MEMBRANE FOULING IN ANAEROBIC MEMBRANE BIOREACTORS

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BACKGROUND

Australian Red Meat Processors can generate large volumes of wastewater rich in organic contaminants and nutrients, and can therefore be strong candidates for treatment processes aimed at recovery of both energy and nutrient resources. Traditional lagoon-based abattoir wastewater treatment processes have a number of limitations relative to newer alternatives. These limitations include land availability (they require relatively large amount of land), biogas capture, odour control, ability to capture nutrients and de-sludging operations. This has led to an emerging and strong case for reactor-based technologies.

Anaerobic Membrane Bioreactors (AnMBRs) are a style of in-vessel anaerobic digester that use diffusive membranes to retain almost all suspended solids within the process (Figure 1), this style of technology is an attractive option to replace lagoons due to its excellent effluent quality, high tolerance to load variations, and ability to produce a solids free effluent for the purposes of reuse.

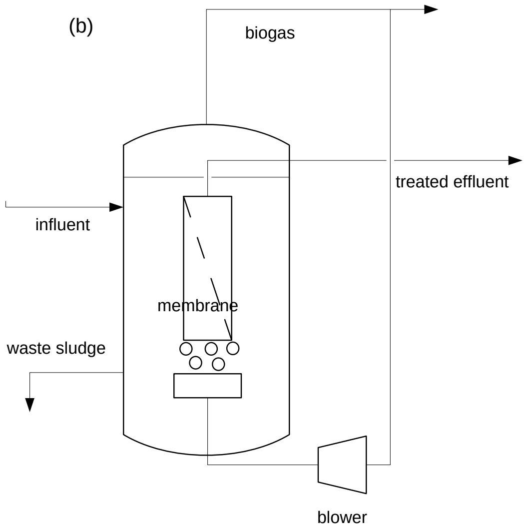

Figure 1: Schematic showing an Immersed AnMBR

AMPC has been working with the University of Queensland to trial a 200L capacity AnMBR pilot plant at two Australian Red Meat Processing Facilities. Cost benefit analysis demonstrates that the capital costs associated with AnMBR technology and the increased operational costs from membrane fouling and membrane cleaning provide strong motivation for ongoing research and optimisation. This factsheet highlights the outcomes of research into improving AnMBR processes by predicting and managing membrane fouling effectively.

WHAT IS MEMBRANE FOULING?

Membrane fouling is the accumulation of material, typically solids, on the membrane surface or within the membrane pores. At lower levels, membrane fouling can have a positive impact on effluent quality by allowing microorganisms to remove soluble material as it passes through the fouling layer. However, at higher levels membrane fouling increases energy requirements to pass material through the membrane, increases the surface area of membranes required, and may ultimately damage the membranes significantly reducing effluent quality.

Membrane fouling is the result of two competing forces; drag and lift. Drag forces result from filtration, as liquid is drawn through the membrane solid particles are also pulled towards the membrane and this encourages fouling. The effect increases as filtration rates increase. Lift forces result from gas sparging in the reactor. As gas passes across the membrane surface, this creates shear and encourages membrane cleaning. When lift exceeds drag (low flux) fouling levels are low and sustainable (Figure 2a). When drag exceeds lift, fouling is accelerated (Figure 2b) and operator intervention is required. The transition point where drag and lift forces are balanced is known as the Critical Flux. Increasing filtration rates beyond critical flux result in a process will require significant ongoing maintenance. However, operation below critical flux decreases membrane efficiency and overall process efficiency.

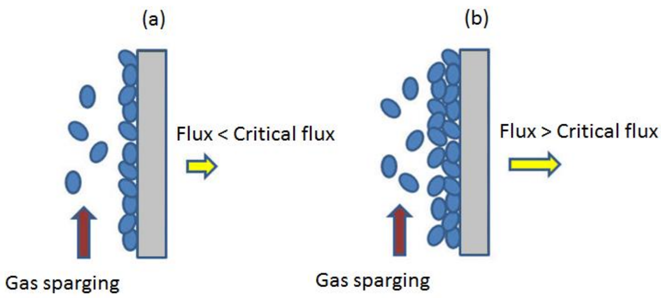

Figure 2: Negligible fouling below critical flux (a) & Accelerated deposition above critical flux (b).

MODELLING MEMBRANE FOULING

Membrane fouling is a complex phenomenon and is influenced by a number of interacting factors. These include the properties of the sludge (stickiness, floc size, cake layer compressibility and viscosity) and process parameters (transmembrane pressure, flux/filtration rate and gas sparging intensity); which can vary between systems and over time. Software model-based analysis that combines multivariable membrane fouling kinetics and hydrodynamic models in an overall model framework provides a better fundamental understanding of the controlling mechanisms of fouling.

Computational fluid dynamics (CFD) employs numerical techniques for the calculation of hydrodynamic parameters such as fluid velocity and shear. UQ have utilised a CFD approach to predict the cake accumulation on the membrane surface within the 200L pilot scale AnMBR.

This model can now be used to assist in design and optimisation of process and operational parameters. The model will also be highly useful in a cost benefit analysis as it allows for dynamic and realistic operational analysis, and can be evaluated in long-term simulations to identify longer term strategies.

Currently, the model calculations are based on numerous properties of the sludge and wastewater in an AnMBR process, such as rheology and stickiness; more detailed analysis of these parameters and factors that impact them, such as waste composition or process temperature would improve the robustness and range of application of the model. Future extensions to the model may be the inclusion of mechanical considerations needed to simulate hollow fibre membranes, biological kinetics and non-liquid shearing.

FURTHER INFORMATION

For further information relating to this fact sheet please contact AMPC via email info@ampc.com.au or by phoning the office on 02 8908 5500.