The Ecoscan 4(4) : 313-316, 2010
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.in

ASSESSMENT OF CHEMICAL LOAD OF RIVER BARAKAR AND DAMODAR WITH RESPECT TO CONTAMINATION OF MUNICIPAL SEWAGE

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ABSTRACT

The present study was conducted to determine the physicochemical characteristics along with heavymetals in the river water. The pH was found in the alkaline range (7.5 - 8.8), while conductance was obtained in the range of 150 - 540 μS/cm. Manganese (Mn), iron (Fe) and lead (Pb) in the range of 0.005 - 0.217 mg L^{-1}, 0.14-1.125 mg L^{-1}, 0.00 - 0.095 mg L^{-1} respectively. Maximum mean concentration of Fe (0.728 mg L^{-1}) was observed in premonsoon season, Mn (0.120 mg L^{-1}) in monsoon but Pb (0.039 mg L^{-1}) exhibited their maximum during the postmonsoon season. Fe, Mn and Pb concentration also varied with the change of sampling locations. The highest mean concentrations (mg L^{-1}) of Fe (0.581) were observed at site 1 at river Barakar, those for Mn (0.097), Pb (0.034), EC (340) and TDS (221.19) at site 2 of river Barakar at municipal wastewater discharge point, whereas the maximum of HCO_3 (149.33) and K (5.06) was obtained at the downstream station, Asansol at river Damodar. The concentration of various heavy metals in the surface water of the river Damodar followed the sequence: Fe>Mn>Pb. Most of the parameters including heavymetals showed elevated concentrations during premonsoon season, while least concentrations were observed during monsoon season. Continuous assessment of river water quality on routine basis is imperative and a sustainable management is required to reduce the pollution.

KEY WORDS
Seasonal variation
River water
Municipal wastewater Heavymetal
Nutrient enrichment

Received : 25.08.2010
Revised : 22.10.2010
Accepted : 17.11.2010

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INTRODUCTION

The anthropogenic inputs of sewage, without prior treatment, in aquatic environments, affect the geochemical composition of receiving water bodies. Indiscriminate and unscientific disposal of municipal sewage has severely deteriorated the aquatic environment leading nutrient enrichment of the receiving water body (Akpan, 2004) which in turn affects environmental health worldwide. If massive amount of wastewater from municipal sewage are treated properly those may be potentially used for fish production, irrigation aquaculture and for many other uses. Nutrient enrichment of lakes, reservoirs, wetlands, rivers and streams is one of the most prevalent environmental problems responsible for freshwater quality degradation on a worldwide scale (Harper, 1992; Welch and Lindell, 1992; Smith *et al.*, 1999; Biggs, 2000; Dodds and Welch, 2000; Newall and Tiller, 2002) and causes due to urban and agricultural runoff, industrial wastes, and sewage effluents. Anthropogenic activities at basin scales cause increased waterborne pollution from point and diffuse sources, affecting aquatic ecosystems. Various works regarding water Quality influenced by municipal sewage and effluents have been carried out on Ganga (Sinha *et al.*, 1991), Kathajodi River in Cuttack city in Orissa (Das and Acharya, 2003, Girija *et al.*, 2007) in India.

Heavy metals in drinking water represent a variety of health concerns among them some are known or suspected carcinogens, such as lead and cadmium. Metals like manganese, chromium, copper, nickel and zinc are essential to human nutrition at low doses, yet demonstrate adverse health effect at higher doses (NAS SDWC, 1977; N.R.C., 1989). Various pathophysiological effects, including interference with heme synthesis, anemia, kidney damage, and elevations in blood pressure is occurred due to lead exposure when across a broad range of blood lead levels (U.S.E.P.A., 1990). The heavymetal lead (Pb) has no known physiological activity, but they are detrimental beyond a certain limit (Marschner, 1995; Bruins *et al.*, 2000). Therefore, monitoring of lead is important for safety assessment of the environment in general and human health in particular. The deficiency or excess of certain trace elements in irrigation water have a great significance as it can retard growth and metabolic activities. The trace elements in water, especially heavy metals, can impact on human health.

