Zooplankton Diversity and Water Quality Assessment of Lentic Waters of Jammu, India

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Abstract: An attempt was made to study the abiotic parameters of three water bodies of Jammu region along with their impact on distribution and presence of zooplankton. The total of 49 organisms belonging to five groups of zooplankton viz Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda were identified. Of the three stations, ostracods were recorded from station 1 only. Phylum Rotifera was observed to be dominant in all the three stations. Many pollution indicator species like *Brachionus calyciflorus, Brachionus angularis, Keratella tropica, Polyarthra vulgaris, Filinia longiseta, Moina brachiata, and Chydorus sphaericus* were recorded from Station 1. Both biotic and abiotic components indicate that station 1 is progressing towards eutrophication.

Keywords: Physico-chemical parameters, Zooplankton, Trophic status, Eutrophication, Pollution indicator

Water provides habitat to millions of aquatic organisms and of these, zooplankton form the most dynamic component. These are free swimming organisms in freshwaters represented mostly by five major groups viz Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda. They have significant role in aquatic food web as they transfer energy from primary producers to secondary consumers and act as efficient live feed for fish larvae. The qualitative and quantitative studies of zooplankton help in assessing the pollution level and trophic status of any water body (Thakur et al 2013). Physico-chemical parameters of a water body are used as key factors to determine the trophic status of water bodies and their influence determines zooplanktonic existence as abiotic and biotic components are co-related in any aquatic system. The biotic components represented by zooplankton can be used as a bio tool for trophic status estimation as they react rapidly to changing ecological conditions and thus can be helpful in determining the utility level of water so present. The present work aimed to study the impact of abiotic factor on biotic components of three different water bodies of Jammu region with special emphasis on their trophic status estimation and water quality assessment.

MATERIAL AND METHODS

Study area: Jammu region is blessed with various lentic and lotic water sources. For the present study, three lentic water bodies were selected which are located at different regions of Jammu. Station 1 is a wetland situated at Gharana village (R.S. Pura) at a latitude of 32°32′26′′N and longitude of 74°41′24′′E. This is a world famous wetland being breeding site of Siberian birds. Station 2 is a temple pond situated at Deeli village of Jammu district located at 32°40′38′′N latitude and 74°54′22′′E longitude. Being a sacred pond, it has religious importance. Station 3, also a temple pond situated at Bishnah village of Jammu district located at a latitude of 32.62°N and longitude of 74.87°E topographically being different from previous two as it is surrounded by agricultural fields.

Sample collection: The investigation was carried out during (March 2019-February 2020). Water sample was collected during morning hours for analysing various abiotic and biotic components. For collection of zooplankton, 50 litres of pond water was filtered through plankton net of mesh size 40µm and the filtrate was concentrated to 20 ml followed by preservation in 4% formalin. Further taxonomic analysis was done in laboratory by observing the sample under compound microscope. For quantitative analysis of zooplankton, drop count method (Adoni 1985) was used. The abiotic parameters were analysed following APHA (1985) and identification of zooplankton was done following Kudo (1966), Pennak (1978), Adoni (1985), Michael & Sharma (1988), Edmondson (1992) and Altaff (2004).

RESULTS AND DISCUSSION

Abiotic parameters: The fCO_2 level at Station 1 was higher as compared to the other two stations (Table 1). The probable reason for this can be the thick mat of floating *Eichhornia* sp. which reduces light penetration thereby reducing

photosynthesis inside water resulting in increased fCO_2 level here. Relatively high BOD was obtained from this station. BOD is directly related to the amount of organic matter decomposed and its high value indicates presence of enormous amount of organic matter in this water body. High values of chloride at this station is also an indicator of eutrophy. The bicarbonates, calcium, magnesium and total hardness were high due to low water levels of this wetland. Station 2 had average values for all these abiotic parameters except for high values of phosphates which can be due to anthropogenic activities. In station 3 dissolved oxygen, carbonates, and pH were comparatively higher than the other two stations. High DO level of this station is an indicator of its relatively clearer status.

