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Zooplankton Diversity in Eight Lentic Water Bodies of Haryana, India : A Multilocation Study

Pooja Devi, Anita Bhatnagar

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ABSTRACT

Zooplanktons are very important bio-indicators and also improves the water quality. So, present study has been conducted to evaluate the seasonal variations of zooplanktons in terms of qualitative, quantitative and diversity aspect in lentic water bodies of Haryana. Total 79 taxa were observed during the study period. Species diversity index (H) of zooplankton ranged from 0 to 2.82. Highest zooplankton evenness (1.0) was recorded at site 2 during monsoon season followed by (0.9) at sites 4 and 5 during summer and winter season respectively clearly depicted the almost equal distribution of various species of zooplankton and their compliance against varying physico-chemical factors. The higher value of SDI (0.92) was reported at site 6 was mainly due to the presence of bloom of only one taxa, *Conochilus* in zooplanktons. Species richness was recorded highest at site 2 (98.66) during post-monsoon season followed by 87.47 at site 4 during monsoon season, overall low species diversity was recorded at maximum stations during winter season.

Keywords Water quality, Seasonal, Species diversity, Species richness, Zooplankton.

INTRODUCTION

The physical, chemical factors as well as biological diversity of any aquatic system can determine health of such ecosystems. Primary producers' forms are the main source of food for the zooplankton organisms and these further becomes the food for the higher organisms in food chain (Bhatnagar and Devi 2012). Thus, they constitute the significant part in aquatic food web and also play very crucial role in aquatic biological productivity of freshwater ecosystems (Nimbalkar *et al.* 2013). Conservation of the zooplankton biodiversity is very necessary for maintenance of the health of our ecosystem as different species plays variable roles like nutrient recycling, food for other organisms in food chain and also maintaining soil fertility. So, knowledge of their abundance, species diversity and specific distribution is useful in understanding the tropho-dynamics and trophic progression of aquatic systems. Rotiferans, Cladocerans, Copepods and Ostracods constitutes

Pooja Devi,
Dr B. R. Ambedkar Government College, Kaithal 136027, Haryana, India
Email: pooja.sangwan@rediffmail.com

Anita Bhatnagar*
Department of Zoology Kurukshetra University, Kurukshetra 136119, India
Email: anitabhatnagar@gmail.com
*Corresponding author

the foremost groups of zooplanktons. These groups have an intermediate place in the food web. Large density, stress tolerance, drifting nature and high species diversity of zooplankton makes them very crucial link in the energy transformation process of any aquatic food web (Bhat *et al.* 2014, Kehayias *et al.* 2014, Jeppesen *et al*. 2011, Preston and Rusak 2010). Distribution and diversity of zooplankton is the result of physico-chemical factors and nutrient status of any aquatic body and their population also gives an idea about the nature and potential of water bodies (Kumar *et al.* 2010) as they respond quickly to the aquatic environmental variations (Viz., Biological Oxygen Demand, Temperature, Dissolved Oxygen, pH and Ammonia) with short life cycle.The presence of healthy zooplanktons in an aquatic system is an indication of success in commercial fisheries. Several studies have been done by various scientists viz., Bhatnagar and Singh (2010), Dede and Deshmukh (2015), Pradhan (2014), Nimbalkar *et al*. (2013), Rao (2017) on the zooplankton community structure, abundance and their distribution on various aquatic bodies but a very few and limited studies are available on the zooplanktons in lentic water bodies of Haryana. However, inadequate understanding of zooplankton and their dynamics is a chief problem in our better understanding of life processes in freshwater bodies. So, the present study has been undertaken to evaluate the zooplankton diversity, abundance, distribution in prominent lentic aquatic systems of Haryana, India.

MATERIALS AND METHODS

Study area

The present research has been conducted on the eight lentic waterbodies of Haryana State (India) situated in four districts of Haryana i.e.Yamunanagar, Kurukshetra, Kaithal and Jind shown in Table 1.

