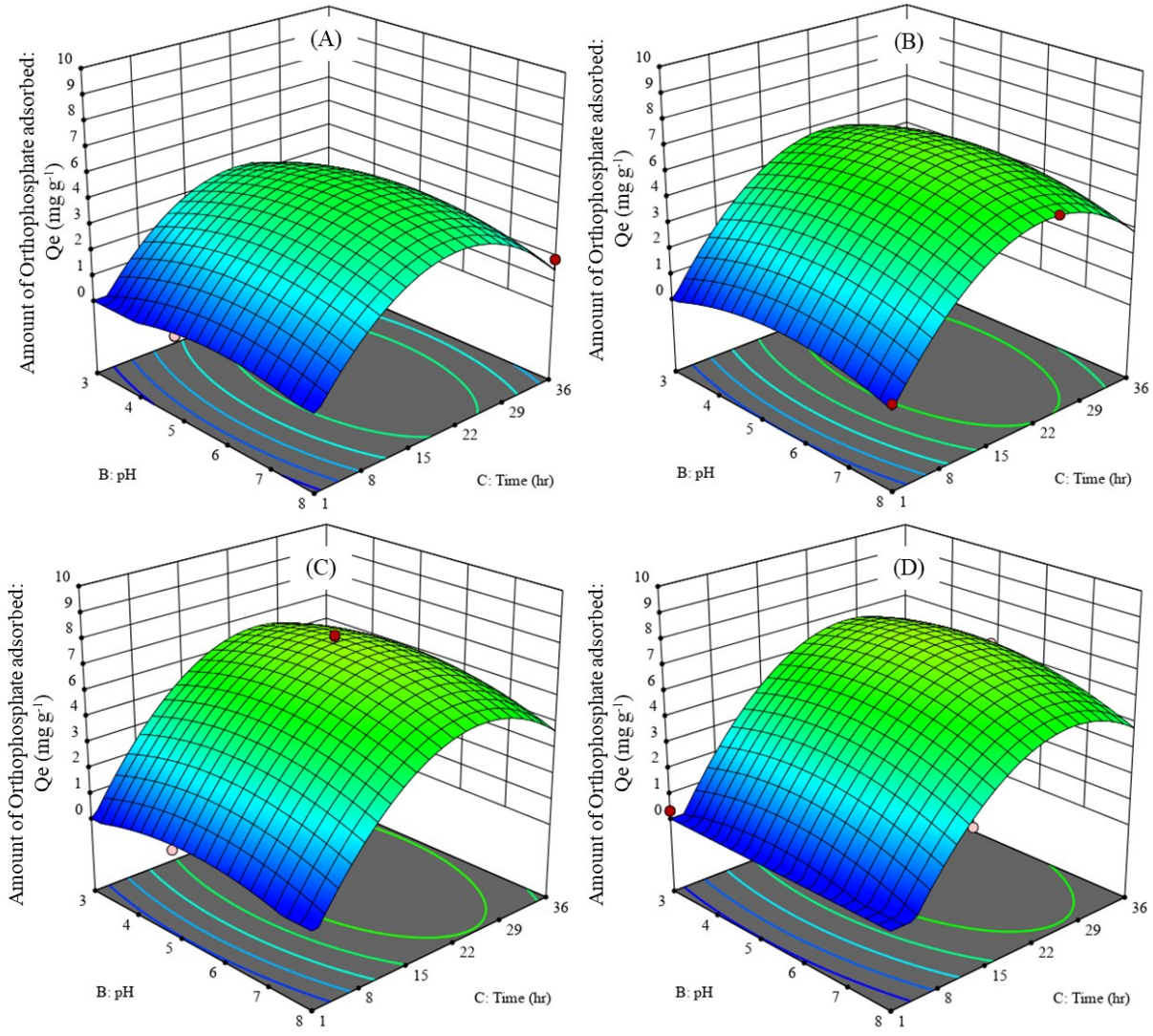
