SUPPLEMENTARY MATERIALS

Efficient removal of lead, cadmium, and zinc from water and soil by MgFelayered double hydroxides: Adsorption properties and mechanisms

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Adsorption experiment

The adsorption capacity is calculated as follows:

$$Q_t = V \times (C_0 - C_t) / m \quad (1)$$

where Q_t is the adsorption of heavy metals by MgFe–LDH@BB, mg·g^{-1}; C_0 and C_t represent the concentrations of Pb, Cd and Zn in the solution before and after the reaction(mg·L^{-1}); V (L) is the volume of the solution; m (g) is the mass of biochar.

The quasi-primary dynamics and quasi-secondary dynamics are modeled with the following equations:

Pseudo First-Order Kinetics: $$\ln(q_e - q_t) = \ln q_e - k_1 t \quad (2)$$

Pseudo Second-Order Kinetics: $$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \quad (3)$$

where q_t and q_e are the adsorbed amounts at time t and adsorption equilibrium (mg·g^{-1}), respectively; k is the kinetic rate constant.

The experiments were carried out using Freundlich, Langmuir, and Temkin models for nonlinear fitting of MgFe–LDH@BB adsorption of Pb, Cd, and Zn data, respectively, using the following equations:

Freundlich: $$q_e = k_F C_e^{1/n} \quad (4)$$

Langmuir: $$q_e = \frac{q_m k_L C_e}{1 + k_L C_e} \quad (5)$$

Temkin: $$q_e = \frac{RT}{b_t} \ln(A C_e) \quad (6)$$

where C_e is the concentration of Pb, Cd, and Zn at adsorption equilibrium, mg·L^{-1}; k_F is Freundlich's constant; k_L is Langmuir's constant; b_t and A are Temkin's constants; and q_m represent the theoretical saturated adsorption capacity, mg·g^{-1}

Table S1. Physico-chemical properties of experimental soils

pH	CEC	SOM	Pb	Zn	Cd
	$cmol \cdot kg^{-1}$	$mg \cdot kg^{-1}$	$mg \cdot kg^{-1}$	$mg \cdot kg^{-1}$	$mg \cdot kg^{-1}$
6.74±0.02	12.38±0.05	6.11±0.07	1615.63±8.16	8060.34±9.14	84.57±2.47

Note: Mean ± standard deviation (n = 3) for each indicator for the test soil.

Table S2. BET parameters for BB and MgFe–LDH@BB

Samples	BET surface area ($m^2 \cdot g^{-1}$)	Total pore volume ($cm^3 \cdot g^{-1}$)	Pore size (nm)
BB	7.42	0.0239	12.89
MgFe–LDH@BB	48.90	0.1587	12.98

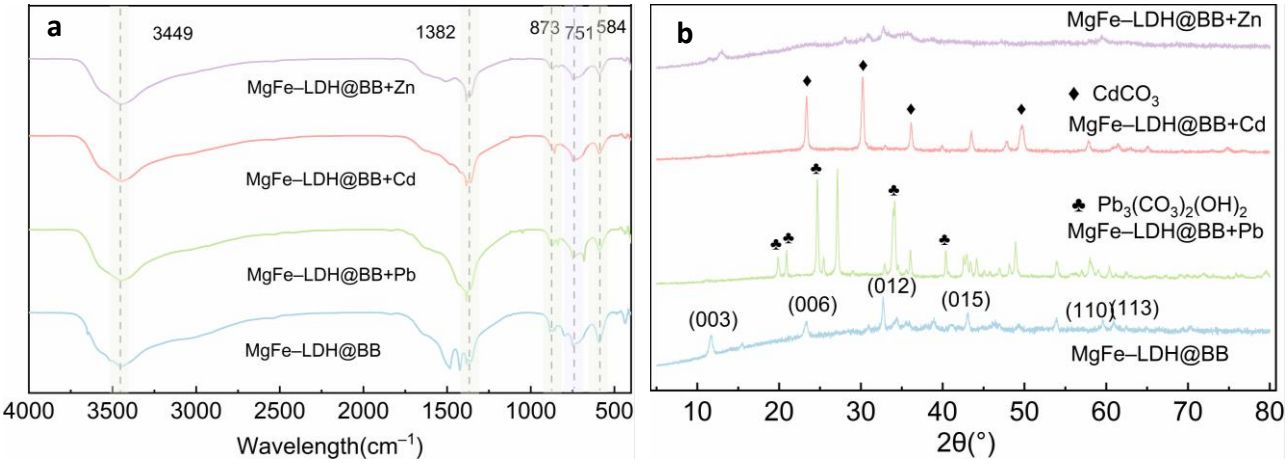

Figure S1 FTIR(a) and XRD(b) pattern of MgFe–LDH@BB before and after adsorption.

