Supplementary information for

Zn^{2+} removal from the aqueous environment using Polydopamine/Hydroxyapatite/Fe_3O_4 magnetic composite under ultrasonic waves

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Content:

- SEM images and Map-EDX results.

- AFM and TEM images of HAp, HAp/Fe_3O_4, and HAp/Fe_3O_4/PDA magnetic composites.

- Independent variables in the Zn^{2+} ions adsorption, actual removal percentage, predicted removal percentage, and the difference between them.

- ANOVA for Zn^{2+} ions adsorption using RSM-CCD.

- Nonlinear relationship of PFO, PSO, and Elovich for Zn^{2+} ions adsorption using PDA/HAp/Fe_3O_4 magnetic composite, HAp/Fe_3O_4 magnetic composite, and HAp.

-Linear relationship of intraparticle diffusion model for Zn^{2+} adsorption process using adsorbents.

- Nonlinear relationship of isotherm models for Zn^{2+} adsorption process using PDA/HAp/Fe_3O_4 magnetic composite, HAp/Fe_3O_4 magnetic composite, and HAp.

- Effect of Na^+ ion and effect of the number of adsorption/desorption steps on the efficiency of Zn^{2+} ions adsorption process using produced adsorbents.

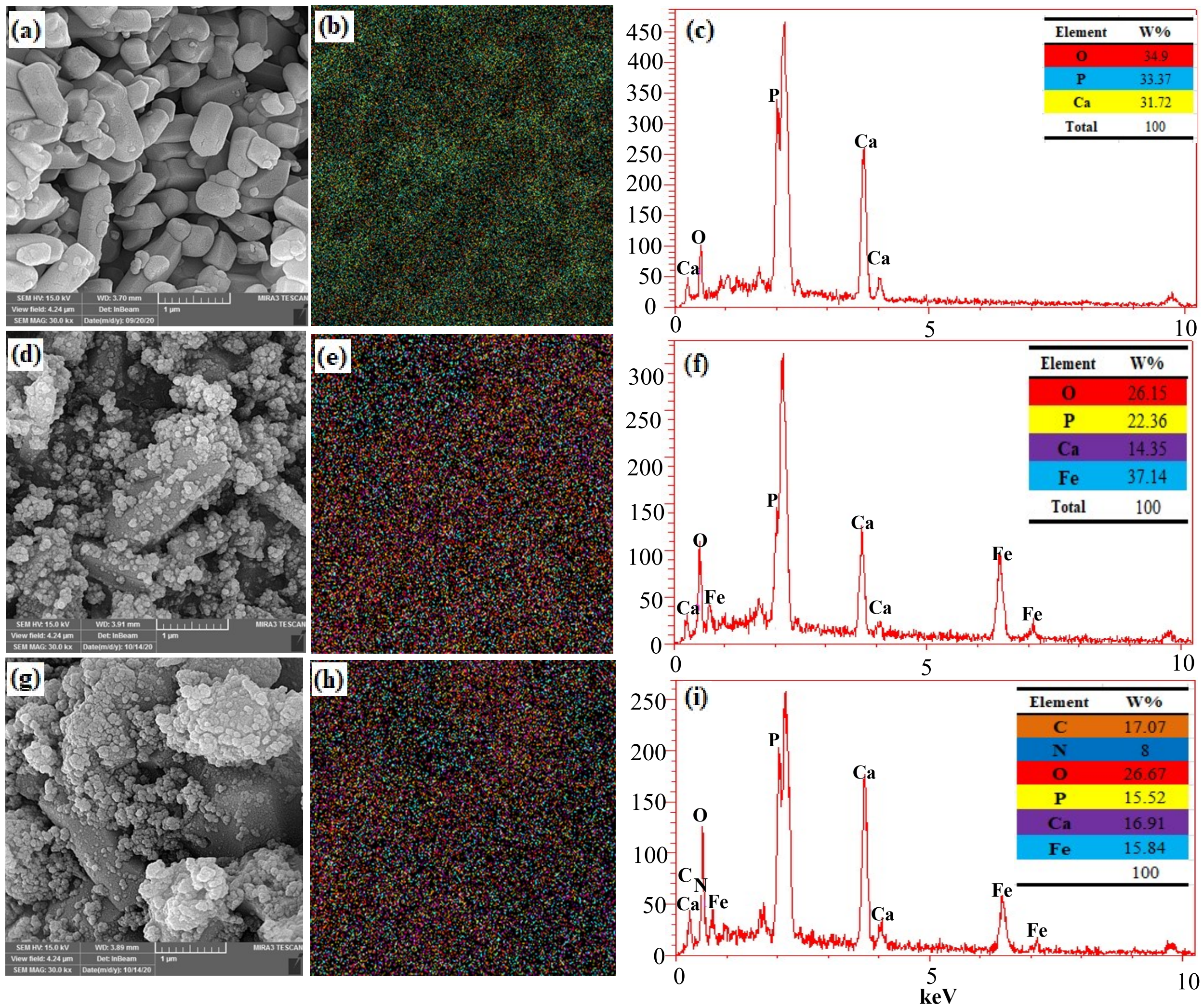


Fig. S1. SEM images and Map-EDX results of (a-c) HAp, (d-f) HAp/Fe_3O_4 and (g-i) PDA/HAp/Fe_3O_4 magnetic composites.

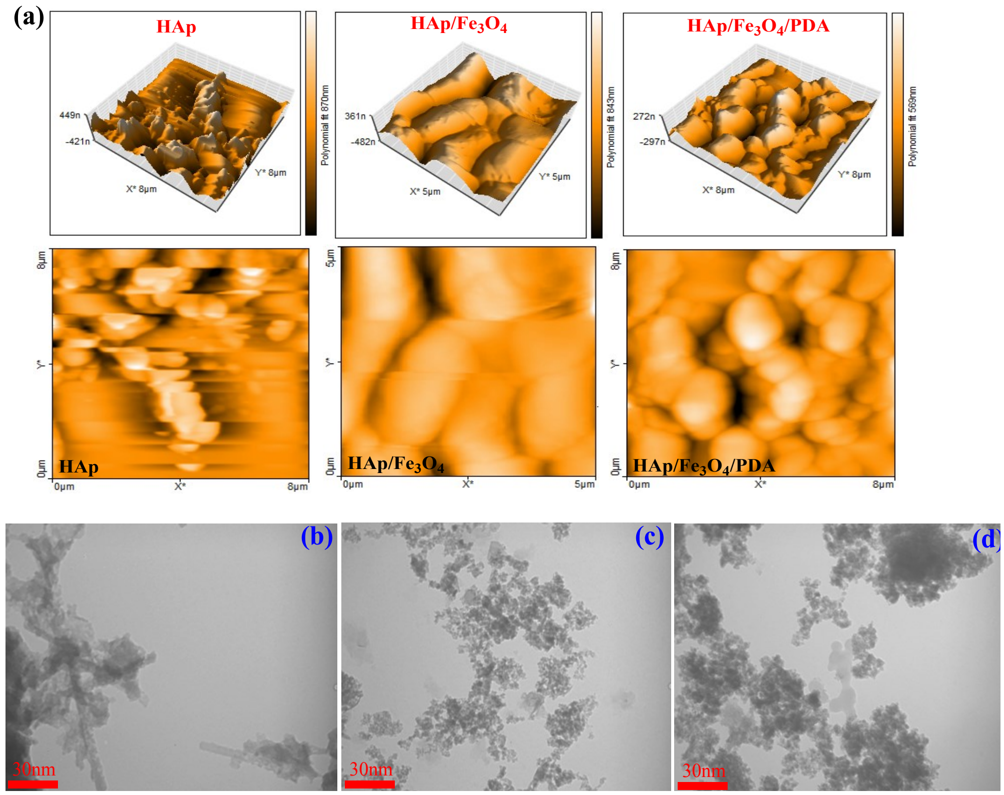


Fig. S2. (a) AFM and TEM images of (b) HAp, (c) HAp/Fe_3O_4, and (d) HAp/Fe_3O_4/PDA magnetic composites.

