

Supplementary Information

Spatial and Temporal Effects of Decommissioning a Zinc Smelter on the Sediment Quality of an Estuary System: Sepetiba Bay, Rio de Janeiro, Brazil

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(a)



(b)

Figure S1. Former Cia. Ingá Mercantil legacy in Sepetiba Bay, Rio de Janeiro, Brazil, before (a) and after (b) the decommissioning.

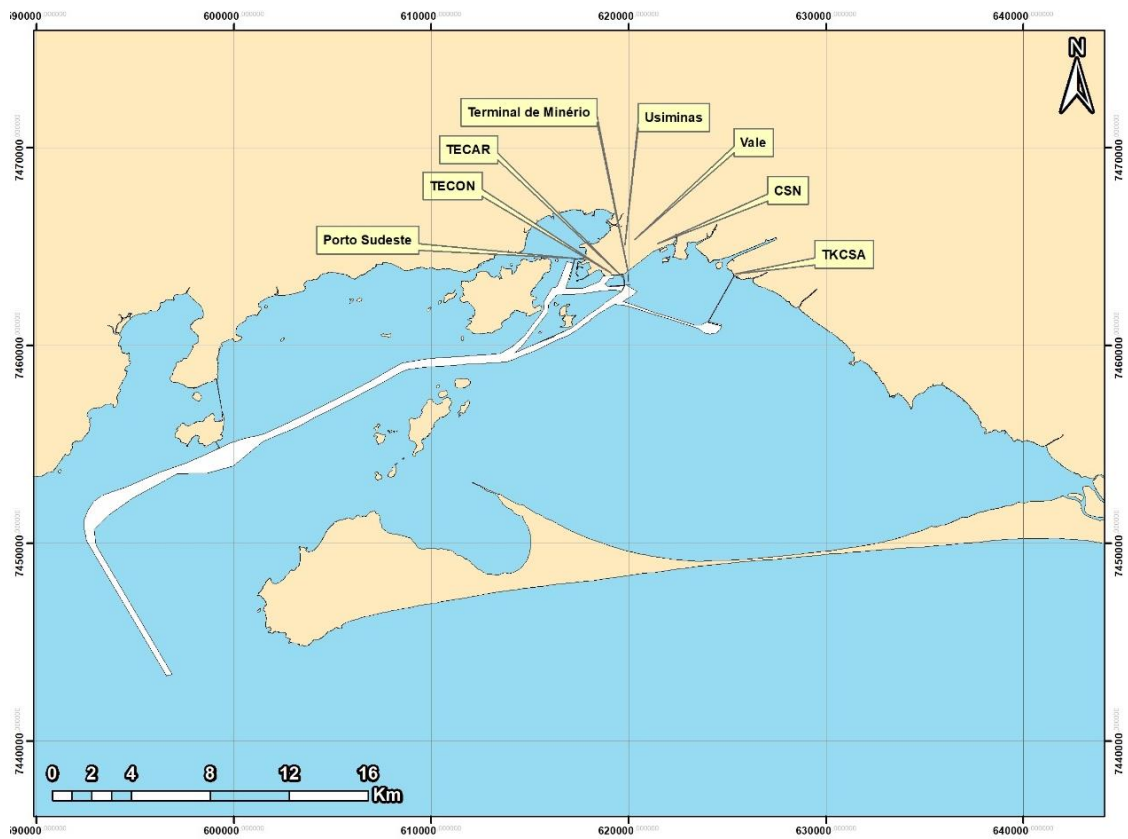


Figure S2. Sepetiba Bay navigation channel, harbors and ship terminals.