For the collection of plankton samples 50 L water was filtered through a net of mesh size 50 µm in collecting tube. Then samples collected in 100 ml plastic bottles and were made up to a standard volume of 40 ml with distilled water and preservation of planktons samples was done with adding 4% buffered formalin.

Identification was planktons was done via the keys from Needham and Needham (1962),Tonapi (1980), APHA (2005).

Plankton's abundance was expressed as plankton per liter (nos. L^{-1}) using were Sedgwick rafter cell method according to APHA (2005) following formula :

Total no. of planktons were calculated as:

$$L^{-1} = (P \times C \times 100)/ L$$

Where,

Table 1. Details of sites selected.

Sl.No.	Name of selected sites	Districts	Latitude, Longitude	Description of anthropogenic activity taking place
1.	Site 1 (KapalmochanTirth)	Yamunanagar	30^0 326' N, 77^0 317' E	Mass bathing
2.	Site 2 (KulotaranTirth)	Kurukshetra	29^0 961'N, 76^0 827' E	Mass bathing and cattle bathing also
3.	Site 3 (Ban Ganga)	Kurukshetra	29^0 956' N, 76^0 778' E	Mass bathing
4.	Site 4 (Brahmsarovar)	Kurukshetra	29^0 937' N, 76^0 813' E	Mass bathing
5.	Site 5 (Jyotisar Tank)	Kurukshetra	29^0 922' N, 76^0 806' E	Mass bathing
6.	Site 6 (SaraswatiTirth)	Kurukshetra	29^0 978' N, 76^0 596' E	Pind-dan (addition of flour, flowers, ashes, oils) and mass bathing
7.	Site 7 (PhalguTirth)	Kaithal	29^0 835' N, 76^0 587' E	Pind-dan and mass bathing
8.	Site 8 (Pandu-PindaraTirth)	Jind	29^0 309' N, 76^0 322' E	Pind-dan and mass bathing

P = Total plankton count of 10 fields,
C = Final concentrated sample volume (i.e. 40 ml),
L = Volume of water that was filtered.

Diversity indices for zooplanktons

Different water quality indices like Shannon-Weiner Diversity Index, Evenness Index, Dominance Index and similarities index were analyzed for the assessment of zooplankton composition, diversity and their distribution.

Shannon Weiner Diversity Index (d)
(Shannon and Weiner 1963)

For the calculation of species diversity of planktons Shannon and Weiner Diversity Index method was followed that is regarded as an index for comparison and evaluation of species diversity between various habitats (Clarke and Warwick 2001).
For the calculation:

$H = - \sum (ni/N) \log_2 ni/N$
H = Shannon Weiner Diversity Index
ni = Number of individuals of i^{th} species
N = Total number of individuals of given sample

Evenness index (IE)

Evenness index is used for the estimation of relative abundance of different species in an area. It is a chief element of diversity indices (Leinster and Cobbold 2012). It also indicates that how much evenly the individuals among different species are distributed.

Calculation :

1) N = Total no. of plankton
2) Proportional depiction of each plankton (p_i) = n/N
3) These proportions (p_i's) was squared and total sum calculated as $\sum p_i^2$
4) $1/\sum p_i^2$ reciprocal value calculated
   This quantity that is ($1/\sum p_i^2$) is Simpson's D and is the measure of plankton diversity
5) Evenness (E) = $D/D_{max.}$ (where Simpson's D was divided by total no. of plankton species (i.e. maximum possible value for $D = D_{max.}$).

Index ranges from $1/D_{max}$ to 1 (equal distribution of all habitats,.

Simpson's Index of Dominance (SDI) (Simpson 1949):

Calculation :

$$D = \frac{\sum n\,(n-1)}{N\,(N-1)}$$

Where,

N = Total number of individuals of a particular species
N = Total number of individuals of all the species.

