RESEARCH ARTICLE

Effect of Domestic Sewage on Phytoplankton Community in River Rapti at Gorakhpur

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ABSTRACT

This paper aims to study the effect of domestic sewage on phytoplankton population in river Rapti at Gorakhpur, U.P. and India. An increase in free CO_2, bicarbonate alkalinity, nitrate, phosphate and BOD while a decrease in pH, DO and carbonate alkalinity was observed at sewage mixing point. However, these parameters gradually changed at the station away from sewage mixing point (downstream) and were within the limits of Indian standards. During the study period total 29 species of phytoplanktons were observed belonging to 4 families: Bacillariophyceae (11), Chlorophyceae (10), Cyanophyceae (6) and Euglenophyceae (2). In present investigation it was observed that population of phytoplankton was very low at station R_2 where sewage mixed into river.

Keywords: Sewage, River, Phytoplanktons, Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae

INTRODUCTION

Water is indispensable for all living organisms on the earth any of the water on this planet is stored in ocean and ice caps, which is difficult to recover for our diverse needs. Any of our demands for water are fulfilled by rain water, which gets deposited in surface and ground water resources. Now days, both surface and ground water resources are contaminated by various sources like industrial effluents, agricultural discharge and municipal waste water associated with large amount of inorganic and organic toxic pollutants along with harmful pathogens (Okoh et al., 2007). Sewage,used water of community generally contains organic as well as inorganic wastes from residences, business houses and industries that might lead to the. It affects physical, chemical and biological characteristics of the water. Hence, continuous monitoring of river's water quality is very essential to determine the state of pollution in our rivers. Communication of this information to general public and government can help to develop the policies for the conservation of our natural fresh water resources (Ali et al., 2000). Phytoplanktons are a predominant type of a plant found in aquatic bodies. The quality and quantity of phytoplankton is good indicator of water quality. Phytoplanktons (algae) are those microscopic plants contain chlorophyll-a that float or swim too feebly to maintain a constant position against a water current (Lee 2008). Many workers have studies the plankton diversity and effect of domestic sewage on it, (Palmer 1980; Arya et al., 1987; Acharjee et al., 1995; Jha et al., 1997; Mathivanan et al., 2007; Hassan et al., 2008). The objective of this work is to show the effect of domestic sewage on phytoplankton population in river Rapti a tributary of river Ghaghara at Gorakhpur, U.P., India.

MATERIALS AND METHODS

Sampling stations:

Three water sampling stations were selected over 5 kms stretch of river Rapti. Station I (R_1): upstream of sewage discharge, station II (R_2): sewage mixing point, here a continuous discharge of city sewage through a large cemented drain occurs on the bank of the river. About 3 kms away from the station I, station III (R_3): downstream of sewage discharge point, about 2 kms away from station II (Agrahari and Kushwaha ,2012).

Sample collection and their physico-chemical analysis:

The study of the river Rapti at Gorakhpur was done for 12 months (Dec 2009 to Nov 2010). Samples of river water were collected in winter (Dec 2009) and summer (Jun 2010) season from all three stations. Samples were collected in plastic bottles for physico-chemical analysis. For biochemical oxygen demand (BOD) and dissolved oxygen (DO) samples were collected in BOD bottles. Temperature, pH and dissolved oxygen were measured at the site (Agrahari and Kushwaha , 2012).

Methods for analysis of physico-chemical parameters:

The physico-chemical analysis was carried out using the methods given by APHA (1976). pH was measured using pH meter and temperature was measured using simple, mercury filled Celsius thermometer. Nitrate, phosphate and sulphate test kits were purchased from Hi-media Laboratories Pvt. Ltd., Mumbai, India (Agrahari and Kushwaha , 2012).

Collection and Preservation of phytoplanktons:

For the analysis of phytoplankton samples were collected by filtering 30 liters of water through standard plankton counting net. Phytoplanktons were counted with the help of Sedwicq Rafter slide. The phytoplankton samples were observed under Olumpus microscope. The phytopllanktons were identified by using books and journals viz. (Agrahari and Kushwaha,2014; APHA 1985; Jena et al., 2005; Pingale and Deshmukh, 2005; Hosmani, 2008; Perumal and Anand, 2008).

Calculation:

Abundance of phytoplankton was estimated as organisms/liter in the concentrated sample using the equation:

$$\text{N (number of individuals)/Liter} = \frac{A \times 1000 \times C}{L}$$

Where,

A =Number of phytoplanktons/cc,

C=Volume of concentrated sample taken for counting

L=Volume of water in liter for collection of sample

1000 = Area of counting chambers

Data was subjected to Analysis of variance using software.

