

Bioenergy Production from MSW by Solids State Anaerobic Digestion
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for

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Report # 2



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Abbreviations, Acronyms, and Units of Measurement

OFMSW - Organic Fraction of Municipal Solid Waste

MSW - Municipal Solid Waste

P&P - Pulp and Paper Mill

SS-AD - Solids State Anaerobic Digestion

BMP – Biochemical Methane Potential

TS - Total Solids

VS – Volatile Solids

SGEF - Student Green Energy Fund

Quarterly Progress Report

November 18, 2014 – February 17, 2015

PROJECT TITLE: Bioenergy Production from MSW by Solid-State Anaerobic Digestion

PROJECT DIRECTOR(S): Dr. Sarina Ergas and Dr. Daniel Yeh

AFFILIATION: University of South Florida

COMPLETION DATE: August 17, 2015 **PHONE NUMBER:** 813-974-1119

PROJECT WEBSITE: <http://mbr.eng.usf.edu/yardwaste/>

Work Accomplished During this Reporting Period

During the second quarter of this Hinkley Center project, the following tasks were accomplished: extended literature review, extended industry survey, TAG expansion, round one bench-scale study, round-two bench-scale study design, pilot-scale SS-AD unit construction, research dissemination and website development. Ariane Rosiario, an undergraduate research assistant is now jointly funded through the Hinkley Center and the USF College of Engineering Research Experience for Undergraduates (REU) program to assist with this research.

Literature Review: The literature review has been extended based on the following objectives:

- Review conventional and novel pretreatment methods for improving the biodegradability of lignocellulosic substrates and the degree that they enhance biodegradation
- Expand breadth of knowledge on the impact of codigestion (i.e. combinations of food waste, yard waste, biosolids, and other OFMSW substrates) on biogas production rates,
- Further develop understanding of economic and environmental advantages of SS-AD.

Industry Survey: The industry survey has been extended based on the following objectives:

- Identify yard waste, food waste, and biosolids sources in Florida (processing locations, methods, and quantities),
- Identify full-scale operations utilizing lignocellulosic substrates and determine pretreatment methods used and effects are on biogas production rates,
- Identify critical factors affecting the potential development of SS-AD projects in the US including: plant capacity, year of operation, digester type, design firm, capital costs, project funding, inoculation strategy, substrates, pre-processing, pretreatment, biogas yield, biogas utilization, leachate reuse strategy, digestate post-processing, digestate use, and O&M costs.

Bench Scale Testing: A first round of bench-scale tests will be ending this week (Figure 1). The goal of the study was to quantify the effect of bioaugmentation with pulp and paper mill sludge (P&P sludge) on methane production from yard waste. The compositions of the three mixtures (M1, M2, and M3) are shown in Figure 2. Preliminary analysis of the bench scale study indicates that methane production has been enhanced via bioaugmentation with P&P sludge. Table 1 summarizes methane production over the course of the first 49 days of the study (reported on a per kg VS and per kg TS basis) and the enhancement from P&P bioaugmentation (% relative to M3 which is considered the baseline, as it did not receive any P&P sludge). Cumulative methane production, after subtracting the methane produced by blanks (which contained inocula only) from the three mixtures are shown in Figure 3. Round two of bench-scale studies will begin this

week. The designs of the studies are in the final stages and will seek to contribute to answering the following research questions, at a minimum: 1) What is the significance of the substrate to inoculum (P&P AD sludge) ratio? 2) Will the P&P AD sludge originating microbes maintain their population in the SS-AD environment?