Sørensen–Similarity index

This is regarded as a statistical tool for the comparison of similarity between two samples .

$$QS = \frac{2C}{A+B} = \frac{2\,[A \cap B}{[A] + [B]}$$

A and B = Number of species in samples A and B, respectively.
C = Common Number of species between two samples.
QS = Quotient of similarity (Ranges 0 to 1).

RESULTS AND DISCUSSION

Zooplanktons are regarded as very sensitive to the environmental alterations, so are considered as indicators for evaluating the ecological conditions of any aquatic body (Parmar *et al.* 2016). Zooplankton diversity might be directly or indirectly influenced by the variations of physico-chemical variables. The zooplanktons were represented by mainly four groups' viz.,Copepoda, Cladocera, Rotifera, Ostracoda and other forms of Arthropods. Population density (nos. L^{-1}) wise zooplankton trend observed was - Rotifers were dominant at sites 2,3,6 and 7; Copepods were dominant at sites 1,4 and 8; Cladocerans were found to be dominant at sites 4 and 5 whereas Ostracods were dominant at site 2 and 5 (Fig. 1). A total of 79 taxa were recorded of these, 15 taxa belonged to Copepoda, 15 belonged to Cladocera, 44 taxa to Rotifera and 4 to other Arthropods, 1 to Ostracoda (Table 2). Among zooplankton the most abundant group recorded was of Rotifers followed

