Anaerobic Digestion Systems:

Integrating emerging technologies to improve environmental and economic impact

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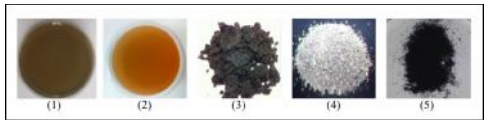
Abstract

This project aims to quantify the climate, air, water, nutrient and economic impacts of integrating emerging, next-generation technologies within anaerobic digestion systems on U.S. dairies: nutrient recovery, pyrolysis, and water recovery. Existing evidence suggests that addressing nutrient concerns and improving project returns on investment could enhance anaerobic digestion adoption rates in the U.S., as well as generate additional environmental benefits. This project will build on technologies that are being developed by the project team through leveraged research. Enhancement of pyrolysis through modification of bio-char for nutrient recovery will be investigated, and all AD-derived fertilizers will be evaluated at the greenhouse scale. Analysis of various levels of technology incorporation and farm scenarios will determine direct and upstream/downstream impacts on greenhouse gas emissions, nutrient and energy flows, project economics, and crop yields.



Manure-derived soil amendments: (1) anaerobically digested liquid manure; (2) ammonium sulfate solution from WSU AIRTRAP systems (USPTO 2011); (3) phosphorus-rich solids from AIRTRAP; (4) slow release ammonium and phosphorus containing struvite crystals from both dairy and municipal waste-water systems (USPTO 2010), and (5) phosphorous-enriched bio-char (Streuble et al. 2011)

Project Rationale

The Issue: Anaerobic digestion (AD), during which naturally occurring microorganisms covert complex organic materials in manure and other wet organic wastes to biogas, has the potential to generate multiple benefits, including renewable energy, reduced greenhouse gas emissions, decreased odors, and decreased pathogen. However, AD adoption rates in the U.S. have been slow, representing less than 6 and 7% of potential dairy farms and cows, respectively (US-EPA 2010).

Our Proposed Contribution: Furthering the development of viable "add-on" technologies as part of an **AD System** will improve AD project economic returns and nutrient management impacts, contributing to greater AD adoption rates.

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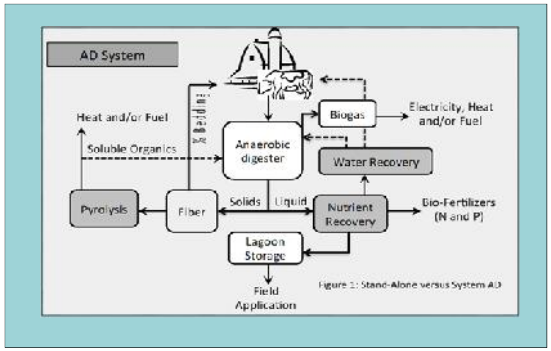
The Integrated AD System

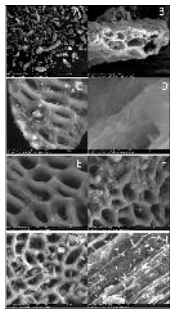


An AD System integrates the core AD technology with other complementary technologies. Refinement of biogas into renewable natural gas is an example of a systems technology that is increasingly being implemented as part of AD projects.

Project Objectives

1. Enhancement of pyrolysis through modification of bio-char for nutrient recovery, with exploration of N, P, and H_2S capture
2. Agronomic evaluation at greenhouse scale of AD-derived fertilizers: surface-modified bio-char, organic P-enriched solids, ammonium sulfate solution, and struvite crystals.
3. Modeling of GHG emissions, nutrient flows, and crop yields of various adoption scenarios for AD systems technologies.
4. Techno-economic analysis of adoption scenarios for AD systems technologies.
5. Extension of research to key stakeholders positioned to facilitate adoption of AD systems (e.g. industry, regulatory agencies, and private carbon market entities).

Emerging Technologies Included in the Project



Pyrolysis: Pyrolysis is an emerging technology that can process AD fiber and other dry materials (e.g. wood chips, field residues, poultry litter). Pyrolysis produces bio-char, bio-oil, heat and/or electricity, depending on the temperatures used. Two processes for AD fiber will be studied:

- Pyrolysis optimized to produce process heat and bio-char. The surface of the bio-char will be modified so it can be used as media for biogas scrubbing (H_2S) filters or for removal of N and P from lagoon wastewaters.
- Pyrolysis optimized to produce a crude bio-oil for use as liquid fuel and a water-soluble fraction containing small chain organics which can be digested for CH_4 production.

Nutrient Recovery Three nutrient recovery technologies will be investigated:

- Physical screening system to remove a significant fraction of suspended P as an organic solid.
- A high temperature aeration treatment with physical screening to remove ammonium as an ammonium salt and the suspended P as a separate organic solid.
- Combined ammonia and soluble P recovery as a single salt (struvite) product.

Water Recovery. Nutrient recovery generates a nutrient-poor wastewater. Two recovery pathways will be explored:

- Returning this wastewater to the digester to dilute high solids wastes (such as "dry" poultry or feedlot manures), enabling digestion in in slurry-based digesters (the most widely adopted technology).
- Additional wastewater treatment approaches to achieve the purity required for animal drinking water.