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Zooplankton Diversity and Physico-Chemical Conditions of a Temple Pond in Birpur (J&K, India)

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Abstract

Zooplankton diversity and physico-chemical parameters of a temple pond, "Datte da Talab" were studied for a period of one year from May 2011 to April 2012. During the present study period, a total of 25 species of zooplankton were recorded out of which rotifera was represented by 12 species, copepoda by 5 species, whereas cladocera and protozoa each represented by 4 species. Rotifera showed its presence throughout the study period and the recorded data clearly showed well-marked seasonal fluctuations in their population with a fall during winter and rise during summer. Zooplankton community when correlated with physico-chemical parameters indicated that the distribution and density of zooplankton species was influenced by physical and chemical factors of the pond environment. The various kinds of indices such as Margalef's index, Menhinck's index, Simpson index, Shannon- Wiener index and Equitability index were used to support the data.

Keywords: Zooplankton, physico-chemical parameters, correlation, diversity index.

Introduction

The word 'Plankton' is originated from the Greek word 'planktos' which means drifting about in water under the action of water movement. The various functional aspects of an aquatic system, such as food chains, food webs, energy flow and cycling of matter are influenced by the zooplankton members, which are important biotic components of an aquatic system [1-4]. All the secondary production in aquatic ecosystems directly or indirectly relies on them. They play a major role in recycling nutrients as well as cycling energy within their respective environments. Their distribution is related with a complex of factors such as change of climatic conditions, physical and chemical parameters and vegetation cover[5-6]. They play an integral role and may serve as bioindicators and is a reliable tool for determining the status of water pollution[7-8]. Thus zooplankton association, richness, abundance, seasonal variation and diversity can be used for the assessment of water quality and for pisciculture management practices. Hence a study was conducted to assess the zooplankton quantitatively and qualitatively along with their correlation with the physico-chemical parameters to get a better understanding of the structure and function of this important aquatic ecosystem.

Material and Methods

Study Area and Stations: The temple pond, "Datte da Talab" is located in Birpur region of Sambha District of J&K state, India. This is the oldest pond in this region having great religious significance. It lies between 32°39′50″ N (latitude) and 74°57′10″ E (longitude) and at an elevation of 423 m above the mean sea level. It has a rectangular shape having a length of 25.2 metres and width of 21.60 metres and 45 cms figure-1. With a view to have an overall idea of the various physico-chemical and biological characteristics of this pond, four stations have been established on the littoral zones of the pond. The stations were named as S-I, S-II, S-III and S-IV. Station-I has been separated from the rest of the pond by a cemented wall and is "Bathing Ghat" for females.

Analysis of Physico-Chemical Parameters: For studying physico-chemical parameters of water, monthly sampling was done from May 2011 to April 2012. Water samples were collected in plastic water samplers of 2 litres capacity. Measurement of parameters like air temperature, water temperature, pH, DO, FCO_2, CO_3^{2-}, HCO^{3-}, Ca^{2+} and Mg^{2+} was done on the spot while rest were determined within two hours of water sample collection in the laboratory by following the standard methodology of Adoni[9] and A.P.H.A[10].

The plankton samples were collected by filtering 20 litres of water through the standard plankton net (25 mesh bolting silk). Finally the volume of planktonic concentrate was adjusted to 20 ml and preserved by adding 5% formalin. Zooplankton species identification was done with the help of standard references[11-12]. The quantitative analysis of planktonic organisms was carried out using Sedgwick Rafter plankton counting cell[10]. The number of plankton per ml of the concentrate was calculated by using the formula:

$$\text{Number/ml} = \frac{C \times 1000}{A \times D \times F} \quad m^3$$

Where, C= no. of organisms counted, A= area of the field, D= depth of the field (mm), (S-R depth of = 1mm), F=no. of fields counted.

Results and Discussion

Physico-chemical parameters are the important constituents of the aquatic system as they reflect the water quality of aquatic ecosystem. Seasonal variations in the physico-chemical parameters in pond, "Datte da Talab" were studied during the study period of May 2011 to April 2012 and are shown in table-1**.**

Mean values of transparency ranged from 32.10 cm (January) to 56.75 cm (August). Higher values of transparency were recorded throughout the year because of settling of suspended organic matter. Water temperature varied in accordance with the air temperature and it ranged from 11.63°C (December) to 33.0°C (May). pH of the water remained alkaline throughout the study period and ranged between 7.65 (November) to 9.40 (February). The higher values of pH in winter season is attributed to decreased temperature and high values of DO and carbonate[13].

