Supplementary information

Dissolved organic matter modified magnetic carbon nanotubes enhance the bioremediation of azo dyes and Cr(VI)

Caiwen He[a], Lipeng Gu[b], Huan He*[,a,c], Zhe Zhang[c], Xiaoxia Wang[a], Fengxia Han**[,a] Bin Huang[a,d], and Xuejun Pan[a,d]

Fig. S1. Nitrogen adsorption-desorption isotherms curves of AQS/Fe_3O_4/CNTs and HA/Fe_3O_4/CNTs

Fig. S2. Fluorescence spectra of AQS/Fe_3O_4/CNTs and HA/Fe_3O_4/CNTs

AQS contained model humic acid polymers, however, HA contained fulvic acid, humic acid and humic acid-like components, therefore, AQS was pure whereas HA contained complicated impurities.

Fig. S3. The cyclic voltammetry (CV) curves of Cr(VI) and methyl orange.

It was found that the reduction of Cr(VI) took precedence over methyl orange decolorization driven by anaerobic bacteria. Because as terminal electron acceptors, Cr(VI) which had relatively active redox activity received electrons in preference to methyl orange according to the cyclic voltammetry (CV) curves.

Fig. S4. The Shannon-weaver index of anaerobic bacteria (AB: bacteria in system with the addition of AQS/Fe_3O_4/CNTs, HB: bacteria in system with the addition of HA/Fe_3O_4/CNTs).

Bacterial community of HB was more diverse than AB, implying that the kind of DOM would affect the biodiversity of the anaerobic bacteria.

Table S1. The significance level of different materials.

Table S2. Effect of Fe_3O_4 on significance level of different groups.

Table S3. Effect of initial Cr(VI) concentration on significance level of different groups.

Table S4. The significance level of single system and binary system.

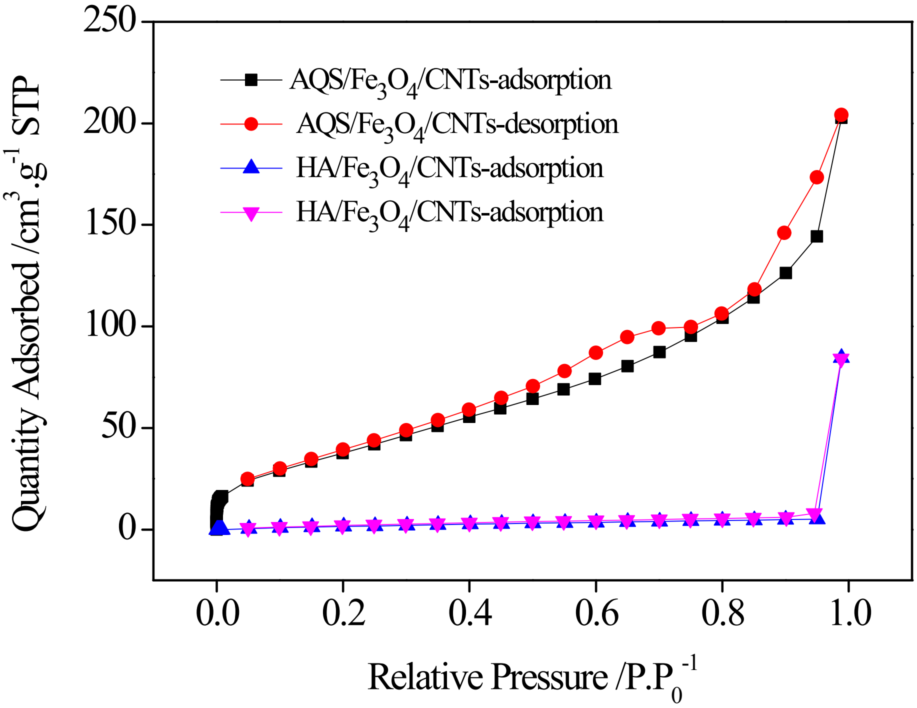

Fig. S1. Nitrogen adsorption-desorption isotherms curves of AQS/Fe_3O_4/CNTs and HA/Fe_3O_4/CNTs.

