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Distribution of heavy metals in the sediments of Hooghly, Jalangi and Churni river in the regions of Murshidabad and Nadia districts of West Bengal, India

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Abstract: The industrial outburst, widespread uses of pesticides and fertilizers, heavy sewage effluents, domestic trash, and pharmaceutical waste through surface runoff have resulted in large scale increase in metal concentrations in surrounding water bodies. In eco-sensitive areas the scenario is becoming one of the major environmental concerns. The present investigation focused on the metal contents in sediments in three rivers of Nadia and Murshidabad districts (West Bengal, India). For sediments analysis 18 sampling sites were selected from three rivers—Hooghly, Churni and Jalangi. The major physicochemical parameters along with concentrations of six heavy metals, viz., chromium (Cr), copper (Cu), arsenic (As), nickel (Ni), zinc (Zn), and lead (Pb) in the river sediments were analyzed. The physicochemical parameters of the studied river sediments were found to be significantly correlated with each other and also correlated with heavy metals in Hooghly River sediment. The area-specific, certain heavy metal concentrations were observed to be significantly high, which may have adversely affected the concerned aquatic ecosystem. Among the studied three rivers, the Churni river was found to be highly contaminated with heavy metals. It has been identified that the main sources of these heavy metals are municipal sewage and runoff from agricultural fields.

Introduction

The world's major freshwater sources, such as rivers, are becoming polluted due to urbanisation and industrial expansion. The main causes of surface water pollution are industrial wastes, transportation using fossil fuels, agricultural leachate, and mining activities (Yong, 1999). The sediments are the ultimate sink of the river pollutants and contaminate the aquatic ecosystem (Mucha et al., 2003). River sediments are an essential ecological component of the riverine ecosystem and a major source of heavy metals in the aquatic environment (Gale et al., 2006). The four key processes—substrate sediment composition, suspended sediment composition, metals connection with distinct geochemical phases in sediments and water chemistry contribute to metal contamination and distribution in natural water bodies (Morillo et al., 2004; Mohiuddin et al., 2011, Bhattacharya et al., 2016). Heavy metal contaminations in river sediment significantly affect benthic and other aquatic organisms at lethal and sub-lethal levels (Cieniawski, 2002; Mohiuddin et al., 2010; Samal et al., 2013; Kjelland et al., 2015). The toxic river contaminants threaten human health through the food chain by bioaccumulation and biomagnifications in fishes (Mulligan et al., 2001; Lasheen and Ammar, 2009). The aquatic plants potentially accumulate heavy metals from sediment contamination around urban areas (Jha et

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al., 2016). The urban particulates also contaminate through toxic metals and contaminate nearby water bodies through surface runoff (Kar et al., 2006). The analysis of sediment quality is important for assessing the status of a total aquatic ecosystem (Adeyamo et al., 2008). Many researchers have investigated the distribution and sources of different heavy metals in different river sediments (Zheng et al., 2008; Barakat et al., 2012; Siddique and Aktar, 2012; Ekwere et al., 2013).

Various researches on heavy metal pollution of estuarine sediments and biota have been conducted around the world (Joseph and Srivastava, 1992; Mitra and Choudhury, 1993; Pa'ez-Osuna and Ruiz-Fernandez, 1995; Mitra, 1998; Miramand, et al., 2001; Bhattacharya, et al., 2001; Sarkar, et al., 2002; Ip et al., 2005; Samal et al., 2013, Chakraborty et al., 2019, Choudhury et al., 2021). Ramesh et al. (2000) estimated the distribution of unusual earth materials and heavy metals in the Himalayan river system's surficial deposits, i.e., Ganges, Yamuna, Brahmaputra, Padma and Meghna. Chakravarty and Patgiri (2009) studied the degree of metal contamination (Cu, Al, Fe, Pb, Mn, Zn, Cr, Ni, and Ti) in the sediments of the Dikrong River (North-East India). Malhotra et al., (2014) studied the soil chemistry of the Yamuna River in Yamuna Nagar (India) with a focus on industrial effluents. From Rishikesh to Allahabad, Goswami (2014) measured the concentrations of heavy metals such as Cd, Cu, Pb, and Zn ions in various matrices of the River Ganges. The levels of several trace elements in a section of the Subarnarekha river from the Chottanagpur Plateau to the lower basin were investigated (Manoj et al., 2012; Manoj and Padhy, 2014; Manoj et al., 2015). Two tributaries' worth of sediments (viz., Haldi and Rupnarayan) of the lower part of the Hugli estuary was investigated for Pb, Cd, Co, Ni, Zn, Fe, and Cu, with a variable correlation coefficient between the metals (Kumar et al., 2011). Banerjee and Gupta (2012) investigated the source and distribution of Cd, Mn, Fe and Pb in the sediment of the river Damodar near Asansol Industrial Area in West Bengal. They had reported the Pb concentrations in the range between 22.59 and 204.42 mg/kg, Mn from 57.25 to 345.86 mg/kg, Fe from 246.35 to 3,243.49 mg/kg, and Cd from 0.235 to 1.653 mg/kg. Bhattacharya et al., (2016) estimated the trace heavy metals in Hooghly river sediment through sequential extraction and observed on average 93% Pb, 70% Co, 62% Cd, and 55% of total Cu were present in the first three labile sequential extraction phases.

The purpose of this study was to determine the level of heavy metal concentrations and physicochemical characteristics of Hooghly, Jalangi, and Churni river sediments in the Nadia and Murshidabad districts of West Bengal, India. Moreover, it was also aimed to investigate the nat-ural and anthropogenic input of heavy metals and to draw attention on the relationships between heavy metal pollu-tion in the study area.

