

Supplementary Information

Modeling and Optimization of Biochar Based Adsorbent Derived from Kenaf Using Response Surface Methodology on Adsorption of Cd²⁺

Table S1. ANOVA findings for response surface quadratic model for Kenaf biochar yield

Source	Sum of Squares	Degree of freedom	Mean Square	F Value	P-value Prob > F	Comments
Model	400.15	9	44.46	23.83	< 0.0001	SD =1.37 Mean =32.83
X ₁	334.83	1	334.83	179.49	< 0.0001	R ² =0.956
X ₂	40.13	1	40.13	21.51	0.0009	R ² (Adj) = 0.9154
X ₃	0.84	1	0.84	0.45	0.5164	C.V.=4.16
X ₁ X ₂	6.66	1	6.66	3.57	0.0881	
X ₁ X ₃	2.53	1	2.53	1.36	0.2711	AP= 17.25
X ₂ X ₃	1.53	1	1.53	0.82	0.3862	
X ₁ ²	13.42	1	13.42	7.19	0.023	
X ₂ ²	0.6	1	0.6	0.32	0.5818	
X ₃ ²	0.33	1	0.33	0.18	0.6822	
Residual	18.65	10	1.87			
Lack of Fit	14.87	5	2.97	3.92	0.0799	not significant
Pure Error	3.79	5	0.76			
Cor Total	418.8	19				

SS is standard deviation, R²: coefficient of determination, R² (Adj): adjusted coefficient of determination, C.V.: Coefficient of variation, and AP: adequate precision

Table S2. ANOVA findings for response surface quadratic model for cadmium removal rate

Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F		Comments
Model	1980.64	9	220.07	45.3	< 0.0001	significant	SD=2.20
X ₁	1920.36	1	1920.36	395.29	< 0.0001		Mean=61.48
X ₂	9.99	1	9.99	2.06	0.182		R ² =0.976 R ² _(Adj) =0.9545
X ₃	3.26	1	3.26	0.67	0.4315		
X ₁ X ₂	7.61	1	7.61	1.57	0.2394		C.V.=3.58
X ₁ X ₃	1.81	1	1.81	0.37	0.5558		
X ₂ X ₃	1.45	1	1.45	0.3	0.5974		AP=25.60
X ₁ ²	28.35	1	28.35	5.84	0.0363		
X ₂ ²	10.96	1	10.96	2.26	0.1639		
X ₃ ²	0.48	1	0.48	0.099	0.7594		
Residual	48.58	10	4.86				
Lack of Fit	43.88	5	8.78	9.34	0.0142	significant	
Pure Error	4.7	5	0.94				
Cor Total	2029.23	19					

SS is standard deviation, R²: coefficient of determination, R²_(Adj): adjusted coefficient of determination, C.V.: Coefficient of variation, and AP: adequate precision

Table S3. ANOVA findings for response surface quadratic model for adsorption capacity

Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F	Comments
Model	225.23	9	25.03	30.08	< 0.0001	significant
X ₁	218.68	1	218.68	262.89	< 0.0001	SD=0.91
X ₂	1.28	1	1.28	1.54	0.2432	Mean=21
X ₃	0.18	1	0.18	0.21	0.6536	R ² =0.964
X ₁ X ₂	0.47	1	0.47	0.56	0.4708	R ² _(Adj) =0.93
X ₁ X ₃	0.045	1	0.045	0.054	0.8208	C.V.=4.45
X ₂ X ₃	0.41	1	0.41	0.49	0.5012	AP=20.87
X ₁ ²	3.69	1	3.69	4.44	0.0613	
X ₂ ²	0.76	1	0.76	0.91	0.3624	
X ₃ ²	0.14	1	0.14	0.17	0.6871	
Residual	8.32	10	0.83			
Lack of Fit	7.8	5	1.56	14.93	0.005	significant
Pure Error	0.52	5	0.1			
Cor Total	233.55	19				

SS is standard deviation, R²: coefficient of determination, R²_(Adj): adjusted coefficient of determination, C.V.: Coefficient of variation, and AP: adequate precision

