SUPPLEMENTARY MATERIALS

Geoaccumulation Index and Potential Ecological Risk Index

$$I_{geo} = log_2(C_i/kB_i) \quad \text{(S1)}$$

where C_i means the measured concentration of the element i, mg/kg; B_i corresponds to the background value of element i, mg/kg; k represents the coefficient of variation of the background value that may be caused by geological factors such as crustal movement, usually taken as 1.5. Based on the varying values of I_{geo}, the degree of HM contamination can be classified as Non ($I_{geo} \leqslant 0$), Mild ($0 < I_{geo} \leqslant 1$), Inclining moderate ($1 < I_{geo} \leqslant 2$), Moderate ($2 < I_{geo} \leqslant 3$), Inclining severe ($3 < I_{geo} \leqslant 4$), Severe ($4 < I_{geo} \leqslant 5$) and Serious ($I_{geo} > 5$) (Muller, 1969).

$$RI = \sum ER^i;\ ER^i = TR^i \times C_f^i; C_f^i = \frac{C_0^i}{C_n^i} \quad \text{(S2)}$$

where C_f^i represents the pollution factor for each HM, C_0^i means the concentration of HMs in the sample, C_n^i is the background value of HMs, ER^i represents the individual ecological risk potential of each metal while TR^i is the toxic response coefficient established by Hakanson (1980). The toxic response coefficients of different HMs were set as follows: two for Cr, five for Pb, ten for As, thirty for Cd, and forty for Hg (Hakanson, 1980). Lastly, the potential ecological risk Index (RI) serves as a composite measure that encompasses various elements of contamination. The background values (BV) utilized for the indices were sourced from the China National Environmental Monitoring Center (CENMC, 1990). The BV for Cr, Pb, Cd, Hg, and As were 71.40, 29.70, 0.13, 0.12, and 15.70 mg kg^{-1}, respectively (CNEMC, 1990). The ER is classified into five categories (Yan et al., 2016): ER <40 (low risk), 40< ER <80 (moderate risk), 80< ER <160 (considerable risk), 160< ER <320 (high risk), and ER >320 (very high risk). The *RI* is classified into four categories (Yan et al., 2016): *RI* <150 (low risk), 150< *RI* <300 (moderate risk), 300< *RI* <600 (considerable risk), and *RI* >600 (high risk).

Health risk assessment

$$ADD_{ing} = C \times \frac{IngR \times CF \times EF \times ED}{BW \times AT_{NOC}} \quad \text{(S3)}$$

$$ADD_{inh} = C \times \frac{InhR \times CF \times EF \times ED}{PEF \times AT_{NOC}} \quad \text{(S4)}$$

$$ADD_{derm} = C \times \frac{SA \times SL \times ABS \times CF \times EF \times ED}{BW \times AT_{NOC}} \quad \text{(S5)}$$

The value of C is taken as the 95% confidence interval of the actual measured soil HM concentration($mg \cdot kg^{-1}$); IngR means the frequency of hand-oral ingestion of soil ($mg \cdot d^{-1}$). CF is conversion factor ($kg \cdot mg^{-1}$); EF is exposure frequency ($d \cdot a^{-1}$); ED is exposure time (a); BW is mean body weight (kg); AT_{NOC} is average non-carcinogenic exposure time (d) for HMs; InhR is respiration frequency ($m^3 \cdot d^{-1}$); PEF is particulate matter emission factor ($m^3 \cdot kg^{-1}$); SL is skin adhesion ($mg \cdot cm^{-2} \cdot d^{-1}$); SA is surface area of skin exposure (cm^2); ABS is skin absorption factor, dimensionless. Specific parameters mainly refer to the Technical Guidelines for Risk Assessment of Contaminated Sites (HJ25.3-2014) in China and related studies at home and abroad (USEPA, 1992, 2000, 2010, 2011; Hu et al., 2017; Hu et al., 2020b; Sun et al., 2022).

