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Role of Sewage Discharge on the Diversity and Distribution of Zooplankton in the Mahanadi River, India

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Abstract: Zooplankton forms an important component of fish fries and helps to transfer energy from primary to secondary and tertiary levels in a food chain. Realizing the paucity of patent literature on the zooplankton population of sewage-fed river Mahanadi, studies were undertaken to assess the seasonal dynamics of zooplankton populations and nutrient status of water for a period of one year covering three seasons. Zooplankton population and water analysis was performed using standard procedure. Maximum population density was observed in the winter season followed by summer and lastly rainy. Higher zooplankton populations were encountered in Sikharpur (site IV). They 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 14 species belonging to six different groups were recorded during the study period. Lower concentration of zooplankton at Sikharpur site indicates polluted zone of 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.

Key words: Abundance, Mahanadi river, Taladanda canal, zooplankton.

Introduction

Water, the life of all living organism, is an important natural resource. Due to human civilization the usable part of water (1% only) has been becoming polluted. Now it is difficult to get pure water to drink or for other purposes. The growth and diversity of aquatic flora and fauna in river system is influenced by several physico-chemical and biological parameters (Valecha and Bhatnagar, 1988; Mishra and Ram, 2007; Guru, 2008). Water supports diverse organisms. Cuttack, the oldest unplanned city of Odisha, India is highly populated and full with slums and basties. The city is surrounded by two rivers on both sides. Mahanadi, the longest river of the state is flowing on the eastern side and the river Kathojodi is running on the west. A large canal i.e. Taladanda canal is running all around the city and on its way it receives industrial effluents, domestic sewage, commercial wastes etc. and dumps all of its collections to the river Mahanadi at Sikharpur without any waste treatment. Poor basti people of Cuttack city use this canal as the place of open defecation.

Most of the people in the city depend on Mahanadi river water for various purposes from drinking to cooking. The studies on the impact of pollution due to sewage and industrial effluents in different river systems is well studied (Behera et al., 1989; Pradhan et al., 1998; Mishra, 2006). Intensive studies relating to impact of

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pollution on zooplankton population has already been reported in different rivers of Indian subcontinent (Khan, 1987; Chauhan, 1993; Sunkad and Patil, 2004; Agarwal and Thapliyal, 2005; Ganesan and Khan, 2008; Ayoade et al., 2009; Jayahaye, 2010). In view of the above fact, a study was carried out emphasizing the impact of pollution load on the population and abundance of zooplankton and their density in a set of samples collected in Mahanadi river, Odisha, India. The purpose of the study is to make the people aware about the pollution load of the said river due to untreated sewage and effluents.

Study Area

Mahanadi originates from Amarkant of Madhya Pradesh and runs through a number of districts of Odisha. It flows through the heart of the Cuttack city (20º 59'N and 85º59'E) 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.

Methodology

The study was conducted for a period of one year covering three seasons. Water samples were collected from four sites within the city i.e. Chahata (site 1), Gadagadia (site 2), Jobra (site 3) and Sikharpur (site 4) at monthly intervals. 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 zooplanktons were collected filtering 60 liters 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 zooplankton 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

Zooplankton, the second trophic level of aquatic ecosystem, forms an important component of fish fries and helps to transfer energy from primary to secondary and tertiary levels in a food chain. Major differences in plankton population were found between the studied water samples. The Sikharpur site with high temperature and better nutrient status exhibited a distinctly higher phytoplankton population. On the other hand there was a substantial lower zooplankton population in site 4. Low dissolved oxygen (DO), high turbidity, better organic load and chemical oxygen demand (COD) at site 4 (Table 1) may restrict the abundance of zooplankton. Low value of DO and high COD have been reported to be associated with high organic matter content and sewage disposal in rivers (Mishra, 1996; Mishra and Ram, 2007; Samantray et al., 2009). The percentage composition and abundances of phytoplanktons fluctuated in all the samples (Table 2). Maximum number of total phytoplankton during summer and winter indicates good physico-chemical conditions. In comparison to phytoplankton, the concentration of zooplankton is very low (Table 2) and constitutes only 11.2%. The concentration of zooplankton was 17.27% of the total plankton in site 1, 12.65% in site 2, 14.1% in site 3 and 3.46% in site 4. Very low % in site 4 may be due to high degree of pollution which become unfavourable for the growth and abundance of zooplankton. The zooplankton of the river is composed of Cladocera, Copepoda, Crustacean larvae, Helmithes larvae, Protozoa and Rotifera (Table 3).

