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Heavy-Metal Concentrations in Sediments Collected from ICRISAT Lake, Patancheru, India

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ABSTRACT
To determine and characterize the initial background concentrations of heavy metals, a total of 50 sediment samples were collected from the largest lake at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in Patancheru, India. The finely ground sediment samples were digested using a microwave-assisted digestion method and analyzed for 15 heavy metals using inductively coupled plasma–optical emission spectrometry (ICP-OES). The results showed that the concentrations of the heavy metals varied greatly with metal and sediment sample, but in general the concentrations were low. Our results suggest that the sediments from this lake (15 ha in area) at the ICRISAT center do not appear contaminated with the heavy metals evaluated, and they indeed reflect normal background concentrations of these metals released through the natural process of weathering.

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Heavy and trace metals contamination; ICP-OES; runoff; sediments; water resources

Introduction

The pollution of natural resources, especially soil and water resources and food systems, with chemicals, especially heavy and trace metals, is becoming of increasing concern as a potential hazard to human and animal health and overall degradation of environmental quality (Tiller 1988; Adriano 2001; Chaney 2012). Among the various pollutants, the contamination of soil and water resources with heavy and trace metals has received a lot of attention because of their potential toxicity to humans and animals through the food and feed chains, respectively (Adriano 2001; Debeka and McKenzie 1995; Chaney 2012).

There are several sources of heavy-metal accumulation in soil and water resources; among them the prominent ones are the mineral and organic fertilizers used to supply plant nutrients in agricultural production systems (Mortvedt 1996; Chaney 2012), added through the natural process of weathering of the parent material (termed natural background concentration of these metals) on which soil is developed (Adriano 2001; Arao et al. 2009), through the use of industrial and domestic wastewater for irrigation in agriculture, and through the use of soils as the dumping and disposal ground for various diverse wastes (Abdu et al. 2011; Kumar and Chopra 2012; Sehgal et al. 2012; Selim 2013).

The role of runoff water and soil erosion, especially during heavy downpour and flood irrigation, is of critical importance because such events not only result in the loss of nutrient-rich surface soil from the fertile land, but the chemical-laden sediments that accumulate offsite in water bodies such as tanks, rivers, and lakes serve as the source of the contamination of water resources with pollutants including heavy and trace metals (Sahrawat et al. 2010). Diverse physical, chemical, and biological

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soil characteristics and interactions among them influence the retention and transport of heavy and trace metals in the soil-water systems; among these soil texture, pH, organic matter, cation exchange capacity, water regime, and redox potential are important (Ashworth and Alloway 2008; Arao et al. 2009; Selim 2013).

The importance of siltation of the water bodies including tanks and lakes cannot be overemphasized in the light of the role sediments play in the offsite contamination of water resources. The main objective of this study therefore was to obtain initial results on the background concentrations of 15 heavy metals in the sediments deposited in the largest lake at the ICRISAT center in Patancheru, India. Such results are needed as the first step to monitor and assess the contamination of the lake with heavy and trace metals in the future.

Materials and methods

After the rainy season of 2012, a total of 50 sediment samples were collected from the largest lake at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in Patancheru (latitude 17° 30' 35.3'' N and longitude 78° 15' 53.4'' E), Telangana, India. Patancheru is 545 m above the mean sea level and receives about 900 mm rainfall (mainly during June through September); and the site falls in the semi-arid climate, with annual mean temperatures ranging from 13 °C (minimum) and 39 °C (maximum).

The lake covers an area of about 15 ha. The sediment samples were collected during May 2012 (dry season). A total of 50 sediment samples were collected from the surface (0–15 cm) soil using a shovel. To represent the sampling point, four or five samples were mixed to make one composite sample. The sediment sampling points are marked in Figure 1 (showing the lake sketch). Before use, the sediment samples were air dried in the shade and powdered using a wooden hammer to pass through a 0.25-mm sieve.

