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RESEARCH ARTICLE

Zoobenthos as indicator of Pollution in relation to environmental variables

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Abstract

The present study was carried out in a fresh water pond from May, 2007 to April, 2008 to observe the changes in the abundance of zoobenthos in relation to various environmental variables. Rotifers and Diptera was found to be most dominant groups in the selected pond show eutrophic condition of pond. The population density of diptera varied from minimum 252 No./ $m^2$to a maximum of 413 No./m^2. Chironomus was found to be the most abundant species in terms of population density amongst dipteran. Water temperature showed a negative correlation (r= 0.502) with zoobenthic community. Plecoptera recorded a significant negative correlation with water temperature (r = -0.631).

Introduction

Benthos is the organisms associated with solid- liquid interphase. The benthos is composed of bottom dwelling organisms and is categorized as phytobenthos and zoobenthos. Benthic macro invertebrates are organisms without backbone that inhabit the bottom substrates of their habitats, for at least part of their life cycle (Rosenberg and Resh, 1993). These animals are wide spread in their distribution and can live on all bottom types, even on manmade objects. The benthic macro invertebrates have significant place in the trophic level of an aquatic system. Chironomids and Oligochaetes have been used as indicators of saprobicity (Brinkhurst and Jameison, 1971).

Benthic macroinvertebrates include insect larvae, annelids (leeches), oligochaetes (worms), crustaceans (crayfish and shrimps), molluscs (clams and mussels) and gastropods (snails). Insect larvae tend to be the most abundant benthic macroinvertebrates in fresh water ecosystem. Some are capable of tolerating higher loads of pollution and can be used as a pollution indicator. On the basis of their size, the benthos is classified in three groups, *Microbenthos* (organisms 1-100 micrometer in size e.g bacteria*), Meiobenthos* (which are 100-1000 micrometer in size), Macrobenthos (which are more than 1000 micrometer in size). As Zoobenthic macro invertebrates tend to remain in their original habitats, they are affected by local changes in water quality.

The factors such as temperature, pH, D.O, CO_2, influence the growth and development of benthic community (Peckarsky et.al., 1990). It is now very well understood that the studies on the zoobenthic communities in freshwater ponds may play an important role in the food web at all trophic levels. Such studies also provide the essential information regarding the abundance and distribution of pollution indicators and their association in a community as a whole. This may add some knowledge to biological control of pollution in ponds.

Methodology

The study was performed from May, 2007 to April, 2008 in a fresh water pond of western region of U.P. This Pond is a perennial freshwater and sewage-fed pond. The depth of the pond varies during different season at different sites. It is a shallow eutrophic body of water having an irregular shore line with varying depth and area. The basin of the pond is more or less flat which is marshy in nature consisting of dead planktonic organisms, decayed leaves, sand, clay, humus, gravels and broken pieces of bricks etc. The drainage system of the pond constitutes many inlet drains which carry the waste water and sewage from the surrounding locality.

Collection of sediment and water samples: The subsurface water (about 30 cm depth) from littoral region of selected pond was collected monthly with the help of Ruttner water sampler bottle with the capacity of two litters and sediment samples were collected monthly with the help of Ekman-dredge of size 15 cm x 15 cm. After collection, sediment samples were kept in plastic bags, labeled and were brought to the laboratory.

Separation of bottom fauna and Identification: For zoobenthos analysis, samples were mixed and diluted with tap water to prepare slurry in a bucket and sticks, leaves, debris were removed. Then slurry was divided into ten subsamples. Each subsample was passed through sieves, B.S. No. 30 (mesh # 500 μm) and B.S. No. 72 (mesh # 200 μm) arranged former above the latter so that smaller organisms (meio) were retained on the smaller sieve. Sieving yielded residue including mixture of animals and sediment. The sample retained on first sieve was emptied in shallow dish and organisms were sorted by using brush, forceps and pipette against a white background. To facilitate the sorting few drops of 10% aqueous solution of Rose Bangal was added. Organisms retained on second sieve were washed into a tray and then samples were taken in vials and labeled. Organisms were preserved in 70 % ethyl alcohol solution for qualitative and quantitative analysis. For larger animals, insect larvae and oligochaetes about 2 ml of preserved sample was taken in a calibrated petri-dish and studied under dissecting microscope.

