catalysts

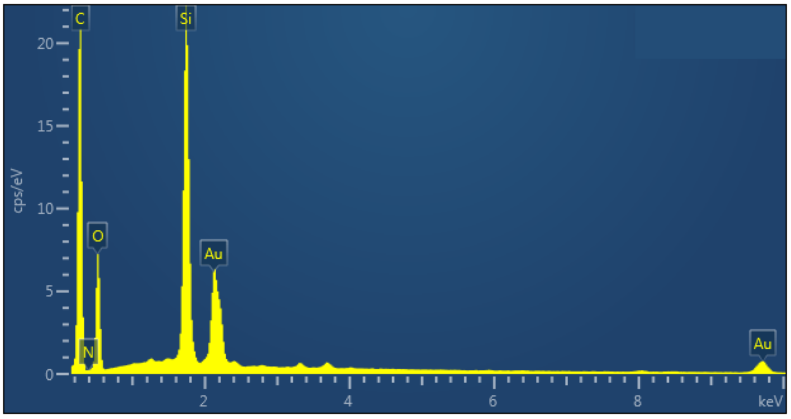
MDPI

Supporting Information

Biochar Derived from Agricultural Wastes as a Means of Facilitating the Degradation of Azo Dyes by Sulfides

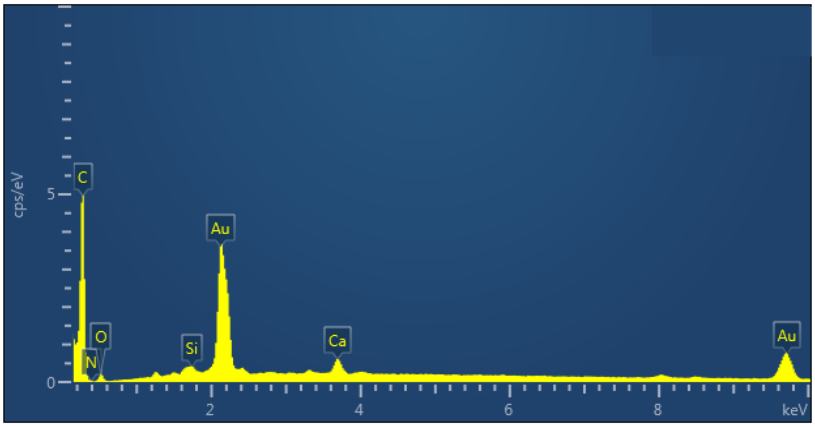
Qilin Han [1], Yadong Yang [1], Ruofan Wang [1], Kai Zhang [1], Na Liu [1,2,*] and Mei Hong [1,*]

[1] Key Laboratory of Groundwater Resources and Environment, Ministry of Education, College of Environment and Resources, Jilin University, Changchun 130021, China; hanql18@mails.jlu.edu.cn (Q.H.); yangyd19@mails.jlu.edu.cn (Y. Y.); wangrf20@mails.jlu.edu.cn (R.W.); zhangkai18@mails.jlu.edu.cn (K.Z.)
[2] Institute of Groundwater and Earth Sciences, Jinan University, Guangzhou; 510632, China
* Correspondence: liuna@jlu.edu.cn (N.L.); hongmei@jlu.edu.cn (M.H.)



