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An assessment of plankton diversity and climate change relationship in physico-chemical environment of Son River in Bhojpur area of Bihar, India

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Abstract

This paper deals with study of physico-chemical climatic changes in the river water of Son along the Bhojpur stretch during a period of 18 months from March 2014 to August 2015. It also deals with interrelationship between the changes in climatic factors with plankton diversity in the river. Thermometric factors have been found to be most remarkable showing inverse relationship with plankton diversity upto a limit. Low dissolved oxygen has been related with high plankton production especially cyanophyceae and copepods. Dominance of cyanophyceae and copepods, low dissolved oxygen, high COD and high phosphate contents indicate river being under stress and organic pollution. Different community diversity parameters like Species Diversity Index (H'), Richness Index (S), Evenness Index (J) and Dominance Index (D) also report the fact that the river is under stress and Zooplankton being found more responsive to physicochemical climate changes than Phytoplankton in the river.

Keywords: Plankton diversity, bio indicator, biotic indices, interrelationship, physico-chemical environment.

Introduction

Biotic component of any aquatic ecosystem specially some plankton species acts as an indicator to determine the productivity potential and health of the system. Phytoplankton and zooplankton play the role of basic support system of aquatic biota in the river and are highly sensitive to the changes in physico-chemical factors of river water. The present study is an effort to establish interrelationship between them by studying various community diversity parameters like Shannon Diversity, Species Richness, Evenness and Dominance. Decline in water quality and bio- diversity is an issue of grave concern for all of us. River Sone flows in Indo-Gangetic plain along the stretch of Bhojpur area in Bihar. The data for the physico – chemical nature of water is collected at five research stations along the river for a stretch of about 105 kms. These data along with plankton assessment data are subjected to PCA (Principal Component Analysis) to understand the inter relationship between physico–chemical climatic factors with plankton diversity.

Materials and methods

Study area is located at five sampling stations along the stretch of river Sone in Bhojpur area. River Sone is a tributary of river Ganga and meets it at Maner, about 15 kms east from 1st sampling station Bahiara (S_1). The other four sampling stations are koelwar (S_2), Babura (S_3), Sandesh (S_4) and Sahar (S_5) (Figure-1).

Sampling were done at an interval of two months from March' 14 to August'15, strictly according to field protocol of CPCB New Delhi. The Bimonthly physico–chemical analysis of water was done by methods of APHA[1]. For DO_2 assessment, wrinkler's method is used, for temperature changes Thermometric method is used and for total Phosphate and nitrate assessment, Spectro photometiric method is used. For plankton assessment sampling was done by hauling of water by plankton net (0.001 mm mesh size). The sample water was mixed with 1.5 ml Lucas reagent and kept in 100 ml in a beaker. Then it is poured on Sedgewick rafter cell. Identification were made by using keys by Michael and Sharma[2], Smirnov[3], Sharma[4]. Number of plankton (phytoplankton and Zooplankton) in the S-R Cells were derived from the following formula APHA[1].

$$No\ of\ species/\text{lit} = \frac{C \times 1000\ mm^2}{L \times D \times W \times S}$$

Where, C = No. of organisms counted, L= Length of each stripe (mm), D = Depth of each stripe (mm), W = Width of each stripe (mm), S = No. of stripes.

Data generated is then subjected to quantitative analysis of community parameters such as Species Diversity Index (H)', Richness Index (S), Evenness Index (J) and Dominance Index (D). Finally, Principal Component Analysis was done to understand the interrelationship between physico-chemical climatic factors with plankton diversity.

Results and discussion

Physico-chemical analysis of Son River water at five research stations from March'14 to August'15 resulted nine sets of data. Mean physico-chemical parameter of Son water at all five

sampling stations has been presented in the form of Table-1. The entire figure at all these five stations shows a marked fluctuation in the water quality showing deterioration at all these five research sites along the river. The physico-chemical climate of river water during this period too shows some significant changes i.e. parameter readings of May'14 matches with readings in March'15. This also affects the plankton diversity indices at that particular month setting an alarm of climate change in the physico–chemical environment of the river water[5].