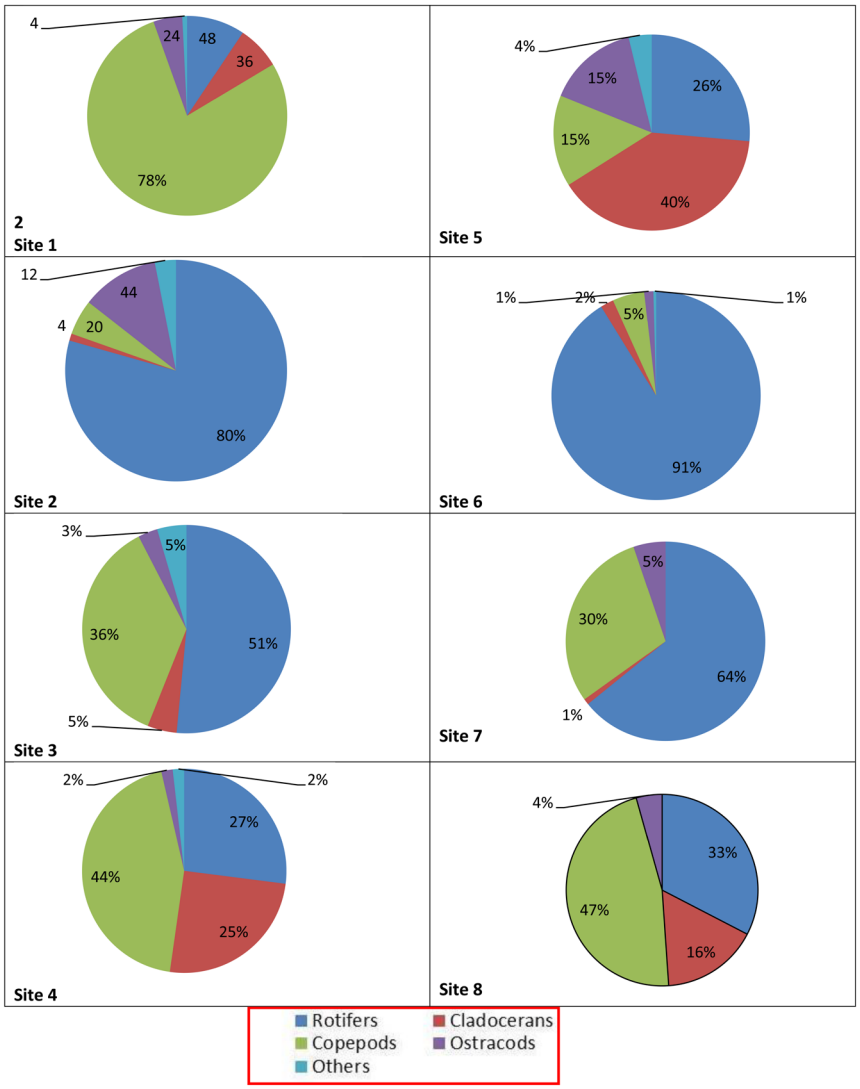

Fig. 1. Percent distribution of different groups of zooplankton at all selected sites (1-8).

by Copepods, Cladocerans, other Arthropods and Ostracods. Among these *Branchionus* spp., *Keratella* spp., *Daphnia* spp., *Bosmina* sp., *Diaptomus* sp., *Limnocalanus* sp., *Cyclops* spp.and *Cypris* sp. were the dominant taxa, observed at most of the sites during the investigation period.

During study period the zooplankton population varied from 120 to 31760 L^{-1}. The highest zooplankton population was observed at site 6 during monsoon season and the lower was recorded at site 5 (120) and at site 3 (160) during monsoon and summer season respectively. Overall the population was recorded higher at sites 3, 4 and 6 during monsoon season and at sites 2, 7 and 8 during post monsoon season whereas lower population was recorded during summer followed by in winters (Tables 3, 4). The maximum abundance of zooplankton was observed at site 6 during monsoon season. This was mainly due to a rotifer i.e. *Conochilus* and the lower was recorded at

Table 2. List of total zooplankton taxa (79) observed during the study period.

1. Copepoda	2. Cladocera	Class 3. Rotifera	4. Ostracoda
1. *Cyclops* sp.	1. *Daphnia* sp.	1. *Keratella cochlearis*	1. *Cypris* sp.
2. *Cyclops stennus*	2. *Daphnia pulex*	2. *Notholaca* sp.	
3. *Eucyclops serrulatus*	3. *Daphnia ambigua*	3. *Asplanchna priodonta*	
4. *Eucyclops prionophorus*	4. *Daphnia middendorfiana*	4. *Asplanchna herricki*	
5. *Mesocyc lopsleuckartii*	5. *Ceriodaphnia cornuta*	5. *Asplanchna brightwelli*	5. Other forms of Arthropods
6. *Tropocyclops parasinus*	6. *Bosmina* sp.	6. *Asplanchna sieboldii*	1. Chironomous larva
7. *Eucyclops phaleratus*	7. Diaphanosoma sp.	7. *Trichocera rattus*	2. Beetle
8. *Diaptomus* sp.	8. *Chydorus sphaericus*	8. *Trichocera elongata*	3. Bug
9. *Phyllodiaptomus* sp.	9. *Simocaphalus* sp.	9. *Trichocera porcellus*	4. Water spider
10. *Phyllodiaptomus smithi*	10. *Leydigia acanthocercoides*	10. *Trichocera capucina*	
11. *Phyllodiaptomus blanci*	11. *Alona puchella*	11. *Lecane arcula*	
12. *Limnocalanus* sp.	12. *Leptodora* sp.	12. *Lecanei napinata*	
13. *Eubranchipus* sp.	13. *Polyphemus* sp.	13. *Lecane ploenensis*	
14. *Canthocamptus* sp.	14. *Alonaaffinis*	14. *Filinia terminalis*	
15. *Nauplius* sp.	15. *Macrothrix* sp.	15. *Filinia longiseta*	
		16. *Monostyla* sp. II	
		17. *Monostyla bulla*	
		18. *Monostyla clasterocerca*	
		19. *Monostyla decipiens*	
		20. *Anauraepsis fissa*	
		21. *Anauraepsis navicula*	
		22. *Euchlanis dilata*	
		23. *Gastropus* sp.	
		24. *Rotaria* sp.	
		25. *Polyurthera* sp.	
		26. *Testudinella* sp.	
		27. *Brachionusrotundiformis*	
		28. *B. angularis*	
		29. *B. plicatilis*	
		30. *B. forficula*	
		31. *B. calyciflorus*	
		32. *B. diversicornis*	
		33. *B. falcatus*	
		34. *B. dimidiatus*	
		35. *B. bidentata*	
		36. *B. caudatus*	
		37. *B. quadridentatus*	
		38. *B. bravispina*	
		39. *B. nilsoni*	
		40. *B. budapestinensis*	
		41. *Keratellatropica*	
		42. *K. quadrata*	
		43. *K. testudo*	
		44. *Conochilus* sp.	