Table S1. Independent variables in the Zn^{2+} ions adsorption, actual removal percentage, predicted removal percentage, and the difference between them.

Run	Factors					Adsorption Zn^{2+} (%)			Run	Factors					Adsorption Zn^{2+} (%)		
	X_1	X_2	X_3	X_4	X_5	Exp.[a]	Pred.[b]	Res.[c]		X_1	X_2	X_3	X_4	X_5	Exp.[a]	Pred.[b]	Res.[c]
1	200	4	10	30	0.8	90.73	91.02	-0.294	24	150	5	25	40	1	92.71	91.7	1.01
2	200	4	20	30	0.8	79.51	78.49	1.02	25	250	3	25	40	0.6	74.69	74.1	0.5891
3	250	3	15	20	1	85.94	84.47	1.47	26	150	5	15	20	0.6	82.81	82.77	0.0434
4	200	2	20	30	0.8	62.25	63.81	-1.56	27	200	4	20	30	0.8	78.13	78.49	-0.3633
5	250	3	15	40	0.6	83.37	82.75	0.6191	28	150	5	15	20	1	86.28	86.04	0.2391
6	250	5	15	40	1	98.68	99.86	-1.18	29	150	3	25	20	1	72.93	72.89	0.0446
7	150	3	15	40	1	84.58	84.43	0.1479	30	250	3	25	40	1	82.93	82.86	0.0674
8	200	4	20	10	0.8	79.15	80.14	-0.991	31	250	3	25	20	1	76.32	75.82	0.4991
9	150	5	15	40	1	94.52	93.08	1.44	32	150	3	25	40	0.6	71.36	71.17	0.1946
10	200	4	20	30	0.8	79.47	78.49	0.9767	33	250	5	15	40	0.6	93.72	93.59	0.1286
11	250	3	15	20	0.6	79.63	79.01	0.6234	34	150	5	25	20	0.6	82.44	81.39	1.05

12	250	5	15	20	1	93.86	93.12	0.7386	35	150	3	25	20	0.6	66.42	67.42	-1
13	150	3	15	40	0.6	75.52	75.67	-0.1504	36	200	4	20	50	0.8	89.28	90.93	-1.65
14	200	4	20	30	0.8	80.68	78.49	2.19	37	250	5	15	20	0.6	90.37	89.85	0.5229
15	150	3	15	20	0.6	72.86	71.93	0.9339	38	250	5	25	40	0.6	89.38	88.07	1.31
16	250	3	15	40	1	90.83	91.51	-0.6826	39	250	5	25	20	1	88.76	87.6	1.16
17	150	3	25	40	1	82.18	79.93	2.25	40	150	5	25	40	0.6	85.84	85.13	0.7091
18	100	4	20	30	0.8	80.38	81.38	-0.996	41	150	3	15	20	1	76.28	77.39	-1.11
19	250	3	25	20	0.6	71.61	70.36	1.25	42	200	4	20	30	1.2	82.79	84.51	-1.72
20	200	4	30	30	0.8	78.65	80.99	-2.34	43	250	5	25	40	1	94.67	94.64	0.0319
21	250	5	25	20	0.6	83.39	84.32	-0.9321	44	200	6	20	30	0.8	85.34	86.42	-1.08
22	200	4	20	30	0.4	70.38	72.48	-2.1	45	300	4	20	30	0.8	89.75	91.39	-1.64
23	150	5	25	20	1	83.74	84.66	-0.9209	46	150	5	15	40	0.6	86.26	86.51	-0.2509

[a] Experimental data [b] Predicted value [c]Residual

Table S2. ANOVA for Zn^{2+} ions adsorption using RSM-CCD.

