

Response of nitrogen removal performance and microbial distribution to seasonal shock nutrients load in a lakeshore multi-cell constructed wetland

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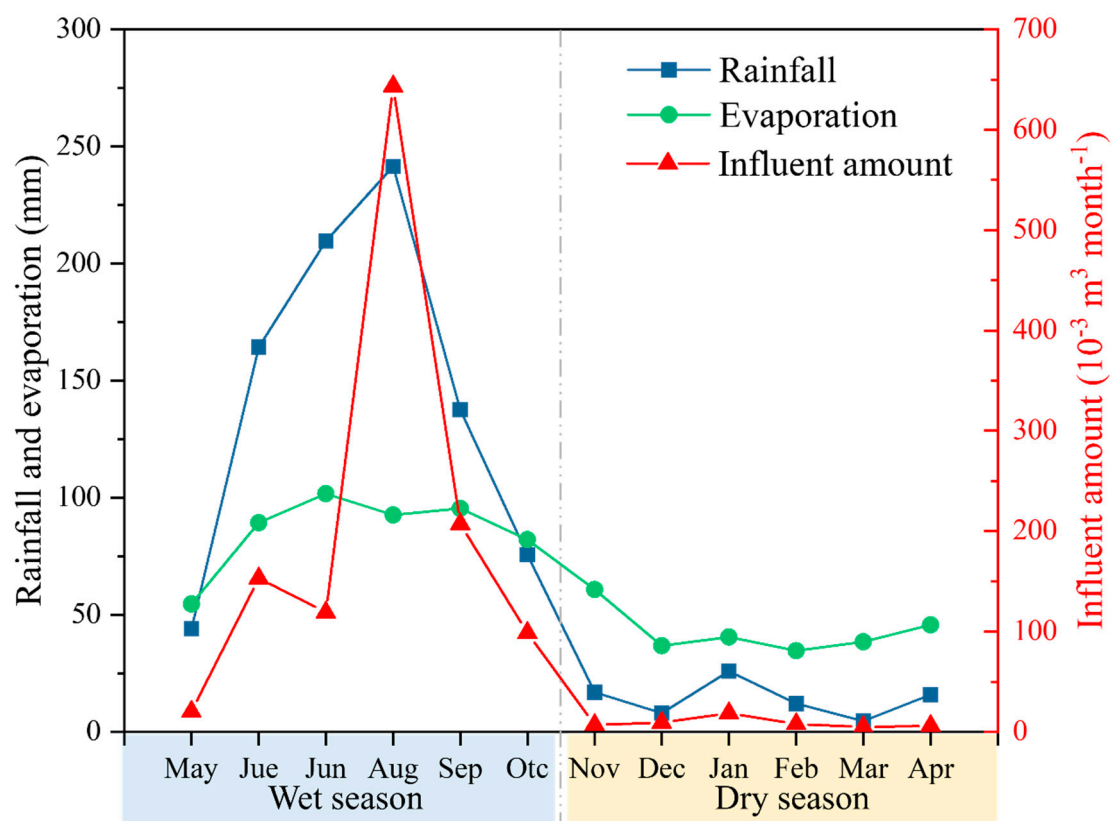


