Supplementary Information

Pyrolysis Temperature Dependence of Pb²⁺ removal by Sewage Sludge Biochar: characteristics evaluation and adsorption performance

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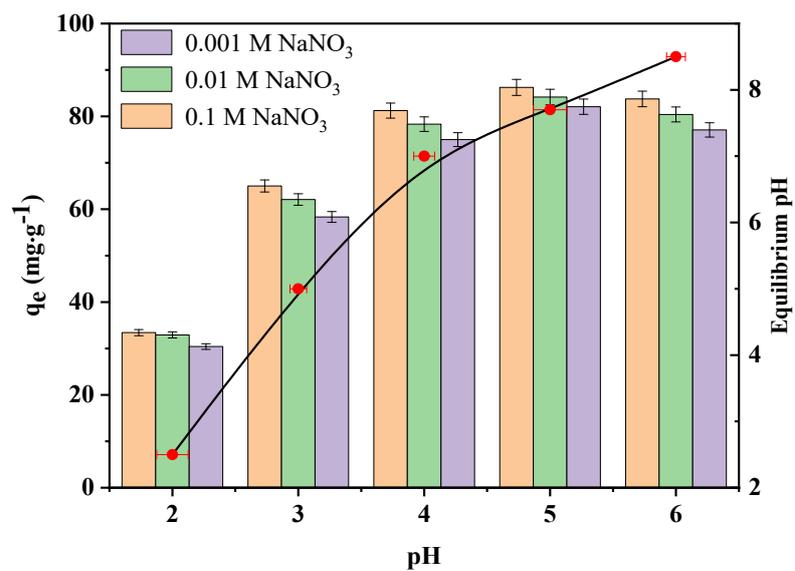
Fig. S1 The amount of Pb^{2+} adsorbed by SSB600 and equilibrium pH at different initial pH

(2.00 – 6.00) and ionic strength (Na$^+$, NO$_3^-$), initial Pb^{2+} concentration: 100 mg·L^{-1}, adsorbent
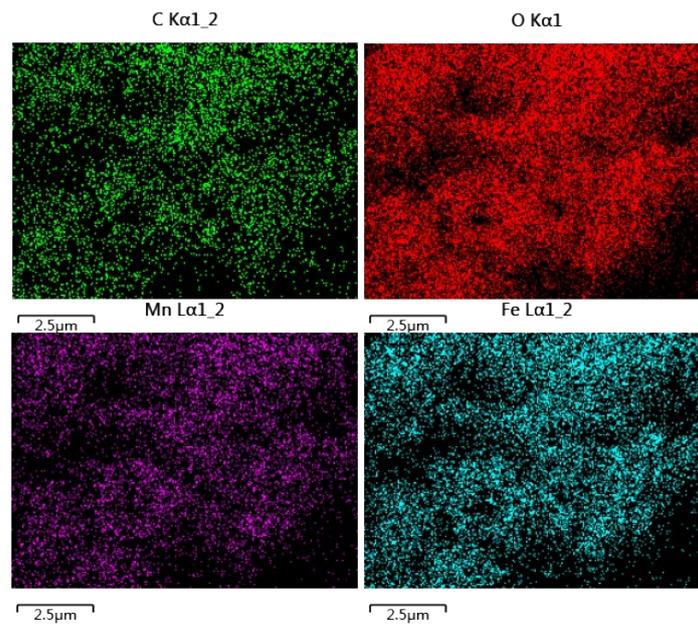
dosage: 1.00 g·L^{-1}, reacting time: 24 h

Fig.S2 The mapping of SSB600, 2000× magnification, accelerating voltage = 3.86 kV, 2000× magnification, accelerating voltage = 3.86 kV
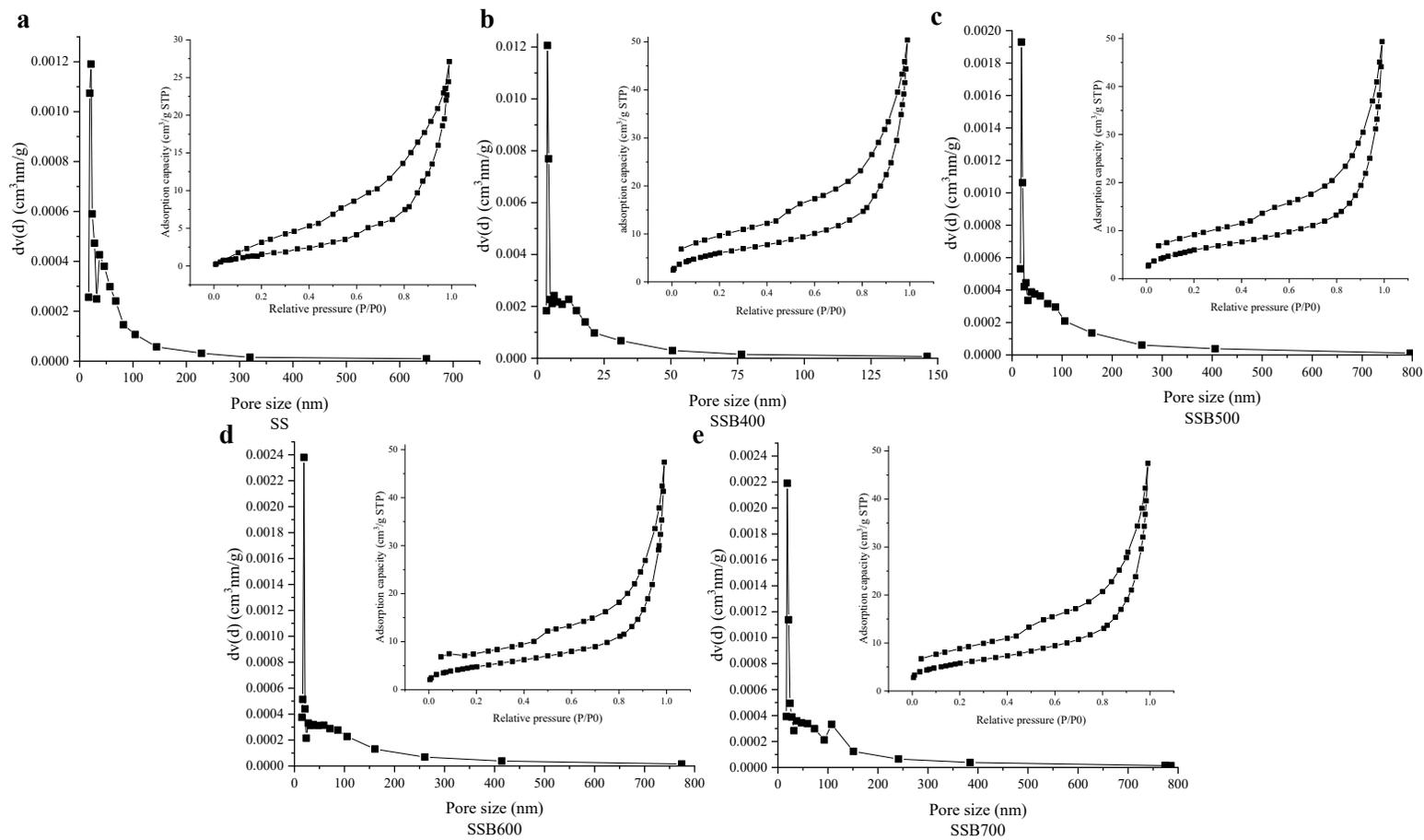
Fig.S3 Adsorption/desorption isotherm and pore size distribution at nitrogen atmosphere of SS (a), SSB400-700 (b-e).