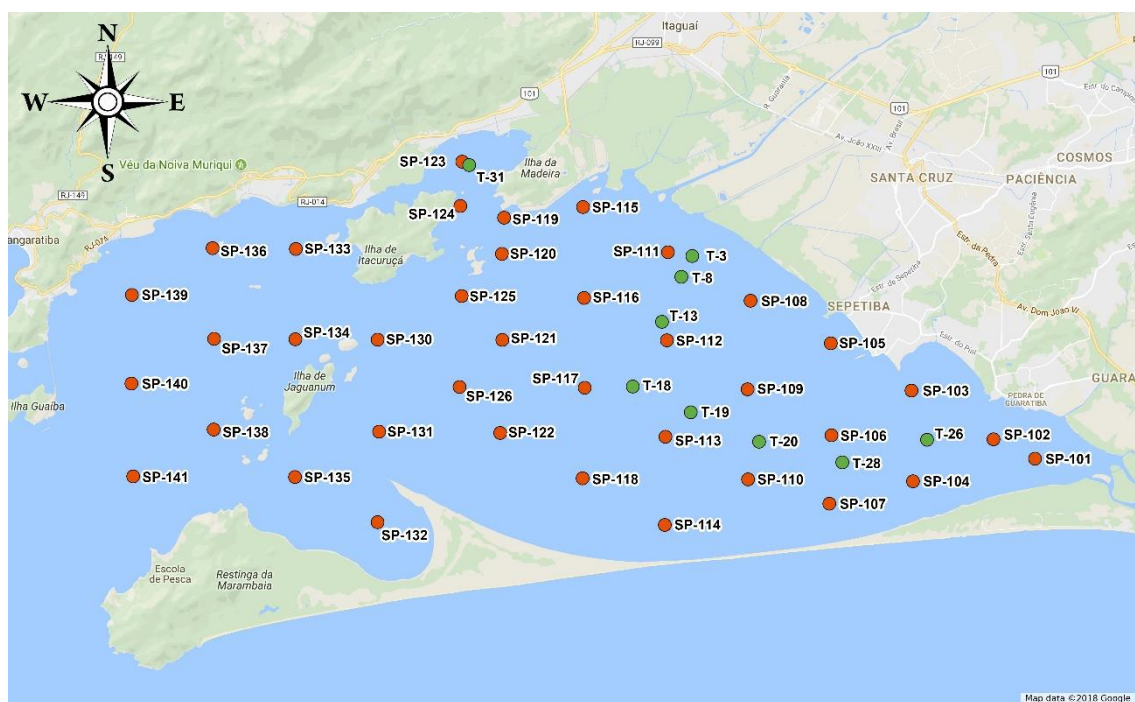


Figure S3. Sepetiba Bay morphology, the surface sediment sampling points (red dots) and the collection locations for sediment cores (green dots).

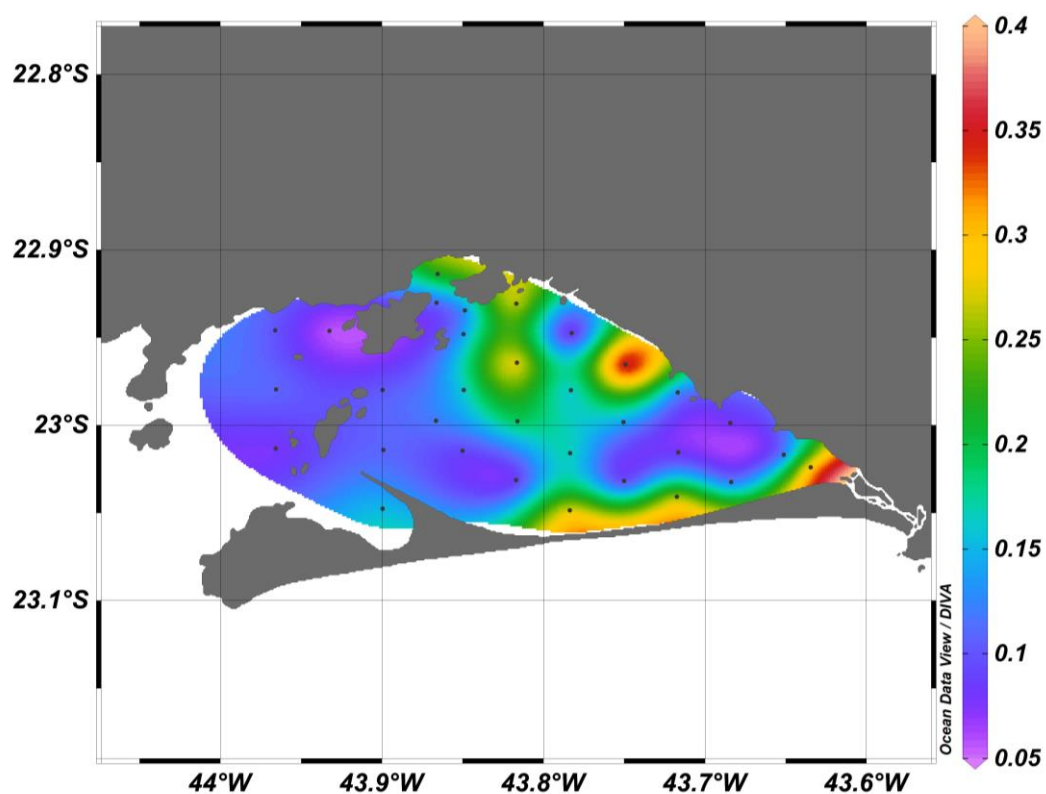


Figure S4. Σ SEM/AVS ratio distribution in surface sediments sampled in 2016 throughout Sepetiba bay.