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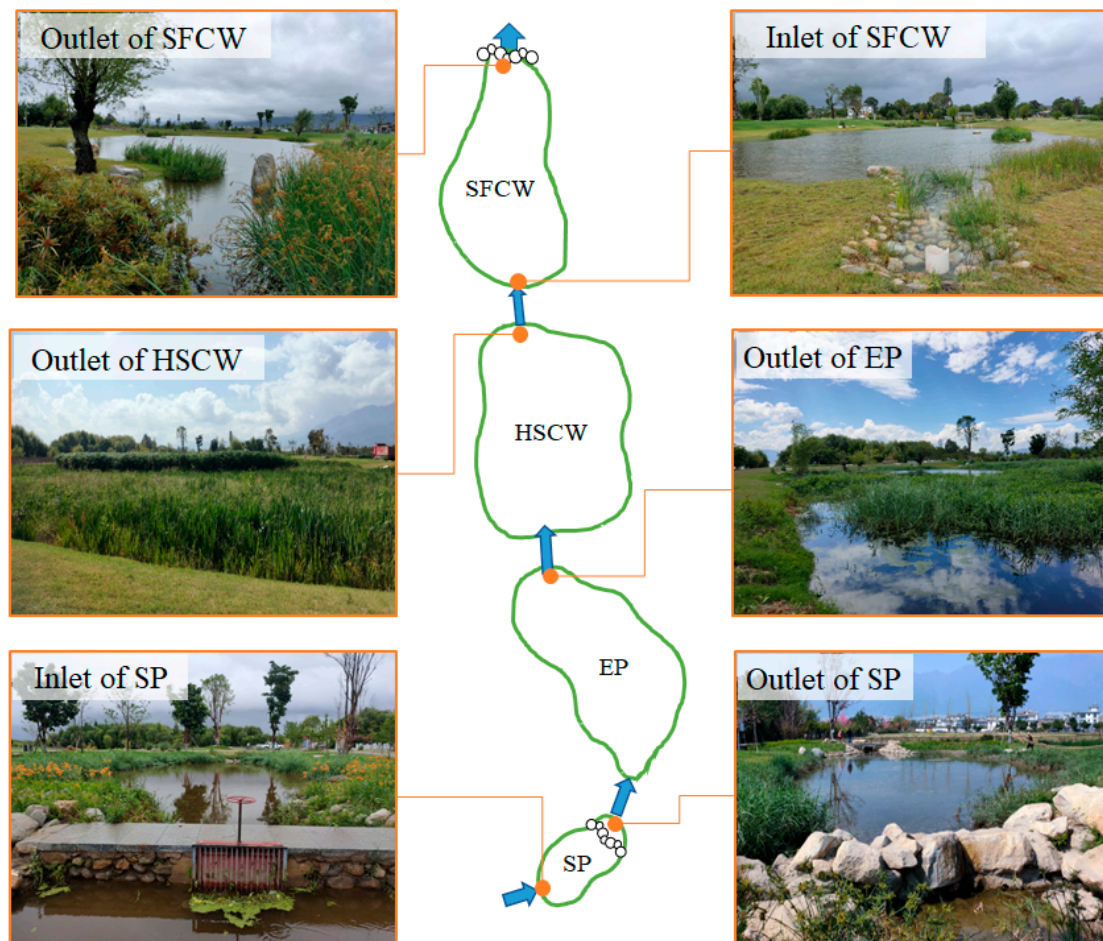


Figure S2. Photographs of the cells in the lakeshore MCW. SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.