Source	Df[a]	Zn (II) Removal (%)				Source	Df[a]	Zn^{2+} Removal (%)			
		SS[b]	MS[c]	F-value	P-value			SS[b]	MS[c]	F-value	P-value
Model	13	2810.83	216.22	138.61	< 0.0001	X_4X_5	1	21.75	21.75	13.94	0.0007
X_1	1	250.8	250.8	160.78	< 0.0001	X_1^2	1	104.38	104.38	66.91	< 0.0001
X_2	1	1278.71	1278.71	819.74	< 0.0001	X_2^2	1	22.61	22.61	14.49	0.0006
X_3	1	231.84	231.84	148.63	< 0.0001	X_3^2	1	122.03	122.03	78.23	< 0.0001
X_4	1	290.84	290.84	186.45	< 0.0001	X_4^2	1	82.58	82.58	52.94	< 0.0001
X_5	1	362.16	362.16	232.17	< 0.0001	Residual	32	49.92	1.56		
X_1X_3	1	34.36	34.36	22.03	< 0.0001	Lack of Fit	29	46.66	1.61	1.48	0.4258
X_2X_3	1	19.53	19.53	12.52	0.0013	Pure Error	3	3.26	1.09		
X_2X_5	1	9.59	9.59	6.15	0.0186	Cor Total	45	2860.75			

Model Statistics	
Std. Dev. (SD): 1.25	R^2: 0.0.9826
Coefficient of Variance (C.V. %): 1.51	Adj-R^2: 0.9755
Adequate precision (Ap): 52.9839	Pred-R^2: 0.9602

[a] Degree of freedom [b] Sum of Square [c] Mean of Square [d] Adequate precision