Biotic parameters: The total of 49 zooplankton species were recorded of which 4 species belonged to phylum Protozoa, 31 species to phylum Rotifera, 9 to Cladocera, 3 to Copepoda and 2 species belonged to phylum Ostracoda. Ostracods showed their presence at station 1 only. Muddy bottom of this station seems to be a supportive condition for their existence. Station wise qualitative analysis showed species diversity in the order Station 1(34)> Station 3(29)> Station 2(28) (Table 2, Fig. 1).The hierarchy of dominance of zooplankton present at the three stations is described below:

Station 1: Rotifera(53%) > Cladocera(26%) > Protozoa(9%) > Copepoda (6%) = Ostracoda (6%) (Fig. 2).

Station 2: Rotifera (75%)> Cladocera (11%) = Protozoa (11%)> Copepoda(3%) (Fig. 3).

Station 3: Rotifera (72%) > Cladocera (14%) > Protozoa (7%) = Copepoda (7%) (Fig. 4)

The phylum Rotifera dominated all the three stations (Fig. 1-4). Among rotifers, family Brachionidae was most abundant. Kour et al (2021), also observed the dominance of family Brachionidae among all zooplankton groups. Comparatively less number of copepods were recorded from all the study sites.

Correlation analysis: Station 1 had the highest species richness (Table 2) which may be due to the high organic load in this water body which supports a wide variety of life forms here. Correlation analysis of this water body revealed positive as well as negative correlation between biotic and abiotic parameters (Table 3). Among zooplankton, Protozoa and Rotifera showed significant positive correlation. Further both groups showed significant positive correlation with chloride and fCO_2 and a significant negative correlation with calcium. Cladocerans were positively co-related with bicarbonates and nitrates and negatively co-related with temperature. Copepods showed negative correlation with sulphates. The positive correlation of ostracods with magnesium and total hardness was also observed. Apart
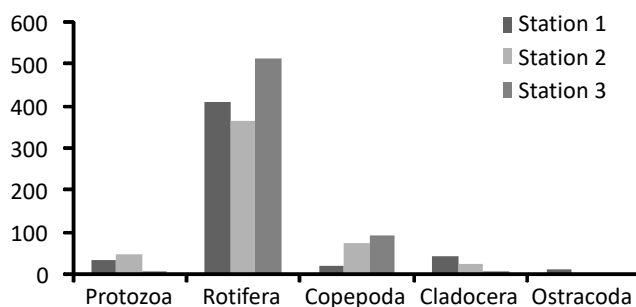

Fig. 1. Comparative abundance of zooplankton at three stations

Table 1. Annual mean values of physico-chemical parameters of the water bodies (Average±SD)

Abiotic parameters	Station 1	Station 2	Station 3
Air temperature (°C)	21.8±10.47	24.5±12.58	20.62±10.87
Water temperature (°C)	22..3±9.56	23.2±10.43	19.5±8.54
pH	7.2±1.23	7.4±0.298	8.27±0.63
DO (mg l^{-1})	3.84±0.32	2.02±0.48	7.92±7.13
fCO_2 (mg l^{-1})	27.28±26.13	10.7±1.78	15.84±4.89
Carbonates (mg l^{-1})	7.2±3.6	-	15.6±7.8
Bicarbonates (mg l^{-1})	640.09±589.07	158.6±15.23	306.22±244.57
Chloride (mg l^{-1})	47.7±27.56	23.7±6.19	25.64±7.98
Calcium (mg l^{-1})	34.47±13.28	33±14.66	22.07±6.25
Magnesium (mg l^{-1})	26.9±8.70	24.5±14.84	24.5±5.37
Total hardness (mg l^{-1})	225.5±37.46	183.5±25.21	183.5±17.35
BOD (mg l^{-1})	2.7±1.02	2.02±0.48	2.02±0.911
Phosphate (mg l^{-1})	0.286±0.044	0.314±0.264	0.112±0.0658
Sulphate (mg l^{-1})	0.002±0.0003	0.0019±0.0003	0.0017±0.0003
Nitrate (mg l^{-1})	0.578±0.0039	0.576±0.0036	0.5819±0.0068