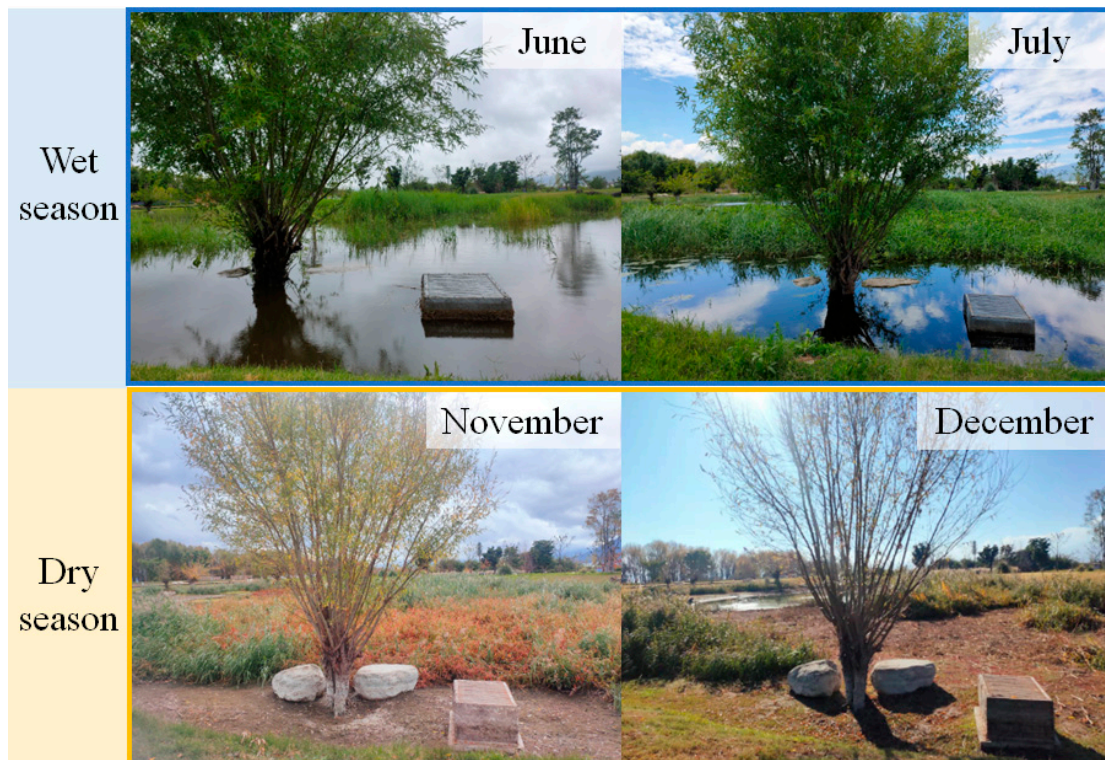


Figure S3. Comparisons of the ecological oxidation pond (EP) in wet and dry seasons.

