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EFFECT OF DOMESTIC SEWAGE ON THE PHYSICO-CHEMICAL QUALITY OF RIVER RAPTI AT GORAKHPUR

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ABSTRACT

Present paper deals with fluctuations observed in physicochemical properties of water of river Rapti at Gorakhpur due to drainage of sewage into it. 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 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 indicating river water safe for growth of aquatic life.

INTRODUCTION

Sewage is the used water of community. It contains water born wastes from residences, business houses and industries. The chemical composition of sewage varies from day to day. It also varies considerably between different cities. Sewage water contains inorganic wastes which creates problems of disposal. It also contains organic matters which may be offensive and dangerous. It has been observed that a number of serious diseases are transmitted through sewage water for example typhoid, gastrointestinal problems, cholera, dysentery, nematodes infection etc. The properties of the water are continuously being disturbed by using rivers and other water bodies as dumping ground of human sewage and industrial wastes. Increase in population, industrialization and urbanization has further increased this problem. Fast urbanization, industrialization resulting in discharge of untreated waste water, coupled with massive abstraction of water for irrigation, industrial and domestic uses, lack of awareness and seasonal variations are the main cause of water quality degradation in the rivers (Trivedi, 2010; Joshi *et al.*, 2006). The utility of river water for various purposes is governed by physico-chemical and biological quality of the water. The assessment of the changes in river communities as a result of the impact of pollution is particularly interesting issue within the frame work of aquatic ecology, since running waters are becoming increasingly affected by anthropogenic discharge (Whitton *et al.*, 1991). Many workers have studied the impact of anthropogenic activities on the environmental conditions (Kang *et al.*, 2004; Shirodkar *et al.*, 2010; Bhardwaj *et al.*, 2010). For optimum development and management of water current information on water quality can not be denied. Therefore, an attempt to study the effect of sewage dumped into the water of river Rapti, a tributary of Ghaghra near Gorakhpur, Uttar Pradesh, India is made in this study.

MATERIALS AND METHODS

Sampling stations

Three water sampling stations were selected over 6 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 3kms away from the station I, station III (R_3): downstream of sewage discharge point, about 3 kms away from station II.

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.

Methods for analysis of physico-chemical parameters

The physico-chemical analysis was carried out using the methods given by APHA, 1976; Trivedi and Goel, 1986 and Adoni, 1985. 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.

RESULTS AND DISCUSSION

The average physico-chemical quality of river Rapti at three sampling stations in Gorakhpur during summer and winter season are presented in Table 1 and 2. Temperature of the river water changed through out the year from 19.9 to 20.0ºC in winter and 33.2 to 33.8ºC in summer season. The pH value of the river water at different stations was recorded to be within 7.0 to 8.2 in winter and 7.4 to 8.5 in summer season. Electrical conductivity of water at different stations was recorded to be 201 to 264 μmhos/cm in winter and 220 to 404 μmhos/cm in summer season. Rise in temperature during summer can be attributed to decrease in water level, low current velocity, clear atmosphere and greater solar radiation. Minimum water temperature in winter months can be explained on the basis of high current velocity and high water level. Low values of pH in winter season and higher values in summer season might be due to an increase in temperature that results in reduction of the solubility of the CO_2 in water (Patil, 1982). Natural water has low conductivity, but pollution increases it. Most of the salts dissolved in water can conduct electricity. Thus, the electrical conductivity of water depends upon the concentration of ions and the status of nutrient in it. Highest value, 404 μmhos/cm, was recorded at station II 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)

Total dissolved solids varied from 110 to 207 ppm in winter season and 122 to 260 ppm in summer season. 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 (Mahor, 2011). However, the fluctuation observed in TDS was well within limits as a maximum value of 400 mg/L of TDS is permissible for diverse fish population (Chhatwal, 1998).

Dissolved O_2 ranged between 3.6 to 10.2 ppm during winter and 2.4 to 7.6 ppm during summer. 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) on addition of sewage waste from human settlements to Dal Lake. Dissolved oxygen shows an inverse relationship with water temperature. Higher values of DO observed during winter, when temperature was lowest, might be due to the fact that the solubility of oxygen in water increases with decrease in temperature (Singh *et al.,* 1980; Ali, 1999). At station II saturation level of dissolved O_2 was very low (2.4 ppm) in summer and (3.6 ppm) in winter. It may be due to high rate of oxygen consumption by oxidizable matter coming in along with sewage.

