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Seasonal Variations and Diversity of Zooplanktons Community Structure in Chenani Hydroelectric Reservoir, its Feeding Channel and River Tawi, Udhampur, J&K, India

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Abstract

Reservoir, its connecting channel and feeder river Tawi were studied for a period of one year from September 2011 to August 2012 for its water quality parameters and zooplanktons community structure. Physico-chemical parameters viz. air temperature, water temperature, transparency, pH, DO, FCO_2, carbonates, bicarbonates, chloride, calcium, magnesium, sulphate, phosphate and nitrate were analysed which showed seasonal fluctuations of these water bodies. Water remained alkaline throughout the study period with pH ranged from 8.1 to 8.9. Parameters viz. bicarbonates, calcium, magnesium and transparency showed increase during post monsoon (September) to winter (February) where as FCO_2, chlorides, phosphates, sulphates and nitrates showed decline during this period. However much fluctuation have not been reported in the concentration of phosphates, sulphates and nitrates which showed an increase during rainy season. Both qualitatively and quantitatively analysis were made to investigate the seasonal fluctuations and distribution of zooplanktons. Qualitatively zooplanktons were composed of six species of Protozoan (Centropyxis aculeate, Nebela collaris, Trinema enchelys, Euglena gracilis, Arcella vulgaris and Amoeba sp.), five species of Rotifera (Lepidella ovalis, Colurella adriatica, Branchionus angularis, Monostyla lemaris and Cephalodella intuta), three species each of Ciliata (Paramecium sp , Euglypha ciliate and Vorticella convallaria), Cladocera (Daphnia silmilis, Alona monocantha and Alona costata) and Copepoda (Eucyclops sp, Mesocyclops sp., and Nauplius larva of Copepod). Quantitatively Protozoa was dominant throughout the study period with Trinema enchelys, Euglena gracilis and Arcella vulgaris constituting the largest share of Protozoan. Copepoda was the second dominant group present throughout the study period followed by Cladocera, Rotifera and last were the group ciliate. Zooplanktons species richness, diversity and evenness were calculated. Values of Margalef's index (R_1= 2.89) and Menhinicks index (R_2=0.92) were found higher at site 6 and site 5 and lowest (2.81 and 0.68) at site 1 respectively. Simpson index (I=0.30) was found higher at site 5 and lowest (0.14) at site 1. Shannon's-Weiner's index (H') values (2.75) was found highest at site 1 and lowest (2.29) at site 5. Maximum species evenness (0.92) was recorded at site 1 while minimum (0.79) at site 5.

Keywords: Zooplanktons, physico-chemical parameters, seasonal fluctuations, correlation, diversity index.

Introduction

Zooplanktons are microscopic organisms, acts as integral components of aquatic food web and contribute significantly to productivity of freshwater ecosystems. They are performing at second trophic level in energy flow and switch over to conversion of detritus matter into edible animal food. They occupy an intermediate position in the food web and mediate the transfer of energy from lower to higher trophic levels[1]. Being heterotrophic in nature, they play a key role in cycling of organic materials in an aquatic ecosystem[2]. Due to short life cycle, zooplankton communities often respond quickly to environmental change[3]. The changes in physico-chemical conditions of water can be reflected directly on the biotic community of ecosystem. As a major element in aquatic biota, the zooplankton community often exhibits dramatic changes in response to the changes in the physico-chemical properties of the aquatic environment. The study of zooplankton has been a fascinating subject for a long time. In the last two decades much attention has been paid in tropical countries towards the study of biology, ecology and toxicology of zooplankton due to their important role in the rapidly emerging concepts in environmental management like environmental Impact Assessment (EIA), bio indication of pollution and biological monitoring. Hence zooplankton association, abundance, seasonal variation, richness and diversity can be used as for the assessment of water pollution and for pisciculture management practices. Thus in the present study, zooplanktons has been studied qualitatively and quantitatively and the results are correlated with the physico-chemical factors to get a better understanding of the structure and function of this important aquatic ecosystem.

