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Water Quality and Phytoplankton Population in Sewage Fed River of Mahanadi, Orissa, India

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KEYWORDS Abundance. Mahanadi River. Phytoplankton. Succession

ABSTRACT Seasonal dynamics of phytoplankton populations and nutrient status of water were studied in sewage fed river Mahanadi of Orissa for a period of one year covering three seasons. Phytoplankton population and water analysis was performed using standard procedure. Maximum population density was observed in the winter season followed by summer and monsoon. Higher phytoplankton populations were encountered in Sikharpur (site IV) which corresponded to the fluctuation of prevailing conductivity, turbidity, dissolved oxygen, better organic load and chemical oxygen demand content of the said habitat. A total of 25 species belonging to three different groups were recorded during the study period. *Spirogyra ornata, Navicula cuspidate, Oscillatoria limnosa* were the most abundant followed by *Zygnema, Ulothrix, Nitchia* and *Phormidium*. Higher concentration of diatom at Sikharpur site indicates polluted zone of the river. *Oscillatoria* and *Nitchella* species at sewage affected sites can be used as an indicator of organic pollution in the river. Our findings highlighted the deterioration of water quality in the river due to industrialization and human activities. Proper biological and chemical treatment of domestic sewage and industrial effluents before discharge to river system is suggested.

INTRODUCTION

Water is important component of all living beings. It also performs unique and indispensible activities in earth ecosystem, biosphere and biogeochemical cycles. The growth and diversity of aquatic microflora in river system is influenced by several physico-chemical and biological parameters. Cuttack, the oldest unplanned city of Orissa, India, is thickly populated and full of slums. The city is bounded by the biggest river of state 'Mahanadi' on the eastern side and 'Kathojodi' on western side. Taladanda canal runs through the heart of the city and receives the domestic, commercial and industrial wastes and dumps it finally into Mahanadi river at Sikharpur. Majority of the people in the city use this water for their daily needs as well as for cooking. The studies on the impact of pollution due to sewage and industrial effluents in different rivers is well studied (Saha et al. 1985; Tiwari and Ali 1987; Sunder 1988).Intensive studies concerning the pattern of colonization and succession of phytoplankton's from diverse sites of Indian subcontinent has earlier been highlighted (Bhowmick and Singh 1985; Behera et al. 1989; Tripathy and Pandey 1990; Vyas and Nama 1990; Pradhan et al. 1998 Mishra 2000; Mishra 2006).But such type of studies in Mahanadi River are limited (Samantray et al. 2009). In view of the above fact, a study was carried out highlighting the role of changing water condition in determining the abundance and succession of phytoplankton in a set of samples collected in Mahanadi river of Orissa, India. The purpose of the study is to make the people aware about the contamination of river water due to untreated sewage and effluents.

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STUDY AREA

Mahanadi emerges from Amarkant of Madhya Pradesh (M. P.) and runs across a number of districts of Orissa. It flows through a vast stretch with numerous perennial and non-perennial streams and forms a network of small and large tributaries before joining the Bay of Bengal near Paradeep. The river is mainly used for fishing, propagation of aquatic life, prawn culture, irrigation etc. The river flows through the heart of Cuttack city (20º 59'N and 85º59'E).

METHODOLOGY

Study was conducted during three seasons. Samples from different locations of the river in and around the city i.e. Chahata (site 1), Gadagadia (site2), Jobra (site3) and Sikharpur (site4) were

collected at monthly interval. The samples were analyzed using standard procedure (APHA 1989). The pH and temperature of water samples were measured in the field. Transparency was recorded by standard Sacchi disc and conductivity by conductivity-meter (Systronic type 311). The determination of total dissolved solid (TDS) was done by a gravimetric process, while the total hardness was carried out by complexometric titration method (APHA 1989). Winkler's method was followed for the analysis of dissolved oxygen, whereas total dissolved organic matter was analyzed by Jhingran et al. (1989) method. Other characteristics of water were estimated as per the procedures followed in NEERI (National Environmental Engineering Research Institute 1988).The phytoplankton's were collected filtering 60 litres of water through a plankton net made up of bolting silk cloth No 25 (Mesh size 0.03-0.04 mm). The quantitative and qualitative analysis of the phytoplankton were done following Vollenwinds (1969).The class wise identification up to species level was performed with the help of Gonzalves and Joshi (1946) and Tonapi (1980).