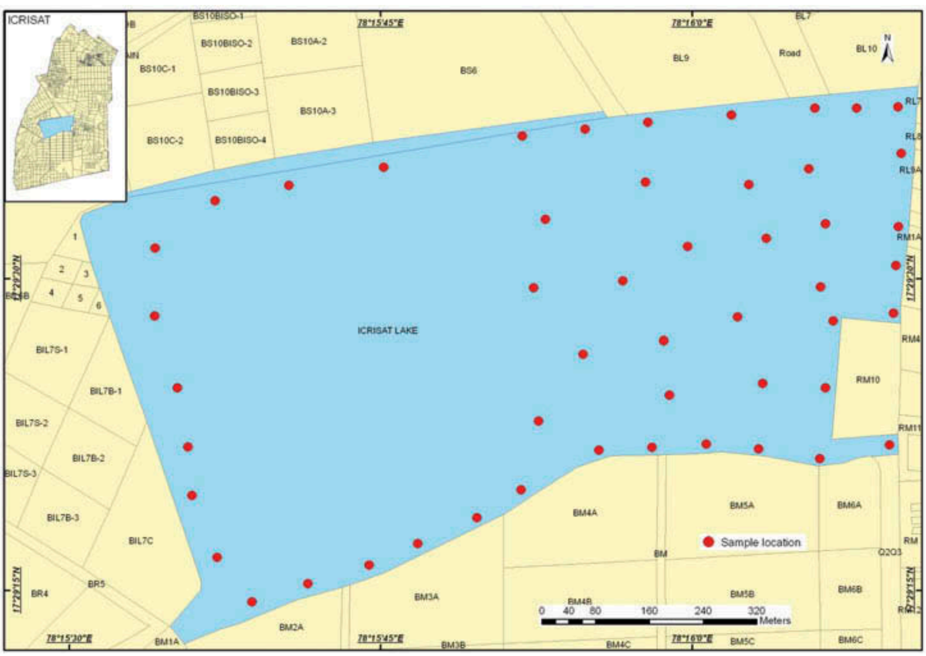

Figure 1. Sediment sampling points marked on the sketch of the lake at the ICRISAT center. BM and RM denote the Black Manmool and Red Manmool field numbers, respectively.

For sediment analysis, pH was measured by a glass electrode using a sediment-to-water ratio of 1:2; electrical conductivity (EC) was measured using EC meter; and organic carbon (C) was determined using the Walkley-Black method (Nelson and Sommers 1996).

Finely ground sediment samples were analyzed for 15 heavy metals, which included cadmium (Cd), arsenic (As), chromium (Cr), cobalt (Co), zinc (Zn), mercury (Hg), boron (B), copper (Cu), lead (Pb), molybdenum (Mo), nickel (Ni), iron (Fe), platinum (Pt), manganese (Mn), and tin (Sn).

A modified version of the Chen and Ma (2001) method as described by Shirisha et al. (2014) was used. The method is based on microwave-assisted digestion of the finely ground sediment samples. Briefly, 2-g sediment samples were weighed in polytetrafluoroethylene (PTFE) Teflon-coated digestion vessels. Twelve ml of freshly prepared aqua regia solution [consisting of 3:1 (v/v) ratio of concentrated hydrochloric acid (HCl)–nitric acid (HNO_3)] was added to the samples, and the samples were then digested at 0.83 × 106 Pa (120 psi) in a microwave oven (Marsxpress CEM microwave CEM Corporation, Matthews, NC, USA) for 15 min at 160 °C. Digested, cooled samples were filtered through Whatman no. 42 filter paper into 100-ml volumetric flasks, and the contents were diluted to 100 ml with distilled water. Blanks were included with the each set of samples digested in triplicate. The heavy metals in the digests were determined using an inductively coupled plasma–optical spectrometer (ICP-OES) (Prodigy, Teledyne Leeman, Hudson, NH, USA) as described by Shirisha et al. (2014).

The results obtained were statistically analyzed. The results presented are the means of three replications (independent analysis) ± standard deviation (SD). Descriptive statistics of the concentrations of various metals in the sediments was also computed.

Results and discussion

The 50 sediment samples collected used in the study for heavy-metal contents had a range in pH, which ranged from 7.7 to 8.3, in EC, which ranged from 0.68 to 1.34 dS m^{-1}, and in organic C, which ranged from 3.9 to 9.5 g kg^{-1}.

The results on the contents of 15 heavy metals in 50 sediment samples are summarized in Table 1. The results given are the average of three replications ± standard deviation (SD). Descriptive statistics including range, mean, maximum, minimum, standard deviation (SD), standard error (SE), and coefficient of variation (CV) of the results on concentrations of heavy and trace metals in sediment samples is given in Table 2.