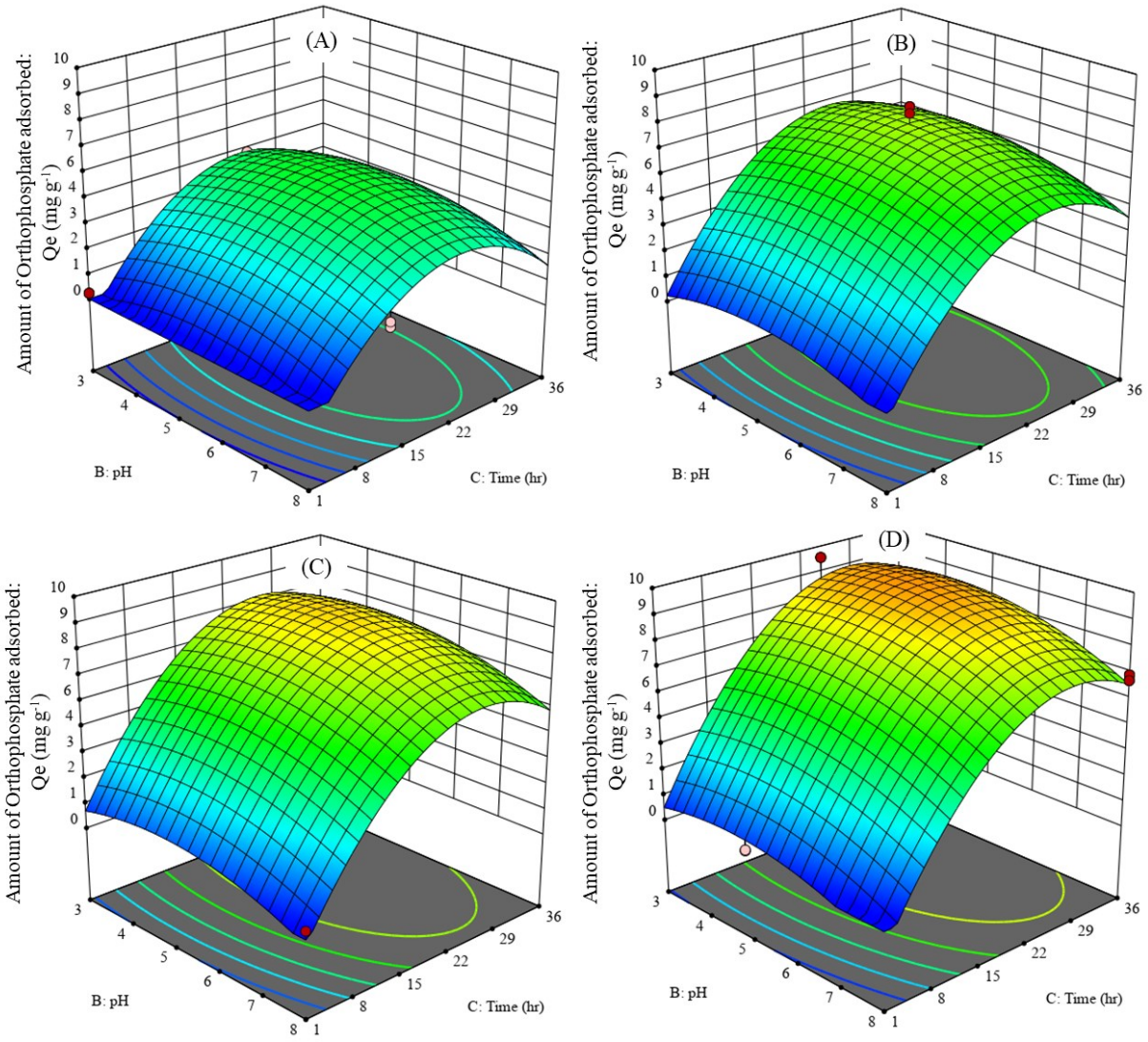
Supplementary Material

