Effectiveness of nitrification and denitrification processes in biofilters treating wastewater from de-icing airport runways

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Table S1. Composition of model wastewater.

	Series 1	**Series 2**	**Series 3**
C/N [gC/gN]	**0.5**	**2.5**	**5.0**
CH_4N_2O [mg/dm^3]		150.00 ± 0.10	
HCOONa [mg/dm^3]	136.00 ± 0.10	657.00 ± 0.10	1326.00 ± 0.10
CH_3COOK [mg/dm^3]	49.00 ± 0.10	237.00 ± 0.10	478.00 ± 0.10

Results of statistical analyses. The value of statistics lower than α=0.05 indicates statistically significant difference (marked in italics).

Table S2. Dependent variable: nitrification efficiency, qualitative variable: temperature.

Dunn's test, C/N= 0.5 gC/gN				
Temperature [°C]	0	4	8	25
0		0.955035	0.078004	*0.000012*
4	0.955035		1.000000	*0.000957*
8	0.078004	1.000000		*0.036496*
25	*0.000012*	*0.000957*	*0.036496*	
Dunn's test, C/N= 2.5 gC/gN				
0		*0.027836*	0.075464	*0.000000*
4	*0.027836*		1.000000	*0.003758*
8	0.075464	1.000000		*0.007920*
25	*0.000000*	*0.003758*	*0.007920*	
Reasonable Significant Difference (RIR) Tukey test, C/N= 5.0 gC/gN				
0		0.733190	0.170475	*0.000172*
4	0.733190		0.521463	*0.000172*
8	0.170475	0.521463		*0.000172*
25	*0.000172*	*0.000172*	*0.000172*	

Table S3. Dependent variable**:** denitrification efficiency, qualitative variable: temperature.

Dunn's test, C/N= 0.5 gC/gN)				
Temperature [°C]	0	4	8	25
0		*0.002638*	1.000000	1.000000
4	*0.002638*		*0.000071*	*0.004753*
8	1.000000	*0.000071*		1.000000
25	1.000000	*0.004753*	1.000000	
Dunn's test, C/N= 2.5 gC/gN				
0		*0.049214*	*0.000025*	*0.000043*
4	*0.049214*		0.146887	0.257396
8	*0.000025*	0.146887		1.000000
25	*0.000043*	0.257396	1.000000	
Dunn's test, C/N= 5.0 gC/gN				
0		*0.020223*	*0.002234*	*0.000000*
4	*0.020223*		1.000000	*0.001239*
8	*0.002234*	1.000000		*0.028929*
25	*0.000000*	*0.001239*	*0.028929*	

Table S4. Dependent variable**:** efficiency of nitrogen compounds removal, qualitative variable: temperature.

Reasonable Significant Difference (RIR) Tukey test, C/N= 0.5 gC/gN				
Temperature [°C]	0	4	8	25
0		0.914368	*0.001829*	*0.000149*
4	0.914368		*0.006877*	*0.000149*
8	*0.001829*	*0.006877*		*0.000167*
25	*0.000149*	*0.000149*	*0.000167*	
Reasonable Significant Difference (RIR) Tukey test, C/N= 2.5 gC/gN				
0		*0.000163*	*0.000163*	*0.000163*
4	*0.000163*		0.930917	*0.000163*
8	*0.000163*	0.930917		*0.000163*
25	*0.000163*	*0.000163*	*0.000163*	
Reasonable Significant Difference (RIR) Tukey test, C/N= 5.0 gC/gN				
0		*0.000161*	*0.000161*	*0.000161*
4	*0.000161*		0.980759	*0.044899*
8	*0.000161*	0.980759		0.130407
25	*0.000161*	*0.044899*	0.130407	

Table S5. Dependent variable**:** efficiency of nitrogen compounds removal, qualitative variable: ratio C/N.

Reasonable Significant Difference (RIR) Tukey test, temperature 0°C			
C/N [gC/gN]	0.5	2.5	5.0
0.5		*0.000130*	*0.000133*
2.5	*0.000130*		0.806484
5.0	*0.000133*	0.806484	
Reasonable Significant Difference (RIR) Tukey test, temperature 4°C			
0.5		0.990335	*0.000127*
2.5	0.990335		*0.000129*
5.0	*0.000127*	*0.000129*	
Reasonable Significant Difference (RIR) Tukey test, temperature 8°C			
0.5		0.138094	*0.000142*
2.5	0.138094		0.060327
5.0	*0.000142*	0.060327	
Reasonable Significant Difference (RIR) Tukey test, temperature 25°C			
0.5		*0.000853*	*0.000125*
2.5	*0.000853*		0.676106
5.0	*0.000125*	0.676106	

Table S6. Dependent variable: concentration of removed nitrogen as a result of denitrification, qualitative variable: temperature.

Dunn's test, C/N= 0.5 gC/gN				
Temperature [°C]	0	4	8	25
0		0.751639	1.000000	*0.005133*
4	0.751639		0.358666	*0.000057*
8	1.000000	0.358666		*0.010898*
25	*0.005133*	*0.000057*	*0.010898*	
Dunn's test, C/N= 2.5 gC/gN				
0		*0.029119*	0.360863	*0.000000*
4	*0.029119*		1.000000	*0.000709*
8	0.360863	1.000000		*0.000006*
25	*0.000000*	*0.000709*	*0.000006*	
Dunn's test, C/N= 5.0 gC/gN				
0		0.999994	0.667623	*0.000161*
4	0.999994		0.597800	*0.000161*
8	0.667623	0.597800		*0.000161*
25	*0.000161*	*0.000161*	*0.000161*	

Table S7. Dependent variable**:** concentration of removed nitrogen as a results of biomass synthesis, qualitative variable: temperature.