Fig S1 The studied profiles in Stagnic Anthrosols derived from granite (GR)

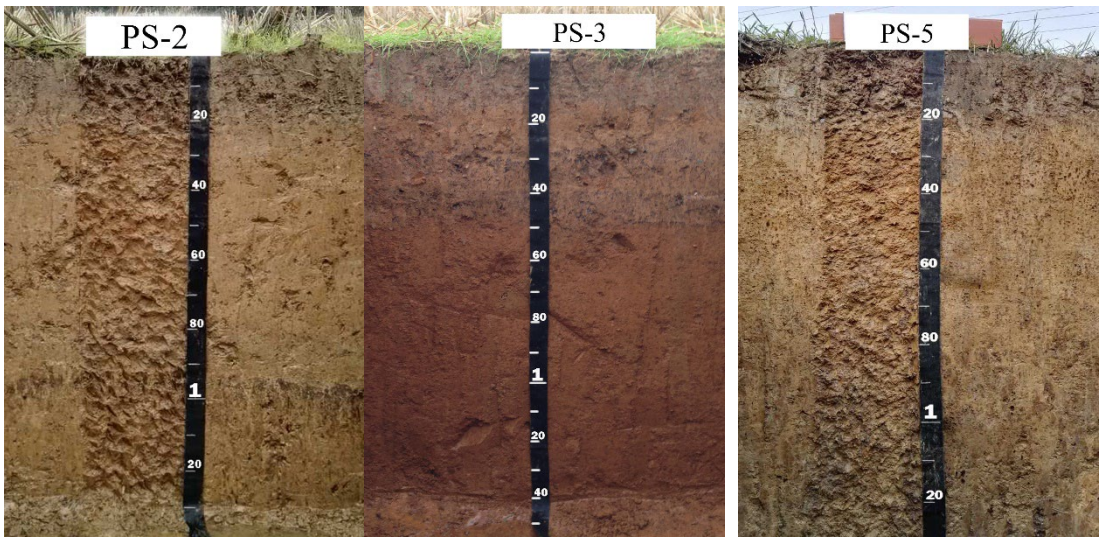

Fig S2 The studied profiles in Stagnic Anthrosols derived from plate shale (PS)

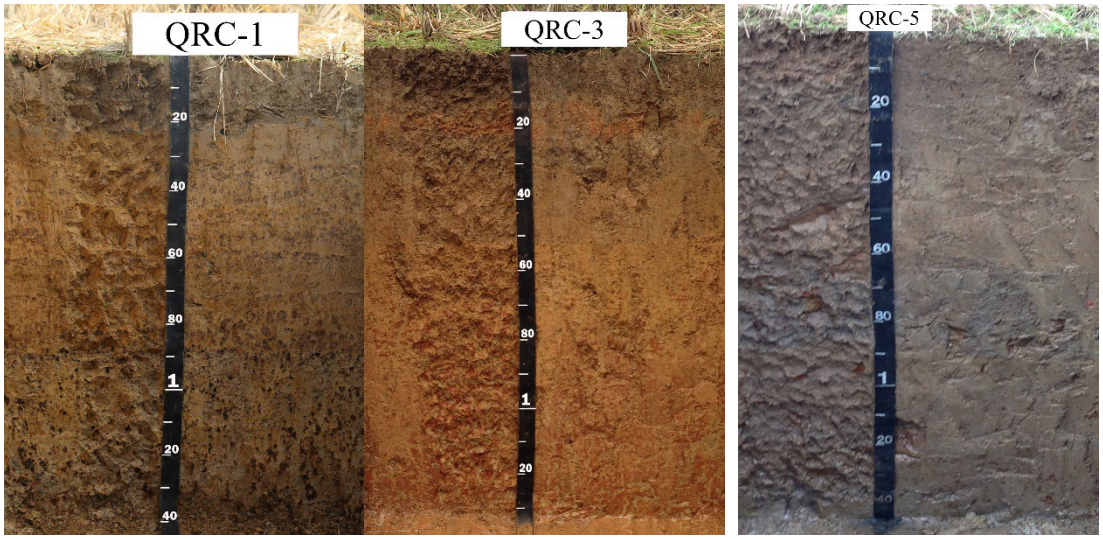

Fig S3 The studied profiles in Stagnic Anthrosols derived from quaternary red clays (QRC)