Regarding the plankton assessment, three zooplankton groups have been identified-Protozoa, Rotifera and Copepoda. Copepoda dominated the zooplankton abundance with 92.52% (Figure-1 and 2). Copepods are represented by about 12 species and their abundance was maximum (1944 cell counts) in S_2 and minimum (678 cell counts) in S_5 [6]. That spatial variation of zooplankton abundance might be due to varied salinity and nutrients[7]. About nine protozoa species have been reported among which S_5 recorded highest number of species (7 species). 12 species of Rotifera dominated by branchionus angularis (71 cell counts, 20.76%) were recorded (Table-2). The Zooplankton groups were mainly represented by Filinia, Keratela, Cyclops, Mesocyclops, Ceriodaphnia, Moina, Daphnia and Alona[8,9].

Table-1: Mean Physico–Chemical parameters of five sampling stations of River son from March 2014 – August 2015.

Parameters	S_1	S_2	S_3	S_4	S_5
Air Temp (C)	28.2	29.7	30.1	27.5	29.3
Water Temp (C)	28.8	30.1	31.4	29.2	29.3
PH	7.6	7.5	7.9	7.3	6.3
Salinity (PPT)	8.1	3.4	1.9	0.93	086
Conductivity (ms/cm)	248.00	237.63	338.61	224.20	259.49
Alkalinity (mg/l)	82.13	68.25	71.46	74.17	90.42
Hardenss (mg/l)	483.41	529.10	251.25	213.37	179.04
DO_2 (mg/l)	3.43	3.56	3.29	2.00	1.64
Free CO_2 (mg/l)	15.30	18.01	18.37	24.48	39.45
Nitrate as N (mg/l)	0.20	0.21	0.19	0.18	0.21
N as Ammonia (mg/l)	0.30	0.26	0.22	0.27	0.22
Phosphate (mg/l)	1.43	1.69	2.01	1.81	2.34
Sulphate (mg/l)	18.94	10.97	9.85	8.83	6.93

Table-2: Zooplankton abundance in son River (March 2014 to August 2015).

Zooplankton taxa	Zooplankton Abundance (Cell Counts)	Percentage Abundance (%)	Number of Species	Station	Zooplankton Abundance (Cell Counts)
Protozoa	99	1.68	9	1	1383
				2	1944
Rotifera	342	5.80	12	3	1058
				4	834
Copepoda	5456	92.52	12	5	678
Total	5897	100	32	5	5897

These data is then used to calculate different diversity indices Shannon diversity, Richness, Evenness and Dominance (Table-3 and Figure-2). These indices reveals that zooplankton population fluctuates according to the changes in physico–chemical environment of the river water. Highest no. and productivity was reported in September'14 and lowest during December'14 in the study area, during these 18 months of study. The reason might be due to heavy rain as evidenced by some workers like Sadguru et.al.[10] and Dhanapathi[11]. An inverse relation exists between thermometric changes and planktonic population. Free CO_2 concentration effects it in terms of phytoplankton uses them in photosynthesis. Hence free CO_2 effects phyto and zooplankton in different ways[12]. pH upto 7.9 has been found to support zooplankton population but no distinct relationship could be established between pH and Zooplankton diversity[13]. But Salinity effects the diversity inversely. Phosphate reading has direct relation with phytoplankton diversity, but no distinct relation with zooplankton diversity. Low DO_2 was found to be related with high plankton production specially zooplankton.

Regarding phytoplankton diversity, here also three groups have been identified- Chlorophyceae, Bacillariophyceae and Myxophyceae or Cyanophyceae. The greatest cell count is at S_1 (1503 cell count), then on S_3 (1277 cell count) for Cyanophyceae. The lowest Cyanophyceae count is reported at S_2 (678 cell count). This might be due to continuous raising of sand from S_2 station (Koelwar), from the river. (Table-3) Dominant Phytoplankton genera reported were Spirogyra, -Ulothrix, Tabillaria, Nabicula, Nitzchia and Microcystis, indicating organic pollution of the river. Diatom population of river is identified with Navicula and Nitzchia mainly. High concentration of these at S_2 and S_5 indicate more polluted zone of river. Better abundance of Chlorophyceae at S_1, S_3 and S_4 indicate comparatively better physico-chemical condition. Low DO_2, high turbidity, better organic load and high chemical oxygen demand (COD) at S_2 and S_5 restrict the abundance of Chlorophyceae[14].