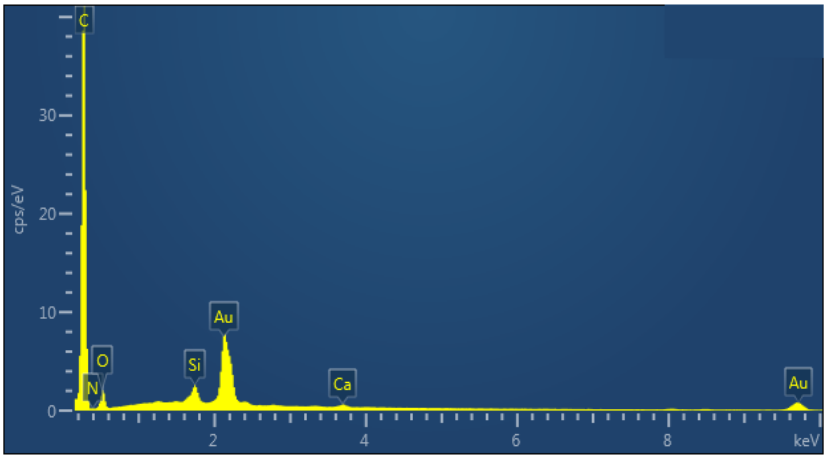
Element	WT%	AT%
C	64.84	73.24
N	0.00	0.00
O	26.78	22.71
Si	8.38	4.05

Fig. S1 EDS spectra of RCB800. The appearance of the gold signal in the spectrum is due to the needs of the test during the SEM-EDS test, the conductivity of the material needs to be enhanced, and a layer of gold is sputtered on the surface of the biochar material. Figure S2, Figure S3, Figure S4, the same.



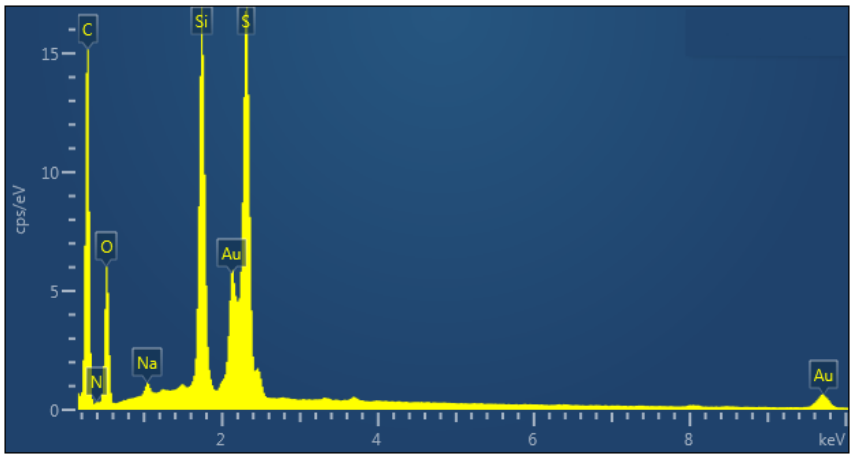
Element	WT%	AT%
C	84.52	89.72
N	0.00	0.00
O	10.92	8.71
Si	0.91	0.41
Ca	3.65	1.16

Fig. S2 EDS spectra of BSB800



Element	WT%	AT%
C	86.25	89.68
N	0.00	0.00
O	12.62	9.85
Si	0.89	0.40
Ca	0.24	0.08

Fig. S3 EDS spectra of CSB800



Element	WT%	AT%
C	65.14	75.21
N	0.00	0.00
O	21.46	18.60
Si	5.54	2.73
Na	0.30	0.18
S	7.56	3.27

