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Impact of Physico-Chemical Characteristics on Zooplankton Community of a Freshwater Wetland of Udaynarayanpur, Howrah,West Bengal, India

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Abstract

Udaynarayanpur Block-market pond, Udaynarayanpur, Howrah received sewage water and sewage materials from adjoining shops, market and human habitation. It was hyper-eutrophic in nature with high contents of nitrates, NH_3-N, phosphates, chlorides, free carbon-di-oxide, dissolved and suspended solids. The zooplankton community comprised of there major groups–Rotifera, Cladocera and Copepoda. Rotifers showed numerical superiority over other groups of zooplankton. The zooplankton population was characterized by a few numerically abundant species that control the bulk of plankton density. The population of total zooplankton and rotifera possessed summer peak occurrence at various sewage sites of the wetland. Zooplankton population was correlated significantly with the changing phenomena of physico-chemical characteristics of water. Eutrophication affected the species composition of zooplankton through chemical alternation of the environment. Several linear regression relationships were also established between zooplankton abundance and physico-chemical characteristics. Increment of population density of several zooplankton organisms (i.e. *Keratella tropica, Polyarthra vulgaris*) and low value of species diversity and species richness indicated the rise of pollutional stress on the Block-market pond.
Key words : Pond, Sewage, Physico-chemical characteristics, Zooplankton.

Zooplanktons are the major trophic link in food chain and being heterotrophic organisms it plays a key role in cycling of organic materials in aquatic ecosystem. The input of increasing load of pollutants and toxic substances into the water has been causing serious disturbance in the aquatic ecosystems. The physico-chemical methods are used to detect effects of pollution on the water quality but changes in the trophic conditions in water are reflected in the biotic community structure as shown by occurrence, diversity and abundance pattern of species (1). The changes in community structures can be explained numerically with diversity index and are useful in assessing water quality based on the principle that clean water supports high community diversity while polluted waters have less diversified biota (2). Monitoring the zooplankton as biological indicators could act as forewarning, when pollution affects food chain (3). With the increment of human settlement polluted sewages were being dumped into the water body. Planktons are considered as indicator of the trophic status of a water body because of their specific qualitative features and their capacity to reproduce in large number under environmental conditions that are favorable to them (4). Plankton has been used for pollution surveillance by many workers (3, 5). Similarly, changes in the water quality and zooplankton quality are indicators of rate and magnitude of cultural eutrophication (4, 6—9). Hence, studies were made to analyze the impact of physico-chemical characteristics on zooplankton community structure of Block-market pond of Udaynarayanpur block, Howrah both quantitatively and qualitatively assess the water quality.

Methods

Block-market pond is located beside the market of Udaynarayanpur block. This wetland has to receive domestic sewage water, waste materials, materials from unauthorized cow sheds, fecal matters from the unwanted users of some parts of the wetland, sewage waters from shops and market. To study the limnological changes, regular samplings of water were

Table 1. Zooplankton community indices of Block-market pond. H′=Shannon - Wiener index of diversity, d=Margalef's species richness.

Indices	Stations B_1	B_2	B_3	Range
H′	0.613–2.801	0.918–2.041	0.502–1.224	0.613–2.041
d	1.508–1.892	1.904–2.112	1.002–1.482	1.002–2.112

done fortnightly during February 2007—January 2008 from three selected stations as follows : Station B_1—Located at the Western side of the wetland near the commercial cattle shed. Several sewage points are located on this side. Station B_2—Located at the middle of southern side and this station is devoid of sewage points. Station B_3—Located at the eastern side. Most of the major sewage points are located on this side.

Water samples were collected in three replicates from surface, column and bottom of each station and mean values of all observations were taken into consideration. For BOD estimation, water samples were collected separately in dark bottles. A total of 17 limnological parameters of water viz. temperature, transparency, pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand; free carbon dioxide, total alkalinity, conductivity, $CaCO_3$ hardness, total suspended solid, total dissolved solid, chloride, ammonia, nitrite, nitrate and phosphate were determined following standard methods (10—13). Using spectrophotometer SQ 118.