Reasonable Significant Difference (RIR) Tukey test, C/N= 0.5 gC/gN				
Temperature [°C]	0	4	8	25
0		0.834000	0.426557	*0.000166*
4	0.834000		0.741932	*0.000166*
8	0.426557	0.741932		*0.000184*
25	*0.000166*	*0.000166*	*0.000184*	
Dunn's test, C/N= 2.5 gC/gN				
0		1.000000	1.000000	*0.016804*
4	1.000000		1.000000	*0.007002*
8	1.000000	1.000000		*0.006550*
25	*0.016804*	*0.007002*	*0.006550*	
Reasonable Significant Difference (RIR) Tukey test, C/N= 5.0 gC/gN				
0		0.854442	0.815181	*0.002081*
4	0.854442		0.999972	*0.013760*
8	0.815181	0.999972		*0.012811*
25	*0.002081*	*0.013760*	*0.012811*	

Table S8. Dependent variable**:** efficiency of organic compounds removal, qualitative variable: temperature.

Reasonable Significant Difference (RIR) Tukey test, C/N= 0.5 gC/gN				
Temperature [°C]	0	4	8	25
0		0.548435	*0.006299*	*0.003236*
4	0.548435		0.052234	*0.021326*
8	*0.006299*	0.052234		0.826778
25	*0.003236*	*0.021326*	0.826778	
Reasonable Significant Difference (RIR) Tukey test, C/N= 2.5 gC/gN				
0		0.774045	0.559793	*0.000211*
4	0.774045		0.983119	*0.000228*
8	0.559793	0.983119		*0.000234*
25	*0.000211*	*0.000228*	*0.000234*	
Reasonable Significant Difference (RIR) Tukey test, C/N= 5.0 gC/gN				
0		0.777328	0.564708	*0.000209*
4	0.777328		0.983434	*0.000209*
8	0.564708	0.983434		*0.000209*
25	*0.000209*	*0.000209*	*0.000209*	

Table S9. Dependent variable**:** efficiency of organic compounds removal, qualitative variable: ratio C/N.

Reasonable Significant Difference (RIR) Tukey test, temperature 0°C			
C/N [gC/gN]	0.5	2.5	5.0
0.5		*0.000201*	*0.000201*
2.5	*0.000201*		0.621224
5.0	*0.000201*	0.621224	
Reasonable Significant Difference (RIR) Tukey test, temperature 4°C			
0.5		*0.000229*	*0.000228*
2.5	*0.000229*		0.573413
5.0	*0.000228*	0.573413	
Reasonable Significant Difference (RIR) Tukey test, temperature 8°C			
0.5		*0.000228*	*0.000228*
2.5	*0.000228*		0.187657
5.0	*0.000228*	0.187657	
Reasonable Significant Difference (RIR) Tukey test, temperature 25°C			
0.5		*0.004225*	*0.020101*
2.5	*0.004225*		0.339094
5.0	*0.020101*	0.339094	

Table S10. Dependent variable**:** concentration of organic compounds in treated wastewater, qualitative variable: ratio C/N.

Reasonable Significant Difference (RIR) Tukey test, temperature 0°C			
C/N [gC/gN]	0.5	2.5	5.0
0.5		*0.000201*	*0.000201*
2.5	*0.000201*		*0.000201*
5.0	*0.000201*	*0.000201*	
Dunn's test, temperature 4°C			
0.5		0.539137	*0.021871*
2.5	0.539137		0.539137
5.0	*0.021871*	0.539137	
Reasonable Significant Difference (RIR) Tukey test, temperature 8°C			
0.5		*0.000228*	*0.000228*
2.5	*0.000228*		*0.000228*
5.0	*0.000228*	*0.000228*	
Reasonable Significant Difference (RIR) Tukey test, temperature 25°C			
0.5		*0.001880*	*0.000268*
2.5	*0.001880*		*0.007050*
5.0	*0.000268*	*0.007050*	

Table S11. Nitrification and denitrification efficiencies and processes in different bioreactor configurations under the conditions tested.

C/N [gC/gN]	Temperature [°C]	Nitrification efficiency [%]	Denitrification Efficiency [%]	Efficiency of total nitrogen removal [%]	Efficiency of organic compounds removal [%]
0.5	0	36.88±6.29	89.88±2.72	34.57±4.54	62.65±6.06
	4	39.98±3.31	84.69±2.72	35.41±3.41	67.25±5.19
	8	41.70±4.02	90.32±2.77	39.39±4.70	77.00±2.59
	25	47.68±2.26	89.83±0.96	45.73±2.84	79.70±1.70
2.5	0	24.88±1.99	92.36±2.62	24.58±2.31	21.21±1.97
	4	34.55±2.80	97.29±1.14	35.26±2.91	24.12±2.01
	8	34.81±3.72	98.60±0.76	36.01±2.94	25.28±1.10
	25	50.08±2.86	98.24±1.60	52.28±3.51	55.19±7.89
5.0	0	24.65±5.15	87.59±4.60	23.21±2.65	18.75±2.63
	4	27.46±5.58	96.64±2.36	28.38±3.17	21.14±2.65
	8	30.49±7.83	97.02±2.50	31.44±4.69	22.10±1.70
	25	50.93±4.35	99.23±0.42	53.68±3.91	62.20±5.31