Material and Methods

Study area and stations: Chenani hydroelectric reservoir is whole concrete and is situated 15 km away from Udhampur city of J&K state of India. It lies between 32°57' N latitude and

75°10' E longitude at an elevation of 1045m above MSL. It is connected with river Tawi with an artificial whole concrete canal of about 9 km. It has the dimension of 750×150×22 feet with a capacity of 15Mw**.** Reservoir, its connecting channel and feeder river Tawi were studied for a period of one year from September 2011 to August 2012. In the present study seven stations viz. I, II, III, IV, V, VI and VII were selected, out of which stations I, II, III and IV lies in the reservoir (stations I and II at the inlet whereas stations III and IV were situated near the outlet). Stations V and VI were situated in the canal (station V at about 4 km away from reservoir and station VI at 5 km beyond station V towards feeding section of river Tawi) and station VII was situated at river Tawi.

Analysis of Physico-chemical parameters: Water samples were collected once every month from these stations and estimated for physico-chemical parameters like water temperature, air temperature, transparency, pH, dissolved oxygen, free carbon dioxide, carbonates, bicarbonates, calcium, magnesium, chloride, sulphates, nitrates and phosphates by standard methods of APHA[4].

Zooplankton sampling and analysis: Zooplankton samples were collected by filtering 25 litres of water through standard plankton net (77 mesh bolting silk) and the samples were fixed in 5% of formalin. Zooplanktons were identified by keys[5-8]. Analysis involved by transferring of 1 ml sub sample from each of the samples to the Sedgewick-Rafter counter and counting of cells within 10 squares of the cells, chosen randomly and Analysis was done on a Sedgwick-Rafter counting cell, under compound microscope.

$$N = \frac{A \times 1000 \times C}{V \times F \times C}$$

Where, N= Number of zooplankton cells or units per litre of original water, A= Total number of zooplankton counted, C= Volume of final concentration of the samples in ml, V=Volume of a field in cubic mm, F= Number of fields counted, L= Volume of original water in litres, Statistical analysis was done using SPSS programme.

Results and Discussion

Seasonal variations in the Physico-chemical parameters of Chenani hydroelectric reservoir, its connecting channel and river Tawi had been studied during the study period of Sept. 2011 to Aug. 2012 and are shown in table 1. Temperature is a key factor which controls all the chemical reactions and biological processes in a water body. Water temperature followed similar trends as that of air temperature and ranged between 9.5^0C (Dec.) to 24^0C (June). pH of water remained alkaline throughout the year and ranged between 8.1 (Jan.) to 8.9 (June). High value of pH may be due to waste discharge, microbial decomposition of organic matter and sewage discharge by surrounding human population [9-10]. Dissolved oxygen showed an increase with the decline in water temperature and its values ranged between 4.75 mgl-1 (Sept.) to 9.60 mgl-1 (Jan.). The value of FCO_2 ranged between 1.20 mgl-1 (Feb.) to 6.29 mgl-1 (Sept.). Dissolved oxygen, bicarbonates, calcium and magnesium showed seasonal fluctuations with an increase from post monsoon (September) to Winter (February) where as values of FCO_2, chloride, phosphate, sulphate and nitrate showed decline in same seasons in all the stations. Data on the temperature, nutrient concentrations, pH range, dissolved oxygen values, and Secchi transparency were in general agreement with limnological characteristics of these water bodies.