As expected, the results varied with metal and the sediment sample (Table 1). The results showed that total Fe concentration was the greatest (mean value being 6056.51 mg kg^{-1}), followed by Mn (287.05 mg kg^{-1}), B (45.96 mg kg^{-1}), Cr (35.02 mg kg^{-1}), Zn (27.33 mg kg^{-1}), Ni (21.98 mg kg^{-1}), Cu (20.05 mg kg^{-1}), Co (11.22 mg kg^{-1}), Pb (10.56 mg kg^{-1}), Pt (1.96 mg kg^{-1}), As (1.66 mg kg^{-1}), Sn (0.49 mg kg^{-1}), Mo (0.42 mg kg^{-1}), Hg (0.11 mg kg^{-1}), and Cd (0.01 mg kg^{-1}) in the 50 sediment samples. The largest variability in the concentrations of metals was observed in the case of Cd (CV = 251.24%); and this was due to very low concentrations of the metal, which ranged from 0.00 to 0.10 mg kg^{-1}. The lowest CV was observed in the concentration of Fe (CV = 24.95%) as its concentration ranged from 3191.84 to 8541.88 mg kg^{-1} (Table 2).

These results show that the concentration of the various heavy metals in the sediment samples analyzed was in the normal or lower range, and they seem below the threshold concentrations fixed for these metals. It may be concluded from these results that the concentrations of various heavy metals reported indeed reflect the normal background concentrations of these metals (Ander et al. 2013).

Table 1. Distribution of 15 heavy metals in 50 sediment samples collected from the ICRISAT Lake in Patancheru, India. Results are presented in mg kg^{-1} of metal ± standard deviation, based on analysis of three independent samples of a metal.