RESULTS AND DISCUSSIOINS

The average physico-chemical quality of river Rapti at three sampling stations in Gorakhpur during summer, winter and rainy seasons are presented in Table 1.

The maximum water temperature 33.8 °C was observed at station R_2 in summer season and minimum 19.9 °C at station R_3 in winter season. The pH value of the river water at different stations was recorded to be within highest 8.5 at station R_1 in summer season and lowest 7.0 at station R_2 in winter season. Highest value of electrical conductivity 404µmhos/cm was recorded at station R_2 in summer season and lowest value 198µmhos/cm was recorded at station R_1 in rainy season and highest value of TDS 286 ppm was recorded at station R_2 in rainy season and lowest value 102 ppm was recorded at station R_1 in winter season. Dissolved O_2 ranged between 10.2 ppm at station R_1 during winter to 2.4 ppm at station R_2 summer season. Low level of DO is again indicative of polluted nature of water body. Free CO_2 ranged between 20 ppm at station R_2 in summer season and 2 ppm at station R_1 and R_3 in winter season. Chloride concentration ranged between 12 ppm at station R_1 in rainy season to 285 ppm at station R_2 in summer season. The carbonate alkalinity varied from and 24.4 ppm at station R_1 in summer season and 3.5 ppm at station R_2 in rainy season. Bicarbonate alkalinity varied from 81 ppm at station R_3 in rainy season to 762 ppm at station R_2 in summer season. Total hardness, Ca hardness and Mg Hardness varied from a maximum of 492 ppm at station R_2 in summer season and 122 ppm at station R_1 in rainy season, 216 ppm at station R_2 in summer season and 44.6 ppm at station R_3 in rainy season and 62.28 ppm at station R_2 to 11.9 ppm at station R_1 in rainy season respectively. Nitrate was ranged between 0.019 ppm at station R_1 to 1.8 ppm at station R_2 in summer season. Nitrate is one of the most important indicators of pollution of water. Phosphate was found to be maximum of 1.6 ppm at station R_2 in summer season and 0.016 ppm at station R_3 in winter season. Sulphate concentration ranged between maximum of 18.5 ppm at station R_2 in summer season to a minimum of 10.4 ppm at station R_3 in rainy season. The BOD of river water varied from a maximum of 109.4ppm at station R_2 in summer season and 2.2 ppm at station R_3 in winter season. COD values ranged between 51 ppm at station R_2 in winter season to 19.2 ppm at station R_1 in rainy season.

Mean values of phytoplankton (units/ml) of river Rapti at three sampling stations (R_1, R_2 and R_3) in summer, winter and rainy seasons are presented in table 2. 29 species of phytoplanktons were observed belonging to 4 families: Bacillariophyceae (11), Chlorophyceae (10), Cyanophyceae (6) and Euglenophyceae (2).

Bacillariophyceae:

In present study the largest and diverse group is Bacillariophyceae. Diatoms were represented by 11 species *Amphora sp., Navicula sp., Fragilaria sp., Nitzschia sp., Gomphonema sp., Pinnularia sp., Syndra sp., Gyrosigma sp., Surirella sp., Diatoma sp.* and *Melosira sp.* . In the present study maximum number of species of Bacillariophyceae 1983 units/ml in summer season was recorded at station R_1. Minimum number of species 533.1 units/ml in rainy season was recorded at station R_2 where sewage mixed into the river.

Chlorophyceae:

Chlorophyceae was the second group after Bacillariophyceae in the number of identified species observed. In this group 10 species were recorded which are *Chlorella sp., Scenedesmus sp., Zygnema sp., Volvox sp., Ankistrodesmus sp., Ulothrix sp., Cosmarium sp., Mougeotia sp., Pediastrum sp.* and *Spirogyra sp.* In the present study maximum number of species of Chlorophyceae 1616.5 units/ml in summer season was recorded at station R_1. Minimum number of species 241.6 units/ml in rainy season was recorded at station R_2.

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Table 1: Mean values of physical and chemical parameters at different sampling stations of the river Rapti at Gorakhpur during summer, winter and rainy seasons.