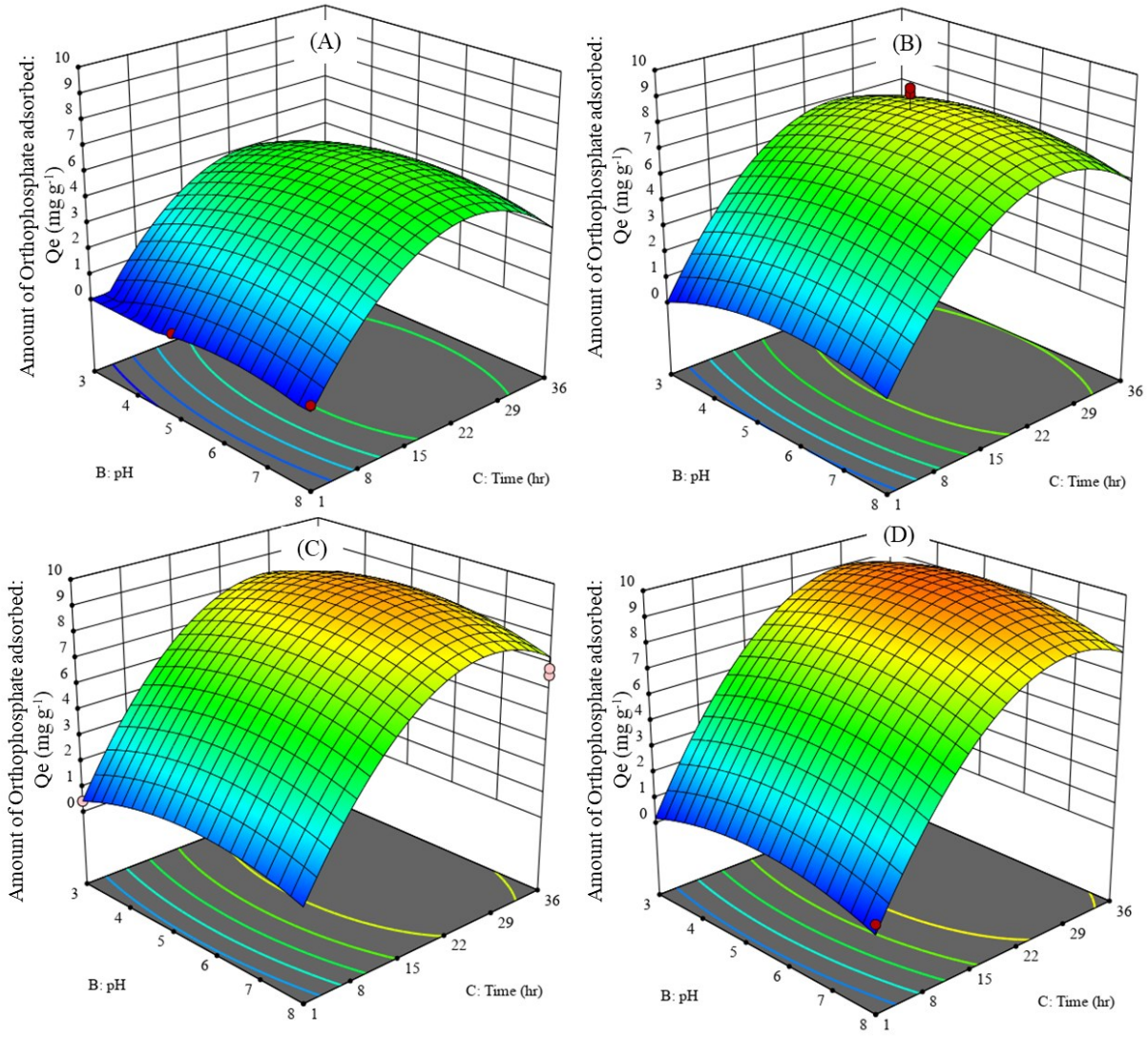
1 Supplementary Figures



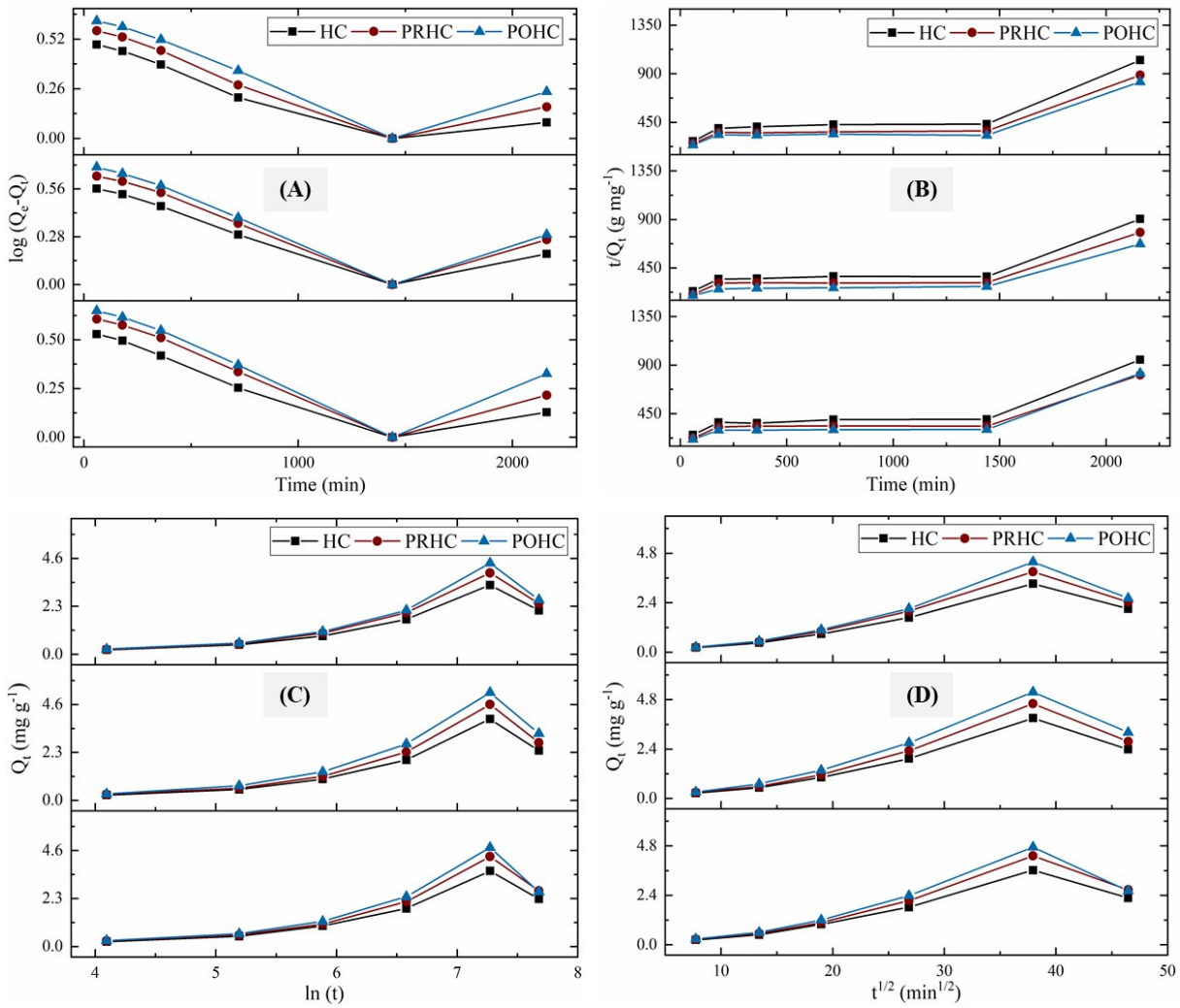
Supplementary Figure 1. Three dimensional response surface curve of adsorption parameters on orthophosphate adsorbed by HC at an initial orthophosphate dose of a). 25mg L^{-1} b). 50mg L^{-1} c). 75mg L^{-1} and d). 100mg L^{-1}