Zooplanktons were collected by filtering 20 liter of water using plankton net of bolting silk No. 40 and preserved in 4% formaldehyde solution. Zooplankton density was estimated by counting them under microscope in Sedgwick rafter cell. Detailed taxonomic identification was carried out following Edmondson (14), Battish (15), Roy (16) and Khan (17).

Diversity index (H′) and species richness (d) were calculated using formula of Shannon and Wiener (18) and Margalef (2) respectively. Pearson's correlation coefficients and stepwise multiple regression analysis were carried out with the help of relevant software program SPSS, version 6.0.

Results

Zooplankton recorded was represented by three groups—Rotifera, Cladocera and Copepoda. Rotifera

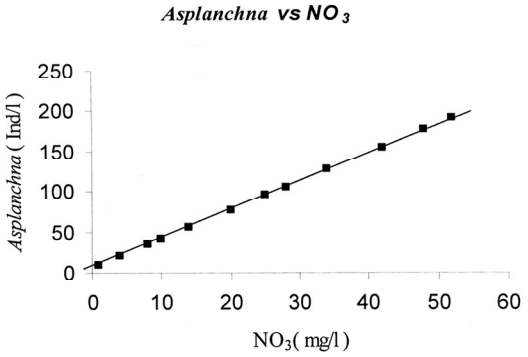

Figure 1. Linear relationship between nitrate (mg/ml) and *Asplanchna* sp. population.

was represented by *Brachionus, Keratella, Lecane, Asplanchna, Polyarthra, Filina;* Cladocera by *Diaphanosoma, Ceriodaphnia, Daphnia, Moina, Bosmina, Acroperus* while Copepoda was represented by two genera i.e., *Heliodiaptomus* and *Mesocyclops.*

The population of total zooplankton showed premonsoon maxima and post-monsoon minima. The population of rotifers showed marked increase during summer which was declined considerably during monsoon months. In general, total rotifer population at B_3 site was higher than other two sites. The density of *Keratella* was higher in sewage sites, i.e. B_1 and B_3. *Polyarthra* population showed marked increase at B_3 site during summer, which declined considerably during rainy season. The cladoceran population was generally higher in B_2 site than $B_1$and B_3. The abundance of copepods was higher at B_3 than at B_1 and B_2. In the present study, Shannon—Wiener diversity index was found to be highest (0.918—2.041) at B_2 site and lowest (0.502—1.224) at B_3. The species richness value was comparatively lower (1.002—1.482) at B_3 site of the pond (Table 1).

Transparency exhibited highest negative correlation (r = –0.4989*) and PO_4 showed highest positive correlation with total zooplankton population (r = 0.7418**) (Table 2). Rotifers showed highest positive correlation (r = 0.7740**) with chloride and highest negative correlation (r = –0.6981**) with transparency. Chloride showed maximum positive correlation (r = 0.6748**) and pH showed negative correlation (r = –0.6958**) with cladoceran population. Total copepod density showed maximum positive r value (r = 0.5342**) with ammonia.

Table 2. Correlation coefficient (*r* value) between physico-chemical characteristics of water and zooplankton abundance (ind/liter) in Block-market pond. * Significant at 5% level, ** Significant at 1% level.

	r values between physico-chemical parameters of water and zooplankton abundance								
	WT	Tr	pH	DO	BOD	COD	FCO_2	TA	Con
ROT		–.6981**			.7470**		.7602**	.5917**	.4599*
Bra	.4051*	–.6363**	–.4909*	–.4490*	.7220**		.7409**	.6453**	.5113*
Ker		–.6235**	–.6108**		.6392**		.6294**	.4185*	
Lec									
Asp	–.4845*	.6361**	.4277*	.5865*	–.4739*	–.4885*	–.7475**	–.6692**	–.6072**
Pol					.4821*				
Fil									
CLA		.6883**	–.6958**		.6744**			.4838*	
Dia		–.6938**	–.6332**		.6872**			.5455**	
Sim							–.6237**	–.5161**	
Cer		–.7629**	–.7139**					.5700**	
Dap									
Moi									
Bos		–.7436**	–.6091**					.5847**	
Acr				–.4587*					
COP			–.4409*	–.6233**	.4862*				
Hel		–.4071*	–.4867*	–.6078**	.5043*				
Mes				–.5820**					
ZOP		–.4989*				.6013**		.5314*	.5792*