For smaller organisms, about 1 ml of preserved sample was taken on Sedgewick Rafter cell and studied under an inverted microscope (Metzer). Individuals were identified up to genus or species level as could be possible and number of each taxon was noted. Density was determined per meter square area and result was expressed as ind/m^2. Identification was done with the help of keys given in Edmondson (1959), Needham and Needham (1962), Pennak (1978) and Tonapi (1980) and density determined per meter square area (ind/m^2).

Air and water temperatures were recorded with the help of mercury thermometer graduated up to 100°C between 8.00-9:00 am.
Conductivity was recorded with the help of digital conductivity meter (Hanna instrument, No. S250178).
The depth at the sampling sites was obtained in cm by sounding the bottom with graduated nylon rope tied to a lead weight.
Transparency, the limit up to which light can penetrate in water body, was measured by using standard Secchi-disc having diameter of 20 cm.
Dissolved oxygen (D.O.) analysis was performed at the sites by Winkler's modified technique (Trivedy and Goel, 1984).
Free carbon dioxide (CO_2) was determined by titrating 100 ml of water sample with N/44 NaOH using Phenolphthalein as an indicator (Theroux *et al.,* 1943).
pH of the water was determined at the sites by using a portable electronic digital pH meter (Hanna instrument, No. S254992).
Alkalinity was estimated by titrating 100 ml water sample with 0.02 N Sulphuric acid using Phenolphthalein and Methyl orange as indicator (Theroux *et al*., 1943).
Hardness of water was estimated by titrating the water sample with 0.01 N EDTA solution using Murexide as an indicator (Trivedy and Goel, 1984).
Calcium and **Magnesium** present in water was estimated by titrimetric method (Trivedy and Goel, 1984).
For **Total Solids (TS)** analysis, 200 ml water sample was taken. The residue left after the evaporation of 200 ml sample of unfiltered water was taken as the amount of total solids (TS) present. The residue left after the evaporation of 200 ml sample of filtered water was taken as the amount of the **total dissolved solids (TDS)** present. The difference between TS and TDS were taken as the amount of **total suspended solids (TS-TDS=TSS)** present. The results were expressed in mg/L.