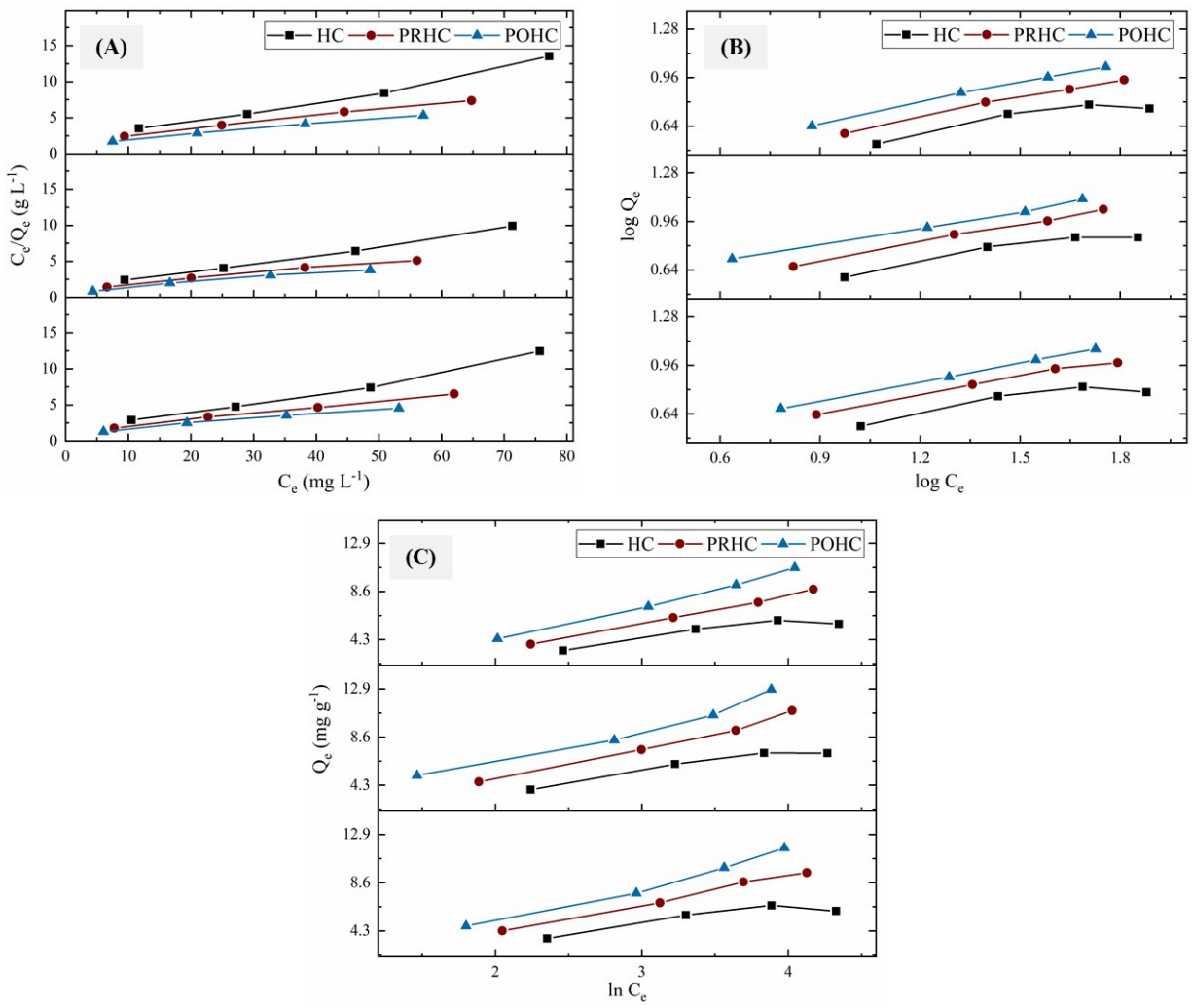
Supplementary Figure 2. Three dimensional response surface curve of adsorption parameters on orthophosphate adsorbed by PRHC at an initial orthophosphate dose of a). 25mg L^{-1} b). 50mg L^{-1} c). 75mg L^{-1} and d). 100mg L^{-1}