Sample ID	As	Hg	Ni	Co	Pb	Mo	Zn	Fe
1	3.86 ± 0.00	0.03 ± 0.00	24.59 ± 0.08	14.63 ± 0.02	19.59 ± 0.01	0.044 ± 0.00	38.09 ± 0.12	7118.14 ± 17.29
2	3.47 ± 0.01	0.00 ± 0.00	28.71 ± 0.02	13.49 ± 0.01	15.26 ± 0.00	0.07 ± 0.00	41.55 ± 0.04	7034.86 ± 4.38
3	3.45 ± 0.01	0.05 ± 0.00	25.01 ± 0.05	13.82 ± 0.02	14.46 ± 0.02	0.31 ± 0.00	35.06 ± 0.08	6707.11 ± 12.40
4	3.42 ± 0.01	0.00 ± 0.00	25.10 ± 0.06	13.39 ± 0.02	14.30 ± 0.01	0.43 ± 0.00	33.91 ± 0.09	6476.7 ± 12.95
5	0.01 ± 0.00	0.03 ± 0.00	15.95 ± 0.02	8.77 ± 0.01	10.70 ± 0.00	0.15 ± 0.00	26.16 ± 0.05	5450.33 ± 8.17
6	1.49 ± 0.02	0.1 ± 0.00	12.54 ± 0.03	6.47 ± 0.01	7.83 ± 0.00	0.16 ± 0.00	16.04 ± 0.04	4372.54 ± 12.41
7	2.89 ± 0.01	0.07 ± 0.01	15.32 ± 0.04	8.47 ± 0.01	9.77 ± 0.00	0.18 ± 0.00	19.57 ± 0.04	4738.24 ± 9.06
8	2.97 ± 0.00	0.02 ± 0.00	18.22 ± 0.03	9.93 ± 0.01	11.31 ± 0.01	0.16 ± 0.00	23.77 ± 0.04	5289.60 ± 8.53
9	2.97 ± 0.01	0.01 ± 0.00	16.40 ± 0.04	9.20 ± 0.01	9.67 ± 0.01	0.13 ± 0.00	22.03 ± 0.07	5094.35 ± 12.15
10	2.49 ± 0.00	0.03 ± 0.00	10.94 ± 0.01	6.34 ± 0.01	6.91 ± 0.00	0.16 ± 0.00	14.40 ± 0.02	3999.70 ± 6.61
11	2.94 ± 0.00	0.04 ± 0.00	14.10 ± 0.01	8.28 ± 0.00	8.23 ± 0.00	0.20 ± 0.00	17.65 ± 0.01	4423.82 ± 4.74
12	4.13 ± 0.01	0.11 ± 0.00	24.86 ± 0.03	12.33 ± 0.01	14.05 ± 0.01	0.36 ± 0.00	33.23 ± 0.05	6193.19 ± 7.33
13	4.86 ± 0.00	0.00 ± 0.00	35.66 ± 0.04	16.10 ± 0.02	14.26 ± 0.02	2.24 ± 0.02	46.18 ± 0.08	8012.44 ± 4.98
14	3.54 ± 0.01	0.00 ± 0.00	35.11 ± 0.04	15.24 ± 0.01	14.26 ± 0.01	0.00 ± 0.00	42.51 ± 0.06	7972.94 ± 3.74
15	2.95 ± 0.01	0.00 ± 0.00	21.46 ± 0.01	9.95 ± 0.00	9.31 ± 0.00	0.04 ± 0.00	21.99 ± 0.00	6412.97 ± 1.31
16	4.20 ± 0.00	0.00 ± 0.00	35.91 ± 0.02	15.67 ± 0.01	14.20 ± 0.00	0.22 ± 0.00	46.23 ± 0.07	8002.19 ± 2.71
17	3.23 ± 0.01	0.00 ± 0.00	23.93 ± 0.01	11.28 ± 0.00	10.94 ± 0.00	0.08 ± 0.00	26.28 ± 0.02	6535.68 ± 3.79
18	4.22 ± 0.01	0.01 ± 0.00	37.46 ± 0.06	17.50 ± 0.02	16.55 ± 0.01	0.24 ± 0.00	47.98 ± 0.06	8039.48 ± 7.98
19	3.43 ± 0.01	0.00 ± 0.00	32.69 ± 0.11	14.94 ± 0.03	16.10 ± 0.01	0.15 ± 0.00	37.57 ± 0.19	7161.25 ± 16.57
20	4.52 ± 0.02	0.00 ± 0.00	34.44 ± 0.12	16.19 ± 0.04	16.41 ± 0.02	0.07 ± 0.00	36.62 ± 0.17	7408.18 ± 18.01