The zooplanktons in Cheneni hydroelectric reservoir, connecting channel and river Tawi comprised of Protozoa (six genera), Ciliate (three genera), Rotifera (five genera), Cladocera (three genera) and Copepod (three genera) as shown in figure 1. Qualitative and Quantitative analysis of different zooplanktons are shown in table 3 and table 4 respectively. Among all the zooplanktons recorded from these water bodies, Protozoa was found to be the most dominant group both qualitatively and quantitatively and was represented by six species viz. *Centropyxis aculeate, Nebela collaris, Arcella vulgaris, Amoeba sp., Euglena gracilis* and *Trinema enchelys.* Protozoa represented 46.54 % of all the zooplanktons recorded from these water bodies during the study period. Maximum density of Protozoa (44.5 ind./litre) was found in station III in summer season where as minima in average no. of Protozoa (24.25 ind. /litre) was noticed in station VI during monsoon season. *Amoeba sp.* is noticed only twice in the month of Sept. and Oct. (2011). Summer rise in quantitative count of total zooplanktons were contributed by Protozoa and may be attributed to increased production of detritus and bacterial richness, at higher temperature, on which Protozoans were known to feed[11- 14]. Low temperature, rise in pH, low bicarbonate, Ca, Mg and total hardness favouring winter highest Protozoan peak in a reservoir[15]. Qualitatively Copepods were represented by *Eucyclops sp., Mesocyclops sp.,* and Nauplius larva of Copepod. Quantitatively Copepod was the second dominant group of Zooplanktons and represents 19.50% of the total population of zooplanktons. Maximum number of Copepods were obtained from station I (25.25 ind./ litre) during Summer season whereas least density of Copepods were found in station VII (2.5 ind./litre). Copepods were also found in maximum number during summer months and minimum during monsoon months[16]. Cladocera was the third dominant group of Zooplanktons and was represented by *Daphnia silmilis, Alona monocantha* and *Alona costata.* The number of Cladocera were found to be maximum in station I (17 ind./litre) during summer season and minima were seen in station VII (1.5 ind./litre) during monsoon season. The group Rotifera was represented by five species viz. *Lepidella ovalis, Colurella adriatica, Branchionus angularis, Monostyla lemaris* and *Cephalodella intuta* and it represents the fourth dominant group and constitute 11.97 % of total zooplanktons. Maxima in number of cell per litre were found in station I having (15.5 ind./litre) during summer season whereas minima (1.5 ind./litre) were found in

station VI during monsoon. The winter rise in Rotifers can be linked to favourable temperature and availability of abundant food in the form of bacteria and suspended detritus[17- 19]. Group Ciliate was the least abundant group forming 8.45 % of total number of zooplanktons, composed of *Paramecium sp., Euglypha ciliate* and *Vorticella convallaria.* Maxima in number of Cilates were found in station II (13 ind./litre) in summer season and minima in station VI (1.25 ind./litre) during monsoon season.

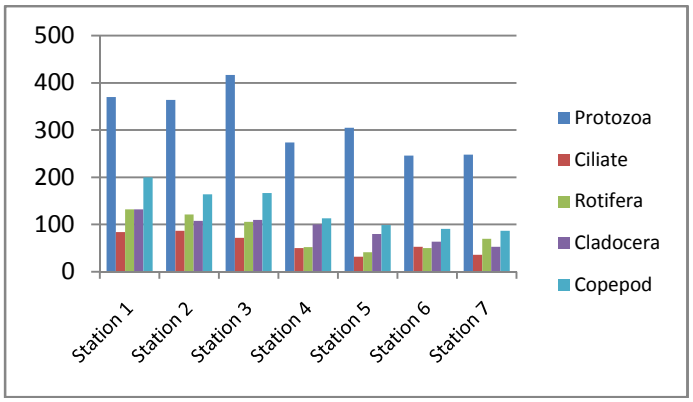

Figure-1
Showing the annual variation in the composition of different groups in seven stations

There were a distinct seasonal fluctuations and composition of the zooplanktons in these water bodies with productive (Feb. to June), retardation (July to August) and recovery (September October) periods. This may be due to similar condition for nutrients as well as some physico-chemical property of water [20]. An overall study of total zooplankton had showed trimodal seasonal variations with October, February, June peaks, July, August and September decline. October rise in zooplanktons were also studied[21- 22]. The low number of zooplanktons in monsoon might be due to the fall in temperature, low light penetration and heavy water flow wash off the surface zooplanktons. The unsettled and disturbed water Column was resulting from the rain water and heavy out flow and inflow retard the zooplankton population[23]. Further, it is a fact that the diversity of zooplankton is always less in the flowing fresh water compared to stagnant water like that of reservoirs. Seasonal variations in the total number of zooplanktons during the study period are given in table 5 and figure 2.

