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Supplementary materials

Table S1. Classifications of the HMs according to the geo-accumulation index.

Classes	Values	Description
0	$I_{geo} \leq 0$	Unpolluted
1	$0 < I_{geo} \leq 1$	From unpolluted to moderately polluted
2	$1 < I_{geo} \leq 2$	Moderately polluted
3	$2 < I_{geo} \leq 3$	From moderately polluted to strongly polluted
4	$3 < I_{geo} \leq 4$	Strongly polluted
5	$4 < I_{geo} \leq 5$	From strongly polluted to extremely polluted
6	$I_{geo} > 5$	Extremely polluted

Table S2. Grades of the HMs according to the E_r^i and RI

E_r^i	Risk Level	RI	Risk Level
$E_r^i < 40$	Low potential risk	RI < 150	Low ecological risk
$40 \leq E_r^i < 80$	Moderate potential risk	150 ≤ RI < 300	Moderate ecological risk
$80 \leq E_r^i < 160$	Considerable potential risk	300 ≤ RI< 600	High ecological risk
$160 \leq E_r^i < 320$	High potential risk	600 ≤ RI	Significantly high ecological risk
$320 \leq E_r^i$	Serious		

Table S3. Definition and reference value of some parameters for human health risk assessment of HMs in soil.

Parameter	Definition	Reference Values		Reference
		Adult	Children	
IngR	The ingestion frequency (mg/day)	200	100	[1]
InhR	The inhalation frequency/(m^3/day)	15	7.5	[2]
PEF	The particle emission factor/(m^3/kg)	1.36×10^9	1.36×10^9	[3]
SA	Surface area of exposed skin/(cm^2)	4350	1600	[2]
AF	Adhesiveness degree of skin/(mg/(cm^2 day))	0.07	0.2	[4]
BW	Body weight/(kg)	53.1	15	[5]
ED	Exposure duration/(year)	Non-carcinogenic 24 carcinogenic 24	Non-carcinogenic 6 carcinogenic 30	[5]
ABS	Absorption factor of skin	0.001	0.001	[4]
EF	The exposure frequency/(day/year)	350	350	[4]
CF	The conversion factor/(kg/mg)	1×10^{-6}	1×10^{-6}	[6]
AT	The average exposure time/(day)	Non-carcinogenic ED × 365 = 8760; carcinogenic 365 × 70 = 25550	Non-carcinogenic ED × 365 = 2190; carcinogenic 365 × 70 = 25550	[5]

Table S4. Parameter values of *RfD* and *SF* in the assessment model of health risk.

Parameter	Cu	Cr	Ni	Zn	Pb	Cd	As	Hg
RfD_{ing}	4.00×10^{-2}	3.00×10^{-3}	2.00×10^{-2}	3.00×10^{-1}	3.50×10^{-3}	1.00×10^{-3}	3.00×10^{-4}	3.00×10^{-4}
RfD_{der}	1.20×10^{-2}	6.00×10^{-5}	5.40×10^{-3}	6.00×10^{-2}	5.25×10^{-4}	1.00×10^{-5}	1.23×10^{-4}	2.4×10^{-5}
RfD_{inh}	4.02×10^{-2}	2.86×10^{-5}	2.06×10^{-2}	3.00×10^{-1}	3.52×10^{-3}	1.00×10^{-5}	3.00×10^{-4}	3.00×10^{-4}
SF_{ing}					8.50×10^{-3}		1.50	
SF_{der}							3.66	
SF_{inh}		4.20×10	8.40×10^{-1}			6.3	1.51×10	

Table S5. The physicochemical parameter of soils in Chongming Island.

