Executive Summary

A scientific basis to change current co-digestion practices

Manure Resource Recovery: Co-Digestion with Fats, Oil, and Grease (STAR-N3R14a/4856)

The Central Issue

Anaerobic digestion of agricultural livestock manure can be a cost-effective solution to minimize greenhouse gas emissions while stabilizing the organic waste material through the recovery of biomethane. Nonetheless, the low biomethane potential of animal manures can poorly impact economic viability of agricultural digesters. Co-digesting high-strength organic wastes with manure can significantly improve process economics by increasing biomethane recovery as well as provide additional revenue from tipping fees. Fats, oils, and greases (FOG) are appealing substrates for codigestion in agricultural digesters because they have a methane yield potential that is approximately 2.7-times greater than livestock manures on a mass-basis (Labatut et al., 2011). The relationship between microbial community structure in the manure digester and bioconversion kinetics of long-chain fatty acid (LCFA) in anaerobic digestion processes has not been well characterized until now.

Context and Background

This study investigated the impacts of long-chain fatty acid (LCFA) loading and feeding frequencies on biomethane production, process stability, bioconversion kinetics, and microbial community structure, during manure anaerobic co-digestion. Contrary to the general co-digestion practice of consistent feeding, a more stable operation occurred for the pulse-fed co-digester than for the continuous-fed digester. Biomethane production increased by a factor of 4.4 due to LCFA addition.

Findings and Conclusions

The study results collectively suggest that pulse feeding (rather than continuous feeding) of LCFA during anaerobic co-digestion selected for higher microbial bioconversion kinetics and functional stability, which were related to changes in the physiological diversity and adaptive capacity of syntrophic and methanogenic communities.

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Management and Policy Implications

Since these findings differ and inform what is accepted as general practice, they received significant interest from the scientific community, as well as water resource recovery facility (WRRF) managers, engineers, operators, and engineering consultants. Co-digestion is a rapidly growing practice at WRRFs in the U.S. and worldwide. A framework of accepted practice is needed to reduce the risk of unintended impacts and promote improved resource recovery through co-digestion. The results of this research demonstrate that there is a significant increase in biomethane production in manure digesters co-digesting FOG. It highlights the importance of co-digestion feeding strategy on digester operations and performance by selecting for more robust microbial populations in digesters during pulsed feeding practice.

Related WRF Research	
Project Title	**Research Focus**
Lessons Learned: Developing Solutions to Operational Side-effects Associated with Co-digestion of High Strength Organic Wastes (ENER8R13)	Examines feedstocks available for use in co-digestion by surveying WRRFs currently with co-digestion programs. Identifies implications of co-digestion with HSWs, from all facets of the operations, including receiving, pre-treatment, digestion, and post-digestion treatment and handling.
Co-Digestion of Organic Wastes – Addressing Operational Side Effects (ENER9C13)	Evaluates co-digestion facility design, performance data, and operation and maintenance issues at five WRRFs. The team conducted laboratory-scale biomethane potential tests on conventional wastewater solids and organic waste to evaluate the impacts of co-digestion on methane production, sludge production, and nitrogen and phosphorus concentrations in recycle streams.
Understanding Impacts of Co-Digestion: Digester Chemistry, Gas Production, Dewaterability, Solids Production, Cake Quality, and Economics (ENER12R13)	Develops a fundamental analytical approach to understand and predict the broad array of impacts of co-digestion, including effects on digester chemistry, digestate rheology and subsequent volume expansion, dewatering, and cake quality in terms of odors. The research team input the results into economic models that showed that return on investment (ROI) varied depending on the HSW applied.
Advancing Anaerobic Digestion of Wastewater Solids and Food Waste for Energy and Resource Recovery: Science and Solutions (ENER20W17)	Provides an overview of recent research findings on co-digestion of organic wastes with wastewater solids. Expert participants discuss, contribute, and identify best practices currently used by water resource recovery facilities from their experience with co-digestion.
Manure Nutrient and Resource Recoverty: Low-Cost Ammonia Stripping (STAR-N3R14)	Demonstrates a low-input, combined ammonia stripping and P recovery process from manure at commercial-scale at two large dairy operations and at a one-million poultry layer operation. Examines system performance, as well as techno-economic capabilities and bio-fertilizer properties.
Nationwide Meta-omics Survey of Anaerobic Digestion and Fermentation Processes for Resource Recovery from Biosolids and Other Organics (U1R15)	Develops a better mechanistic understanding of the microbial communities (both structure and function), carbon conversion pathways, and kinetics in field-scale AD and AF processes.

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