Electronic Supplementary Material (ESI) for RSC Advances.

Electronic Supplementary Information

Investigation of the continuous flow sorption of heavy metals through biomass-packed column: Revisiting Thomas design model for correlation of binary component systems

Felycia E. Soetaredjo*, Alfin Kurniawan, L.K. Ong, Dimas R. Widagdyo, Suryadi Ismadji

Department of Chemical Engineering, Widya Mandala Surabaya Catholic University, Kalijudan 37, Surabaya 60114, Indonesia

* E-mail address: felyciae@yahoo.com; Tel.: +62 31 389 1264; Fax: +62 31 389 1267

Number of pages (including cover sheet) = 7

Number of Supplementary Tables = 3

Number of Supplementary Figures = 5

Table S1 Porous properties of metal oxides-impregnated activated carbons

Activated Carbons	S_{BET} ($m^2\ g^{-1}$)	S_{mic} ($m^2\ g^{-1}$)	V_T ($cm^3\ g^{-1}$)	V_{mic} ($cm^3\ g^{-1}$)	Metal Load (wt.%)
Cd-impregnated AC	1053.44	790.19	0.341	0.252	1.69
Pb-impregnated AC	1062.18	802.06	0.347	0.256	3.31

Table S2 Detail parameters for the laboratory-scale and scale-up column experiments

Parameters	Laboratory-scale	Scale-up	Scaling ratio
Adsorber dimension			
Internal diameter, i.d. (cm)	3	8	2.67
Height, H (cm)	40	100	2.50
Cross-sectional area (cm^2)	7.07	50.27	7.11
Adsorption			
Solution flow rate (ml min^{-1})	10	10	-
Linear velocity (cm min^{-1})	1.41	0.20	0.14
Adsorbent mass (g)	23.43	83.25	3.55
Bed height (cm)	10	10	-

Table S3 The characteristics of real electroplating wastewater

Sampling Point	Parameters								
	pH	TDS[†]	COD[†]	Pb(II)[‡]	Cd(II)[‡]	Ni(II)[‡]	Fe[‡]	Cu(II)[‡]	Cr(VI)[‡]
A	7.18	852.7	18.7	0.018	0.018	0.062	0.015	0.076	0.110
B	6.85	833.5	24.3	0.019	0.022	0.057	0.012	0.082	0.102
C	7.32	848.4	22.5	0.015	0.020	0.060	0.018	0.072	0.105
D	7.41	885.2	25.2	0.018	0.019	0.055	0.013	0.075	0.105
E	6.92	808.3	20.8	0.017	0.023	0.058	0.016	0.080	0.108
MW[*]	7.06	840.6	21.6	0.018	0.021	0.059	0.017	0.079	0.108

[*] MW refers to the mixed wastewater from five sampling points

[†] Concentration unit: mg L^{-1}, determined by ASTM D5907-13 for total dissolved solids (TDS) and ASTM D1252-06(2012)e1 (dichromate oxygen demand method) for chemical oxygen demand (COD)

[‡] Concentration unit: mmol L^{-1}, determined using flame atomic absorption spectrophotometer (Fe was considered as the total concentration of Fe(II) and Fe(III) ions from the instrument reading)

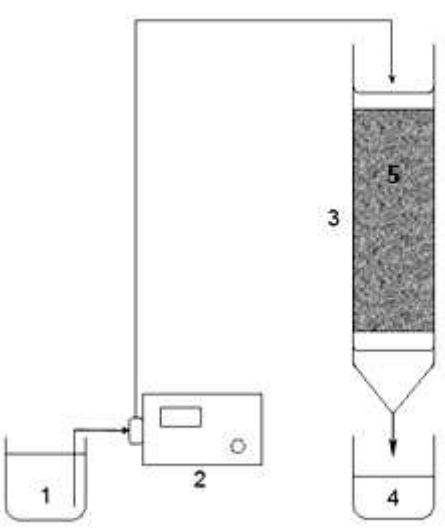

Fig. S1 Schematic of experimental setup for packed bed adsorption

(1 – Influent tank; 2 – Peristaltic pump; 3 – Glass column; 4 – Effluent tank; 5 – Biosorbent)