So neither the nutrient value nor the toxicity of trace elements in irrigation water can be ignored. Heavy metal residues in contaminated sediments may accumulate in microorganisms, aquatic flora and fauna which in turn, may enter into the food chain and eventually causes various human health problems (Cook *et al.*, 1990; Deniseger *et al.*, 1990). The poor quality of water can also adversely affect the plant growth and human health (Wilcox, 1948; Thorne and Peterson, 1954; US Salinity Laboratory Staff, 1954; Holden, 1971; Todd, 1980; Hem, 1991; Karanth, 1997) and causes various environmental consequences. It is an urgent necessity to monitor the water quality of rivers periodically. The objectives of the present study were to determine various physicochemical parameters and the distribution of some heavymetals like lead (Pb), iron (Fe) and manganese (Mn) in river Barakar and Damodar.

MATERIALS AND METHODS

Collection of samples

Surface water was sampled for physico-chemical analysis in a seasonal basis (premonsoon, monsoon and postmonsoon) from river Damodar and its tributary river Barakar. Samples were collected from four sampling stations S1"S3 (river Barakar) and S4 (river Damodar). Grab samples of river water were taken at a depth of 15 cm below the surface in triplicate and mixed to get a composite sample for each spot. Water was stored in highgrade plastic bottles of 1-Lit capacity. All the sample bottles were stored in ice boxes and brought to the laboratory for further analysis.

Chemical analysis

Various physicochemical parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), calcium(Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^{-}), fluoride (F^{-}), nitrate (NO^{3-}), bicarbonate(HCO_3^{-}), sulphate ($SO4^{2-}$), Phosphate (PO_4^{3-}), sodium (Na^{+}), potassium (K^{+}), iron (Fe), manganese (Mn), lead (Pb) were determined following the methods of APHA (1998). Electrical conductivity (EC) and pH values were measured in the field using a portable conductivity and pH meter. The samples were preserved at 4^0C in the laboratory for trace metal and nutrients analysis. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined using the titrimetric method. Chloride (Cl) concentration was measured by $AgNO_3$ titration method and bicarbonate (HCO_3^{-}) was determined using acid titration method; sulfate measured by $BaCl_2$ method using spectrophotometer. Phosphate (PO_4^{3-}) and nitrate analysis was carried out using spectrophotometer; sodium (Na^{+}) and potassium (K^{+}) was analyzed using flame photometer. The concentration of heavymetals in water was estimated by Atomic Absorption Spectrophotometer (GBC Avanta).

RESULTS AND DISCUSSION

Physico-chemical characteristics of river water

The physico-chemical properties of water and different heavymetal concentrations are presented in the Table 1. Any alteration in water pH is accompanied by the change in other physicochemical parameters; its values ranged from 7.6 (S4) to 8.8 (S1) during premonsoon sampling; 7.7 (S1) to 8.1 (S2) during monsoon sampling and 7.5 (S4) to 7.9 (S1) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). The electrical conductivity is a valuable indicator of the amount of material dissolved in water; and its values ranged from 220 μS/cm (S4) to 540 μS/cm (S2) during premonsoon sampling; 150 μS/cm (S3) to 210 μS/cm (S2) during monsoon sampling and 200 μS/cm (S1) to 280 μS/cm (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Total dissolved solids (TDS) indicates the general nature of water quality or salinity; and its values ranged from 132 mg L^{-1} (S4) to 357.6 mg L^{-1} (S2) during premonsoon sampling; 103 mg $L^{"1}$ (S4) to 145 mg L^{-1} (S2) during monsoon sampling and 122 mg L^{-1} (S1) to 179 mg L^{-1} (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table I).

Sulphate concentration in the study area ranged from 21.11 mg L^{-1} (S1) to 59.4 mg L^{-1} (S2) during premonsoon sampling; 10.24 mg L^{-1} (S1) to 42.53 mg L^{-1} (S2) during monsoon sampling and 7.25 mg L^{-1} (S1) to 28.22 mg L^{-1} (S4) during postmonsoon sampling with a wide range of fluctuations at different locations (Table I). Phosphate is always indicative of eutrophy; and its values ranged from 0.06 mg L^{-1} (S4) to 1.84 mg L^{-1} (S2) during premonsoon sampling; 0.01 mg L^{-1} (S1) to0.19 mg L^{-1} (S2) during monsoon sampling and 0.04 mg L^{-1} (S1) to 0.05 mg L^{-1} (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table I). Nitrate is commonly present in surface water; and its values ranged from 1.45 mg $L^{"1}$ (S2) to 3.61 mg L^{-1} (S1) during premonsoon sampling; 0.00 (S4) to 3.85 mg L^{-1} (S2) during monsoon sampling and 0.14 mg L^{-1} (S4) to 1.35 mg L^{-1} (S1) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). The nutrients-NO_3^{-} and PO_4^{3-} exhibited seasonal variation in this study indicating higher concentration during the summer season and lowest concentration during monsoon due to precipitation and dilution.