In all the sites one major peak generally occurs in November and one minor peak in May. But in the polluted zone of Sikharpur the single major peak was observed during September. It was observed that the peak of zooplankton approximately coincide with phytoplankton peak. Different investigators working with zooplankton have pointed out that abundance in zooplankton is chiefly dependent upon the abundance of phytoplankton (Mathew, 1969; Sugunan, 1980). But some other authors pointed out that food of zooplankton chiefly consists of nanoplankton including bacteria (Henuska, 1949) and suspended organic matter rich with bacteria (Darnette, 1961). During present investigation both the zooplankton and phytoplankton peak-coincided with each other to indicate the possibility of zooplanktons subsisting on nanoplankton. The concentration of zooplankton was highest in site 3 and lowest in site 4. High concentration of zooplankton in site 3 may be due to high water

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 planktons concentration at different study sites

Season	*S*	*R*	*W*	*S*	*R*	*W*	*S*	*R*	*W*	*S*	*R*	*W*
Sites		*Site1*			*Site 2*			*Site 3*			*Site 4*	
Total phytoplanktons	255	168.3	311	298.7	192.6	410	551.3	303	498.3	587.3	281.6	563.3
% of phytoplankton	85.3	79.3	82.6	90.3	83.2	87.3	88.3	84.5	84.2	98.9	89.1	98.2
Total zooplanktons	44	44	65.3	32	39	59.6	73	55.6	93.3	6.6	34.3	10.3
% of zooplankton	14.7	20.7	17.4	9.7	16.8	12.7	11.7	15.5	15.8	1.1	10.9	1.8
Total planktons	299	212.3	376.3	330.7	231.6	469.6	624.3	358.6	591.6	593.9	315.9	573.6

Table 3: Distribution of zooplankton at different sites

Zooplankton	*Sites*			
	Chahata	*Gadagadia*	*Zobra*	*Sikharpur*
Ancylostoma duodenale	-	-	+	+
Ascaris lumbricoide (larvae)	-	-	+	+
Brachionus falcatus	+	+	-	-
B. forficula		-	+	-
Daphnia sp.	+	-	+	-
D. similis	+	-	-	-
Diaptomus sp.	+	+	+	+
Entamoeba histolytica (larvae)	-	-	-	+
Giardia intestinalis	-	-	+	+
Mesocyclops hyalinus	-	-	+	+
M. leuckarti	-	-	+	+
Microcyclop sp.	+	+	+	
Naupilius larvae	+	+	+	+
Simocephalus sp.	+	-	+	-

level and low water current. Low concentration of zooplankton at site 4 may be due to its pollution load. It was observed that concentration of zooplankton was very low in summer and winter but increases significantly in rainy season due to dilution of pollutant. During rainy season the abundance of Helminthes larvae may be due to washing of faecal material from the vast catchment area.

Conclusion

Concentration of zooplankton is very low in river Mahanadi due to pollution load. From the present investigation it can be concluded that river Mahanadi at Cuttack city is highly polluted as the domestic sewage and industrial effluents are discharged into it. 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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Calendar of Events

India Water Week 2013
8th to 12th April 2013
New Delhi, NCT of Delhi, India
Website: http://www.indiawaterweek.in
Contact person: RK Jain
Organized by: Ministry of Water Resources

Water & Environment 2013: CIWEM's Annual Conference
10th to 11th April 2013
London, United Kingdom
Website: http://www.ciwem.org/events/annual-conference.aspx
Contact person: Lauren Goozee
Organized by: CIWEM

International Conference on Integrated Waste Management and Green Energy Engineering (ICIWMGEE' 2013)
15th to 16th April 2013
Johannesburg, South Africa
Website: http://psrcentre.org/listing.php?subcid=202&mode=detail
Contact person: Prof Dr. Edison Muzenda
Organized by: Planetary Scientific Research Centre (PSRC)

Advanced Water Management for Oil & Gas (2nd Edition)
15th to 17th April 2013
Prague, Czech Republic
Website: http://www.marcusevans-conferences-paneuropean.com/WateMgt_confalerts
Contact person: Kristiyan Sokolov

3rd International Conference on Environment Science and Engineering (ICESE 2013)
21st to 22nd April 2013
Beijing, China
Website: http://www.icese.org/
Contact person: Mr. Lee
Organized by: CBEES

Energy & Environment: Bringing together Economics and Engineering
9th to 10th May 2013
Porto, Portugal
Website: http://www.fep.up.pt/conferences/icee/
Contact person: Chair: Isabel Soares

Water Resources Management 2013
21st to 23rd May 2013
New Forest, United Kingdom
Website: http://www.wessex.ac.uk/13-conferences/water-resources-management-2013.html
Contact person: Irene Moreno Millan
Organized by: Wessex Institute of Technology

River Basin Management 2013
22nd to 24th May 2013
New Forest, United Kingdom
Website: http://www.wessex.ac.uk/13-conferences/river-basin-management-2013.html
Contact person: Irene Moreno Millan
Organized by: Wessex Institute of Technology

Climate Change and Population Conference 2013
3rd to 7th June 2013
Accra, Ghana
Website: http://www.ug.edu.gh/ccpop-ghana2013/
Contact person: Delali B. Dovie
Organized by: University of Ghana, The Regional Institute for Population Studies [RIPS], Legon

ACSEE 2013 - The Third Asian Conference on Sustainability, Energy and the Environment
6th to 9th June 2013
Osaka, Japan
Website: http://acsee.iafor.org
Contact person: Kiyoshi Mana
Organized by: The International Academic Forum (IAFOR), in affiliation with its global university partners