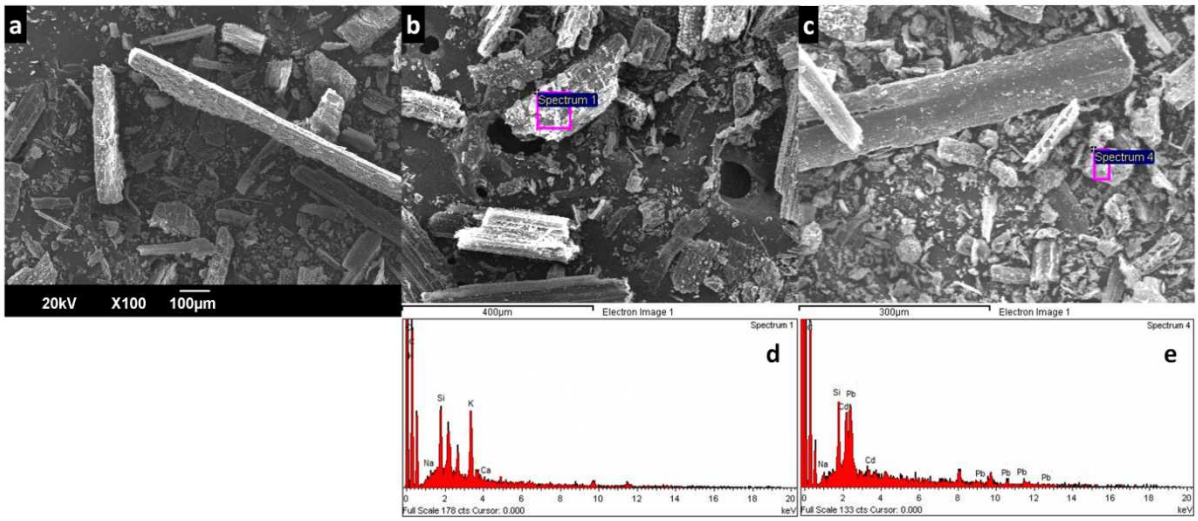

Fig. S2 SEM images of native (a – b) and metal-loaded rice straw (c) and the EDX spectra of native (d) and metal-loaded rice straw (e)

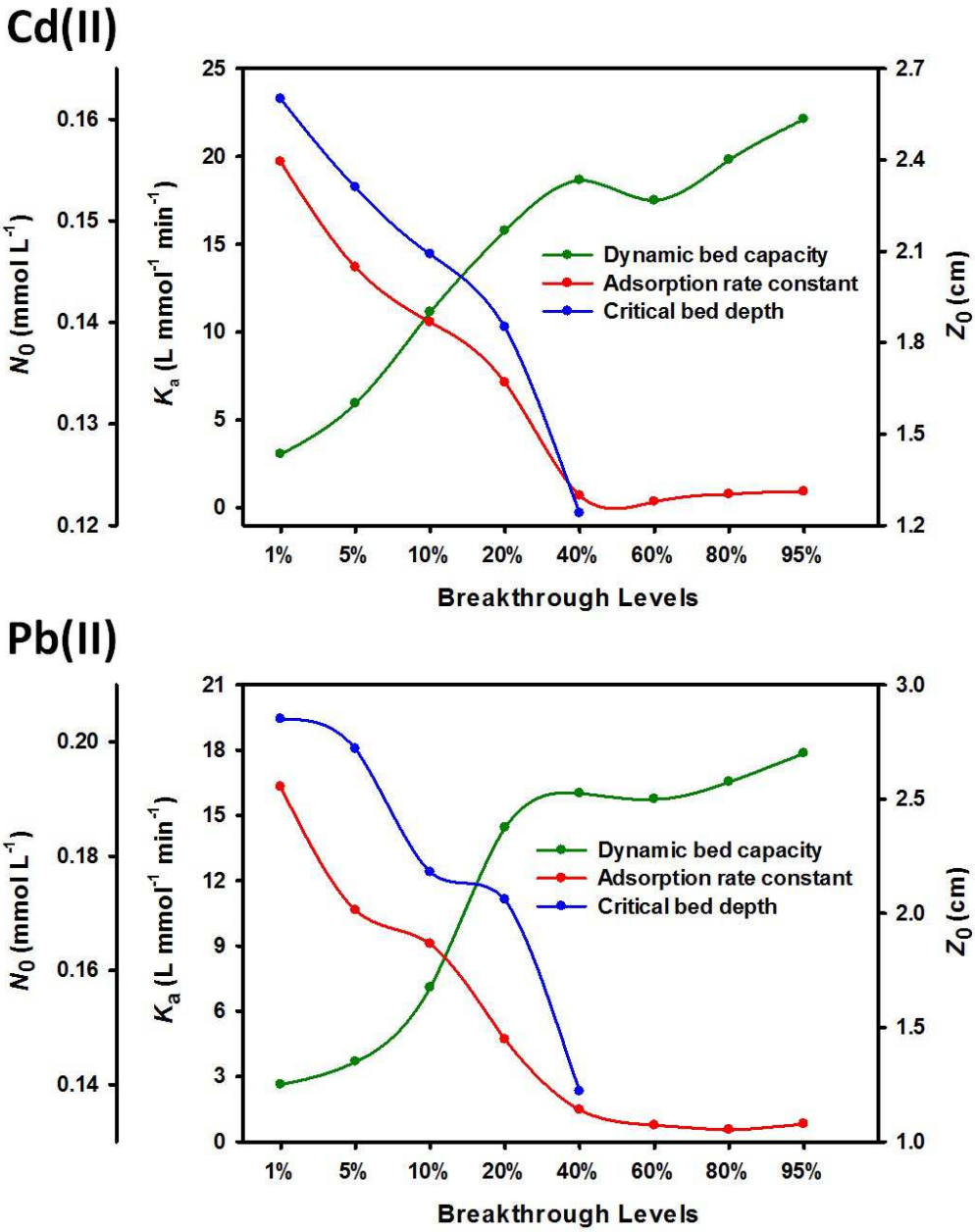

Fig. S3 The predicted trends of BDST column parameters corresponding to the variation in the breakthrough points (C_0 = 0.01 mmol L^{-1} and solution flow rate = 10 ml min^{-1})