PCA (Principal Component Analysis) of community diversity parameters show that Mean Species Richness index of zooplankton ranged from 0.721 to 1.142 while Mean Dominance Index shows a variation from 0.386 to 0.198. This indicates that phyto and zooplankton were dominated by each other in different months of a year. Their diversity dominated each other in different seasons during this study period (Table-4 and 5). These community indices reveal that zooplankton population is influenced directly by changes in physico-chemical environment of the river water. Highest diversity index has been reported in September'14 and lowest during December'14 in these study stations during the study period of 18 months. The reason might be due to heavy rain as evidenced by Sadguru et.al.[10].

Table-3: Zooplankton Species Diversity Indices in the five study stations of Son river from March'14 to August'15.

Taxa	Species Diversity Index	Study Station				
		S_1	S_2	S_3	S_4	S_5
Protozoa	S	1.872	1.243	1.017	1.214	1.643
	H'	1.981	1.752	1.523	1.612	1.821
	J	0.953	0.972	0.721	1.142	0.871
	D	0.136	0.173	0.194	0.125	0.189
Rotifer	S	2.153	2.224	3.007	1.617	1.527
	H'	2.267	2.255	2.284	1.883	1.492
	J	0.942	0.913	0.921	0.973	0.932
	D	0.113	0.124	0.101	0.143	0.192
Copepoda	S	0.845	1.212	1.593	1.501	1.692
	H'	1.845	2.171	2.431	2.332	2.151
	J	0.956	0.945	0.980	0.972	0.861
	D	0.198	0.438	0.992	0.101	0.386