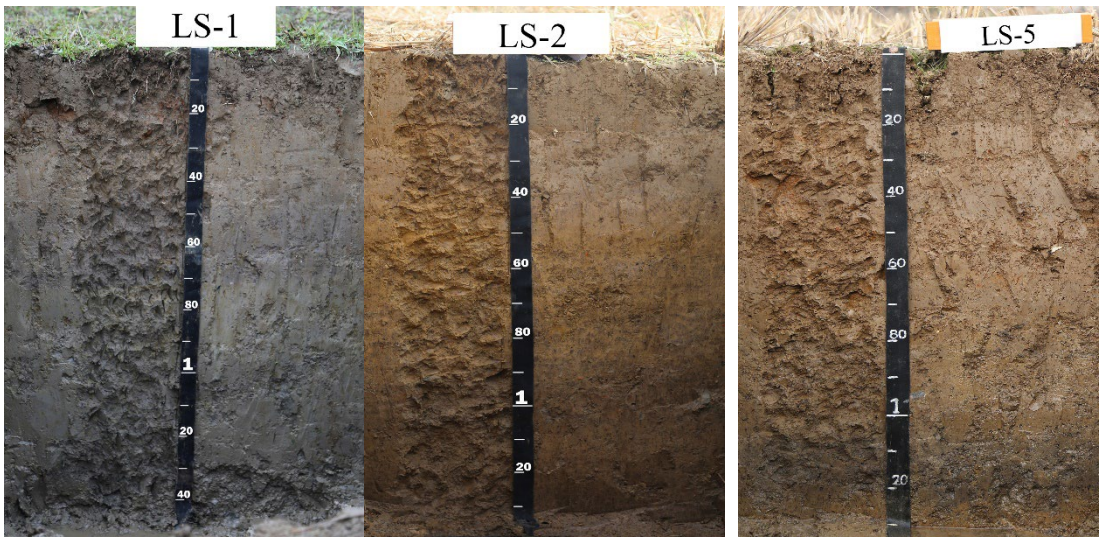

Fig S4 The studied profiles in Stagnic Anthrosols derived from limestone (LS)

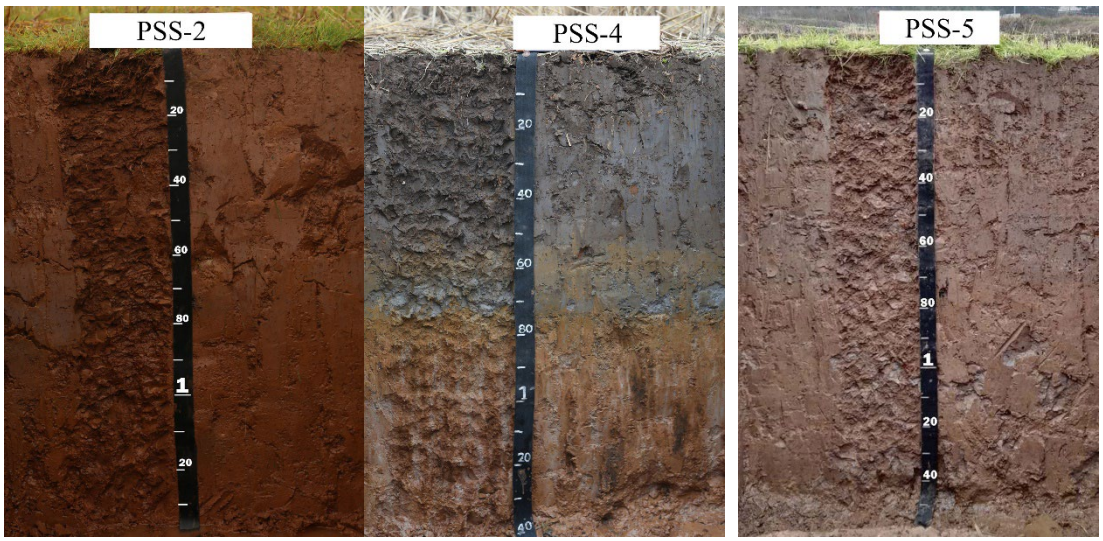

Fig S5 The studied profiles in Stagnic Anthrosols derived from purple sandy shale (PSS)

