Supplementary Materials:

Nitrogen removal ability and characteristics of the laboratory-scale tidal flow constructed wetlands for treating ammonium-nitrogen contaminated groundwater

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(a)

1. Setup and start-up (14 days) tidal flow and continuous flow CWs

2. Operation of tidal flow (21-h flooded with 4 L of groundwater and 3-h rest) and continuous flow (4 L d⁻¹) CWs using NH_4^+ -N (30 mg L⁻¹) groundwater for 105 days

3. Monitoring of NH4+-N, NO2--N, and NO3--N concentration in influent and effluent samples

- Collection of influent and effluent samples from CWs at every 7 days.
- Determination of $\rm NH_4^+\text{-}N, \rm NO_2^-\text{-}N,$ and $\rm NO_3^-\text{-}N$ concentrations.
 - Calculation of N-removal efficiency.

$4.\,Monitoring \,of\,N-removal \,potential\,of\,\,zeolite\,\,materials\,in\,parallel\,with\,the\,above\,step$

- Collection of zeolite (100 g) from each CW at every 14 days.
- NH₄⁺-N removal experiment using the zeolite in flasks at 120 rpm and 25°C for 24 h.
- Measurement of $N\dot{H}_4^+$ -N, NO_2^- -N, and NO_3^- -N concentrations in the flasks.
- Calculation of first-order $\rm NH_4^+-N$ removal rate (h^{-1}) by zeolite materials (100 g).
- The first-order NH_4^+ -N removal rate can be considered as the NH_4^+ -N adsorption rate on zeolite.

(b)

1. Setup and start-up (14 days) tidal flow CWs with and without common reed-vegetation

2. Operation of tidal flow (21-h flooded with 0.5 L of groundwater and 3-h rest) CWs using NH_4^+ -N (30 mg L^{-1}) groundwater for 60 days

3. Monitoring of NH₄⁺-N, NO₂⁻-N, and NO₃⁻-N concentration in CWs on 60th day

- Collection of samples from CWs at every few hours.
- Determination of $\rm NH_4^+\text{-}N, \rm NO_2^-\text{-}N,$ and $\rm NO_3^-\text{-}N$ concentrations.

(c)

1. Setup and start-up (14 days) tidal flow CWs with and without common reed-vegetation

2. Operation of tidal flow (21-h flooded with 0.5 L of groundwater and 3-h rest) CWs using NH₄⁺-N (30 mg L^{-1}) groundwater for 60 days

These steps were same as section 2.2.2

3. Denitrification experiment using zeolites and common reed plant roots from CWs on 60th day

- Collection of zeolite (100 g) and common reed roots (5 g) from CW with vegetation.
- Collection of zeolite (100 g) from CW without vegetation.

• Denitrification experiment using the zeolite/common reed roots or zeolite alone in vials with 50 mL of synthetic groundwater (30 mg NO_3^- -N L^{-1}), under anaerobic condition.

- Collection of samples from vials at every few hours.
- Determination of NH4+-N, NO2--N, and NO3--N concentrations.



Figure S1. The experimental flowcharts of section 2.2.1 (a), 2.2.2 (b), 2.2.3 (c), and 2.4 (d).

Target gene	Primer	Sequences (5'-3')	Amplification size (bp)	Annealing Temp (°C)	Reference
Bacterial	341F	CCTACGGGAGGCAGC			
16S rRNA		AG	102	60	[24]
	534R	TACCGCGGCTGCTGGC	193	00	[34]
		AC			
amoA	amo598f	GAATATGTTCGCCTGA			
		TTG	120	56	[35]
	amo718r	CAAAGTACCACCATA			
		CGCAG			
nxrA	Elpor A	CAGACCGACGTGTGC	322	58	[36]
	FIIOIA	GAAAG			
	R1norA	TCYACAAGGAACGGA			
		AGGTC			
narG	1960m2f	TA(CT)GT(GC)GGGCAG		58	[37]
		GA(AG)AAACTG	100		
	2050m2r	CGTAGAAGAAGCTGG	100		
		TGCTGTT			
nirK	nirK583F	TCATGGTGCTGCCGCG	326	63	[38]
		KGACGG			
	nirK909R	GAACTTGCCGGTKGCC			
		CAGAC			
nirS	nirScd3af	GT(C/G)AACGT(C/G)AA	425	57	[39]
		GGA(A/G)AC(C/G)GG			
	nirSR3cd	GA(C/G)TTCGG(A/G)TG			
		(C/G)GTCTTGA			
nosZ	nosZ1527F	CGCTGTTCHTCGACAG			
		YCA	250	58	[40]
	nosZ1773R	ATRTCGATCARCTGBT			
		CGTT			

Table S1. Target genes for qPCR analysis, primers and sequences, amplification sizes, and annealing temperatures



Figure S2. First-order kinetic models for the decrease in NH₄⁺-N concentrations during the first 2-3 hours of N-removal potential experiment in zeolite-microbe association of (**a**) tidal flow CWs and (**b**) continuous flow CWs.