Correlation between zooplanktons species and physico-chemical parameters of water such as water temperature, pH, transparency, pH, dissolved oxygen, free carbon dioxide, carbonates, bicarbonates, calcium, magnesium, chloride, sulphates, nitrates and phosphates were studied as shown in table 2. The correlation studies between different zooplanktons groups population density and physico-chemical parameters showed negative correlation with temperature, chloride, nitrates, phosphates and sulphates whereas showed positive but not significant correlation with transparency, free CO_2, pH and bicarbonates at 5% level of significance. Analysis of co-efficient of correlation (r) of total Protozoans and total zooplanktons had shown mostly insignificant results and is in accordance to the findings[24- 25]. The species diversities, richness and equitability index's were analysed using the following indices of Shannon-Wiener index (H')[26], Simpson index (I)[27], Margalef's index (R_1)[28], and Evenness index (E)[29]. Analysis of data revealed that maximum species diversity and richness in term of Shannon-Wiener index (H'= 2.75) and Margalef's index (R_1 =2.92) were found in station I and station VI and minimum (H'= 2.29 and R_1 =2.81) at site VI and station I respectively. Value of Evenness (E) was higher at site I while low at site VI as given in table 5 and figure 3.

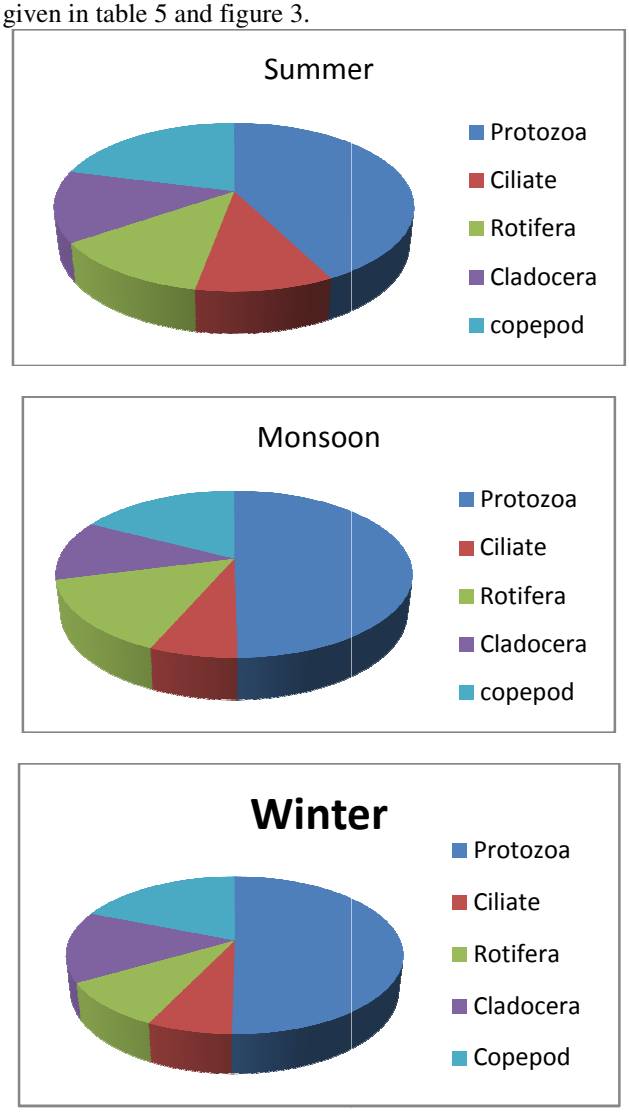

Figure-2
Showing the seasonal variation in the composition of different groups in seven stations during study period