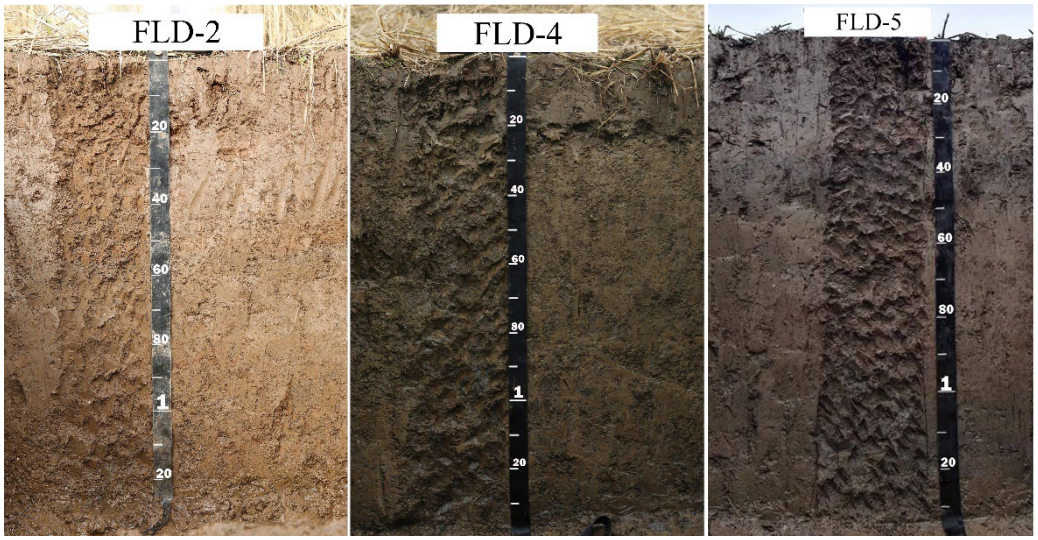

Fig S6 The studied profiles in Stagnic Anthrosols derived from fluvial-lacustrine deposit (FLD)

Table S1. Content of different heavy metals for all soil samples

Element	Cr	Pb	Cd	Hg	As
Item	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1	84.0	35.4	0.334	0.145	17.5
2	98.4	30.1	0.223	0.0662	14.7
3	70.2	23.3	0.232	0.0490	12.4
4	105	33.5	0.431	0.194	13.8
5	98.2	29.4	0.267	0.0797	15.4
6	102	29.6	0.266	0.0973	10.5
7	86.4	27.8	0.331	0.117	10.9
8	84.5	27.7	0.321	0.125	10.7
9	88.6	27.1	0.340	0.112	10.9
10	74.0	36.4	0.255	0.145	14.6
11	81.6	29.9	0.160	0.0920	15.1
12	60.3	24.4	0.088	0.0664	8.47
13	102	31.9	0.230	0.174	12.7
14	84.9	26.4	0.142	0.0740	11.0
15	90.4	30.1	0.104	0.0679	15.4
16	72.5	28.3	0.585	0.169	7.50
17	61.4	18.6	0.226	0.0257	5.09
18	65.9	20.8	0.171	0.0354	7.41
19	69.2	29.2	0.240	0.100	8.65
20	59.7	23.9	0.133	0.0322	8.60
21	83.0	18.8	0.048	0.0274	11.2
22	83.0	18.6	0.132	0.0785	9.89
23	65.7	29.7	0.077	0.0540	13.6
24	57.5	24.0	0.064	0.0362	11.1
25	53.9	23.5	0.236	0.128	11.5
26	71.8	38.9	0.140	0.0706	7.49
27	52.8	23.3	0.081	0.0486	4.40
28	49.3	19.6	0.253	0.194	14.8
29	71.6	29.3	0.135	0.112	13.5
30	61.8	23.4	0.133	0.0990	16.5
31	50.0	37.3	0.622	0.172	7.75
32	45.2	19.3	0.324	0.0977	8.23
33	48.5	20.2	0.315	0.109	5.11
34	66.3	33.2	0.221	0.171	10.2
35	52.3	30.0	0.234	0.124	10.1
36	33.1	27.1	0.223	0.0827	10.1
37	68.2	59.2	0.886	0.316	8.55
38	59.5	23.3	0.463	0.155	10.0