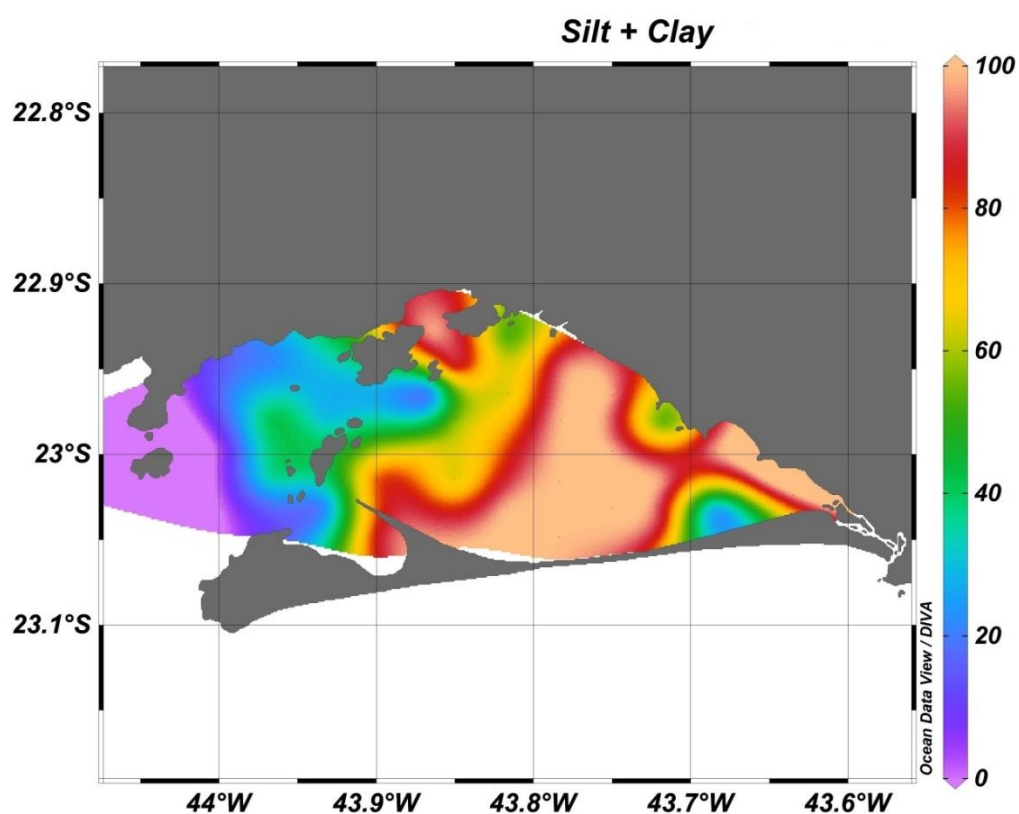


Figure S5. Fine particles (silt + clay) percentage distribution in surface sediments sampled in 2016 throughout Sepetiba bay.