Free CO_2 ranged between 2 to 6 ppm in winter and 6 to 20 ppm in summer season. Free CO_2 present in large amount at station II 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 (20 ppm) recorded at station II 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 Bhatt *et al.*, 1985; Hedge and Bharti, 1985; Adoni, 1985; Sunder, 1988; Sinha, 1988 and Pandey *et al.*, 1988.

The carbonate alkalinity varied from 4.0 to 14.4 ppm in winter season and 8 to 24.4 ppm in summer season. Bicarbonate alkalinity varied from 204 to 660 ppm in winter season 128 to 762 ppm in summer season. The increased values of carbonate alkalinity in summer months over the winter were observed reaching maximum 24.4 ppm and coincided with the decrease in water level, rise in temperature and increase in the productivity. Khan and Siddique, (1970) reports similar fluctuations in the values of carbonate alkalinity mainly due to photosynthetic activity of aquatic plants and phytoplankton's. Minimum values (4.0 ppm) of carbonate alkalinity were recorded during winter months, presence of carbonate alkalinity is an indication of higher rate of carbon assimilation, an increase in alkalinity values may be due to decrease in the water level (Bhatnagar and Sharma, 1973). An increase in bicarbonates with decreases in water level is also reported by Singhal *et al.,* 1986. The accumulation of large quantities of bicarbonates during summer months may be due to low water level and presence of excess of free CO_2 produced as a result of the process of decomposition. Sundar, 1988 too observed accumulation of bicarbonates in summer due to increased rate of decomposition. Hedge and Bharati, 1985 noticed the high value of bicarbonates of Ca and Mg in summer months, when the temperature of water was high and the water level was low. Maximum values of bicarbonates alkalinity recorded at station II and III 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.

Total hardness (188 to 424 ppm in winter and 200 to 492 ppm in summer), Ca hardness (49.7 to 95.6 ppm in winter and 65.4 to 216.8 ppm in summer) and Mg hardness (21.88 to 62.28 ppm in winter and 24.16 to 54.38 ppm in summer) was observed. Unni, 1985 has suggested that total hardness can be used as an indicator for clarifying domestic pollution. Maximum hardness recorded during summer at all the stations may be due to high temperature, low water level and addition of calcium and magnesium salts from detergent and soaps

Table 1: Mean values of physico-chemical parameters of water in river Rapti at Gorakhpur in winter season

Tests	Stations		
	R_1	R_2	R_3
Temperature(ºC)	20.0	20.0	19.9
pH	8.0	7.0	8.2
Electrical Conductivity(μmhos/cm)	201	264	224
Total Dissolved Solids(ppm)	110	207	164
Dissolved O_2(ppm)	10.2	3.6	8.2
Free CO_2(ppm)	2.0	6.0	2.0
Chloride(ppm)	20	270	48
Carbonate Alkalinity(ppm)	14.4	4.0	8.4
Bicarbonate Alkalinity(ppm)	208	660	301
Total Hardness(ppm)	188	424	220
Ca Hardness(ppm)	49.7	95.6	69.6
Mg Hardness(ppm)	21.88	62.28	24.0
Nitrate(ppm)	0.019	0.072	0.038
Phosphate(ppm)	0.02	0.38	0.016
Sulphate(ppm)	14.8	18.5	14.5
BOD(ppm)	3.2	69.4	2.2
COD(ppm)	22.0	51.0	39.8

Table 2: Mean values of physico-chemical parameters of water in river Rapti at Gorakhpur in summer season