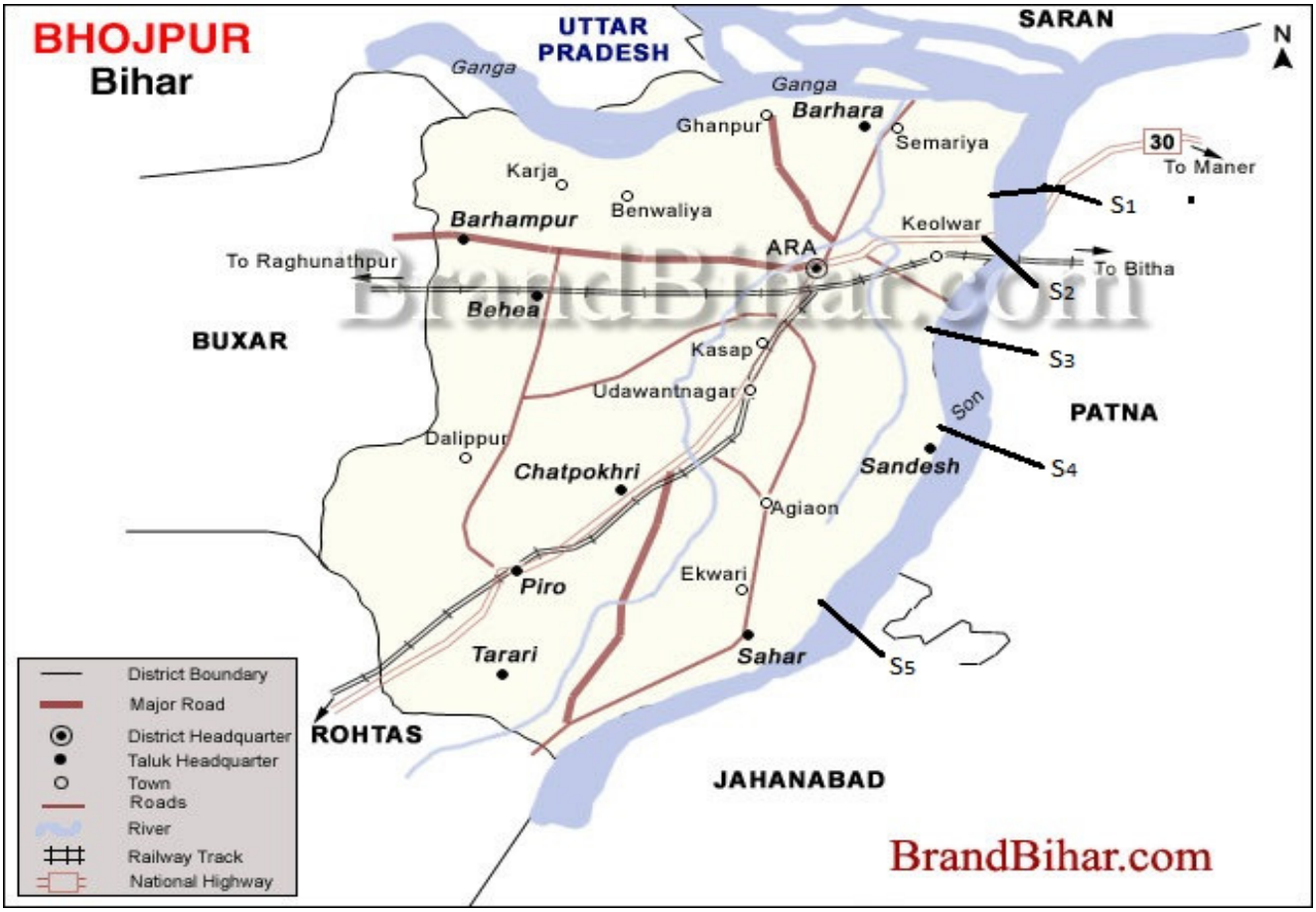

Figure-1: Location of five Research Stations in the river stretch of Son in Bhojpur Area (S_1 to S_5).

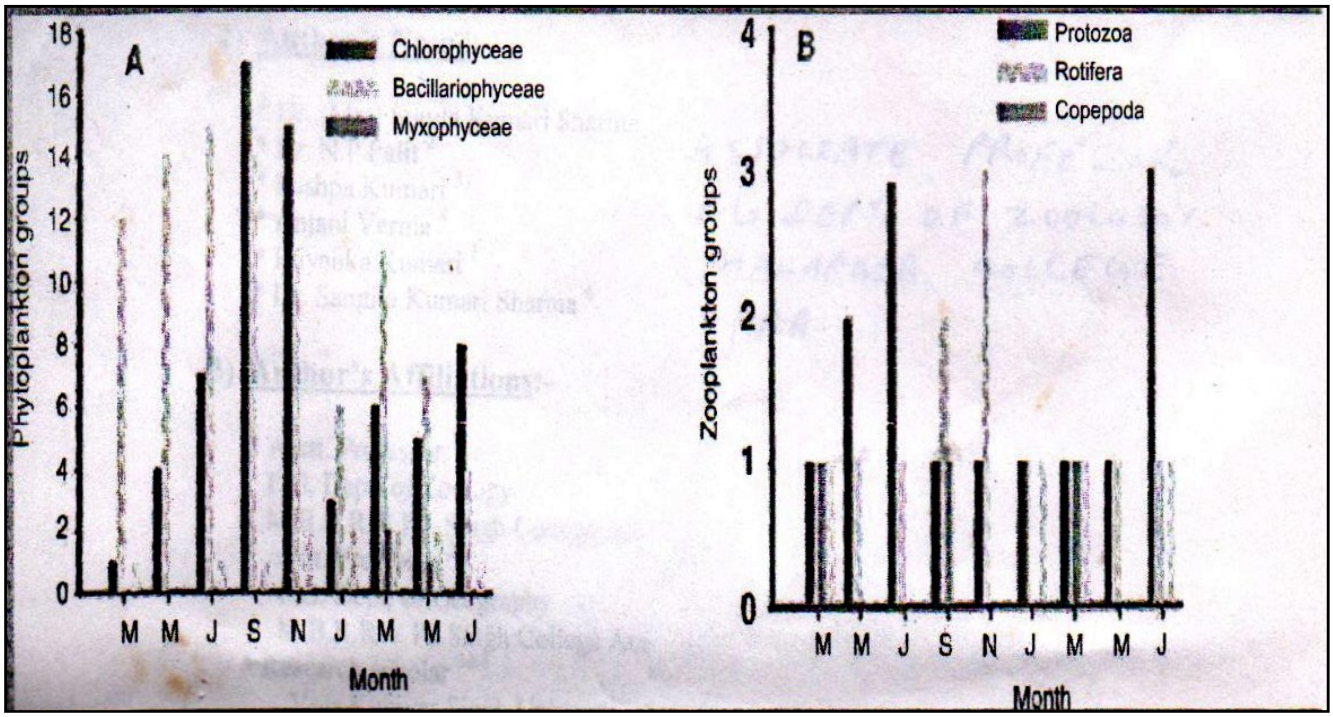

Figure-2: Abundance of Phytoplankton and Zooplankton in the river Son in Bhojpur Area in Bihar (from March'14 to August'15).