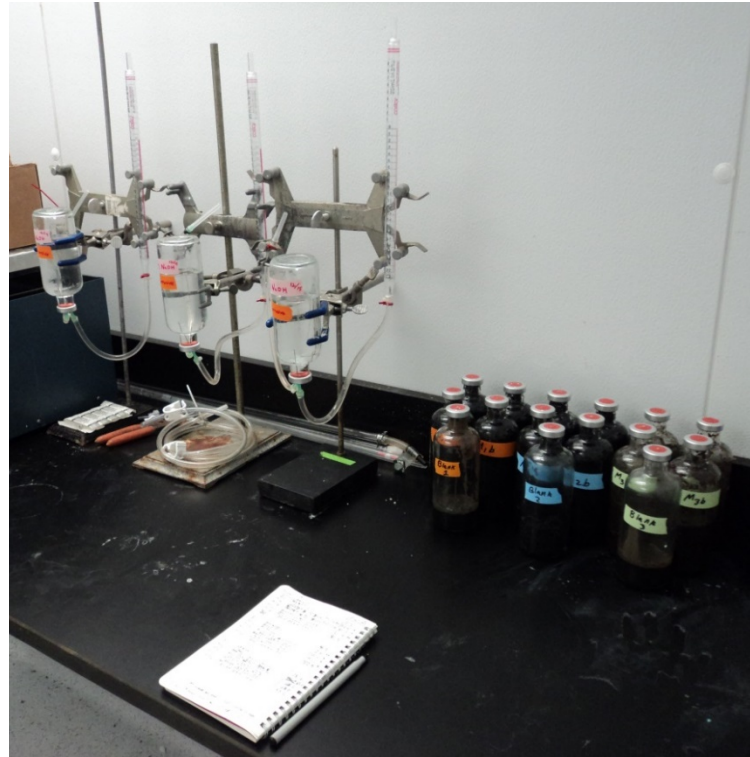


Figure 1: Round one bench-scale study setup.

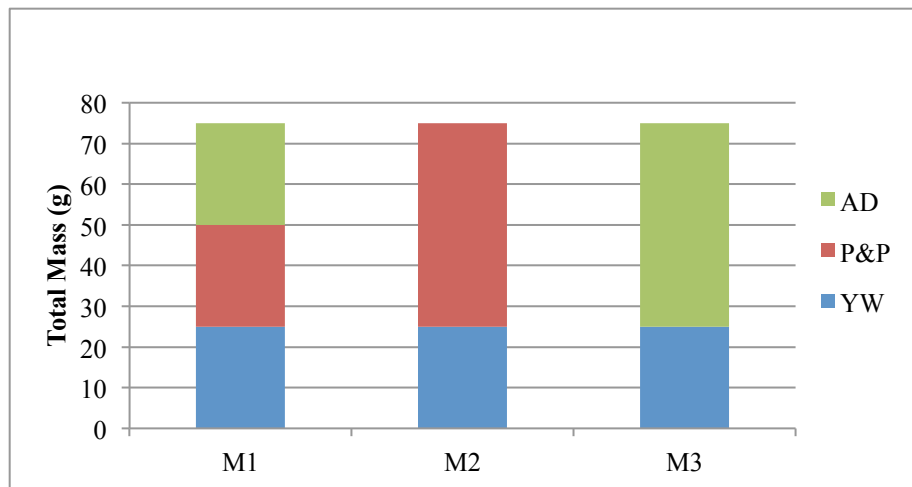


Figure 2: Composition of the mixtures tested in round one bench-scale studies.

Table 1: Preliminary cumulative methane production quantities from BMP assays.

	Total Methane (L)	L CH ₄ / kg VS	L CH ₄ / kg TS	% Increase
M1	0.605	63.80	33.65	-2%
M2	0.672	70.89	37.39	+11.1%
M3	0.618	65.17	34.37	baseline

