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Relation between the stability of activated sludge flocs and membrane fouling in MBR: Under different SRTs

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HIGHLIGHTS

- ▶ MBR flocs stability at different SRTs was estimated based on the modified AE-model.
- ▶ Higher EPS, filamentous bacteria and RH might lead to poorer floc stability.
- ▶ The MBR fouling rate was correlated with the shear sensitivity of sludge flocs.

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ABSTRACT

A recent modified adhesion–erosion model (AE-model) was developed to evaluate stability of activated sludge flocs in membrane bioreactor (MBR). The fouling phenomena and sludge characteristics were also studied. The sludge flocs at higher sludge retain time (SRT) were found to be more stable during the shear test, with a lower shear sensitivity of 0.0199, than the sludge flocs at lower SRT, which had a higher shear sensitivity of 0.0348. There was a close correlation between membrane fouling and the shear sensitivity of sludge flocs under test conditions. The higher shear sensitivity means more primary particles, a less porous fouling layer and a relative higher filtration resistance, leading to a more severe membrane fouling. Sludge characteristics were the main factor influencing floc stability. The sludge with higher extracellular polymer substances (EPS), relative hydrophobicity (RH) and more filamentous bacteria at lower SRT might lead to more loose structure and poorer floc stability.

1. Introduction

Membrane bioreactor (MBR) is being increasingly applied for wastewater treatment, which uses membrane to replace the gravitational settling of the conventional activated sludge process (CASP) for the solid–liquid separation (Delgado et al., 2011; Meng et al., 2009; Zahid and El-Shafai, 2011). Because of the complete physical retention of bacterial flocs, the MBR has many advantages over conventional wastewater treatment processes, including reduced footprint, highly-improved effluent quality, higher biomass concentration and less sludge production (Le-Clech et al., 2006; Zhu et al., 2011). However, membrane fouling, which increases operational and maintenance costs, is a major obstacle to the wide application of MBRs (Clouzot et al., 2011; Kimura et al., 2009).

A large amount of work has been carried out on membrane fouling in MBRs and membrane fouling can be attributed to both membrane pore clogging and sludge cake deposition on the membrane surface, of which the cake layer is usually the predominant fouling component (cake resistance contributed 80% to the total resistance of a submerged MBR) (Khan et al., 2009; Meng et al., 2007; Zhang et al., 2011). It is reasonable to think that sludge flocs play a major role in the formation of the cake layer on the membrane surface (Le-Clech et al., 2006). Sludge flocs consist of a multitude of microorganisms, colloids, extracellular polymeric substances (EPS) and cations (Jost Wingender et al., 1999). In terms of floc size, the particle size distribution of activated sludge is bimodal, with flocs sized 25–100 μm and primary particles sized 0.5–5 μm (Mikkelsen and Keiding, 1999). The primary particles in sludge flocs are to large extent single bacteria, but may contain other colloidal matter. Primary particles were removed from sludge surface by hydrodynamic force, and due to the small size of primary particles, might have a significantly negative effect on membrane fouling. A larger number of fine flocs can cause the clogging of the porous structure formed by the larger particles in sludge cakes during conventional filtration, leading to high specific cake resistance (Mikkelsen and Keiding, 2002). In MBR, the smaller fractions of poly-disperse particles deposited on the membrane

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