Supplementary material

Characterization of pruned tea branch biochar and the mechanisms underlying its adsorption for cadmium in aqueous solution

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Text S1. Adsorption kinetics

The pseudo-first-order model is expressed as Eq. (A1):

$$\ln\left(Q_e - Q_t\right) = lnQ_e - k_1 t \quad \text{(A. 1)}$$

Where Q_e and Q_t are the adsorption capacity of Cd^{2+} (mg/g) at equilibrium and time t (min), respectively; k_1 (min^{-1}) is the rate constant of the pseudo-first-order adsorption. The constraints (Q_0=0; t_0=0) have been correctly applied to this model.[1]

The pseudo-second-order model is shown as Eq. (A2):

$$\frac{t}{Q_t} = \frac{1}{k_2 \cdot Q_e^2} + \frac{t}{Q_e} \quad \text{(A. 2)}$$

Where k_2 (g/(mg·min)) represents the rate constant of the pseudo-second-order adsorption.

The other adsorption model is Elovich kinetic, which is shown as Eq. (A3):

$$Q_t = \frac{1}{\beta} ln(1 + \alpha\beta t) \quad \text{(A. 3)}$$

Where α (mg/(mg·min)) is the rate constant of initial adsorption, and β is the desorption constant related to the adsorbent surface coverage and chemical adsorption activation energy.

Text S2. Adsorption isotherms

The Langmuir isotherm model proposes that adsorption is localized on a monolayer, adsorption sites are homogeneous while no interaction happens between adsorbate molecules. This model in linear can be expressed by Eq. (A4)：

$$\frac{C_e}{Q_e} = \frac{C_e}{Q_{max}} + \frac{1}{Q_{max}K_L} \quad \text{(A. 4)}$$

Where Q_{max} is the maximum adsorption capacity (mg/g); K_L (L/mg) is the Langmuir constant related to the adsorption energy; C_e (mg/L) are the Cd^{2+} concentrations after adsorption.

Freundlich isotherm assumes that the adsorption is monolayer and reversible, while it can be used for multilayer adsorption occurs on heterogeneous surface. It can be described in linear form as follow Eq. (A5):

$$lnQ_e = lnk_F + \frac{1}{n}lnC_e \quad \text{(A. 5)}$$

Where K_F (mg/g) and n are Freundlich constants.

The Tempkin isotherm model supposes that the adsorption heat of absorbent decreases linearly with the of increase surface coverage. Uniform distribution of the binding energy is one of the features in this model. The linear form of the Temkin isotherm can be expressed by Eq. (A6):

$$Q_e = Blnk_t + BlnC_e \quad \text{(A. 6)}$$

Where K_t is the equilibrium binding constant, and B is related to the heat of adsorption.

Table S1. Analysis of mineral composition of various sources

Various sources	Mineral composition (%)					
	P	K	Ca	Na	Mg	Fe
TB	0.02	0.94	1.12	0.11	0.85	0.04
TBB400	0.03	2.87	1.64	0.28	1.09	0.14
TBB500	0.04	3.16	1.99	0.34	1.29	0.18
TBB600	0.04	3.24	2.43	0.38	1.40	0.22
TBB700	0.06	3.37	2.65	0.43	1.43	0.28
TBB800	0.07	3.55	2.82	0.45	1.44	0.30

References

1. S. Brandani. *Adsorption.*, 2021, **27**, 353-368.