SNAPSHOT

AUSTRALIAN MEAT PROCESSOR CORPORATION

Anaerobic Membrane Bioreactors: In vessel technology for high rate recovery of energy and nutrient resources.

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Project Description

Red meat slaughterhouses can generate large volumes of wastewater rich in both organic contaminants and nutrients and can therefore be strong candidates for treatment processes aimed at recovery of energy and/or nutrient resources. The focus of this project was to continue development, optimization and integration of i) anaerobic membrane bioreactors (AnMBRs) as a high rate in-vessel anaerobic technology for recovery of energy from slaughterhouse wastes, and ii) struvite crystallization for low cost recovery of phosphorous (and nitrogen) from slaughterhouse wastes. This project builds on previous research and investment by AMPC and leverages significant investment and expertise from other Australian industries.

Project Outcome

During this project, a pilot-scale process for integrated energy and nutrient recovery (based on AnMBR and struvite crystallization technology) was operated successfully onsite at an Australian slaughterhouse treating combined wastewater. Key process data is shown in the table below. A summary of project outcomes is:

- The maximum organic loading rate to the AnMBR has been identified at 3-4 kgCOD.m^{-3}.d^{-1} and this limit was largely due to the biomass/sludge inventory being maintained in the AnMBR;
- Standard AnMBR operation is under mesophilic temperatures (37°C). Operation at thermophilic temperature (55°C) did not increase maximum organic loading, but may have improved mixing and reduced membrane fouling.
- During operation of the AnMBR at 37°C, nutrient recovery in the effluent accounted for 75% of N (as NH_3) and only 74% of P (as PO_4). This suggested that the mesophilic AnMBR was not optimized for nutrient recovery;
- Operation of the AnMBR at 55°C, results in minor improvements to nutrient mobilisation in the effluent with 95% of N (as NH_3) and 85% of P (as PO_4) mobilised. Increased P mobilisation increases the potential for recovery of value add products;
- Effective solids management, i.e. through membrane screening conducted as part of the AnMBR operation in the integrated process has a substantial positive impact on struvite product quality.
- In the conventional (37°C) AnMBR + Struvite process, 25% of P was retained in the AnMBR sludge, 60% was recoverable as struvite product and 15% remained in the wastewater stream as soluble P;
- In the enhanced (55°C) AnMBR + Struvite process, 20% of P was retained in the AnMBR sludge, 68% was recoverable as struvite product and 13% remained in the wastewater stream as soluble P.
- While the enhanced thermophilic process has the potential to increase struvite P capture and therefore increase value recovery from the process, these operating conditions do not increase the overall effluent quality and may increase the odour risk of the struvite process due to increased ammonia concentrations.

Performance of Integrated Process							
	TS	TCOD	TP	PO_4-P	TKN	Mg	Ca
	$g.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$
Raw Wastewater	**5.9**	**11536**	**39.8**	**27.4**	**366.3**	**16.1**	**61.1**
AnMBR Effluent/Crystallizer Feed	**0.01**	**325**	**30.9**	**31.4**	**318.1**	**13.8**	**24.8**
Treated Effluent	N/A	N/A	**10.5**	**6.8**	**269.8**	**48.6**	**19.1**

Benefit for Industry

As a relatively new technology, the economics of AnMBR processes require further assessment and validation. Preliminary assessments indicate that capital investment required for AnMBRs will be greater than existing options such as Covered Anaerobic Lagoons (CALs), however product recovery is improved. Comparative costs for a large plant processing 1,500 head per day and generating wastewater of 3.3 $ML.d^{-1}$ are estimated at:

	Capital Cost ($)	Operating Cost ($/yr)	Total Revenue ($/yr)	Trade Waste Saving[1] ($/yr)	Annual Operating ($/yr)	Simple Payback (yrs)
CAL	$4,052,000	$156,818	-$909,216		-$752,398	5.4
CAL + Ferric	$4,279,000	$492,865	-$909,216	-$84,920	-$501,271	8.5
CAL + Struvite	$4,563,000	$270,349	-$1,025,671	-$84,920	-$840,242	5.4
AnMBR	9,696,000	$255,937	-$1,363,824		-$1,107,887	8.8
Struvite	$511,000	$113,531	-$116,455	-$84,920	-$87,844	5.8
AnMBR + Struvite	$10,207,000	$369,468	-$1,480,279	-$84,920	-$1,195,731	8.5
Optimised AnMBR + Struvite	$7,092,000	$305,414	-$1,480,279	-$84,920	-$1,259,785	5.6

[1] Considers only additional trade waste savings from P removal. Trade waste costs for volume, COD and nitrogen loads are expected to be similar and are therefore are included in calculations.

There are several strategies that could be investigated to reduce the capital requirements of AnMBRs and improve the payback period. These strategies include:

i) Using lower cost infrastructure (European style panel tanks are significantly lower cost than steel tanks used in the current CBA and this would reduce capital cost per tank volume);

ii) Developing an optimised AnMBR process tolerant to higher organic loading rates (managing the biomass/sludge inventory is critical to this and should facilitate higher OLR and smaller vessel size); and

iii) Improving primary treatment upstream (AnMBRs are designed on organic load rather than treatment time – improvements to primary treatment units can significantly reduce the organic load entering the AnMBR and therefore the vessel size required.

This work confirms that AnMBRs are now a viable treatment option for Australian red meat processors, when compared to lagoon based treating AnMBRs have significant advantages including:

i) Less susceptible to process interruptions due to high FOG content and therefore not reliant on primary treatment;

ii) Much higher volumetric loading rates and therefore require footprint at least 10x smaller than lagoon based treatment;

iii) Improved effluent quality, improved gas capture, reduced odour;

iv) Potential to manipulate operational conditions for optimal nutrient recovery or production of other value-add products;

These advantages have significant impacts when considered advanced downstream processes such as struvite precipitation or water recycling, but have not been quantified in the CBA. Due to the small footprint, AnMBRs are less likely to be impacted by space restrictions or geotechnical issues – which may impact the construction and cost of large lagoons. These factors were not considered during the CBA in this project, but may impact the outcome.

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