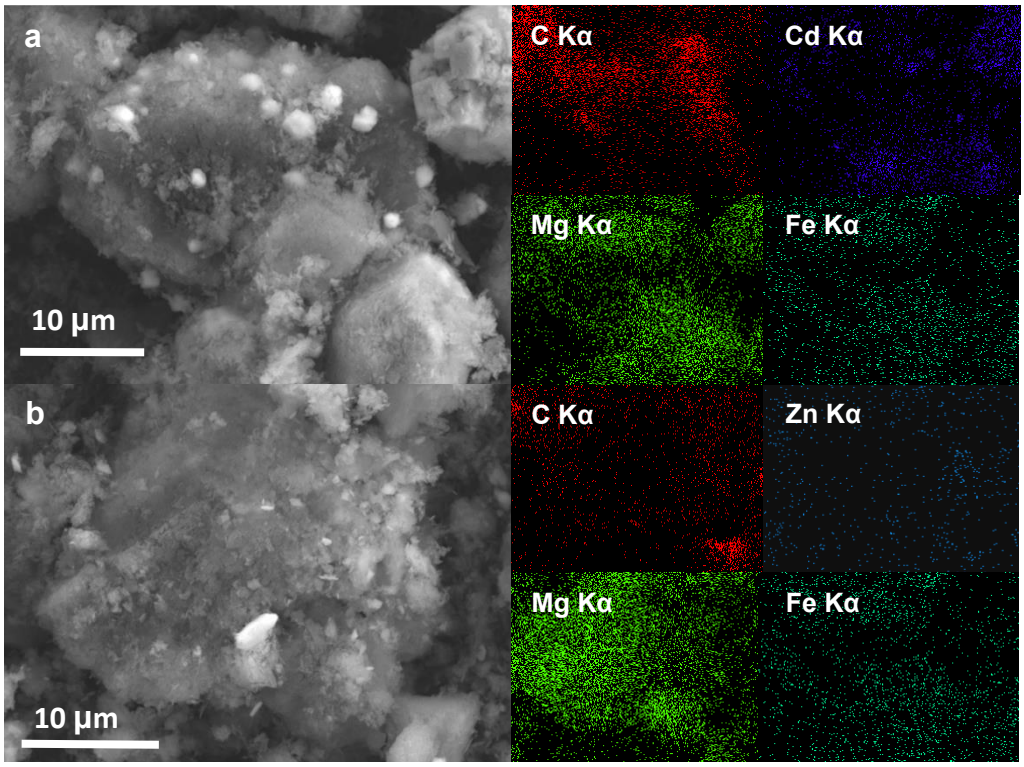

Figure S2 SEM-EDS images of MgFe–LDH@BB after adsorption of Cd (a), and Zn (b)

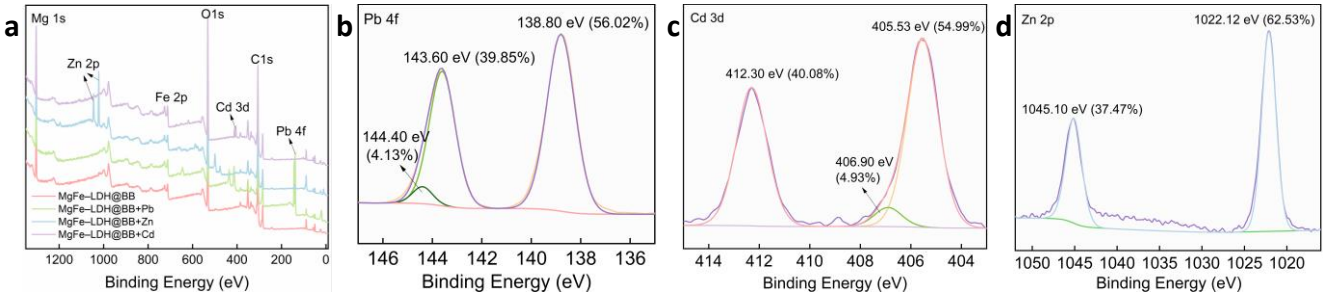

Figure S3 XPS spectra before and after adsorption of Pb, Cd, and Zn by MgFe–LDH@BB ((b), (c), (d) represent Pb4f, Cd3d, Zn2p, and Total spectrum (a).

