

Study on the Decontamination Effect of Biochar-Constructed Wetland under Different Hydraulic Conditions

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Table S1. Concentration of influent pollutants of first hydraulic retention time test (mg/L). NH₃-H: Ammonia nitrogen. TN: Total nitrogen. TP: Total phosphorus. COD: Chemical oxygen demand.

	Concentration of Influent Pollutants (mg/L)			
	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	8.97	12.81	2.22	46.00
Shell Ceramsite	8.99	12.83	2.22	46.00
Shell Zeolite	9.00	12.84	2.23	46.00
Coconut Shell Zeolite	8.36	12.20	2.07	46.00
Coconut Shell	7.19	11.03	1.78	46.00
Shell	8.63	12.47	2.14	46.00

Table S2. Concentration of influent pollutants of second hydraulic retention time test (mg/L).

	Concentration of Influent Pollutants (mg/L)			
	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	31.37	36.79	6.08	197,44
Shell Ceramsite	28.88	34.30	5.60	183,34
Shell Zeolite	31.74	37.16	6.15	201,00
Coconut Shell Zeolite	32.00	37.42	6.20	199,54
Coconut Shell	30.26	35.68	5.86	191,15
Shell	31.79	37.21	6.16	199,82

Table S3. Concentration of influent pollutants of the first hydraulic load test (mg/L). Hydraulic load: 5 (cm/d), 10 (cm/d), 20 (cm/d), 30 (cm/d).

Concentration of Influent Pollutants (mg/L)									
5 (cm/d)	NH ₃ -H	TN	TP	COD	10 (cm/d)	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	8.06	16.32	1.40	27.00	Coconut Shell Ceramsite	8.70	14.88	1.48	36.00
Shell Ceramsite	8.04	16.30	1.40	27.00	Shell Ceramsite	8.53	14.70	1.45	36.00
Coconut Shell Zeolite	7.54	15.80	1.31	27.00	Coconut Shell Zeolite	8.66	14.84	1.47	36.00
Shell Zeolite	7.78	16.04	1.35	27.00	Shell Zeolite	8.62	14.79	1.46	36.00
Coconut Shell	8.01	16.27	1.39	27.00	Coconut Shell	8.64	14.82	1.47	36.00
Shell	7.17	15.43	1.25	27.00	Shell	8.68	14.86	1.47	36.00
Concentration of Influent Pollutants (mg/L)									
20 (cm/d)	NH ₃ -H	TN	TP	COD	30 (cm/d)	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	8.45	13.49	1.46	31.00	Coconut Shell Ceramsite	8.58	13.02	1.49	30.00
Shell Ceramsite	8.42	13.46	1.45	31.00	Shell Ceramsite	8.45	12.89	1.46	30.00
Coconut Shell Zeolite	8.41	13.45	1.45	31.00	Coconut Shell Zeolite	8.52	12.96	1.48	30.00
Shell Zeolite	8.48	13.51	1.46	31.00	Shell Zeolite	8.45	12.89	1.46	30.00
Coconut Shell	8.39	13.42	1.45	31.00	Coconut Shell	8.52	12.96	1.48	30.00
Shell	8.43	13.47	1.45	31.00	Shell	8.56	13.00	1.48	30.00

Table S4. Concentration of influent pollutants of the second hydraulic load test (mg/L).

Concentration of Influent Pollutants (mg/L)									
5 (cm/d)	NH ₃ -H	TN	TP	COD	10 (cm/d)	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	28.49	30.62	5.39	153,27	Coconut Shell Ceramsite	31.88	33.47	6.06	153,99
Shell Ceramsite	31.50	33.63	5.95	165,53	Shell Ceramsite	31.32	32.90	5.96	151,70
Coconut Shell Zeolite	30.69	32.81	5.80	162,21	Coconut Shell Zeolite	31.36	32.94	5.96	151,86
Shell Zeolite	31.23	33.36	5.90	164,42	Shell Zeolite	31.56	33.15	6.00	152,68
Coconut Shell	31.54	33.67	5.96	165,68	Coconut Shell	31.54	33.12	6.00	152,59
Shell	31.46	33.58	5.95	165,35	Shell	31.29	32.87	5.95	151,56
20 (cm/d)	NH ₃ -H	TN	TP	COD	30 (cm/d)	NH ₃ -H	TN	TP	COD
Coconut Shell Ceramsite	31.09	33.45	5.91	143,78	Coconut Shell Ceramsite	31.74	40.80	6.00	166,31
Shell Ceramsite	31.64	33.99	6.02	146,00	Shell Ceramsite	31.67	40.73	5.99	166,04
Coconut Shell Zeolite	31.39	33.75	5.97	144,99	Coconut Shell Zeolite	31.63	40.68	5.98	165,84
Shell Zeolite	31.59	33.95	6.01	145,82	Shell Zeolite	30.89	39.95	5.84	162,84
Coconut Shell	31.45	33.81	5.98	145,23	Coconut Shell	31.67	40.73	5.99	166,04
Shell	31.62	33.98	6.01	145,93	Shell	31.67	40.73	5.99	166,04