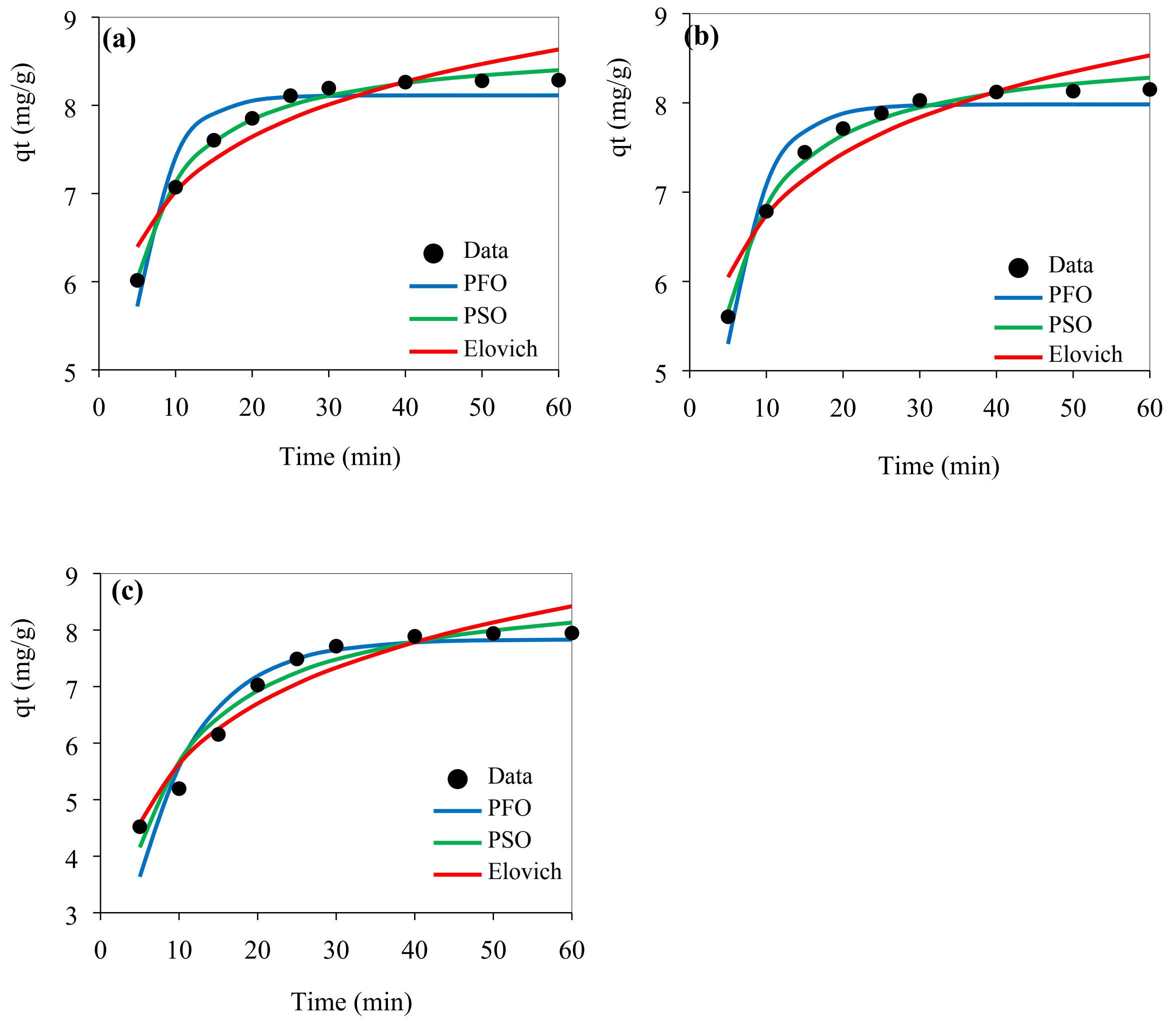


Fig.S3. Nonlinear relationship of PFO, PSO, and Elovich for Zn^{2+} ions adsorption using (a) PDA/HAp/Fe_3O_4 magnetic composite, (b) HAp/Fe_3O_4 magnetic composite, and (c) HAp.

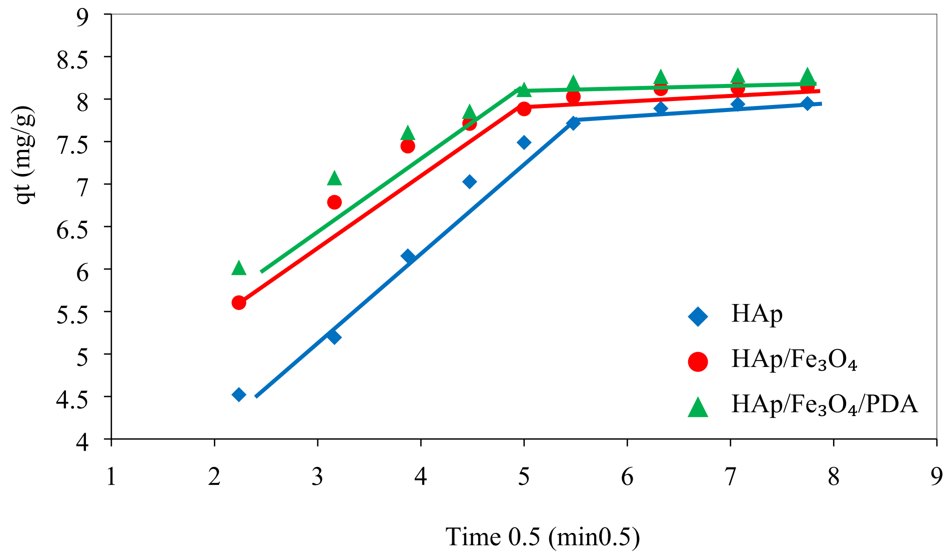


Fig. S4. Linear relationship of intraparticle diffusion model for Zn^{2+} adsorption process using adsorbents.