Zooplanktons species diversity index and Simpson's index (I) varied from 0 to 1 gives the probability that two individuals drawn from a population belonged to the same species. Shannon's index (H') combines species richness and species evenness components as one overall index of diversity. Higher

values of these index's indicated greater species diversity, hence it showed higher species diversity at site I. Further higher values of species richness at site 1 showed abundant food and suitable physico-chemical factors compared to other sites. Higher the value of S-WDI, the greater is the plankton diversity[30].

Conclusion

Zooplanktons density was maximum in summer and least in the monsoon seasons. Summer rise in zooplanktons may be due to favourable physico-chemical parameters whereas monsoon decline is due to dilution effect, high turbidity and less photosynthetic activity by the primary producers. On other hand chemical variables are also within the permissible limit, indicates that these water bodies are productive and suitable for fish culture, irrigation, domestic and drinking purpose.

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Table-1
Mean variations in the physico chemical parameters of seven stations during Sept. 2011 to Aug. 2012

Parameters	units	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Air temp.	^{0}C	27.79 ± 6.89	27.80 ± 6.88	27.79 ± 6.89	27.80 ± 6.88	27.80 ± 6.88	27.80 ± 6.88	27.80 ± 6.88
Water temp.	^{0}C	17.46 ± 5.81	17.51 ± 5.80	17.55 ± 5.75	17.55 ± 5.75	17.44 ± 5.79	17.40 ± 5.83	17.41 ± 5.83
Transparency	cm	209.91 ± 110.03	210.25 ± 109.29	209.23 ± 110.42	209.50 ± 110.30	211.16 ± 110.64	210.50 ± 109.71	210.58 ± 109.38
pH		8.37 ± 0.158	8.40 ± 0.158	8.40 ± 0.165	8.37 ± 0.224	8.39 ± 0.189	8.35 ± 0.175	8.36 ± 0.102
Dissolved O2	mg/l	7.77 ± 1.64	7.76 ± 1.64	7.76 ± 1.65	7.76 ± 1.64	7.76 ± 1.64	7.75 ± 1.64	7.76 ± 1.65
Free CO2	mg/l	3.95 ± 1.58	3.94 ± 1.58	3.93 ± 1.57	3.94 ± 1.58	3.93 ± 1.57	3.95 ± 1.57	3.95 ± 1.57
Bicarbonates	mg/l	118.76 ± 20.42	121.53 ± 19.00	120.91 ± 20.25	121.91 ± 18.38	120.26 ± 19.17	118.78 ± 20.30	118.78 ± 20.35
Carbonates	mg/l	00	00	00	00	00	00	00
Chloride	mg/l	8.24 ± 4.14	8.85 ± 4.55	8.38 ± 3.96	8.26 ± 4.37	8.65 ± 4.93	8.16 ± 4.15	8.12 ± 4.47
Calcium	mg/l	70.07 ± 12.24	65.01 ± 20.31	66.53 ± 17.42	70.56 ± 12.08	70.42 ± 12.06	69.87 ± 12.10	69.44 ± 12.31
Magnesium	mg/l	57.26 ± 22.71	55.90 ± 22.22	56.77 ± 22.60	56.04 ± 21.68	57.13 ± 23.01	58.66 ± 22.59	56.92 ± 22.53
Sulphate	mg/l	0.079 ± 0.053	0.077 ± 0.052	0.079 ± 0.053	0.077 ± 0.052	0.077 ± 0.052	0.077 ± 0.050	0.078 ± 0.051
Nitrate	mg/l	0.170 ± 0.053	0.162 ± 0.051	0.164 ± 0.059	0.169 ± 0.054	0.157 ± 0.047	0.164 ± 0.053	0.155 ± 0.052
Phosphate	mg/l	0.171 ± 0.055	0.156 ± 0.060	0.170 ± 0.053	0.156 ± 0.051	0.158 ± 0.051	0.166 ± 0.052	0.161 ± 0.051