Results

Diptera- Diptera density varied from a minimum of 252 No/m^2 in July, 2007 to a maximum of 413 No/m^2 in December, 2007 (Table-2& 4; fig- 1). Total percent contribution of Diptera among all another zoobenthic group was 18 %. Statistically Diptera recorded negative correlation with water temperature (r =-0.507) (Table-3, fig.- 2).
Coleoptera- Its density varied from a minimum of 174 No/m^2 in May, 2007 to a maximum of 286 No/m^2 in August, 2007(Table-2& 4). Total percent contribution of Coleoptera among all another zoobenthic group was 12% (fig- 1).
Plecoptera- Its density varied from a minimum of 23 No/m^2 in June, 2007 to a maximum of 59 No/m^2 in January, 2008 (Table-2& 4). Total percent contribution of Plecoptera among all another zoobenthic group was 2 % (fig- 1). Plecoptera showed high positive significant correlation with dissolved oxygen (r = 0.775) whereas negative correlation with water temperature (r = -0.631) (Table-3, fig.- 2).
Ephemeroptera -Density varied from a minimum of 3 No/m^2 in December, 2007 to a maximum of 7 No/m^2 in February, 2008 (Table-2& 4). Total percent contribution of Ephemeroptera was 0% (its abundance is negligible) (fig- 1). Ephemeroptera showed significant positive correlation with dissolved oxygen (r = 0.532;Table-3, fig. 2).
Oligochaeta- Its density varied from a minimum of 236 No/m^2 in April, 2008 to a maximum of 332 No/m^2 in January, 2008 (Table-2& 4; fig- 1). Total percent contribution of Oligochaeta was 16%.
Ostracoda- Its density varied from a minimum of 136 No/m^2 in April, 2008 to a maximum of 206 No/m^2 in December, 2007 (Table-2& 4; fig- 1). Total percent contribution of Ostracoda among all another zoobenthic group was 9%. Ostracoda showed significant high negative correlation with water temperature (r = -0.771; Table-3, fig-2).
Copepoda- Its density varied from a minimum of 126 No/m^2 in February, 2008 to a maximum of 369 No/m^2 in August, 2007 (Table-2& 4; fig- 1). Total percent contribution of Copepoda among all another zoobenthic group was 13 %.
Cladocera- Cladocera density varied from a minimum of 111 No/m^2 in June, 2007 to a maximum of 314 No/m^2 in April, 2008 (Table-2& 4; fig- 1). Total percent contribution of Cladocera among all another zoobenthic group was 10 % (Fig.-1).
Rotifera- Density varied from a minimum of 283 No/m^2 in May, 2007 to a maximum of 431 No/m^2 in August, 2007 (Table-2& 4; fig- 1). Total percent contribution of Rotifera was 20 %. Rotifera showed negative correlation with water temperature (r = -0.208).
pH- The pH value ranged between 7.8 to 9.5 during different months. Zoobenthos showed a positive correlation(r =0.348) with pH (Table- 1 and 3).
Dissolved oxygen- The D.O. value ranged from minimum 2.8 mg/l in the month of June, 2007 to a maximum of 20.0 mg/l in the month of January, 2008 (Table- 1).
T.D.S- The value of T.D.S ranged from minimum 152 mg/l in the month of September, 2007 to a maximum of 618 mg/l in the month of May, 2007. There was a seasonal rhythm of T.D.S. with a peak in early summer. The transparency showed a significant negative correlation (r =-0.706) with T.D.S., whereas a positive correlation (r = 0.255) have been obtained between T.D.S and Zoobenthos (Table- 3).
Free CO_2 -The free CO_2 was always found to be absent throughout the study period (Table- 1).
Hardness - Total hardness showed wide range from minimum 90 in the month of December, 2007 to 213 mg/l in the month of March, 2008 (Table-1).
The calcium ranged from a minimum 12.8 mg/l in the month of September, 2007 to maximum 85.3 mg/l in the month of March, 2008 (Table-1). Lower value of Calcium recorded during monsoon season and higher values were recorded during summer season.
Water temperature shows a negative correlation (r = -0.426) with dissolved oxygen. The Calcium showed a positive correlation (0.428) with zoobenthic community. Water temperature showed a negative correlation (r= 0.502) with zoobenthic community where as a positive correlation (r = 0.570) (Table- 3).

In the present study, Rotifer dominated the other groups of zoobenthos contributing highest average percentage (20%) followed by Diptera (18%), Oligochaetes (16%), Copepods (13%), Ostracods (9%), Cladocera (10%), Plecoptera (2%) and Ephemeroptera (0%). The water temperature exhibited a negative correlation with benthic community (r= .502), whereas pH illustrated a positive correlation (r= 0.348) with benthic community. Zoobenthos displayed a positive correlation with D.O. (r = 0.098), T.D.S. (r = 0.255) and carbonates (r = 0.300) (Table- 3).

Table 1
Monthly variation in different environmental parameters

Month	pH	Water Temp	Air temp	Transparency (cm)	D.O.	Free CO_2	Hardness Mg/l	Hydroxide Mg/l	Carbonate HCO_3^{--}	Bicarbonate HCO_3^{-}	Total alkalinity	T.D.S	Ca++	Mg++	Conductivity
May	9.5	26	28	21.50	14.4	Absent	112	-	210	270	480	618	24.48	12.4	1740
June	8.9	32	34	19.25	2.8	-	110	-	150	240	390	186	30.19	8.4	1800
July	9.2	39	37	21.00	5.6	-	98	-	140	270	410	182	27.33	7..3	1107
Aug	9.0	30	34	21.00	5.8	-	105	-	170	210	380	157	28.05	9.0	956
Sep.	7.8	34	32	15.50	2.4	-	92	-	-	435	435	152	12.8	40.28	1200
Oct	9.5	28	27.5	20.00	17.4	-	96	-	184	316	500	155	38.2	38.4	1456
Nov	9.5	20	18	17.00	16.6	-	98	-	200	380	480	198	30.4	5.8	1800
Dec	9.2	18	20	13.00	4.0	-	90	-	-	775	775	189	68.9	19.97	1100
Jan	8.9	17	16	16.00	20.0	-	130	-	156	494	650	255	44.0	5.3	1630
Feb	8.6	19	25	20.00	11.4	-	158	170	400	-	570	260	20.04	26..3	1462
Mar	8.0	23	24	23.00	12.8	-	213	-	200	525	725	250	85..3	19.2	1362
April	8.9	28	26	24.50	16.8	-	190	-	180	370	550	255	68.9	19.9	1250

