

**A Sustainable Layered Double Hydroxide-Pine Cone Biochar (LDH/PCBC) composite for
Enhanced Removal of Ciprofloxacin from Water**

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SUPPLEMENTARY INFORMATION

Table S1: The distribution and amount of the encrypted units from the RSM experiments

Independent variables	Ranges and levels				
	$-\alpha$	-1	0	+1	$+\alpha$
pH(A)	2	3	7	11	12
LDH/PCBC dose (B)(g/L)	0.05	0.1	0.3	0.5	0.55
Concentration of CPF(C)(mg/L)	31.25	50	125	200	218.75
Temperature (D)(K)	279.25	283	298	313	316.75

Table S2: Adsorption capacity values for the adsorption of CPF on LDH/PCBC obtained using CCD and RSM

Run No.	pH	LDH/PCBC dose (g/L)	Initial CPF concentration (mg/L)	Temperature (K)	Experimental	Predicted	Residual
1	3	0.1	50	283	54.28	53.09	1.20
2	11	0.1	50	283	52.83	50.98	1.85
3	3	0.5	50	283	87.17	86.19	0.98
4	11	0.5	50	283	85.50	84.82	0.68

5	3	0.1	200	283	45.13	43.33	1.80
6	11	0.1	200	283	42.73	41.25	1.48
7	3	0.5	200	283	75.57	75.25	0.32
8	11	0.5	200	283	74.58	73.92	0.66
9	3	0.1	50	313	79.26	79.00	0.26
10	11	0.1	50	313	77.18	77.16	0.02
11	3	0.5	50	313	95.29	96.43	-1.15
12	11	0.5	50	313	94.45	95.34	-0.88
13	3	0.1	200	313	69.06	69.41	-0.35
14	11	0.1	200	313	67.53	67.60	-0.07
15	3	0.5	200	313	84.72	85.66	-0.93
16	11	0.5	200	313	83.74	84.60	-0.86
17	2	0.3	125	298	78.51	79.81	-1.30
18	12	0.3	125	298	75.93	77.83	-1.90
19	7	0.05	125	298	51.29	55.84	-4.55
20	7	0.55	125	298	88.50	87.15	1.35
21	7	0.3	31	298	91.37	93.33	-1.96
22	7	0.3	218	298	79.28	80.52	-1.24
23	7	0.3	125	279	64.03	70.80	-6.77
24	7	0.3	125	316	97.24	93.67	3.57
25	7	0.3	125	298	87.00	84.43	2.57
26	7	0.3	125	298	86.92	84.43	2.49
27	7	0.3	125	298	87.17	84.43	2.74

Table S3: ANOVA results for adsorption capacity of CPF by using LDH/PCBC

Source	Sum of square	DDL	Mean square	F-value	p-value
Model	6117.23	14	436.95	40.86	< 0.0001
A-pH	12.02	1	12.02	1.12	0.3099
B-LDH/PCBC dose	3000	1	3000	280.56	< 0.0001
C-Initial CPF concentration	502.43	1	502.43	46.99	< 0.0001
D-Temperature	1600.72	1	1600.72	149.7	< 0.0001
AB	0.5576	1	0.5576	0.0521	0.8232
AC	0.0011	1	0.0011	0.0001	0.9919
AD	0.0718	1	0.0718	0.0067	0.936
BC	1.39	1	1.39	0.1299	0.7248
BD	245.54	1	245.54	22.96	0.0004
CD	0.0269	1	0.0269	0.0025	0.9609
A ²	75.58	1	75.58	7.07	0.0208
B ²	401.82	1	401.82	37.58	< 0.0001
C ²	14.96	1	14.96	1.4	0.2599
D ²	11.59	1	11.59	1.08	0.3183
Total Error	128.32	12			
Total (corr.)	6245.55	26			

Table S4: Cost analysis of LDH/PCBC biochar development for real scale applications

Expense head	Details	Estimate (\$)
Raw materials	10 tons of biochar waste	300
	Solvents/chemicals	200
Utilities	Electricity-500kWh/month	50
	Water-10 cubic meters/month	20
Production cost	Modification of PCBC	1,300
	Application cost \$80/ton	640
Testing & quality control		1,000
Overhead	R & D	1,400
	Administrative	800
Labour	150 hours/month (1 technician)	1,000
Waste management		700
Contingency		500
	TOTAL	7,910

The yield of LDH/PCBC is around 80%, *i.e.* 8 tons/10 tons

Hence, the cost per unit (per ton of LDH/PCBC) is $\$7,910/8 = \988.75 per ton.