Unit	Statistic	pH	CEC	TP	TN	OC
		-	cmol (+)/kg	mg/kg	g/kg	g/kg
Agricultural Land	Mean	8.26	12.25	814.92	1.04	11.25
	Min	7.63	4.43	455.00	0.35	4.50
	Max	8.67	26.60	1460.00	1.83	26.10
	SD	0.25	3.97	176.73	0.34	3.80
	Skewness	-0.72	0.91	0.64	0.37	1.41
	CV (%)	3.03	32.46	21.69	32.64	33.78
Forest Land	Mean	8.23	12.94	716.45	1.08	13.03
	Min	7.90	5.72	381.00	0.16	5.44
	Max	8.73	23.30	1020.00	1.94	31.20
	SD	0.20	4.76	138.18	0.39	5.10
	Skewness	0.44	0.65	-0.12	0.10	1.32
	CV (%)	2.45	36.80	19.29	35.76	39.15
Wetland	Mean	8.49	12.01	765.76	0.83	9.53
	Min	7.78	3.33	545.00	0.19	2.10
	Max	10.09	25.10	1290.00	1.30	14.40
	SD	0.46	5.98	186.99	0.34	4.00
	Skewness	2.24	0.55	1.48	–0.50	-0.81
	CV (%)	5.46	49.79	24.42	40.43	41.96
Construction Land	Mean	8.20	11.08	866.13	0.95	10.50
	Min	7.94	5.67	536.00	0.57	4.80
	Max	8.46	18.70	1510.00	1.51	17.10
	SD	0.15	3.38	241.47	0.26	3.27
	Skewness	–0.01	0.57	1.18	0.81	0.54
	CV (%)	1.88	30.48	27.88	27.82	31.13
The Study Area	Mean	8.28	12.25	787.01	1.01	11.40
	Min	7.63	3.33	381.00	0.16	2.10
	Max	10.09	26.60	1510.00	1.94	31.20
	SD	0.29	4.51	186.33	0.35	4.33
	Skewness	1.89	0.72	0.99	0.22	1.14
	CV (%)	3.45	36.84	23.68	35.06	38.03

SD: Standard Deviation CV: Coefficient of Variation.

Table S6. Classifications of coefficients of variation (CV).

Classes	Values	Description
1	CV < 20%	Low variability
2	20% < CV ≤ 50%	Moderate variability
3	50% < CV ≤ 100%	High variability
4	CV > 100%	Exceptionally high variability

Table S7. Concentrations of soil HMs in the study area under land use.

Unit	Statistic	Cu	Cr	Ni	Zn	Pb	Cd	As	Hg
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Agricultural Land	Mea	31.29	87.52	35.35	89.12	26.67	0.202	9.32	0.074
	Min	10.90	71.80	26.40	52.60	16.20	0.080	6.22	0.028
	Max	104.00	114.00	48.50	163.00	49.40	0.390	15.30	0.244
	SD	13.37	11.28	5.25	22.31	5.61	0.062	2.32	0.035
	CV (%)	0.43	0.13	0.15	0.25	0.21	0.309	0.25	0.472
Forest Land	Mean	30.03	88.14	34.16	95.08	33.10	0.212	8.68	0.074
	Min	15.60	69.20	25.60	52.50	16.70	0.093	4.54	0.021
	Max	56.20	134.20	44.30	210.00	195.00	0.320	13.30	0.213
	SD	9.47	12.16	4.61	27.28	30.92	0.052	2.04	0.034
	CV (%)	0.32	0.14	0.14	0.29	0.93	0.243	0.23	0.466
Wetland	Mean	30.21	90.10	35.85	87.23	27.56	0.227	10.42	0.063
	Min	11.60	55.10	21.90	51.40	16.20	0.134	5.03	0.009
	Max	47.80	121.60	51.30	136.00	42.80	0.350	17.20	0.135
	SD	10.45	17.03	7.87	20.72	7.50	0.070	3.61	0.031
	CV (%)	0.35	0.19	0.22	0.24	0.27	0.311	0.35	0.493
Construction Land	Mean	27.24	86.71	32.39	95.44	36.43	0.200	8.20	0.106
	Min	12.90	76.50	27.20	59.90	17.30	0.080	6.30	0.034
	Max	37.40	114.40	36.90	181.10	132.30	0.394	9.50	0.187
	SD	6.24	9.01	2.64	27.32	26.34	0.062	0.94	0.043
	CV (%)	0.23	0.10	0.08	0.29	0.72	0.309	0.11	0.403

SD: Standard Deviation CV: Coefficient of Variation.

Table S8. The exceeding rate for soil HMs under different land use (%).

