Salt stress in MBRs: dynamics of sludge properties, membrane fouling and remediation through PAC dosing

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Abstract: The influence of a monovalent salt shock on sludge composition and filterability was monitored in a pilot-scale membrane bioreactor (MBR) for wastewater treatment. High-frequency sampling of sludge throughout the experiment revealed the dynamics of key sludge parameters, such as submicron particle concentrations in suspension, floc size distribution and both sludge-bound and supernatant extracellular polysaccharides (EPS). A clear increase in submicron particles, supernatant proteins and polysaccharides shortly after the salt shock, in combination with higher reversible membrane fouling rates, indicated a deterioration of the sludge quality and decrease of filterability. A similar salt shock experiment with powdered activated carbon (PAC) addition for remediation proved successful as it resulted in no significant increases of abovementioned parameters.

Keywords: salt shock; submicron particle size concentration; floc size

Introduction

Full-scale MBR plants for wastewater treatment are susceptible to inflow disturbances. Specifically for combined sewer systems and industrial wastewater flows, monovalent salt shocks in the inflow can deteriorate sludge quality and increase membrane fouling. Pilot-scale experiments have indicated an increase in membrane fouling and thus decreased sludge filterability (Reid et al., 2006; Remy et al., 2011) but the underlying mechanisms are still not well understood. Moreover, while it seems reasonable to relate certain fouling events to increased monovalent salt concentration, for full-scale MBRs, the combined effects of salt, temperature and other possible disturbances blur the assessment of this relationship. This experimental study therefore aims to provide more insight in the dynamics of activated sludge during a salt shock by focusing on high-frequency monitoring of key sludge parameters.

Material and methods

Two identical lab-scale pilot MBRs (A, B) with hydraulic retention time (HRT) of 8h, sludge retention time (SRT) of 15 days and a volume of 25L were fed with conventional wastewater (COD: 307mg/L ± 123) and continuously monitored. MBR A served as a blank without any additions, MBR B experienced a continuous shock load (NaCl = 0.2%) during six hours in the first experiment. In the second experiment, 0.5g PAC per liter sludge was added as well. Measurements included EPS (in sludge and supernatant), submicron particle concentration ([10-600nm], Nanosight NS500), floc size distributions (DIPA 2000) and improved flux step tests (van der Marel et al., 2009) while PAC was applied for remediating salt shock effects by enhancing flocculation.

Results and discussion

The filterability tests indicated a significant increase in fouling rate starting within hours after initiating the salt shock. This effect lasted for approx. 2 HRT. The same trend could be seen for submicron particle concentration, i.e. increasing concentrations during the salt shock, followed by a return to values similar to the blank reactor (Figure 1.1). The addition of PAC resulted in a non-significant change in fouling rate and submicron particle concentration (Figure 1.2).

In general, salt shock-induced changes in sludge composition were observed for max. 2 HRTs before returning to steady state values, suggesting the reversibility of a salt shock. During this period, PAC addition could attenuate undesired effects of a salt shock on sludge filterability and membrane fouling. More results (LC-OCD, floc size distribution and EPS) and discussion regarding the link between salt shocks and increase in submicron particle concentration will be included in the full paper.

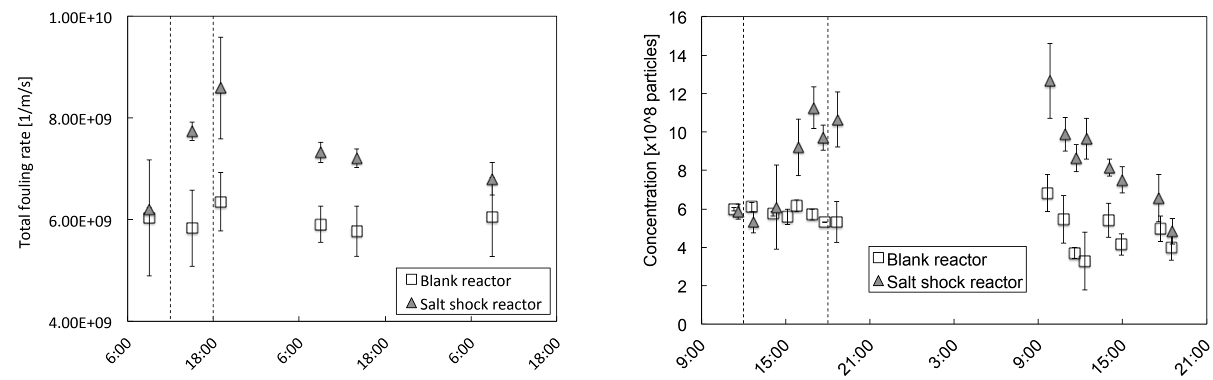

Figure 1.1: Fouling rate (left) and submicron particle concentration (right) for a blank reactor vs. salt shock reactor. Vertical dashed lines indicate start and finish of the salt shock.

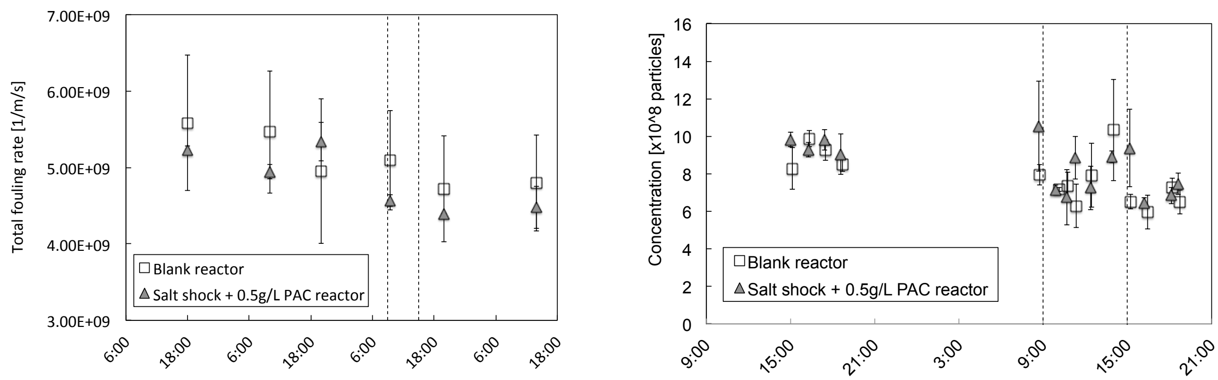

Figure 1.2: Fouling rate (left) and submicron particle concentration (right) for a blank reactor vs. salt shock + 0.5g/L PAC reactor. Vertical dashed lines indicate start and finish of the salt shock.

References

Reid, E., Liu, X., & Judd, S. 2012. Effect of high salinity on activated sludge characteristics and membrane permeability in an immersed membrane bioreactor. *J. Membr. Sci.* **283**, 164–171.

Remy, M., Temmink, H, van den Brink, P., & Rulkens, W. 2011. Low powdered activated carbon concentrations to improve MBR sludge filterability at high salinity and low temperature. *Desalination* **276**, 403–407.

Van den Broeck, R., Van Dierdonck, J., Caerts, B., Bisson, I., Kregersman, B., Nijskens, P., Dotremont, C., Van Impe, J.F., & Smets, I.Y. 2010. The impact of deflocculation–reflocculation on fouling in membrane bioreactors. *Sep. Pur. Technol.* **71**, 279–284.

van der Marel, P., Zwijnenburg, A., Kemperman, A., Wessling, M., Temmink, H., & van der Meer, W. 2009. An improved flux-step method to determine the critical flux and the critical flux for irreversibility in a membrane bioreactor. *J. Membr Sci*, **332**, 24–29.