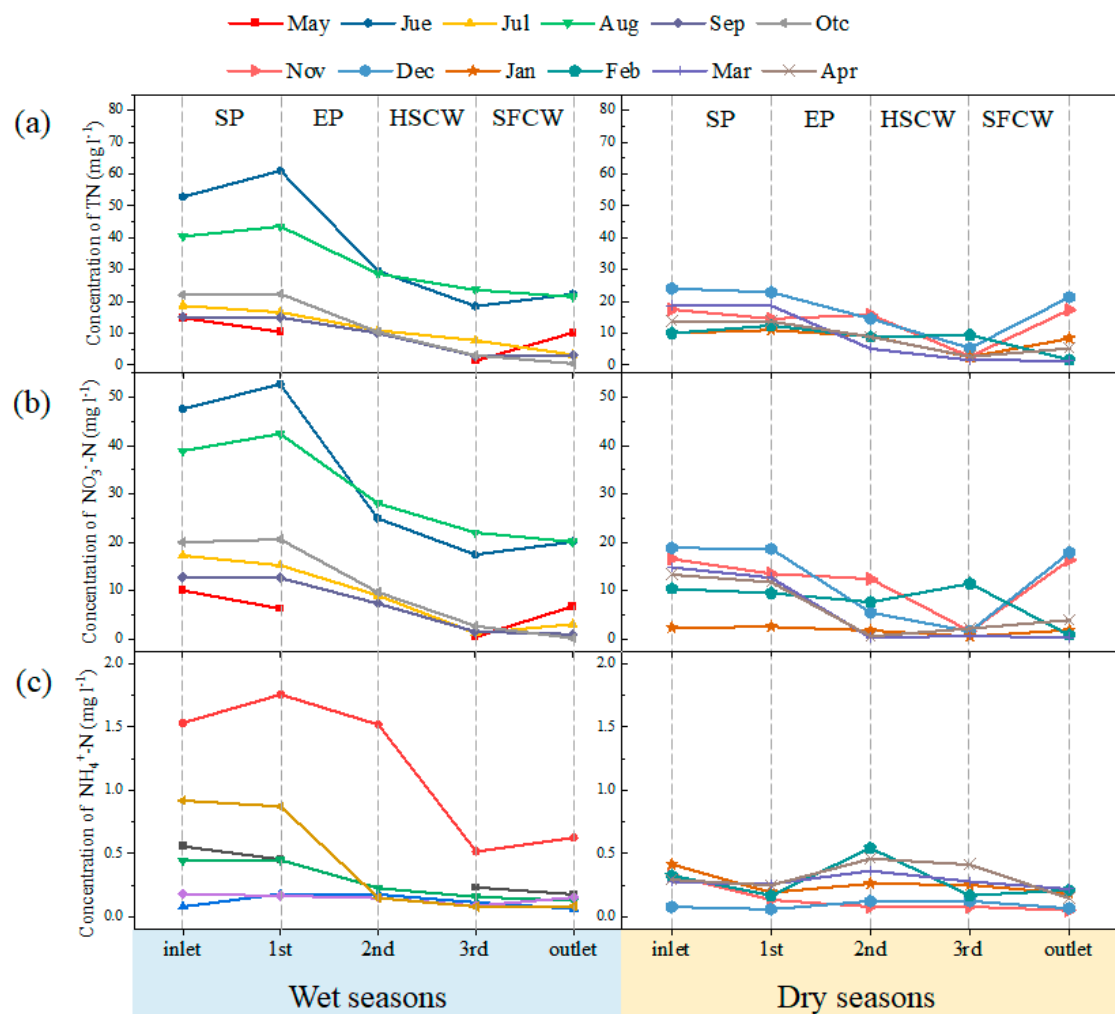


Figure S4. The nitrogen concentrations of the influent along the flowing rate. **(a)** TN; **(b)** NO₃⁻-N; **(c)** NH₄⁺-N. SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.

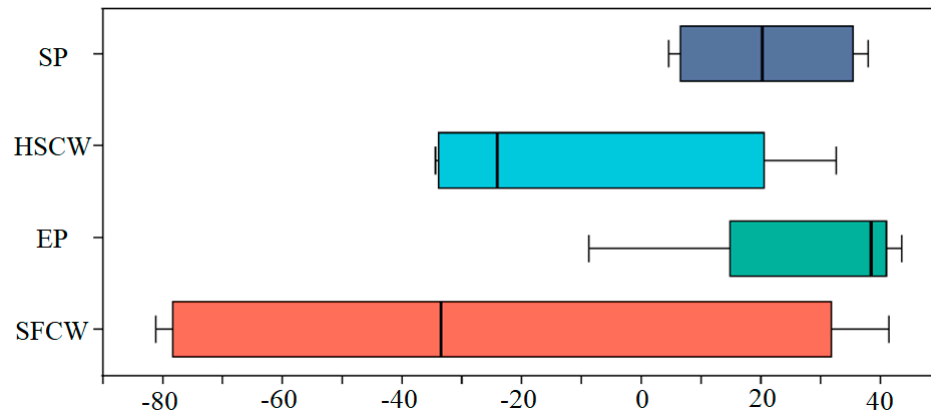


Figure S5. The visualization of beta diversity and analysis of similarities (ANOSIM). SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.