Materials and Methods

Study area

Sediment samples were taken from 18 sites along the Hooghly, Jalangi, and Churni rivers in West Bengal's Murshidabad and Nadia districts. In the river Hooghly, the samples were taken from 9 distinct locations, taking into account (i) in the upper stretch from Berhampore, Murshidabad (Sample ID: B1, B2, and B3 in Haridasmati Ghat, K. N. College Ghat, Dashamundu Kalibari Ghat, respectively), (ii) then from Nabadwip, Nadia, in the middle stretch of the river (Sample ID: N1, N2, and N3 in Fashitala Ghat, Dando Panitala Ghat, and Karmo Mandir Ghat, respectively), and (iii) in the lower stretch from Chakdah, Nadia (Sample site and ID: C1, C2,and C3 in Gour Gobindo Ghat, Poradanga Ghat, and Raninagar Ghat).

In the river Jalangi, samples were collected from 3 different sites of Mayapur (Sample ID and site: M1, M2, and M3 in Mayapur Ghat, Iscon Ghat, and Hulor Ghat, respectively).

In Churni river, the samples were collected from 6 different in Aranghata (Sample ID and site: A1, A2, and A3 in Aranghata Shashan Ghat, Aranghata Brij Ghat, and Aranghata Jugal Mandir Ghat, respectively.) and Ranaghat (Sample ID and site: R1, R2, and R3 in Thanapara Ghat, Boro Bazar Ghat, and Thanapara Ghat, respectively), Nadia, in the upper and lower stretch of this river respectively.

Samples collection

The sediment samples were collected from the shallow river bed in a composite sampling manner up to 6 cm depth with the help of a screw bottom soil sampler and hand shovel. The samples were transported to the Environmental Science laboratory of the Department of Environmental Science, University of Kalyani. Air-dried, homogenised, and sieved using a 2-mm polyethylene sieve to remove large debris, stones, and pebbles, then disaggregated with a porcelain pestle and mortar. The sediment samples were then placed in clean, self-sealing plastic bags for further examination.

Estimation of the physiochemical properties of the sediments

The pH of the soil was determined by a soil-water ratio of 1:5 (1 soil: 5 water) (Rayment & Higginson, 1992).

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Electrical conductivity was determined with the help of a conductivity meter in the same soil water ratio (Rayment & Higginson, 1992). Total organic carbon was analyzed by Walkley and Black method (modified) (Walkley & Black, 1934; Walkley, 1947). Nitrate concentration was measured by Phenol di-sulphonic acid method (APHA, 2003). Phosphate concentration was measured by Ammonium molybdate and Stannous chloride solution (APHA, 2003). Finally, hardness was determined by the EDTA method (APHA, 2003).

Estimation of the heavy metals in sediments

Sample digestion

The heating block digestion process was used to digest soil samples (Rahman et al., 2007). In a dry, clean digestive tube, 0.5 g of soil was placed, and 5 ml of 65% nitric acid was added. The combination was let to sit for a whole night. The digestion tubes were placed in the digestion chamber on a sand bath the next day, and the temperature was raised to 60 °C. The tubes were removed from the sand bath and allowed to cool after heating for 1 h at this temperature. The tubes were then heated again at 160 °C with 2 ml concentrated perchloric acid and 3 ml sulphuric acid added. When dense white perchloric acid fumes appeared, the heating operation was halted. The digests were chilled, then diluted to 25 ml with deionized water and filtered through filter paper into a plastic bottle.

Reduction process of arsenic

5 ml digested samples were taken in each tube from the container. 1ml of concentrated HCl, 1 ml of 5% KI, and 1 ml of 5% ascorbic acid were added respectively. Then it was incubated for 45 min. Volume was made up with 2 ml of Millipore water. Then the concentration of As was measured by FIAS attached with AAS.

Heavy metals analysis

The filtrate of the digested soil samples (n = 3) was analyzed for Cu, Ni, Zn, Cr, Pb using the Atomic Absorption Spectrophotometer (AAS) of the Perkin Elmer AAnalyst 400 model. The total arsenic in the samples was determined using an externally calibrated flow injection hydride generation atomic absorption spectrophotometer (FI-HG-AAS, Perkin Elmer A Analyst 400) (Welsch et al., 1990). The optimum HCl concentration was 10% v/v and 0.4% $NaBH_4$ produced the maximum sensitivity. Analytical grade reagents were used in the corresponding blank samples for calibration. To assure continuing accuracy, standard reference materials (SRM) from the National Institute of Standards and Technology (NIST) in the United States were analysed in the same way at the start, during, and after the measurements. Each sample's mean values from three replicates (n = 3) were calculated and considered.

Results and Discussion

Physiochemical characteristics of the river sediment

Variation of pH in Hooghly river and their tributary

The pH of the river water was unchanged significantly and observed a neutral to alkaline in nature (Table 1). The pH was observed in 7.67 to 7.9, where the lowest pH was observed in Aranghata in Churni river and the highest pH in Haridasmati Ghat (Berhampur region) of Hooghly river. In the Hooghly river, the average pH (7.816, 7.866, and 7.773) were noticed in Berhampore, Nabadwip, and Chakdah respectively. In the Churni River, the pH variation was observed as 7.683 and 7.826 in Aranghata and Ranaghat, respectively. In Mayapur region of Jalangi River exhibited a pH range of 7.83-7.87.

