

Brachionus calyciflorus: was poorly represented in winter and dominated summers. The species dominated the Vikram Tearth Sarovar throughout the study period. The species was abundant on those sites which were (i) grossly polluted, (ii) shallow in nature, and (iii) having profuse growth of macrophytes. Kaul *et al*., (1978) also believed that the species is indicative of gross organic pollution while studying the plankton ecology of Shadipora pond in Kashmir.
***Keratella cochlearis*:** The species was very less abundant at Vikram Tearth Sarovar during the present study. This Species usually prefers less polluted water. This observation is in agreement with the findings of Nogueira (2001) and Sampaio *et al.*, (2002).

***Keratella tropica*,** was abundant in summer and post monsoon season at those sites which received sewage outfalls and agricultural waters and thus showed degraded water quality due to pollution. Species dominated Vikram Tearth Sarovar. *Keratella tropica* was present throughout the year (2018) with most dominant being in the summer and post monsoon season. Our observation agreed with Sladeck (1983) and Sharma (1986) who represented it as indicator species, preferring eutrophic waters.

***Lecene flexilis*,** dominated Vikram Tearth sarovar during the study entire study period for the year 2018. The species was abundant during summers and post monsoon season, when there was luxuriant growth of macrophytes. While as during winter season the species were less or absent. This species prefer macrophytes so as to avoid predation. This observation is in agreement with the findings of Hann (1995) and Green (2003).

***Cephalodella sp.* and *Cephalodella megalocephala*.** The species registered their peak population in summer and post monsoon season in Vikram Tearth Sarovar when there was luxuriant growth of macrophytes. They dominated Vikram tearth sarovar during summers for the year 2018. Our observation agreed with Kiya and Altinda (2009) who reported that the species remain associated with macrophytes and prefer a wide range of environmental conditions.

***Hexarthra mira*,** the species was abundant in summer and post monsoon season in Vikram Tearth Sarovar. The species was present and dominated the selected site for the year 2018. The assumption gains further support from the studies of Sladecek (1983) who categorized it as inhabitant of critically polluted sites and that of Sousa *et al*,. (2008) who opined the species prefers turbid environments.

***Asplanchna priodonta*,** the species was recorded at sites in Vikram Tearth Sarovar which were subjected to more anthropogenic pressures. The species dominated winters besides post monsoon season throughout the study. Our observation is in consonance with Balkhi (1983) and Nogrady and Segers (2002) who opinioned that this rotifer prefers eutrophic environment.

***Trichocerca cylindrical* and *Trichocerca sp.*,** The species preferred clean waters. The species were rare in Vikram Tearth sarovar throughout the study period for the year 2018. Our observation is in consonance with Sladecek (1983) categorized it as oligotrophic in nature.

***Chydorus sphaericus* and *C. ovalis*,** The species inhibited and dominated Vikram tearth Sarovar and were present throughout year (2018). Both these species prefer eutrophic waters and feed on detritus. The species dominated summer and postmonsson season. This observation is in agreement with the findings of Yousuf (1979) and Balkhi *et al.*, (1987).

***Moina sp*.** Also dominated the Vikram Tearth Sarovar and was present throughout the year (2018) with higher density being recorded during summer and post monsoon season. The species flourishes in polluted waters. Our observation is in agreement with the findings of Siraj *et al.*, (2006) who reported the species as bioindicator of water pollution.

***Diaptomus sp.*,** during the entire study period for the year 2018, the species being rare in summer and was fairly present in cold to moderately warm waters. The species was rare or absent during the whole study period. Our observation is in line with Shah *et al.* (2013) who opined the species prefers clean waters.

Brachionus: Trichocerca Ratio ($Q_{B/T}$)

Brachionus: Trichocerca ratio was introduced by Sladecek in 1983. It is also called as Sladecek's $Q_{B/T}$ quotient. As per Sladecek (1983), the genus *Brachionus* are generally found in eutrophic waters (except two species i.e. *B. plicatilis* inhabitant of brackish waters and *B. sericus* a typical acidophilic species) and the genus *Trichocerca*are are purely oligotrophic in behavior or clean water inhabitant. This ratio can be used for individual water body or even for the individual sample.

If the value of this quotient is less than 1.0 it means oligotrophic condition, values between 1.0 and 2.0 reflect mesotrophic and values over 2.0 indicate eutrophic conditions. During the present study, the ratio of *Brachionus* to *Trichocerca* at Vikram Tearth sarovar was 7:2 ($Q_{B/T} = 3.5$). That reflects the eutrophic nature of the water bodies under study as per Sladecek (1983).