Sodium concentration is very important parameter for irrigation water quality; and its values ranged from 12.35 mg L^{-1} (S2) to 19.32 mg L^{-1} (S1) during premonsoon sampling; 5.36 mg L^{-1} (S3) to 14 mg L^{-1} (S2) during monsoon sampling and 98.24 mg L^{-1} (S1) to 14.2 mg L^{-1} (S4) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Potassium concentration in the study area ranged from 2.5 mg L^{-1} (S4) to 6.5 mg L^{-1} (S3) during premonsoon sampling; 1.25 mg L^{-1} (S1) to 5.36 mg L^{-1} (S4) during monsoon sampling and 2.5 mg L^{-1} (S1) to 47.32 mg L^{-1} (S4) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Chloride is one of the important indicators of pollution; and its values ranged from 10.2 mg L^{-1} (S4) to 32.56 mg L^{-1} (S1) during premonsoon sampling; 4.25 mg L^{-1} (S4) to 12.32 mg L^{-1} (S1) during monsoon sampling and 7.32 mg L^{-1} (S1) to 17.32 mg L^{-1} (S1) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Fluoride concentration in the study area ranged from 0.36 mg L^{-1} (S4) to 0.86 mg L^{-1} (S3) during premonsoon sampling 0.25 mg L^{-1} (S4) to 0.56 mg L^{-1} (S3) during monsoon sampling; and 0.469 mg L^{-1} (S2) to 1.37 mg L^{-1} (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1).

Calcium, an essential element for living organisms; and its values ranged from 15.14 mg L^{-1} (S3) to 22.71 mg L^{-1} (S1) during premonsoon sampling; 12.62 mg L^{-1} (S3) to 14.30 mg L^{-1} (S1 and S4) during monsoon sampling and 10.93 mg L^{-1} (S1) to 36.17 mg L^{-1} (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Magnesium, an essential nutrient for plants as well as for animals and its values ranged from 9.13 mg L^{-1} (S3) to13.43 mg L^{-1} (S4) during premonsoon sampling; 7.43 mg L^{-1} (S2) to 9.32 mg L^{-1} (S4) during monsoon sampling and 7.43 mg L^{-1} (S2) to 23.52 mg L^{-1} (S3) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). HCO_3 concentration in the study area ranged from 88 mg L^{-1} (S1) to 128 mg L^{-1} (S2) during premonsoon sampling; 92 mg

