ANAEROBIC MEMBRANE BIOREACTORS

1.1 Date of issue: XX XX XX

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 membranes to retain almost all suspended solids within the process. 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.

AMPC is working with the University of Queensland (UQ) to develop and optimise AnMBR technology for the red meat processing industry.

PILOT PLANT DESIGN

AnMBRs can be operated in several process configurations (Figure 1), the main difference being the installation of the membrane, either directly within the reactor or located as part of a side-stream re-circulation line. UQ's research is focused on immersed membrane technology.

The AnMBR pilot plant (Figure 2) consists of a 200L stainless steel reactor containing a vertical mounted submerged hollow fibre membrane.

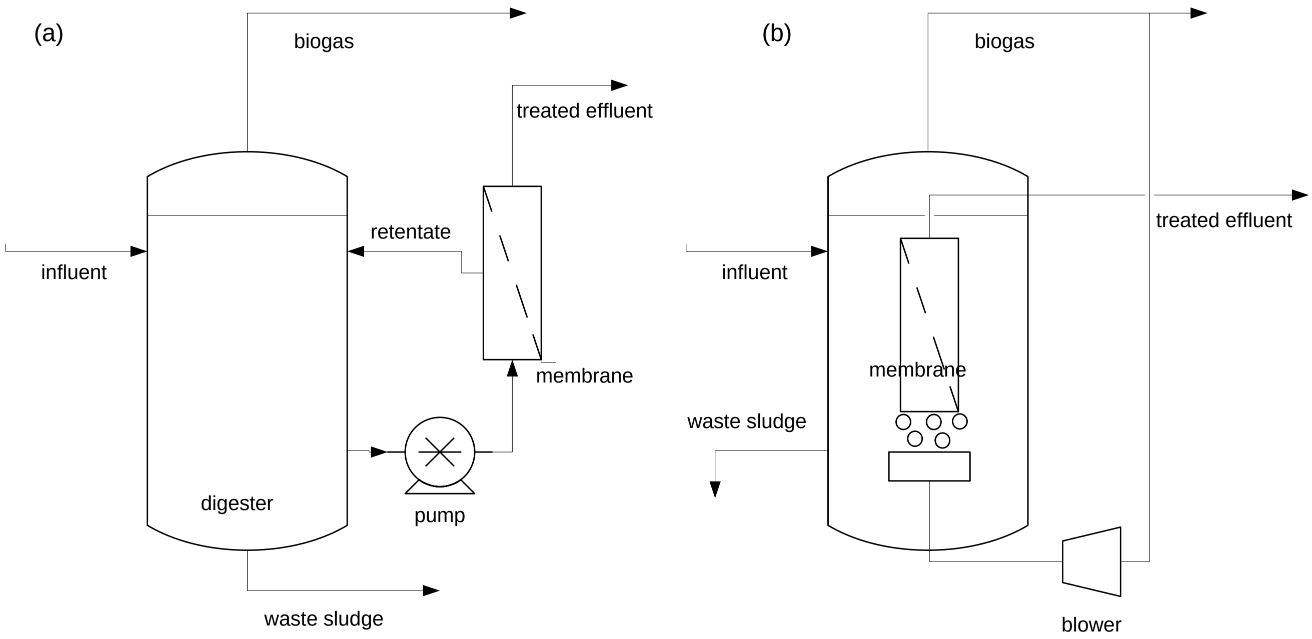

Figure 1: MBR configurations, including (a) Sidestream membrane bioreactor (sMBR) and (b) Immersed membrane bioreactor (iMBR).

Figure 2: AnMBR Pilot Plant and hollow fibre membrane module.

PILOT PLANT PERFORMANCE

The response of methane gas production relative to the organic loading rate (OLR) is shown in Figure 3. Gas production was highly responsive, indicating the process is substrate limited and could operate at higher loads.