Diversity indices

Shannon- Weiner index (1948) is the most common index used in ecology (Buzas and Hayek, 1996; Gorelick, 2006; Shah and Pandit, 2013).This index provides us the information about the two important aspects of biological community *i.e.*, richness and evenness (Melo, 2008). Generally the value of the same index varies from 0 to 5. In the present study the Vikram Tearth Sarovar recorded higher values indicating stable environmental conditions as the site has good macrophytic growth which provides shelter, food and protection to these Zooplanktons, a fact also supported by (Sommer *et al*., 1986; Hann and Zrum, 1997; Pandit, 1998; Moya and Duggen, 2011).

CONCLUSION

The current study for the year 2018(Jan-Dec) in Vikram Tearth Sarovar Ujjain (M.P) clearly shows the possible use of zooplankton as indicators to determine the nature of freshwater bodies. As different species of planktons have varying degrees of tolerance to changing environmental conditions were recorded during the present study. Furthermore, the analysis during the year 2018 (Jan- Dec) indicates that the selected water body (Vikram Tearth Sarovar) from Ujjain city (M.P) is under severe anthropogenic pressures, as evidenced by elevated B/T values and a plethora of pollution markers (Zooplanktons).

ACKNOWLEDGMENTS

Thanks are due to the Pollution control Board Indore (M.P) and Govt. Holkar Science College, Indore (M.P) for providing necessary laboratory facilities and also support to our research.