Table S1 The yields of biochar pyrolyzing by various agricultural biomass (final pyrolysis temperature: 600℃)

	SSB600	Corn straw biochar	Rice straw biochar	Vinasse biochar	Rape straw biochar	Peanut shell biochar	Coffee residue biochar
yields	57.0 %	55.0 %	44.0 %	32.0 %	48.3 %	49.1 %	30.0%

Table S2 The parameters of Weber-Morris's intraparticle diffusion model for Pb^{2+} adsorption by SSB

sample	Weber - Morris´s intra - particle diffusion equation					
	k_1	R_1^2	k_2	R_2^2	k_3	R_3^2
SSB400	20.9	0.982	4.45	0.934	0.973	0.958
SSB500	27.4	0.974	4.24	0.998	0.932	0.984
SSB600	31.6	0.959	3.98	0.952	0.492	0.979

Table S3 the comparison of properties, Pb^{2+} adsorption performance, and mechanisms between other biochars and SSB600

Materials & pyrolysis temperature	BET (m²·g⁻¹)	Q$_m$ (mg·g⁻¹)	pH	Mechanisms	Reference
Sewage sludge，300 – 600 °C	23.72	18.2	5.00	Ion exchange, precipitation, complexation	Zhang et al (2013)[1]
Douglas fir, 900 – 1000 °C	745	40.0	9.20	Ion exchange, complexation, electrostatic interaction, physical adsorption	Akila et al (2018)[2]
Peanut shell, 250 °C	82.7	88.1	4.70	Precipitation, electrostatic attraction, ion exchange, complexation	Chen et al (2021)[3]
Commercial activated carbon, —	4.27×10³	27.3	7.00	Ion exchange, complexation	Asuquo et al (2017)[4]
Municipal sewage sludge, 600°C	22.4	132	8.90	Precipitation, cation exchange, complexation, π-electron interaction	this study

Table S4 the composition of DOM in SSB600

DOM composition		SSB600
Heavy metals in DOM	Cd	0.000 ± 0.000
	Pb	0.000 ± 0.000
	Cu	0.001 ± 0.000
	Cr	0.001 ± 0.000
	As	0.001 ± 0.000
Organic matters composition in DOM	Amide class	8.24
	Hydrocarbons	7.90
	Heterocyclic nitrogen	4.66
	Phenols	1.17
	Polycyclic Aromatic Hydrocarbons	1.09
	Carboxylic acids	3.09
	Acrylates	0.997
	Indole compounds	0.000
	Furan compounds	5.89
	Aldehydes	0.153
ecological toxicity risk assessment	the fluorescence inhibition efficiency of *Vibrio fischeri*	8.60 %

References:

[1] Zhang, W., et al., *Pb(II) and Cr(VI) sorption by biochars pyrolyzed from the municipal wastewater sludge under different heating conditions.* Bioresour Technol, 2013. **147**: p. 545-552.

[2] Karunanayake, A.G., et al., *Lead and cadmium remediation using magnetized and nonmagnetized biochar from Douglas fir.* Chemical Engineering Journal, 2018. **331**: p. 480-491.

[3] Chen, C. and M. Qiu, *High efficiency removal of Pb(ii) in aqueous solution by a biochar-supported nanoscale ferrous sulfide composite.* RSC Advances, 2021. **11**(2): p. 953-959.

[4] Asuquo, E., et al., *Adsorption of Cd(II) and Pb(II) ions from aqueous solutions using mesoporous activated carbon adsorbent: Equilibrium, kinetics and characterisation studies.* Journal of Environmental Chemical Engineering, 2017. **5**(1): p. 679-698.