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ScienceDirect
Desalination 236 (2009) 135–142
DESALINATION
www.elsevier.com/locate/desal

Membrane air flow rates and HF sludging phenomenon in SMBR

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Received 30 June 2007; revised accepted 7 October 2007

Abstract

This paper sets out to characterize the sludging dynamics in a MBR hollow fibre system. Rates of sludge accumulation inside the membrane bundle and rates of sludge removal by aeration are evaluated in order to reach the optimal use of membrane aeration, avoiding any irreversible sludging. Experiments were performed in a submerged membrane bioreactor. Capillary membrane modules were placed on the outside of the bioreactor in a side stream position. Air was injected below each membrane module, ensuring vertical air lift circulation. During experiments, two air flow rates were compared (100 and 300 L/h). Some membrane air bubbling characteristics are described in terms of bubble size and bubble penetration inside the HF bundle. Results showed that membrane air flow rates appeared as a determining criterion to minimize sludging when filtering under intensive conditions (30 LMH permeate flux, 8–10 g/L TSS) with an air flow rate of 300 L/H allowing continuous functioning, and an air flow rate of 100 L/h which did not. Specific experiments to evaluate sludge removal rates from the HF bundle showed the high capacity of aeration to remove sludge from the HF bundles as soon as no dead zones appeared. These dead zones corresponded to local dried sludge accumulation (10–12% DM). The compactness of such dried deposit appeared non-reversible even when practising the higher 300 L/h membrane air flow rate, inducing a more intensive filtration condition in the working zone and more intensive irreversible sludging.

Keywords: Air flow rate; Hollow fibre; Membrane bioreactor; Sludging

1. Introduction

In submersed membrane bioreactors SMBR, hollow fibre HF configurations are attractive technologies because of their great filtration area developed by volume unit. Nevertheless, membrane fouling control remains one of the main factors which limit the wide development of HF technologies due to irreversible sludge

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Presented at the International Membrane Science and Technology Conference, IMSTEC 07, 5–9 November 2007, Sydney, Australia

doi:10.1016/j.desal.2007.10.060

accumulation on and between fibres (sludging phenomenon).

One of the most common strategies to reduce and control sludging is to practise varying degrees of aeration close to membrane surfaces [1,2] inducing local shear stress and favouring hydraulic distribution throughout the fibre network. However membrane aeration represents an important part of SMBR functioning costs [3] and it appears important to achieve an optimized use of the membrane air process.

Many parameters affect membrane aeration efficiency and the induced hydraulic distribution, largely depending on the module configuration relative to its size, fibre density, fibre length and diameter [4–6]. To limit membrane fouling and sludge accumulation, the importance of (i) fibre movement [7], (ii) adequate distance between fibres [8], (iii) air diffuser arrangement below or inside the fibre bundle [9,10], unsteady aeration conditions and sludge concentration in the bulk [11] have also been pointed out.

To illustrate the difficulty of sludging control in SMBR equipped with submersed HF bundles, experiments were carried out in a lab scale bioreactor equipped with external filtration cells, where air flow distribution around HF bundles was perfectly defined. Sludging intensity was evaluated according to air membrane intensity. To permeate flux intensity, specific experiments were conducted to evaluate the air membrane capacity to remove sludge from bundles.

2. Materials and methods

2.1. Description of pilot set up

Experiments were performed in a submerged membrane bioreactor (Fig. 1) composed of two parts: the bioreactor (50 L) and external side-stream filtration cells packed with HF membrane bundles.

The MBR was ring shaped to favour the perfect circulation and mixing of the biological suspension.

Two filtration cells equipped with hollow fibre bundles were placed outside the bioreactor in a side stream position. Air was injected beneath each membrane bundle. The rising of air bubbles ensured a vertical air-lift circulation which led to circulation of the liquid between membrane modules and bioreactor. To avoid any sludge accumulation in the filtration cells

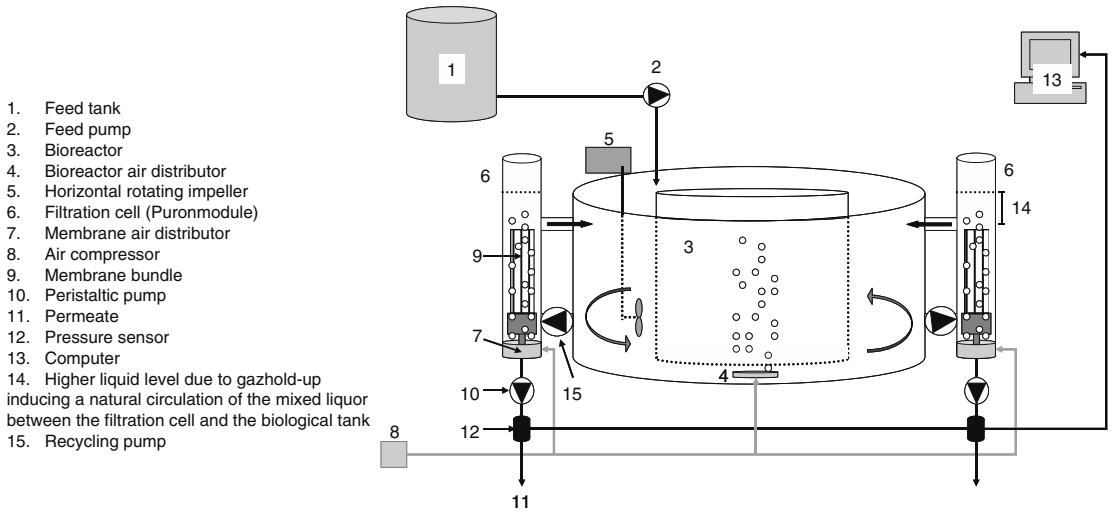

Fig. 1. Pilot configuration.