	Cu	Cr	Ni	Zn	Pb	Cd	As	Hg	Mean
Agricultural Land	82.35	100.00	98.04	70.59	45.10	96.08	21.57	54.90	71.08
Forest Land	72.73	100.00	93.94	84.85	48.48	96.97	9.09	54.55	70.08
Wetland	76.47	88.24	82.35	76.47	58.82	100.00	35.29	52.94	71.32
Construction Land	81.25	100.00	100.00	87.50	68.75	100.00	0.00	87.50	78.13

Table S9. The calculated E_r^i and RI in Chongming Island.

	E_r^i (Individual Metal)								RI (Multi-metal)
	Cu	Cr	Ni	Zn	Pb	Cd	As	Hg	
Mean	6.69	2.88	6.45	1.23	5.76	64.46	8.16	47.10	142.73
Min	2.41	1.81	4.07	0.69	3.12	24.89	4.05	5.54	62.56
Max	23.01	4.40	9.54	2.83	37.50	121.99	15.36	150.15	299.62

Table S10. The hazard quotient of HMs for three exposure pathways for children and adult in four land use types.

Risk	Gender	Land Use	Cu	Cr	Ni	Zn	Pb	Cd	As	Hg
HQ_{ing}	Children	Agricultural land	5.00×10^{-3}	1.86×10^{-1}	1.13×10^{-2}	1.90×10^{-3}	4.87×10^{-2}	1.29×10^{-3}	1.99×10^{-1}	1.57×10^{-3}
		Forest land	4.80×10^{-3}	1.88×10^{-1}	1.09×10^{-2}	2.03×10^{-3}	6.05×10^{-2}	1.36×10^{-3}	1.85×10^{-1}	1.57×10^{-3}
		Wetland	4.83×10^{-3}	1.92×10^{-1}	1.15×10^{-2}	1.86×10^{-3}	5.03×10^{-2}	1.45×10^{-3}	2.22×10^{-1}	1.35×10^{-3}
		Construction land	4.35×10^{-3}	1.85×10^{-1}	1.04×10^{-2}	2.03×10^{-3}	6.65×10^{-2}	1.28×10^{-3}	1.75×10^{-1}	2.25×10^{-3}
	Adults	Agricultural land	2.83×10^{-3}	1.05×10^{-1}	6.38×10^{-3}	1.07×10^{-3}	2.75×10^{-2}	7.31×10^{-3}	1.12×10^{-1}	8.87×10^{-4}
		Forest land	2.71×10^{-3}	1.06×10^{-1}	6.17×10^{-3}	1.14×10^{-3}	3.42×10^{-2}	7.67×10^{-4}	1.04×10^{-1}	8.87×10^{-4}