Table-2
Correlation between physico-chemical parameters and various zooplankton groups

Parameters	Protozoa	Ciliate	Rotifera	Cladocera	Copepod
Water temp.	- 0.31	- 0.15	- 0.20	- 0.15	0.01
Transparency	- 0.12	0.06	0.04	0.22	0.25
pH	- 0.08	0.32	0.34	0.21	0.42
Dissolved O2	-0.44	- 0.28	0.07	- 0.31	- 0.16
Free CO2	0.38	0.25	- 0.02	0.38	0.22
Bicarbonates	0.39	0.39	0.06	0.14	0.15
Carbonates	-	-	-	-	-
Chloride	- 0.40	- 0.07	- 0.04	- 0.22	- 0.09
Calcium	- 0.30	0.03	0.05	- 0.25	- 0.01
Magnesium	0.12	- 0.01	- 0.01	0.21	0.07
Sulphate	- 0.10	- 0.49	- 0.36	- 0.11	- 0.29
Nitrate	- 0.47	- 0.48	- 0.15	- 0.47	- 0.36
phosphate	- 0.46	- 0.38	- 0.48	- 0.61	- 0.49

Table-3
Monthly variation in zooplanktons species occurrence during Sept. 2011 to Aug. 2012

Zooplanktons	Summer				Rainy				Winter			
Protozoa	**Mar. 2012**	**Apr. 2012**	**May 2012**	**June 2012**	**July 2012**	**Aug. 2012**	**Sep. 2011**	**Oct. 2011**	**Nov. 2011**	**Dec. 2011**	**Jan. 2011**	**Feb. 2011**
Centropyxis aculeate	-	+	+	+	-	-	+	+	+	+	+	+
Nebela collaris	+	+	+	+	-	-	+	+	+	+	+	-
Arcella vulgaris	+	+	+	+		-	+	+	+	+	+	+
Euglena gracilis	+	+	+	+	-	-	+	+	+	+	+	+
Trinema enchelys	+	+	+	+	-	-	+	+	+	+	+	+
Amoeba sp.	-	-	-	-	-	-	+	+	-	-	-	-
Ciliate												
Paramecium sps	-	+	+	+	-	-	-	-	-	-	-	-
Euglypha ciliate	+	+	+	+	-	-	+	+	+	+	+	+
Vorticella convallaria	+	+	+	+	-	-	-	+	-	+	+	+
Rotifera												
Lepidela ovalis	-	+	+	+	-	-	+	+	+	+	+	+
Colurella adriatica	-	+	+	+	-	-	+	+	-	+	+	+
Monostyla lemaris	-	+	+	+	-	-	+	+	-	-	+	-
Cephalodella intuta	+	+	+	+	-	-	+	+	+	+	+	+
Branchionus angularis	-	+	+	+	-	-	+	+	+	+	+	+
Cladocera												
Daphnia similis	+	+	+	+	-	-	+	+	+	+	+	+
Alona monacantha	+	+	+	+	-	-	+	+	+	+	+	+
Alona costata	+	+	+	+	-	-	+	+	+	+	+	+
Copepoda												
Eucyclops sp.	+	+	+	+	-	-	+	+	+	+	+	+
Mesocyclops sp.	+	+	+	+	-	-	+	+	+	+	+	+
Nauplius larva of copepod	+	+	+	+	-	-	+	+	+	+	+	+