site 5 (120) and at site 3 (160) during monsoon and summer season respectively. According to Bhat *et al.* (2014) the abundance of zooplankton during summer season may be due to high phytoplankton density and increased decaying organic matter during this season.

Species diversity index (H) or Shannon - Weiner diversity index is regarded as a sensitive indicator of pollution. Species diversity index of zooplankton ranged from 0 to 2.82. Similar range of 'H' was also reported by Bhat *et al.* (2014) in their study on Bhoj wetland and also by Sulehria and Malik (2013). The value of (H) was found maximum at site 6 (2.82) during post-monsoon season followed by at site 4 (2.66) during post-monsoon and then at site 7 (2.46) during summer period. The value of (H) was found

Table 3. Sørensen similarity index of zooplankton among all the selected sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Site 1	1.000	0.163	0.212	0.262	0.224	0.268	0.163	0.222
Site 2		1.000	0.184	0.194	0.109	0.094	0.196	0.235
Site 3			1.000	0.231	0.204	0.286	0.265	0.241
Site 4				1.000	0.242	0.319	0.226	0.269
Site 5					1.000	0.283	0.217	0.137
Site 6						1.000	0.302	0.241
Site 7							1.000	0.196
Site 8								1.000

to be above 2.00 at sites 1, 2, 4 and 7 during summer season, only at site 7 during monsoon season, at sites 1, 2, 4 and 6 during post monsoon season and at site 1 during the winters while lower value of (H) was observed at site 2 during monsoon (Table 5). From these present results it was depicted that higher diversity was found in summer and post- monsoon seasons whereas low diversity was noticed during monsoon and winters. This range of Shannon Weiner Diversity Index more than 2 indicated the greater diversity of zooplankton at corresponding sites during the respective seasons. However, according to Bhat *et al*. (2014) the highest value of (H) i.e. 2.82 for zooplankton thus findings of present studies depicted all sites as less diverse and with poor in water quality.

Index of Evenness (IE) of zooplankton ranged from 0 to 1.0. It was recorded maximum at site 2 during monsoon season and minimum at site 5 also during monsoon time (Table 5). Sharma and Sharma (2012) have observed the values of IE from 0.049 to 0.110 at the floodplain lake of Brahmaputra River basin, India. Values of IE (Table 5) near 1 or equal to indicates uniform or even distribution of species whereas the values far from 1 reflected the uneven distribution of the species. The IE values was observed 1 at site 2 during monsoon period, followed by 0.9 at site 4 and 5 during summer and winter season respectively and then 0.89 at site 8 during monsoon season depicting the uniform distribution of zooplankton. Higher values of zooplankton evenness at these sites indicated the impartial abundance of various species of zooplankton and their tolerance towards varying physico-chemical variables. The IE value was recorded 0 was at site 5 (Jyotisar) in monsoon season indicated the uneven distribution of zooplankton species at the site.

Species Dominance Index (SDI) of zooplankton ranged from 0.0 to 0.92. It was observed maximum at site 6 during monsoon season and minimum at site 2 during monsoon period (Table 5). The highest value of SDI at site 6 was mainly due to the presence of bloom of only one taxa, *Conochilus* during the monsoon season and it indicated the eutrophic nature of the site similar to the findings of Singh *et al.*(2016).