Dissolved oxygen varied from 1.18 mg/l (July) to 11.3 mg/l (February) and it showed higher value in winter season and low value in summer season[14-15]. FCO_2 recorded its presence in some winter months (November and January) which may be associated with low temperature, decreased water level and overcastting of sky with the clouds[16]. Carbonates showed their absence in November and January and this is due to the presence of FCO_2 during this period. An increase in the values of bicarbonates was recorded in summer and monsoon seasons. Chloride is an important indicator of organic pollution[17]. Its concentration varied from 11.98 mg/l (October) to 52.70 mg/l (May). The maximum (40.90 mg/l) and minimum (16.43 mg/l) values of calcium were recorded in the months of November and February respectively. Magnesium concentration varied from 16.53 mg/l (February) to 42.28 mg/l (October). Phosphate varied from 0.0 (Sep., Nov., Jan. and Feb.) to 0.0564 mg/l (May). A very low value of phosphates was recorded at all the stations. Lower values in phosphates during winter and spring periods resulted from its utilization by the algal planktons for photosynthesis [18]and low water circulation[19]. Presence of nitrates in water indicates the final stage of mineralization and nitrates varied from 0.572503 mg/l (December) to 0.57283 mg/l (July).

Figure-1
View of pond "Datte da Talab"

Table-1
Mean variations in the physico-chemical parameters of four stations during May 2011 to April 2012

Parameters	Units	Station-I	Station-II	Station-III	Station-IV
Depth	cm	53.93±11.75	41.025±5.16	44.65±7.14	43.83±7.78
Transparency	cm	51.53±11.06	38.98±5.55	46.33±11.74	42.57±7.34
Air temp.	°C	27.73±7.60	25.93±8.10	27.27±7.47	26.95±7.22
Water temp.	°C	24.75±7.58	24.46±6.98	25.48±7.71	24.42±7.97
pH		8.24±0.45	8.56±0.46	8.42±0.57	8.39±0.46
FCO2	mg/l	2.33±4.07	0.5±1.66	0.5±1.66	0.98±2.36
Carbonates	mg/l	31.15±25.52	35.3±19.33	36.05±19.80	35.6±23.76
Bicarbonates	mg/l	340.35±82.90	324.66±19.33	313.38±76.60	317.73±75.81
DO	mg/l	4.21±2.98	5.35±3.98	5.37±3.84	5.14±3.49
Chloride	mg/l	22.29±12.80	21.87±10.34	20.86±10.54	21.33±10.35
Calcium	mg/l	30.55±7.56	27.07±7.13	23.96±5.82	25.40±6.61
Magnesium	mg/l	28.35±6.67	27.78±8.51	27.21±8.54	26.29±7.45
Nitrate	mg/l	0.572666±0.000223	0.572553±0.000112	0.572636±0.000234	0.572578±0.000109
Phosphate	mg/l	0.013981±0.018061	0.009235±0.011649	0.011594±0.01287	0.028794±0.039455

Zooplankton in the present study was comprised of Rotifera (12 genera), Copepoda (5 genera), Cladocera (4 genera) and Protozoa (4 genera). Qualitative and quantitative analysis of different zooplankton are shown in table- 2 and table- 3. In the present work, Rotifera constituted the most dominating group contributing 46.67% to the total zooplankton population followed by Copepoda (33.50%), Cladocera (13.53%) and Protozoa (6.3%). Rotifera was represented by *Brachionus calyciflorus, B. quadridentatus, B. patulus, Lecane sp., Monostylla sp*., *Asplanchna sp., Colurella sp., Filinia longiseta, Keratella quadrata, Lepadella ovalis, Testudinella sp. and Polyarthra sp*. Rotifer population showed its peak during summer season and after following a decline during monsoon season, their population attained its minimum value in winter season. High rotifer population in summers may be attributed to high temperature[20-23], alkaline pH[24-26], higher values of chlorides, nitrates and phosphates in summer season[27], presence of sediments in suspension[28] and abundant food[29]. Declining population of rotifers was however recorded during monsoon season which could be due to dilution of water resulting in less nutrients, low transparency, reduced DO level and pH[30]. Winter fall in rotifers could be assigned to fall in temperature[31] and increased Cladoceran count that bears inverse relationship with rotifer[32].

Copepod formed the second most abundant group of zooplankton and was represented by *Cyclops sp*., *Eucyclops sp., Mesocyclops sp., Diaptomus sp. and Naupilus* larvae. Their count remained low during summer and high during winter. Similar trend has already been pointed by several workers[33-34]. The predominance of copepods in winter samples reveals their ability to low temperature, high DO, total alkalinity and phytoplankton[23].