Fig. S4 EDS spectra of RCB800-2

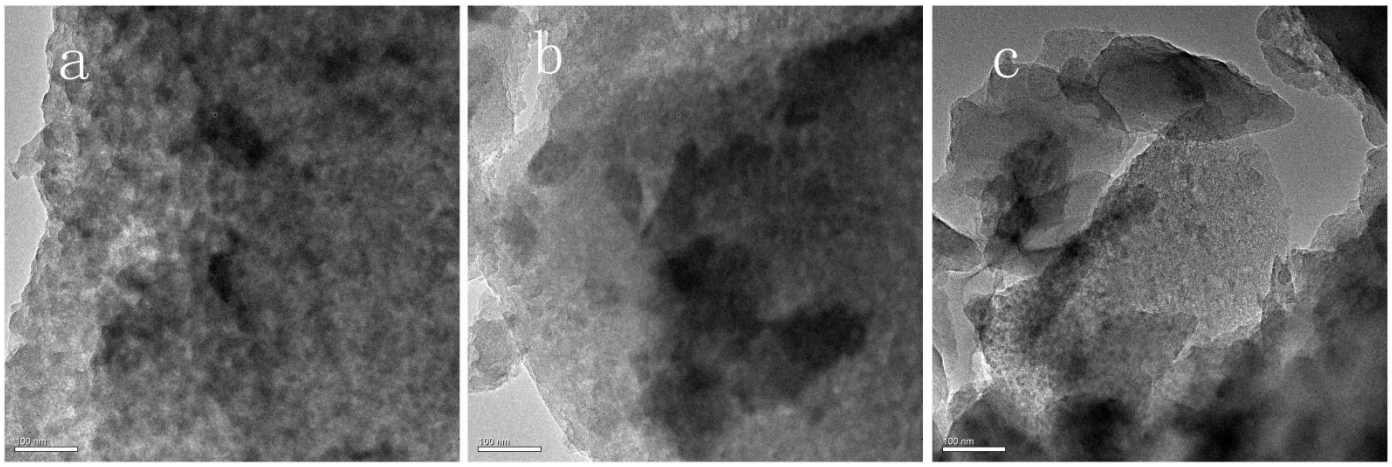


Fig. S5 TEM images of (**a**) RCB800, (**b**) BSB800, and (**c**) CSB800

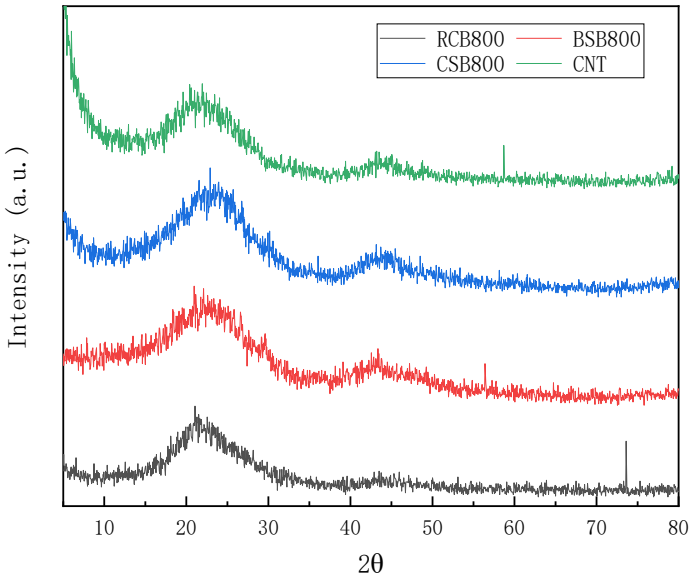


Fig. S6 XRD spectrums of RCB800, BSB800, CSB800, and CNT

Table S1 Fraction of different types of Carbon of material surface from XPS spectra (at. %)

Biochar	C1	C2	C3	C4
RCB800	77.82%	13.99%	2.97%	5.21%
BSB800	75.03%	14.57%	5.33%	5.06%
CSB800	79.69%	12.72%	7.59%	0.00%

Table S2 Fraction of different types of Oxygen of material surface from XPS spectra (at. %)

Biochar	O1	O2	O3
RCB800	15.75%	59.07%	25.18%
BSB800	36.89%	36.86%	26.25%
CSB800	44.95%	46.07%	8.98%