Variation of conductivity in Hooghly and their tributary

The average conductivity in the Berhampore, Nabadwip, and Chakdah regions of the Hooghly river was noticed as 3.621, 3.315, and 3.621 µS/cm, respectively (Table 1). In the Churni River, the average conductivity was observed as 7.344 and 5.355 µS/cm in Aranghata and Ranaghat, respectively. In Mayapur region of Jalangi River exhibited a conductivity range of 3.122-4.59 µS/cm. The highest conductivity of 9.72 µS/cm was noticed in Aranghata Shashan Ghat. The lowest conductivity of 3.06 µS/cm was noticed K. N. College Ghat and Gour Gobindo Ghat.

Variation of hardness in Hooghly and their tributary

The Hooghly river's average hardness in the Berhampore, Nabadwip, and Chakdah regions was noticed as 1731.133, 1198.766, and 6777.333 mg/kg respectively (Table 1). In the Churni River, the average hardness was observed as 1,515 and 2,046 mg/kg in Aranghata and Ranaghat, respectively. In Mayapur region of Jalangi River exhibited a hardness range of 1,469.6 mg/kg. The lowest hardness of 1,116.7 mg/kg was noticed in Karmo Mandir Ghat. The highest hardness of 9,418.8 mg/kg and 9298 mg/kg was noticed in Gour Gobindo Ghat and Raninagar Ghat.

Variation of organic carbon in Hooghly and their tributary

The average organic carbon (%) in the Berhampore, Nabadwip, and Chakdah regions of the Hooghly river were noticed as 0.876, 0.378, and 0.584%, respectively (Table 1). In the Churni River, the average organic carbon was observed as 1.770 and 2.097% in Aranghata and

Ranaghat, respectively. In Mayapur region of Jalangi River exhibited the organic carbon range of 0.928-1.651% (Average 1.203%). The highest organic carbon of 2.167% was noticed the Thanapara Ghat in the Churni River. The lowest organic carbon of 0.361% was noticed in Karmo Mandir Ghat and Fashitala Ghat in the Hooghly River.

0.176, 0.650, and 0.160 mg/kg, respectively (Table 1). In the Churni River, the average phosphate was observed as 0.160 and 0.196 mg/kg in Aranghata and Ranaghat, re-spectively. Phosphate levels in the Mayapur section of the Jalangi river ranged from 0.110-0.240 mg/kg (average 0.186 mg/kg). The lowest phosphate of 0.07 mg/kg was noticed in Raninagar Ghat in the Hooghly river.

Table 1. Location and physiochemical parameter of the river sediments

Sample ID	River	Sampling area	Sampling location	GPS	pH	Conductivity (µ S/cm)	Hardness (mg/Kg)	Organic carbon (%)	Nitrate (mg/Kg)	Phosphate (mg/Kg)
B1	Rivers Hooghly	Berhampore	Haridasmati Ghat	24.069; 88.236	7.9	3.825	1826.7	0.98	0.42	0.2
B2			K. N. College Ghat	24.091; 88.245	7.74	3.06	2052.1	0.927	0.88	0.13
B3			Dashamundu Kalibari Ghat	24.110; 88.245	7.81	3.978	1314.6	0.722	0.76	0.2
N1		Nabadwip	Fashitala Ghat	22.995; 88.405	7.86	3.366	1314.6	0.361	0.54	0.19
N2			Dando Panitala Ghat	23.400; 88.373	7.87	3.366	1165	0.413	0.4	0.3
N3			Karmo Mandir Ghat	23.396; 88.371	7.87	3.213	1116.7	0.361	0.46	0.16
C1		Chakdah	Gour Gobindo Ghat	23.409; 88.376	7.67	3.06	9418.8	0.567	0.52	0.27
C2			Poradanga Ghat	23.099; 88.511	7.89	4.437	1615.2	0.516	0.6	0.14
C3			Raninagar Ghat	23.080; 88.494	7.76	3.366	9298	0.67	0.8	0.07
A1	Churni River	Aranghata	Aranghata Shashan Ghat	23.249, 88.606	7.67	9.792	1503	1.65	0.74	0.16
A2			Aranghata Brij Ghat	23.245; 88.607	7.71	6.426	1462.9	1.702	0.92	0.17
A3			Aranghata Jugal Man-dir Ghat	23.240; 88.607	7.67	5.814	1579.1	1.96	0.92	0.15
R1		Ranaghat	Thanapara Ghat	23.176, 88.553	7.83	5.508	2324.6	2.167	0.78	0.2
R2			Boro Bazar Ghat	23.183; 88.565	7.82	5.049	1939.8	2.115	0.32	0.17
R3			Thanapara Ghat	23.177, 88.556	7.83	5.508	1875.7	2.01	0.68	0.22
M1	Jalangi River	Mayapur	Mayapur Ghat	23.413; 88.383	7.83	4.59	1127.6	1.651	0.14	0.24
M2			Iscon Ghat	23.417; 88.395	7.85	3.672	1629.9	0.928	0.1	0.21
M3			Hulor Ghat	23.413, 88.383	7.87	3.122	1651.3	1.032	0.3	0.11

Variation of nitrate in Hooghly and their tributary

The Hooghly river's average nitrate in the Berhampore, Nabadwip, and Chakdah regions was noticed as 0.686, 0.466, and 0.640 mg/kg, respectively (Table 1). In the Churni River, the average nitrate was observed as 0.860 and 0.593 mg/kg in Aranghata and Ranaghat, respectively. In Mayapur region of Jalangi River exhibited the nitrate range of 0.1-0.3 mg/kg (Average 0.180 mg/kg). The lowest nitrate of 0.1 mg/kg was noticed at Iscon Ghat in the Mayapur region of Jalangi River. The highest nitrate of 0.92 mg/kg was noticed at Aranghata Brij Ghat and Aranghata Jugal Mandir Ghat in Aranghata, Churni river.