Tests	Stations									Between Stations	Between Seasons
	Summer			Winter			Rainy				
	R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}		
Temp (^{0}C)	33.500	33.800	33.200	20.000	20.000	19.900	27.500	27.700	26.500	*(p<0.05)	**(p<0.01)
pH	8.500	7.400	8.200	8.000	7.000	8.200	8.200	7.200	7.500	*(p<0.01)	
Elec Cond, (μmhos/cm)	220.000	404.000	309.000	201.000	264.000	224.000	198.000	245.000	203.000	*(p<0.05)	*(p<0.05)
TDS (ppm)	122.000	260.000	182.000	102.000	207.000	164.000	140.000	286.000	185.000	*(p<0.01)	*(p<0.01)
DO_2 (ppm)	7.600	2.400	6.900	10.200	3.600	8.200	8.800	3.600	8.000	**(p<0.01)	*(p<0.01)
Free CO_2 (ppm)	8.000	20.000	6.000	2.000	6.000	2.000	4.000	18.000	5.400	*(p<0.01)	*(p<0.05)
Cl_2 (ppm)	35.000	285.000	46.000	20.000	270.000	48.000	12.000	109.000	20.200	*(p<0.01)	
CO_3 (ppm)	24.400	8.000	14.000	14.400	4.000	8.400	6.800	3.500	4.000	*(p<0.01)	*(p<0.01)
HCO_3 (ppm)	372.000	762.000	608.000	208.000	660.000	301.000	92.000	115.000	81.000	*(p<0.05)	*(p<0.01)
Tot Hard (ppm)	200.000	492.000	268.000	188.000	424.000	220.000	122.000	450.000	198.000	**(p<0.01)	*(p<0.01)
Ca Hard (ppm)	65.400	216.800	68.600	49.700	95.600	69.600	54.500	65.800	44.600		
Mg Hard (ppm)	24.160	54.380	39.640	21.880	62.280	24.000	11.900	51.100	25.760	*(p<0.01)	
NO_3 (ppm)	0.038	1.800	0.190	0.019	0.072	0.038	0.049	0.480	0.071	*(p<0.01)	
PO_4 (ppm)	0.060	1.600	0.400	0.020	0.380	0.016	0.040	1.540	0.600	*(p<0.01)	
SO_4 (ppm)	11.600	18.400	12.600	14.800	18.500	14.500	11.900	12.900	10.400	*(p<0.01)	*(p<0.01)
BOD (ppm)	6.800	109.400	5.900	3.200	69.400	2.200	4.000	70.400	5.000	*(p<0.01)	
COD (ppm)	23.200	46.500	32.500	22.000	51.000	39.800	19.200	49.600	30.800	*(p<0.01)	

**(p<0.01) indicates highly significant differences

*(p<0.01) and *(p<0.05) indicates significant differences

Table 2: Mean values of phytoplanktons (units/ml) at different sampling stations in the river Rapti at Gorakhpur during summer, winter and rainy seasons.

	Tests	Stations									Between Stations	Between Seasons
		Summer			Winter			Rainy				
		R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}		
Bacillariophyceae	*Amphora sp.*	183.30	125.00	75.00	241.60	166.60	100.00	183.30	58.30	150.00	*(p<0.05)	
	Navicula sp.	266.60	166.60	166.60	233.30	200.00	66.60	225.00	100.00	83.30	*(p<0.01)	
	Fragilaria sp.	316.60	283.30	283.30	250.00	100.00	175.00	66.60	83.30	83.30		*(p<0.01)
	Nitzschia sp.	183.30	58.30	66.60	100.00	-	-	58.30	66.60	50.00	*(p<0.05)	
	Gomphonema sp.	208.30	175.00	141.60	200.00	166.60	100.00	100.00	66.60	-	*(p<0.01)	**(p<0.01)
	Pinnularia sp.	175.00	66.60	91.60	266.60	83.30	100.00	100.00	58.30	-	*(p<0.01)	*(p<0.05)
	Synedra sp.	225.00	200.00	166.60	-	-	-	100.00	-	83.30		*(p<0.01)
	Gyrosigma sp.	125.00	75.00	83.30	-	-	-	141.60	100.00	100.00	*(p<0.05)	*(p<0.01)
	Surirella sp.	-	-	-	-	-	-	100.00	-	66.60		*(p<0.01)
	Diatoma sp.	133.30	66.60	75.00	125.00	-	100.00	-	-	-		*(p<0.05)
	Melosira sp.	166.60	-	100.00	-	-	-	-	-	-		*(p<0.05)
	Total	**1983.00**	**1216.40**	**1249.60**	**1416.50**	**716.50**	**641.60**	**1074.80**	**533.10**	**616.50**		
Chlorophyceae	*Chlorella sp.*	175.00	-	66.60	-	-	-	-	-	-		
	Scenedesmus sp.	133.30	50.00	175.00	150.00	-	200.00	150.00	66.60	91.60	*(p<0.01)	
	Zygnema sp.	275.00	83.30	141.60	116.60	-	58.30	-	-	-		*(p<0.01)
	Volvox sp.	133.30	66.60	91.60	-	-	-	150.00	50.00	83.30	*(p<0.05)	*(p<0.01)
	Ankistrodesmus sp.	300.00	166.60	225.00	250.00	75.00	66.60	-	-	-		*(p<0.01)
	Ulothrix sp.	100.00	58.30	75.00	200.00	75.00	91.60	150.00	50.00	100.00	*(p<0.01)	
	Cosmarium sp.	133.30	50.00	166.60	66.60	75.00	100.00	-	-	-		*(p<0.01)
	Mougeotia sp.	200.00	66.60	100.00	-	-	-	141.60	75.00	83.30		*(p<0.01)
	Pediastrum sp.	-	-	-	166.60	50.00	100.00	-	-	-		*(p<0.01)
	Spirogyra sp.	166.60	58.30	200.00	200.00	-	75.00	-	-	-		*(p<0.05)
	Total	**1616.50**	**599.70**	**1241.40**	**1149.80**	**275.00**	**691.50**	**591.60**	**241.60**	**358.20**		