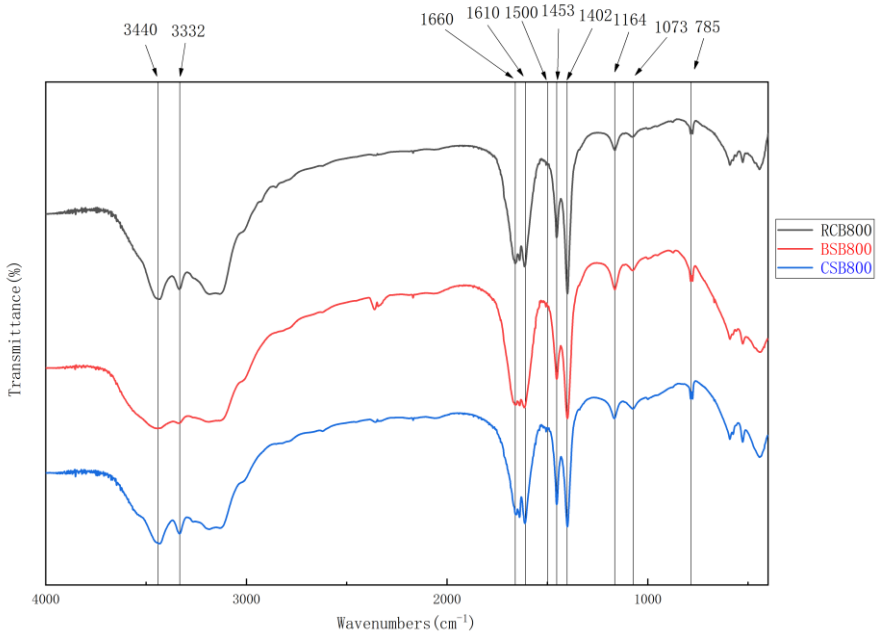


Fig. S7 FTIR spectra of biochar materials

Table S3 Degradation parameters of MO by sulfide with RCB800

Reaction conditions	k (min^{-1})	λ (min)	P	R^2
MO+RCB800	-	-	-	-
MO+S^{2-}	0.156	59.677	1.002	0.99954
MO+S^{2-}+RCB800	0.182	14.488	1.001	0.99680
MO+S^{2-}+BSB800	0.169	30.195	0.998	0.99968
MO+S^{2-}+CSB800	0.164	24.267	1.005	0.99703
MO+S^{2-}+CNT	0.180	14.637	1.001	0.99716
MO+S^{2-}+RCB800WW	0.156	27.833	1.004	0.99970

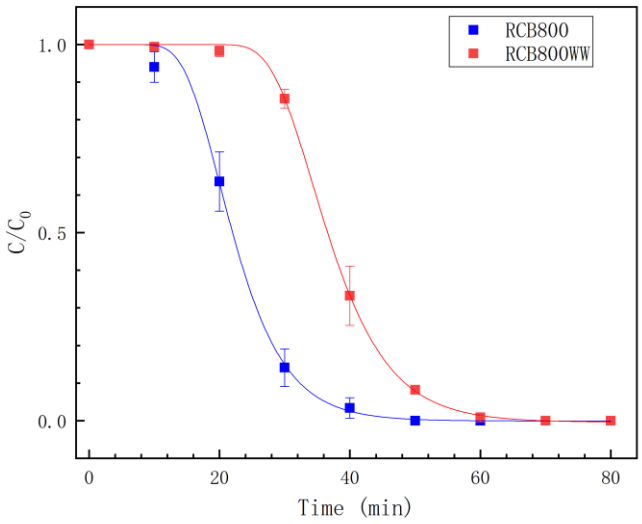


Fig. S8 Degradation of MO (0.5 mM) by sulfide (6 mM) with RCB800 and RCB800 without washing. The dosage of materials was 100 mg/L, pH = 7.4, and the temperature was 30 °C

Table S4 Degradation parameters of MO by sulfide with RCB800 at 20 °C, 30 °C, and 40 °C

Temperature (℃)	k (min^{-1})	λ (min)	P	R^2
20	0.128	16.952	1.015	0.99642
30	0.182	14.488	1.001	0.99680
40	0.226	8.900	1.002	0.99992