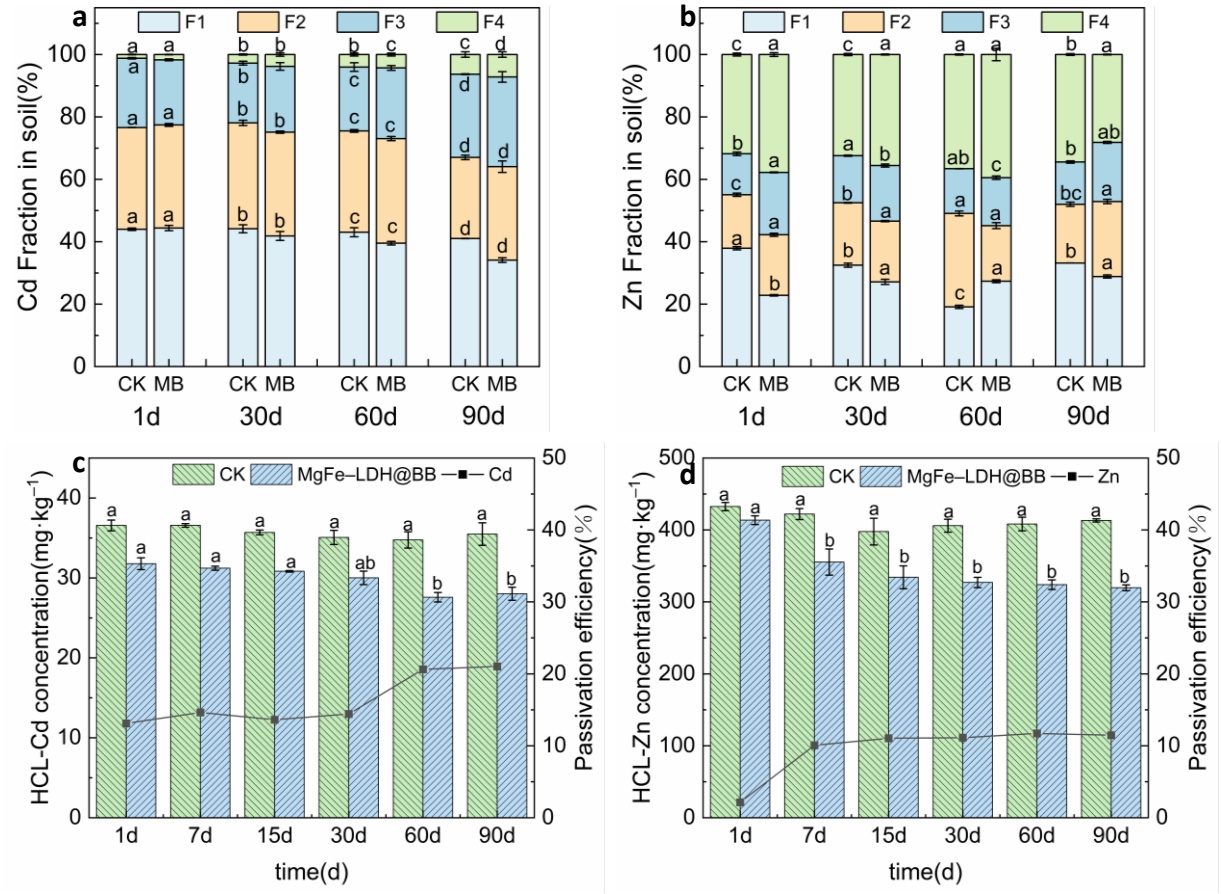

Figure S4 Fraction of Cd (a) and Zn (b) in soil (a); HCl extraction rate of Cd (c) and Zn(d) after 1, 7, 15, 30, 60 and 90 d immobilization in soil.

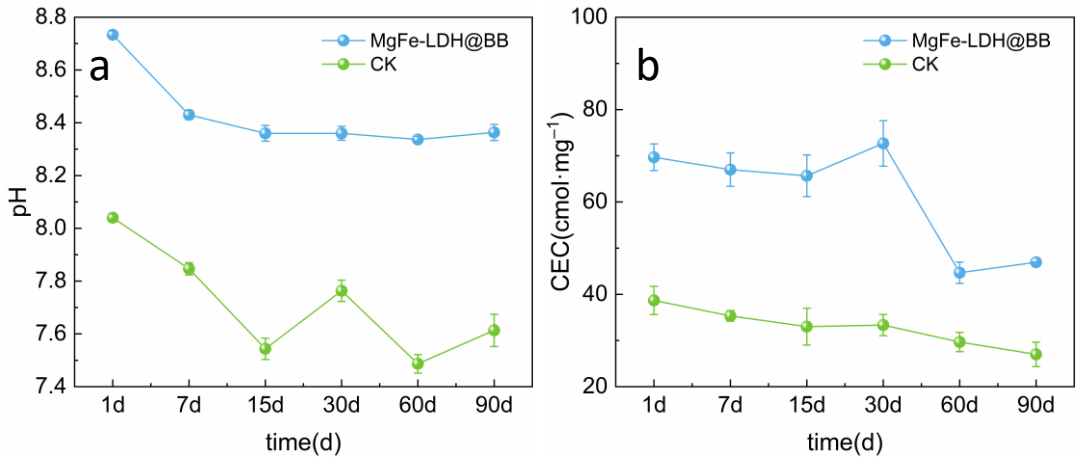

Figure S5 Trends in soil pH (a) and cations (b).