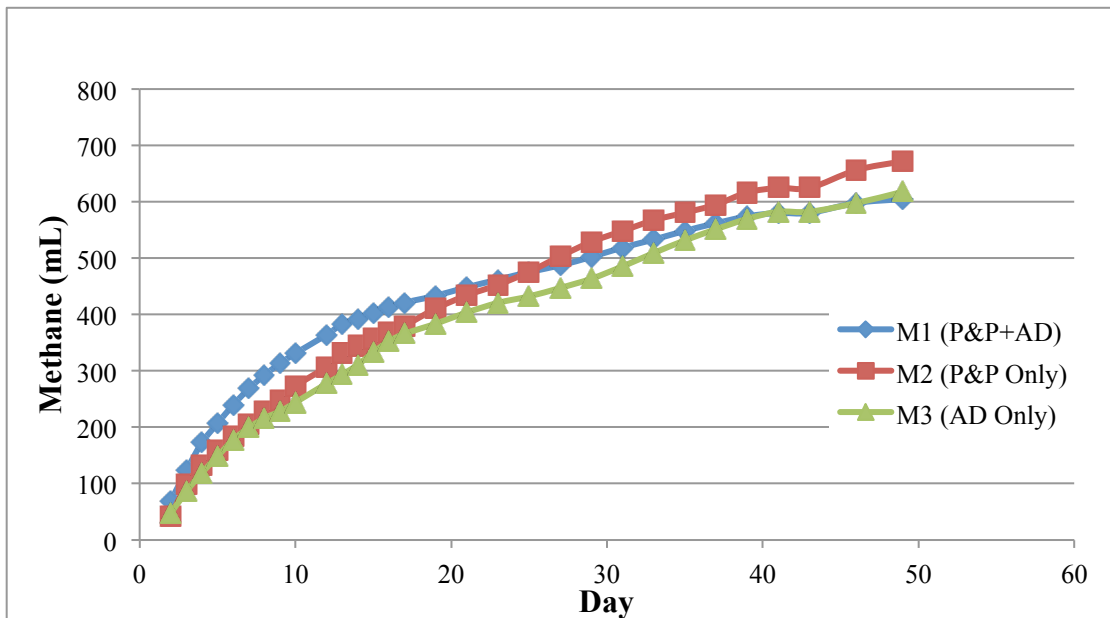


Figure 3: Cumulative methane production (days 1-49) of the round one bench-scale studies.

Pilot Scale Testing: The construction of a pilot-scale system is nearly complete (Figure 4). Pilot-scale experiments are still being designed, but it is expected that the system will be in operation by the end of the month.

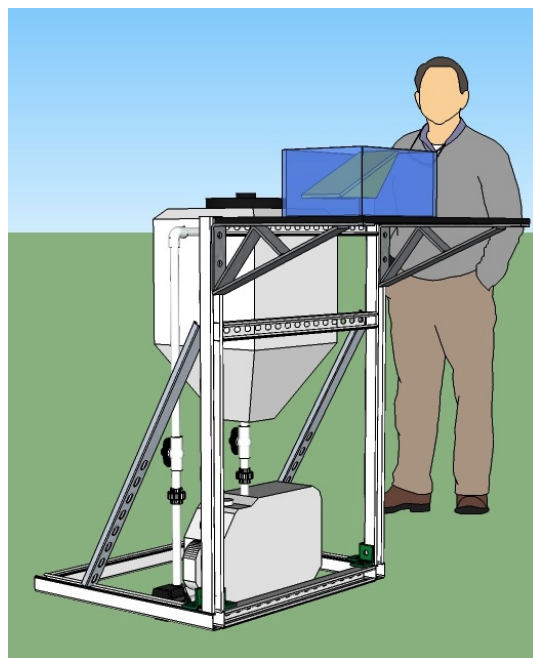


Figure 4: Pilot system Schematic.

Information Dissemination Activities

- A poster was presented at USF’s Research Day
- SS-AD was demonstrated at the USF Engineering Expo on the weekend of February 13th
- An article was submitted on SS-AD in Florida to *Talking Trash*, the Florida Chapter of SWANA newsletter, which is expected to be included in the March newsletter
- A proposal was submitted to *Biocycle Magazine* for an article on lignocellulosic pretreatment strategies for SS-AD
- A poster will be presented at the AEESP Distinguished Lecture poster session at UCF on February 27th
- A poster will be presented at the USF Graduate Student and Postdoctoral Research Symposium on March 10th
- A poster will be presented at the USF Undergraduate Research & Arts Colloquium on April 9th
- An abstract was submitted for a poster presentation at NAWTEC in Tampa on April 29th
- An abstract was submitted for a presentation at WASTECON in Orlando on August 25th

Metrics

1. Graduate students funded by this Hinkley Center project

Table 2: Graduate student researches funded by the Hinkley Center Project.

Last name, first name	Rank	Department	Professor	Institution
Hinds, Gregory	Masters Student	Civil/ Environmental Engineering	Dr. Sarina Ergas	University of South Florida
Dick, George	Masters Student	Civil/ Environmental Engineering	Dr. Daniel Yeh	University of South Florida

2. Undergraduate researchers working on this Hinkley Center Project

Ariane Rosario

Department: Civil & Environmental Engineering, University of South Florida

Adviser: Dr. Sarina Ergas

3. Research publication resulting from this Hinkley Center project

One article has been submitted for publication in the March addition in of the Florida section of SWANA newsletter, *Talking Trash*, and another article has been proposed to *Biocycle Magazine*.