Table S5 Degradation parameters of MO by sulfide with RCB800 at pH=6.2, 7.4, 8.1, and 10.2

pH	k (min^{-1})	λ (min)	P	R^2
6.2	0.053	12.064	1.136	0.99284
7.4	0.182	14.488	1.001	0.99680
8.1	0.105	21.719	1.025	0.99636
10.2	—	—	—	—

Table S6 Degradation parameters of MO by sulfide with RCB800 and by polysulfides

Reaction condition	k (min^{-1})	λ (min)	P	R^2
MO+S_n^{2-}	0.332	1.756	0.978	0.99994
MO+RCB800+S^{2-}	0.182	14.488	1.001	0.99680

Table S7 Degradation parameters of MO by sulfide with zeolite and AQDS

Catalyst	k (min^{-1})	λ (min)	P	R^2
Zeolite	0.172	17.039	1.002	0.99994
100mM AQDS	0.152	49.296	1.017	0.99917
500mM AQDS	0.157	6.499	1.003	0.99623

Table S8 Degradation parameters of MO by different concentrations of sulfide

Conditions of concentration	k (min^{-1})	λ (min)	P	R^2
2mmol/L sulfide	0.090	20.560	0.964	0.98928
4mmol/L sulfide	0.143	19.604	0.999	0.99828
6mmol/L sulfide	0.182	14.488	1.001	0.99680
8mmol/L sulfide	0.182	9.229	1.007	0.99789

Table S9 Degradation parameters of different concentrations of MO by sulfide

Conditions	k (min^{-1})	λ (min)	P	R^2
0.1mmol/L MO	0.149	12.880	1.011	0.99395
0.2mmol/L MO	0.150	13.256	1.010	0.99479
0.3mmol/L MO	0.145	12.853	1.011	0.99528
0.4mmol/L MO	0.160	14.814	1.007	0.99689
0.5mmol/L MO	0.182	14.488	1.001	0.99680

Table S10 Degradation parameters of MO by sulfide with RCB800 for different times of use

Conditions	k (min^{-1})	λ (min)	P	R^2
RCB800	0.182	14.488	1.001	0.99680
RCB800-2	0.184	15.560	0.999	0.99989
RCB800-3	0.153	16.629	1.000	0.99962

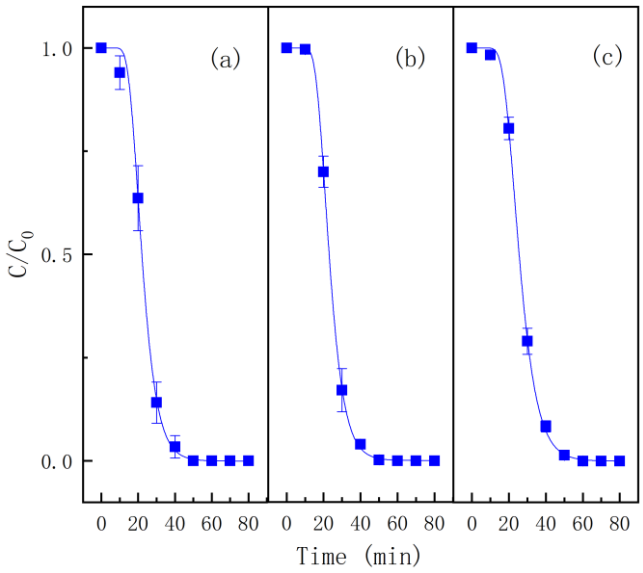


Fig. S9 Degradation of MO (0.5 mM) by sulfide (6 mM) with (**a**) RCB800, (**b**) RCB800-2, used twice, and (**c**) RCB800-3, used three times. The dosage of materials was 100 mg/L, pH = 7.4, and the temperature was 30 °C

Table S11 Degradation parameters of MR by sulfide

Conditions	k (min^{-1})	λ (min)	P	R^2
MR+S^{2-}	0.279	7.461	0.972	0.99795
MR+S^{2-}+RCB800	0.252	47.834	1.002	0.99989