Variation of phosphate in Hooghly and their tributary

The Hooghly river's average phosphate in the Berhampore, Nabadwip, and Chakdah regions was noticed as

The highest phosphate of 0.27-0.30 mg/kg was noticed in Gour Gobindo Ghat and Dando Panitala Ghat in the Hooghly River.

Heavy metal contamination in rivers sediments

Arsenic contamination in Hooghly, Jalangi and Churni rivers sediments

The concentrations As of 4.29, 3.68, and 3,13 mg/kg were noticed in the sediment of the Berhampore, Naba dwip, and Chakdah regions in the Hooghly River, respectively (Table 2). In Churni River, 5.04 and 4.49 mg/kg of as were observed in Aranghata and Ranaghat regions, respectively, whereas 4.05 mg/kg of As was noticed in the sediment of Jalangi River. Thus, the As concentration in the sediment of these rivers gradually decreases from upstream to lower stream onward. The highest concentration of As was noticed in Dashamundu Kalibari Ghat (4.46 mg/kg) of Hooghly River, Aranghata Brij Ghat (5.2 mg/kg) in Churni River, and Iscon Ghat (4.38 mg/kg) in Jalangi River. The lowest concentration of As was noticed, Raninagar Ghat (1.986 mg/kg) in Hooghly river.

Table 2. Heavy metal concentration in the river sediments

Sampling ID	River	Sampling area	Sampling location	Heavy metal Concentration (mg/kg)					
				Arsenic	Nickel	Copper	Zinc	Chromium	Lead
B1	Rivers Hooghly	Berhampore	Haridasmati Ghat	4.387	107.05	42.8	133.4	134.5	12.1
B2			K. N. College Ghat	4.028	110.85	42.8	143.7	139.5	11.1
B3			Dashamundu Kalibari Ghat	4.46	123.2	47	136.4	129.3	17.2
N1		Nabadwip	Fashitala Ghat	3.946	67.3	26.8	83.1	69.6	0
N2			Dando Panitala Ghat	3.486	61.6	64.1	91.2	83.4	1.2
N3			Karmo Mandir Ghat	3.012	60.6	45.5	79.9	77.2	7.3
C1		Chakdah	Gour Gobindo Ghat	3.289	78.1	26.5	96.5	82.7	10.7
C2			Poradanga Ghat	4.138	112.9	49.15	115.7	172.8	10.8
C3			Raninagar Ghat	1.986	77.7	59.1	101.5	103.2	6
A1	Churni River	Aranghata	Aranghata Shashan Ghat	5.139	138.4	71.3	158.3	134	13.5
A2			Aranghata Brij Ghat	5.299	135.9	66.7	159.6	159.3	13.7
A3			Aranghata Jugal Mandir Ghat	4.711	127.3	60.3	141.9	135	10.8
R1		Ranaghat	Thanapara Ghat	2.066	135.8	79.6	186.6	149.8	24.7
R2			Boro Bazar Ghat	5.266	128	73.5	165.8	131.3	17.2
R3			Thanapara Ghat	4.89	96.8	76.6	188.7	146.4	16.2
M1	Jalangi River	Mayapur	Mayapur Ghat	3.738	145.3	84.3	145.5	149.5	17.3
M2			Iscon Ghat	4.388	77.5	59.2	105.5	148.4	16.3
M3			Hulor Ghat	4.043	88.2	65.4	129.1	160.7	13.6

Nickel contamination in Hooghly, Jalangi and Churni rivers sediments

The Ni concentrations of 113.7, 63.16, and 89.56 mg/kg were noticed in the sediment of Berhampore, Nabadwip, and Chakdah regions in Hooghly River, respectively (Table 2). In the Churni river, 133.86 and 120.2 mg/kg of Ni were observed in the Aranghata and Ranaghat region, respectively, whereas 103.66 mg/kg of Ni was noticed in the sediment Jalangi river. The Ni concentration in the sediment of these rivers gradually decreases from upstream to lower stream, onward except Chakdah. The highest concentration of Ni was noticed in Dashamundu Kalibari Ghat (113.7 mg/kg) in Hooghly river, Aranghata Shashan Ghat (138.4 mg/kg) in Churni river, and Mayapur Ghat (145.3 mg/kg) in Jalangi River. The lowest concentration of Ni was noticed in Karmo Mandir Ghat (60.6 mg/kg) in the Hooghly river.

Copper contamination in Hooghly, Jalangi and Churni rivers sediments

The concentrations of Cu of 44.2, 45.46, and 44.91 mg/kg were noticed in the sediment of the Berhampore, Nabadwip, and Chakdah regions in the Hooghly river, respectively (Table 2). In the Churni River, 66.1 and 76.56 mg/kg of Cu was observed in the Aranghata and Ranaghat region, respectively, whereas 69.63 mg/kg of Cu was noticed in the sediment Jalangi river. The highest concentration of Cu was noticed in Dando Panitala Ghat (64.1 mg/kg) of Hooghly River, Thanapara Ghat (79.6 mg/kg) in Churni River and Mayapur Ghat (84.3 mg/kg) in Jalangi River. The lowest concentration of Cu was no-ticed in Karmo Mandir Ghat (60.6 mg/kg) in the Hooghly River.

Zinc contamination in Hooghly, Jalangi and Churni rivers sediments

The concentrations of Zn of 137.83, 84.73, and 104.56 mg/kg were noticed in the sediment of the Berhampore, Nabadwip, and Chakdah regions in the Hooghly River, respectively (Table 2). In the Churni River, 153.26 and 180.36 mg/kg of Zn was observed in Aranghata and Ranaghat region, respectively, whereas 126.7 mg/kg of Zn was noticed in the sediment of Jalangi River. The highest concentration of Zn was noticed in K. N. College Ghat (143.7 mg/kg) of Hooghly River, Thanapara Ghat (188.7 mg/kg) in Churni River and Mayapur Ghat (145.5 mg/kg) in Jalangi River. The lowest concentration of Zn was noticed in Dando Panitala Ghat (91.2 mg/kg) in the Hooghly river.