21	1.39 ± 0.03	0.18 ± 0.00	36.50 ± 0.03	18.62 ± 0.01	18.90 ± 0.01	1.69 ± 0.00	48.05 ± 0.04	8104.10 ± 6.01
22	0.95 ± 0.01	0.28 ± 0.00	32.29 ± 0.02	16.71 ± 0.01	16.70 ± 0.02	1.57 ± 0.00	41.60 ± 0.04	7740.98 ± 4.70
23	0.00 ± 0.01	0.17 ± 0.00	33.93 ± 0.07	16.90 ± 0.03	15.58 ± 0.02	1.26 ± 0.00	40.30 ± 0.10	8026.08 ± 7.77
24	0.23 ± 0.00	0.033 ± 0.00	31.50 ± 0.07	16.02 ± 0.02	13.46 ± 0.01	1.22 ± 0.00	39.12 ± 0.03	7866.31 ± 7.47
25	0.00 ± 0.01	0.04 ± 0.00	41.44 ± 0.8	19.40 ± 0.03	16.48 ± 0.01	1.18 ± 0.00	53.67 ± 0.10	8541.88 ± 4.90
26	0.00 ± 0.01	0.00 ± 0.00	41.40 ± 0.05	20.32 ± 0.01	18.38 ± 0.02	1.14 ± 0.00	55.22 ± 0.04	8462.96 ± 3.00
27	0.00 ± 0.01	0.05 ± 0.00	33.86 ± 0.05	17.89 ± 0.01	16.94 ± 0.01	1.10 ± 0.00	42.19 ± 0.06	7860.59 ± 6.48
28	0.68 ± 0.01	0.18 ± 0.00	23.88 ± 0.02	13.52 ± 0.01	12.65 ± 0.00	1.16 ± 0.00	27.73 ± 0.03	7053.12 ± 4.79
29	0.71 ± 0.01	0.31 ± 0.00	6.72 ± 0.00	4.77 ± 0.00	4.15 ± 0.00	1.31 ± 0.00	3.81 ± 0.01	3191.84 ± 3.31
30	0.54 ± 0.01	0.36 ± 0.00	9.25 ± 0.01	6.06 ± 0.00	5.43 ± 0.00	1.38 ± 0.00	6.79 ± 0.02	4061.40 ± 5.41
31	0.19 ± 0.01	0.24 ± 0.00	8.65 ± 0.01	6.32 ± 0.00	6.69 ± 0.00	1.28 ± 0.00	5.90 ± 0.01	4317.14 ± 3.92
32	0.81 ± 0.01	0.20 ± 0.00	9.63 ± 0.01	7.20 ± 0.00	5.58 ± 0.01	1.32 ± 0.00	8.45 ± 0.02	4409.92 ± 5.72
33	0.85 ± 0.00	0.03 ± 0.00	9.81 ± 0.01	7.04 ± 0.01	5.53 ± 0.00	0.00 ± 0.00	14.34 ± 0.02	4364.28 ± 5.71
34	0.85 ± 0.01	0.12 ± 0.00	10.86 ± 0.00	6.23 ± 0.00	6.37 ± 0.00	0.00 ± 0.00	12.91 ± 0.01	4552.07 ± 1.24
35	0.40 ± 0.01	0.12 ± 0.00	13.32 ± 0.01	7.15 ± 0.01	5.32 ± 0.00	0.00 ± 0.00	17.09 ± 0.01	4962.41 ± 3.84
36	0.00 ± 0.00	0.01 ± 0.00	21.60 ± 0.03	10.25 ± 0.01	6.40 ± 0.01	0.00 ± 0.00	27.22 ± 0.03	6419.95 ± 4.10
37	0.54 ± 0.00	0.07 ± 0.00	16.79 ± 0.04	8.95 ± 0.01	7.21 ± 0.02	0.00 ± 0.00	20.86 ± 0.04	5505.32 ± 8.77
38	0.78 ± 0.00	0.08 ± 0.00	13.73 ± 0.03	7.88 ± 0.01	6.55 ± 0.01	0.00 ± 0.00	17.05 ± 0.04	4741.19 ± 11.12
39	1.02 ± 0.01	0.20 ± 0.00	9.86 ± 0.02	6.15 ± 0.01	5.35 ± 0.00	0.00 ± 0.00	11.43 ± 0.02	3720.72 ± 8.44
40	0.92 ± 0.01	0.13 ± 0.00	11.95 ± 0.02	6.60 ± 0.01	5.56 ± 0.00	0.00 ± 0.00	15.11 ± 0.03	4319.47 ± 8.33