39	64.4	20.9	0.441	0.108	9.62
40	66.9	27.9	0.320	0.107	9.88
41	67.3	23.2	0.168	0.0641	9.89
42	58.3	22.1	0.133	0.0484	8.53
43	59.8	33.7	0.307	0.0891	7.19
44	57.7	27.7	0.197	0.0881	7.25
45	59.1	28.6	0.179	0.0307	8.24
46	61.3	35.4	0.168	0.117	8.25
47	50.6	27.2	0.164	0.0994	7.16
48	54.4	27.5	0.144	0.0736	7.73
49	65.3	29.4	0.615	0.134	6.93
50	61.1	24.7	0.541	0.120	8.46
51	62.4	25.1	0.316	0.0885	8.02
52	38.6	26.5	0.159	0.132	1.44
53	39.3	23.0	0.110	0.0819	2.86
54	39.3	18.3	0.093	0.0738	4.35
55	52.9	25.5	0.290	0.110	1.55
56	55.3	25.4	0.212	0.105	1.45
57	55.5	28.3	0.189	0.0736	1.16
58	44.5	39.3	0.481	0.189	11.6
59	53.9	32.7	0.354	0.143	11.1
60	56.9	28.5	0.263	0.0576	18.8
61	53.8	56.0	0.462	0.469	10.3
62	62.5	42.0	0.301	0.216	17.2
63	69.2	43.5	0.142	0.223	27.3
64	94.8	73.7	0.918	0.232	29.8
65	80.6	54.2	0.918	0.200	30.6
66	85.1	50.1	0.905	0.227	33.6
67	72.6	55.1	0.416	0.141	11.8
68	72.8	42.0	0.236	0.0807	8.61
69	95.3	30.4	0.113	0.0512	7.80
70	66.5	44.2	0.606	0.784	18.3
71	69.1	38.4	0.369	0.924	25.0
72	61.4	36.8	0.293	0.972	37.3
73	64.5	50.3	0.728	0.310	13.1
74	69.5	41.1	0.392	0.218	11.7
75	73.6	44.1	0.384	0.211	11.8
76	51.0	31.1	0.414	0.128	6.65
77	53.7	29.6	0.336	0.106	10.6
78	48.7	29.2	0.188	0.0900	7.00
79	41.8	29.7	0.509	0.320	5.56
80	53.7	26.5	0.546	0.279	9.18
81	39.9	23.6	0.399	0.663	7.40

82	57.7	30.9	0.286	0.0610	3.04
83	50.2	27.8	0.074	0.0288	8.61
84	47.8	30.8	0.055	0.0232	3.73
85	58.6	48.7	0.483	0.266	19.6
86	62.6	49.6	0.394	0.278	23.0
87	59.6	51.1	0.399	0.309	22.6
88	61.7	39.9	0.749	1.35	27.6
89	56.2	34.8	0.670	0.845	90.6
90	62.7	36.6	0.479	0.716	41.5
91	70.7	30.6	0.208	0.0559	4.06
92	61.0	26.3	0.142	0.0573	5.23
93	64.8	25.9	0.092	0.0487	7.99
94	75.5	70.2	0.866	0.190	15.4
95	63.0	29.4	0.442	0.0699	8.05
96	57.6	27.1	0.170	0.136	15.7
97	31.0	64.2	0.234	0.213	4.87
98	29.1	56.6	0.226	0.151	6.38
99	30.6	62.8	0.124	0.0872	4.29
100	24.7	44.2	0.310	0.163	5.92
101	30.6	38.0	0.115	0.0513	10.7
102	27.6	33.7	0.136	0.0492	6.96
103	62.7	59.5	0.538	0.379	18.4
104	64.6	35.8	0.363	0.258	41.3
105	75.2	38.3	0.137	0.287	27.8
106	24.3	68.4	0.316	0.402	11.8
107	25.1	64.6	0.204	0.206	8.45
108	21.7	55.5	0.172	0.120	4.09
109	47.8	43.6	0.434	0.176	8.76
110	45.9	33.1	0.317	0.0910	14.7
111	61.8	34.4	0.186	0.0705	11.0
112	52.7	40.9	0.309	0.132	7.54
113	46.4	28.2	0.155	0.0580	8.20
114	45.8	28.8	0.105	0.0405	8.37
115	74.8	44.5	0.332	0.184	13.8
116	49.6	33.6	0.202	0.109	14.1
117	55.1	26.1	0.147	0.0839	13.3
118	58.6	117	0.276	0.311	8.18
119	62.9	102	0.243	0.155	8.65
120	55.6	92.2	0.100	0.172	7.76
121	90.2	156	1.280	0.244	19.7
122	55.1	57.1	1.159	0.0973	49.4
123	74.4	62.4	0.318	0.0770	23.1
124	35.9	74.4	0.366	0.175	9.14