Table 2
Distribution and abundance of Zoobenthos (No/m^2)

Months / Genera	May'07	June	July	Aug	Sep	Oct	Nov	Dec	Jan'08	Feb	Mar	Apr
ROTIFERA												
Branchionus bidentatus	48	47	43	53	43	59	63	72	45	78	29	63
B. calyciflorus	59	72	85	191	95	85	68	63	71	74	53	88
Keratella quadrata	53	48	56	39	65	64	42	63	61	49	53	59
K. tropica	51	58	57	36	57	63	69	75	82	53	71	83
Filinia sp.	41	53	61	74	51	53	59	65	59	48	38	37
Notholca	31	49	34	38	47	52	63	72	78	53	49	39
Total	**283**	**327**	**336**	**431**	**358**	**376**	**364**	**410**	**396**	**355**	**293**	**369**
CLADOCERA												
Daphnia sp.	89	63	54	79	73	97	79	87	95	68	159	186
Bosmina sp.	73	48	75	92	43	38	83	61	152	89	115	128
Total	**162**	**111**	**129**	**171**	**116**	**135**	**162**	**148**	**247**	**157**	**274**	**314**
COPEPODA												
Cyclops sp.	133	85	149	173	183	67	84	98	54	98	219	112
Diaptomus sp.	86	219	115	196	95	83	82	72	94	28	92	45
Total	**219**	**304**	**264**	**369**	**278**	**150**	**166**	**170**	**148**	**126**	**311**	**157**
OSTRACODA												
Cypridopsis	58	57	53	63	53	69	73	82	55	66	39	55
Nauplius	56	64	48	39	45	66	55	61	69	61	63	38
Eggs	44	29	39	55	42	46	52	63	65	45	48	43
Total	**158**	**150**	**140**	**157**	**140**	**181**	**180**	**206**	**189**	**172**	**150**	**136**
OLIGOCHAETA												
Tubifex	52	63	53	62	74	52	56	72	92	81	56	42
Chaetogaster	56	72	75	35	44	86	48	49	76	45	38	36

Nais	82	75	93	86	78	56	62	54	58	29	73	62
Aelosma niveum	64	46	48	64	49	38	56	53	52	54	62	58
A.quaternarium	39	32	28	53	45	63	32	42	54	45	56	38
Total	**293**	**288**	**297**	**300**	**290**	**295**	**254**	**270**	**332**	**254**	**285**	**236**
EPHEMEROPTERA												
Baetis	2	1	3	2	2	2	3	1	4	2	3	1
Caenis	2	2	1	2	3	2	1	2	3	2	3	4
Total	**4**	**3**	**4**	**4**	**5**	**4**	**4**	**3**	**7**	**4**	**6**	**5**
PLECOPTERA												
Atoperala	31	23	27	33	32	43	53	38	59	43	32	54
Total	**31**	**23**	**27**	**33**	**32**	**43**	**53**	**38**	**59**	**43**	**32**	**54**
COLEOPTERA												
Berosus	23	24	27	32	29	22	56	57	24	25	24	23
Hydaticus	36	48	54	59	29	42	39	38	56	29	32	46
Hydracarina	73	67	56	87	108	72	91	61	73	91	87	75
Hydranchna	42	71	51	108	92	53	31	67	40	76	98	54
Total	**174**	**210**	**188**	**286**	**258**	**189**	**217**	**223**	**193**	**221**	**241**	**198**
DIPTERA												
Chironomus	168	101	60	159	70	98	87	122	98	102	104	97
Tanypus	68	98	39	49	94	45	69	109	78	89	98	86
Pentaneura	45	96	98	65	45	104	84	98	92	56	59	65
Culicoides	45	72	55	95	80	65	99	84	92	45	48	50
Total	**326**	**367**	**252**	**368**	**289**	**312**	**339**	**413**	**360**	**292**	**309**	**298**
Grand total	**1650**	**1783**	**1637**	**2119**	**1766**	**1685**	**1739**	**1881**	**1928**	**1627**	**1901**	**1767**

