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Pork CRC
CRC for High Integrity Australian Pork

Project Number & Title 4C-113: Enhanced Methane Bioenergy Recovery at Australian piggeries through Anaerobic Co-digestion

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Aims and Objectives This project investigated anaerobic co-digestion (AcoD), whereby two or more wastes are co-treated in a covered pond or digester to boost biogas production and/or provide gate fee income from receiving and treating wastes from other industries at a piggery. The microbial health of a digester or covered pond is important, because poor AcoD performance instead reduces biogas, causes odour, and increases residues to post-handle and dispose of. Pond or digester health is maintained by NOT adding too much manure/other wastes, in terms of volumetric and organic loading. It was not known how waste mixture composition and low operating temperatures in ambient covered ponds (15-25°C) would influence loading limits for AcoD. These knowledge gaps were addressed in the project via fundamental laboratory analysis by two PhD projects, lab-scale AcoD testing of various wastes and tracking of two full-scale co-digestion trials.

Key Findings

1) Carbon to Nitrogen (C/N) ratios are commonly used to select balanced waste mixtures for aerobic composting. However, this research found that C/N is not adequate to predict AcoD performance. Instead, AcoD performance is reasonable when essential nutrients are available, and inhibition thresholds and loading limits are not exceeded. Loading limits depend on carbon type (carbohydrate vs. lipids vs. protein) in waste mixtures. Lipid/fat is generally preferred, followed by carbohydrates, and protein is ranked last because of high ammonia inhibition risk. Settling/floating behaviour of lipids/fat and complex lignocellulosic carbohydrates (e.g. straw) was not assessed in the project and may negatively affect covered pond operations.
2) AcoD is generally slower at colder temperatures. A decrease in temperature affects some biological reactions more than others do. This increases the risk of microbial imbalances in AcoD at cooler temperatures.
3) Thirty wastes were ranked as candidates for AcoD. Glycerol and Fat Oil and Grease (where available) ranked highest, with high concentrations and good biological performance, but their addition needs to be carefully controlled to prevent organic overload. Macerated food waste and food industry wastes were also strong candidates because of rapid digestion, low impact on residual solids and low inhibition risk. However, such wastes are relatively dilute and may have volumetric loading constraints. Agricultural wastes had mixed rankings, with energy dense wastes such as Dissolved Air Floatation sludge or protein and lipid-rich animal screenings being suitable, but lower energy wastes, such as paunch, waste activated sludge and pig manure ranking poorly unless produced and digested at the same site (not transported over long distances for treatment). Low energy wastes can be co-digested with high-energy wastes.
4) Two full-scale co-digestion trials were tracked during the project, one at a municipal wastewater treatment plant and one at a piggery co-digesting pig manure and paunch in a mixed vessel. The results from the full-scale trials agreed with the laboratory test findings.

Application to Industry

With ambient temperature covered ponds, maximum loads of other wastes can occur during warmer temperatures of Spring-Summer, potentially including minimal amounts of protein. Other wastes should be reduced during cooler months of Autumn-Winter and protein-based wastes and soluble sugar-based wastes avoided. Complex cellulosic wastes may be applied, but at roughly 50% lower loading in cooler months than in warmer months. Lipids are generally slow to digest and require long treatment times, especially at cooler temperatures.

Increased biogas revenue/savings should be balanced with increased residue disposal costs (nutrient value can be a benefit if used as fertilizer). There may be opportunities to receive and treat wastes for a gate fee, but wastes with recalcitrant contaminants (e.g. heavy metals or pesticides) should be avoided. Purchasing wastes from other industries is generally not economically feasible and it does not make economic sense to pay for transport of wastes over extended distances.