Table 2. Continued.

	r values between physico-chemical parameters of water and zooplankton abundance							
	CaHa	TSS	TDS	Cl	Amn	NO_2	NO_3	PO_4
ROT	.6472**	.5183**	.6440**	.7740**				.6329**
Bra	.5748**	.4891*	.7032**	.8252**			–.4740*	.5378**
Ker	.5200**		.4619*	.5725**		–.5241**		.5221**
Lec					.5024*	.4083*		
Asp	–.4179*	–.4161*	–.6867**	–.6514**	–.5375**		.7335**	
Pol	.4594*	.5792**				–.6674**	–.4611*	
Fil								
CLA	.4290*			.6748**				.4457*
Dia	.4928*	.4861*	.5920**	.7527**		–.4866**		.5982**
Sim	–.4686*	–.4889*	–.5063**	–.5870**				
Cer			.5433**					.6693**
Dap								–.4403*
Moi								
Bos	.4770*		.6236**	.8230**		–.4484*		.5837**
Acr					.5742**		–.5521**	
COP					.5342**		–.5420**	
Hel					.5325**		–.5634**	
Mes					.4831*		–.4981	
ZOP			.7132**				–.4814*	.7418**

Highest R^2 value was related to *Polyarthra* (0.9389**) followed by total rotifers (0.9152**) (Table 3). Free CO_2, BOD, NO_3 and ammonia were found to be important factors affecting the total rotifera density and jointly explain 92% variation. R^2 value shown for *Keratella* by Free CO_2, BOD, NO_2, ammonia was 0.7879** which was followed by *Lecane* (0.6637**) and *Asplanchna* (0.6649**).

The pH, COD and cloride bear a relationship with total cladocerans and 78% variation of density can be explained. *Diaphanosoma* was influenced by three independent variables, i.e. pH, COD, Cl (R^2 =

Table 3. Stepwise multiple regression analysis between physico-chemical characteristics of water and abundance (ind/liter) of total and dominant groups and genera of zooplankton in Block-market pond. β_j = Partial regression coefficient, β_0 = Constant, R^2 = Coefficient determination, * : $P < 0.05$, ** : $P < 0.01$.

Zooplankton Parameters	Physico-chemical Parameters	β_j	β_0	R^2
Total	BOD	7.3123**		
Zooplankton	PO_4	21.0435**	83.3212**	0.71587**
	FCO_2	94.5257**		
Total	BOD	29.8567**		
Rotifera	NO_3	–1156.8134**	42.6132**	0.9152**
	Amn	–56.1806**		
Bra	Cl	0.7073**	–40.6628**	0.6809**
	FCO_2	20.9652**		
	BOD	8.0046**		
Ker	NO_2	–249.0792*	–10.0491*	0.7879**
	Amn	–19.371**		
	TDS	–0.0339**		
Lec	Amn	1.9715**	11.0093**	0.6637**
	FCO_2	–1.9402*		
Asp	NO_3	3.5524**	5.9846**	0.6649**
	pH	18.7581**		
	TA	–0.3431*		
	COD	0.1586*		
Pol	Con	0.2297*	69.7683**	0.9389**
	CaHa	–1.2090*		
	NO_3	–224.0917**		
	Amn	–12.0526**		
Total	pH	–170.3850**		
Cladocera	COD	–0.9406**	1502.2100*	0.7756**
	Cl	1.7013**		
	pH	–26.0547**		
Dia	COD	–0.1675**	206.4923**	0.7803**
	Cl	0.4019**		
Sim	FCO_2	–3.9353**	8.2781**	0.5890*
	Amn	1.8802**		
Cer	Tr	–2.3346**		
	COD	–0.1494*	143.5269**	0.6747**
Dap	PO_4	–8.0361*	24.4049**	0.1939*
Acr	Amn	0.8218**	–1.7856*	0.3297**
Total Copepoda	DO	–85.0739**	825.2446**	0.3885**
	pH	–34.1488**		
Hel	DO	–7.5009**	413.9455**	0.6057**
	CaHa	–0.3429*		
	pH	–99.7536**		
Mes	DO	–31.3972**	1197.6282**	0.6896**
	TDS	–0.4129**		

0.7803**). Abundance of *Simocephalus* was controlled simultaneously by two physico-chemical parameters and explained 59% variability and transparency and COD jointly explained 67% variation of *Ceriodaphnia* abundance.