125	32.5	75.1	0.139	0.102	12.7
126	28.3	69.4	0.108	0.117	11.4
127	36.3	40.6	0.243	0.100	33.7
128	34.6	28.8	0.146	0.0579	69.1
129	45.0	29.2	0.131	0.0436	94.3
130	65.9	53.0	0.454	0.178	14.7
131	66.6	44.8	0.299	0.170	25.5
132	56.1	39.2	0.164	0.129	16.1
133	64.1	110	1.492	0.248	30.4
134	60.7	102	0.843	0.397	27.1
135	61.5	131	1.733	0.276	25.5
136	63.6	36.7	0.545	0.121	13.7
137	68.9	30.3	0.509	0.103	11.6
138	63.6	30.7	0.164	0.116	12.8
139	26.4	86.8	0.311	0.106	4.12
140	27.1	67.0	0.219	0.124	5.62
141	29.4	62.6	0.172	0.109	3.82
142	66.7	41.8	0.263	0.164	9.37
143	53.5	36.4	0.133	0.123	23.7
144	49.5	33.7	0.167	0.0503	14.0
145	60.1	46.3	0.411	0.202	11.8
146	55.7	37.6	0.190	0.172	16.3
147	62.6	33.9	0.172	0.0656	12.0
148	62.9	72.9	0.595	0.230	25.0
149	43.8	68.9	0.652	0.164	30.9
150	54.3	71.9	0.781	0.167	31.2
151	53.7	36.4	0.427	0.112	12.6
152	45.8	21.3	0.322	0.0686	9.87
153	34.3	21.3	0.115	0.0101	9.72
154	50.8	35.1	0.157	0.0568	3.68
155	51.4	30.7	0.101	0.0363	8.22
156	27.2	30.0	0.058	0.225	7.57
157	63.9	38.9	0.359	0.136	12.8
158	67.2	31.9	0.333	0.106	15.7
159	66.5	30.7	0.171	0.0504	11.5
160	50.2	33.9	0.475	0.127	12.8
161	65.4	28.8	0.507	0.0715	10.1
162	53.6	27.4	0.451	0.0605	8.99
163	37.1	62.4	0.142	0.117	10.5
164	37.5	63.9	0.196	0.122	10.7
165	50.3	61.1	0.196	0.114	9.92
166	60.3	48.7	0.249	0.128	12.9
167	59.5	29.0	0.075	0.0781	13.6

168	70.1	28.2	0.063	0.0796	14.4
169	77.8	41.0	0.260	0.107	14.7
170	51.7	32.8	0.242	0.0662	15.3
171	58.4	31.2	0.134	0.0477	13.3
172	54.4	53.4	0.591	0.159	15.5
173	50.6	52.1	0.578	0.0948	14.4
174	48.8	47.2	0.351	0.0812	21.0
175	46.8	67.3	0.329	0.154	4.81
176	35.7	49.7	0.172	0.116	8.39
177	38.4	49.7	0.098	0.124	14.6
178	68.4	40.5	0.305	0.118	15.3
179	60.1	36.0	0.199	0.0954	17.5
180	61.3	35.4	0.132	0.0615	16.0
181	36.1	47.0	0.305	0.132	10.8
182	47.5	30.4	0.287	0.0455	15.1
183	41.2	28.2	0.390	0.0305	14.8
184	67.7	38.2	0.350	0.114	16.6
185	70.8	36.6	0.366	0.0939	17.9
186	86.4	32.4	0.356	0.0543	12.0
187	88.6	44.8	0.179	0.223	7.74
188	70.4	36.8	0.101	0.254	16.3
189	66.9	29.2	0.082	0.0616	13.5
190	81.8	43.9	0.519	0.181	41.1
191	85.1	35.5	0.369	0.0716	46.3
192	66.6	34.3	0.172	0.0738	15.5
193	63.2	34.9	0.217	0.120	14.3
194	58.4	32.0	0.173	0.0559	15.7
195	62.3	29.8	0.137	0.0708	15.2