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PLANKTONIC DIVERSITIES AND DENSITIES WITH RESPECT TO ITS RELATIONSHIPS TO THE NUTRIENTS IN RIVER GADHI AND DEHARANG RESERVOIR

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ABSTRACT:

The decrease of biodiversity related to the global climate change is stimulating the scientific community towards a better understanding of the relationships between biodiversity and ecosystem functioning. In ecosystems where marked biodiversity changes occur at seasonal time scales, it is easier to relate them with ecosystem functioning. The objective of this work is to analyse the relationship between phytoplankton diversity, zooplankton diversity and various nutrients. During the study period the correlations among Shanon diversity (H1) of phytoplankton and zooplankton, densities of Zooplankton and Phytoplankton as well as nutrients (Phosphates, Nitrates and Silicates), at various sites on River Gadhi and Deharang Reservoir were studied. There was no significant correlation between diversity and various nutrients. The relation between phytoplankton diversity and density also was found to be negative. The negative correlation also existed between zooplankton densities and phytoplankton densities at various sites. Negative correlation between nutrients and phytoplankton as well as zooplankton diversity was usually noted except few months. The correlation between diversity of zooplankton and phytoplankton was also found to be negative most of the time. However, the correlation was never found to be very strong except very few exceptions.

KEY WORD: Correlation, Shanon Diversity Index, Nutrients.

INTRODUCTION:

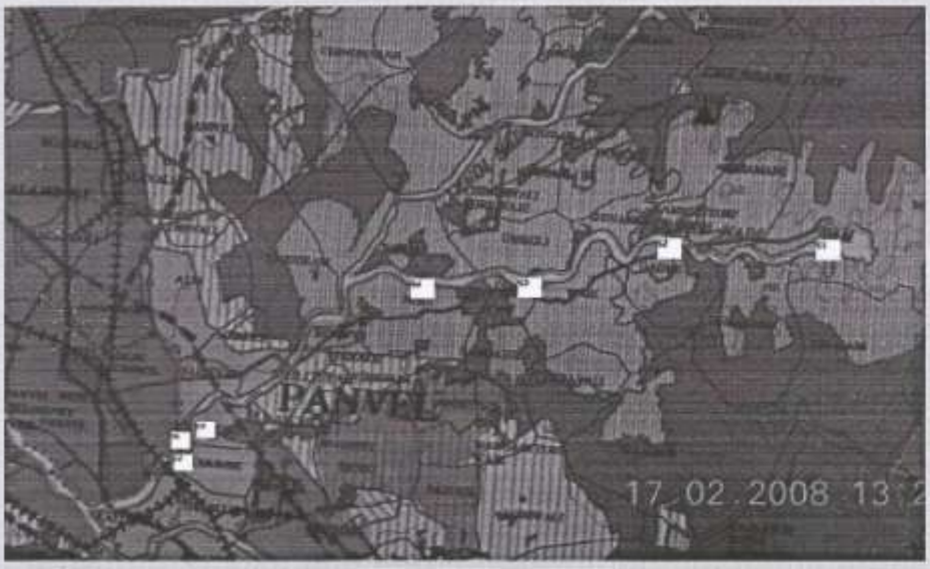
Biodiversity (hereafter referred as diversity) is a measure of community structure, whether it is expressed merely as species richness or with a specific index. Less diverse community resources may be more easily monopolized by bloom forming species and that phytoplankton – zooplankton interactions are less stable, possibly hampering trophic transfer (Ptacnik et al. 2008). Species diversity is a key concept in ecology, yet the mechanisms regulating diversity in most systems are not completely understood. To address this issue, we analyzed the relationship between phytoplankton and zooplankton diversity and limiting resources (N, P, Si). Also the relationships among nutrients as well as densities and diversities of phytoplankton and zooplankton were also studied. Hutchinson (1961) noted that species richness and diversity of phytoplankton communities are often greater than the number of measured limiting resources even when conditions are apparently close to equilibrium. This paradox has been evaluated both theoretically and experimentally (Reynolds 1984, Grover 1990, Sommer 1993, 1995, Siegal 1998). It has been pointed out since the early days that increase in nutrient supply bring about a simultaneous increase in diversity (Yourt, 1956; Margalef, 1961). Although it was supported that increases in nutrient concentrations were inducing an increase in diversity (Margalef, 1961), the possible mechanisms were not well understood and the information on the relation between nutrients and diversity index values was rather scanty. Efforts have been reported in literature to select indices for eutrophication assessment (Hooper, 1969; Karydis and Tsirtsis, 1996; Tsirtsis and Karydis, 1998). The need for using diversity indicators to evaluate ecosystem disturbance has been proposed since sixties (Wilhm and Dorris, 1968). This is because chemical substances with adverse effects on the biotic elements of the ecosystem can be numerous and if interactions (positive or negative) are to be taken into account, the impact assessment is both complicated and dubious.

