The contribution of various sludge fractions to fouling in membrane bioreactors

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Contribution of various sludge fractions to fouling in membrane bioreactors

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Introduction

Membrane bioreactors (MBR) for wastewater treatment provide high effluent quality, low footprint and efficient sludge degradation. However, the technology is limited by the accumulation of sludge compounds (fouling) on and within the membranes, which reduce the performance of the filtration process. Therefore, several studies have been performed in order to characterize and limit fouling in MBR. It is still not well described how the different sludge fractions (flocs, bacteria, colloids, extracellular polymeric substances (EPS) and macromolecules) influences fouling (1). The resistance-in-series experimental approach is often applied (1) but the method uses an indirect approach to assess the contribution of sludge fractions as it is assumed that fractions resistances are additive.

Aim

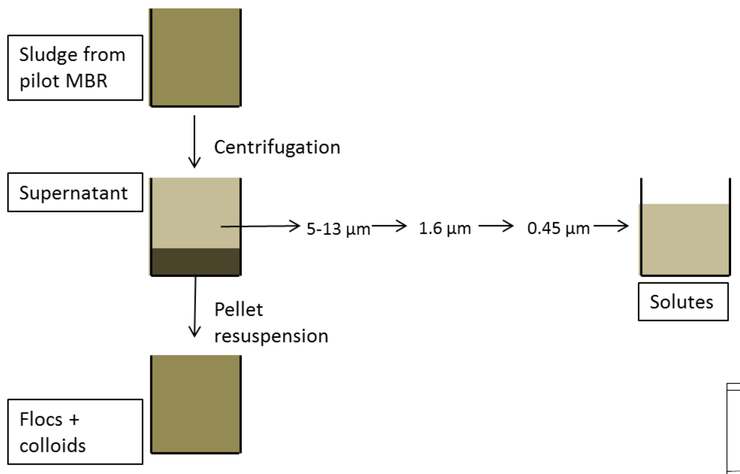
To analyze the fouling potential of different sludge fractions with an alternative approach: analyzing the relevant fractions and their filtration properties individually by transmembrane pressure (TMP) stepping experiments. Sludge supernatant, solutes and flocs are extracted from sludge samples and model solutions of EPS and bacteria are produced, to investigate their filtration properties.

Methodology

Sludge compounds filtration properties

Filtrations of:

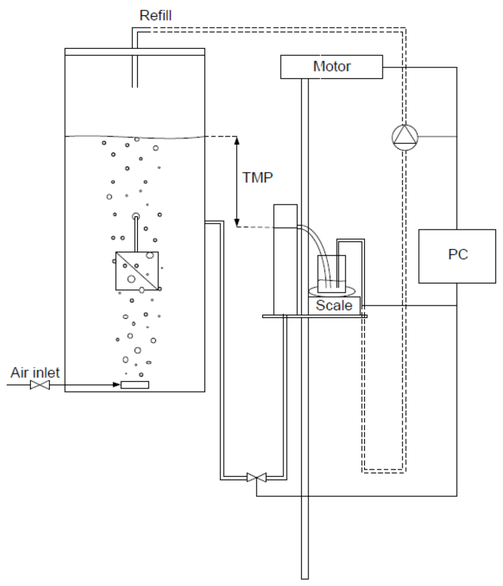
- Fractionated sludge samples (see figure below)
- A model solution of extracellular polymeric substances (EPS) containing protein and humic acid
- *Pseudomonas* UK4 in phosphate buffer
- Model supernatant of EPS and Pseudomonas UK4 in concentrations ranging from 1 ·10^5 cells/mL to 1·10^9 cells /mL



Filtrations methodology

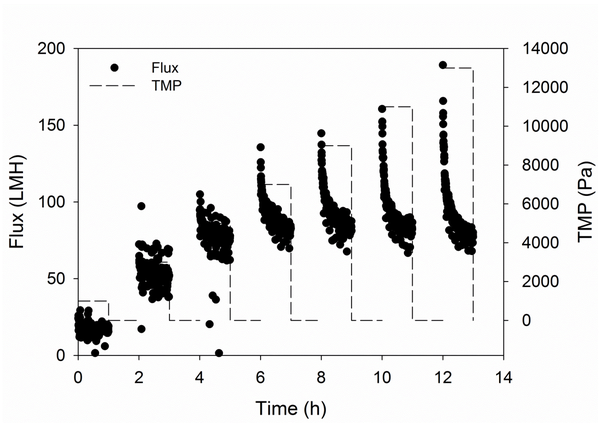
TMP-step filtrations and modeling (2) to determine:

- Limiting flux, J_{LIM},
- Initial specific resistance, α_0,
- Compressibility parameter, P_a.