Table S5. Concentration of pollutants of outflow of first hydraulic retention time test (mg/L). The time is 0–84 hours.

Concentration of Pollutants of Outflow (mg/L)									
COD	0	12	24	36	48	60	72	84	
Coconut Shell Ceramsite	46.00	14.81	8.22	4.48	4.46	5.3	5.34	6.39	
Shell Ceramsite	46.00	17.04	6.23	5.94	7.23	6.33	6.34	6.83	
Shell Zeolite	46.00	22.76	21.18	9.43	13.15	11.1	13.92	13.95	
Coconut Shell Zeolite	46.00	19.01	11.94	7.8	7.11	8.3	5.74	6.28	
Coconut Shell	46.00	9.43	3.48	0.84	0.91	0.72	0.85	1.34	
Shell	46.00	16.47	6.83	4.25	5.84	4.16	5.18	7.99	
NH ₃ -H	0	12	24	36	48	60	72	84	
Coconut Shell Ceramsite	8.97	3.71	2.09	1.37	1.07	0.65	1.01	1.00	
Shell Ceramsite	8.99	2.47	1.85	1.88	0.59	1.07	0.72	0.79	
Shell Zeolite	9.00	4.76	2.95	3.36	1.44	1.78	1.61	1.25	
Coconut Shell Zeolite	8.36	4.51	4.2	2.79	2.59	2.26	2.53	2.53	
Coconut Shell	7.19	2.64	0.46	0.27	0.23	0.22	0.38	0.37	
Shell	8.63	2.4	1.26	0.42	0.36	0.42	0.33	0.37	
TP	0	12	24	36	48	60	72	84	
Coconut Shell Ceramsite	2.22	0.95	0.47	0.36	0.42	0.46	0.34	0.30	
Shell Ceramsite	2.22	1.05	0.55	0.58	0.39	0.4	0.32	0.3	
Shell Zeolite	2.23	0.67	0.47	0.41	0.11	0.18	0.11	0.11	
Coconut Shell Zeolite	2.07	0.98	0.86	0.9	0.74	0.58	0.49	0.52	
Coconut Shell	1.78	0.32	0.15	0.06	0.12	0.07	0.05	0.04	
Shell	2.14	0.45	0.25	0.03	0.05	0.14	0.13	0.11	
TN	0	12	24	36	48	60	72	84	
Coconut Shell Ceramsite	12.81	5.02	2.57	1.50	1.47	1.54	1.98	2.07	
Shell Ceramsite	12.83	3.8	2.04	1.23	1.1	0.62	1.61	1.78	
Shell Zeolite	12.84	5.68	5.31	3.89	3.33	3.08	3.83	3.84	
Coconut Shell Zeolite	12.20	5.43	4.26	3.23	3.28	3.86	3.09	3.46	
Coconut Shell	11.03	3.42	1.96	0.17	0.67	0.44	0.39	1.15	
Shell	12.47	1.9	1.37	0.53	0.29	0.4	0.48	0.5	

Table S6. Concentration of pollutants of outflow of second hydraulic retention time test (mg/L).