Table 2. Organisms recorded from the three stations

Family	Zooplankton species	St. 1	St. 2	St. 3
Phylum Protozoa				
Centropyxidae	*Centropyxis aculeata* (Ehrenberg) Stein	+	++	+
Vorticellidae	*Vorticella* sp.	++	+	+
Epistylidae	*Epistylis* sp.	+++	+	++
Difflugiidae	*Difflugia accuminata* (Ehrenberg 1838)	-	+	-
Phylum Rotifera				
Family Brachionidae	*Brachionus calyciflorus* (Pallas 1766)	+++	+	+
	B. falcatus (Zachariad 1898)	-	++	+++
	B. caudatus (Barrois and Daday 1894)	-	++	+
	B. bidentata (Anderson 1889)	-	-	+
	B. quadridentatus(Hermann 1783)	++	+	+
	B. forficula (Wierzejski 1891)	+	+	+
	B. rubens (Ehrenberg.1838)	+	+	+
	B. angularis (Gosse 1851)	++	+	-
	B. budapestinensis (Daday 1885)	-	+	-
	Keratella tropica (Apstein 1907)	++	+	+
	Keratella quadrata (O.F.Muller 1786)	-	-	+
	Platyias patulus(O.F.Muller 1786)	+	+	+
	P. quadricornis (Wiszniewski 1954)	+	-	-
	Anuraeopsis fissa (Gosse 1851)	-	+	+
Family Euchlanidae	*Euchlanis dilatata* (Myers)	++	-	-
Family Synchaetidae	*Polyarthra vulgaris* (Carlin 1943)	+	+	+
Family Asplanchnidae	*Asplanchna brightwelli* (Gosse 1850)	++	+	+
Family Testudinellidae	*Testudinella patina* (Hermann 1783)	++	-	-
Family Mytillinidae	*Mytilina ventralis* (Ehrenberg 1832)	+	-	-
Family Epiphanidae	*Epiphanes brachionus*(Ehrenberg 1837)	+	-	-
	E. clavulata (Ehrenberg 1831)	-	+	-
Family Lecanidae	*Lecane leontina* (Turner 1892)	+	+	+
	L. curvicornis (Murray 1913)	+	++	+
	Monostyla bulla (Gosse 1851)	+	-	+
	M. decipiens (Murray 1913)	-	-	+
Family Lepadellidae	*Lepadella ovalis* (O.F. Muller 1786)	+	-	-
Family Trichocercidae	*Trichocerca similis* (Wierzejski 1893)	-	+	+
Family Notommatidae	*Cephalodella gibba*(Ehrenberg 1832)	+	+	+
Family Philodinidae	*Philodina* sp.	+	+	+
Family Filinidae	*Filinia longiseta* (Ehrenberg 1834)	++	+	+
Family Hexarthridae	*Hexarthra mira* (Hudson 1871)	-	+	-
Phylum Arthropoda				
Subphylum Crustacea				
Order Cladocera				
Family Chydoridae	*Alona* sp.	+	+	+
	Chydorus sphaericus (Muller 1785)	++	+	+
	Pleuroxus sp. (Baird 1843)	+	-	-
Family Moinidae	*Moina brachiata* (Jurine 1820)	+++	+	+
Family Macrothricidae	*Macrothrix rosea* (Jurine 1820)	+	-	+
Family Daphniidae	*Ceriodaphnia* sp. (Dana 1853)	+	-	-
	Scapholeberis kingi (Sars 1903)	+	-	-
	Simocepahalus vetulus (Schodler 1858)	+	-	-
Family Sididae	*Diaphanosoma* sp.	+	-	-
Subclass Copepoda				
Family Cyclopidae	*Mesocyclops leuckarti* (Claus 1857)	+	+	+
	Cryptocyclops bicolor (Sars 1863)	-	-	+
	Eucyclops agilis (Koch 1838)	+	-	-
Phylum Ostracoda				
Family Cyprididae	*Stenocypris* sp.	++	-	-
	Cypris sp.	+	-	-