Table 2: Continued…

Tests		Stations									Between Stations	Between Seasons
		Summer			Winter			Rainy				
		R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}	R_{S1}	R_{S2}	R_{S3}		
Cyanophyceae	*Microcystis sp.*	291.60	300.00	100.00	133.30	166.60	150.00	-	-	-		*(p<0.01)
	Oscillatoria sp.	200.00	266.60	100.00	166.60	166.60	75.00	100.00	125.00	100.00	*(p<0.05)	
	Anabaena sp.	200.00	200.00	200.00	166.60	175.00	50.00	100.00	133.30	91.60		*(p<0.05)
	Merismopedia sp.	100.00	200.00	100.00	-	-	-	-	-	-		*(p<0.01)
	Spirulina sp.	100.00	100.00	66.60	-	-	-	-	-	-		*(p<0.01)
	Nostoc sp.	166.60	266.60	183.30	75.00	158.30	66.60	-	-	-	*(p<0.05)	*(p<0.01)
	Total	**1058.20**	**1333.20**	**749.90**	**541.50**	**666.50**	**341.60**	**200.00**	**258.30**	**191.60**		
Euglenophyceae												
	Euglena sp.	200.00	75.00	66.60	100.00	-	66.60	-	-	-		*(p<0.05)
	Phacus sp.	100.00	100.00	175.00	150.00	-	100.00	-	-	-		*(p<0.05)
	Total	**300.00**	**175.00**	**241.60**	**250.00**	**-**	**166.60**	**-**	**-**	**-**		

**(p<0.01) indicates highly significant differences
*(p<0.01) and *(p<0.05) indicates significant differences

Cyanophyceae:

Cyanophyceae was represented by 6 species of which *Microcystis sp., Oscillatoria sp., Anabaena sp., Merismopedia sp., Spirulina sp.*and *Nostoc sp.* In the present study maximum number of species of Cyanophyceae 1333.2 units/ml in summer season was recorded at station R_2. Minimum number of species 191.6 units/ml in rainy season was recorded at station R_3.

Euglenophyceae:

Only two species of Euglenophyceae were recorded that is *Euglena sp*. and *Phacus sp.* In the present study maximum number of species of Euglenophyceae 300 units/ml in summer season was recorded at station R_1. Minimum number of species 166.6 units/ml in summer season was recorded at station R_3. Group Euglenophyceae was absent in rainy season.