Table S4. ANOVA findings for response surface quadratic model for the specific surface area of biochar

Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F	Comments
Model	17069.73	9	1896.64	34.78	< 0.0001	significant
X ₁	16063.62	1	16063.62	294.54	< 0.0001	SD=7.38
X ₂	692.63	1	692.63	12.7	0.0051	Mean =126
X ₃	13.95	1	13.95	13.15	0.071	R ² = 0.969
X ₁ X ₂	4.35	1	4.35	0.08	0.7833	R ² (Adj)= 0.94
X ₁ X ₃	4.35	1	4.35	0.08	0.7833	C.V.=5.87
X ₂ X ₃	32.4	1	32.4	0.59	0.4587	AP=22
X ₁ ²	0.11	1	0.11	1.98E-03	0.9654	
X ₂ ²	43.16	1	43.16	0.79	0.3946	
X ₃ ²	229.81	1	229.81	4.21	0.0672	
Residual	545.37	10	54.54			
Lack of Fit	544.56	5	108.91	669.54	< 0.0001	significant
Pure Error	0.81	5	0.16			
Cor Total	17615.11	19				

SS is standard deviation, R²: coefficient of determination, R² (Adj): adjusted coefficient of determination, C.V.: Coefficient of aariation, and AP: adequate precision

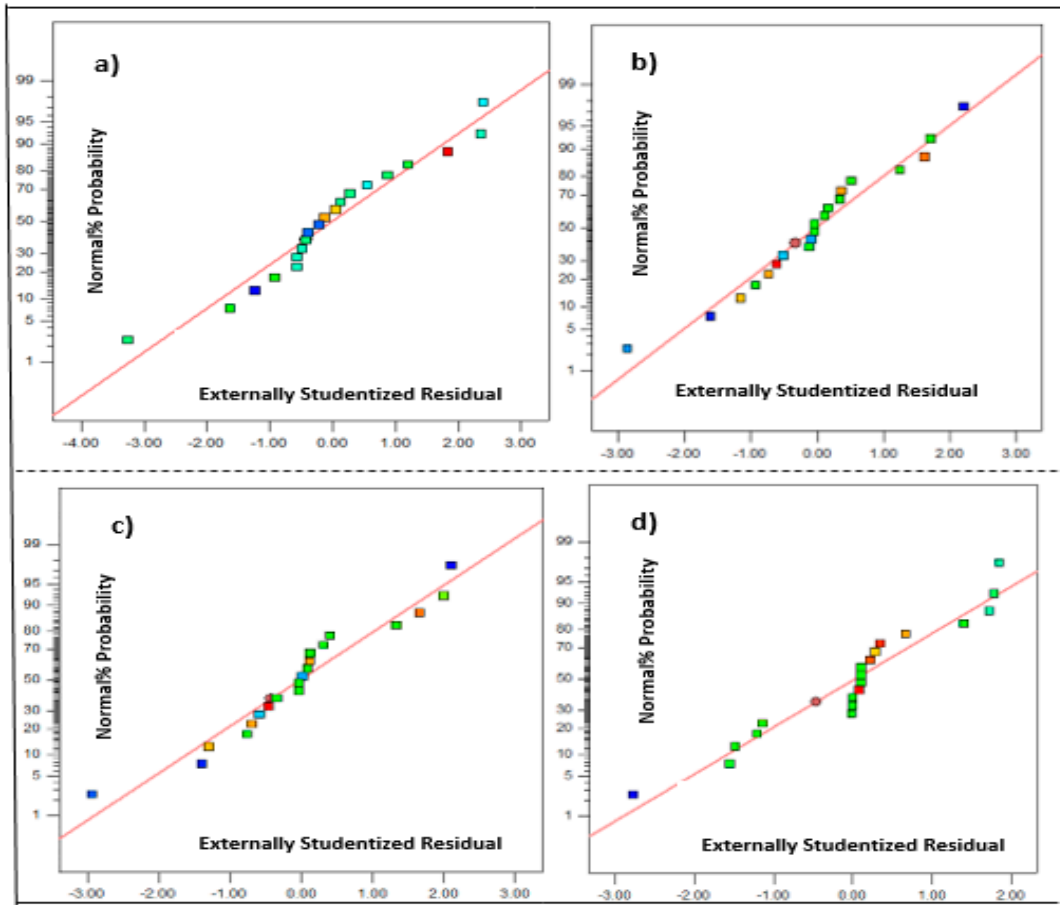


Figure S1 Externally studentized residual vs normal probability plot a) Kenaf biochar yield, b) Cadmium removal rate, c) Adsorption capacity and d) Specific surface areas of biochar.

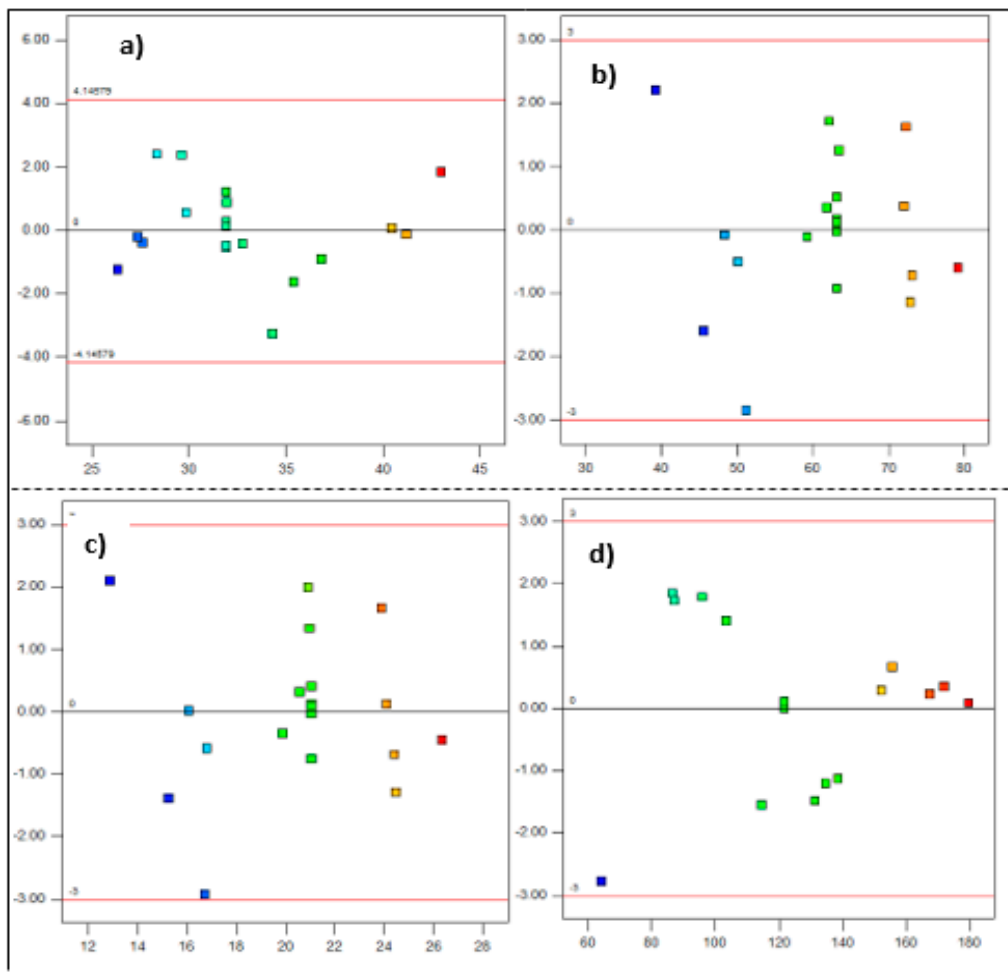


Figure S2. Predicted versus Internally studentized residual of a) Kenaf biochar yield, b) Cadmium removal rate, c) Adsorption capacity and d) Specific surface areas of biochar.