In-situ, on-line biofouling monitoring in gravity-driven membrane filtration system using optical coherence tomography

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Introduction

Gravity-driven membrane (GDM) filtration is a promising membrane bioreactor (MBR) configuration. The system is operated under ultra-low pressure by gravity, requiring a minimal energy. Its potential for decentralized systems in developing countries has been proved considering insufficient energy and capital sources. Biofouling as a bottleneck in all membrane systems, is of great interest in GDM research. The flux stabilization observed in several studies is attributed to the cake layer formation and structure changing on membrane surface (Akhondi et al., 2015). Besides, the mechanism of membrane fouling in GDM can be different from that in normal MBR, which is usually equipped with pumps for extra pressure (Peter-Varbanets et al., 2011). Present researches on GDM system provide information on flux and fouling performance under various operating parameters and with different membrane modules, but mostly are limited to seawater pre-treatment and surface water treatment, and only a few mentioned about wastewater treatment. The objective of this study was therefore, to evaluate the filtration performance and fouling aspects in a submerged GDM filtration system for advanced wastewater treatment.

Material and Methods

A flat-sheet polysulfone ultrafiltration (UF) membrane was immersed in a GDM filtration cell, fed with two different concentrations of secondary wastewater effluent. Morphology of biofilm layer was acquired by an in-situ and on-line optical coherence tomography (OCT) scanning in a fixed position at regular intervals. The thickness, roughness and cake layer porosity calculated from OCT images were related to the variation of flux, fouling resistance and permeate quality. At the end of experiment, fouling was quantified by total organic carbon (TOC) and adenosine tri-phosphate (ATP) method. Confocal laser scanning microscopy (CLSM) was also applied for biofouling morphology observation. The reversibility of cake layer was tested by contact angle measurement before and after physical cleaning.

Results and Discussion

In this study, the filtration performance of a GDM system was evaluated and the fouling development was monitored. Fouling characterization and reversibility were tested as well. After 30 days running, the flux stabilization was observed, and a lower concentration of influent in the second experiment led to a higher level of stabilized flux (**Figure 1**). The dynamic evolution of biofouling was confirmed by OCT scanning (**Figure 2**). Acquirement of morphology descriptors (i.e. thickness, relative roughness, absolute roughness and porosity) matched well with flux and resistance variation, which can be divided into four phases. The measurement of effluent quality indicated satisfying removal efficiency in the system. Especially, with developing of the fouling layer, permeate quality was improved. A fouling characterization was carried out and the contact angle of membrane under different conditions was measured. The contact angle of the membrane

after basic physical cleaning was recovered (**Table 1**), indicating the high reversibility of cake layer on the membrane under ultra-low pressure operation. The potential of GDM in both flux maintaining and long-term operation in advanced wastewater treatment with high quality of effluent was demonstrated.

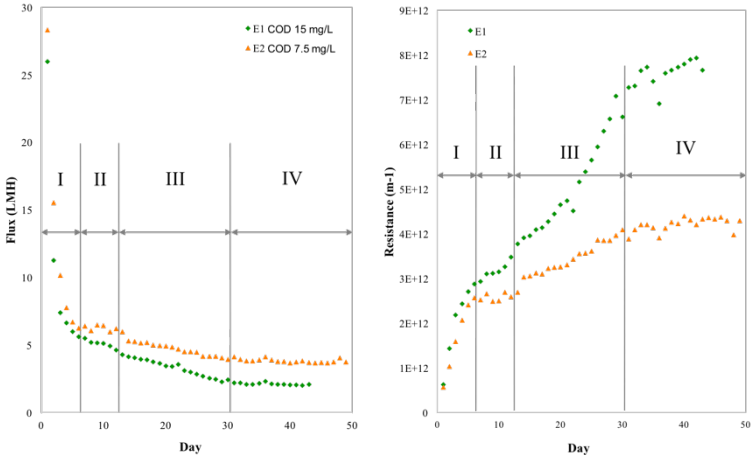


Figure 1. Variations of flux and resistance during the experiments divided into four phases.

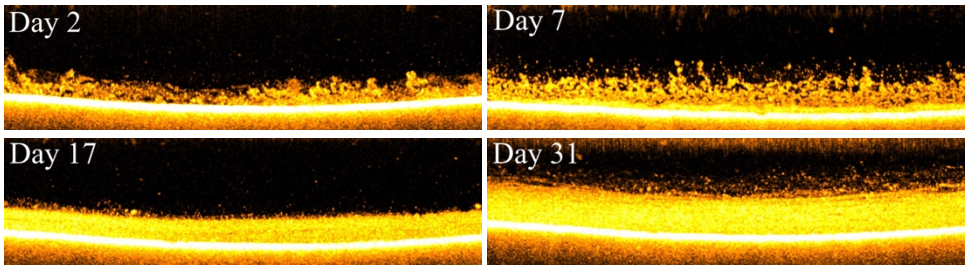


Figure 2. Evolution of biofilm morphology by OCT routine scanning over the time.

Table 1. Variations of contact angle of virgin membrane and fouled membrane before and after cleaning.

Samples	Average contact angles (°)
Virgin membrane	61.22±1.23
Fouling membrane	27.46±2.42
Physical-cleaning membrane	60.53±0.58

Conclusions

An energy-saving gravity-driven membrane (GDM) filtration system was tested and evaluated for advanced wastewater treatment. Fouling evolution was monitored by OCT and the morphology was described quantitatively. Flux variation and effluent quality was associate with the fouling development. The fouling characterization and reversibility test confirmed a long-term operation of GDM filtration system with satisfactory performance. This study provides integrated approach to assess both the filtration process and fouling condition in a membrane based system.

References

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