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ANNUAL DYNAMICS OF DIATOMS IN SHIVNA RIVER AT MANDSAUR (M.P, INDIA) IN RELATION TO POLLUTION

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ABSTRACT

Rivers are considered the most endangered ecosystems globally and it is urgent for human beings to estimate river conditions and quality trends. Diatoms provide perhaps the most adaptable and important tool for the assessment of aquatic environments. They are not as prone to washouts or other changes in aquatic ecosystem that directly affect planktons or vertebrates. They are the simple indicator to sample, from streams, urban canals or wetlands, being generally equally represented across all surfaces at a single location. Many countries now use diatoms as a main factor of their biomonitoring programmes. Therefore**,** we investigated whether the biological traits of diatoms in rivers (life-forms, size and classes) could be used to assess organic pollution and trophic level at Shivna river of Mandsaur, Madhya Pradesh (India). The research work was conducted from July 2012 to June 2013 at three different sites (upstream RG, Mid stream PN, and downstream NRO). Various physico chemical parameters of River water from three different sites were also determined on monthly basis and compared with abundance of diatoms. We found a total 33 taxa belonging to 17 genera during the experimental period. One Genera and 16 Taxa from Centralas and 32 from Pennales were found. The abundances of diatoms is differed significantly between the three different organic pollution and trophic levels. The water quality parameters were significantly related to diatoms abundance.

KEYWORDS: Biodiversity, Diatoms, Shivna River, Water quality.

INTRODUCTION

Fresh water ecosystems are very important as they provide water for many human uses. But the coincident with rapid population and economic growth in the late 20th century various factors and mismanagement of the resources reduced biodiversity have altered the structure and function of rivers.[1] Various physical, chemical and biological approaches are often measured as basic monitoring needs, as they can provide complete information for proper water management.[2] (Metcalfe JL,1989). However it is very difficult to examine all possible variables because they are costly, unpredictable and even often poorly reflective of biological conditions. For that reason, biomonitoring has proven to be a necessary add-on to traditional monitoring.[3]

Algae like diatoms can serve as bioindicators to combine their total environment and their responses to changes in environmental conditions.[4], [5], [6],[7] Diatoms are renowned globally as one of the most appropriate organisms for water quality assessment due to their stable presence along the aquatic system and also because they give a quick response to environment changes. It helps to obtain an ecological outline of the current status of streams and rivers as they respond more rapidly to environmental changes than higher level organisms. It is well known fact that the composition of diatom groups is affected by chemical parameters of water[8], nutrient level[9] and organic pollution load.[10] Various biotic indexes, for instance the Biological Diatom Index (BDI)[11], [12] and the Pollution Sensitivity Index (IPS) have been developed to assess the intensity of pollution in rivers.[13] They are now compulsory under the European Water Framework Directive (WFD) (European commission, 2000) for the assessment of aquatic environment quality.[14]

But the research in river diatoms is very little due to practical complexities in the analysis and sampling in flowing water. Therefore, we aimed to deal with the use of diatoms in the monitoring and assessment of water bodies and check problems associated with their use in different regions. We also suggest approaches and further research that may facilitate the use of diatom collections for biological appraisal of river health.

MATERIALS AND METHODS

Study area

Mandsaur district is located on northwest part of Madhya Pradesh state extends between the parallels of latitude 23 46' and 24 45' north and between meridians of longitude 74 44' and 75 54' east. River Shivna is the tributary for river Chambal that flows from south directions. It is seasonal river and highly polluted by both municipal and industrial waste. Three different stations of the river of both upstream and downstream were selected for the present investigation and named as Station I, II and III (I Upstream –Ramghat II. Middle stream- Pashupatinath temple and Downstream –Near Railway over Bridge).

Study of biodiversity of diatoms

Samples were collected in 2012-13 on monthly basis from all the three sampling stations. Planktonic net, hand picking and squeezing of aquatic plant and brushing stones with a toothbrush etc were employed for the sample collection and were collected and were preserved in 4% formaldehyde in small plastic bottles. The taxonomic identifications and counts were made by standard methods described by Afnor[11] using the Krammer and Lange-Bertalot[15] floras and other particular bibliographical data. Water quality parameters like temperature, PH, Dissolved oxygen (DO), Turbidity, alkalinity, Chloride, Nitrate, Phosphate was carried out according to standard methods APHA.[16] One-way ANOVAs were employed to find out whether there were any significant differences between the various biological traits in the organic pollution and trophic level classes (Sigma Stat 3.10 soft ware).