Table 1: Physico-chemical characteristics of Barakar and Damodar river water

Sites	Season	pH	EC	TDS	SO_4^{2-}	PO_4^{3-}	NO_3^-	Na^+	K^+	Cl^-	F^-	Ca^+	Mg^+	HCO_3^-	Mn	Fe	Pb
S1	Premonsoon	8.80	310	210.5	21.11	0.95	3.61	19.32	4.1	32.56	0.536	22.708	12.038	88	0.0238	0.479	0.002
	Monsoon	7.70	190	119.5	10.24	0.01	0.46	10.5	1.25	12.32	0.465	14.298	8.474	96	0.095	0.14	0.0017
	Postmonsoon	7.90	200	121.5	7.25	0.04	1.35	8.24	2.5	7.32	0.698	10.934	8.0503	144	0.027	1.125	0.044
	Mean	8.13	233	150.5	12.87	0.33	1.81	12.69	2.62	17.40	0.57	15.98	9.52	109.33	0.0486	0.5813	0.0159
	SEM	0.34	38	30.0	4.21	0.31	0.94	3.38	0.82	7.72	0.07	3.50	1.26	17.49	0.0232	0.2889	0.014
	SD	0.59	67	52.0	7.29	0.53	1.62	5.85	1.43	13.36	0.12	6.06	2.19	30.29	0.0402	0.5004	0.0243
S2	Premonsoon	8.40	540	357.6	59.4	1.84	1.45	12.35	2.21	22.23	0.536	14.298	9.3214	128	0.0503	0.986	0.0078
	Monsoon	8.10	210	145.0	42.53	0.19	3.85	14	3.32	8.24	0.269	13.457	7.4294	208	0.217	0.253	0.00
	Postmonsoon	7.90	270	161.0	10.45	0.04	0.74	8.32	2.65	14.32	0.469	12.616	7.4343	96	0.024	0.49	0.095
	Mean	8.13	340	221.2	37.46	0.69	2.01	11.56	2.73	14.93	0.42	13.46	8.06	144.00	0.0971	0.5763	0.0343
	SEM	0.15	101	68.3	14.36	0.58	0.94	1.69	0.32	4.05	0.08	0.49	0.63	33.31	0.0604	0.216	0.0305
	SD	0.25	176	118.4	24.87	1.00	1.63	2.92	0.56	7.01	0.14	0.84	1.09	57.69	0.1047	0.374	0.0528
S3	Premonsoon	8.10	410	259.4	35.21	0.86	2.05	16.6	6.5	17.32	0.864	15.139	9.1288	204	0.0158	0.69	0.0185
	Monsoon	7.80	150	109.6	15	0.08	0.96	5.36	2.34	8.65	0.56	12.616	7.4343	92	0.163	0.536	0.00
	Postmonsoon	7.90	280	178.5	11.35	0.05	0.14	12.45	4.21	14.32	1.368	36.165	23.517	136	0.006	0.245	0.009
	Mean	7.93	280	182.5	20.52	0.33	1.05	11.47	4.35	13.43	0.93	21.31	13.36	144.00	0.0616	0.4903	0.0092
	SEM	0.09	75	43.3	7.42	0.27	0.55	3.28	1.20	2.54	0.24	7.46	5.10	32.58	0.0508	0.1305	0.0053
	SD	0.15	130	75.0	12.85	0.46	0.96	5.68	2.08	4.40	0.41	12.93	8.84	56.43	0.088	0.226	0.0093
S4	Premonsoon	7.60	220	131.5	32.32	0.06	1.86	18.32	2.5	10.2	0.358	17.662	13.433	204	0.1688	0.756	0.025
	Monsoon	8.00	180	103.0	12.54	0.02	0	9.5	5.36	4.25	0.245	14.298	9.3214	88	0.005	0.47	0.00
	Postmonsoon	7.50	200	129.9	28.22	0.04	0.75	14.2	7.32	17.3	0.725	15.139	10.194	156	0.022	0.36	0.009
	Mean	7.70	200	121.5	24.36	0.04	0.87	14.01	5.06	10.58	0.44	15.70	10.98	149.33	0.0653	0.5287	0.0113
	SEM	0.15	12	9.2	6.03	0.01	0.54	2.55	1.40	3.77	0.14	1.01	1.25	33.65	0.052	0.118	0.0073
	SD	0.26	20	16.0	10.44	0.02	0.94	4.41	2.42	6.53	0.25	1.75	2.17	58.29	0.09	0.2044	0.0127

All parameters except pH and EC (µS/cm) are expressed in milligrams per liter

L^{-1} (S3) to 208 mg L^{-1} (S2) during monsoon sampling and 96 mg L^{-1} (S2) to 156 mg L^{-1} (S4) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1).

Heavy metal concentration in river water

Manganese (Mn) concentration in the study area ranged from 0.016 mg L^{-l} (S3) to 0.169 mg L^{-l} (S4) during premonsoon sampling; 0.005 mg L^{-1} (S4) to 0.217 mg L^{-1} (S2) during monsoon sampling; and 0.006 mg L^{-1} (S3) to 0.027 mg L^{-1} (S1) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). The manganese (Mn) concentrations in the river water are below or close to the standard drinking water quality guideline (0.4 mg L^{-1}) suggested by WHO (2006). Iron values in the study area ranged from 0.479 mg L^{-1} (S1) to 0.986 mg L^{-1} (S2) during premonsoon sampling; 0.140 mg L^{-1} (S1) to 0.536 mg L^{-1} (S3) during monsoon sampling and 0.245 mg L^{-1} (S3) to1.125 mg L^{-1} (S1) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1).