REFERENCES

1. Adoni, A.D. (1985). Work Book of Limnology. Pritibha Publication, Sagar, M.P., India.
2. Amoros, C. (1984). Introduction Pratique à la Systématique des Organisms des eaux Continentales Françaises. Crustacés Cladocères. Bull. Soc. Linn. Lyon. 72- 145.
3. Balkhi, M. H., Yousuf, A. R. and Qadri, M. Y. (1987). Hydrobiology of Anchar lake. J. Comp. Phys. Ecol., 12: 131 – 139
4. Balkhi, S.M.H. (1983). Zooplankton Communities of Nilnag Lake, Kashmir. M.Phil. Dissertation, University of Kashmir, Srinagar -190006, J and K, India.
5. *Cohn, F. (1853).Beiträge zur Biologie der Pflanzen.*
6. Dussart, B.H. and Defaye, D. (1995). Copepoda: Introduction to the Copepoda. (H.J.F. Dumond ed.) The Hague: SPB Academic Publishing. III. The Netherlands 277pp.
7. Fileto C, Arcifa MS, Ferrão-Filho AS, Silva LHS Influence of phytoplankton fractions on growth and reproduction of tropical cladocerans. Aquatic Ecology 2004; 38: 503-514. (http://dx.doi.org/10.1007/ s10452- 004-4087-x).
8. George, G., Seeraj, C.R. and Roy, D.S. (2011). Brachionid rotifer diversity in Andaman waters. Indian Journal of Geo-Marine Sciences, 40(3): 454–459.
9. Green, J. (2003). Associations of planktonic and periphytic rotifers in a tropical swamp, the Okavango Delta, Southern Africa. Hydrobiologia, 490: 197–209.
10. Hann, B. J. (1995). Invertebrates associations with submersed aquatic plants in a prairie wetland. USF (Delta Marsh) Annual report, Vol. 30.
11. Illiopoulou-Georgudaki, J.,Kantzaris,V., Katharios, P., Kaspiris, P., Georgiadis,T. and Montesantou, B. (2003). An application of different bioindicators for assessing water quality: a case study in the rivers. Alfeios and Pineios (Peloponnisos, Greece). Ecol. Indic. 2 (4): 345-360.
12. Kaul, A. K. (1978). Kashmir weather and climate. Inquiry (Coll. Edu. Srinagar, India) 5:17-36.
13. Kolenati, F.R.A. Uber Nutzen und Schaden der Trichopteren, (1848). Stettiner entomol. 9: 50-52
14. Koste, W. (1978). Rotatoria Borntraeger, Berlin, 673p.
15. Kumar, R. and Kapoor, R. (2006). Water quality monitoring in respect to physico chemical characteristics of a Tropical Lake of Udaipur city, Rajasthan. Indian.J. Enivron. And Ecoplan. 12(3): 775-782.
16. Mahananda HB, Mahanand MR, Mohanty BP (2005) Studies on the physico-chemical and biological parameters of a fresh water pond ecosystem as an indicator of water pollution. Ecol Environ Conserv 11(3–4):537–541
17. McGeoch, M.A. (1998) The Selection, Testing and Application of Terrestrial Insects as Bioindicators. Biological Reviews, 73, 181-201.
18. Nandini, S., Ramírez-García P. and. Sarma, S.S.S (2005). Seasonal variations in the species diversity of planktonic rotifers in Lake Xochimilco, Mexico. J. Freshwater Ecology, 20: 287-294.
19. Nogrady, T. and Segers, H. 2002. Rotifera. Asplanchnidae, Gastropodidae, Lindiidae, Microcodidae,Synchaetidae, Trochosphaeri-dae and Filinia. Backhuys Publishers, Leiden, The Netherlands. Vol.6: 264p
20. Nogueira, M. G. (2001). Zooplankton composition, dominance and abundance as indicators of environmental compartimentalization in Jurumirim Reservoir (Paranapanema River), São Paulo, Brazil. Hydrobiologia, 455: 1-18.
21. Pennak, R.W.(1978). Freshwater Invertebrates of United States of America. Wiley Interscience Pub., N. Y
22. Sampaio, E.V., O. Rocha, T. Matsumura-Tundisi and J.G. Tundisi, (2002). Composition and abundance of Zooplankton in the limnetic zone of seven reservoirs of the Paranapanema River, Brazil. Braz. J. Biol., 62: 525-545.
23. Schriver P, Bøgestrand J, Jeppesen E, Søndergaard M. Impact of submerged macrophytes on fish-zooplanktonphytoplankton interactions: Large-scale enclosure experiments in a shallow eutrophic lake, Freshwater Biology, 1995; 33: 255–270 http://dx.doi.org/10.1111/j.1365-2427.1995.tb01166.x).
24. Shah JA, Pandit AK.Taxonomic survey of crustacean zooplankton in Wular lake of Kashmir Himalaya. Journal of Evolutionary Biology Research,2014; 6(1), 1-4.
25. Shah, J. A. and Pandit, A. K. (2013).Seasonal succession of crustacean zooplankton in Wular lake of the Kashmir Himalaya. Arch. Biol. Sci., Belgrade, 65 (3), 1063- 1068. (DOI: 10.2298/ABS1303063B)
26. Shannon.C.E. and W. Weaver: The Mathematical Theory of Communication. University of Illinois Press. Urbana, IL., USA (1949).
27. Sharma, J.P. and Srivastava, J.B. (1986). Ecological observations on rotifer fauna of some freshwater ponds of Jammu (J and K) India. Geobios new reports, 5: 6- 10.
28. Siraj, S., Yousuf, A. R., Bhat, F. A. and Parveen, M. (2006). Impact of floating gardens on the water quality and zooplankton community in Dal lake, Kashmir. J. Res. Dev., 6: 25 – 34.
29. Sládecek, V. (1983). Rotifers as indicators of water quality. Hydrobiologia, 100:169- 201.
30. Sousa, W., Attayde, J.L., Rocha, E.S. and Eskinazi-Sant'anna, E.M. (2008). The response of zooplankton assemblages to variations in the water quality of four man-made lakes in semi-arid northeastern Brazil. Journal of Plankton Research, 30 (6): 699-708.
31. Tasevska, O., Kostoski, G. and Guseska, D. (2010). Rotifers based assessment of the lake dojran water quality. Ohrid, Republic of Macedonia, 25: 1-8.
32. Welch, P.S.(1952). Limnology. 2nd ed Mc Graw Hill Book Co., New York. 538 p.

33. Xie P, Iwakuma T, Fujii K. Changes in the structure of a zooplankton community during a Ceratium (dinoflagellate) bloom in a eutrophic fishless pond. Journal of Plankton Research 1998; 20:1663-1678. (http:// dx.doi.org/ 10.1093/ plankt/20.9.1663).
34. Xiong, J., Mei, X. and Liu, J. (2003). Comparative studies on community estructure, biodiversity of plankton and zoobenthos in four lakes of different trophic states in China. Asian Fish. Sci., 16: 361-372.
35. Yousuf, A.R. (1979). Limnology and Fisheries of Lake Manasbal, Kashmir. Ph.D thesis University of Kashmir, J& K, India.