

Supplementary information

In-situ Synthesis of Zero-valent Iron Decorated Lignite Carbon for Heavy Metals Removals from Aqueous Solutions

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Analysis methods

SEM, SEM-EDX and TEM analyses

SEM analysis of lignite and ZVI-LXs was operated at 5 kV. SEM-EDX probes the surface region elemental compositions of C, O, Ca, Mg, Si, Fe, Cu, Pb, and Cd in lignite and ZVI-LXs before and after metal sorption.

The samples were vortexed in ethanol for ~2 min and then dried in vacuum prior to the TEM analysis. TEM images of ZVI-LXs will be accessed for determination of particle size and shape of ZVI-LXs.

Table S1. Kinetic parameters from fitting aqueous Cd^{2+} , Cu^{2+} , and Pb^{2+} sorption versus time data over ZVI-L1000 to the pseudo-first-order and pseudo-second-order kinetic models (0.05 g adsorbent dose, 100 mg/L Cd^{2+} / Cu^{2+} / Pb^{2+} solution, 25 mL solution volume, pH values 6.4 (Cd^{2+}), 6.2 (Cu^{2+}), and 5.4 (Pb^{2+}) and at 25 °C, 5 min-1 h)

Kinetic model	Kinetic parameters	Values				Ref.
		k_1/k_2	$q_e(\text{exp})$	$q_e(\text{calc})$	R^2	
Pseudo-first-order	ZVI-L1000+ Cd^{2+}	0.012	10.2	1.2	0.889	(Toor and Jin, 2012)
	ZVI-L1000+ Cu^{2+}	0.003	19.3	0.9	0.108	
	ZVI-L1000+ Pb^{2+}	0.004	22.5	1.6	0.14	
Pseudo-second-order	ZVI-L1000+ Cd^{2+}	0.16	10.2	10.4	0.999	(Ho and McKay, 1999)
	ZVI-L1000+ Cu^{2+}	0.53	19.3	18.8	0.999	
	ZVI-L1000+ Pb^{2+}	0.12	22.5	21.5	0.997	

q_e (mg/g) Equilibrium adsorbate capacity (mg/g)

q_t (mg/g) - Adsorbate capacity at time t (mg/g)

k_1 -First order rate constant (min^{-1})

k_2 -Second order rate constant (min^{-1})

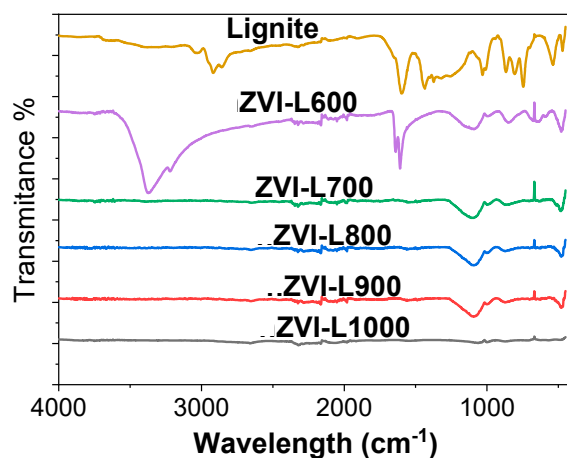


Figure S1. FTIR analysis of different ZVI-LXs synthesized at 600-1000 °C vs lignite.

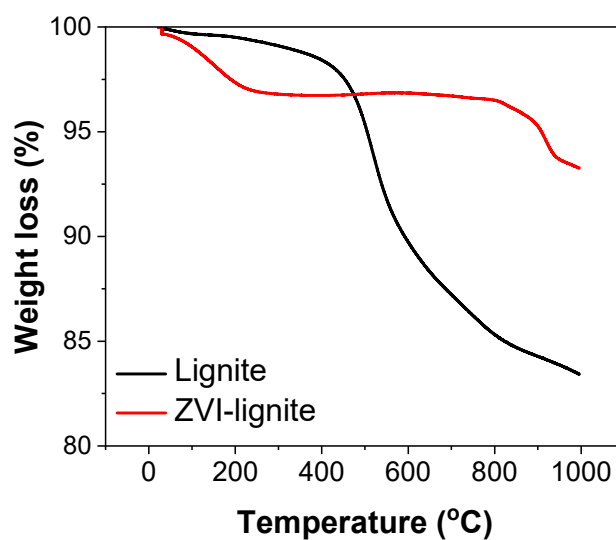


Figure S2. TGA profiles of lignite and ZVI-L1000 under nitrogen (N₂ flow rate of 50 °C/min)