(*Continued*)

Table 1. (Continued).

Sample ID	As	Hg	Ni	Co	Pb	Mo	Zn	Fe
41	0.53 ± 0.01	0.14 ± 0.00	18.81 ± 0.04	9.64 ± 0.01	7.77 ± 0.01	0.00 ± 0.00	23.95 ± 0.05	5603.46 ± 10.26
42	0.70 ± 0.00	0.15 ± 0.00	14.74 ± 0.01	8.92 ± 0.00	7.74 ± 0.00	0.00 ± 0.00	18.11 ± 0.02	4673.83 ± 4.59
43	0.99 ± 0.01	0.30 ± 0.00	11.73 ± 0.02	6.50 ± 0.01	5.93 ± 0.01	0.10 ± 0.01	14.90 ± 0.02	4126.53 ± 4.46
44	0.79 ± 0.01	0.46 ± 0.00	11.95 ± 0.01	6.66 ± 0.00	6.66 ± 0.01	0.00 ± 0.00	14.25 ± 0.02	4663.48 ± 7.34
45	0.21 ± 0.02	0.25 ± 0.00	24.57 ± 0.08	11.59 ± 0.03	8.89 ± 0.01	0.00 ± 0.00	31.01 ± 0.12	6998.02 ± 16.25
46	0.36 ± 0.01	0.29 ± 0.00	24.02 ± 0.03	11.22 ± 0.01	8.54 ± 0.02	0.00 ± 0.00	29.71 ± 0.05	6939.97 ± 7.26
47	0.00 ± 0.01	0.14 ± 0.00	28.47 ± 0.04	12.09 ± 0.02	7.78 ± 0.00	0.00 ± 0.00	35.19 ± 0.05	7527.38 ± 5.45
48	0.09 ± 0.00	0.20 ± 0.00	21.96 ± 0.07	10.11 ± 0.02	7.73 ± 0.01	0.00 ± 0.00	24.93 ± 0.09	6253.76 ± 17.38
49	0.89 ± 0.01	0.25 ± 0.00	18.59 ± 0.05	8.96 ± 0.02	6.23 ± 0.00	0.00 ± 0.00	18.52 ± 0.05	5673.25 ± 12.24
50	0.64 ± 0.00	0.26 ± 0.00	18.78 ± 0.01	9.38 ± 0.00	7.29 ± 0.01	0.00 ± 0.00	20.35 ± 0.01	5700.21 ± 2.55