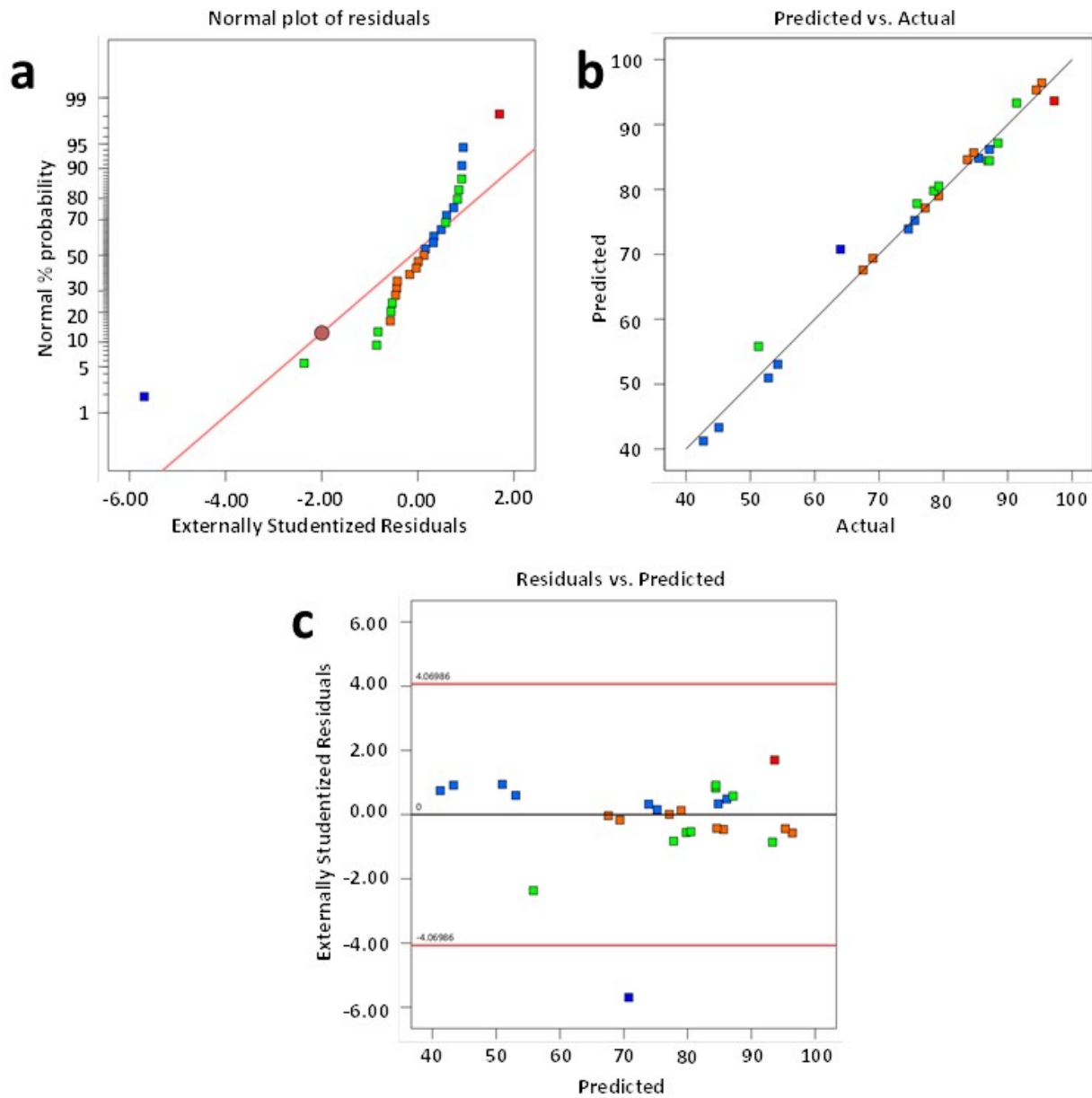


Figure S1. Diagnostic plots of the quadratic model: a) Normal probability versus externally studentized residuals; (b) externally studentized residuals against predicted (c) predicted against actual