Table-4: Phytoplankton abundance in Son River during March'14 to August'15.

Phytoplankton taxa	Phytoplankton abundance (cell counts)	Percentage abundance	Number of Species	Station	Phytoplankton Abundance (cell counts)
Chlorophyceae	86	5.53	6	S1	1503
Becillariophyceae	298	11.35	8	S2	678
Cyanophyceae	4846	83.12	11	S3	1227
	5230	100.00	25	S4	988
				S5	834
				Total	5230

Table-5: Phytoplankton Species Diversity Indices in the five study stations of Son river from March'14 to August'15.

Taxa	Species Diversity Index	Study Station				
		S_1	S_2	S_3	S_4	S_5
Chlorophyceae	S	1.885	2.024	2.421	1.528	1.779
	H'	0.926	0.787	1.452	0.845	1.957
	J	1.541	0.924	0.962	1.086	0.978
	D	1.110	0.198	0.428	0.907	0.849
Bacillariophyceae	S	1.767	2.345	1.874	1.248	1.767
	H'	0.909	0.198	0.305	0.465	0.849
	J	1.212	0.934	0.874	1.622	1.007
	D	0.948	0.824	0.409	0.664	0.811
Copepoda	S	2.345	1.876	2.024	1.528	1.326
	H'	0.110	0.198	0.428	0.465	0.909
	J	1.541	1.189	0.924	0.765	0.962
	D	1.959	1.543	1.421	0.845	0.787

The higher diversity indices indicate high plankton collection at S_1, S_3 and S_5 sites while lower one at S_2 and S_5 indicate low DO_2 consumption hence lower plankton collection[15]. Dominance indices of zooplankton indicate dominance of Copepods particularly Brachionus species which has been found to be influenced by pH, DO_2, temperature, nutrient composition and high level of phosphate. The Phytoplankton indices show dominance of Cyanophyceae not by chlorophyceae at all these five study stations. This indicate river water under domestic Sewage pollution stress[14]. Low DO_2 and high COD at all these research station confirms the dominance of Cyanophyceae and high organic matter content in the river[16]. An inverse relation exists between thermometric changes and plankton population. Free CO_2 concentration effects it in terms of pytoplanktons uses them in photosynthesis hence it effects the Zoo and phytoplankton community differently. Salinity effect community diversity indices inversely while phosphate reading has direct relation with phytoplankton abundance. But it has no straight effect on Zooplankton diversity[17]. Low DO_2 has been found to be related with high plankton production specially zooplankton.

Conclusion

Regarding Plankton diversity assessment, zooplankton abundance is marked by three zooplankton groups-Protozoa, Rotifera and Copepoda. Copepods dominated the-zooplankton abundance with 92.52% indicating organic pollution in the river. They were mainly represented by Filinia, Keretela, Cyclops, Mesocyclops, Ceriodaphnia, Moina, Daphnia and Alona. Station S_2 and S_3 recorded maximum number of species (12) and S_5 reported minimum no. of species (5). Acanthocylops bicuskidatons (980 cell counts, 17.98%) was the most dominant one. The phytoplankton community is represented by Bacillariophyceae and Myxophyceae or Cyanophyceae. Dominant genera were Spirogyra, Ulothrix, Tabillaria, Nabicula and Microcystis.

The greater no. of microcystys indicates algal growth and pollution in the river. The abundance of phytoplankton was found dependent upon temperature turbidity and nutrients. This effect was also reported by Sukumaran and Das[18]. Zooplankton abundance reported gradual increase in winter reaching maximum in summer. This finding is in similar pattern reported by Pathani and Upadhyay[19] except for a slight decline in the month of December.

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