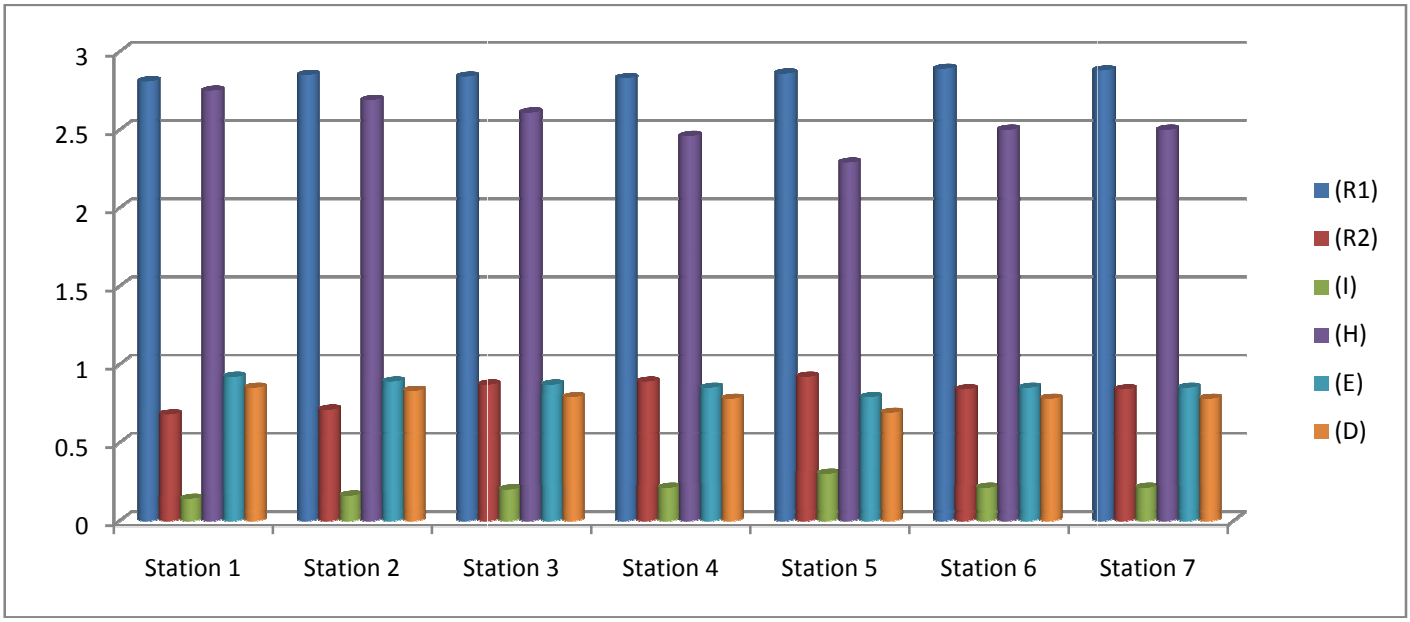

Figure-3
Showing species richness, diversity and evenness index's of total zooplanktons species at seven study sites.
Where, N_0 = No. of species, R_1 = Margalef's index, R_2 = Menhinick's index, I =Simpson index, H = Shannon Weiner index, E = Evenness index and D = Dominance index

Table-4
Monthly variation in zooplanktons (no./litre) of water at seven stations from Sep. 2011 to Aug. 2013