Concentration of Pollutants of Outflow (mg/L)								
COD	0	12	24	36	48	60	72	84
Coconut Shell Ceramsite	197,44	76.44	60.47	37.27	31.74	36.03	45.86	46.59
Shell Ceramsite	183,34	90.71	36.83	50.31	36.83	37.11	40.39	35.06
Shell Zeolite	201,00	82.75	75.41	26.26	27.06	25.84	31.84	30.10
Coconut Shell Zeolite	199,54	96.22	82.49	46.51	47.58	50.28	41.36	43.76
Coconut Shell	191,15	53.27	30.48	6.69	8.20	6.99	10.48	12.69
Shell	199,82	47.01	17.01	5.94	8.93	10.25	9.90	19.19
NH ₃ -H	0	12	24	36	48	60	72	84
Coconut Shell Ceramsite	31.37	15.64	9.98	6.84	5.12	5.44	6.40	7.02
Shell Ceramsite	28.88	10.06	8.38	7.40	4.91	4.79	4.61	4.97
Shell Zeolite	31.74	18.30	12.29	16.53	7.96	8.62	8.58	8.41
Coconut Shell zeolite	32.00	14.94	13.53	7.90	5.66	6.57	5.50	5.88
Coconut Shell	30.26	13.27	4.77	2.77	1.77	2.89	3.51	3.13
Shell	31.79	11.50	7.76	3.67	3.31	3.86	2.81	3.38
TP	0	12	24	36	48	60	72	84
Coconut Shell Ceramsite	6.08	2.17	1.66	1.51	1.78	1.69	1.46	1.47
Shell Ceramsite	5.60	3.47	2.12	2.05	1.22	1.37	1.28	1.23
Shell Zeolite	6.15	2.24	0.60	0.60	0.77	0.82	0.68	0.80
Coconut Shell Zeolite	6.20	2.54	2.14	2.39	1.46	1.15	1.08	1.01
Coconut Shell	5.86	1.43	0.87	0.08	0.08	0.09	0.06	0.04
Shell	6.16	1.75	1.26	0.37	0.24	0.11	0.15	0.10
TN	0	12	24	36	48	60	72	84
Coconut Shell Ceramsite	36.79	16.70	11.38	6.60	8.07	7.13	8.02	9.90
Shell Ceramsite	34.30	13.19	8.27	5.44	4.57	6.44	6.70	7.68
Shell Zeolite	37.16	13.20	11.54	5.36	6.99	6.91	7.26	7.99
Coconut Shell Zeolite	37.42	19.12	16.97	12.33	15.20	14.49	15.33	16.43
Coconut Shell	35.68	7.05	3.07	0.19	0.84	0.77	0.33	0.68
Shell	37.21	9.83	7.25	3.35	2.37	2.92	2.97	3.67

Table S7. Concentration of pollutants of outflow of the first hydraulic load test (mg/L).

Concentration of Pollutants of Outflow (mg/L)									
NH ₃ -H	5	10	20	30	TN	5	10	20	30
	(cm/d)	(cm/d)	(cm/d)	(cm/d)		(cm/d)	(cm/d)	(cm/d)	(cm/d)
Coconut Shell Ceramsite	0.39	0.33	0.37	0.85	Coconut Shell Ceramsite	1.63	2.35	2.37	2.99
Shell Ceramsite	0.13	0.42	0.3	1.73	Shell Ceramsite	0.93	2.92	2.76	4.43
Coconut Shell Zeolite	0.54	0.79	1.58	3.16	Coconut Shell Zeolite	1.92	3.44	3.45	4.61
Shell Zeolite	0.79	1.17	1.4	4.38	Shell Zeolite	1.42	1.74	2.77	4.93
Coconut Shell	0.2	0.28	0.46	1.16	Coconut Shell	0.74	1.84	2.65	3.3
Shell	0.09	0.09	0.16	0.93	Shell	0.27	1.64	1.7	2.1
TP	5	10	20	30	COD	5	10	20	30
	(cm/d)	(cm/d)	(cm/d)	(cm/d)		(cm/d)	(cm/d)	(cm/d)	(cm/d)
Coconut Shell Ceramsite	0.18	0.24	0.29	0.72	Coconut Shell Ceramsite	4.44	3.7	3.44	6.83
Shell Ceramsite	0.12	0.13	0.22	0.44	Shell Ceramsite	5.41	4.95	3.41	7.86
Coconut Shell Zeolite	0.12	0.16	0.15	0.25	Coconut Shell Zeolite	2.36	2.29	3.81	5.11
Shell Zeolite	0.23	0.22	0.28	0.45	Shell Zeolite	3.37	3.69	3.86	8.93
Coconut Shell	0.15	0.15	0.1	0.32	Coconut Shell	3.31	4.5	3.29	4.44
Shell	0.15	0.15	0.16	0.3	Shell	2.61	1.68	3.16	3.73

Table S8. Concentration of pollutants of outflow of the second hydraulic load test (mg/L).