The main objective of this study is to find out the relation between phytoplankton diversity, zooplankton diversity and the nutrients (N, Si, P). Also the relation between phytoplankton density and diversity, zooplankton density and diversity as well as phytoplankton density and zooplankton density and phytoplankton diversity and zooplankton diversity were studied for a Gadhi river and Deharang Reservoir.

The present study was carried out on Deharang Reservoir and Gadhi River which runs outskirts of Panvel town (longitude 18°58' N and latitude 73° 12' E). It has a stretch of 16 km and during its course it runs through many villages and Panvel town receiving anthropogenic load.

Topographically, the climate is not very hot and is typically coastal sultry type. The temperature ranges between 30.3°C -22.6°C. It receives average rainfall of 2177 mm. There are virtually two distinct periods, rainy and dry period. Dry period comprises winter and summer (www.maharashtra.gov.in).

During the present study, seven sites (Fig. 1) were selected on the Reservoir and the River. The river starts from a reservoir, which is located at the bottom of mountain hills. The reservoir collects water from natural springs and the water runoff that flows down the mountains during the rainy season. This was referred as S1 in the present study. The site S2 is just 2 km downstream to the reservoir and has no much human hindrance. Site S3 is 5 km downward to the reservoir. It has comparatively more anthropogenic activities than earlier sites. As we move the downstream, sites S4, S5, S6, S7 are located at the distance of one or two km from the earlier sites and every site receives sewage except S7 which receives cremation ash.



MATERIALS AND METHODS:

Nutrients analysis

For study of nutrients, surface water samples from different sites, at the bank of the river were collected. The samples could not be taken from the middle as there was no facility to reach the centre of the river. Two to three samples were collected from each site and the data was pooled together.

The samples were collected monthly, in early morning hours, in clean plastic carboy of 2 litres capacity. Water analysis was performed as per the methods prescribed in Standard Methods (APHA,1990) by using following methods.

Silicates	Molybdosilicate Method
Nitrates	Phenoldisulphonic Acid Method
Phosphates	Stannous Chloride Method

Phytoplankton

Using a wide mouth container, 500 ml of surface water sample was collected from different spots at every site from near the boundaries of the river and the reservoir. The samples from every station were preserved in separate container for phytoplankton. For immediate fixation, Lugol's Iodine solution made in formalin was used in the field and later 4% formaldehyde was used for long term preservation.

The phytoplanktons were concentrated by allowing them to settle for about 15 to 20 days and then the upper water was decanted by using a rubber tube. The phytoplanktons were identified by using standard identification keys (Fritsch, 1979; Sarode and Kamat, 1984; Bellinger, 1992).

For quantitative estimation, the counting was done by using Lackey's Drop method (APHA 1985). Density of phytoplankton (units/lit.) was calculated using following formula.

$$\text{Phytoplankton units/lit} = \frac{R \times At \times 10^3}{As \times S \times V} \times \frac{1}{C}$$

Where,

R = Number of organisms counted per subsample

At = Area of coverslip, mm2

As = Area of one strip, mm2

S = Number of strips counted, and

V = Volume of sample under the coverslip, ml

C = Concentration factor

$$\text{Concentration Factor (C)} = \frac{\text{Total Volume of Water concentrated}}{\text{Final volume made after concentration}}$$

Zooplankton

The sample collection, for the quantitative study of zooplankton was done by using a wide mouth container. 40 ltrs of water was collected from different spots from every site from the boundaries of the bank of the river and reservoir was filtered using net of mesh size 45 µm. The filtered samples were preserved separately for each site with 4% Lugol's Iodine made in formalin in a separate container.

Identification of zooplankton was done with the help of standard keys (Ward and Whipple, 1958; Battish, 1992; Pennak, 1995; and Dhanapathi, 2000).

The density count of zooplankton was done by observing subsamples under compound microscope and the number was calculated in units per liter by using following formula.

$$\text{Zooplankton per liter} = \frac{\text{No. of zooplankton/ml} \times \text{Dilution factor} \times \text{Volume of the concentrate (ml)} \times 1000}{\text{Total volume of water filtered}}$$

Shannon's index (H)

This index is calculated as,

$$H' = -\sum (pi \times \ln pi) \text{ (Shannon, 1949)}$$

Where,

Pi = ni/N

ni = total number of individuals of a species

N = total number of individual of all species.

RESULTS:

From the above study, at different sites different correlations among various parameters were recorded.

At site S1, silicates and nitrates showed significant ($r^2 = 0.5$) positive correlation. Phytoplankton density showed strong positive correlation between phosphates and silicates ($r^2 = 0.5$ and 0.6 respectively). Nutrients did not show any significant correlation with phytoplankton as well zooplankton diversity. Phytoplankton diversity and zooplankton density were positively correlated but the correlation was not much significant. Densities of phytoplankton and zooplankton were found to be independent of each other as Pearson's correlation value was very insignificant ($r^2 = -0.05$).