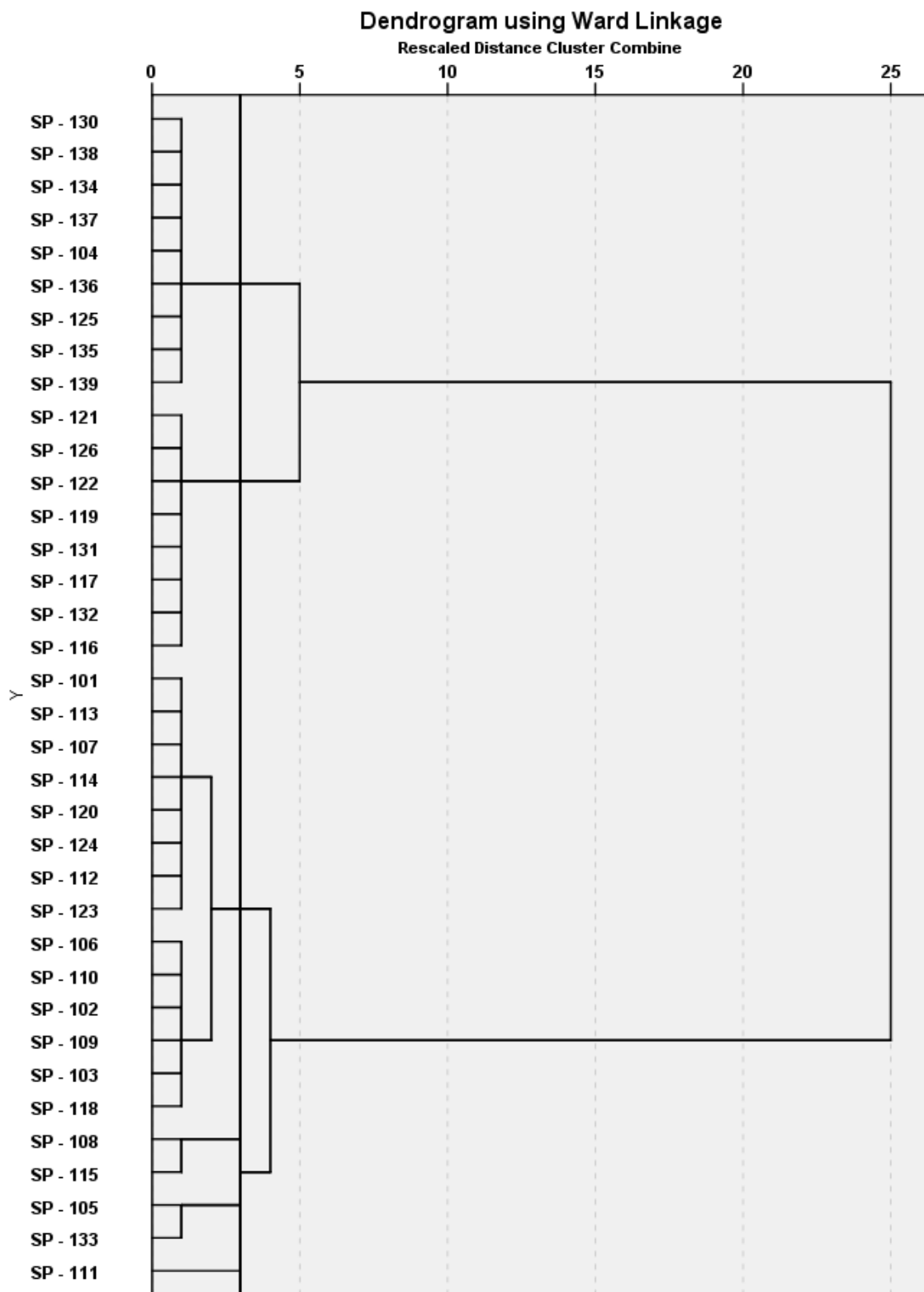
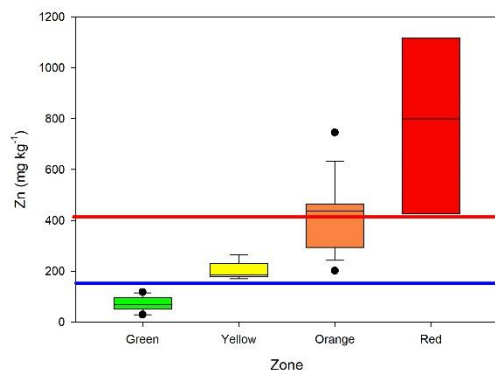
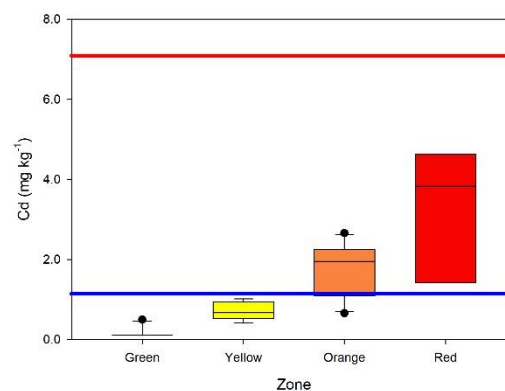


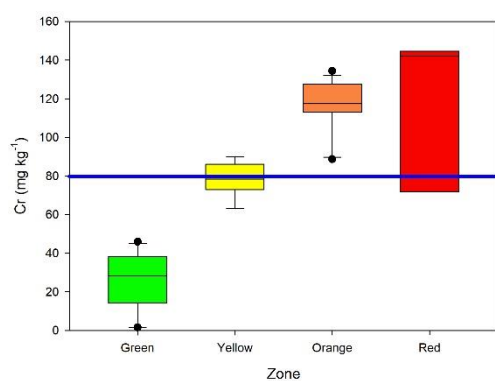
Figure S6. Dendrogram based on the sampling points.



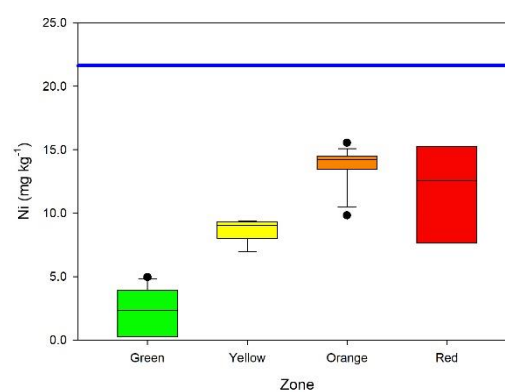
(a)



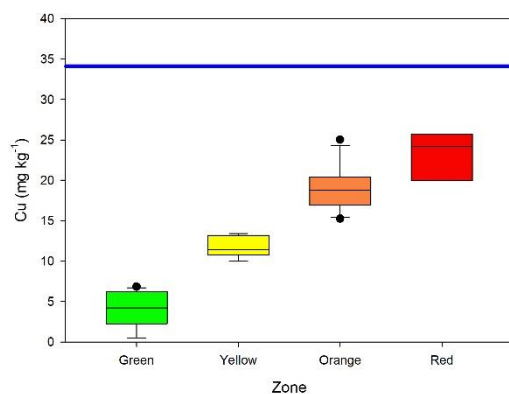
(b)