Concentration of Pollutants of Outflow (mg/L)									
NH ₃ -H	5	10	20	30	TN	5	10	20	30
	(cm/d)	(cm/d)	(cm/d)	(cm/d)		(cm/d)	(cm/d)	(cm/d)	(cm/d)
Coconut Shell Ceramsite	2.16	3.03	2.67	5.27	Coconut Shell Ceramsite	0.85	3.7	3.76	5.82
Shell Ceramsite	2.78	2.79	3.18	11.64	Shell Ceramsite	3.42	10.25	9.95	17.38
Coconut Shell Zeolite	4.18	4.65	8.54	15.3	Coconut Shell Zeolite	2.05	4.55	6.25	11.03
Shell Zeolite	1.69	2.42	3.27	11.46	Shell Zeolite	4.5	6.67	9.42	18.35
Coconut Shell	0.28	0.23	0.67	2.44	Coconut Shell	0.69	2.72	4.48	7.36
Shell	0.84	0.69	1.61	5.53	Shell	1.84	5.07	6.97	10.06
TP	5	10	20	30	COD	5	10	20	30
	(cm/d)	(cm/d)	(cm/d)	(cm/d)		(cm/d)	(cm/d)	(cm/d)	(cm/d)
Coconut Shell Ceramsite	1.05	1.48	1.56	3.65	Coconut Shell Ceramsite	33.22	25.85	25.49	53.89
Shell Ceramsite	0.79	0.93	1.35	2.74	Shell Ceramsite	27.83	13.84	28.48	57.31
Coconut Shell Zeolite	0.77	0.96	1.09	1.36	Coconut Shell Zeolite	21.85	16.22	29.26	39.44
Shell Zeolite	0.56	0.47	0.77	1.3	Shell Zeolite	11.82	8.33	13.35	36.64
Coconut Shell	0.27	0.27	0.7	2.17	Coconut Shell	13.23	7.88	22.37	39.71
Shell	0.33	0.34	1.07	1.76	Shell	24.75	19.98	17.67	30.98

Table S9. The mean and the standard deviation of removal rate of COD of hydraulic retention time test (%).

T (h)	COD											
	Shell	yEr ±	Coconut Shell	yEr ±	Shell Zeolite	yEr ±	Coconut Shell Zeolite	yEr ±	Shell Ceramsite	yEr ±	Coconut Shell Ceramsite	yEr ±
0	0	0	0	0	0	0	0	0	0	0	0	0
12	70.34	6.13	75.82	3.68	54.68	4.15	55.23	3.45	56.73	6.21	64.55	3.26
24	88.33	3.16	88.25	4.19	58.22	4.26	66.36	7.69	83.18	3.27	75.75	6.38
36	93.90	3.13	97.34	0.84	83.21	3.72	79.86	3.17	79.82	7.26	85.69	4.56
48	91.42	4.11	96.86	1.15	78.97	7.56	80.35	4.19	82.09	2.18	87.12	3.19
60	92.91	1.96	97.38	1.04	81.51	5.64	78.38	3.58	83.00	3.24	85.11	3.36
72	91.90	3.15	96.34	1.82	76.95	7.21	83.39	4.12	82.09	4.12	82.59	5.81
84	86.51	3.88	95.22	1.86	77.35	7.67	82.21	4.14	83.01	2.13	81.25	4.85

Table S10. The mean and the standard deviation of removal rate of NH₃-H of hydraulic retention time test (%).

T (h)	NH ₃ -H											
	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
0	0	0	0	0	0	0	0	0	0	0	0	0
12	54.41	4.26	68.88	3.69	44.71	2.36	49.70	3.62	59.74	3.59	68.00	4.18
24	72.44	4.23	75.21	4.21	64.26	2.98	53.76	3.96	88.89	4.65	80.47	4.89
36	81.48	3.28	76.73	2.36	55.31	7.39	70.95	4.36	93.51	2.67	91.81	3.34
48	85.87	2.19	88.23	5.23	79.43	4.52	75.70	6.62	95.44	1.29	92.73	3.12
60	87.73	5.06	85.74	2.31	76.53	3.69	76.19	3.26	93.71	3.26	91.51	3.65
72	84.18	4.56	88.03	3.98	77.53	4.56	76.26	6.56	91.56	3.15	93.65	2.49
84	83.25	5.62	87.03	4.23	79.79	6.29	75.67	5.94	92.26	2.58	92.53	3.16

Table S11. The mean and the standard deviation of removal rate of TN of hydraulic retention time test (%).