Sites S2, silicates and phytoplankton density showed strong positive correlation ($r^2 = 0.7$). Phytoplankton density and diversity were also found to be positively correlated ($r^2 = 0.5$). All nutrients were very insignificantly correlated with each other. The densities of zooplankton and phytoplankton were very insignificantly correlated ($r^2 = -0.06$). There was little positive relation between zooplankton density and diversity ($r^2 = 0.3$)

At site S3, no significant correlation was noted among the parameters. All nutrients were in weakly correlated with each other. Phosphates and nitrates showed negative correlation with phytoplankton diversity ($r^2 = -0.4$). Silicates showed positive correlation with phytoplankton densities and zooplankton densities ($r^2 = 0.4$ and 0.3 respectively). Diversities of phytoplankton and zooplankton were negatively correlated with silicates ($r^2 = -0.3$ and 0.4 respectively). Phytoplankton diversity and zooplankton diversity were in positive correlation with each other ($r^2 = 0.4$). Densities of phytoplankton and zooplankton were very insignificantly correlated.

At site S4, silicate showed strong positive correlation with phosphate ($r^2 = 0.5$), phytoplankton density ($r^2 = 0.7$) and zooplankton density ($r^2 = 0.7$). Phytoplankton and zooplankton densities showed very strong correlation ($r^2 = 0.8$) at this site. The diversities of phytoplankton and zooplankton were not much significantly correlated with any of nutrients as well as their densities. However, weak negative correlation existed between nitrates and diversities of phytoplankton and zooplankton ($r^2 = 0.3$ and 0.2). Silicates and densities of phyto and zooplankton also showed positive correlation ($r^2 = 0.2$ and 0.4).

At site S5 zooplankton diversity showed significant relation with silicates ($r^2 = -0.5$) and nitrates ($r^2 = -0.5$) and phytoplankton diversity and zooplankton density ($r^2 = -0.5$). Nutrients had no significant correlation with each other. Phytoplankton diversity was negatively correlated with silicates ($r^2 = -0.4$), whereas zooplankton density showed positive correlation with silicates ($r^2 = 0.5$) and phosphates ($r^2 = 0.4$). Phytoplankton diversities and zooplankton diversities were also in positive relation with each other though the values were not much significant ($r^2 = 0.4$), but the densities of phytoplankton and zooplankton were not related with each other.

Site S6 showed positive correlation between nitrate and silicate (r^2 =0.4). Phytoplankton density and zooplankton diversity were also in positive correlation (r^2 =0.4). Zooplankton density showed positive correlation with diversity of phytoplankton (r^2 =0.4) and zooplankton (r^2 =0.4). Silicate and phosphate did not show any significant correlation with densities and diversities of zooplankton and phytoplankton. However phosphate and zooplankton diversity were in negative correlation with each other upto some extent (r2 =- 0.4).

Correlation Coefficient of Various Parameters at S1							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.124	1					
Silicates	0.506	0.117	1				
Diversity (Phytoplankton)	-0.034	0.027	-0.001	1			
Diversity (Zooplankton)	0.266	0.169	0.090	0.091	1		
Density (Phytoplankton)	0.344	0.457	0.668	-0.223	0.073	1	
Density (Zooplankton)	-0.067	-0.224	-0.114	0.317	-0.094	-0.051	1

Correlation Coefficient of Various Parameters at S2							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.124	1					
Silicates	0.506	0.117	1				
Diversity (Phytoplankton)	-0.034	0.027	-0.001	1			
Diversity (Zooplankton)	0.266	0.169	0.090	0.091	1		
Density (Phytoplankton)	0.344	0.457	0.668	-0.223	0.073	1	
Density (Zooplankton)	-0.067	-0.224	-0.114	0.317	-0.094	-0.051	1

Correlation Coefficient of Various Parameters at S3							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.222	1					
Silicates	0.204	0.041	1				
Diversity (Phytoplankton)	-0.373	-0.351	-0.272	1			
Diversity (Zooplankton)	-0.296	0.165	-0.393	0.437	1		
Density (Phytoplankton)	-0.259	-0.003	0.394	-0.027	1	1	
Density (Zooplankton)	-0.052	-0.001	0.329	-0.243	-0.361	0.014	1

Correlation Coefficient of Various Parameters at S4							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.008	1					
Silicates	0.121	0.527	1				
Diversity (Phytoplankton)	-0.330	0.096	-0.104	1			
Diversity (Zooplankton)	-0.235	0.081	0.070	0.111	1		
Density (Phytoplankton)	-0.145	0.732	0.219	-0.077	0.134	1	
Density (Zooplankton)	-0.169	0.703	0.361	0.119	0.038	0.843	1