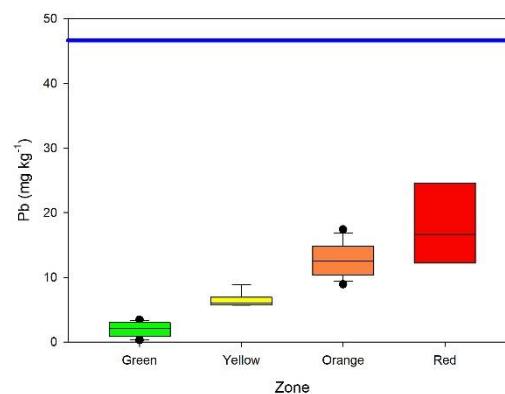
(c)



(d)



(e)



(f)

Figure S7. Box-plots of the metal concentrations classified according to the cluster groups with the red horizontal line representing the sediment quality guideline (SQG) from CONAMA resolution 454/201, blue lines representing SQG 1 and the red lines representing SQG2 for each element.

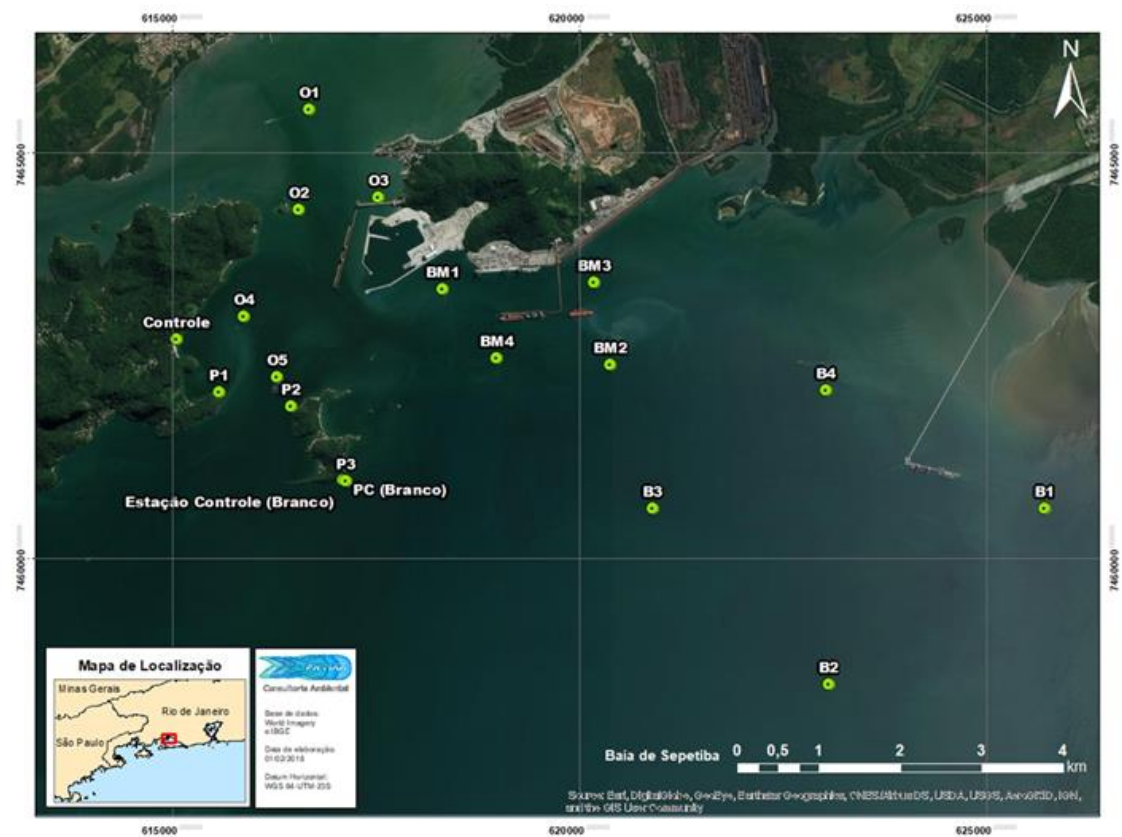


Figure S8. Sampling points of the oyster biomonitoring program developed at Sepetiba bay.