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Chromium contamination in Hooghly, Jalangi and Churni rivers sediments

The concentrations of Cr of 134.43, 76.73, and 119.56 mg/kg were noticed in the sediment of the Berhampore, Nabadwip, and Chakdah regions in the Hooghly River, respectively (Table 2). In the Churni River, 142.76, and 142.5 mg/kg of Cr was observed in Aranghata and Ranaghat region, respectively, whereas 152.86 mg/kg of Cr was noticed in the sediment of Jalangi river. The Cr concentration in the sediment of these rivers gradually decreases from upstream to lower stream, onward except Chakdah. The highest concentration of Cr was noticed in Poradanga Ghat (172.8 mg/kg) of Hooghly River, Aranghata Brij Ghat (159.3 mg/kg) in Churni River, and Mayapur Ghat (145.3 mg/kg) in Jalangi River. The lowest concentration of Cr was noticed in Hulor Ghat (160.7 mg/kg) in the Hooghly river.

Lead contamination in Hooghly, Jalangi and Churni rivers sediments

The concentrations of Pb of 13.46, 2.8, and 9.16 mg/kg were noticed in the sediment of the Berhampore, Nabadwip and Chakdah regions in the Hooghly River, respectively (Table 2). In the Churni River, 12.66 and 19.36 mg/kg of Pb was observed in Aranghata and Ranaghat regions, respectively, whereas 15.73 mg/kg of Pb was noticed in the sediment of Jalangi River. The highest concentration of Pb was noticed in Dashamundu Kalibari Ghat (17.2 mg/kg) in Hooghly River, Thanapara Ghat (24.7 mg/kg) in Churni River, and Mayapur Ghat (17.3 mg/kg) in Jalangi River while the average concentration of Ni, Pb, Zn, and Cu in sediments from Haldi River was 22.4, 13.9, 48.7, and 17.0 mg/kg respectively (Kumar et al., 2011). The lowest concentration of Pb was noticed in Dando Panitala Ghat (1.2 mg/kg) in Hooghly river.

Correlation of inter-element with environmental factor in sediment in different river sediments

There are some environmental parameters are highly corelated with each other and also correlated with heavy metal in Hooghly River sediment (Table 3). pH and Phosphate are highly corelated (r=0.89). Conductivity of the sediments is highly correlated with the Organic carbon (r=0.81), Nitrate (r=0.97), Ni (r=0.87), Zn (r=0.78), Cr (r=0.96) and Pb (r=0.91). The Organic carbon is high corelated with the Nitrate (r=0.91) along with other heavy metal such as As (r=0.75), Ni (r=0.99), Zn (r=0.99) and Cr (r=0.93), and Pb (r=0.97). The Phosphate is highly corelated with Cu (r=80). Ni is highly corelated with Zn (r=0.98), Cr (r=0.96), and Pb (r=0.99). Also, Zn is highly correlated with Cr (r=0.91) and Pb (r=0.96), where as As is moderately correlated with Ni (r=66), Zn (r=0.78), Cr (r=0.46), and Pb (r=0.59) as a multi element correlation. Bhattacharya et al., (2016) reported that the average metal concentrations in Hooghly river sediment were found to decrease in the order Ni> Zn> Cu> Cr> Pb> Co> Cd.

However, in the case of overall river sediments, the pH and Phosphate are moderately correlated (r=0.52) (Table 4). Conductivity of the overall river sediments is highly to moderately correlated with the rganic carbon (r=0.79),

Table 3. Correlation of inter-element with environmental factor in sediment in Hooghly River correlation.

	pH	Conductivity (μ S/cm)	Hardness (mg/Kg)	Organic carbon (%)	Nitrate (mg/Kg)	Phosphate (mg/Kg)	Arsenic (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)
pH	1											
Conductivity (μ S/cm)	-0.88	1										
Hardness (mg/Kg)	-0.88	0.57	1									
Organic carbon (%)	-0.44	**0.81**	-0.01	1								
Nitrate (mg/Kg)	-0.77	**0.97**	0.39	0.91	1							
Phosphate (mg/Kg)	**0.89**	**-0.99**	-0.59	-0.79	-0.97	1						
Arsenic (mg/kg)	0.25	0.22	-0.66	0.75	0.41	-0.19	1					
Nickel (mg/kg)	-0.55	**0.87**	0.11	**0.99**	**0.95**	-0.86	0.66	1				
Copper (mg/kg)	0.46	**-0.82**	-0.01	**-0.99**	**-0.92**	**0.80**	**-0.73**	**-0.99**	1			
Zinc (mg/kg)	-0.40	**0.78**	-0.05	**0.99**	**0.89**	-0.76	**0.78**	**0.98**	**-0.99**	1		
Chromium (mg/kg)	-0.74	**0.96**	0.35	**0.93**	**0.99**	-0.96	0.46	**0.96**	**-0.93**	**0.91**	1	
Lead (mg/kg)	-0.62	**0.91**	0.19	**0.97**	**0.97**	-0.90	0.59	**0.99**	**-0.98**	**0.96**	**0.98**	1