RESULTS AND DISCUSSION

A comparative study on microbial composition of water at four sites revealed that, Sikharpur site with high temperature and better nutrient status harbored more phytoplankton (Table 1). The quantitative and qualitative difference of microbial population of four sites indicates that nutrient composition influences microbial inhabitants of the water. A distinctive pattern of phytoplankton structure was observed at all the four sites. The percentage composition and abundance of different phytoplankton groups fluctuated in all the samples (Table 2). Maximum number of total phytoplankton during summer and winter indicates good physico-chemical conditions (Kant and Kachroo 1977). Chlorophyceae is predominant in site 1 and 2 and showed two maxima one each in early in summer and early winter. This bimodal pattern of peak population was also reported (Velecha and Bhatnagar1988; Guru 2008). Low dissolved oxygen (DO), high turbidity; better organic load and chemical oxygen demand (COD) at site 4 may restrict the abundance of Chlorophyceae. Low value of DO and high COD have been reported to be associated with high organic matter content and sewage disposal in rivers (Rai 1974; Mishra 1996; Mishra and Ram 2007). The concentration

Table 1: Seasonal variation of physico-chemical properties of different study sites

Different Parameters	*Chahata*			*Gadagadia*			*Zobra*			*Sikharpur*		
	Summer	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*
Temperature(°C)	31.16	28.66	26.5	30.5	29.83	26.76	32.16	30.33	26.83	32.16	29.0	27.16
Conductivity(microS/cm)	126	90	118.3	193.3	142.5	155	210	143.5	166.6	1053.3	616.6	723.3
Transparency	57.3	28	53.3	59,3	27.3	55.3	74.0	38.7	56.3	42.0	29.3	63.3
pH	8.06	7.53	7.83	7.81	7.34	7.82	9.11	8.46	8.2	9.0	7.55	8.59
Dissolved oxygen(mg/l)	6.43	6.8	7.53	8.33	6.93	8.93	8.93	8.4	8.2	4.26	5.33	4.73
Total alkalinity	51.6	41.0	60.0	74.0	66.3	79.0	78.3	56.7	88.3	211.0	105.2	293.3
Carbonate (mg/l)	9.0	0.0	1.33	10.0	3.0	2.0	6.66	2.33	4.0	6.33	0.0	0.66
Bicarbonate (mg/l)	42.66	41.0	58.66	64.0	63.0	77.0	71.66	54.3	84.3	204.7	105.2	292.7
Chloride (mg/l)	10.0	8.5	9.17	17.68	12.01	11.34	17.18	10.00	7.33	88.39	53.70	75.08
Total hardness	58.66	45.00	62.6	70.3	56.6	68.00	78.6	48.5	70.3	202.3	94.5	179.3
Calcium hardness (mg/l)	32.6	25.00	35.00	34.6	35.83	36.6	39.3	28.6	40.3	123.0	54.0	101.0
Magnesium hardness(mg/l)	26.0	20.0	27.6	35.6	20.83	31.3	39.3	19.83	30.0	79.3	40.5	78.3
Phosphate (mg/l)	0.0078	0.0096	0.0093	0.0052	0.0063	0.0023	0.0236	0.0059	0.0024	0.249	0.033	0.131
Nitrate (mg/l)	0.293	0.146	0.286	0.213	0.06	0.197	0.97	0.54	0.66	1.3	0.275	0.45
Chemical oxygen demand (mg/l)	43.93	25.62	51.25	153.7	109.83	146.4	392.51	95.19	388.09	922.65	307.5	615.1
Total dissolved organic matter (mg/l)	6.53	4.53	3.00	9.3	5.00	2.26	14.00	5.41	1.6	31.6	15.83	15.93
Total dissolved solid (mg/l)	95.93	103.6	114.76	171.9	131.3	138.83	223.5	154.2	168.7	752.96	540.43	575.73

