FIGURE 1: Three 10L laboratory scale continuously stirred tank reactors.

Anaerobic co-digestion of slurry with organic waste

TEAGASC researchers are involved in a study examining the survival of pathogens during anaerobic co-digestion of slurry with a fats, oil and grease substrate.

Background

Manure and slurry from pig, beef, dairy, and poultry enterprises are considered valuable organic fertilisers, but typically contain a broad range of bacterial, viral and parasitic pathogens. These pathogens can be transferred as bioaerosols during landspreading, ingested directly from grass or vegetables, or washed off into surrounding watercourses, posing a significant threat to human and animal health (Bicudo *et al.*, 2003). Some benefits of farm-based anaerobic digestion (AD) include: localised renewable energy production; odour control; organic waste management; and, noxious and greenhouse gas mitigation (Auer *et al.*, 2017). Farm-based AD could also potentially reduce pathogen loads in the environment and their associated public health risks. AD of slurry can reduce pathogen numbers (Sahlstrøm, 2003), but Irish farm-based AD surveys by partners in this project highlighted survival of a number of important pathogens. Pathogen survival may be significantly impacted by factors such as: initial pathogen load; addition of co-digestion substrates such as food production waste; and, operating conditions of AD plants. Congealed fats, oils and grease (FOG) are a major cause of urban drainage maintenance problems; therefore, well-maintained grease traps are mandatory for food service establishments in the EU, providing a ready supply of FOG for co-digestion with animal wastes. Data for pathogen survival during mesophilic AD of cattle slurry mixed with FOG are currently not available. Thus, the aim of this study was to examine the survival of indicator pathogens in AD of slurry with FOG as co-substrate.

Study design

Slurry was obtained from three Irish dairy farms and stored in a shed at ambient temperature. Triplicate 10L continuously stirred tank reactors (CSTRs) were operated under conditions representative of Irish farm-based AD, i.e., 37°C, batch-feeding slurry augmented with FOG, and a 28-day retention time (**Figure 1**). AD plant performance was assessed by measuring biogas production, pH, chemical oxygen demand, volatile solids (VS) and ammonia concentration throughout the trial. Pathogen survival was assessed by quantifying faecal coliforms, *E. coli* and enterococci over the duration of the experiment.

Initial results

The physicochemical data recorded throughout the trial were analysed to ensure that reactors performed optimally. Temporal changes in pH, ammonia and VS degradation were optimal and were similar for the three reactors. Total chemical oxygen demand (COD) and soluble COD removal and methane generation (mL CH_4/g VS) indicated good performance overall.

All pathogens declined over the duration of the 28-day AD process, generally to below 1,000cfu/g by day seven. Although enterococci numbers were slightly above 1,000cfu/g after 21 days, a 2.5-$\log_{10}$ reduction (below 1,000cfu/g) was observed after 28 days (**Figure 2**). Total faecal coliforms and *E. coli* survival showed similar trends until day 21, with 4.0 and 3.8-$\log_{10}$ reductions in faecal coliforms and *E. coli*, respectively (**Figure 2**). By day 28 *E. coli* was no longer detected,

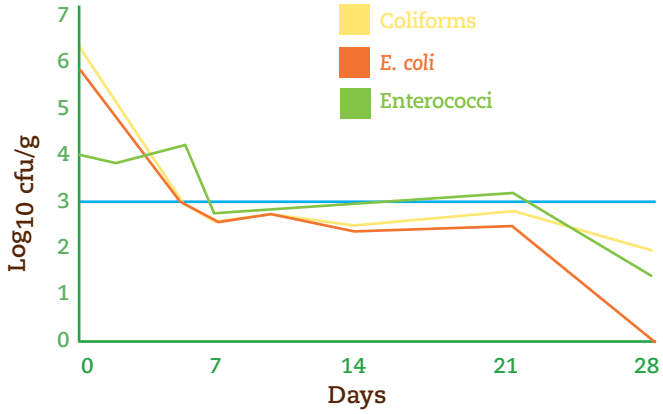

FIGURE 2: Average pathogen indicator survival in 10L reactors (n=3). Blue line indicates 1,000cfu/g threshold.

indicating a 5.9-log_{10} die-off during that period. The initial 3-log_{10} reductions of both coliforms and *E. coli* occurring within seven days, followed by relatively stable survival until 21 days, suggests the presence of resilient pathogen strains or cells with increased ability to survive under mesophilic AD conditions. For comparison, levels of pathogen indicators in stored slurry were monitored and much lower pathogen reductions were observed. By day 28 total coliform and *E. coli* levels in stored slurry had declined by 1.4 and 1.8-log_{10}, respectively, while enterococci levels reduced by 0.67-log_{10}. After two months of storage, none of the bacterial pathogen indicators in slurry had dropped below 1,000cfu/g, suggesting that slurry would not be considered safe for landspreading if pathogen indicator thresholds required for AD were applied.

Future direction

Significant pathogen indicator die-off was observed but insufficient reduction in enterococci was achieved until day 28. This highlights the opportunity for process optimisation with a focus on pathogen reduction. Other project partners are focusing on survival of protozoa and viral pathogens (UCD) and bacterial pathogens (Teagasc Ashtown) in this experiment. The significant reduction in pathogen numbers in AD compared to stored slurry does however highlight the potential for farm-based AD to decrease pathogen load in the environment and, consequently, to mitigate the risks to human and animal health. Optimisation of operational conditions for pathogen reduction is currently underway. Future work will investigate pathogen survival in soil and potential losses to water from landspreading. Pathogen loss to water will be investigated in runoff trials using simulated rainfall in the field to assess comparative risk from digestate and unprocessed slurry. The combined results of this multidisciplinary research will significantly contribute to Irish AD policy.

Acknowledgements

The authors thank Fiona Brennan, Teagasc Johnstown Castle, for her valuable contribution to this study. This work was carried out as part of the FIRM Project, 14 F847, 'The comparative public health risks associated with spreading anaerobic digestate, animal manure and slurry on land: Science, policy and practice', funded by the Irish Department of Agriculture, Food and the Marine. Project partners include: D. Bolton P.I. (Teagasc Ashtown); P. White, B. Markey, A. Zintl, E. Cummins, A. Auer, T. DeWaal, and N. Vande Burgt (UCD); and, V. O'Flaherty (NUIG).

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Authors

Stephen Nolan
Microbiology, School of Natural Sciences, NUIG
Correspondence: s.nolan16@nuigalway.ie

Owen Fenton
Principal Research Officer, Teagasc Crops, Environment and Land Use Programme, Johnstown Castle, Co Wexford

Karl Richards
Principal Research Officer and Head of Department Environment Soils and Land Use, Teagasc, Crops, Environment and Land Use Research Programme, Johnstown Castle

Florence Abram
Microbiology, School of Natural Sciences, National University of Ireland Galway