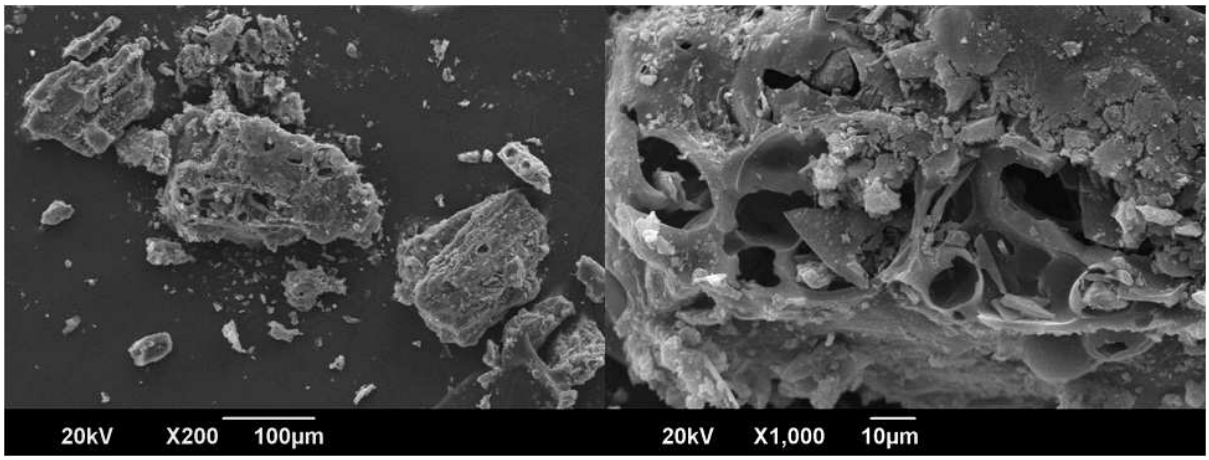

Fig. S4 SEM images of metal oxides-impregnated activated carbons

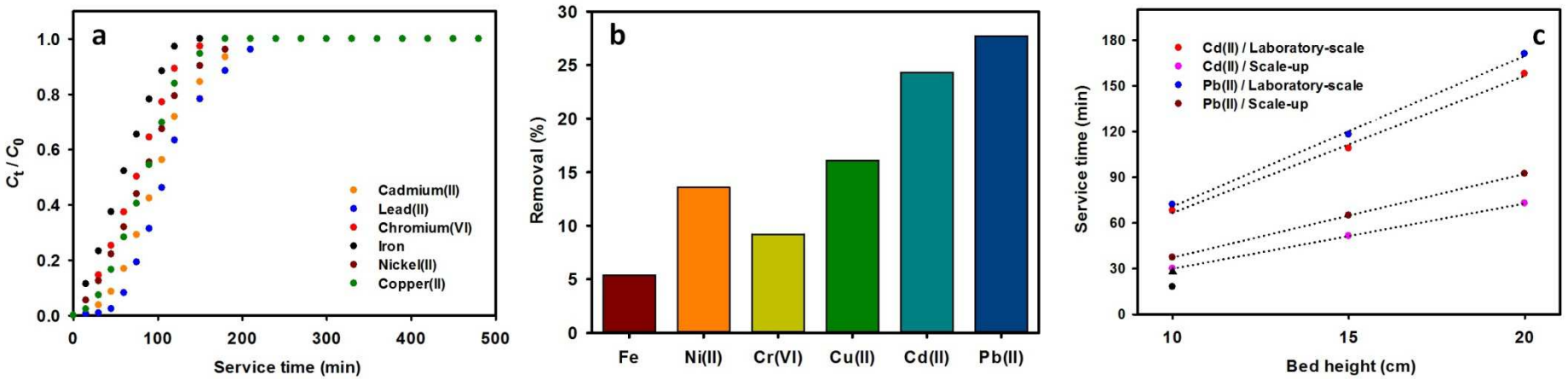

Fig. S5 Experimental breakthrough curves (a) and the removal percentages of metal ions present in the real wastewater (b). Scheme C shows the BDST relation plots between laboratory-scale and scale-up column tests (experimental breakthrough time of Cd(II) – ● and Pb(II) – ▲)