Supplementary Figure 3. Three dimensional response surface curve of adsorption parameters on orthophosphate adsorbed by POHC at an initial orthophosphate dose of a). 25mg L^{-1} b). 50mg L^{-1} c). 75mg L^{-1} and d). 100mg L^{-1}



Supplementary Figure 4. Kinetic plots of orthophosphate removal a). Pseudo-first order, b). Pseudo-second order, c). Elovich and d). Intraparticle diffusion



Supplementary Figure 5. Isotherm plots of orthophosphate removal a). Langmuir, b). Freundlich and c). Tempkin

2 Supplementary Tables

Supplementary Table 1. Experimental design runs and their analogous results

Run	Orthophosphate dose (mg L^{-1})	pH	Contact time (hr)	Hydrochar type	Amount of Orthophosphate adsorbed : Qe (mg g^{-1})
1	75	5	1	HC	0.431
2	25	8	36	HC	2.106
3	50	5	24	POHC	8.338
4	75	5	24	HC	7.181
5	50	5	24	PRHC	7.487
6	50	5	24	PRHC	7.781

7	75	8	36	POHC	6.206
8	75	8	1	PRHC	0.356
9	100	5	36	HC	5.600
10	25	8	12	PRHC	1.994
11	50	3	36	HC	3.688
12	100	3	1	HC	0.350
13	75	5	24	HC	7.263
14	25	5	1	HC	0.256
15	50	3	6	HC	1.462
16	75	3	36	PRHC	5.944
17	25	3	36	POHC	2.981
18	75	5	24	POHC	10.575
19	100	5	36	HC	5.838
20	25	8	1	POHC	0.250
21	100	8	1	POHC	0.425
22	25	3	1	PRHC	0.269
23	25	8	12	PRHC	2.213
24	25	3	24	HC	3.619
25	100	5	12	HC	3.775
26	75	3	6	PRHC	2.269
27	25	3	24	PRHC	4.313
28	100	8	12	HC	2.800
29	25	5	36	PRHC	2.769
30	100	8	36	PRHC	6.350
31	100	3	36	POHC	8.200
32	100	5	1	PRHC	0.450
33	100	8	36	PRHC	6.587
34	25	5	1	POHC	0.306
35	50	8	24	HC	5.250
36	50	5	12	POHC	4.050
37	50	5	24	POHC	8.584
38	75	3	1	POHC	0.469
39	25	5	1	HC	0.278
40	100	3	24	PRHC	9.500
41	50	8	1	HC	0.313
42	25	3	12	POHC	2.388
43	75	8	36	POHC	6.492
44	100	5	1	PRHC	0.482
45	100	5	6	POHC	3.350