Cladocera formed the third most abundant group of zooplankton and was represented by *Daphnia sp., Alona costata, Alona monocantha* and *Chydorus sp*. after attaining minimum value in summer, the Cladoceran density recorded a rise in the post-monsoon season and finally acquired highest value during winter season. Post monsoon rise in Cladoceran population may be due to increase in pH[35] and luxirant growth of phytoplankton. Cladocera were higher in winter due to The favourable temperature and availability of abundant food in the form of bacteria, nanoplankton and suspended detritus in winter season favoured the high population of cladocerans during this season[36].

Table-2
Zooplankton species occurrence during May 2011 to April 2012 in Datte da Talab, Pond

	Summer				Monsoon				Winter			
Protozoa	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Centropyxis aculeate	+	+	+	+	+	+	+	+	+	+	-	+
Vorticella sp.	-	+	+	+	+	+	+	-	-	-	-	-
Arcella vulgaris	-	-	-	+	+	+	+	-	-	-	-	-
Difflugia sp.	-	-	-	+	+	-	-	-	-	-	-	-
Rotifera												
Brachionus calyciflorus	+	+	+	+	+	-	+	-	+	+	-	-
B. quadridentatus	-	+	+	+	+	+	+	+	-	-	-	-
B. patulus	+	+	+	+	+	+	+	+	+	-	+	+
Asplanchna sp.	-	-	+	+	+	-	-	+	-	-	-	-
Colurella sp.	-	-	-	+	-	+	+	+	+	-	-	-
Filinia longiseta	-	-	-	-	-	-	+	+	+	-	-	-
Keratella quadrata	-	-	+	+	+	+	+	+	+	+	-	+
Lepadella ovalis	-	+	+	+	+	+	-	-	+	-	+	-
Lecane sp.	+	+	+	+	+	+	+	+	-	+	+	+
Monostylla sp.	-	+	-	-	+	+	+	+	+	-	+	+
Testudinella sp.	-	-	-	+	-	-	+	-	-	-	-	-
Polyarthra sp.	-	-	-	+	-	-	-	-	-	-	-	+
Cladocera												
Daphnia sp.	-	-	-	-	-	-	-	-	+	+	+	+
Alona monocantha	-	+	+	+	-	-	+	-	+	+	+	+
Alona costata	+	-	-	-	+	-	-	-	+	+	+	+
Chydorus sp.	-	-	-	-	+	-	-	+	+	+	-	+
Copepoda												
Cyclops sp.	+	+	+	+	+	+	+	+	+	+	+	+
Eucyclops sp.	+	-	+	-	-	+	+	-	+	+	+	+
Mesocyclops sp.	+	+	+	+	-	-	+	+	+	+	+	+
Diaptomus sp.	+	+	+	+	+	-	-	-	-	+	+	+
Naupilus larvae	+	+	+	+	-	-	-	-	+	+	+	+

Protozoa was represented by *Centropyxis aculeate*, *Difflugia sp., Vorticella sp*. and *Arcella vulgaris*. They were found to remain low in winter and high in summer and monsoon seasons. The rise in protozoan population during monsoon season could be related to the fact that the monsoon rains bring a lot of organic matter from the catchment areas which have a large no. of bacteria and therefore act as a source of food for protozoans.

To study the relative effect of some environmental factors, correlation analysis was made between zooplankton and physico-chemical parameters table-4. The temperature is significantly and positively correlated with rotifer population, rotifer and protozoans showed positive and significant correlation with water temperature, carbonates, chlorides, phosphates and nitrates whereas cladocerans were negatively and significantly with water temperature, carbonates, calcium and magnesium. Various indices such as Shannon- Wiener (H′) index, Simpson index (I), Margalef's index (R_1) and Equitability index (E) were used to analyse species diversity, richness and evenness respectively. The analysed data revealed the maximum species diversity in terms of Shannon-Wiener index (H′ =2.98) at Station-I whereas minimum value of this was recorded at station-III. The maximum (R_1=2.96) and minimum (R_2=2.88) values of species richness were recorded at Station-I and Station-IV respectively. Value of evenness (E) was higher at Station-IV and lower at Station-III table-5.