Table 3. Correlation between biotic and abiotic parameters of Station 1

Correlations

	AT	WT	pH	DO	fCO2	CAR	BICAR	CHL	CAL	MAG	TH	BOD	PHOS	SUL	NIT	PROTOZOA	ROTIFERA	CLADOCERA	COPEPODA	OSTRACODA
AT	1																			
WT	.987*	1																		
pH	.962*	.951*	1																	
DO	-0.824	-0.879	-0.688	1																
fCO2	0.269	0.274	0.521	0.138	1															
CAR	0.453	0.531	0.242	-0.870	-0.549	1														
BICAR	-.999**	-.989*	-0.948	0.852	-0.225	-0.499	1													
CHL	0.163	0.239	0.397	0.016	0.901	-0.309	-0.135	1												
CAL	-0.278	-0.309	-0.524	-0.055	-.987*	0.443	0.239	-.957*	1											
MAG	-0.141	-0.260	0.037	0.675	0.550	-0.922	0.189	0.188	-0.412	1										
TH	-0.380	-0.522	-0.428	0.597	-0.348	-0.489	0.393	-0.668	0.492	0.591	1									
BOD	0.570	0.696	0.567	-0.782	0.244	0.647	-0.587	0.524	-0.380	-0.659	-.966*	1								
PHOS	.975*	.973*	.996**	-0.748	0.469	0.325	-.966*	0.375	-0.483	-0.051	-0.476	0.622	1							
SUL	0.350	0.302	0.579	0.176	0.943	-0.632	-0.301	0.706	-0.880	0.737	-0.075	0.022	0.512	1						
NIT	-0.767	-0.664	-0.652	0.520	0.110	-0.269	0.765	0.401	-0.187	-0.122	-0.283	0.044	-0.645	-0.154	1					
PROTOZOA	0.156	0.226	0.395	0.045	0.917	-0.346	-0.126	.999**	-.966*	0.230	-0.636	0.491	0.370	0.732	0.392	1				
ROTIFERA	0.342	0.378	0.578	-0.022	.977*	-0.376	-0.306	.957*	-.997**	0.360	-0.539	0.441	0.542	0.867	0.148	.964*	1			
CLADOCERA	-0.827	-0.773	-0.658	0.773	0.270	-0.601	0.843	0.419	-0.292	0.247	-0.023	-0.233	-0.683	0.087	0.931	0.425	0.233	1		
COPEPODA	-0.508	-0.416	-0.671	-0.064	-0.764	0.537	0.463	-0.423	0.666	-0.766	-0.142	0.110	-0.603	-0.931	0.487	-0.452	-0.662	0.219	1	
OSTRACODA	0.076	-0.085	0.111	0.401	0.128	-0.595	-0.043	-0.310	0.034	0.830	0.824	-0.755	0.041	0.440	-0.568	-0.271	-0.065	-0.236	-0.670	1

* . Correlation is significant at the 0.05 level (2-tailed).
** . Correlation is significant at the 0.01 level (2-tailed).

from this, bicarbonates showed a significant negative correlation with temperature and pH. A significant positive correlation was observed between phosphates, temperature and pH and a significant negative correlation between phosphates and bicarbonates was observed. Chloride and fCO_2 were positively correlated and both showed a significant negative correlation with calcium.

Station 2 bears the highest anthropogenic influence which is supported by less abundance of copepods in this station. In this station, a positive correlation was observed between Ostracoda and Cladocera. Ostracoda showed positive correlation with DO, BOD, magnesium and total hardness. Rotifera showed positive correlation with temperature. Cladocera, DO and BOD were positively co-related and a negative correlation was observed between Cladocera and fCO_2. Chloride showed a significant positive correlation with phosphates and a significant negative correlation with sulphates. DO, BOD, magnesium and total hardness were positively co-related (Table 4)

In Station 3, cladocerans and protozoans were positively co-related. Protozoans also showed a significant positive correlation with chloride. Rotifers showed positive correlation with pH. A significant negative correlation between cladocerans and magnesium and a positive correlation between cladocerans and chloride was observed. Copepods showed a significant negative correlation with carbonates, bicarbonates and total hardness and positive correlation with temperature and fCO_2. Among abiotic parameters, a significant positive correlation was observed between carbonates,

bicarbonates and total hardness. Magnesium showed negative correlation with temperature and chloride (Table 5).