		Wetland	2.73 × 10^{-3}	1.08 × 10^{-1}	6.47 × 10^{-3}	1.05 × 10^{-3}	2.84 × 10^{-2}	8.18 × 10^{-4}	1.25 × 10^{-1}	7.62 × 10^{-4}
		Construction land	2.46 × 10^{-3}	1.04 × 10^{-1}	5.85 × 10^{-3}	1.15 × 10^{-3}	3.76 × 10^{-2}	7.23 × 10^{-4}	9.87 × 10^{-2}	1.27 × 10^{-3}
HQ_{inh}	Children	Agricultural land	2.74 × 10^{-7}	1.08 × 10^{-3}	6.05 × 10^{-7}	1.05 × 10^{-7}	2.67 × 10^{-6}	7.13 × 10^{-6}	1.09 × 10^{-5}	8.66 × 10^{-8}
		Forest land	2.63 × 10^{-7}	1.09 × 10^{-3}	5.85 × 10^{-7}	1.12 × 10^{-7}	3.31 × 10^{-6}	7.49 × 10^{-6}	1.02 × 10^{-5}	8.65 × 10^{-8}
		Wetland	2.65 × 10^{-7}	1.11 × 10^{-3}	6.13 × 10^{-7}	1.03 × 10^{-7}	2.76 × 10^{-6}	7.99 × 10^{-6}	1.22 × 10^{-5}	7.44 × 10^{-8}
		Construction land	2.39 × 10^{-7}	1.07 × 10^{-3}	5.54 × 10^{-7}	1.12 × 10^{-7}	3.65 × 10^{-6}	7.06 × 10^{-6}	9.63 × 10^{-6}	1.24 × 10^{-7}
	Adults	Agricultural land	1.55 × 10^{-7}	6.10 × 10^{-4}	3.42 × 10^{-7}	5.92 × 10^{-8}	1.51 × 10^{-6}	4.03 × 10^{-6}	6.19 × 10^{-6}	4.89 × 10^{-8}
		Forest land	1.49 × 10^{-7}	6.14 × 10^{-4}	3.30 × 10^{-7}	6.31 × 10^{-8}	1.87 × 10^{-6}	4.23 × 10^{-6}	5.76 × 10^{-6}	4.89 × 10^{-8}
		Wetland	1.50 × 10^{-7}	6.27 × 10^{-4}	3.47 × 10^{-7}	5.79 × 10^{-8}	1.56 × 10^{-6}	4.51 × 10^{-6}	6.92 × 10^{-6}	4.20 × 10^{-8}
		Construction land	1.35E-07	6.04 × 10^{-4}	3.13 × 10^{-7}	6.34 × 10^{-8}	2.06 × 10^{-6}	3.99 × 10^{-6}	5.44 × 10^{-6}	7.02 × 10^{-8}
HQ_{derm}	Children	Agricultural land	5.33 × 10^{-5}	2.98 × 10^{-2}	1.34 × 10^{-4}	3.04 × 10^{-5}	1.04 × 10^{-3}	4.14 × 10^{-4}	1.55 × 10^{-3}	6.28 × 10^{-5}
		Forest land	5.12 × 10^{-5}	3.00 × 10^{-2}	1.29 × 10^{-4}	3.24 × 10^{-5}	1.29 × 10^{-3}	4.35 × 10^{-4}	1.44 × 10^{-3}	6.28 × 10^{-5}
		Wetland	5.15 × 10^{-5}	3.07 × 10^{-2}	1.36 × 10^{-4}	2.97 × 10^{-5}	1.07 × 10^{-3}	4.63 × 10^{-4}	1.73 × 10^{-3}	5.39 × 10^{-5}
		Construction land	4.64 × 10^{-5}	2.96 × 10^{-2}	1.23 × 10^{-4}	3.25 × 10^{-5}	1.42 × 10^{-3}	4.10 × 10^{-4}	1.36 × 10^{-3}	9.01 × 10^{-5}
	Adults	Agricultural land	1.43 × 10^{-5}	8.02 × 10^{-3}	3.60 × 10^{-5}	8.17 × 10^{-6}	2.79 × 10^{-4}	1.11 × 10^{-4}	4.17 × 10^{-4}	1.69 × 10^{-5}
		Forest land	1.38 × 10^{-5}	8.08 × 10^{-3}	3.48 × 10^{-5}	8.71 × 10^{-6}	3.47 × 10^{-4}	1.17 × 10^{-4}	3.88 × 10^{-4}	1.69 × 10^{-5}
		Wetland	1.38 × 10^{-5}	8.26 × 10^{-3}	3.65 × 10^{-5}	7.99 × 10^{-6}	2.89 × 10^{-4}	1.25 × 10^{-4}	4.66 × 10^{-4}	1.45 × 10^{-5}
		Construction land	1.25 × 10^{-5}	7.95 × 10^{-3}	3.30 × 10^{-5}	8.75 × 10^{-6}	3.82 × 10^{-4}	1.10 × 10^{-4}	3.66 × 10^{-4}	2.42 × 10^{-5}

Table S11. Major sources of HMs.

HMs	Sources	References
Cu	Petrochemical wastewater	[7]
	Metal process and smelt	[8]
	Fertilizer and pesticides	[9–13]
Cr	Industrial activities	[14–18]
	Coal combustion	[8]
Ni	Industrial activities	[19]
Zn	Petrochemical wastewater	[7]
	Traffic	[20]
	Livestock manure	[21,22]
	Fertilizer and pesticides	[23,24]
Pb	Traffic emission	[8,25–28]
	Coal combustion	[29,30]
	Industrial waste	[30–32]
Cd	Lubricating oil and tires	[33]
	Coal combustion	[34]
	Fertilizer	[35,36]
	Galvanization	[32]
	Petrochemical	[37]
	Industrial activities	[38]

