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## **► To cite this version:**

Romuald van Kaam, Dominique Anne-Archard, Marion Alliet, Simon Lopez, Claire Albasi. Aeration mode, shear stress and sludge rheology in a submerged membrane bioreactor: some keys of energy saving. *Desalination*, 2006, 199 (1-3), pp.482-484. 10.1016/j.desal.2006.03.112 . hal-01623792

**HAL Id: hal-01623792**

**<https://hal.science/hal-01623792>**

Submitted on 25 Oct 2017

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# **Aeration mode, shear stress and sludge rheology in a submerged membrane bioreactor: some keys of energy saving.**

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## **Introduction**

It is nowadays well known that Membrane Bioreactors (MBR) are advantageous processes allowing to guarantee a rejection of treated effluent respecting both reliability and recent sanitary rules of the European Community. However main drawback for these processes remains the fouling of the membrane which reduces the production performances of the bioreactor. Fouling depends on many parameters dealing with physico-chemistry, biology and operating conditions. It depends in particular on the flocculation state of the sludge. Roughly, it can be take as an assessment that the more flocculated the sludge is the weaker the fouling becomes.

In the case of immersed membrane bioreactors, the mixed liquor flocculation can be altered by the shearing generated by the aeration used to limit the fouling. The goal of our work is thus to study the potential of shearing generated by the system of aeration on the sludge flocculation. Rheological analyses are a possible key of explanation and lead to a process control proposal.

This work intends to show how a precise characterization of the flocculation state of the mixed liquor is thus of primary importance in order to optimize the choice of the operating conditions of the bioreactor.

## **Experimental**

### *Membrane Reactor*

The experimental study was performed using a 10 L submerged membrane bioreactor (SMBR). Bundle of 0.3 m<sup>2</sup> u-shaped polysulfone hollow fibres membrane provided by Polymem was submerged in the bioreactor. The permeate was continuously removed by a volumetric pump under a constant flux of 10 L/h.m<sup>2</sup>. The operating parameters were continuously recorded by a DasyLab control program. To prevent fouling alternative solutions were applied: no-suction time, backflushing and tangential aeration close to the membrane surface.

### *Sludge Characterization*

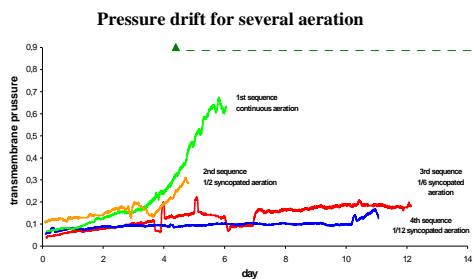
Sludge samples are taken from the immersed membrane bioreactor treating synthetic or domestic water. Results for both types of effluents are discussed.

It was characterized on one hand by the settling index, indicating the flocculation state of the sludge. On the other hand, rheological analyses were performed on a Bohlin C-VOR 200 rheometer which allows both viscometry and oscillation modes. Characterizations were done by stepped shear stress or by ramped shear stress with usual cone and plate geometry (typically 2°, 60mm diameter) and with serrated plates.

## **Results and discussion**

The first results show the influence of sequencing the aeration on the fouling limitation. Four aeration regimes were tested in the MBR pilot including continuous and sequenced regimes spending the same volume of aeration. These experiments pointed out the benefit of a

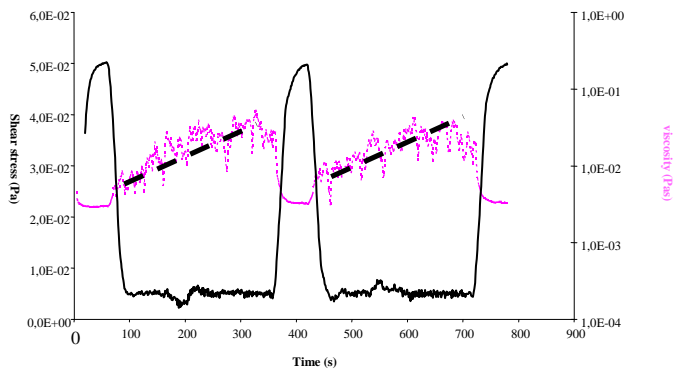
syncopated mode (Figure below). Beside the pilot behaviour, first investigations have been made on the settling ability of the sludge (table below). Continuous aeration leads to deflocculating the sludge.



Mode	Air flow	Settling index
Continue	50 L/h	No settling
1/2	100L/h	not measured
1/6	200 L/h	241 (settling)
1/12	370 L/h	86 (very good settling)

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Depending on the imposed shear stress value, sludge reveals two flow regions where viscosity varies in a factor  $10^4$  (established for stepped shear stress measures). Comforted by additional rheological characterizations, this reveals the viscoplastic behaviour of the sludge from MBR (whatever domestic or synthetic effluents are considered). The corresponding threshold is associated to modifications in the sludge structure, based on granulometric analysis and DCO quantification of the supernatant.



Alternating stepped shear stress below and beyond the threshold (figure above) shows that the fluid can partly recover its structure. This explains why a continuous air injection leads to a more deflocculated sludge than an intermittent one. Moreover, this displays that pauses during the aeration process are of greatest interest and give keys to propose efficient aeration.

Finally a comparison between two different mixed liquors was carried out: the first one was subjected during 15 days to a continuous aeration, while the second one was subjected to intermittent aeration. The rheological analysis was completed with the sludge filterability and the DCO amount in the supernatant. Higher DCO amount and fouling ability for the continuously aerated sludge were found.

An energetic study concludes this work, taking into account the advantages on sequencing the aeration on the sludge quality and on the gain in pressure drift that it induces.

The authors wanted to thank The Conseil Régional Midi Pyrénées for partially financing this work. Polymem, as the person of Olivier Lorain has also to be thanked for freely providing membranes.