Zooplankton as bioindicators: The potentiality of zooplankton as pollution indicators and their role in trophic status estimation of water bodies has long been considered by many workers (Parmar et al 2016, Ferdous and Muktadir 2009, Ramchandra et al 2006). Many pollution indicator rotifer species such as *Brachionus calyciflorus, B. angularis, Keratella tropica, Filinia longiseta, Polyarthra vulgaris, Euchlanis dilatata, Testudunella patina, Asplanchna brighwelli, Cephalodella gibba* were numerically abundant at station 1 (Table 2). Abundance of these pollution tolerant species in organically rich water bodies was also recorded by Thakur et al (2013) and Murkute and Chavan (2016).

Rotifers such as *Brachionus falcatus, Anuraeopsis fissa and Trichocerca* sp. showed their presence at station 2 and 3 and were completely absent from Station 1. These rotifers commonly dwell in oligotrophic waters (Arora 1966). Their
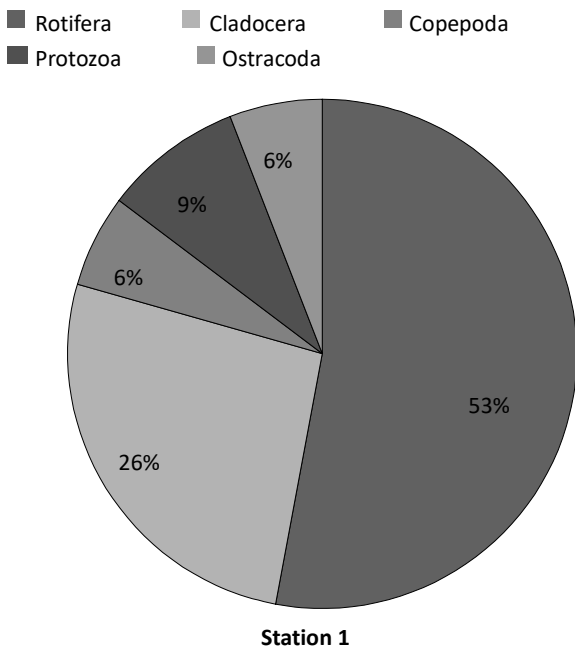
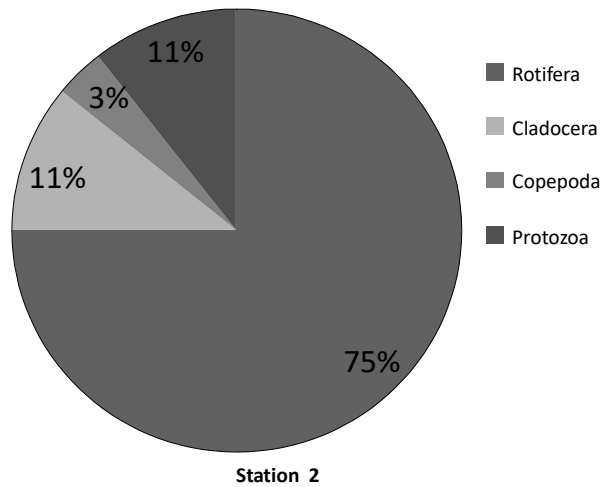**Fig. 3.** Percentage composition of zooplankton at station 2