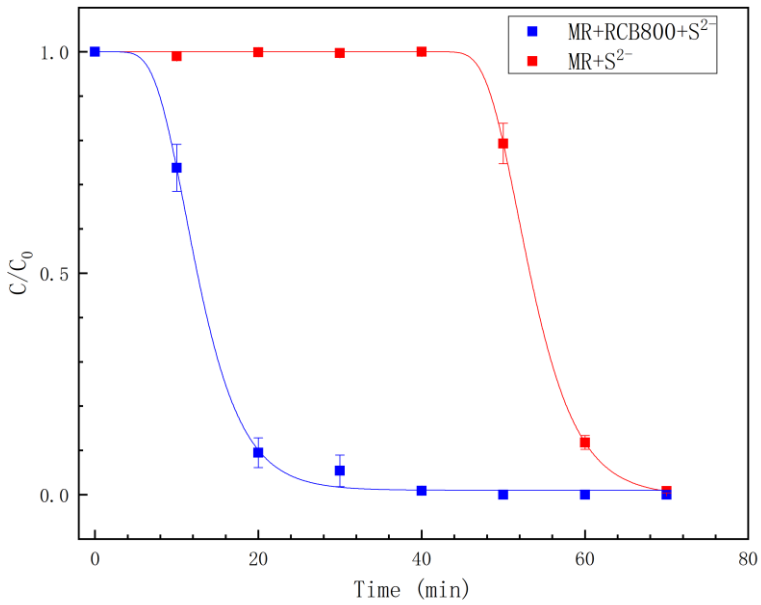


Fig. S10 Degradation of MR (0.5 mM) by sulfide (6 mM) with RCB800 and the control experiment. The dosage of materials was 100 mg/L, pH = 7.4, and the temperature was 30 °C

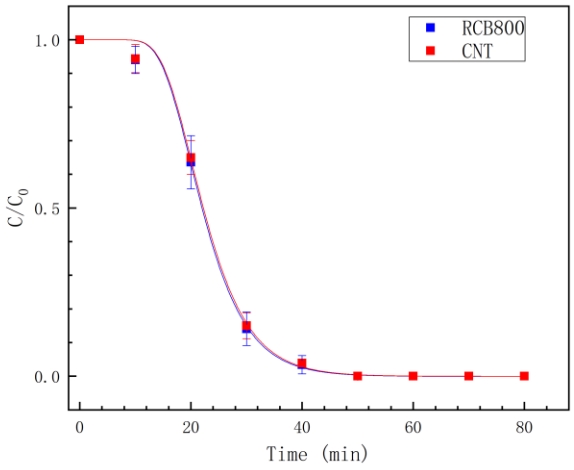


Fig. S11 Degradation of MO (0.5 mM) by sulfide (6 mM) with RCB800 and CNT. The dosage of materials was 100 mg/L, pH = 7.4, and the temperature was 30 °C

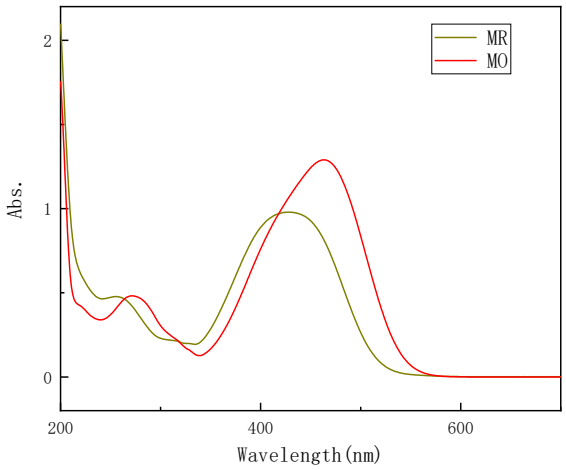


Fig. S12 UV-vis spectrograms of MR and MO