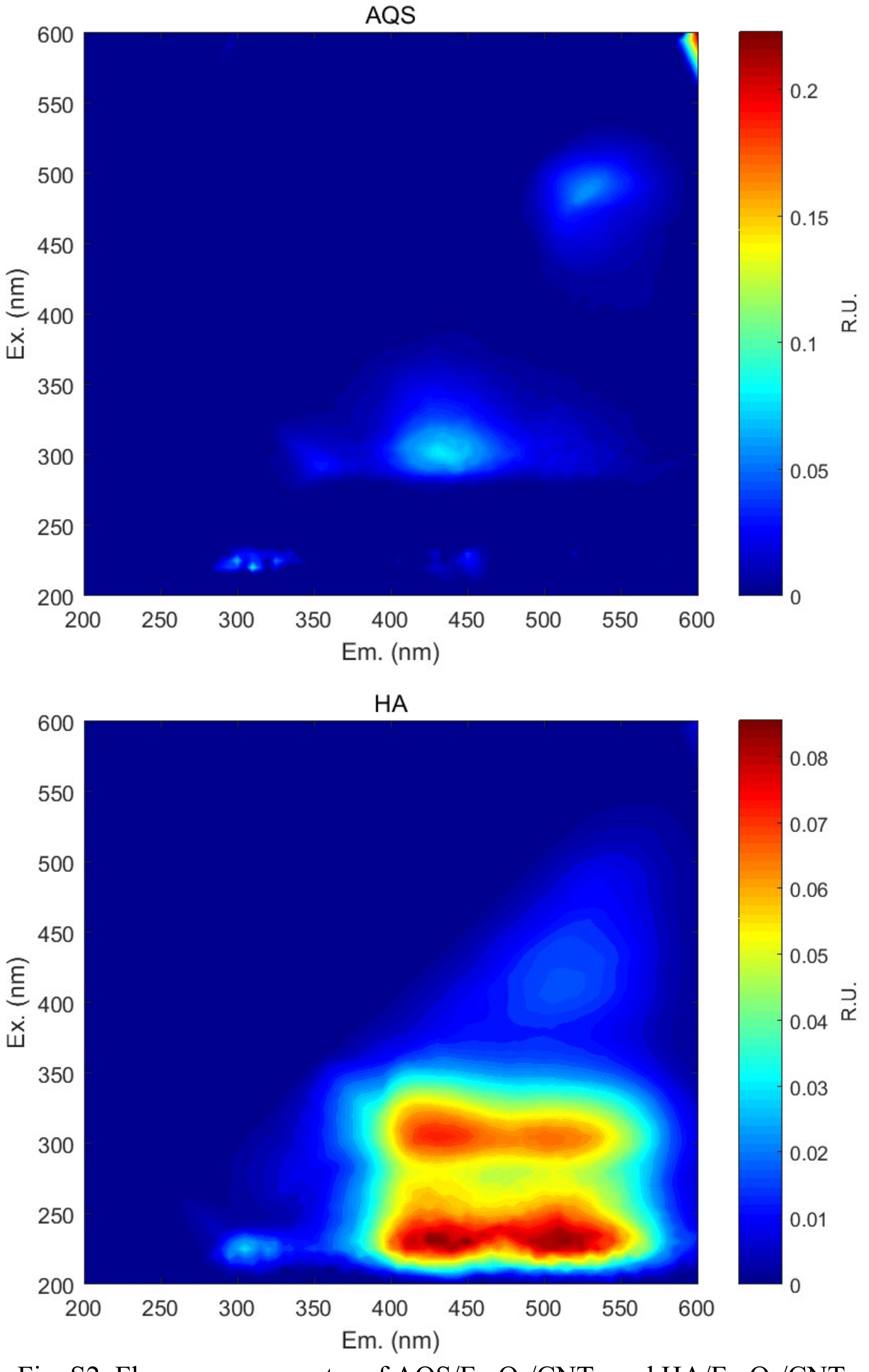

Fig. S2. Fluorescence spectra of AQS/Fe_3O_4/CNTs and HA/Fe_3O_4/CNTs.