Table-3
Statistical Briefs of various environmental variables with Zoobenthos

	Parameters	**Coefficient of Correlation 'r'**	Significance at ($p \leq 0.05$)
Water Temperature	Dissolved Oxygen	**-0.426**	-
	Rotifera	**-0.208**	-
	Ostracoda	**-0.771**	√
	Diptera	**-0.507**	√
	Plecoptera	**-0.631**	√
Zoobenthos	Dissolved Oxygen	**0.580**	√
	pH	**0.348**	-
Hardness	Total dissolved Solid	**0.255**	-
	Carbonate	**0.300**	-
Transparency	Bicarbonate	**0.570**	√
D.O.	Calcium	**0.428**	-
	T.D.S	**0.340**	-
	pH	**-0.706**	√
	Ephemeroptera	**-0.532**	√
	Plecoptera	**-0.775**	√
Water temperature	Zoobenthos	**-0.502**	√

Table-4
Maximum, Minimum values and percecent contribution of different groups of Zoobenthos

Groups	Min	Max	% Contribution
Diptera	252	413	**18**
Coleoptera	174	286	**12**
Plecoptera	23	59	**2**
Ephemeroptera	3	7	**0**
Oligochaeta	236	332	16
Ostracoda	136	206	**9**
Copepoda	126	369	**13**
Cladocera	111	314	**10**
Rotifera	283	431	**18**