4. Research presentations resulting from this Hinkley Center project

Hinds, Gregory. “Bioenergy Production from Municipal Solid Waste through Solid-State Anaerobic Digestion.” University of South Florida, College of Engineering Research Day. Tampa, Florida. 19 Nov. 2014.

- How have the research results from this Hinkley Center project been leveraged to secure additional research funding?

A proposal was submitted to the Environmental Research and Education Fund (EREF) for research on bioaugmentation of lignocellulosic waste and life cycle assessment, which is currently pending. As mentioned in the first quarterly report, an interdisciplinary team of students and faculty submitted a proposal to the USF Student Green Energy Fund (SGEF) to conduct a feasibility study on implementing SS-AD on the USF campus. Unfortunately, this proposal was not accepted because of a lack of preliminary research data indicating the feasibility of the project. However, this proposal is being followed up on by eight graduate and undergraduate students who are conducting a life cycle assessment (LCA) to compare the existing organic waste management strategy at USF (transport offsite and incineration) with alternative onsite management strategies including SS-AD. The team plans to leverage the findings from this study to reapply for the SGEF in the fall.

- What new collaborations were initiated based on this Hinkley Center Project?

Dr. Yu Zhang from the USF Transportation Engineering program has expressed interest in contributing to the food waste collection side of the project and contributing to an article to *Biocycle Magazine* by providing a short sidebar for the article. Two graduate students from ICT Prague are completing final preparations to spend three months as visiting students at USF to collaborate on SS-AD research. The research team has been actively communicating with industry professionals (engineering, waste management, and legislative). At least two have agreed to participate in the project as a part of the TAG: Bruce Clark of SCS Engineers (knowledgeable about history of SS-AD in Florida, barriers to SS-AD implementation in Florida, and SS-AD projects around the country) and Chris Bolyard of Waste Management (knowledgeable about organic waste hauling, organic waste sources, and quantities).

- How have the results from this Hinkley Center funded project been used by FDEP or other stakeholders?

The results have not yet been used by the FDEP or other stakeholders.

Tag Members

Table 3: TAG members, their affiliations, and their titles.

TAG Member	Affiliation	Title
Steven G. Morgan	FDEP	Waste Permitting, Environmental Services Section, SW District
Wendy Mussoline	UF, Dept. of Soil & Water Science	Postdoc, Environmental Biotechnology Lab
Juan R. Oquendo	Gresham, Smith, & Partners	Sr. Environmental Engineer & Waste to Energy Leader
Debra R. Reinhart	UCF, Dept. Civil, Environmental & Construction Eng.	Professor & Assistant Vice President
Larry Ruiz	Hillsborough County	Landfill Operations Section Manager
Adrie Veeken	Attero, the Netherlands	Bio-based Products Business Developer
Shawn Veltman	CHA Consultants	Director of Technical Services, Water & Wastewater
Bruce Clark	SCS Engineers	Senior Engineer
Chris Bolyard	Waste Management, Inc	Manager

Tag Meetings

The first TAG meeting was held on November 6, 2014. Several TAG members participated remotely. The discussion was very productive and yielded several valuable insights. After the discussion, TAG members who attended in person toured the lab facilities. The second TAG meeting is scheduled for Wednesday, March 11th. The format will be similar to that of our last meeting.

References

APHA, Standard Methods for the Examination of Water and Wastewater 20th ed., 1998.
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Association/Water Environment Federation.

Angelidaki, I., Alves, M., Bolzonella, D., Borzacconi, L., Campos, J.L., Guwy, A.J., Kalyuzhnyi, S., Jenicek, P., van Lier, J.B. 2009. Defining the biomethane potential (BMP) of solid organic wastes and energy crops: a proposed protocol for batch assays. *Water Sci. Technol.* 59 (5), 927–934.

Owens, J.M., Chynoweth, D.P., 1993. Biochemical methane potential of municipal solid waste (MSW) components. *Water Sci. Technol.* 27 (2), 1–14.