

1 **Supplementary Materials**

2 **Suppression of lead environmental risks in cropland**  
3 **soil by biomass ash and its modified product**

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18 **S1:**

19 I. XRD Analysis of the by-products generated during the modification procedure

20 After the modification of BA, the liquid waste of the hydrothermal reaction was  
21 collected into a 50 ml centrifuge tube and freeze dried for 24 h by using LBJ-10C  
22 freeze dryer (Four-Ring Science Instrument Plant Beijing Corporation, China).  
23 Finally, the dry powder was analyzed by X-ray diffraction (XRD, D8 Advance,  
24 Bruker AXS, Germany) over an angular range of 15 to 90  $2\theta$  with Cu  $K\alpha$  radiation  
25 (40kV, 40mA) to determine the crystal type of the by-products generated during the  
26 modification procedure.

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28 II. XRF Analysis of BA and MA

29 The relative content of trace elements in BA and MA were determined by X-Ray  
30 Fluorescence spectra (XRF, ZSX pimusII, Rigaku Corporation, Japan) with the  
31 effective measuring range from fluorine to uranium (F to U).

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33 III. XPS Analysis of the incubation soils

34 After incubation, the mass concentration of the elements (Ca, P, O, C, and Si) in soils  
35 with or without BA and MA was determined by using X-ray photoelectron  
36 spectroscopy (XPS, AXIS ULTRA, Shimadzu, UK) with transmission rod through  
37 ultra-high vacuum isolation valve.

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40 IV. Characterization of Soils

41 **1. Soils pH** was measured using a pH meter (FE20, Shanghai Mettler - Toledo  
42 Instrument Co., Ltd., China) with solid / water ratio of 1:2.5 (w/w), and the mixture  
43 was stirred and left for 0.5 h at room temperature (25 °C);

44 **2. Organic matter (OM)** was analyzed using Walkley-Black procedure (Walkley and  
45 Black, 1934);

46 **3. Cation exchange capacity (CEC)** was determined by using ammonium acetate  
47 method (USEPA, 2007);

48 **4. Available phosphate (P), potassium (K), and nitrogen (N)** were determined  
49 according to the forest soil analysis method (State Forestry Administration, 1999);

50 **5. Total Pb contents in the soil** were determined by using inductively coupled  
51 plasma optical emission spectrometer (ICP-OES, PE Optima 2100DV, Perkin-Elmer,  
52 USA) after the soil sample ( $0.2\pm 0.0001$  g, grounded and passed through a 0.15 mm  
53 sieve) was digested with hydrochloric acid (HCl), nitric acid (HNO<sub>3</sub>), perchloric acid  
54 (HClO<sub>4</sub>), and hydrofluoric acid (HF) (4:4:2:8 by volume) on a hot plate. A certified  
55 soil reference material (GBW07402, CRM/RM Information center of China) was used  
56 to evaluate the validity of the results.

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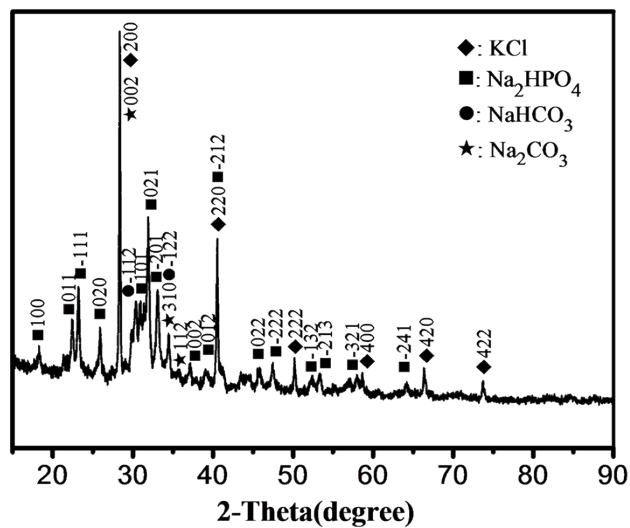
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77 **Figure S1.** XRD pattern of the soluble by-products generated during the modification  
 78 process/hydrothermal reaction.

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**Table S1.** Properties of BA and MA used in this study

Parameter	Biomass ash (BA)	Modified biomass ash (MA)
pH	10.06 <sup>b</sup>	10.24
Ca(mg/g) <sup>a</sup>	69.61	ND <sup>c</sup>
Cu(mg/kg)	52.3	30.9
Pb(mg/kg)	46.0	44.9
Zn(mg/kg)	207	132
Cr(mg/kg)	55.6	54.6

91 <sup>a</sup>Total content of Ca in BA was measured by using an atomic absorption spectrometer  
92 (AAS, contraAA 700, Analytik Jena AG, Germany) with Lanthanum chloride as  
93 deionization agent. <sup>b</sup> Mean of three replicates (n=3). <sup>c</sup> ND, no determined.

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**Table S2.** Relative content of various elements in BA and MA

Parameter	Biomass ash (BA)	Modified biomass ash (MA)
Ca(%)	31.9	30
Si(%)	27.9	29
Fe(%)	12	10.6
K(%)	11.7	7.1
Al(%)	4.31	4.52
Mg(%)	3.13	3.14
Cl(%)	1.76	0.219
P(%)	1.65	9.96
S(%)	1.62	0.127
Ti(%)	1.16	1.06
Na(%)	0.852	2.8
Mn(%)	0.548	0.466
Ba(%)	0.342	0.336
Sr(%)	0.325	0.264
F(%)	0.272	0.0506

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115 **Table S3.** Mass concentration of elements (Ca, P, O, C, and Si) in incubation soils  
116 with or without BA and MA.

Treatment	O 1s	Ca 2p	C 1s	P 2p	Si 2p
CK	57.15%	0.31%	20.71%	BDL <sup>a</sup>	21.83%
2.5% BA	56.09%	1.61%	20.46%	BDL	21.84%
5% BA	54.51%	1.72%	21.9%	BDL	21.87%
2.5% MA	58.06%	1.93%	19.36%	0.83%	19.82%
5% MA	56.27%	2.95%	18.55%	1.49%	20.74%

117 <sup>a</sup>BDL, below detection limit.