Table-3
Monthly variation in zooplanktons (no./l) of water at four Stations from May 2011 to April 2012

	Station	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
Protozoa	I	3.3	5.1	6.3	3.6	2.7	0.6	0.6	0.9	0.0	0.3	0.6	0.6
	II	4.2	4.2	5.1	3.0	2.1	0.9	0.9	0.6	0.0	0.6	0.3	0.6
	III	4.2	3.3	4.5	3.7	0.9	1.2	0.9	0.6	0.6	0.9	0.6	2.1
	IV	5.4	5.4	6.5	4.8	2.7	1.2	1.5	0.9	0.3	0.9	0.6	0.3
	Mean	4.28	4.5	5.6	3.38	2.1	0.96	0.98	0.75	0.23	0.68	0.53	0.9
Rotifera	I	26.7	33.3	26.4	14.7	18.9	14.1	16.5	6.8	2.1	3.9	6.6	13.5
	II	34.5	40.2	29.4	16.2	19.2	15.3	9.9	7.8	4.5	2.7	5.4	4.5
	III	26.6	26.1	42.3	15.0	12.3	22.5	12.0	13.5	10.2	7.2	2.4	6.3
	IV	32.4	20.1	21.9	16.2	19.5	19.5	8.4	9.0	8.1	9.0	3.6	9.3
	Mean	30.05	29.93	30	15.53	17.48	17.85	11.7	9.28	6.23	5.7	4.5	8.4
Copepoda	I	8.7	7.2	3.0	1.5	2.4	2.4	19.2	21.3	21.9	14.4	9.2	6.9
	II	9.6	8.1	3.9	1.8	1.5	2.7	17.4	27.0	27.0	16.5	10.8	7.8
	III	5.4	4.5	3.3	5.1	2.1	3.3	18.0	25.2	25.2	18.6	12.3	6.3
	IV	10.8	6.6	6.0	4.2	2.7	5.1	9.9	30.0	22.8	15.6	13.7	19.8
	Mean	8.63	6.6	2.55	3.15	2.18	3.38	16.13	25.88	24.1	16.26	11.5	10.2
Cladocera	I	1.2	0.9	1.8	0.0	0.6	1.5	11.4	12.9	11.7	4.8	0.9	1.8
	II	0.6	1.2	1.5	1.8	1.2	1.8	12.3	14.1	13.5	5.1	1.2	0.9
	III	0.9	0.9	2.4	0.6	1.5	2.7	11.4	11.7	11.1	4.2	1.8	0.9
	IV	0.6	1.8	0.6	1.2	1.2	2.7	12.3	9.9	15.0	8.7	3.9	0.6
	Mean	0.83	1.2	1.58	0.9	1.13	2.18	11.85	12.15	12.83	5.7	1.95	1.05

Table-4
Correlation between physico-chemical parameters and various zooplankton groups

Parameters	Protozoans	Rotifers	Copepods	Cladocerans
Depth	0.09	-0.05	-0.47	-0.34
Transparency	0.02	-0.15	-0.38	-0.25
Air temp.	0.65	0.61	-0.74	-0.90
Water temp.	0.71	0.64	-0.83	-0.94
pH	-0.07	-0.22	0.36	-0.03
Carbonates	0.80	0.67	-0.59	-0.70
Bicarbonates	0.02	0.17	0.23	0.53
DO	-0.8	-0.41	0.72	0.57
Chloride	0.54	0.62	-0.20	-0.30
Calcium	-0.16	0.03	0.20	0.52
Magnesium	-0.39	-0.10	0.24	0.51
Phosphate	0.76	0.71	-0.50	-0.59
Nitrate	0.65	0.44	0.53	-0.33

Table-5
Annual variations of zooplanktons and biodiversity indices in different stations

Diversity indices	Index	S-I	S-II	S-III	S-IV
Species richness	(No.)	25	25	25	25
	R_1	2.96	2.93	2.92	2.88
	R_2	0.43	0.42	0.41	0.39
Species diversity	I	0.13	0.12	0.13	0.11
	H	2.93	2.90	0.89	2.98
Species evenness	E	0.91	0.90	0.89	0.92
Dominance	D	0.87	0.87	0.86	0.88

N_0 = No. of species, R1 = Margalef's index, R2 = Menhinick index, I= Simpson index, H= Shannon-Wiener index, E= Equitability index and D= Dominance index

Conclusion

Higher values of species diversity and species richness at all the sites depicts the favourable conditions in terms of physico-chemical conditions and food at all the sites. Although zooplankton exists under a wide range of environmental conditions, yet many species are limited by DO, temperature and other physico-chemical factors. The presence of different species of *Brachionus* indicates that the pond is approaching towards eutrophication and is organically polluted. Different species of zooplankton showed their abundance according to the favourable conditions, so they disappeared in unfavourable conditions and appeared on the return of favourable conditions.

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