N.B.: *Bold is highly correlated*

Nitrate (r=0.59), As (r=79), Ni (r=0.77), Cu (r=60), Zn (r=0.67), Cr (r=0.46) and Pb (r=0.39). Organic carbon is also highly correlated with heavy metals. Like the Hooghly River sediment, the heavy metal of the overall river sediments is a positive correlation (As, Ni, Cu, Zn, Cr, and Pb). Thus, it is clearly observed that organic carbon and conductivity greatly influence the As and other heavy metal concentration in sediments. In a previous study on the sediments of Subarnarekha River, a close relationship was reported between organic carbon and metal content in river bed sediments (Manoj et al., 2012), which is strongly comparable with the present study also, organic carbon is positively related to the metal contents. It is necessary to identify the natural amounts of these metals in order to assess the metal concentration in river sediments. Aside from natural sources, heavy metals can enter the aquatic system through anthropogenic sources such as industrial solid and liquid waste, municipal sewage, and so on. The fallout from industrial pollutants in the atmosphere may cause pollution to some extent.

In this study, the main sources of these heavy metals (As, Ni, Cu, Zn, Cr, and Pb) in the sediments of Hooghly River, Churni River, and Jalangi River are the municipal sewage wastes and agricultural run-off as major industries are not present nearby the sampling sites. The major cause of As contamination in these areas is its natural geological presence in the local bedrock. Arsenic concentration in the Hooghly river gradually decreases in down streams. In the Churni river, the As concentration is higher in the upper steam than the downstream. The maximum concentration of arsenic among the three rivers was in the Churni River. In all the sites of Jalangi River, the concentration of this metal is more or less similar. Thus, the main source of high level As in these river sediments is natural anthropogenic, which is harmful to the living organisms; and can cause serious health problems.

Conclusion

Significantly, the pH of the river water was unchanged and observed a neutral to alkaline in nature. The highest conductivity of 9.72 µS/cm was noticed in Aranghata Shashan Ghat. In the case of the hardness, the highest hardness of 9418.8 mg/kg and 9298 mg/kg was noticed in Gour Gobindo Ghat and Raninagar Ghat. The highest organic carbon of 2.167% Ghat was noticed in the Thanapara Ghat in the Churni River. The highest nitrate of 0.92 mg/kg was noticed at Aranghata Brij Ghat and Aranghata Jugal Mandir Ghat in Aranghata, Churni River. The highest phosphate of 0.27-0.30 mg/kg was noticed in Gour Gobindo Ghat and Dando Panitala Ghat in the Hooghly river. The highest concentration of As was noticed in Dashamundu Kalibari Ghat (4.46 mg/kg) of Hooghly River, Aranghata Brij Ghat (5.2 mg/kg) in Churni river, and Iscon Ghat (4.38 mg/kg) in Jalangi River. The highest concentration of Ni was noticed in Dashamundu Kalibari Ghat (113.7 mg/kg) of Hooghly River, Aranghata Shashan Ghat (138.4 mg/kg) in Churni river, and Mayapur Ghat (145.3 mg/kg) in Jalangi river. The highest concentration of Cu was noticed in Dando Panitala Ghat (64.1 mg/kg) of Hooghly river, Thanapara Ghat (79.6 mg/kg) in Churni river and Mayapur Ghat (84.3 mg/kg) in Jalangi river. The lowest concentration of Cu was noticed in Karmo Mandir Ghat (60.6 mg/kg) in the Hooghly river. The highest concentration of Zn was noticed in K. N. College Ghat (143.7 mg/kg) of Hooghly river, Thanapara Ghat (188.7 mg/kg) in Churni river and

Table 4. Correlation of inter-element with environmental factor in sediment in overall river sediments.

	pH	Conductivity (µ S/cm)	Hardness (mg/Kg)	Organic carbon (%)	Nitrate (mg/Kg)	Phosphate (mg/Kg)	Arsenic (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)
pH	1											
Conductivity (µ S/cm)	-0.79	1										
Hardness (mg/Kg)	-0.22	-0.23	1									
Organic carbon (%)	-0.37	**0.79**	-0.31	1								
Nitrate (mg/Kg)	-0.77	0.59	0.18	0.24	1							
Phosphate (mg/Kg)	**0.52**	-0.38	-0.32	-0.53	-0.26	1						
Arsenic (mg/kg)	-0.56	**0.79**	-0.61	**0.68**	0.40	-0.39	1					
Nickel (mg/kg)	-0.62	**0.77**	-0.19	**0.84**	0.46	-0.79	**0.83**	1				
Copper (mg/kg)	-0.11	0.60	-0.36	**0.89**	-0.17	-0.37	**0.50**	**0.60**	1			
Zinc (mg/kg)	-0.33	0.67	-0.26	**0.94**	0.33	-0.63	**0.66**	**0.89**	**0.75**	1		
Chromium (mg/kg)	-0.34	0.46	-0.07	**0.71**	0.01	-0.89	**0.58**	**0.85**	**0.66**	**0.76**	1	
Lead (mg/kg)	-0.11	0.39	-0.14	**0.82**	-0.02	-0.76	0.47	**0.79**	**0.76**	**0.89**	**0.90**	1

N.B.: **Bold is highly correlated**

Mayapur Ghat (145.5 mg/kg) in Jalangi river. The highest concentration of Cr was noticed in Poradanga Ghat (172.8 mg/kg) of Hooghly River, Aranghata Brij Ghat (159.3 mg/kg) in Churni River, and Mayapur Ghat (145.3 mg/kg) in Jalangi River. The highest concentration of Pb was noticed in Dashamundu Kalibari Ghat (17.2 mg/kg) in Hooghly River, Thanapara Ghat (24.7 mg/kg) in Churni River, and Mayapur Ghat (17.3 mg/kg) in Jalangi River. Significantly the overall river sediments, the pH and Phosphate are moderately correlated (r=0.52). Organic carbon is also highly correlated with heavy metals. In most of the Hooghly River regions, the lowest concentration of heavy metal was noticed.