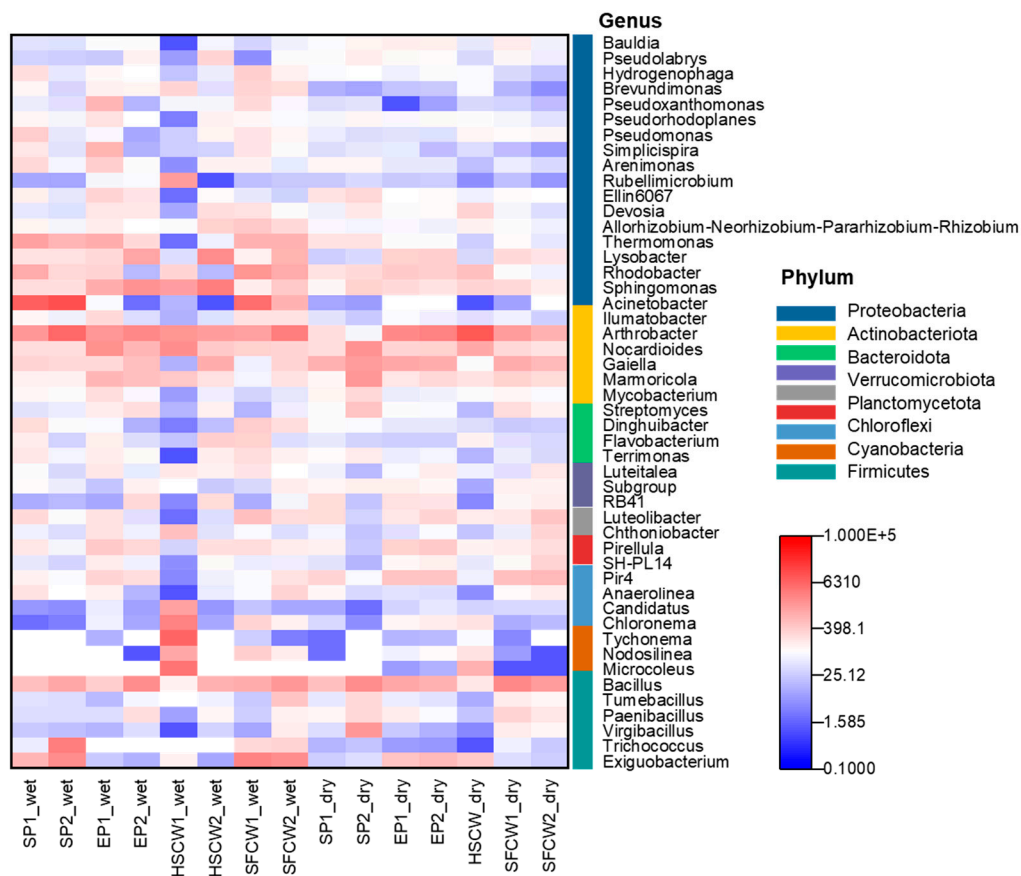


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Table S1. Basic information of the multi-cell constructed wetlands.

Cell	Area (m ²)	Maximum design water depth (m)	Plant configuration	Plant coverage (%)
SP *	356±23	1	<i>Phragmites australis</i> , <i>Cyperus</i> <i>involucratus</i> , <i>Canna indica</i> var. <i>flava</i>	10±5
EP *	2037±120	1	<i>Phragmites australis</i>	60±5
HSCW *	3478±34	0.8	<i>Iris pseudacorus</i> L., <i>Cyperus</i> <i>involucratus</i>	95±5
SFCW *	2411±48	0.35	<i>Juncus effusus</i> , <i>Canna indica</i> , <i>Cyperus</i> <i>involucratus</i> , <i>Myriophyllum aquaticum</i> (Vell.) Verdc.	90±5

* SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.

Table S2. Land use in the catchment around the lakeshore MCW.

Agricultural land (%)	Residential land (%)	Woodland (%)	Water (%)	Other (%)
65.07	22.48	11.21	0.61	0.63

Table S3. Monthly nitrogen concentration and removal performance of the lakeshore MCW.

		C_{in} (mg l ⁻¹)	C_{out} (mg l ⁻¹)	RE * (%)	MRR * (mg m ⁻² day ⁻¹)	MRR _v * (mg m ⁻³ day ⁻¹)	MLR * (mg m ⁻² day ⁻¹)	HRT * (day)	HLR * (m day ⁻¹)
Jar.	TN	10.04±0.50	8.34±0.42	17.42	131.90	181.66	22.71	9.63	0.08
	NH ₄ ⁺ -N	0.04±0.02	0.18±0.01	56.10	17.56	24.18	0.94		
	NO ₃ ⁻ -N	2.40±0.12	1.89±0.09	21.78	39.38	54.23	5.42		
Feb.	TN	10.00±0.50	1.65±0.08	83.90	263.68	363.17	9.43	23.11	0.03
	NH ₄ ⁺ -N	0.33±0.02	0.21±0.01	36.88	3.79	5.22	0.31		
	NO ₃ ⁻ -N	10.37±0.52	0.80±0.04	92.48	301.33	415.02	9.77		
Mar.	TN	18.59±0.93	1.35±0.07	93.19	328.23	452.06	10.57	38.32	0.02
	NH ₄ ⁺ -N	0.27±0.01	0.22±0.01	23.99	1.24	1.71	0.16		
	NO ₃ ⁻ -N	14.83±0.74	0.29±0.01	98.14	275.76	379.80	8.43		
Apr.	TN	13.71±0.69	5.23±0.26	63.42	208.48	287.14	9.86	30.28	0.02
	NH ₄ ⁺ -N	0.29±0.01	0.15±0.01	52.23	3.68	5.07	0.21		
	NO ₃ ⁻ -N	13.30±0.67	3.95±0.20	71.51	228.14	314.22	9.57		
May	TN	14.75±0.74	10.19±0.51	31.21	376.95	519.17	36.23	8.87	0.08
	NH ₄ ⁺ -N	0.56±0.03	0.18±0.01	68.26	31.16	42.92	1.37		
	NO ₃ ⁻ -N	10.04±0.50	6.79±0.34	32.66	268.49	369.79	24.66		

