

## Supplementary Materials

**Table S1.** Operating parameter of the microwave digestion system for digesting soil samples for analyzing heavy metals

Nr	Operating parameters of microwave digestion Mars 6	
1	Power	(~ 1200 W)
2	Rising temperature duration	10 minutes
3	Holding time	15 minutes
4	Digestion temperature	170 °C
5	Cooling time	20 minutes

**Table S2.** ICP-MS Agilent 7900 parameters and the recovery values of heavy metals

Operating conditions of ICP-MS Agilent 7900			
High-Frequency Power (w)	~1600		
Sampling depth (mm)	~10		
Carrier gas flow rate (L/min)	~0,7		
Auxiliary gas flow rate (L/min)	~0,3		
Peristaltic nebulizer (concentric glass)	MicroMist		
Spray chamber temperature (°C)	2		
Helium gas flow rate (mL/min)	~4,3		
Hydrogen gas flow rate (mL/min)	~4,2		
Peristaltic pump speed	0,1 (0,5 mL/min)		
Internal standard	<sup>115</sup> In		
Isotopes	<sup>208</sup> Pb, <sup>111</sup> Cd, <sup>66</sup> Zn		
LOD and LOQ values of metals using ICP-MS	Element	LOD (ng/L)	LOQ (ng/L)
	Pb	13.7	41.5
	Zn	1.5	4.5
Recovery values of metal elements (%) for MESS-4	Element	Recovery (%)	RSD (%)
	Pb	109.27	9.82
	Zn	103.22	13.47

**Table S3.** Tessier's sequential extraction procedure

Step	Fractions	Reagent extractions/ conditions
1	Exchangeable (F1)	10 mL NH <sub>4</sub> OAc 1M, 1 hour shaking
2	Carbonates bound (F2)	20 mL NH <sub>4</sub> OAc 1M/HOAc pH = 5, 5 hours shaking
3	Fe and Mn oxides bound (F3)	20 mL NH <sub>2</sub> OH.HCl 0,04M/HOAc 25%, 5 hours shaking
4	Organic matter bound (F4)	10 mL NH <sub>4</sub> OAc 3,2M + HNO <sub>3</sub> 20%, 0.5 hour shaking
5	Residual (F5)	50 mL HNO <sub>3</sub> + HCl (v/v = 1:3), 0.5 hour shaking

**Table S4.** The percentages of Pb and Zn's chemical fractionations in the soils following one-month incubation with biochar (PSB300, CCB300) and the mixture of biochar/apatite.

Metal	Sample	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)
<b>Pb</b>	CS	19.4	46.2	11.6	4.3	18.4
	PSB3:3	14.2	47.3	13.4	4.9	20.2
	PSB3:5	14.7	47.7	11.6	5.3	20.7
	PSB3A3	16.4	44.9	12.2	4.4	22.1
	CCB3:3	16.8	46.3	13.1	4.7	19.1
	CCB3:5	15.6	48.7	10.8	4.8	20.1
	CCB3A3	17.3	48.9	10.7	4.6	18.5
<b>Zn</b>	CS	14.9	25.7	31.4	1.3	26.7
	PSB3:3	10.5	28.1	31.6	1.5	28.4
	PSB3:5	11.1	29.2	27.6	1.9	30.1
	PSB3A3	11.3	28.9	29.5	1.4	28.9
	CCB3:3	13.0	26.7	28.3	1.5	30.4
	CCB3:5	11.2	28.5	26.2	1.8	32.2
	CCB3A3	12.0	29.3	26.4	1.8	30.4