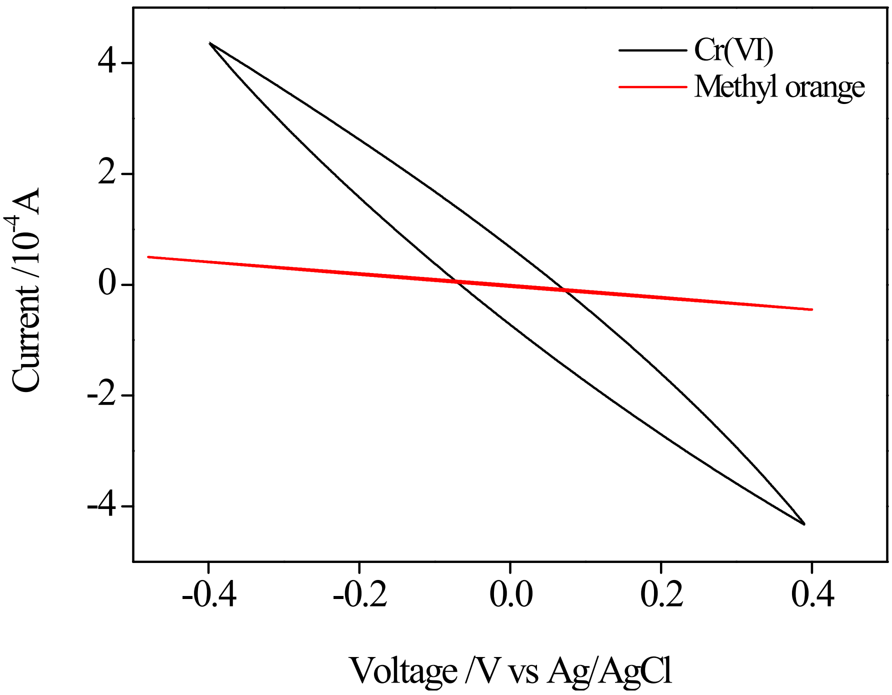

Fig. S3. The cyclic voltammetry (CV) curves of Cr(VI) and methyl orange.

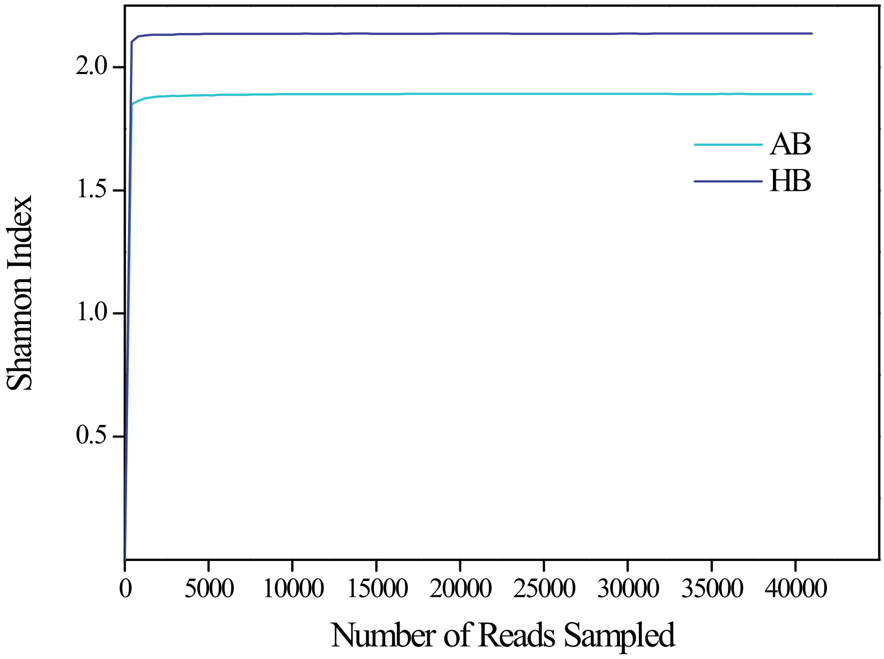

Fig. S4. The Shannon-weaver index of anaerobic bacteria (AB: bacteria in system with the addition of AQS/Fe_3O_4/CNTs, HB: bacteria in system with the addition of HA/Fe_3O_4/CNTs).

Table S1. The significance level of different materials.

(I) Material	(J) Material	t (h)	*p* Cr(VI)	*p* MO
		6	0.001	0.116
		12	0.023	0.774
AQS/Fe_3O_4/CNTs-0.5	HA/Fe_3O_4/CNTs-0.8	24	0.007	0.339
		30	0.056	0.220
		36	0.002	0

MO, methyl orange. $p \leq 0.05$ represent significant differences.