DISCUSSION

In present investigation an increase in electrical conductivity, TDS, free CO_2, bicarbonate alkalinity, total, Ca and Mg hardness, chloride, nitrate, phosphate, sulphate, BOD and COD while a decrease in pH, DO_2 and carbonate alkalinity was observed at sewage mixing point. However, these parameters gradually changed at the station away from sewage mixing point (downstream). A highest value of electrical conductivity was recorded at station R_2 in summer season. This might be due to the addition of sewage into it. An increase in electrical conductivity is regarded as pollution indicator in water bodies (Das et al., 2006; Agarhari and Kushwaha, 2012). An increase in TDS at station where sewage meets river water indicates an increase in pollution. Water with high dissolved solid is of inferior quality and may induce adverse response in the body of the consumer (Agarhari and Kushwaha, 2012; Mahor, 2011). Low level of DO is again indicative of polluted nature of water body. Such low level of oxygen was also noted by Iqbal et al. (2006). At station R_2 saturation level of dissolved O_2 was very low in winter and rainy season. It may be due to high rate of oxygen consumption by oxidizable matter coming in along with sewage. Free CO_2 present in large amount at station R_2 can be attributed to high BOD load that comes with consumption of oxygen and release of CO_2 by the respiratory activity of the living organisms. Maximum values of free CO_2 recorded at station R_2 during summer might be due to acceleration in the rate of decomposition of organic matter by microbes, decrease of photosynthetic activity and high rate of respiration by benthic biota and microorganisms as observed by Hedge and Bharti (1985) and Sinha (1988). Maximum values of bicarbonates alkalinity recorded at station R_2 and R_3 were probably due to the input of domestic sewage. Shah (1988) noticed higher concentration of bicarbonate alkalinity in the domestic sewage during the study of river Jhelum. High fluctuation of Ca, Mg and total hardness were recorded at station R_2. In the present study higher values of Ca, Mg and total hardness observed at all the three sampling stations (Table 1 and 2) may be due to input of domestic sewage which contains organic matters. Cl_2 was found to be highly marked, higher values of Cl_2 recorded at station R_2 was due to the continuous influx of contaminated domestic sewage. Similar results are reported by Sinha (1988) in the case of river Yamuna and river Damodar. The maximum values of phosphate observed at station R_2, in comparison to other stations throughout the study period may be due to the discharge of contaminated domestic sewage containing decayed organic matter (Shah, 1988; Rana and Palria, 1988). Higher values were recorded at station R_2, owing to high amount of organic matter in domestic sewage (Paramshivam and Sreenivasan (1981) and Somashekar (1985) also reported that an increase in BOD and bacterial level as indicative of increasing pollution, which is supported by Sinha (1988). Station wise, maximum values of COD were recorded at station R_2 indicating presence of organic wastes in sewage.

In present investigation it was observed that population of phytoplankton was low at station R_2 where sewage mixed into river. This lowering of phytoplankton population at station R_2 is due to the presence of organic and inorganic matters of sewage that affects the physico-chemical quality of water as evidenced earlier by many workers (Kang et al., 2004; Shirodkar et al., 2010; Bhardwaj et al., 2010). And physico-chemical properties show effect on the phytoplankton diversity. Many previous studies showed the effect of physico-chemical parameters on plankton community. Hassan *et al*., (2008) studied the effect of chemical and physical properties of River water in Shatt-AI-Hilla on phytoplankton communities, Sukumaran and Das, (2002) reported that the basic process of phytoplankton production was dependent upon temperature, turbidity and nutrients. The role of temperature in the development of algae has been emphasized by many workers from time to time (Palharya et al., 1993). Limnological studies of water quality are based on the principle that every type of aquatic ecosystem is associated with one specific community of organisms, the living communities that develop in aquatic ecosystems depend on specific physico-chemical characteristics of water and are noticeably modified when those conditions change (Kushwaha and Agrahari, 2014). Factors such as dissolved oxygen, transparency, depth, salinity, pH, temperature and nutrients influence the occurrence, abundance and distribution of Planktonic organisms (MBO, 2007) and effect their composition and distribution from place to place and year to year due to the dynamic nature of the aquatic system (FAO, 2006). In present observation temperature shows a moderate value in summer season which is favorable for growth of phytoplankton. Nutrients (nitrates and phosphates) showed low values in both seasons where as it increases at station-R_2 due to presence of domestic sewage. Dissolved Oxygen decreases at station R_2 that causes lowering of phytoplankton population. Presence of Dissolved oxygen is essential to maintain the biological life in the water Palhrya, et al., 1993). In this observation it was found that group Cyanophyceae showed higher population at station R_2 in comparison to other station because member of Cyanophyceae group are known to be highly adaptive and can colonize even the polluted area (Palhrya, et al., 1993). Present observation also showed seasonal variations in phytoplankton communities, phytoplankton productivity was high during summer and low during winter season as evidenced earlier by Sadguru et al., (2002), Sharma et al., (2011) and Agrahari and Kushwaha (2012). The lowering of population of phytoplankton in winter can be attributed to low temperature (Sadguru et al., 2002; Hassan et al., 2008; Gross and Pfiester, 1988).

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