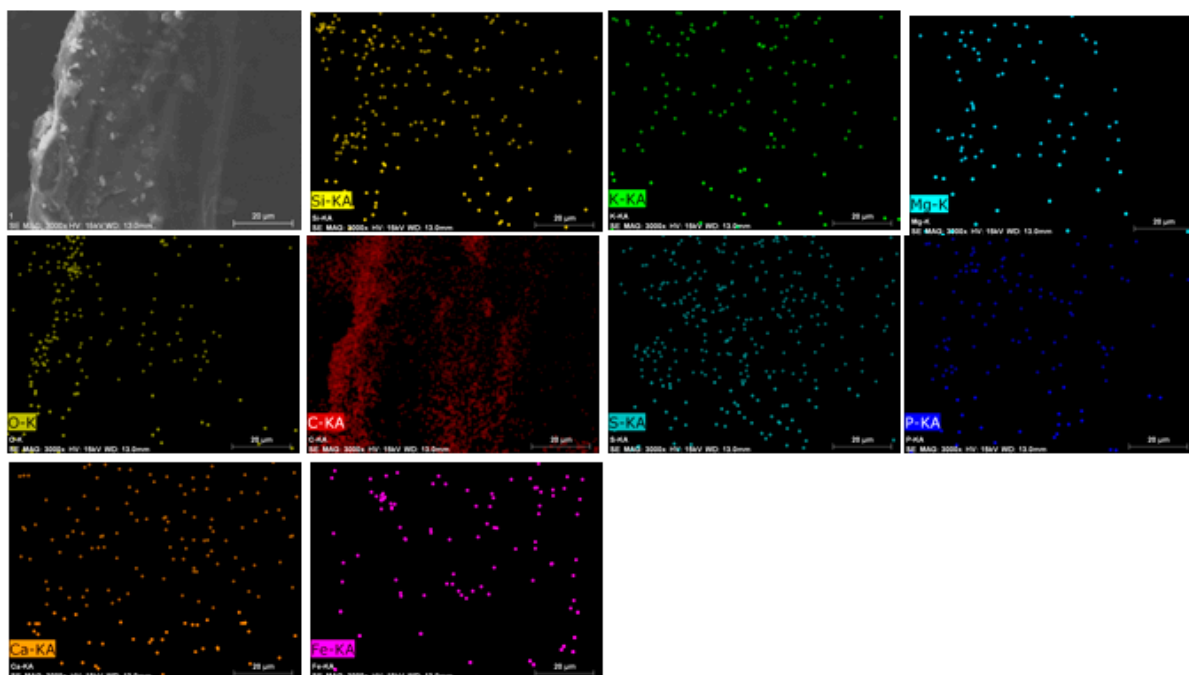


Figure S3. SEM image and their corresponding EDX mapping spectra of lignite.

a Lignite		a ZVI-L700		b ZVI-L1000	
Element	Atomic%	Element	Atomic%	Element	Atomic%
C K	93.34	C K	82.31	C K	73.69
Fe K	0.03	Fe K	4.60	Fe K	24.92
O K	6.47	O K	8.81	O K	0.94
S K	0.10	S K	0.43	S K	0.22
Cl K	0.00	Cl K	0.86	Cl K	0.00

Figure S4. Comparison of elemental distribution for lignite, ZVI-L700, and ZVI-L1000.

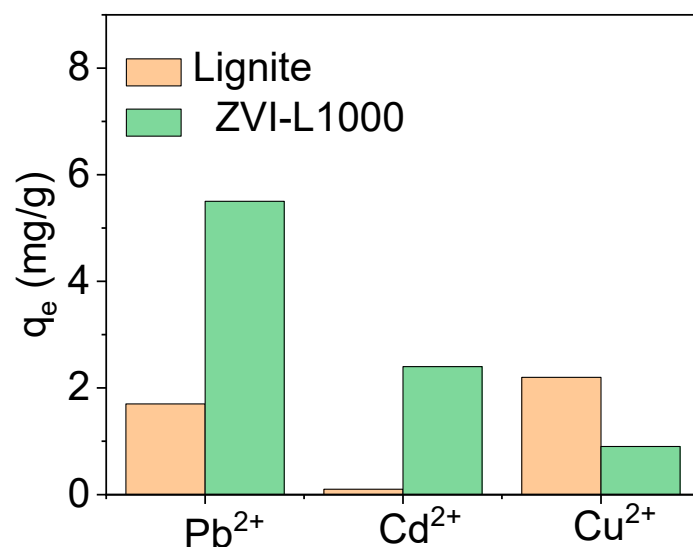


Figure S5. Simultaneous removal of Pb²⁺, Cu²⁺, and Cd²⁺ (400 ppm each) by lignite and ZVI-L1000 at pH 5 (solution volume 25 mL, 25 °C, 15 min).

References

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