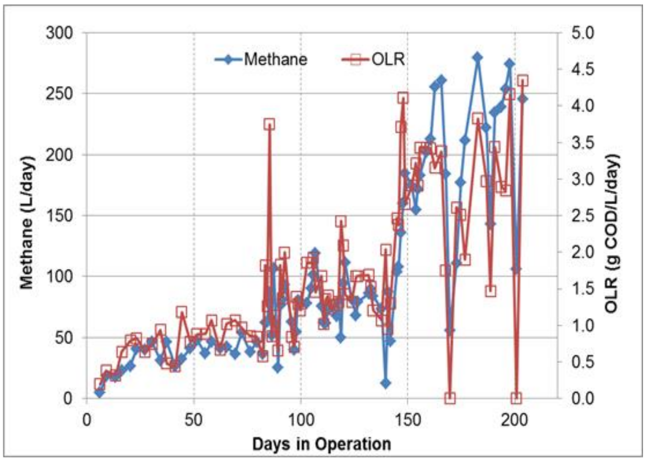

Figure 3: Response of methane production relative to the OLR

The breakdown of chemical oxygen demand (COD) added to the reactor and removed as biogas or treated effluent is shown in Figure 4. COD removal from the wastewater was over 95%. i.e. less than 5% of COD from the wastewater feed remained in the treated permeate while over 95% of COD was converted to biogas. The biogas composition was typically 70% methane (CH_4) and 30% carbon dioxide (CO_2), during full and steady operation methane production corresponded to approximately 760 L CH_4 per kg VS added (365 L CH_4 per kg COD added).

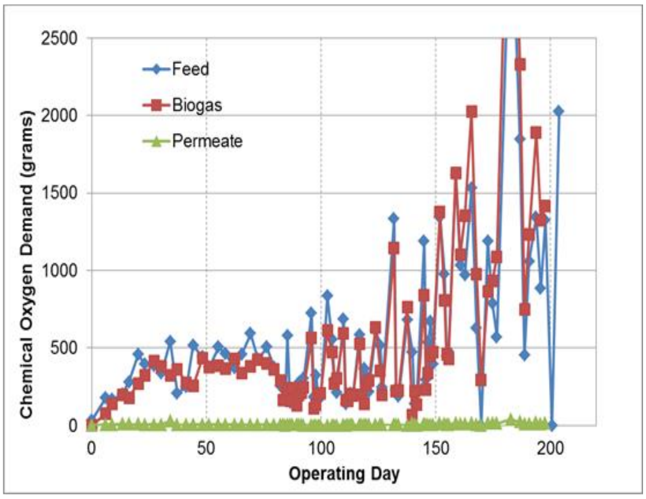

Figure 4: Breakdown of COD added to the reactor and removed as biogas or treated effluent

ECONOMIC ANALYSIS

The capital cost of an AnMBR is comparable to a covered anaerobic lagoon (CAL), when idealized design parameters of 10 kgCOD m^{-3} d^{-1} loading rate and 15 $L.m^{-2}h^{-1}$ membrane flux are used. However the capital cost remains high when using parameters demonstrated in the research to date. The composition of feed wastewater and treated effluent from the Pilot Plant is shown in Table 1.

Project results demonstrated the AnMBR was not operating at maximum capacity which highlights the potential for improved economic outcomes through continued research into process optimization.

Operating costs of an AnMBR show improved revenue compared to a CAL. This is due to increased gas capture resulting in improved energy recovery and the potential to recover nutrients (however the nutrient value represents only 20% of revenue). There are additional benefits such as reduced footprint and improved environmental performance, however the potential impact of these benefits may be specific to each processing facility.

Table 1: Composition of feed wastewater and treated effluent (Permeate) from the AnMBR Pilot Plant

		TS	VS	tCOD	sCOD	FOG	VFA	TKN	NH_3-N	TP	PO_4-P
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Minimum	1,200	900	2,084	470	266	11	107.6	12.0	8.9	3.7
Feed	Average	3,378	2,834	5,919	1,187	1,407	159	190.2	24.4	19.1	7.9

	Maximum	7,000	6,200	13,381	2,778	5,953	566	294.8	59.6	34.6	17.3
Permeate	Minimum	N/A	N/A	23	23	N/A	6	139.6	124.0	8.4	8.3
	Average	N/A	N/A	71	71	N/A	15	172.6	170.2	14.1	12.8
	Maximum	N/A	N/A	379	379	N/A	67	207.2	209.0	38.3	37.1

CONTINUING RESEARCH

Project results demonstrated the AnMBR was not yet operating at maximum capacity. This highlights the potential for improved economic outcomes through continued research into process optimization. There are several areas for improvement through research; i) optimization of the OLR will reduce capital costs of the process vessels; ii) optimization of membrane flux will reduce membrane surface area requirements and associated capital costs, and iii) optimized fouling control will reduce operating expenses.

During operation, nutrient recovery in the effluent accounted for 90% of N (as NH_3) and only 74% of P (as PO_4). As nutrient release was lower than COD removal, this suggests that the AnMBR was not optimized for nutrient recovery. There is further scope for development and optimization of an integrated process for recovery of energy and nutrient recovery resources based on AnMBR and crystallization technology.

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.