Table 1. (continued).

Sample ID	Mn	Cd	Cr	Pt	Sn	B	Cu
1	361.04 ± 0.05	0.00 ± 0.00	44.49 ± 0.26	5.42 ± 0.03	0.68 ± 0.00	63.53 ± 0.27	23.91 ± 0.04
2	348.59 ± 0.08	0.00 ± 0.00	39.94 ± 0.06	5.75 ± 0.01	0.89 ± 0.00	60.27 ± 0.10	29.02 ± 0.02
3	318.53 ± 0.12	0.00 ± 0.00	40.58 ± 0.16	3.56 ± 0.02	0.92 ± 0.00	49.30 ± 0.28	25.81 ± 0.03
4	330.25 ± 0.10	0.00 ± 0.00	36.38 ± 0.17	3.34 ± 0.02	0.67 ± 0.00	43.71 ± 0.18	24.80 ± 0.03
5	266.05 ± 0.05	0.00 ± 0.00	28.29 ± 0.07	2.77 ± 0.00	0.46 ± 0.00	43.12 ± 0.17	18.69 ± 0.01
6	205.80 ± 0.04	0.00 ± 0.00	19.45 ± 0.08	2.41 ± 0.01	0.30 ± 0.00	37.05 ± 0.23	13.27 ± 0.01
7	286.37 ± 0.12	0.00 ± 0.00	19.35 ± 0.06	2.28 ± 0.01	0.28 ± 0.00	29.02 ± 0.11	14.72 ± 0.02
8	303.01 ± 0.02	0.00 ± 0.00	23.30 ± 0.07	2.76 ± 0.01	0.45 ± 0.00	41.13 ± 0.19	17.80 ± 0.01
9	293.47 ± 0.18	0.00 ± 0.00	22.49 ± 0.10	2.85 ± 0.02	0.46 ± 0.00	36.07 ± 0.09	15.96 ± 0.03
10	223.02 ± 0.12	0.00 ± 0.00	16.84 ± 0.05	2.68 ± 0.00	0.22 ± 0.00	28.93 ± 0.11	10.39 ± 0.01
11	240.70 ± 0.11	0.00 ± 0.00	18.58 ± 0.03	2.97 ± 0.00	0.18 ± 0.00	30.07 ± 0.07	13.01 ± 0.01
12	336.99 ± 0.04	0.00 ± 0.00	27.87 ± 0.09	4.50 ± 0.01	0.51 ± 0.00	49.26 ± 0.21	24.52 ± 0.01
13	372.54 ± 0.24	0.00 ± 0.00	53.07 ± 0.06	7.18 ± 0.01	0.68 ± 0.01	78.53 ± 0.08	32.72 ± 0.06
14	328.75 ± 0.14	0.00 ± 0.00	53.82 ± 0.08	7.36 ± 0.01	0.79 ± 0.00	75.87 ± 0.12	29.47 ± 0.03
15	281.78 ± 0.07	0.00 ± 0.00	37.43 ± 0.02	4.72 ± 0.00	0.47 ± 0.00	50.83 ± 0.03	17.50 ± 0.00
16	357.74 ± 0.06	0.00 ± 0.00	55.35 ± 0.05	7.25 ± 0.00	0.75 ± 0.00	81.08 ± 0.09	29.93 ± 0.02
17	279.24 ± 0.03	0.00 ± 0.00	37.04 ± 0.04	4.73 ± 0.01	0.56 ± 0.00	50.51 ± 0.05	20.50 ± 0.00
18	387.73 ± 0.15	0.00 ± 0.00	50.64 ± 0.16	6.86 ± 0.02	0.84 ± 0.00	75.36 ± 0.20	33.25 ± 0.02
19	331.42 ± 0.26	0.00 ± 0.00	40.67 ± 0.23	5.88 ± 0.03	0.80 ± 0.00	61.41 ± 0.29	30.62 ± 0.06
20	390.24 ± 0.27	0.00 ± 0.00	42.93 ± 0.26	5.43 ± 0.04	0.75 ± 0.00	64.10 ± 0.36	31.73 ± 0.07
21	398.47 ± 0.09	0.00 ± 0.00	52.23 ± 0.11	0.00 ± 0.00	1.01 ± 0.00	62.40 ± 0.09	35.53 ± 0.01
22	395.66 ± 0.08	0.00 ± 0.00	48.79 ± 0.09	0.00 ± 0.00	0.63 ± 0.00	57.35 ± 0.09	31.82 ± 0.02
23	390.59 ± 0.22	0.00 ± 0.00	59.15 ± 0.15	0.00 ± 0.00	0.32 ± 0.00	67.39 ± 0.14	33.26 ± 0.05
24	384.48 ± 0.13	0.00 ± 0.00	59.42 ± 0.18	0.00 ± 0.00	0.50 ± 0.00	68.28 ± 0.17	35.59 ± 0.16
25	381.30 ± 0.22	0.00 ± 0.00	75.42 ± 0.17	0.00 ± 0.00	0.73 ± 0.01	88.01 ± 0.19	39.92 ± 0.04
26	412.51 ± 0.03	0.00 ± 0.00	74.18 ± 0.13	0.00 ± 0.00	0.76 ± 0.01	87.24 ± 0.15	40.34 ± 0.02
27	402.07 ± 0.07	0.00 ± 0.00	60.39 ± 0.15	0.00 ± 0.00	0.32 ± 0.00	73.36 ± 0.17	33.18 ± 0.03
28	331.94 ± 0.06	0.00 ± 0.00	46.11 ± 0.07	0.00 ± 0.00	0.44 ± 0.01	56.29 ± 0.08	23.28 ± 0.01
29	146.28 ± 0.03	0.03 ± 0.00	18.23 ± 0.02	1.39 ± 0.00	0.00 ± 0.00	18.11 ± 0.02	6.07 ± 0.00
30	178.38 ± 0.04	0.02 ± 0.00	23.30 ± 0.04	0.91 ± 0.00	0.00 ± 0.00	25.14 ± 0.04	8.44 ± 0.01
31	153.11 ± 0.03	0.00 ± 0.00	29.74 ± 0.03	1.22 ± 0.00	0.00 ± 0.00	26.68 ± 0.03	7.99 ± 0.01
32	177.19 ± 0.02	0.00 ± 0.00	28.21 ± 0.05	0.79 ± 0.00	0.19 ± 0.01	27.50 ± 0.05	8.32 ± 0.01
33	162.42 ± 0.07	0.00 ± 0.00	27.92 ± 0.05	1.37 ± 0.00	0.00 ± 0.00	28.80 ± 0.10	8.64 ± 0.01
34	150.02 ± 0.08	0.00 ± 0.00	20.87 ± 0.00	0.00 ± 0.00	0.20 ± 0.00	24.06 ± 0.01	9.73 ± 0.01
35	176.55 ± 0.10	0.00 ± 0.00	23.98 ± 0.04	0.00 ± 0.00	0.08 ± 0.00	27.29 ± 0.03	10.80 ± 0.01
36	256.64 ± 0.10	0.00 ± 0.00	36.41 ± 0.06	0.00 ± 0.00	0.20 ± 0.00	42.06 ± 0.07	16.80 ± 0.01
37	213.83 ± 0.11	0.00 ± 0.00	28.30 ± 0.10	0.00 ± 0.00	0.58 ± 0.02	32.51 ± 0.09	13.50 ± 0.02
38	189.0 ± 0.05	0.00 ± 0.00	22.76 ± 0.10	0.00 ± 0.00	0.00 ± 0.00	26.37 ± 0.11	11.60 ± 0.02
39	145.18 ± 0.09	0.00 ± 0.00	17.08 ± 0.06	0.73 ± 0.01	0.00 ± 0.00	18.93 ± 0.06	7.46 ± 0.01
40	198.72 ± 0.10	0.00 ± 0.00	18.78 ± 0.06	0.00 ± 0.00	0.00 ± 0.00	23.43 ± 0.06	9.92 ± 0.01
41	264.30 ± 0.19	0.00 ± 0.00	25.95 ± 0.05	0.00 ± 0.00	0.00 ± 0.00	33.99 ± 0.10	14.75 ± 0.02