Table S1. Surface sediment sampling points coordinates

Sampling station	Geographical coordinates (GMS)		UTM-23S / Datum WGS 84	
	Latitude	Longitude	X	Y
SP-101	23°01'26.35"S	43°38'04.66"O	639910	7453173
SP-102	23°01'00.36"S	43°39'04.85"O	638204	7453988
SP-103	22°59'55.18"S	43°41'03.92"O	634832	7456023
SP-104	23°01'56.49"S	43°41'01.72"O	634854	7452292
SP-105	22°58'52.17"S	43°43'00.98"O	631516	7457991
SP-106	23°00'55.13"S	43°42'59.96"O	631512	7454209
SP-107	23°02'26.30"S	43°43'02.92"O	631403	7451406
SP-108	22°57'55.39"S	43°44'57.29"O	628219	7459766
SP-109	22°59'53.45"S	43°45'01.61"O	628065	7456136
SP-110	23°01'53.98"S	43°45'01.02"O	628050	7452429
SP-111	22°56'50.34"S	43°46'57.29"O	624818	7461795
SP-112	22°58'48.16"S	43°46'58.94"O	624741	7458172
SP-113	23°00'57.10"S	43°47'00.87"O	624653	7454207
SP-114	23°02'54.68"S	43°47'01.78"O	624597	7450591
SP-115	22°55'50.05"S	43°49'00.66"O	621319	7463678
SP-116	22°57'51.62"S	43°48'59.14"O	621332	7459939
SP-117	22°59'51.59"S	43°48'58.20"O	621329	7456249
SP-118	23°01'52.51"S	43°49'01.23"O	621213	7452531
SP-119	22°56'04.39"S	43°50'55.23"O	618052	7463263
SP-120	22°56'52.63"S	43°50'58.33"O	617952	7461780
SP-121	22°58'47.54"S	43°50'57.57"O	617946	7458246
SP-122	23°00'52.03"S	43°51'00.62"O	617829	7454418
SP-123	22°54'49.45"S	43°51'55.99"O	616339	7465581
SP-124	22°55'48.52"S	43°51'58.48"O	616254	7463765
SP-125	22°57'49.11"S	43°51'59.07"O	616279	7460056
SP-126	22°59'50.55"S	43°51'59.66"O	616163	7456322
SP-130	22°58'47.33"S	43°53'58.61"O	612791	7458292
SP-131	23°00'50.23"S	43°53'56.66"O	612818	7454512
SP-132	23°02'51.17"S	43°53'58.63"O	612734	7450793
SP-133	22°56'46.24"S	43°55'57.41"O	609435	7462041
SP-134	22°58'46.62"S	43°55'57.91"O	609394	7458339
SP-135	23°01'50.83"S	43°55'58.71"O	609330	7452674
SP-136	22°56'44.96"S	43°57'58.13"O	605997	7462105
SP-137	22°58'46.23"S	43°57'56.12"O	606028	7458375
SP-138	23°00'47.33"S	43°57'56.74"O	605984	7454651
SP-139	22°57'47.46"S	43°59'55.33"O	602646	7460206
SP-140	22°59'46.05"S	43°59'55.82"O	602607	7456559
SP-141	23°01'49.99"S	43°59'53.36"O	602651	7452747

Table S2. Sediment core sampling points coordinates

Sampling station	Geographical coordinates (GMS)		UTM-23S / Datum WGS 84	
	Latitude	Longitude	X	Y
T-3	22°56'55.5"S	43°46'22.2"O	625816	7461627
T-8	22°57'23.4"S	43°46'37.9"O	625363	7460773
T-13	22°58'23.4"S	43°47'05.8"O	624551	7458935
T-18	22°59'50.0"S	43°47'48.2"O	623323	7456283
T-19	23°00'24.3"S	43°46'24.2"O	625707	7455208
T-20	23°01'03.6"S	43°44'45.0"O	628519	7453976
T-26	23°01'01.1"S	43°40'41.3"O	635458	7453991
T-28	23°01'31.1"S	43°42'44.2"O	631950	7453100
T-31	22°54'53.9"S	43°51'46.0"O	616624	7465442

Table S3. Metal concentration in surface sediments

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 101 A	339		1.9		113		20		14		10	
SP - 101 B	360	347	2.0	2	113	113	20	20	14	14	10	10
SP - 101 C	343		2.0		112		19		14		10	
SP - 102 A	443		2.3		115		20		14		15	
SP - 102 B	433	445	2.3	2	115	116	20	21	14	14	14	15
SP - 102 C	459		2.3		118		21		14		15	
SP - 103 A	586		2.8		128		25		15		16	
SP - 103 B	590	584	2.5	3	129	129	24	24	15	15	17	17
SP - 103 C	576		2.7		129		24		14		17	
SP - 104 A	113		0.5		23.1		4.9		3.6		2.9	
SP - 104 B	116	112	0.5	0	24.8	25	5.5	5	3.7	4	3.0	3
SP - 104 C	108		0.5		27.0		5.4		3.8		3.2	
SP - 105 A	569		2.8		131		26		14		18	
SP - 105 B	537	556	2.5	3	127	128	25	25	14	14	17	17
SP - 105 C	563		2.6		125		24		14		17	
SP - 106 A	458		2.1		120		20		15		14	
SP - 106 B	460	457	2.0	2	117	118	19	19	15	14	14	14
SP - 106 C	454		1.9		117		19		14		14	
SP - 107 A	440		2.2		89.9		15		11		8.9	
SP - 107 B	449	452	2.2	2	89.1	90	15	15	11	11	8.8	9
SP - 107 C	468		2.2		91.6		16		11		9.1	

Table S3. Metal concentration in surface sediments (cont.)