		c_{in} (mg l ⁻¹)	c_{out} (mg l ⁻¹)	RE * (%)	MRR * (mg m ⁻² day ⁻¹)	MRR _V * (mg m ⁻³ day ⁻¹)	MLR * (mg m ⁻² day ⁻¹)	HRT * (day)	HLR * (m day ⁻¹)
Jun.	TN	52.90±2.65	22.29±1.11	57.69	18886.75	26012.64	982.10	1.17	0.62
	NH ₄ ⁺ -N	1.53±0.08	0.63±0.03	59.03	560.37	771.79	28.48		
	NO ₃ ⁻ -N	47.57±2.38	20.08±1.00	57.60	16954.59	23351.47	882.99		
Jul.	TN	18.63±0.93	3.21±0.16	82.62	7398.74	10190.26	268.64	1.51	0.48
	NH ₄ ⁺ -N	0.08±0.01	0.06±0.01	19.51	7.52	10.36	1.16		
	NO ₃ ⁻ -N	17.27±0.86	3.06±0.15	82.13	6819.07	9391.87	249.08		
Aug.	TN	40.41±2.02	21.45±1.07	46.81	49175.12	67728.67	3151.33	0.28	2.60
	NH ₄ ⁺ -N	0.45±0.02	0.13±0.01	70.85	819.60	1128.84	34.70		
	NO ₃ ⁻ -N	38.91±1.95	20.12±1.01	48.20	48739.36	67128.49	3033.86		
Sep.	TN	15.05±0.75	3.10±0.16	79.34	9988.12	13756.59	377.68	0.87	0.84
	NH ₄ ⁺ -N	0.18±0.01	0.15±0.01	13.60	20.39	28.09	4.50		
	NO ₃ ⁻ -N	12.80±0.64	1.02±0.05	92.02	9858.04	13577.44	321.37		
Oct.	TN	22.09±1.10	0.43±0.02	98.03	8623.04	11876.48	263.88	1.82	0.40
	NH ₄ ⁺ -N	0.92±0.05	0.09±0.01	90.58	331.49	456.57	10.98		
	NO ₃ ⁻ -N	20.02±1.00	0.19±0.89	99.03	78393.69	10871.95	239.12		
Nov.	TN	17.45±0.87	17.34±0.87	5.80	28.25	38.90	14.60	26.02	0.03

	c_{in} (mg l ⁻¹)	c_{out} (mg l ⁻¹)	RE *	MRR *	MRR _V *	MLR *	HRT *	HLR *
			(%)	(mg m ⁻² day ⁻¹)	(mg m ⁻³ day ⁻¹)	(mg m ⁻² day ⁻¹)	(day)	(m day ⁻¹)
	NH ₄ ⁺ -N	0.33±0.02	0.05±0.01	85.49	7.90	10.88	0.28	
	NO ₃ ⁻ -N	16.58±0.83	16.36±0.82	6.53	30.19	41.59	13.88	
Dec.	TN	24.05±1.20	21.34±1.07	13.57	119.67	164.82	26.45	19.81
	NH ₄ ⁺ -N	0.08±0.01	0.07±0.01	15.97	0.46	0.64	0.09	0.04
	NO ₃ ⁻ -N	18.83±0.94	17.89±0.89	7.49	51.68	71.18	20.70	

Data are presented as means ± standard deviation (S.D.) with n = 3.

* RE: removal rate; MRR: mass removal rate per square meter; MRR_V: mass removal rate per cubic meter; HRT: hydraulic residence time; HLR: hydraulic loading rate.