Table 4. Season wise distribution of total zooplankton population (nos. L-1) at all the selected sites. All values are Mean ± SE of mean Means with different capital letters in the same column and different small letters in the same row are significantly ($p< 0.05$) different (Duncan's Multiple Range test). The first capital letter is denoting the site wise comparison in same season and small letter is denoting only one site comparison during different seasons.

	Summer	Monsoon	Post-Monsoon	Winter
Site 1	1360 ± 80^{Aa}	1280 ± 80^{CDa}	1000 ± 40^{Cb}	1320 ± 40^{Aa}
Site 2	$760\pm40B^{Cb}$	200 ± 40^{Ec}	1800 ± 40^{Ba}	
Site 3	160 ± 0^{Db}	2000 ± 80^{BCa}	400 ± 80^{Db}	280 ± 40^{Eb}
Site 4	840 ± 40^{Bb}	1720 ± 120^{BCa}	1480 ± 40^{BCa}	600 ± 40^{CDb}
Site 5	$400\pm80C^{Db}$	120 ± 40^{Ec}	960 ± 80^{Ca}	440 ± 40^{DEb}
Site 6	1280±80Ac	31760 ± 800^{Aa}	3560 ± 280^{Ab}	680 ± 80^{BCc}
Site 7	$1600\pm320A^{c}$	2600 ± 40^{Bb}	3760 ± 320^{Aa}	520 ± 40^{CDd}
Site 8	1480 ± 40^{Aa}	560 ± 80^{DEc}	1000 ± 120^{Cb}	800 ± 80^{Bbc}

Table 5. Seasonal variations in Shannon-Weiner diversity Index (H), Index of Evenness (IE) and Species Dominance Index (SDI) and Species Richness index (R) of zooplankton at all the selected sites.