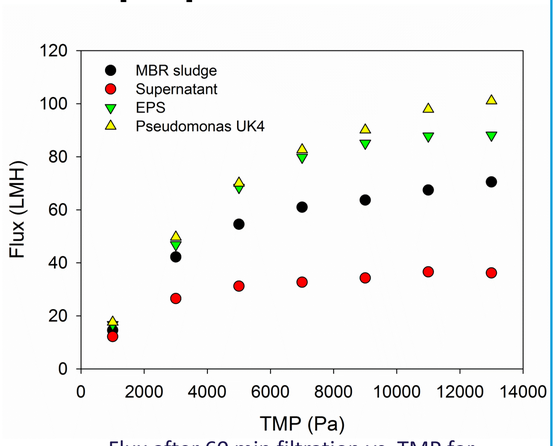


Filtration system with immersed flat sheet PVDF membrane scoured with air.

Sludge compounds filtration properties



Flux and TMP vs. time in a TMP-step filtration experiment.

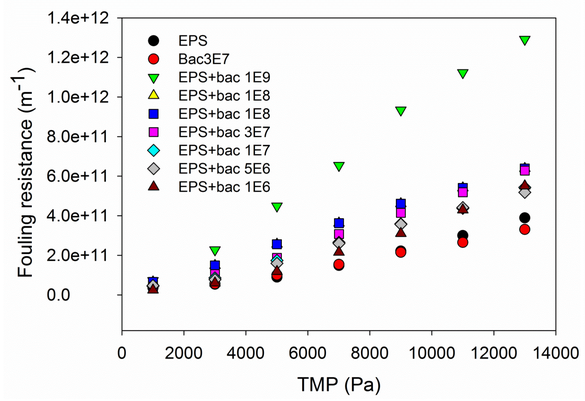


Flux after 60 min filtration vs. TMP for filtrations of different sludge compounds.

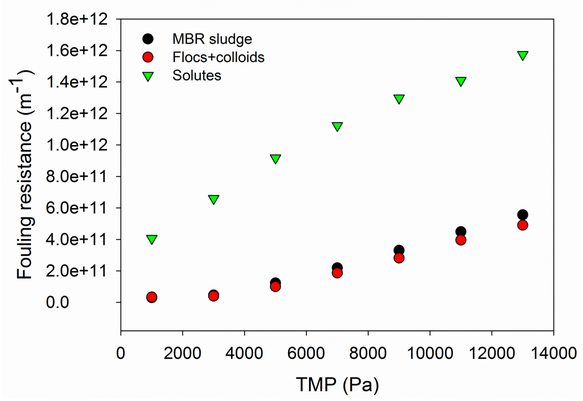
Limiting flux and fouling layer specific resistance and compressibility parameters for filtrations of sludge sludge supernatant, model EPS and Pseudomonas UK4 bacteria.

	Sludge	Supernatant	EPS	Pseudomonas UK4
SS (g/L)	9.57	0.68	0.03	0.003
J_{LIM} (LMH)	70	37	88	101
R_c (1/m)	4.2E+11	1.0E+12	3.3E+11	2.8E+11
α_0 (m/kg)	9.9E+10	5.8E+12	1.7E+13	3.1+E14
P_a (Pa)	504	2160	6480	(incompressible)

Flocs and bacteria influence on fouling



Fouling resistance after 60 min filtration of solutions with EPS and bacteria in varying concentrations.



Fouling resistance after 60 min filtration of fractionated sludge samples.

Findings

- Single cell bacteria and EPS suspensions show lower filtration properties than MBR sludge in terms of lower flux and higher specific resistance of fouling layers.
- Single cell bacteria and EPS solutions form fouling layers that are less compressible than MBR sludge and supernatant.
- For EPS and bacteria suspensions, higher concentrations of bacteria showed higher degree of fouling.
- The resistances of fouling layers formed by single sludge fractions are not additive. Sludge flocs are beneficial for filtration, as they form a fouling layer with low specific resistance and high permeability.
- Future investigations should involve changing the relative content of solutes, colloids and bacteria to sludge flocs in MBR sludge rather than analyzing single fractions filtration properties.

References

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