Correlation Coefficient of Various Parameters at S5							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	0.086	1					
Silicates	0.284	-0.066	1				
Diversity (Phytoplankton)	-0.057	0.055	-0.420	1			
Diversity (Zooplankton)	-0.496	-0.165	-0.495	0.372	1		
Density (Phytoplankton)	-0.063	0.167	-0.126	-0.276	-0.231	1	
Density (Zooplankton)	0.128	0.397	0.473	-0.516	0.210	-0.030	1

Correlation Coefficient of Various Parameters at S6							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.217	1					
Silicates	0.419	-0.218	1				
Diversity (Phytoplankton)	-0.097	0.152	-0.164	1	1		
Diversity (Zooplankton)	-0.131	-0.372	0.111	-0.233	1		
Density (Phytoplankton)	0.095	-0.092	-0.145	0.173	0.414	1	
Density (Zooplankton)	0.149	-0.129	-0.080	0.356	0.372	0.189	1

Correlation Coefficient of Various Parameters at S7							
	Nitrate	Phosphate	Silicates	Diversity (phyto plankton)	Diversity (Zoo plankton)	Density (Phyto plankton)	Density (Zoo plankton)
Nitrate	1						
Phosphate	-0.135	1					
Silicates	0.335	0.304	1				
Diversity (Phytoplankton)	-0.165	0.355	0.083	1			
Diversity (Zooplankton)	-0.017	-0.216	-0.241	0.270	1		
Density (Phytoplankton)	0.115	0.183	0.163	0.349	0.345	1	
Density (Zooplankton)	0.340	-0.236	0.291	0.047	0.094	0.202	1

No strong correlation was observed among any parameters at site S7. However, nitrate and phosphate showed weak positive correlation (r^2 =0.3) with silicate. Phytoplankton diversity and phosphate also showed positive correlation (r^2 =0.4) upto certain extent. Phytoplankton density showed weak positive correlation with zooplankton and phytoplankton diversity (r^2 =0.3).

DISCUSSION:

Ecosystem functioning depends on multiple interactions between physical, chemical and biological determinants. Indeed, ecosystem processes (productivity and nutrient recycling) result directly from the diversity of functional traits in the biotic communities, which is in turn determined by the species composition and diversity. This species diversity results from both biotic introductions and environmental pressures. As a result, changes in biodiversity in response to environmental selection pressures tend to have a direct impact on ecosystem processes.

During the study, we observed different responses in species diversity and density to the various nutrients. The responses also varied from site to site. No particular pattern was found to be continuous. Among the nutrients, nitrate is one of the essential factors for the growth of algae, which showed usually negative correlation except at site 6 and 7. At site S6 and S7, the correlation was slightly positive. The negative correlation indicates that the amount of nitrate decreased with increasing growth of algae. It may be possible that increasing density of algae would have used the nitrates in water (Munawar 1970). However, phosphates, though as essential element for phytoplankton growth showed positive correlation at almost all sites except S3 and S6. Surprisingly, these two sites had more phosphorus input in the form of detergent, as at S3, clothe washing is routine activity whereas S6 receives sewage. It may indicate that phytoplankton require phosphate as nutrient in very less concentration. When the concentration of these nutrients is optimum, they show positive correlation; however, as the concentration goes high, the densities of phytoplankton do not grow in accordance. Rather, their number remains within carrying capacities of the given system and the relation between density and phosphate concentration appears negative. In case of silicates, the positive correlation was strongly seen at upstream sites, however as the river approached town, the correlation was found to be decreasing.

Phytoplankton diversity did not show any correlation with nutrients at upstream. However, nutrient rich sites showed positive correlation between phytoplankton diversity and nutrients. This may indicate that very high concentration of nutrients may lead to the growth of even such algae which could not grow when the concentration of nutrients was low. This also could be due to lack of competition for nutrition.

Phytoplankton diversity and zooplankton diversity as well as density did not have any significant correlation at any site throughout the study period. It might indicate that zooplankton are not much selective in their feeding habits.

Phytoplankton diversity and density are also found to be independent of each other.

Phytoplankton density and zooplankton diversity are also independent factors suggesting that variation in number of species of zooplankton does not depend on the biomass of available food. However, optimum density of phytoplankton should be available to feed the present zooplankton population. The dependence of the densities of the zooplankton and phytoplankton are difficult to predict in open water as they are subject to be eaten by other aquatic organisms like fishes.

CONCLUSION:

In conclusion, it might be outlined that the diversity indices like Shannon Index, that are used to indicate the eutrophication cannot be applied to the water bodies like Gadhi River and Deharang Reservoir which are subjected to various anthropological activities and varied pollution stress. Very high concentration of nutrients does not indicate significant correlation with phytoplankton as well as zooplankton.

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