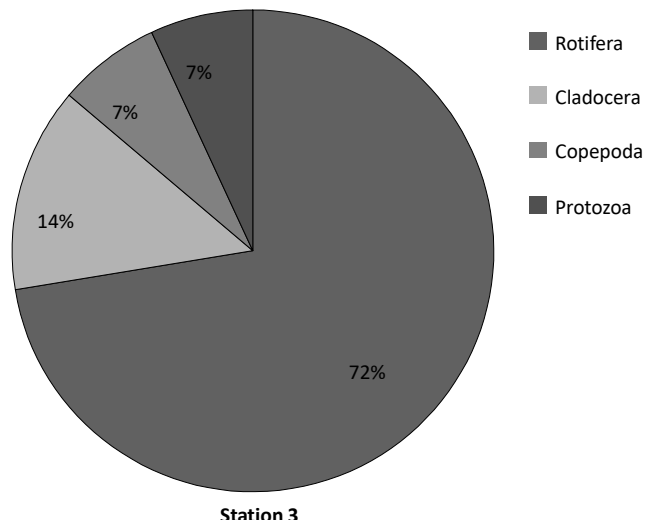**Fig. 2.** Percent contribution of zooplankton at station 1

Fig. 4. Percentage composition of zooplankton at station 3

Table 4. Correlation between biotic and abiotic parameters of Station 2

Correlations

	AT	WT	pH	DO	fCO2	BICAR	CHL	CAL	MAG	TH	BOD	PHOS	SUL	NIT	PROTOZOA	ROTIFERA	CLADOCERA	COPEPODA	OSTRACODA
AT	1																		
WT	.996**	1																	
pH	0.067	0.131	1																
DO	0.849	0.874	0.573	1															
fCO2	-0.486	-0.470	-0.471	-0.719	1														
BICAR	0.007	0.020	0.765	0.469	-0.825	1													
CHL	0.717	0.740	-0.149	0.438	0.242	-0.575	1												
CAL	-0.607	-0.666	-0.802	-0.887	0.462	-0.445	-0.434	1											
MAG	0.637	0.691	0.803	0.924	-0.560	0.517	0.382	-.993**	1										
TH	0.667	0.710	0.786	.957*	-0.689	0.607	0.298	-.960*	.986*	1									
BOD	0.849	0.874	0.573	1.000**	-0.719	0.469	0.438	-0.887	0.924	.957*	1								
PHOS	0.582	0.597	-0.336	0.225	0.426	-0.747	.974*	-0.228	0.166	0.073	0.225	1							
SUL	-0.868	-0.871	0.212	-0.554	-0.010	0.468	-.954*	0.413	-0.394	-0.357	-0.554	-0.907	1						
NIT	0.335	0.411	0.875	0.685	-0.238	0.402	0.337	-0.944	0.909	0.838	0.685	0.160	-0.224	1					
PROTOZOA	0.100	0.155	-0.010	-0.027	0.710	-0.652	0.740	-0.270	0.162	0.003	-0.027	0.782	-0.505	0.414	1				
ROTIFERA	0.917	0.947	0.269	0.851	-0.281	-0.052	0.844	-0.791	0.781	0.749	0.851	0.701	-0.881	0.620	0.426	1			
CLADOCERA	0.796	0.787	0.403	0.908	-0.914	0.592	0.171	-0.640	0.719	0.816	0.908	-0.025	-0.391	0.370	-0.418	0.635	1		
COPEPODA	-0.654	-0.625	0.645	-0.166	-0.219	0.723	-0.813	-0.060	0.074	0.092	-0.166	-0.864	0.884	0.247	-0.386	-0.562	-0.126	1	
OSTRACODA	0.662	0.687	0.726	0.948	-0.855	0.726	0.135	-0.854	0.908	.965*	0.948	-0.093	-0.262	0.683	-0.252	0.645	0.919	0.133	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5. Correlation between biotic and abiotic parameters of Station 3