RESULT AND DISCUSSION

Results (Table.1) clearly indicated that Pennales dominated over the Centrales which were represented by the single genus *Cyclotella* only. The diatoms found to be dominant in the benthic habit were *Nitzschia* sp., *Synedra* sp., *Gomphonema* sp., and *Navicula* sp. The most abundant diatoms in the river Shivna were *Fragillaria capuciana, Synedra ulna, Gomphonema lanceolatum, Cymbella affinis* and *Navicula pupula*. Results also show that the species diversity of Bacillariophyceae was 16 genera and 36 species and distributed almost equally in all three research stations studied. However, the percentage species composition was much higher at Site-I and III in all seasons. As a whole the diversity of Diatoms were fairly dominant though out the study except during monsoon. The outcome of this study also revealed that their growth was abundant during the winter season as reported by earlier workers.[17],[18], [19], [20] Species diversity was greater at Staion-I than other study stations of the River. At Station-II, 11 species *Cyclotella meneghiniana, Cocconeis placentula, Navicula cryptocephala, N.pupula, Pinnularia gibba, Amphipleura pellucida, Pleurosigma angulatum, Gomphonema lanceolatum, G. olivaceum, G. parvulum, Cymbella cistula, Rhopalodia gibba, Nitzschia closterium* and *N.recta* were found to be dominant. But at Station-III diatoms were represented by 11 genera in which *Cyclotella meneghiniana, N.pupula, Pinnularia gibba, Amphipleura pellucida, Pleurosigma angulatum, Gomphonema lanceolatum, G. olivacevm, Cymbella cistula, Rhopalodia gibba* and *Nitzschia closterium* and were found as dominant forms.

Results clearly indicate that there were significant differences in the life forms, distribution and diversity of the diatoms between the organic pollution and trophic level in all three research stations studied. The River Shivna at Mandsaur, exhibit considerable size differences. It is highly polluted particularly in urban sections. It appears that even though the River with different typology, the distribution of diatom size classes and life-forms are strongly affected by trophic level and organic pollution of the water. These associations were in agreement with our knowledge on ecological preferences. In our study, the relative abundances of the tube forming diatoms increased when the organic pollution and trophic level were low while the abundance of stalked diatoms is high when pollution level is low. It may be due to the fact that stalked diatoms are less well adapted at incorporating nutrients adsorbed on the substratum, but better at exploiting the nutrients dissolved in the water as confirmed by Rimet et al.[21]

The results observed on the streams of the River Shivna have shown that the abundance of motile species increased with organic matter and nutrient concentration, as already observed by Passy.[22] It may be due to the fact that motile diatoms can secrete extracellular enzymes which enable them to use macromolecules adsorbed on the substrates or sediments[23] or as they are often bigger than low-profile diatoms, which enable them to store more nutrients or they also have the advantage over sessile species of being able to move rapidly from nutrient poor microenvironments to ones with higher concentrations of nutrients and organic molecules.[24] However, among the traits tested, some did not show any interesting abilities in assessing nutrient and organic pollution. The high density of diatoms have been reported to be associated with addition of sewage and industrial effluent at Site-II and Site-III respectively, which results in a fall of species diversity Impact of water quality difference is reflected in higher diatom diversity at Site-I but more assemblage downstream. Diatoms are durable organism able to survive in both low and high nutrients and pH.

Table.1.Analysis of physicochemical parameters at various Sites during study period.

Parameter	Sites	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Temperature°C	I	23.8	22.3	28.4	23.4	22.7	20.5	19.3	20.7	29.1	30.2	31.2	32.6
	II	23.7	23.1	27	23.7	22.6	20	20.3	20.6	29.4	30.2	31.8	32.7
	III	23.7	22.1	28.4	23.2	22	20.7	19.7	20.8	29	30.7	31.5	39.8
PH	I	7.7	7.7	7.6	8	8.5	8.3	8.6	8.4	8.4	8.3	8.2	8.1
	II	7.6	7.6	7.5	8.1	8.6	8.4	8.7	8.3	8.1	8.2	8.1	8.2
	III	7.3	7.8	7.6	8.7	8.1	8.2	8.5	8.3	8.3	8.4	8.3	8.4
DO (mg/l)	I	7	7.7	7.6	8	8.5	8.3	8.6	8.4	8.4	8.3	8.2	8.1
	II	6.9	7.1	7.4	8.1	8.4	8.3	8.6	8.1	7	6.2	6.1	6.2
	III	6.9	7.1	7.4	8.1	8.4	8.3	8.6	8.1	7	5.2	6.1	6.2
Alkalinity(mg/l)	I	71	74	70	65	58	64	57	60	64	61	65	67
	II	82	79	75	69	67	69	67	70	75	76	79	81
	III	79	74	74	65	58	64	55	66	68	62	66	72
Chloride(mg/l)	I	24.74	24.22	23.51	20.23	18.3	19.6	20.18	23.1	23.65	20.14	22.11	24.81
	II	26.1	27.1	26.16	22.18	21.2	20.11	22.64	25.1	23.45	22.74	24.61	27.71
	III	28.81	27.44	25.4	22.71	24.24	23.78	24.67	24.16	25.6	26.56	25.34	27.26
Nitrate(mg/l)	I	0.201	0.191	0.166	0.157	0.182	0.156	0.179	0.191	0.216	0.237	0.21	0.209
	II	0.248	0.23	0.228	0.178	0.167	0.19	0.181	0.195	0.19	0.24	0.23	0.28
	III	0.241	0.25	0.238	0.223	0.18	0.18	0.202	0.192	0.205	0.233	0.247	0.275
Phosphate(mg/l)	I	0.523	0.519	0.53	0.527	0.516	0.514	0.516	0.517	0.52	0.512	0.526	0.529
	II	0.532	0.53	0.523	0.52	0.524	0.529	0.53	0.531	0.532	0.537	0.536	0.533
	III	0.584	0.59	0.588	0.581	0.587	0.517	0.57	0.573	0.572	0.573	0.579	0.583

Table.2. Comparative analysis of Diatoms in relation to class and order.