Supplementary Table 2. Description of adsorption kinetics and isotherm models

Model	**Formul**a	Constants

Adsorption Kinetics		
Pseudo-first order[1]	$\log(qe - qt) = \log qe - \frac{k_1}{2.303}t$	k_1 - Equilibrium rate constant of pseudo first order adsorption (min^{-1})
Pseudo-second order[2]	$\frac{t}{q_1} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e}$	k_2 - Adsorption rate constant (g mg^{-1} min^{-1})
Elovich[3]	$q_t = q_0 + \frac{1}{\beta}\ln(\alpha\beta) + \frac{1}{\beta}ln(t)$	α - Initial rate constant (mg g^{-1} min^{-1}) β - Constant related to the surface coverage and activation energy for chemisorption (g mg^{-1})
Intraparticle diffusion[4]	$q_t = k_t.t^{\frac{1}{2}} + C$	K_i - Intraparticle diffusion rate constant (mg g^{-1} $min^{-1/2}$) C - Constant associated with the thickness of the boundary layer (mg g^{-1})
Adsorption Isotherms		
Langmuir[5]	$\frac{c_e}{q_e} = \frac{1}{K_L X_m} + \frac{c_e}{X_m}$	K_L - Langmuir constant (L mol^{-1}) X_m - Maximum adsorption capacity (mg g^{-1})
Freundlich[6]	$\log q_e = \log k_f + \frac{1}{n}\log c_e$	K_f - Constant related with the adsorption capacity of the sorbent n - Intensity of sorption
Temkin[7]	$q_e = \frac{RT}{B}\ln K_T + \frac{RT}{B}\ln c_e$	B - Temkin constant (J mol^{-1}) K_T - Temkin isotherm energy constant (L g^{-1})
	q_e - Adsorption capacity adsorbed at equilibrium (mg g^{-1}) q_t - Adsorption capacity adsorbed at time t (mg g^{-1}) c_e - Equilibrium concentration of the adsorbate (mg L^{-1})	

Supplementary Table 3. Derived equations for kinetics and isotherms studies

Adsorption Kinetics				
	Models	**pH 3**	**pH 5**	**pH 8**
HC	Pseudo-first order	y = -0.0002x + 0.48	y = -0.0002x + 0.52	y = -0.0002x + 0.45
	Pseudo-second order	y = 0.261x + 240.2	y = 0.2486x + 225.7	y = 0.2808x + 263.9
	Elovich	y = 0.8253x - 3.475	y = 0.8786x - 3.703	y = 0.7603x - 3.207
	Intraparticle diffusion	y = 0.0738x - 0.28	y = 0.0785x - 0.31	y = 0.0681x - 0.27
PRHC	Pseudo-first order	y = -0.0002x + 0.56	y = -0.0002x + 0.59	y = -0.0002x + 0.52

	Pseudo-second order	y = 0.2139x + 218.7	y = 0.2098x + 199.7	y = 0.2355x + 236.5
	Elovich	y = 0.9838x - 4.18	y = 1.0363x - 4.38	y = 0.8958x - 3.79
	Intraparticle diffusion	y = 0.0882x - 0.38	y = 0.0926x - 0.38	y = 0.08x - 0.337
POHC	Pseudo-first order	y = -0.0002x + 0.59	y = -0.0003x + 0.63	y = -0.0002x + 0.57
	Pseudo-second order	y = 0.2284x + 185.8	y = 0.1817x + 173	y = 0.2143x + 224.3
	Elovich	y = 1.0303x - 4.329	y = 1.1841x - 4.999	y = 0.9867x - 4.205
	Intraparticle diffusion	y = 0.091x - 0.322	y = 0.1054x - 0.41	y = 0.0883x - 0.39
Adsorption Isotherms				
HC	Langmuir	y = 0.1461x + 0.960	y = 0.1215x + 1.092	y = 0.1525x + 1.319
	Freundlich	y = 0.2844x + 0.301	y = 0.314x + 0.311	y = 0.307x + 0.224
	Temkin	y = 1.3782x + 0.719	y = 1.7006x + 0.345	y = 1.3756x + 0.226
PRHC	Langmuir	y = 0.0857x + 1.230	y = 0.0746x + 1.087	y = 0.0897x + 1.672
	Freundlich	y = 0.3909x + 0.294	y = 0.4007x + 0.339	y = 0.4206x + 0.191
	Temkin	y = 2.5516x - 0.962	y = 2.8823x - 0.979	y = 2.5003x - 1.738
POHC	Langmuir	y = 0.0683x + 1.030	y = 0.0662x + 0.735	y = 0.0725x + 1.281
	Freundlich	y = 0.4174x + 0.34	y = 0.3695x + 0.474	y = 0.443x + 0.260
	Temkin	y = 3.1553x - 1.192	y = 3.0347x + 0.395	y = 3.0938x - 1.975

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