Correlations

	AT	WT	pH	DO	fCO2	CAR	BICAR	CHL	CAL	MAG	TH	BOD	PHOS	SUL	NIT	PROTOZOA	ROTIFERA	CLADOCERA	COPEPODA
AT	1																		
WT	.989*	1																	
pH	-0.045	-0.046	1																
DO	-0.263	-0.293	.951*	1															
fCO2	0.548	0.476	0.680	0.616	1														
CAR	-0.866	-0.819	-0.391	-0.232	-0.893	1													
BICAR	-0.850	-0.789	-0.353	-0.221	-0.901	.994**	1												
CHL	0.696	0.772	0.393	0.091	0.420	-0.638	-0.554	1											
CAL	0.263	0.391	-0.376	-0.606	-0.515	0.156	0.234	0.545	1										
MAG	-0.880	-0.939	-0.031	0.268	-0.320	0.672	0.609	-0.914	-0.626	1									
TH	-0.885	-0.845	-0.378	-0.205	-0.872	.999**	.988*	-0.675	0.103	0.711	1								
BOD	0.068	0.196	0.447	0.212	-0.046	-0.026	0.080	0.754	0.649	-0.510	-0.066	1							
PHOS	0.017	-0.035	-0.930	-0.799	-0.481	0.292	0.221	-0.596	0.016	0.223	0.299	-0.744	1						
SUL	-0.605	-0.597	-0.768	-0.590	-0.894	0.867	0.827	-0.758	0.134	0.587	0.869	-0.397	0.729	1					
NIT	-0.163	-0.027	-0.327	-0.473	-0.743	0.522	0.597	0.281	0.908	-0.269	0.475	0.664	-0.031	0.369	1				
PROTOZOA	0.580	0.677	0.370	0.066	0.277	-0.492	-0.397	.984*	0.644	-0.873	-0.533	0.851	-0.620	-0.665	0.432	1			
ROTIFERA	0.181	0.166	.971*	0.891	0.826	-0.598	-0.566	0.497	-0.380	-0.191	-0.586	0.384	-0.880	-0.890	-0.431	0.438	1		
CLADOCERA	0.758	0.844	0.045	-0.266	0.179	-0.525	-0.447	0.936	0.749	-.977*	-0.571	0.663	-0.298	-0.519	0.451	0.932	0.163	1	
COPEPODA	0.870	0.824	0.388	0.227	0.889	-1.000**	-.994**	0.644	-0.147	-0.679	-.999**	0.032	-0.293	-0.868	-0.514	0.499	0.596	0.533	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

presence at Station 2 and Station 3 indicate comparatively less organic matter in these water bodies. Apart from rotifers, cladocerans also act as bioindicator of health of the aquatic system. Cladocerans like *Moina brachiata, Chydorus sphaericus, Ceriodaphnia* sp*., Alona* sp*., Diaphanosoma* sp. were commonly observed at Station 1. These cladoceran species are considered as good indicators of eutrophic conditions by many workers (Ferdous and Muktadir 2009, Singh et al 2013) and their presence at Station 1 further authenticate the eutrophic nature of this water body. Protozoans such as *Epistylis* sp. and *Vorticella* sp. indicate presence of high amount of organic matter in any water body. Both these species were recorded from Station 1 in considerable number. Their abundance in a water body is an indicator of high trophic status (Singh et al 2013). Copepods,in general, flourish well in relatively stable environments and indicate good health of water body. In the present case, copepods were less abundant than other groups in all sites. Considering this data, Station 1 was found to have more organic load as compared to other two stations as this water body had many pollution tolerant and bioindicator species (Table 2). This station is tending fast towards eutrophism as evident by both biotic and abiotic parameter.

CONCLUSION

A well-marked correlation among biotic and abiotic components of water systems was observed. The three stations, situated at distant places of Jammu region, showed a total of 49 zooplankton species belonging to 5 groups. Various pollution indicator species like *Brachionus calyciflorus, B. angularis, Keratella tropica, Polyarthra vulgaris, Filinia longiseta, Moina brachiata, and Chydorus sphaericus* were reported. Ostracods being the only group showing selectivity for soft bottom and thus were present only at Station 1. Overall analysis of zooplankton revealed station 1 to be most inclined towards eutrophication as compared to the other two stations due to abundance of indicator species and this was also supported by abiotic data.

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