Tests	Stations R_1	R_2	R_3
Temperature(°C)	33.5	33.8	33.2
pH	8.5	7.4	8.2
Electrical Conductivity(μmhos/cm)	220	404	309
Total Dissolved Solids(ppm)	122	260	182
Dissolved O_2(ppm)	7.6	2.4	6.9
Free CO_2(ppm)	8.0	20.0	6.0
Chloride(ppm)	35	285	46
Carbonate Alkalinity(ppm)	24.4	8.0	14.0
Bicarbonate Alkalinity(ppm)	372	762	608
Total Hardness(ppm)	200	492	268
Ca Hardness(ppm)	65.4	216.8	68.6
Mg Hardness(ppm)	24.16	54.38	39.64
Nitrate(ppm)	0.038	1.80	0.19
Phosphate(ppm)	0.06	1.60	0.40
Sulphate(ppm)	11.6	18.4	12.6
BOD(ppm)	6.8	109.4	5.9
COD(ppm)	23.2	46.5	32.5

used for washing cloths (Patil, 1982; Bagde and Verma, 1985; Ajmal and Razi-ud-din,1988). High fluctuation of Ca, Mg and total hardness were recorded at station II. 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. Higher content of Ca hardness during summer months may be due to rapid oxidation of organic matter added along with domestic sewage (Rai, 1974; Singh and Bhowmick, 1985; Datta *et al*., 1988; Sundar, 1988).

Chloride concentration ranged between 20 to 270 ppm in winter and 35 to 285 ppm in summer season. High chloride concentration was recorded at station II due to addition of domestic sewage. Maximum value of Cl_2 recorded during summer and winter months at all the stations and could be attributed to input of highly soluble Cl_2 salts through run-off from the human settlements, presence of large amount of organic matter of both allocthanous and autocthanous origin and high rate of evaporation coupled with the low current velocity of the river water (Pandit, 1999). Similar observations were made by Rao, 1971, 1972; Prasad and Qayynm, 1976 which has been further supported by Sunder, 1988 in the study of river Jhelum and river Hindon. Harrison, 1999 reported that the chloride concentration depends on the water level. When the water level decreases, the Cl_2 concentration increases, they further observed that when water level rises due to rain, the consequent dilution decreases the Cl_2 concentration. Station wise variation of Cl_2 was found to be highly marked, higher values (270-285 ppm) of Cl_2 recorded at station II 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.

Nitrate was between 0.019 to 0.072 ppm in winter and 0.038 to 1.80 ppm in summer. Nitrate is one of the most important indicators of pollution of water. The most important source of the nitrate is biological oxidation of organic nitrogenous substances which come in sewage and industrial wastes or produced indigenously in the water.

Phosphate was found to be 0.016 to 0.38 ppm in winter and 0.06 to 1.60 ppm in summer season. Sulphate, common form of sulphur in freshwater (Wetzel, 2001), varied from 14.5 to 18.5 ppm in winter and 11.6 to 18.4 ppm in summer. Increased application of fertilizers, use of detergents and domestic sewage greatly contribute to the heavy loading of phosphorus in the water (Golterman, 1975). Maximum amount of phosphate during summer and minimum amount of sulphur through out the year was observed in the present study. The maximum values of phosphate (1.60 ppm) observed at station II, 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; Somashekar, 1988; Ghose and Sharma, 1988).

The BOD and COD of river water varied from 2.2 to 69.4 ppm in winter and 5.9 to 109.4 ppm in summer season and 22.0 to 51.0 ppm in winter and 23.2 and 46.5 ppm in summer respectively. Higher values of BOD during summer months may be attributed to the maximum biological activity at elevated temperature, whereas the lowest BOD in winter indicated lower biological activity. Similar observations were made by Agrawal *et al.,* 1976; Rai, 1978; Bagde and Verma, 1985; Rao *et al*., 1985 and Sengar *et al*., 1985. Station wise, the BOD values show high fluctuation primarily due to the addition of domestic sewage. Higher values (69.4 ppm in winter and 109.4 ppm in summer) were recorded at station II, owing to high amount of organic matter in domestic sewage (Paramshivam and Sreenivasan, 1981; Somashekar, 1985; Kudesia and Verma 1986). Rao, (1976); Campbell, (1978); Mahadevan and Krishnaswamy, (1984) also reported that an increase in BOD and bacterial level as indicative of increasing pollution, which is supported by Sinha, (1988) Chandrashekar *et al*., 2003. The highest values of COD were noted in month of winter and lowest values of COD were recorded in summer season. Station wise, maximum values of COD were recorded at station II indicating presence of organic wastes in sewage.

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