Table S2. Effect of Fe_3O_4 on significance level of different groups.

(I) Materials	(J) Materials	*p* (6 h)		*p* (12 h)		*p* (24 h)		*p* (30 h)		*p* (36 h)	
		Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO
AQS/Fe_3O_4/CNTs-0.5	AQS/CNTs-0.5	0.379	0.457	0.545	0.455	0.095	0.099	0.157	0.009	0.026	0.009
	HA/Fe_3O_4/CNTs-0.8	0	0.617	0.001	0.924	0.007	0.282	0.028	0.092	0.079	0.039
	HA/CNTs-0.8	0	0.326	0	0.042	0.001	0.014	0	0	0	0
	Fe_3O_4/CNTs	0	0.335	0	0.029	0	0.003	0	0	0	0
AQS/CNTs-0.5	HA/Fe_3O_4/CNTs-0.8	0	0.226	0	0.511	0.153	0.511	0.323	0.204	0.522	0.404
	HA/CNTs-0.8	0	0.101	0	0.151	0.010	0.282	0.001	0.003	0.028	0
	Fe_3O_4/CNTs	0	0.104	0	0.108	0.001	0.062	0	0	0	0
HA/Fe_3O_4/CNTs-0.8	HA/CNTs-0.8	0.185	0.617	0.011	0.049	0.138	0.099	0.003	0	0.009	0
	Fe_3O_4/CNTs	0.028	0.630	0.001	0.034	0.010	0.019	0	0	0	0
HA/CNTs-0.8	Fe_3O_4/CNTs	0.282	0.985	0.153	0.837	0.151	0.359	0.024	0.154	0.003	0.015

MO, methyl orange. $p \leq 0.05$ represent significant differences.

Table S3. Effect of initial Cr(VI) concentration on significance level of different groups.

(I) Initial Cr(VI) concentration (mg L^{-1})	(J) Initial Cr(VI) concentration (mg L^{-1})	*p* (6 h)		*p* (12 h)		*p* (24 h)		*p* (30 h)		*p* (36 h)	
		Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO	Cr(VI)	MO
10 ($AQS/Fe_3O_4/CNTs$)	15	0	0.231	0	0.112	0.002	0.002	0	0.001	0	0
	20	0	0.359	0	0.130	0	0	0	0	0	0
	25	0	0.087	0	0.073	0	0	0	0	0	0
15 ($AQS/Fe_3O_4/CNTs$)	20	0.663	0.754	0.312	0.928	0.035	0.002	0	0.023	0	0
	25	0.125	0.535	0.100	0.785	0.008	0.001	0	0.009	0	0
20 ($AQS/Fe_3O_4/CNTs$)	25	0.242	0.359	0.458	0.717	0.381	0.561	0.085	0.564	0.101	0.232
10 ($HA/Fe_3O_4/CNTs$)	15	0.033	0.273	0.008	0.001	0.002	0.009	0	0	0	0
	20	0.027	0.455	0.003	0	0	0.002	0	0	0	0
	25	0.015	0.086	0.001	0	0	0.002	0	0	0	0
15 ($HA/Fe_3O_4/CNTs$)	20	0.901	0.705	0.491	0.218	0.028	0.349	0.006	0.016	0	0.007
	25	0.621	0.455	0.182	0.147	0.013	0.279	0.002	0.007	0	0.003
20 ($HA/Fe_3O_4/CNTs$)	250	0.710	0.273	0.480	0.796	0.625	0.872	0.358	0.625	0.317	0.654

MO, methyl orange. $p \leq 0.05$ represent significant differences.

Table S4. The significance level of single system and binary system.

(I) Systems	(J) Systems	p ($AQS/Fe_3O_4/CNTs$)					p ($HA/Fe_3O_4/CNTs$)				
		6 h	12 h	24 h	30 h	36 h	6 h	12 h	24 h	30 h	36 h
Cr(VI)-S	Cr(VI)-B	0.063	0.394	0.006	0.011	1.000	0.042	0.400	0.046	0	0.002
MO-S	MO-B	0.002	0.012	0.002	0.008	0.286	0.003	0.044	0.003	0	0.002

S, single pollutant system with Cr(VI) or methyl orange alone; B, binary pollutants system with Cr(VI) or methyl orange in combination. MO, methyl orange. $p \leq 0.05$ represent significant differences.