(*Continued*)

Table 1. (Continued).

Sample ID	Mn	Cd	Cr	Pt	Sn	B	Cu
42	198.21 ± 0.02	0.00 ± 0.00	21.41 ± 0.02	0.00 ± 0.00	0.17 ± 0.01	25.48 ± 0.03	12.21 ± 0.01
43	207.17 ± 0.13	0.00 ± 0.00	16.58 ± 0.03	0.22 ± 0.01	0.51 ± 0.02	21.67 ± 0.04	9.13 ± 0.00
44	205.81 ± 0.11	0.10 ± 0.00	19.64 ± 0.05	0.47 ± 0.01	0.95 ± 0.00	24.44 ± 0.05	10.32 ± 0.01
45	348.64 ± 0.35	0.04 ± 0.00	35.88 ± 0.19	0.00 ± 0.00	1.14 ± 0.00	48.06 ± 0.22	19.66 ± 0.04
46	338.54 ± 0.41	0.02 ± 0.00	34.85 ± 0.10	0.00 ± 0.00	0.93 ± 0.00	47.78 ± 0.12	18.96 ± 0.02
47	351.99 ± 0.37	0.01 ± 0.00	42.6 ± 0.07	0.00 ± 0.00	0.96 ± 0.00	57.23 ± 0.09	21.62 ± 0.03
48	327.96 ± 0.31	0.05 ± 0.00	28.48 ± 0.15	0.00 ± 0.00	0.85 ± 0.00	41.04 ± 0.20	17.27 ± 0.03
49	324.90 ± 0.19	0.05 ± 0.00	23.34 ± 0.09	0.00 ± 0.00	0.67 ± 0.00	34.51 ± 0.11	13.93 ± 0.02
50	297.44 ± 0.08	0.06 ± 0.00	22.71 ± 0.02	0.00 ± 0.00	0.81 ± 0.00	33.61 ± 0.03	14.82 ± 0.02

Table 2. Descriptive statistics of the results on concentration (mg kg^{-1}) of heavy metals in sediment samples.

Variable	N	Mean	Minimum	Maximum	Range	SD	SE	CV (%)
As	50	1.66	0.00	4.86	0.00–4.86	1.53	0.22	92.45
Co	50	11.22	4.77	20.32	4.77–20.32	4.23	0.60	37.68
Hg	50	0.11	0.00	0.46	0.00–0.46	0.11	0.02	100.22
Ni	50	21.98	6.72	41.45	6.72–41.45	9.85	1.39	44.82
B	50	45.96	18.11	88.01	18.11–88.01	19.62	2.77	42.68
Cd	50	0.01	0.00	0.10	0.00–0.10	0.02	0.00	251.24
Cr	50	35.02	16.58	75.42	16.58–75.42	15.35	2.17	43.82
Cu	50	20.05	6.07	40.34	6.07–40.34	9.76	1.38	48.70
Fe	50	6056.51	3191.84	8541.88	3191.84–8541.88	1511.10	213.70	24.95
Mn	50	287.05	145.18	412.51	145.18–412.51	82.89	11.72	28.87
Mo	50	0.42	0.00	2.24	0.00–2.24	0.60	0.08	141.56
Pb	50	10.56	4.15	19.59	4.15–19.59	4.47	0.63	42.32
Pt	50	1.96	0.00	7.36	0.00–7.36	2.42	0.34	123.75
Sn	50	0.49	0.00	1.14	0.00–1.14	0.33	0.05	67.53
Zn	50	27.33	3.81	55.22	3.81–55.22	13.27	1.88	48.54

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