Thus, some physico-chemical parameters of the studied three river sediment are highly correlated with each other and also correlated with heavy metals in Hooghly River sediment. Correlation between the Physico-chemical parameters and the heavy metals exhibited a great influence on the metal contents of river sediments. The organic carbon, hardness, and conductivity are positively related to the metal contents. The location-specific certain heavy metal concentration is observed significantly high, which adversely impacts the aquatic ecosystem. the maximum levels of all the metals were found in this river. The geogenic and anthropogenic activities, including municipal sewage disposal and agricultural run-off play an important role in contaminating heavy metals in sediment. Proper actions should be taken to reduce the levels of heavy metals in the rivers. Treatment of effluents before their disposal, use of green manures, biofertilizers, and less use of chemicals in agricultural activities are some steps which can help to reduce the levels of heavy metals in rivers. The freshwater sources and lifeline of human civilization, and rivers should be conserved and protected for a sustainable future.

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References

Adeyemo, O. K., Adedokun, O. A., Yusuf, R. K., & Abeleye, E. A. (2008). Seasonal changes in physico-chemical parameters and nutrient load of river sediments in Ibadan city, Nigeria. *Global nest. The International Journal*. 10(3): 326-336.

APHA (American Public Health Association). (2003). Standard methods for examination of water and waste water. 23th Ed.Washington DC, USA.

Banerjee, U., & Gupta, S. (2012). Source and distribution of lead, cadmium, iron and manganese in the river Damodar near Asansol Industrial Area, West Bengal, India. *International Journal of Environmental Sciences*. 2(3): 1531-1542.

Barakat, A., El Baghdadi, M., Rais, J., & Nadem, S. (2012). Assessment of heavy metal in surface sediments of Day River at Beni-Mellal region, Morocco. *Research Journal of Environmental and Earth Sciences*. 4(8):797-806.

Bhattacharya, P., Samal, A. C., Bhattacharya, T., & Santra, S. C. (2016). Sequential extraction for the speciation of trace heavy metals in Hooghly river sediments, *India. Int. J. Exp. Res. Rev*. 6: 39-49.

Bhattacharyya, A. K., & Mitra, A. C. A. (2001). Accumulation of heavy metals in commercially edible fishes of *Gangetic West Bengal. Res. J. Chem. Environ*. 5: 27-28.

Chakraborty, D., Das, D., Samal, A. C., & Santra, S. C. (2019). Prevalence and Ecotoxicological significance of heavy metals in sediments of lower stretches of the *Hooghly estuary, India. Int. J. Exp. Res. Rev.*19: 1-11.

Chakravarty, M., & Patgiri, A. D. (2009). Metal pollution assessment in sediments of the Dikrong River, NE India. *Journal of Human Ecology*. 27(1): 63-67.

Choudhury, C. P., Chanda, A., Das, S., & Ghosh, T. (2021). Geochemical Dynamics of Heavy Metals in the Sediments of HooghlyMatla Estuary–A Review. *International Journal of Advanced Research in Engineering and Technology*. 12(4): 363-373.

Cieniawski, S. (2002). A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems. US Environmental Protection Agency, Great Lakes National Program Office.

Ekwere, A., Ekwere, S., & Obim, V. (2013). Heavy metal geochemistry of stream sediments from parts of the eastern Niger Delta Basin, South-Eastern Nigeria. *RMG-M & G*. 60: 205-210.

Gale, R. J. B., Gale, S. J., & Winchester, H. P. (2006). Inorganic pollution of the sediments of the River Torrens, South Australia. *Environmental Geology*. 50(1): 62-75.

Goswami, D.N. (2014). Determination of Heavy Metals, viz. Cadmium, Copper, Lead and Zinc in the Different Matrices of the Ganges River from Rishikesh to Allahabad through Differential Pulse Anodic Striping Voltametry. *International Journal* *of Advanced Research in Chemical Science*. 1(5): 7-11

Ip, C. C. M., Li, X. D., Zhang, G., Wong, C. S. C., & Zhang, W. L. (2005). Heavy metal and Pb isotopic compositions of aquatic organisms in the Pearl River Estuary, South China. *Environmental Pollution*. 138(3): 494-504.

Jha, P., Samal, A. C., Santra, S. C., & Dewanji, A. (2016). Heavy metal accumulation potential of some wetland plants growing naturally in the city of Kolkata, India. *American Journal of Plant Sciences*. 7(15): 2112.

Joseph, K. O., & Srivastava, J. P. (1992). Heavy metal load in prawn, Penaeus indicus(H. Milne Edwards) inhibiting Ennore Estuary in Madras. *Journal of the Inland Fisheries Society of India. Barrackpore*. 24(1): 30-33.

Kar, S., Nath, B., Samal, A. C., & Santra, S. C. (2006). Arsenic in urban particulates–A case study in Kolkata metropolis. *Current Science*. 90(2): 158-160.

Kjelland, M. E., Woodley, C. M., Swannack, T. M., & Smith, D. L. (2015). A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. *Environment Systems and Decisions*. 35(3): 334-350.

Kumar, B., Kumar, S., Mishra, M., Prakash, D., Singh, S. K., Sharma, C. S., & Mukherjee, D. P. (2011). An assessment of heavy metals in sediments from two tributaries of lower stretch of Hugli estuary in West Bengal. *Archives of Applied Science Research*. 3(4): 139-146.