As	Coal combustion	[24,33,39]
	Industrial discharge	[40–42]
	Fertilizer and pesticides	[23,43]
Hg	Fertilizer	[25]
	Coal combustion	[27,30,44–47]

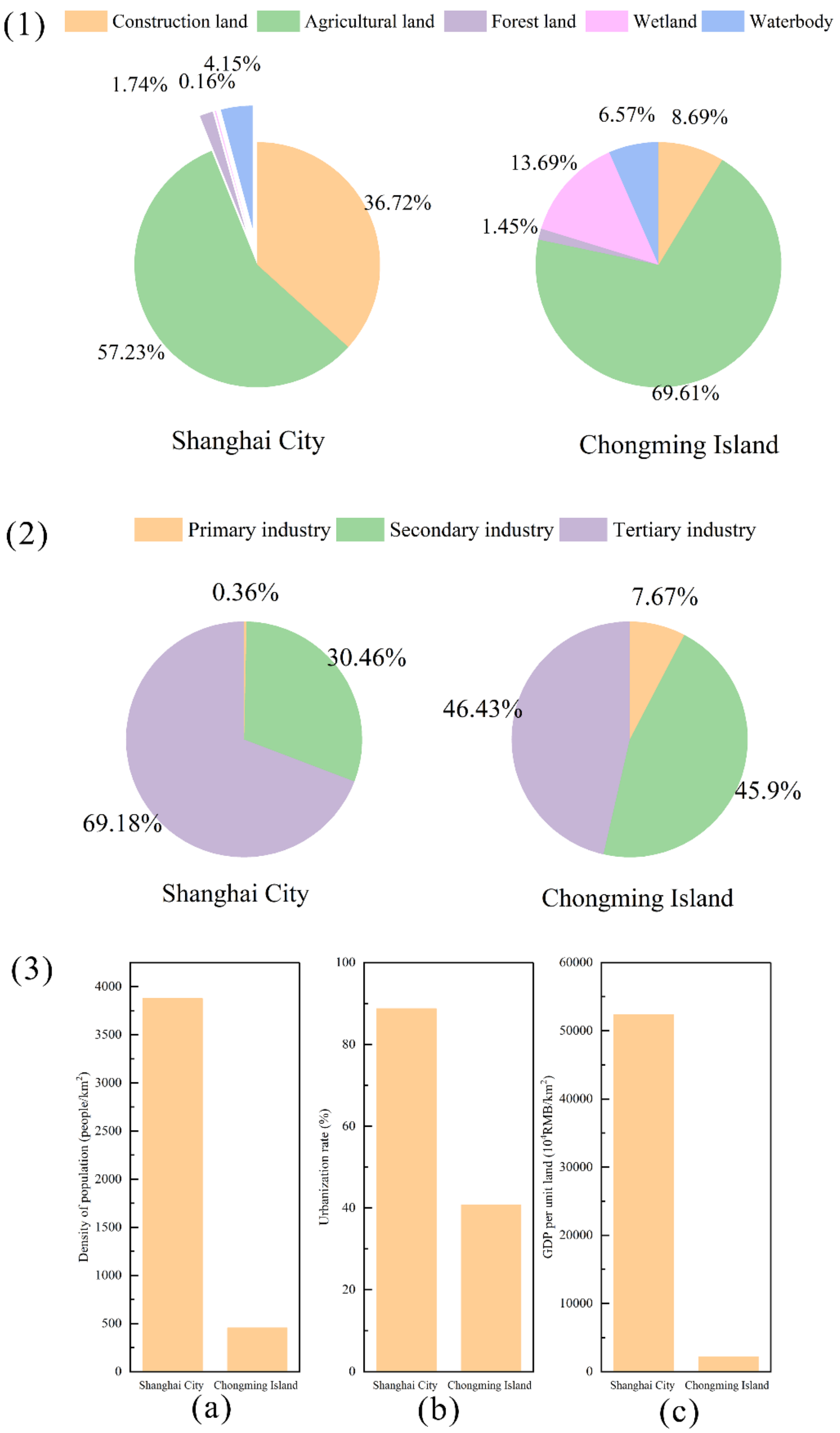

Figure S1. Comparison between Shanghai City and Chongming Island: (**1**) The proportion of land use; (**2**) The proportion of the first, second and third industries; (**3**) **a**. Density of population, **b.** urbanization rate, **c.** GDP per unit land.

