Influence of mechanical mixing rates on sludge characteristics and membrane fouling in MBRs

JAMAL KHAN S. [a], VISVANATHAN C. [a], JEGATHEESAN V.[b] and BEN AIM R.[c]

[a]Environmental Engineering and Management Program, School of Environment, Resources and Development, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand (E-mail: visu@ait.ac.th)

[b]School of Engineering, James Cook University, Townsville, Queensland 4811, Australia

[c]UMR5504, UMR792 Ingénierie des Systèmes Biologiques et des Procédés, CNRS, INRA, INSA, F-31400, Toulouse, France

Abstract

The influence of mixing intensities in terms of mechanical mixing on activated sludge characteristics as well as membrane fouling in membrane bioreactors (MBRs) was investigated. Four MBRs were operated at similar operating conditions with variation of mixing intensities. The control reactor (MBR 1) was operated with aeration only supplemented by mechanical stirring at 150, 300 and 450 rpm in MBR 2, 3 and 4, respectively. Particle size distribution (PSD), soluble and bound extracellular polymeric substances (EPS), capillary suction time (CST) and specific cake resistance (α) of the mixed liquor and their correlation with membrane fouling was studied. It was found that MBR 3 showed minimum fouling in terms of membrane operating time. In addition, the fouling potential of the MBR 3 mixed liquor in terms of CST and α was lowest. The soluble EPS increased with increase in velocity gradient (G). Moreover, it was found that the mean particle size decreased and the dispersion of PSD increased with increase in the G value. These results reveal that biofouling can be significantly controlled by inducing appropriate rapid mixing conditions.

Keywords: Membrane fouling; Mixing intensity; Particle size distribution; Extracellular polymeric substances (EPS); Specific cake resistance

1. Introduction

Membrane bioreactor (MBR) offers several advantages compared with conventional wastewater treatment processes including high biodegradation efficiency, excellent quality of effluent, smaller sludge production and compactness (Stephenson et al., 2000). However, the wide spread application of the MBR process is constrained by membrane fouling and it is considered as the most serious problem affecting system performance. Fouling results in permeate flux decline due to the interaction of the membrane and activated sludge leading to more frequent membrane cleaning and necessary membrane replacement. Fouling of membranes in MBRs is determined by three factors, the nature of the feed to the membrane, the membrane properties and the hydrodynamic condition experienced by the membrane (Zhang et al., 2006).

So far, several techniques for fouling control have been investigated including sub-critical flux operation, intermittent suction and backwashing (Chang et al., 2002). Moreover, membrane scouring with aeration has been an effective technique for fouling reduction in submerged MBRs. Lee et al. (2006) found that membrane fouling in terms of rate of trans-membrane pressure (TMP) rise was dependent on air flow rate and TMP rose up more slowly with the increase in airflow rate. It was further established by Lee et al. (2006) that the increase in membrane operating time was attributed to crossflow aeration despite decrease in microbial floc size. Generally, the aeration intensity necessary to provide adequate mixing of the activated sludge and control of cake layer formation is often much more than required for maintaining oxygen supply to the microorganisms. In recent researches, MBRs were operated with diffuser at the base to maintain aerobic condition and additional diffuser for air scouring of the membrane module (Le-Clech et al., 2003; Germain et al., 2005). The sludge characteristics affect fouling of membranes and have been investigated biologically by varying sludge retention time (SRT) (Lee et al., 2003; Bouhabila et al., 2001). The present study aims at modifying the properties of the activated sludge and investigating physical control of membrane fouling by introducing mechanical mixing in addition to aeration. The sludge