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# Optimised hydrodynamics for membrane bioreactors with immersed flat sheet membrane modules

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ABSTRACT

Since aeration is the largest cost factor in membrane bioreactor (MBR) operation it is clear that the biggest leap towards energy and operational costs savings can be achieved by improving the use of air. Many basics of the complex two-phase flow in membrane modules and in the overall MBR tank as well as their interactions, however, are still poorly understood. This work focuses both on fundamental studies on shear stress exerted by rising bubbles and on optimising the geometries of tank and module accordingly in order to obtain an improved deposition control at minimum energy input. For both, parameter studies were carried out by numerical simulations which were validated with experimental measurements. The optimum bubble size/channel width combination depended on the superimposed liquid velocity. The relationship between the liquid circulation velocity and the aeration intensity was measured for different reactor and module geometries. A modification of the Chisti model for airlift loop reactors was also performed which can be used as a design rule for tank and module geometry or aeration rate. At the same gas flow rate, a 30–50% increase in liquid circulation velocity was achieved by a simple modification of the sparger and the entry zone to the riser section.

***Keywords:*** Air scour; Fouling; Hydrodynamic optimisation; MBR design; Shear stress; Single bubble

## 1. Introduction

One of the main drawbacks of membrane bioreactors (MBRs) are the higher operational costs in comparison to conventional activated sludge plants. Especially the energy consumption for air scouring to limit the cake layer on the membranes still causes significantly higher costs with up to 60% of the total energy costs [1–3].

Gas sparging is an established method to limit depositions on membranes and often the subject of publications related to membrane processes [4]. More literature is available on gas/liquid flow inside tubular membranes [5] or around submerged hollow fibres [6–8]. Due to this and the fact that hydrodynamic parameters such as the bubble distribution are somewhat easier to control in flat sheet than in hollow fibre modules, this work will focus on the former. Since many fundamentals of multiphase flow in MBRs are still unknown and difficult to access experimentally, there is no common way to construct and operate flat sheet modules as yet (see Table 1) which leads to a wide range of specific aeration demand ($SAD_m$) values and waste of energy.

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