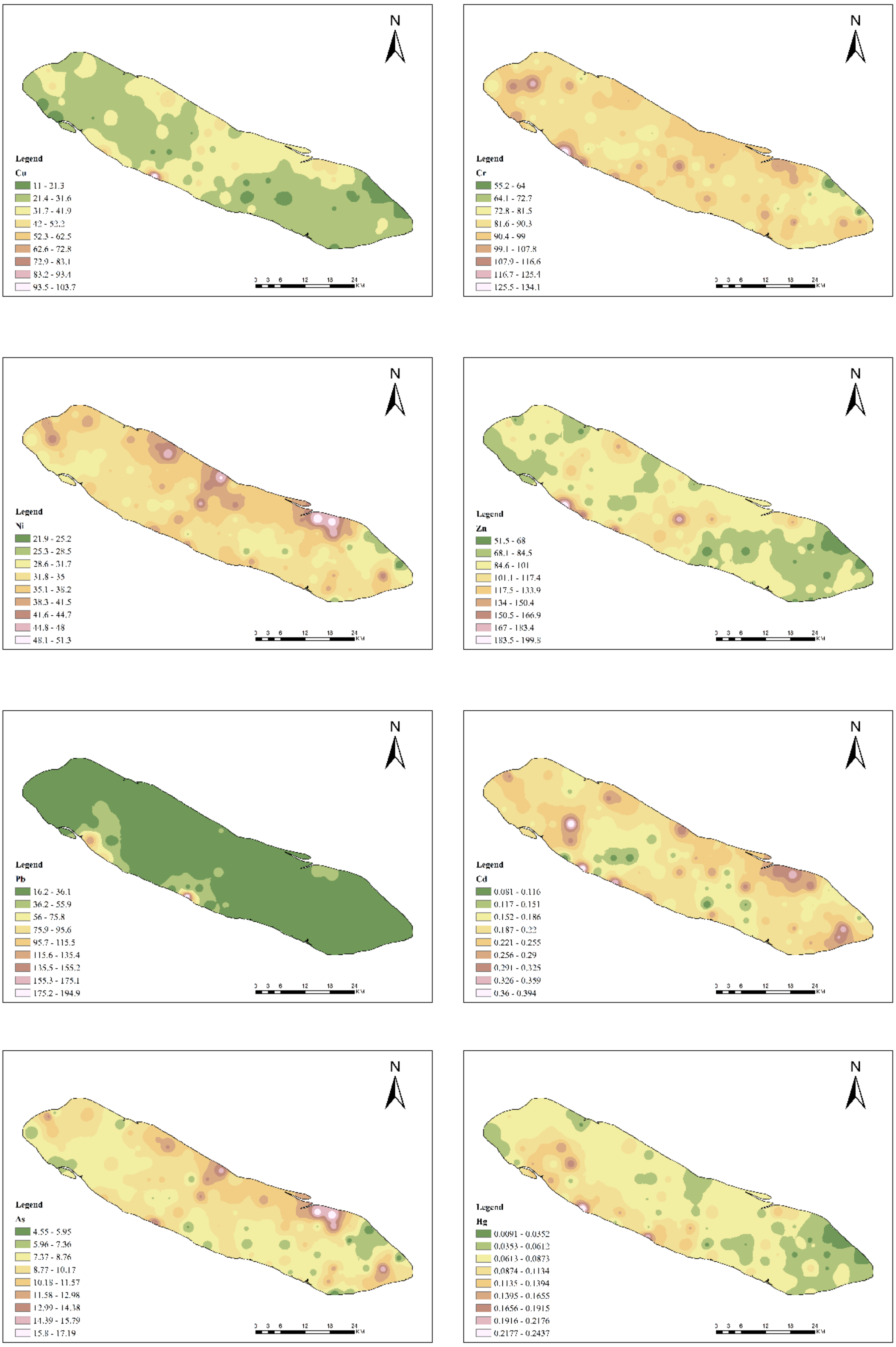

Figure S2. Distribution map of the average concentration of heavy metals (Cu, Cr, Ni, Zn, Pb, Cd, As and Hg) in Chongming Island.

