

# Investigating the effect of colloids on the performance of a biofilm membrane reactor (BF-MBR) for treatment of municipal wastewater

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## Abstract

Performance of membrane reactor in combination with moving-bed-biofilm reactor (BF-MBR) for treatment of municipal wastewater was investigated in relation to different organic loading rates; high and low rates. The membrane was operated with a constant flux of 50 LMH and 96% recovery. The fouling rate was evaluated as development of the trans-membrane pressure (TMP) during the operational time. Suspended solids (SS) concentrations, organic matter (COD/FCOD), particle size distributions (PSD), capillary suction time (CST) and time to filter (TTF) were measured daily and further related to TMP in order to determine major fouling factors. A higher fouling potential was observed for high-rate operating conditions. A fraction of organic matter below 1.2  $\mu\text{m}$  was mostly related to changes in TMP. Furthermore, a higher amount of particulate fraction below 0.1  $\mu\text{m}$  in membrane reactors during high-rate operating conditions presented a dominant contribution to membrane fouling and colloidal fouling.

**Keywords:** biofilm membrane reactor, colloidal fouling, particle size distribution, fractional COD distribution

## Introduction

Membrane bioreactors (MBR) combine the biological treatment processes with membrane filtration to provide an advanced level of organic and SS removal. The process is a refinement of the conventional activated sludge (AS) process where membranes primarily serve to replace the clarifier. The current and most commonly used MBR reactor design employed in municipal wastewater treatment is the submerged process configuration where the membrane modules are immersed in an aerated biological reactor (AS-MBR). An alternative treatment scheme to the AS-MBR is combining a biofilm reactor with membrane filtration for enhanced biomass separation (BF-MBR) (Leiknes et al., 2005; Åhl et al., 2005; Melin et al., 2005). Biofilm processes are also used in wastewater treatment and several reactor designs can be applied, i.e. trickling filters, rotating biological contactors, fluidised bed reactors etc. The moving bed biofilm reactor (MBBR) is an alternative biofilm reactor supplied by AnoxKaldnes (Norway). The MBBR process consists of small plastic biofilm carriers used to create a very large surface area for the biofilm to grow on and are suspended in the reactor by aeration (Ødegaard et al., 1994). Compared to other biofilm reactors the MBBR tolerates high particulate and organic loading rates and is not susceptible to clogging by particulates (Ødegaard et al., 2000). The process is also very compact compared to conventional AS processes. A critical and inherent feature in any membrane process is fouling of the membrane. Understanding and controlling membrane fouling will therefore be a central issue in developing either of the systems. Fouling is caused by different

substances (i.e. solids, particles, dissolved constituents) and the mechanisms are rather complex and interrelated. The SS concentrations in the effluent from an MBBR reactor are typically below 200 mg/l depending on site wastewater characteristics and loading rates and the SS to be removed from the effluent are therefore relatively low. This aspect of the process is beneficial when considering the combination of the biofilm reactor with membrane separation of the biomass. Given that the high MLSS concentrations commonly used in AS-MBR processes present a fouling issue, one would expect that a benefit of the BF-MBR would be to reduce membrane fouling as operation with low SS loading is possible. Coupling a compact biofilm process with efficient particle separation potentially provides a stable high-quality effluent with the possibility for better fouling control based on lower SS in the membrane reactor.

Membrane fouling manifests in various ways and certain types of fouling (reversible) can be removed by backwashing, i.e. cake formation and loose deposits, while others are permanent (irreversible), fouling which is only recoverable by chemical cleaning (Leiknes et al., 2005). A key factor to MBR development is fouling minimisation and control. A lot of effort and research has been done to gain more knowledge of the phenomenon in the past 10 to 15 years. A literature review shows that the number of references sorted out with the keywords: fouling and membrane and (particle or suspension or dispersion) raised from less than 5 in the early 1990s to around 40 per year in 2004 (Aimar, 2003). Suspended solids are very often identified as a main foulant (Defrance et al., 2000; Bae et al., 2005) where the significance of the submicron colloidal fraction in the SS has been reported to correlate with membrane fouling rates (Wisniewski et al., 2000; Li et al., 2005; Rosenberger et al., 2006). In MBR processes fouling has also been attributed to extracellular polymeric substances (EPS) and soluble microbial products (SMP) (Nagaoka et al., 1996; Chang et al., 2002; Li et al., 2005; Rosenberger et al., 2006).

The objective of this study was to investigate the effect of

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