Seasons	Index	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
	H	2.20±0.10^{B}	2.03±0.14^{BC}	0.69±0.00^{E}	2.35±0.04^{B}	1.93±0.04^{C}	1.42±0.02^{D}	2.46±0.04^{A}	1.88±0.03^{C}
	IE	0.75±0.07^{ABC}	0.81±0.12^{AB}	0.67±0.00^{BC}	0.90±0.01^{A}	0.70±0.01^{BC}	0.57±0.02^{C}	0.79±0.03^{AB}	0.70±0.04^{BC}
Summer	SDI	0.12±0.01^{C}	0.13±0.02^{C}	0.47±0.00^{A}	0.09±0.00^{C}	0.11±0.11^{C}	0.28±0.01^{B}	0.08±0.00^{C}	0.17±0.01^{BC}
	R	49.11±0.59^{ABC}	34.63±0.42^{AB}	5.55±0.00^{BC}	46.81±0.37^{A}	35.44±0.38^{BC}	24.25±0.31^{C}	65.71±2.64^{AB}	34.98±0.19^{BC}
	H	1.78±0.16^{B}	0.66±0.03^{C}	1.79±0.42^{B}	2.66±0.06^{A}	0.00±0.00^{C}	0.25±0.01^{C}	2.33±0.03^{A}	1.33±0.00^{B}
	IE	0.65±0.12^{B}	1.00±0.00^{A}	0.29±0.18^{C}	0.77±0.02^{AB}	0.00±0.00^{A}	0.14±0.00^{C}	0.75±0.04^{AB}	0.89±0.01^{AB}
Monsoon	SDI	0.19±0.04^{B}	0.0	0.15±0.01^{B}	0.07±0.00^{B}	0.73±0.27^{A}	0.92±0.00^{A}	0.11±0.01^{B}	0.26±0.01^{B}
	R	33.95±0.44^{B}	2.98±0.20^{A}	68.87±0.52^{C}	87.47±1.19^{AB}	3.81±1.73^{A}	56.44±0.18^{C}	61.16±0.17^{AB}	12.05±0.43^{AB}
	H	2.03±0.03^{BC}	2.33±0.06^{B}	1.30±0.26^{DE}	2.44±0.06B	1.98±0.01^{BC}	2.82±0.02^{A}	1.22±0.05^{E}	1.94±0.03^{C}
Post-	IE	0.81±0.09^{A}	0.45±0.02^{CD}	0.72±0.18^{AB}	0.75±0.03^{AB}	0.55±0.02^{BC}	0.70±0.02^{ABC}	0.23±0.01^{D}	0.55±0.03^{BC}
monsoon	SDI	0.15±0.02^{C}	0.11±0.00^{C}	0.28±0.07^{B}	0.09±0.00^{C}	0.14±0.00^{C}	0.07±0.00^{C}	0.49±0.02^{A}	0.16±0.01^{C}
	R	32.23±0.28^{A}	98.66±0.42^{CD}	14.67±0.81^{AB}	64.96±0.35^{AB}	50.17±0.92^{BC}	117.44±1.58^{ABC}	47.41±0.69^{D}	45.98±1.21^{BC}
	H	2.13±0.03^{B}	-	1.07±0.03^{D}	1.74±0.01^{C}	1.33±0.00^{D}	1.72±0.17^{C}	0.62±0.02^{E}	1.79±0.11^{C}
	IE	0.58±0.03^{B}	-	0.57±0.03^{B}	0.54±0.01^{B}	0.90±0.00^{A}	0.49±0.08^{B}	0.87±0.03^{A}	0.80±0.11^{A}
Winter	SDI	0.19±0.01^{D}	-	0.33±0.03^{B}	0.17±0.00^{D}	0.26±0.00^{C}	0.18±0.03^{D}	0.57±0.02^{A}	0.17±0.03^{D}
	R	39.06±0.24^{B}	-	13.29±0.58^{B}	36.83±0.60^{B}	11.34±0.27^{A}	41.51±1.26^{B}	3.95±0.08^{A}	26.26±0.60^{A}

Species Richness Index (R) of the zooplankton ranged from 3.81 to 98.66 (Table 5). It was found maximum at site 6 during post-monsoon period followed by 87.47 at site 4 during monsoon, 65.71 at site 7 during summers and was recorded minimum at site 5 during monsoon time. However, overall low species diversity was recorded at maximum stations during winter season.

Sorensen similarity index of zooplankton (Table 3) was recorded highest between Brahmsarovar and Saraswati Tirth (0.318), followed by SaraswatiTirth and Phalgu (0.302), Banganga and SaraswatiTirth (0.285), Kirmach and Banganga (0.258), Brahmsarovar and Pindara (0.258), Kapalmochan and Jyotisar, Jyotisar and SaraswatiTirth (0.283). Similarity values ranged between 0.094 and 0.318. The similarity index was recorded minimum 0.094 and 0.108 between Kirmach and Saraswati Tirth and Kirmach and Pindara. Similarly, the value was less for Jyotisar and Pindara. This range is similar to the range as reported by Brakovska *et al.* (2012) during study of two lakes. The low similarity index values depicted that different locations and different water quality conditions of different sites so different zooplankton species composition. Total 79 taxa of zooplankton (Table 2) were recorded during the present studies; high numbers of species were recorded from group rotifera (56%) followed by Copepoda (19%), Cladocera (19%), Ostracoda (1%), which in turn was followed by other arthropods forms (5%) and similar results were also observed by Bhat *et al*. (2014) who reported the trend in zooplankton species as Rotifers >Cladocerans>Copepoda>Ostracods. Among all zooplankton *Cyclops, Keratella* and *Daphnia* were the most abundant and common zooplankton taxa. Among zooplankton the role of Copepods group in energy transfer via food chain and their occurrence in large numbers indicates higher level of nutrients. Copepods were observed in abundance at sites 1, 4 during all the four seasons, at site 2 during summer season (similar to the findings of Bhat *et al*. 2014), at sites 3 and 7 during monsoon season. Copepods were also dominant at site 5, 6, 8 during post-monsoon season. However, copepods population was observed higher in winter season at site 1 that confirms the findings of Echaniz and Vignatti (2010). A total of 15 taxa were recorded from all the sites viz.,*Cyclops* sp., *Cyclops stennus, Eucyclops serrulatus, Eucyclops prionophorus, Mesocyclops leuckartii, Tropocyclops parasinus, Eucyclops phaleratus, Diaptomus* sp., *Phyllodiaptomus* sp., *Phyllodiaptomus smithi, Phyllodiaptomus blanci, Limnocalanus* sp., *Eubranchipus* sp., *Canthocamptus* sp., *Nauplius* sp. Among these *Cyclops* sp. was recorded most abundant taxa at all the sites while *Nauplius* sp. was also in abundance at all the sites except sites 2 and 8. Dominance of genera *Cyclops* and *Nauplius* were also reported by