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 108 A	1130		4.7		146		27		13		17	
SP - 108 B	1130	1116	4.6	5	142	142	25	26	13	13	17	17
SP - 108 C	1088		4.6		139		25		12		16	
SP - 109 A	1100		2.3		124		22		14		14	
SP - 109 B	593	746	2.4	2	129	127	22	22	15	14	15	15
SP - 109 C	545		2.3		127		22		14		15	
SP - 110 A	377		1.6		117		18		15		13	
SP - 110 B	384	389	1.7	2	117	117	18	18	14	14	13	13
SP - 110 C	405		1.6		116		18		14		13	
SP - 111 A	433		1.4		145		24		15		25	
SP - 111 B	428	427	1.4	1	145	145	25	24	15	15	25	25
SP - 111 C	421		1.5		144		24		15		25	
SP - 112 A	393		1.8		87.1		16		10		9	
SP - 112 B	425	405	2.0	2	90.5	89	17	16	10	10	10	10
SP - 112 C	399		2.0		88.6		16		10		10	
SP - 113 A	439		1.8		119		18		14		12	
SP - 113 B	435	439	1.8	2	123	121	18	18	15	14	13	12
SP - 113 C	443		1.7		120		18		14		12	
SP - 114 A	420		2.1		114		19		14		10	
SP - 114 B	428	434	2.1	2	113	114	19	19	14	14	10	10
SP - 114 C	454		2.2		114		19		14		11	

Table S3. Metal concentration in surface sediments (cont.)

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 115 A	818		3.9		72.4		21		7.4		12	
SP - 115 B	821	799	4.0	4	76.1	72	21	20	8.2	8	13	12
SP - 115 C	759		3.6		66.7		19		7.2		12	
SP - 116 A	248		1.0		60.7		11		6.8		5.7	
SP - 116 B	280	265	1.0	1	66.2	63	11	11	7.1	7	6.4	6
SP - 116 C	268		1.0		63.2		11		6.9		6.0	
SP - 117 A	226		0.9		77.2		11		8.8		6.2	
SP - 117 B	195	217	0.9	1	79.0	78	12	11	9.2	9	6.4	6
SP - 117 C	232		0.9		76.7		11		8.7		6.2	
SP - 118 A	276		1.1		117		17		15		12	
SP - 118 B	264	273	1.0	1	114	115	17	17	14	15	11	12
SP - 118 C	278		1.0		116		16		15		12	
SP - 119 A	176		0.7		78.5		13		10		8.8	
SP - 119 B	190	187	0.7	1	78.9	79	13	13	9.1	9	8.8	9
SP - 119 C	194		0.7		79.9		13		8.7		9.0	
SP - 120 A	198		0.6		99.0		15		13		10	
SP - 120 B	189	202	0.7	1	100	100	16	15	13	13	10	10
SP - 120 C	220		0.7		102		15		13		10	
SP - 121 A	106		0.4		43.9		6.8		5.0		3.4	
SP - 121 B	113	118	0.4	0	44.7	44	6.9	7	5.1	5	3.4	3
SP - 121 C	135		0.4		43.5		6.8		4.8		3.4	

Table S3. Metal concentration in surface sediments (cont.)

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 122 A	178		0.4		82.9		10		8.7		5.9	
SP - 122 B	191	181	0.4	0	75.1	76	10	10	8.5	8	5.7	6
SP - 122 C	173		0.4		70.7		10		8.0		5.5	
SP - 123 A	466		1.4		134		20		15		15	
SP - 123 B	463	466	1.3	1	135	134	21	20	15	15	15	15
SP - 123 C	469		1.3		133		19		15		15	
SP - 124 A	277		0.7		128		19		13		12	
SP - 124 B	259	261	0.7	1	125	126	18	18	13	13	12	12
SP - 124 C	248		0.7		124		18		13		12	
SP - 125 A	56.3		< 0.2		15.8		2.7		< 0.5		0.8	
SP - 125 B	52.1	53	< 0.2	< 0.2	12.0	14	2.2	2	< 0.5	< 0.5	0.6	1
SP - 125 C	51.6		< 0.2		14.4		1.9		< 0.5		0.8	
SP - 126 A	96.6		< 0.2		48.9		6.8		5.0		3.3	
SP - 126 B	104	101	< 0.2	< 0.2	46.3	46	6.4	6	4.7	5	3.2	3
SP - 126 C	101		< 0.2		42.6		6.2		4.1		3.0	
SP - 130 A	79.1		< 0.2		35.3		7.0		3.2		2.1	
SP - 130 B	67.1	69	< 0.2	< 0.2	27.1	30	5.9	6	2.4	3	1.7	2
SP - 130 C	60.4		< 0.2		27.4		5.6		2.6		2.2	
SP - 131 A	163		0.4		81.1		11		8.8		5.6	
SP - 131 B	178	170	0.5	1	86.3	85	12	12	10	9	6	6
SP - 131 C	171		0.7		87.4		12		9.5		6.6	