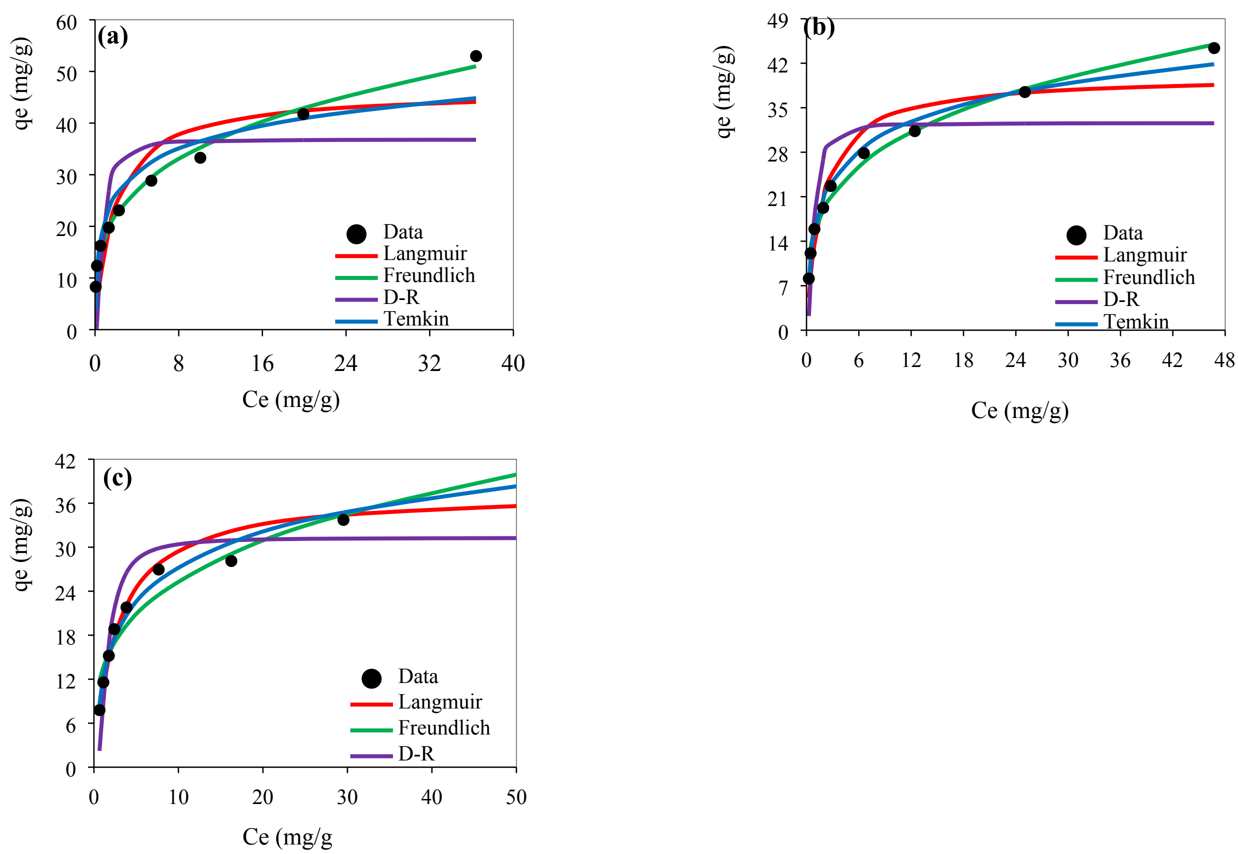
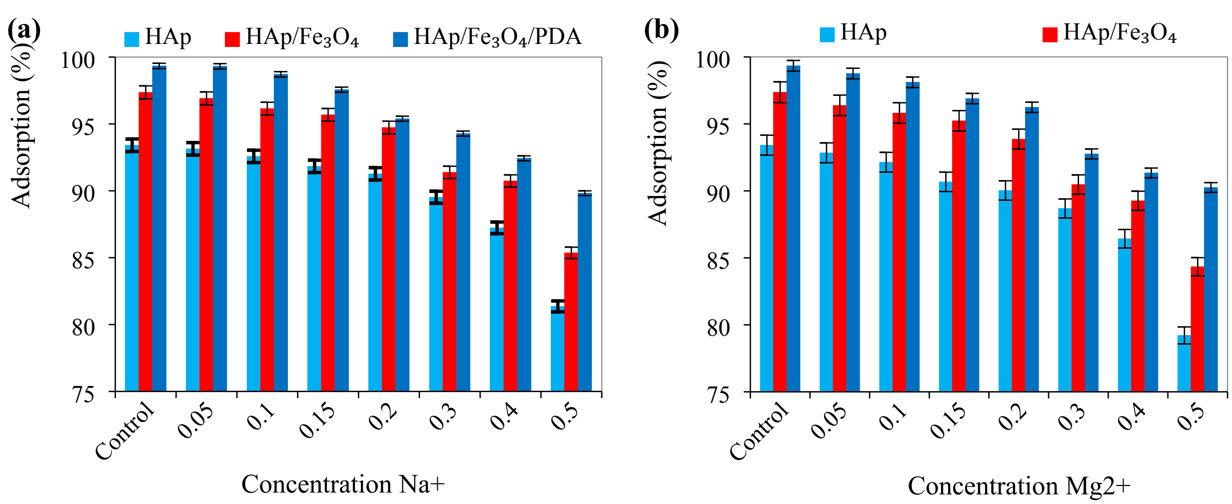