Group	Stations	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Protozoa	I	17	45	19	24	38	45	22	39	47	48	14	12	370
	II	19	39	13	38	24	47	20	34	47	63	16	4	364
	III	15	57	30	29	44	34	37	63	27	51	17	13	417
	IV	16	20	12	15	31	30	26	21	32	47	14	10	274
	V	11	34	19	26	16	42	20	30	21	48	24	14	305
	VI	10	26	22	16	23	34	28	17	19	36	12	3	246
	VII	9	26	19	13	22	39	23	24	17	33	13	10	248
	Mean	13.85	35.28	19.14	23	28.28	38.71	25.14	32.57	30	46.57	15.71	9.42	317.7
Ciliate	I	7	4	4	3	5	9	8	10	7	13	4	1	84
	II	5	8	5	2	4	9	11	13	12	16	2	0	87
	III	4	0	2	5	3	8	9	8	11	19	3	0	72
	IV	5	0	2	0	3	4	7	6	4	12	4	2	50
	V	0	5	0	2	3	3	6	3	2	8	0	0	32
	VI	1	4	3	6	5	2	3	5	8	12	3	1	53
	VII	2	4	2	5	2	3	2	2	5	8	1	0	36
	Mean	3.42	3.57	2.57	3.28	3.57	5.42	6.57	6.71	7	12.57	2.42	0.57	59.14
Rotifera	I	11	18	5	11	7	9	4	19	12	27	7	2	132
	II	10	14	12	13	6	6	9	7	14	15	14	1	121
	III	9	13	7	17	3	5	4	12	13	17	6	0	106
	IV	1	3	1	2	4	2	0	11	10	14	4	0	52
	V	0	3	2	3	2	4	2	3	9	10	3	0	41
	VI	0	7	9	1	2	0	2	0	12	12	4	1	50
	VII	7	10	1	1	6	3	4	9	11	14	2	2	70
	Mean	5.42	9.71	5.28	6.85	4.28	4.14	3.57	8.71	11.57	15.57	5.71	0.85	81.71
Cladocera	I	5	12	9	6	13	12	10	16	19	23	4	3	132
	II	4	10	11	9	9	6	8	11	16	18	6	0	108
	III	6	11	12	5	9	4	9	9	19	22	2	2	110
	IV	7	12	12	9	12	9	8	9	10	10	2	0	100
	V	4	7	9	5	7	9	10	4	7	12	4	1	80
	VI	5	7	6	10	4	9	4	1	2	14	2	0	64
	VII	0	2	5	7	1	3	7	9	6	9	4	0	53
	Mean	4.42	8.71	9.14	7.28	7.85	7.42	8.0	8.42	11.28	15.42	3.42	0.85	92.42
Copepod	I	11	12	16	15	14	12	13	11	32	45	13	6	200
	II	15	15	17	3	4	4	14	15	27	35	10	5	164
	III	5	9	11	12	10	15	12	17	24	41	8	3	167
	IV	10	9	17	8	11	5	10	13	14	20	4	2	113
	V	8	8	13	11	9	13	9	7	8	13	0	3	99
	VI	4	9	11	9	4	12	7	6	12	15	0	2	91
	VII	3	5	9	11	4	7	10	13	9	12	0	2	87
	Mean	8.0	9.50	13.42	9.85	8.0	9.71	10.71	11.71	18.0	25.85	5.0	3.28	131.5

Table-5
Seasonal variations in the total number of five groups of zooplanktons in all the stations

Group	Summer	Monsoon	Winter	No. of Organisms	Percentage (%)
Protozoa	940	520	764	2224	46.54
Ciliate	230	70	104	404	8.45
Rotifera	276	152	144	572	11.97
Cladocera	302	122	222	646	13.52
Copepod	464	181	287	932	19.50

Table-6
Annual variation of zooplanktons and biodiversity indices in different stations

Diversity indices	Index	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Species	(N_0)	20	20	20	20	20	20	20
Richness	(R_1)	2.81	2.85	2.84	2.83	2.86	2.89	2.88
	(R_2)	0.68	0.71	0.87	0.89	0.92	0.84	0.84
Species Diversity	(I)	0.14	0.16	0.20	0.21	0.30	0.21	0.21
	(H)	2.75	2.69	2.61	2.46	2.29	2.50	2.50
Species Evenness	(E)	0.92	0.89	0.87	0.85	0.79	0.85	0.85
Dominance	(D)	0.85	0.83	0.79	0.78	0.69	0.78	0.78

Where, N_0 = No. of species, R_1= Margalef's index, R_2 = Menhinick's index, I =Simpson index, H = Shannon Weiner index, E = Evenness index and D = Dominance index.

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