			STATION-I		STATION-II`		STATION-III	
BACILLARIO-PHYCEAE	**TOTAL GENERA**	**TOTAL TAXA**	**GENERA**	**TAXA**	**GENERA**	**TAXA**	**GENERA**	**TAXA**
CENTRALES	1	1	1	1	1	1	1	1
PENNALES	16	32	11	22	11	18	11	19
TOTAL	17	33	12	23	12	19	12	20

Seasonal Occurrence and Abundance of the Diatoms at Different Sites of Shivna River.

Centrales	Site	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Cyclotella meneghiniana	I	-	-	-	-	-	-	R	R	R	-	-	-
	II	-	-	-	-	R	R	C	C	C	R	-	-
	III	-	-	-	-	R	R	C	C	C	R	-	-
Fragilaria capuciana	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	C	C	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Synedra ulna	I	-	-	-	C	C	C	A	C	A	R	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	C	C	C	-	-	-	-
Eunotia pectinalis	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	R	R	-	-	-	-	-	-
Achnanthes microcephla	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	R	R	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Cocconeis placentula	I	-	-	-	-	-	-	-	-	C	C	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
C. Placentula Her	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	C	C	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
N. cari	I	-	-	-	-	-	-	-	-	R	C	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-

	III	-	-	R	-	-	-	-	-	-	-	-	-
N. cryptocephala	I	-	-	-	-	-	-	R	-	R	R	-	-
	II	-	-	-	-	-	R	C	C	A	C	C	R
	III	-	-	-	-	-	-	C	C	A	-	-	-
N. hasta	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	R	R	R	-
N. pupula	I	-	-	-	-	-	-	A	A	-	-	-	-
	II	-	-	R	R	R	C	A	C	A	-	-	-
	III	-	-	-	-	-	-	C	C	A	-	-	-
N. viridula	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	R	-	-
Pinnularia borealis	I	-	-	-	R	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
P. interrupta	I	R	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	A	R	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Amphipleura pellucid	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	R	C	C	A	C	C	R	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Pleurosigma angulatum	I	-	-	R	R	R	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	R	R	-	-	-	-	-	-
Gomphonema aequatoriale	I	-	-	-	-	R	C	-	-	-	-	-	-
	II	-	-	-	-	-	R	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Gomphonema sp.	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	C	C	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
G. lanceolatum	I	-	-	-	-	-	C	C	-	-	-	-	-
	II	-	-	-	-	-	-	C	C	-	-	-	-
	III	-	-	-	-	-	-	-	-	C	-	-	-
G. olivaceum	I	-	-	-	-	-	-	C	-	-	-	-	-
	II	-	-	-	-	-	-	R	-	-	-	-	-
	III	-	-	-	-	-	-	R	A	A	-	-	-
G. parvulum	I	-	-	-	R	-	R	-	-	-	-	-	-
	II	-	-	R	R	C	C	C	C	R	C	-	-
	III	-	-	-	-	C	C	C	-	-	-	-	-
G. sphaerophorum	I	-	-	-	-	-	R	R	R	-	-	-	-
	II	-	-	-	-	-	C	C	C	R	R	-	-
	III	-	-	-	-	-	-	R	A	-	-	-	-
Cymbella affinis	I	-	-	-	-	-	-	C	C	A	A	A	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	R	-	-	-
C. cistula	I	-	-	-	-	-	-	C	C	C	C	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
C. tumida	I	-	-	-	-	-	-	R	-	-	-	-	-
	II	-	-	-	-	-	-	-	R	R	-	-	-
	III	-	-	-	-	R	R	R	R	R	-	-	-
Amphora acutiuscula	I	-	-	-	-	-	-	R	-	-	-	-	-
	II	-	-	-	-	-	-	-	R	R	-	-	-
	III	-	-	-	-	R	R	R	R	-	-	-	-
A.ovalis	I	C	C	C	-	-	C	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-

Epithemia sorex	I	-	-	-	-	-	-	-	-	R	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Rhopalodia gibba	I	-	-	-	-	-	Ac	R	-	R	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	R	Ac	R	R	-	-	-	-	-	-	-	-
Nitzschia closterium	I	-	-	-	-	-	C	-	C	C	C	-	-
	II	C	-	-	-	-	C	-	-	-	C	C	-
	III	-	-	-	-	-	-	-	C	-	-	-	-
N. recta	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	R	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
Surirella linearis	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	R	R	R	R	-	-	-
S. robusta	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-

A- Abundance, C-Common, R- Rare, Ac- Accidental.

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