Fig. S5. Nonlinear relationship of isotherm models for Zn^{2+} adsorption process using (a) PDA/HAp/Fe_3O_4 magnetic composite, (b) HAp/Fe_3O_4 magnetic composite, and (c) HAp.

Table S3. Comparison of adsorption capacity of investigated adsorbents with other adsorbents used for Zn^{2+} adsorption.

Adsorbent	q_{max} (mg/g)	Reference
Chitosan/Hydroxyapatite/nano-Magnetite composite	6.497	[1]
watermelon rind	52.816	[2]
CSH-Mt	16.74	[3]
SiO_2	9.107	[4]
$MnFe_2O_4$@CS-SiO_2 microsphere	60.13	[5]
muskmelon peel biochar	72.99	[6]
modified water hyacinth (*Eichhornia crassipes*) fibers	18.9	[7]
Li-Al HTlc	20.5-49.9	[8]
Bentonite clay	2.1	[9]
Mesoporous silica particles functionalized triethylenetetramine	13.6	[10]
waste-reclaimed material	0.106	[11]
Fe_2O_3@SBA-15 − CS − APTMS	100.47	[12]
granules prepared using sludg	1.23	[13]
HAp	37.57	Present work
HAp/Fe_3O_4	40.07	Present work
HAp/Fe_3O_4/PDA	46.37	Present work



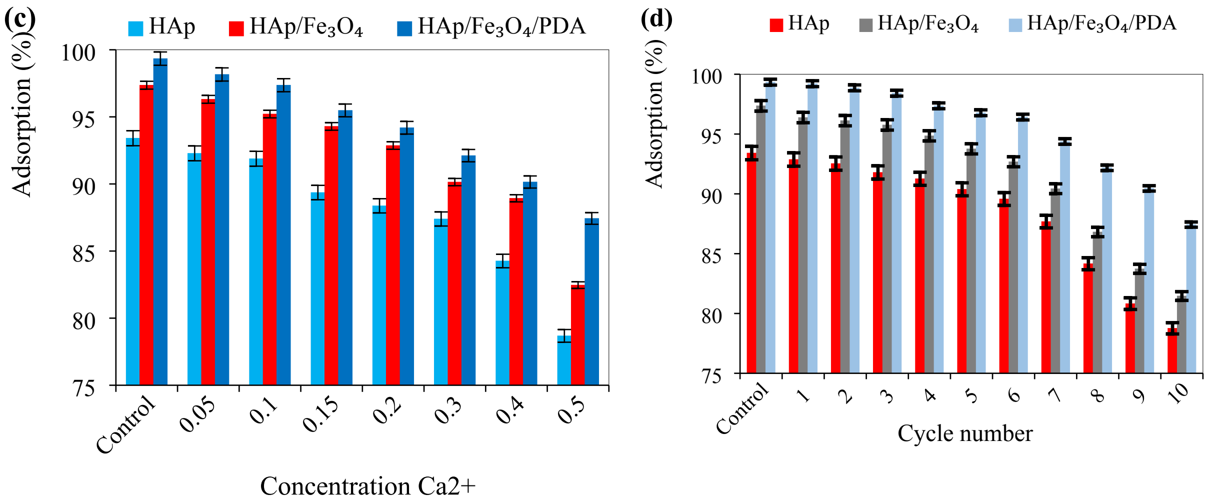


Fig. S6. (a) Effect of Na^{+} ion sand (b) effect of the number of adsorption/desorption steps on the efficiency of Zn^{2+} ions adsorption process using produced adsorbents.

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