The impact of secondary operating temperature on in-line coagulation/flocculation and fouling of membranes used in tertiary treatment

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Supplementary Material

I. Descriptions of SBRs

Two identical lab-scale sequencing batch reactors (SBR) were operated with a 4 h cycle duration to approximate continuous flow conditions (Fig. S1). One SBR was operated at 20℃ as a control while the other SBR was operated at 8℃ for over one year. The temperatures are representative of summer and winter operating conditions in Ontario, Canada. The SBRs were fed with real municipal wastewater collected every two days from the City of Waterloo sewer system and sieved with a 2 mm mesh to remove large particles. The raw wastewater was chilled at 4℃ during storage to ensure the stability of organic matter. The solids retention time (SRT) was maintained at 25 days. Both SBRs reached pseudo steady state before sampling.

Each reactor consisted of a 12 L polymethyl methacrylate container with a working volume of 10 L. A mechanical mixer with a shaft paddle operating at 150 rpm was employed to mix the SBR contents. A constant airflow for aeration was provided through an air diffuser located at the bottom of the reactor. A water jacket, controlled by a chiller (Polyscience, USA), was used to maintain the water temperature inside the test SBR while the control reactor was operated at room temperature (20℃). The water temperature was regularly monitored by a thermometer. The SBR time sequence process was controlled using LabView® software (version 2017, National Instruments Corporation, USA).

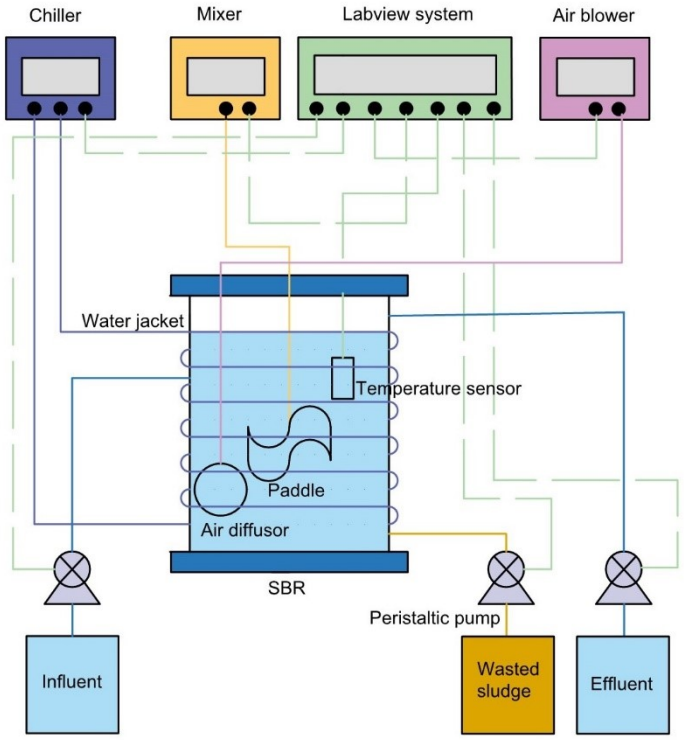

Fig. S1. Schematic of laboratory-scale SBR.

II. Table S1. Characteristics of raw wastewater and SBR effluents.

Parameters	Raw wastewater	SBR (20°C) HRT = 10 h	SBR (8°C)
Turbidity (NTU)	305±27	3.6±0.5	8.2±1.9
sCOD (mg/L)	156±13	47±6	79±9
tCOD (mg/L)	501±22	81±8	107±8
DOC (mg/L)	50±6	10.5±0.5	14.9±0.7
NO_3^--N(mg/L)	0.46±0.04	40±3	34±3
NO_2^--N (mg/L)	[a]	[a]	[a]
NH_4^+-N (mg/L)	57±5	[a]	[a]

[a] Below detection limits (2 mg/L for ammonia-N, 0.6 mg/L for nitrite-N.

III. Table S2. Summary of the five constant flow combined fouling models (Bolton et al. 2006).

Model	Equation	Fitted parameters
Cake-complete	$\frac{P}{P_0} = \frac{1}{(1 - K_b t)}(1 - \frac{K_c J_0^2}{K_b} ln(1 - K_b t)$	K_c (s/m^2), K_b (s^{-1})
Cake-intermediate	$\frac{P}{P_0} = exp(K_i J_0 t)(1 + \frac{K_c J_0}{K_i}(\exp(K_i J_0 t) - 1))$	K_c (s/m^2), K_i (m^{-1})
Complete-standard	$\frac{P}{P_0} = \frac{1}{(1 - K_b t)(1 + \frac{K_s J_0}{2K_b} \ln(1 - K_b t)^2}$	K_b (s^{-1}), K_s (m^{-1})
Intermediate-standard	$\frac{P}{P_0} = \frac{\exp(K_i J_0 t)}{(1 - \frac{K_s}{2K_i}(\exp(K_i J_0 t) - 1)^2}$	K_i (m^{-1}), K_s (m^{-1})

Cake-standard	$\frac{P}{P_0} = \left(1 - \frac{K_s J_0 t}{2}\right)^{-2} + K_c J_0^2 t$	K_c (s/m^2), K_s (m^{-1})