Table 2: Seasonal variation of Phytoplankton at different study sites

Phytoplanktons	*Chahata*			*Gadagadia*			*Zobra*			*Sikharpur*		
	Summer	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*	*Summer*	*Rainy*	*Winter*
Chlorophyceae	130.0	84.7	103.7	166.7	80.7	162.7	208.0	158.7	220.7	38.7	29.0	60.0
Bacillariophyceae	48.7	36.0	112.7	50.7	37.3	127.3	174.0	88.3	160.0	211.0	100.0	258.7
Myxophyceae	76.3	47.7	94.7	81.3	74.7	120.0	169.3	56.0	117.7	337.7	152.7	244.7
Total Phytoplankton	255.0	168.4	311.1	298.7	192.7	410.0	551.3	303.0	498.4	587.4	281.7	563.4

Table 3: ANOVA

Sources	*DF*	*SS*	*MSS*	*F value*		*p Value*	
Varieties	3n	115778.2	38592.7	11.3**	4.8 *	9.8 **	23.7***
Season	2n	105528.2	52764.1	15.5**	5.1*	10.9**	27.0***
Error	6n	20428.2	3404.7				
Total	11						

of Bacillariophyceae was placed third in order of abundance in this river. It attains maxima during winter in all the sites expect site 3 and minima during winter in all the sites except site 3 and minima during winter. ANOVA clearly indicated significant seasonal difference between the samples of phytoplankton (Table 3).

The diatom population of the river is composed of mainly *Navicula* and *Nitzchia*. High concentration of diatom at site 4 indicates polluted zone of the river (Palmer 1969; Kanon and Krishnamurthy 1985).Important parameters such as conductivity, turbidity, total dissolved solids and chemical oxygen demand are substantially high at sewage affected site. Deterioration of water quality at site 3 and 4 is attributed to drains of chemical laboratory, industrial effluents and domestic sewage. The study also shows that Myxophyceae was dominant at site 4. Dominance of Myxophycean population in polluted habitat has also been reported earlier (Mishra and Ram 2007; Guru 2008). Total phosphate, total nitrate and chloride contents play a vital role in their distributional pattern. The species composition in four sites shows marked difference with change in habitat (Table 4). A total of 25 species belonging to three different groups were recorded during the study period. The study also shows that *Spirogyra ornata*, *Navicula*, *cuspidate*, *Oscillatoria limnosa* were the most abundant species followed by *Zygnema*, *Ulothrix*, *Nitchia* and *Phormidium*. Their occurrence might be due to ability of these groups of phytoplankton's to survive in adverse conditions and to adjust with the environment. *Oscillatoria* and *Nitchella* species at sewage affected sites can be used as an indicator of organic pollution in the river.

CONCLUSION

It can be concluded that river Mahanadi at Cuttack city is highly polluted and rapidly turning towards eutrophication. Its water has become unsuitable for human consumption. Proper biological and chemical treatment of domestic sewage and industrial effluents before discharge to river system is suggested.

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Table 4: Distribution of phytoplankton at different sites

Phytoplankton	*Sites*			
	Chahata	*Gadagadia*	*Zobra*	*Sikharpur*
Chlorophyceae				
1. Ankistrodesmus falcatus	-	-	+	+
2. Desmidium schaartzisi	+	+	-	-
3. Oedodendron species	+	+	-	-
4. Spirogyra ornata	+	+	+	-
5. Spondytosum papillatum	+	+	+	+
6. Stigeoclonium colin	-	-	+	+
7. Ulothrix species	+	+	+	-
8. Zygnema species	+	+	-	-
Bacillariophyccae				
1. Cymbella species	+	+	+	+
2. Fragilaria species	+	-	+	-
3. Navicula cuspidate	+	-	+	+
4. N.radiosa	-	+	-	+
5. N. tuscula	-	-	+	+
6. N.viridula	-	-	-	+
7. Nitzchia species	+	+	-	+
8. Synedra ulna	+	-	+	+
Myxophyceae				
1. Oscillatoria chlorina	-	-	+	+
2. O.curvicep	-	+	+	+
3. O.formosa	+	+	+	+
4. O.irrigua	-	+	-	+
5. O.limnosa	+	-	+	+
6. O.tenuis	-	-	+	+
7. Lyngbya species	+	+	+	+
8. Phormidium luridum	-	+	+	+
9. P.valderianum	+	-	+	+

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