Table S3. Metal concentration in surface sediments (cont.)

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 132 A	188		0.6		90.3		14		9.3		5.6	
SP - 132 B	183	186	0.6	1	89.4	90	13	13	9.4	9	5.5	6
SP - 132 C	188		0.8		89.8		13		10		6.1	
SP - 133 A	280		0.7		132		20		16		12	
SP - 133 B	277	276	0.8	1	132	131	18	19	16	16	12	13
SP - 133 C	271		1.0		130		18		15		13	
SP - 134 A	81.0		< 0.2		33.8		4.2		2.8		1.9	
SP - 134 B	76.6	79	< 0.2	< 0.2	32.0	33	4.7	4	2.6	3	1.9	2
SP - 134 C	78.9		< 0.2		32.4		3.6		2.7		2.4	
SP - 135 A	49.7		< 0.2		16.2		2.6		< 0.5		1.3	
SP - 135 B	46.2	48	< 0.2	< 0.2	13.5	14	2.3	2	< 0.5	< 0.5	1.0	1
SP - 135 C	49.5		< 0.2		13.6		1.8		< 0.5		1.4	
SP - 136 A	70.1		< 0.2		28.6		4.3		2.5		2.3	
SP - 136 B	93.9	83	< 0.2	< 0.2	29.0	28	3.6	4	2.3	2	2.4	2
SP - 136 C	86.1		< 0.2		27.1		3.8		2.3		2.6	
SP - 137 A	87.6		< 0.2		43.5		6.1		4.2		2.7	
SP - 137 B	91.5	91	< 0.2	< 0.2	44.5	44	7.0	6	4.1	4	3.0	3
SP - 137 C	93.6		< 0.2		43.5		6.0		4.1		3.3	
SP - 138 A	63.0		< 0.2		30.7		5.7		2.4		2.0	
SP - 138 B	63.1	63	< 0.2	< 0.2	29.0	29	5.4	5	2.4	2	1.9	2
SP - 138 C	62.9		< 0.2		28.5		4.9		2.2		2.4	

Table S3. Metal concentration in surface sediments (cont.)

Sample/Replicate	Concentration / (mg kg ⁻¹)											
	Zinc	Mean	Cadmium	Mean	Chromium	Mean	Lead	Mean	Nickel	Mean	Copper	Mean
SP - 139 A	60.5		< 0.2		18.9		3.8		0.7		0.8	
SP - 139 B	61.5	60	< 0.2	< 0.2	19.4	19	3.6	4	0.8	1	0.8	1
SP - 139 C	57.3		< 0.2		19.4		4.3		0.8		1.2	
SP - 140 A	27.5		< 0.2		1.7		< 1.0		< 0.5		0.3	
SP - 140 B	30.0	30	< 0.2	< 0.2	1.5	2	< 1.0	< 1.0	< 0.5	< 0.5	0.2	0
SP - 140 C	31.8		< 0.2		1.5		< 1.0		< 0.5		0.6	
SP - 141 A	33.1		< 0.2		1.9		< 1.0		< 0.5		0.2	
SP - 141 B	28.0	30	< 0.2	< 0.2	1.8	2	< 1.0	< 1.0	< 0.5	< 0.5	0.1	0
SP - 141 C	27.9		< 0.2		2.0		< 1.0		< 0.5		0.6	

Table S4. Obtained metal recovery based on the application of the EPA 3050b method to the CRM MESS-3 (n = 5)

Element	Obtained / (mg kg ⁻¹)	Certified / (mg kg ⁻¹)	Recovery / %
Zn	162.0 ± 1.9	162 ± 8	102
Pb	19.8 ± 0.5	21.1 ± 0.7	93.8
Cu	32.5 ± 0.4	33.9 ± 1.6	95.9
Cd	0.23 ± 0.01	0.24 ± 0.01	95.8
Cr	58.1 ± 0.5	105 ± 4	55.3
Ni	46.6 ± 1.0	46.9 ± 2.2	99.4
Hg	0.083 ± 0.006	0.091 ± 0.009	91.2