Heliodiaptomus abundance was controlled simultaneously by three physico-chemical parameters, i.e. pH, DO, CaHa and explained 61% variability whereas *Mesocyclops* were influenced by pH, DO, TDS (R^2 = 0.6896**). Linear regression relationship between *Brachionus* and chloride was

$$Y = -40.663 + 0.707\ X\ (P < 0.01)$$

Where Y = Population of *Brachionus* (Ind/liter), X = Concentration of chloride (mg/liter)

The regression equation between *Asplanchna* population and NO_3 (Fig. 1) was

$$Y = 5.985 + 3.552\ X\ (P < 0.01)$$

Where Y = Population of *Asplanchna* (Ind/liter), X = Concentration of NO_3 (mg/liter).

Discussion

The zooplankton community was mainly comprised three groups, viz. Rotifera, Cladocera and Copepoda. The density of zooplankton fluctuated widely and was related to the nature of wetlands and stations (19). In the present study highest density was recorded in the site with high organic load (B_3 site). In the zooplankton community of an ecosystem, the main role is played by only a few commonly occurring species (20—22). Anderson (20) found that a few numerically abundant species contributed 27% of the communities in 340 lakes and ponds of Canada. Yousuf and Quadri (23) found that 35.5% of total community was contributed by only four species in some freshwater lakes and ponds of Kashmir, India. During the present study, only four genera controlled the bulk of zooplankton density.

Rotifera showed a numerical superiority over the other groups of zooplankton and George (24) indicated the eutrophic nature of Udaynarayanpur block-market. The present observations point to the occurrence of a summer periodicity in rotifers. Moreover, the reproductive rate of rotifers is related strongly to the quality of food and temperature (25, 26). In the present study *Brachionus* population was significantly correlated ($P < 0.05$) with temperature. Billings Reservoir - Sau Paulo, South America showed an environment in advanced stage of eutrophication (27, 28). It showed high contents of nutrients and low transparency values (19, 29) where within the zooplankton composition, rotifers were more significant than copepods and cladocerans. Similar results were also observed in the present study.

Diversity indices are used to measure the stress in the environment. Trivedi (12) has emphasized the importance of species diversity in assessing the water quality and reported that polluted water supports low organism diversity while the clean water supports high diversity. Highly enriched condition obviously limited the species diversity at almost all groups of zooplankton (26, 30). In the present study Udaynarayanpur Block-market pond is enriched with organic matter ($B_2 < B_1 < B_3$). The species diversity index value is lower in B_1 and B_3 sites than B_2. After application of the relationship put forward by Wilham and Dorris (31) between the diversity values and pollutional status it can be concluded that B_1 and B_3 sites are more polluted than B_2 site. Larger the species richness index value denotes a more healthy body of water (32). The species richness value of zooplankton population is lower in Block-market pond and comparatively higher value was observed in B_2 site than B_1 and B_3 sites.

Weimin and Xiaoming (33) showed positive correlation between zooplankton abundance and phosphate in Chenghu lake, China. According to Evans (34), the concentration of phosphate decides the abundance of zooplankton. Moitra and Bhattacharya (35), Wynne and Gophen (36), Banik et al. (37) and Padmanabha and Belagali (38) showed the positive regression between phosphate and zooplankton abundance. Total zooplankton abundance was positively correlated ($P < 0.01$) with phosphate contained in the present study.

Arora (39) has emphasized the role of rotifers in assessing the water quality and stated the presence of *Keratella tropica, Filinia longiseta, Polyarthra vulgaris* and *Brachionus angularis* as indicators of pollution. Increment of population density of several zooplankton organisms (i.e. *Keratella tropica, Polyarthra vulgaris*) indicated the rise of pollutional stress on Block-market pond. Low value of species richness and diversity indices revealed the poor status of Block-market pond (i.e. with high organic load).

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