Lead is an extremely pervasive and toxic environmental contaminant; and its values ranged from 0.002 mg L^{-1} (S1) to 0.025 mg L^{-1} (S4) during premonsoon sampling; 0.00 mg L^{-1} (S2, S3, S4) to 0.002 mg L^{-1} (S1) during monsoon sampling and 0.009 mg L^{-1} (S3) to 0.095 mg L^{-1} (S2) during postmonsoon sampling with a wide range of fluctuations at different locations (Table 1). Pb values were characterized by remarkable seasonal variations and fluctuated between 0.00 to 0.095 mg L^{-1}. The lead (Pb) concentrations in some sites of the studied river is exceeds the standard drinking water quality guideline (0.01 mg L^{-1}) suggested by WHO (2006). The increase in lead concentration in the Damodar river water may be due to the direct discharge from different sources (industrial waste and atmospheric inflow of dust containing car exhausts). The concentration of dissolved metals in the study area shows decreased values in the monsoon season as compared to nonmonsoon season, which is perhaps due to the dilution effect of the rain fall.

CONCLUSION

The study reveals that there is a considerable variation in the concentration of heavy metals in water samples. These variations may be due to the change in the input of munincipal sewage waste being added to river. From the above studies at the discharge area it has been found that the sewage water is rich in essential major nutrients (N, P, K) as well as manganese (Mn) as micronutrients. Increase of NO_3^- in sewage may cause eutrophication when it regularly mixes in the riverine aquatic system. Presence of fluoride bearing minerals in the host rocks and their interaction with river water is considered to be the main cause for fluoride. The result of the study showed a negative impact of the discharged municipal effluent on the receiving river and calls for a regular and consistent monitoring to ensure best management practices.

ACKNOWLEDGEMENT

The authors wish to thank Prof. J.K. Datta, Prof. A.R. Ghosh and Dr N.K. Mondal, Dept of Environmental Science, The University of Burdwan, West Bengal for their valuable suggestions and cooperation throughout this research work.

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Rivers are considered as one of the main resources of water supply for various applications such as agricultural, drinking and industrial purposes. Also, these resources are used as a place for discharge of sewages, industrial wastewater and agricultural drainage. Regarding the fact that each river has a certain capacity for acceptance of pollutants, nowadays qualitative and environmental investigations of these resources are proposed.Â Thus it becomes quite convenient to opine on the quality of the water tested with respect to its pollution level. Read more. Article. The chemical pollution of the river Ganga in Patna city in Bihar state has been found somewhat alarming beside the storm drain, especially in the regions like Rajapur, Mandiri and Krishnaghat. For some time now, this romantic view of the Ganges has collided with India's grim realities.Â Damodar River: Today the picture of Damodar or Damuda, considered a sacred river by the local tribals,in Jharkhand State of India is quite like a sewage canal shrunken and filled with filth and rubbish, emanating obnoxious odours. It is also contaminated with toxic metals like arsenic, mercury, flouride, and lead.Â Assessment of the water quality of Purna river, Valsad (Gujarat) with special reference to the heavy metal pollution, in Pollution and Biomonitoring of Indian Rivers. Ed. UNIVERSITY OF BELGRADE Faculty of Chemistry Assessment of the Factory Impact on Water Quality in Stira River.Â Sources of faecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff.Â Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives in it. Water pollution is the contamination of water bodies, e.g. lakes, rivers, oceans, and groundwater (AZEEM, 2014). 16 Natural water always contains dissolved and suspended substances of organic and mineral origin. Untreated sewage and industrial effluents together with reduced water flow and water level were found to increase bacterial counts during summer at Site 2 (Padma Garden). Although the present situation is not serious and alarming enough, the river water requires intensive monitoring to improve its quality for better and sustainable management.Â Most of the septic tanks of Rajshahi City are connected with municipal drains, which are one of the major sources of fecal coliform bacteria in Padma River.Â Higher temperature is also attributed to high load of indicator bacteria which was early reported by Isobe et al.Â Although during monsoon season water level of river was high, significant positive relation of FC with DO and BOD 5 indicates the mixing of domestic wastes along with flood water.