TN												
T (h)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
0	0	0	0	0	0	0	0	0	0	0	0	0
12	57.72	3.12	65.97	4.41	60.11	4.36	52.19	3.29	74.59	5.64	79.18	5.59
24	74.53	5.45	80.01	4.12	63.79	5.15	59.88	5.22	86.81	4.59	84.75	4.23
36	85.18	3.12	87.27	3.14	77.64	7.95	70.30	3.26	98.95	0.52	93.37	2.36
48	83.30	5.24	89.03	2.36	77.64	3.55	66.23	6.86	95.78	1.87	95.64	2.01
60	84.30	3.69	88.19	6.95	78.71	2.69	64.84	3.56	96.92	0.91	94.48	2.31
72	81.38	3.18	83.97	3.51	75.30	5.16	66.87	7.83	97.75	1.33	94.07	2.06
84	78.48	5.39	81.87	4.26	74.30	4.19	63.87	7.77	93.85	4.25	93.07	2.93

Table S12. The mean and the standard deviation of removal rate of TP of hydraulic retention time test (%).

TP												
T (h)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
0	0	0	0	0	0	0	0	0	0	0	0	0
12	60.65	3.62	45.33	7.36	66.74	3.24	55.80	3.22	78.81	3.23	75.23	3.69
24	75.65	2.99	68.73	6.54	84.55	5.66	61.93	3.62	88.32	3.11	83.86	4.36
36	79.43	4.26	68.73	5.32	86.01	4.26	59.03	2.44	97.78	0.91	96.19	2.25
48	75.98	5.26	80.35	2.12	91.22	3.66	70.32	6.19	95.98	2.58	97.03	0.86
60	75.65	3.46	78.74	3.28	89.27	2.55	76.77	4.65	97.15	1.28	95.85	2.44
72	80.26	4.26	81.42	4.23	92.03	3.16	79.35	3.15	97.98	1.04	95.68	1.88
84	81.08	5.26	82.32	4.24	91.03	3.99	79.35	4.41	98.67	0.73	96.68	1.77

Table S13. The mean and the standard deviation of removal rate of COD of hydraulic load test (%).

COD												
Hydraulic Load (cm/d)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Coconut Shell Zeolite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
5	80.94	2.62	81.58	1.61	88.89	2.36	90.16	2.65	89.88	2.14	87.68	2.65
10	86.47	3.26	88.57	2.31	91.48	2.16	92.15	2.39	91.17	3.67	91.08	4.26
20	85.58	3.31	84.74	4.25	83.76	3.94	89.19	1.65	86.99	2.39	88.85	0.96
30	72.42	4.82	69.64	4.16	79.59	3.37	73.86	3.64	80.64	4.56	84.45	3.11

Table S14. The mean and the standard deviation of removal rate of NH₃-H of hydraulic load test (%).

NH ₃ -H												
Hydraulic Load (cm/d)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Coconut Shell Zeolite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
5	93.79	1.36	94.79	3.62	89.57	3.21	92.22	2.36	98.32	0.78	98.01	0.69
10	93.37	2.88	93.08	1.98	88.04	2.88	89.39	2.95	97.99	1.28	98.40	0.60
20	93.55	2.12	93.18	3.24	77.02	4.23	86.55	3.11	96.20	1.67	96.52	1.62
30	86.74	3.34	71.38	8.13	57.28	5.64	55.56	7.34	89.35	2.96	85.84	3.29

Table S15. The mean and the standard deviation of removal rate of TN of hydraulic load test (%).

TN												
Hydraulic Load (cm/d)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Coconut Shell Zeolite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
5	93.61	3.62	92.07	2.23	90.78	2.96	88.83	2.32	96.69	1.26	96.40	1.88
10	86.58	2.36	74.50	5.65	81.51	4.69	84.05	4.19	89.68	2.12	86.78	2.19
20	85.59	3.16	75.09	4.36	77.91	3.58	75.90	3.64	83.51	3.24	83.43	3.94
30	81.37	4.35	61.50	4.18	68.67	4.21	57.92	3.87	78.25	3.69	79.58	4.28

Table S16. The mean and the standard deviation of removal rate of TP of hydraulic load test (%).

TP												
Hydraulic Load (cm/d)	Coconut Shell Ceramsite	yEr ±	Shell Ceramsite	yEr ±	Coconut Shell Zeolite	yEr ±	Shell Zeolite	yEr ±	Coconut Shell	yEr ±	Shell	yEr ±
5	83.69	3.23	89.08	2.36	88.63	1.89	86.82	3.68	92.41	3.04	91.19	3.21
10	79.66	4.12	87.57	3.26	86.64	2.66	88.45	3.69	92.62	2.92	92.00	2.24
20	76.88	3.29	81.05	3.56	85.74	3.96	84.10	3.01	90.62	2.36	85.68	3.54
30	45.39	6.21	61.93	7.69	80.16	2.97	73.33	4.34	70.90	7.09	75.38	4.71