Bhat *et al.* (2014) during their study on Bhoj wetland of Bhopal. *Tropocyclops parasinus* and *Mesocyclopsl euckart*i were common during the winter season at site 1. The copepods abundance was very low at the sites 2 and 6 may be attributed to the dominance of rotifers group here.The cladocerans prefer to live in clear waters (Rajashekhar *et al.* 2009). The group cladocera contributed about 19 % of the total zooplankton species encountered during the present studies. Out of cladocera a total of 15 genera have been identified in the present studies viz., *Daphnia* sp., *Daphnia pulex, Daphnia ambigua, Daphnia middendorfiana, Ceriodaphnia cornuta*, *Bosmina* sp., *Diaphanosoma* sp., *Chydorus sphaericus, Simocaphalus* sp., *Leydigia acanthocercoides, Alona puchella, Leptodor*a sp., *Polyphemus* sp., *Alonaaffinis, Macrothrix* sp. Cladocerans were found in abundance at site 4 and 5. At site 4 the population of cladocerans were recorded higher during monsoon and post-monsoon season whereas at site 5 in all the seasons except monsoon period. The population was observed higher during the summer season at site 1. In contrary to this observation, the population was recorded higher in winter season at site 8 that is also reported by Echaniz and Vignatti (2010). Overall, cladocera populations were recorded very low at sites 2, 3, 6 and 7.

Ostracoda contributed only 1% of the total zooplankton, similar to the studies of Bhat *et al.* (2014). *Cypris* was the main taxa observed among the ostracoda. Rajagopal *et al.* (2010) reported *Cypris* sp. in eutrophic waters.

CONCLUSION

The present study depicted variations in zooplankton species composition as well as density (nos.L^{-1}) with seasons. The zooplanktons were represented by mainly four groups' viz., Copepoda, Cladocera, Rotifera, Ostracoda and other forms of Arthropods. A total of 79 taxa were recorded. Of these, 15 taxa (Copepoda), 15 taxa (Cladocera), 44 taxa (Rotifera) and 4 taxa (Arthropods), 1 to Ostracoda. Among these most abundant group recorded was rotifera followed by copepods, cladocerans, other arthropods and ostracoda. Among all zooplanktons *Branchionus* spp., *Keratella* spp., *Daphnia* spp., *Bosmina* sp., *Diaptomus* sp., *Limnocalanus* sp., *Cyclops* spp. and *Cypris* sp. were the dominant taxa, observed at most of the sites. Inclusively higher zooplankton diversity was reported in summer and post-monsoon seasons whereas low diversity was found during the monsoon and winters at the selected sites. Regular monitoring and quantitative and qualitative assessment of zooplankton is very significant for indication of water quality, for the maintenance of suitable aquaculture operations by taking suitable remedial measures to control pollution of aquatic systems.

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