Table S4. Results of one-way ANOVA for the effects of various seasons or treatment

processes on the nitrogen removal efficiency of the lakeshore MCWs.

		TN		NH ₄ ⁺ -N		NO ₃ ⁻ -N	
Factors		F	P	F	P	F	P
Seasons	Jan.	1449.711	0.000	1402.050	0.000	1481.153	0.000
	Feb.	1284.953	0.000	1487.206	0.000	1427.115	0.000
	Mar.	618.934	0.000	1572.705	0.000	1568.448	0.000
	Apr.	1593.140	0.000	1598.175	0.000	1332.964	0.000
	May	1329.725	0.000	45.59514	0.000	1276.717	0.000
	Jun.	190.325	0.000	1456.248	0.000	1284.004	0.000
	Jul.	106.056	0.000	1557.289	0.000	1598.064	0.000
	Aug.	150.828	0.000	595.6724	0.000	918.0054	0.000
	Sep.	1022.747	0.000	1582.264	0.000	537.2155	0.000
	Otc.	445.375	0.000	890.2646	0.000	489.2385	0.000
	Nov.	1185.982	0.000	441.4404	0.000	1301.881	0.000
	Dec.	1400.985	0.000	1563.641	0.000	1309.637	0.000
Treatment	SP	28.62152	0.000	1272.254	0.000	1063.208	0.000
process	EP	382.0684	0.000	1221.456	0.000	349.2848	0.000
	HSCW	266.2212	0.000	486.0679	0.000	1297.086	0.000
	SFCW	1004.04	0.000	1165.174	0.000	974.7029	0.000

Table S5. Sequencing statistics for the sediment samples of lakeshore MCW.

	Sample ID	Sequences	Base numbers	Mean	Min length	Max length	OTUs	Coverage
		numbers		length (bp)	(bp)	(bp)		
Dry	SP-1 *	70767	17906733	253	204	331	4916	0.9579
	SP-2	72882	18440644	253	204	339	4218	0.9626
	EP-1 *	48612	12302162	253	204	307	5104	0.9566
	EP-2	51390	13004609	253	204	331	4968	0.9577
	HSCW *	45278	11456661	253	204	314	2569	0.9780
	SFCW-1 *	57960	14666205	253	202	294	5334	0.9570
	SFCW-2	60879	15405214	253	202	309	5241	0.9583
Wet	SP-1	109399	27678717	253	201	323	3691	0.9650
	SP-2	77286	19553417	253	207	287	3075	0.9671
	EP-1	111312	28164748	253	200	305	3063	0.9753
	EP-2	107099	27103394	253	202	314	4118	0.9681
	HSCW-1	106466	26936039	253	203	315	1065	0.9906
	HSCW-2	101424	25667940	253	204	332	3842	0.9704
	SFCW-1	102031	25816829	253	204	318	2940	0.9723
	SFCW-2	82136	20781991	253	201	301	4306	0.9632
Total		1204921	304885303	-	-	-	58450	-

* SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.

Table S6. Microbial diversity indices for the cells of lakeshore MCW.

	Sample ID	Sobs	Shannon	ACE	Chao1	Simpson
Dry	SP *	4567±349	6.89±0.24	6445±423	6353±444	0.0049±0.0018
	EP *	5036±68	7.08±0.04	6985±76	6894±51	0.0057±0.0010
	HSCW *	2569±128	5.34±0.27	3627±181	3659±183	0.0472±0.0024
	SFCW *	5288±47	7.29±0.02	7071±69	6987±89	0.0031±0.0006
Wet	SP	3591±528	5.47±0.63	5795±276	5283±256	0.0328±0.0173
	EP	3383±308	6.56±0.17	4853±637	4761±551	0.0062±0.0005
	HSCW	2454±1389	5.66±1.06	3510±1594	3296±1654	0.0217±0.0171
	SFCW	3623±683	6.18±0.37	5594±410	5158±739	0.0137±0.0036

Data are presented as means ± standard deviation (S.D.) with n = 2.

* SP: storage pod; EP: ecological oxidation pond; HSCW: horizontal subsurface flow constructed wetland; SFCW: surface flow constructed wetland.