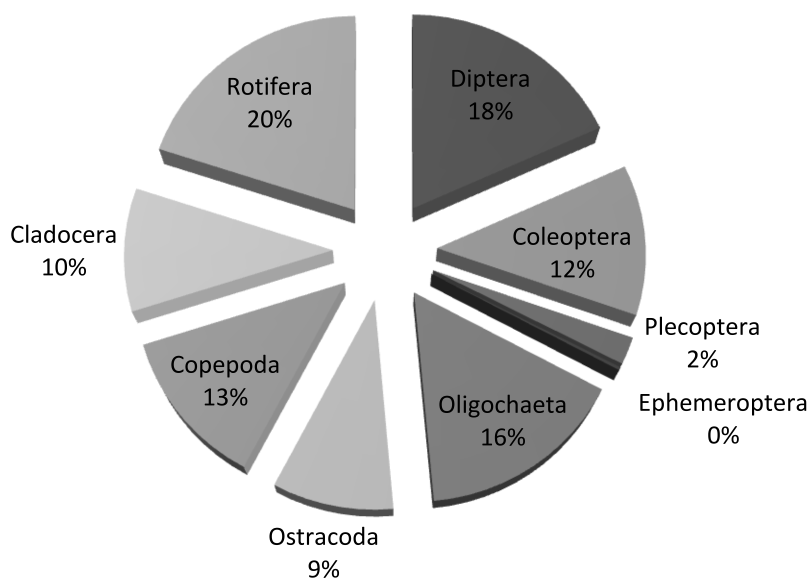

Fig. 1

Percent contribution of different groups of Zoobenthos

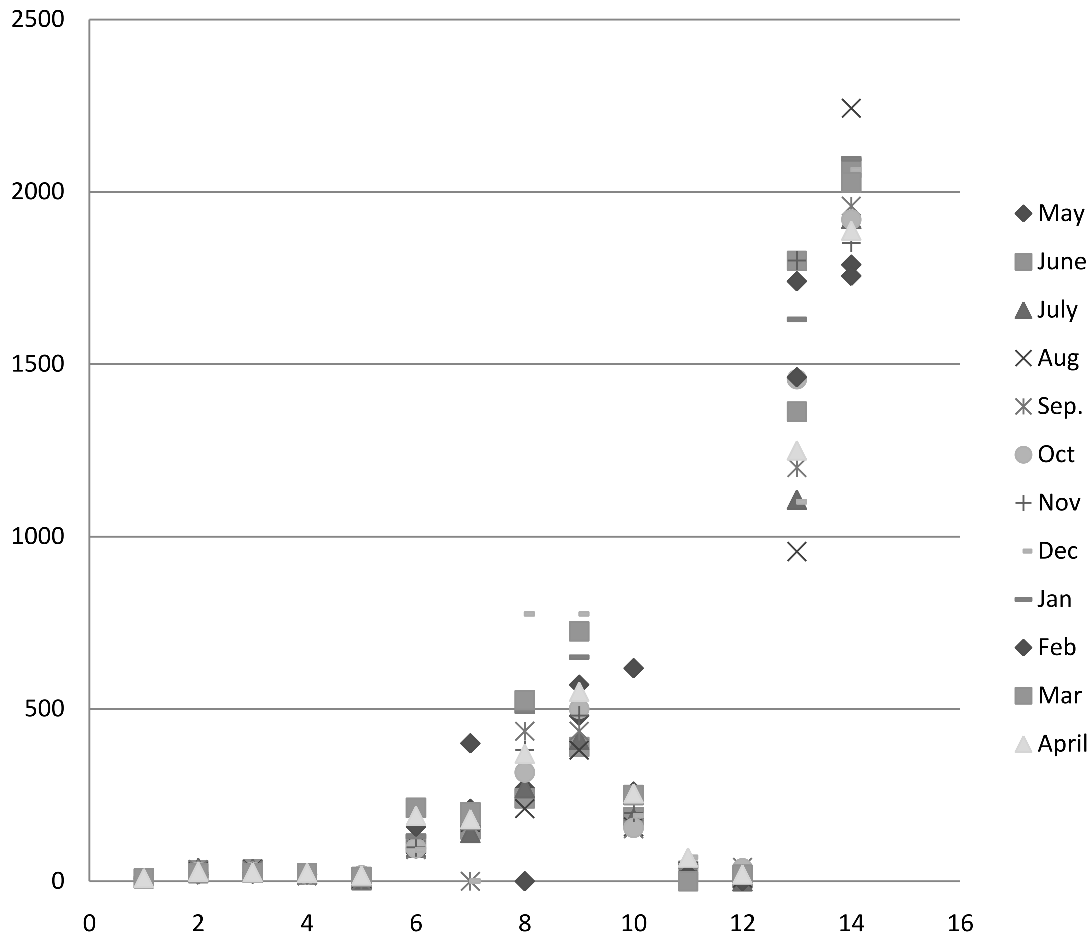

Fig. 2 Relation of Zoobenthos with environmental variables during different months

Discussion

Rotifers in general and chironomids in particular dominated zoobenthos community throughout the study period. Presence of chironomidae throughout the study period showed polluted stage of pond. Bass (1986) has also observed maximum population of chironomids during winter month with peak during spring. Cowell and Vodopich (1981) have found uniformity in the abundance of oligochartes throughout the year. Caddisflies are found across a range of habitats from cool stream to warm streams, lakes, marshes and ponds (Peckarsky et.al. 1990). Insects mayflies (Ephemeroptera) are most abundant in cool, unpolluted, headwater streams but they may be found in standing (lentic) water as well. They prefer clean water and an average oxygen supply, but some species can tolerate low dissolved oxygen supply, but some species eg. *Callibaetis* can thrive in low dissolved oxygen. Stonefly requires high dissolved oxygen concentration and tends to be found in cold, flowing water with a gravel or stone bottom.

Some species may be found along lake shore with wave action (Peckarsky et.al. 1990). In the present investigation too, the seasonal fluctuation in the abundance of oligochaetes were not so much pronounced. The substantial and high selective nature of cladoceran and cyclopoids predatation on rotifers (Williamson, 1983) might be one of the reasons for reduction in the density of rotifers in winter. The water body was covered by macrophytes, which might be responsible for complete absence of CO_2 in surface water. Moreover, the presence and absence of free CO_2 in the surface water is mostly governed by its utilization by algae during photosynthesis and through respiration, decomposition and diffusion from air (sreenivasan, 1974). The D.O. value were recorded maximum 20.0 mg/l which might be due to dense growth of aquatic plants especially Hydrodicyton, which forms mat like covering on the basin near shore line of pond. During winter season, the low predation pressure and low turbidity increase oxygen concentration making the conditions favourable for benthic community, while in summer season low transparency, high turbidity low oxygen, and high predation are the possible reason for the fluctuations in insect density. Absence of free CO_2 throughout the study period may be due to its conversion in to carbonate and bicarbonate as well as its utilization in the process of photosynthesis.

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