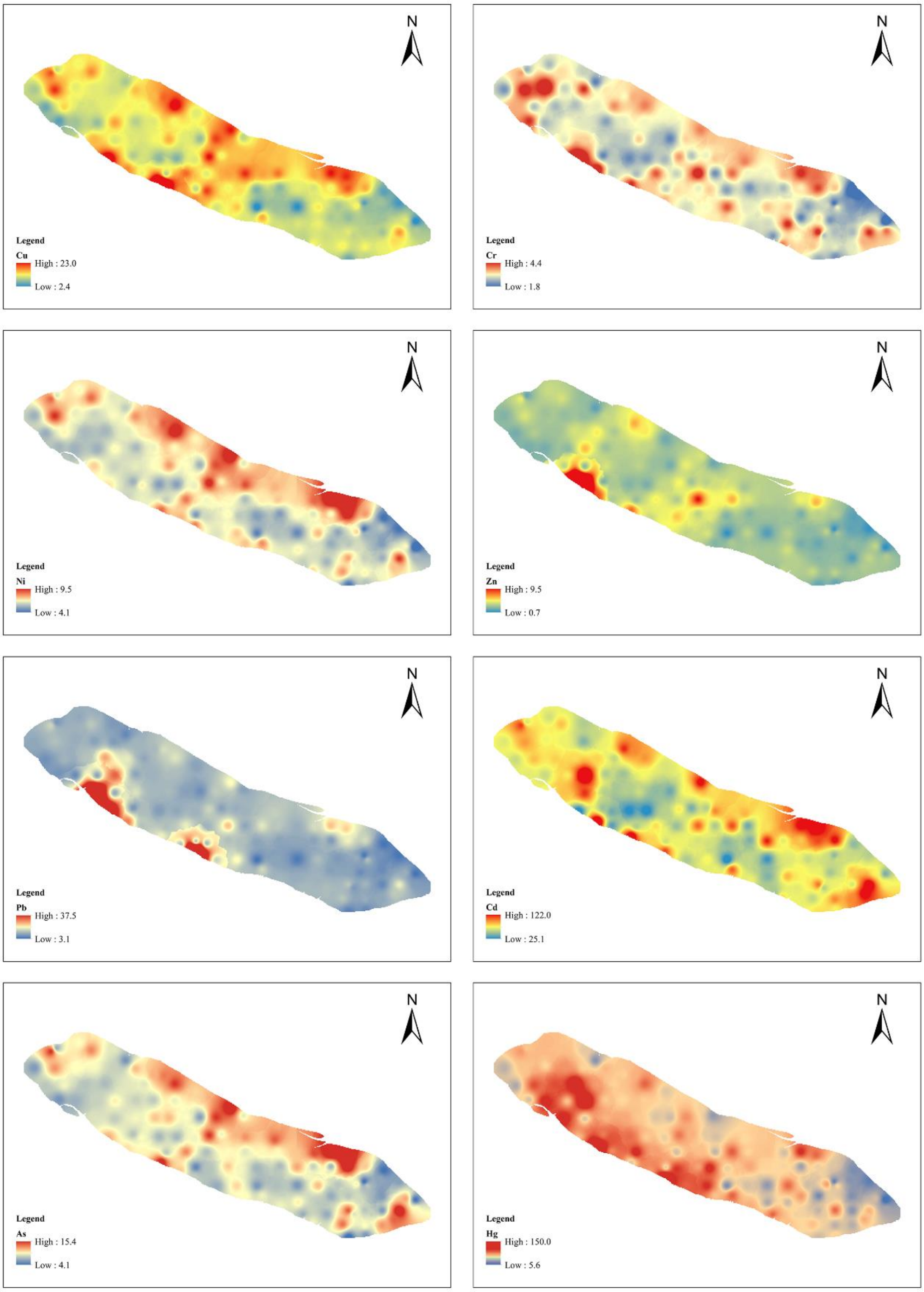

Figure S3. Distribution map of E_r^i values of heavy metals (Cu, Cr, Ni, Zn, Pb, Cd, As and Hg) in Chongming Island

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