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Short Communication

Osmotic pressure effect on membrane fouling in a submerged anaerobic membrane bioreactor and its experimental verification

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HIGHLIGHTS

- Cake layer formed on membrane was hydrated, rich of EPS and negative charged.
- A mathematical model of osmotic pressure from cake layer filtration was developed.
- Osmotic pressure accounted for the largest fraction of the operation pressure.
- Osmotic pressure effect was a major mechanism responsible for fouling in MBRs.

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ABSTRACT

A laboratory-scale submerged anaerobic membrane bioreactor (SAnMBR) treating sewage was used to investigate the membrane fouling mechanism. Characterization of cake layer formed on membrane surface showed that cake layer was hydrated, rich of extracellular polymeric substances (EPS) and negative charged with the charge density of 0.21–0.46 meq/kg MLSS. Detailed analysis revealed a new membrane fouling mechanism, osmotic pressure during cake layer filtration process due to the interception of ions. An osmotic pressure model was then developed to elaborate the existence of osmotic pressure and to estimate the contribution of osmotic pressure to membrane fouling. The calculated results showed that osmotic pressure accounted for the largest fraction of total operation pressure, indicating that osmotic pressure generated by the retained ions was one of the major mechanisms responsible for membrane fouling problem in MBRs. These findings provided a new insight into membrane fouling in MBRs.

1. Introduction

Membrane bioreactor (MBR) technology offer many advantages over the conventional activated sludge process, and has been considered as one of the most promising processes for wastewater treatment and reclamation in the past decades (Drews, 2010; Huang et al., 2010; Lin et al., 2012; Spagni et al., 2012). However, its widespread application is restricted by membrane fouling (Drews, 2010; Kola et al., 2012; Lin et al., 2012) which reduces productivity and increases operational costs, mainly due to the requirement of extra cleaning and backwashing and increased trans-membrane pressures (TMP) to obtain constant permeate production (Drews, 2010; Huang et al., 2010). The investigation of the mechanism of membrane fouling is essential to the development of effective fouling control strategies for MBRs.

In general, cake layer formation is the predominant cause of membrane fouling in a submerged MBR (SMBR) (Cho and Fane, 2002; Lin et al., 2009). The bulk activated sludge in SMBR is apparently the source of cake layer formed on membrane surface. Therefore, the cake layer properties and membrane fouling are highly determined by the activated sludge properties. A generally accepted model of activated sludge consists of aggregated microbial organisms and colonies, embedded in a matrix of extracellular polymeric substances (EPS). EPS typically contains polysaccharides, proteins, humic compounds and nucleic acids (Laspidou and Rittmann, 2002). All these polymeric substances carry negative charged functional groups including carboxyl, phosphoric, amine and hydroxyl groups (Pan et al., 2010), leading to the presence of large concentrations of counter-ions within the matrix of EPS for reasons of electroneutrality (Keiding et al., 2001). It has been reported that the charge density of activated sludge was within the range of 0.28–0.63 meq/kg VSS (Morgan et al., 1990; Boyette et al., 2001). The specific structure and charged property of EPS would definitely exert an impact on membrane fouling in MBR. However, the mechanism regarding the

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