Lasheen, M. R., & Ammar, N. S. (2009). Speciation of some heavy metals in River Nile sediments, Cairo, Egypt. *The Environmentalist*. 29(1): 8-16.

Malhotra, P., Chopra, G., & Bhatnagar, A. (2014). Studies on Sediment Chemistry of River Yamuna with Special Reference to Industrial Effluents in Yamuna Nagar, India. *Current World Environment.* 9(1): 210.

Manoj, K., & Padhy, P. K. (2014). Distribution, enrichment and ecological risk assessment of six elements in bed sediments of a tropical river, Chottanagpur Plateau: a spatial and temporal appraisal. *Journal of Environmental Protection*. 5(14): 1419.

Manoj, K., Kumar, B., & Padhy, P. K. (2012). Characterisation of Metals in Water and Sediments of Subarnarekha River along the Projects' Sites in Lower Basin, India. *Universal Journal of Environmental Research & Technology*. 2(5):402-410.

Manoj, K., Padhy, P. K., & Chaudhury, S. (2015). Distribution pattern analysis of six trace element and development of trace element pollution index for a peninsular river basin, chottanagpur plateau. *Indian Journal of Environmental Protectection*. 35: 666-679.

Miramand, P., Guyot, T., Rybarczyk, H., Elkaim, B., Mouny, P., Dauvin, J. C., & Bessineton, C. (2001). Contamination of the biological compartment in the Seine estuary by Cd, Cu, Pb, and Zn. *Estuaries*. 24(6): 1056-1065.

Mitra, A. (1998). Status of coastal pollution in West Bengal with special reference to heavy metals. *Journal of Indian Ocean Studies*. 5(2): 135-138.

Mitra, A., & Choudhury, A. (1993). Trace metals in macrobenthic molluscs of the Hooghly estuary, India. *Mar. Poll. Bull*. 26(9): 521-522.

Mohiuddin, K. M., Ogawa, Y. Z. H. M., Zakir, H. M., Otomo, K., & Shikazono, N. (2011). Heavy metals contamination in water and sediments of an urban river in a developing country. *International Journal of Environmental Science & Technology*. 8(4): 723-736.

Mohiuddin, K. M., Zakir, H. M., Otomo, K., Sharmin, S., & Shikazono, N. (2010). Geochemical distribution of trace metal pollutants in water and sediments of downstream of an urban river. *International Journal of Environmental Science & Technology*. 7(1): 17-28.

Morillo, J., Usero, J., & Gracia, I. (2004). Heavy metal distribution in marine sediments from the southwest coast of Spain. *Chemosphere*. 55(3): 431-442.

Mucha, A. P., Vasconcelos, M. T. S., & Bordalo, A. A. (2003). Macrobenthic community in the Douro estuary: relations with trace metals and natural sediment characteristics. *Environmental Pollution*. 121(2): 169-180.

Mulligan, C. N., Yong, R. N., & Gibbs, B. F. (2001). An evaluation of technologies for the heavy metal remediation of dredged sediments. *Journal of Hazardous Materials*. 85(1-2): 145-163.

Páez-Osuna, F., & Ruiz-Fernandez, C. (1995). Comparative bioaccumulation of trace metals in Penaeus stylirostris in estuarine and coastal environments. *Estuarine, Coastal and Shelf Science*. 40(1): 35-44.

Rahman, M. A., Hasegawa, H., Rahman, M. M., Rahman, M. A., & Miah, M. A. M. (2007). Accumulation of arsenic in tissues of rice plant (Oryza sativa L.) and its distribution in fractions of rice grain. *Chemosphere*. 69(6): 942-948.

Ramesh, R., Ramanathan, A. L., Ramesh, S., Purvaja, R., & Subramanian, V. (2000). Distribution of rare earth elements and heavy metals in the surficial sediments of the Himalayan river system. *Geochemical Journal*. 34(4): 295-319.

Rayment, G. E., & Higginson, F. R. (1992). Australian laboratory handbook of soil and water chemical methods. Inkata Press.

Samal, A. C., Bhattacharya, P., Banerjee, S., Majumdar, J., & Santra, S. C. (2013). Distribution of arsenic in the estuarine ecosystem of Nayachar Island, West Bengal, India. *Earth Science India*. 6(II): 70-76.

Sarkar, S. K., Bhattacharya, B., Debnath, S., Bandopadhaya, G., & Giri, S. (2002). Heavy metals in biota from Sundarban Wetland Ecosystem, India: Implications to monitoring and environmental assessment. A*quatic Ecosystem Health & Management.* 5(4): 467-472.

Siddique, M. A. M., & Aktar, M. (2012). Heavy metals in salt marsh sediments of porteresia bed along the Karnafully River coast, Chittagong. *Soil and Water Research.* 7(3): 117-123.

Walkley, A. (1947). A critical examination of a rapid method for determining organic carbon in soils—effect of variations in digestion conditions and of inorganic soil constituents. *Soil Science*. 63(4): 251-264.

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci*. 37(1): 29-28.

Welsch, F. P. (1990). Trace elements determination of arsenic and selenium using continuous-flow hydride generation atomic absorption spectrophotometry (HG-AAS). *Quality Assurance Manual for the Branch of Geochemistry*. Pp.38-45.

Yong, T. C. (1999). Water pollution by agriculture, agro industry and mining in metalsia. In Proceedings of the Regional Workshop on Water quality Management and control of Water pollution in *Asia and the pacific FAO Water Reports*. 21: 133-138.

Zheng, N. A., Wang, Q., Liang, Z., & Zheng, D. (2008). Characterization of heavy metal concentrations in the sediments of three freshwater rivers in Huludao City, Northeast China. *Environmental Pollution*. 154(1): 135-142

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