Energy and Nutrient Resources from Organic Wastes for Small Farms

Ryan E. Graunke[1] and Ann C. Wilkie[2]

[1]School of Natural Resources and Environment

[2]Advisor, Soil and Water Science Department

Abstract

Organic wastes, energy, and organic fertilizer have a synergistic, closed-loop relationship that has become disconnected in modern society. Current organic waste disposal requires substantial energy and eliminates these nutrients from the productive cycle. Through anaerobic digestion of food waste, energy as methane-rich biogas and organic nutrients as biofertilizer are simultaneously produced. This process creates a sustainable cycle that mimics nature through the reuse of waste products for resource extraction. Small farms present an ideal scenario for this opportunity to occur. Small farms have many sources of on-farm feedstocks that are suitable for digestion, including culled/diseased crops, animal manure, and food waste. Food waste from surrounding communities could also be brought onto the farm as an additional source of energy and nutrients. This has many benefits for the small farmer and the community. The farmer is able to reduce energy and fertilizer costs by producing these products on-site. The surrounding community is able to reduce the problems associated with disposal of food waste, while furthering the 75% recycling goal set by the Florida legislature. This project seeks to assess the opportunity for small-farm food waste digestion through examining community food waste production and characterizing this food waste for energy potential and nutrient availability. Waste audits were performed at local schools and restaurants to determine available food waste. Food waste was characterized for total Kjeldahl nitrogen and total phosphorous. It is hypothesized that food waste digestion is a feasible option for small farmers to obtain energy and nutrients from organic waste resources.

Introduction

Background

- Microbial degradation under anaerobic conditions produces methane-rich biogas (Wilkie 2006).
- Humans can harness the power of these microbes to treat organic waste while producing usable energy.
- Nutrients in feedstock remain in effluent and can be utilized as a biofertilizer.
- Nutrients are mineralized and liquefied during digestion, facilitating their agricultural application (Fig. 1).

Project Overview

- Small farms represent an ideal location for the anaerobic digestion of organic wastes.
- On-farm feedstocks include manure, carcasses, culled/diseased crops, spoiled prepared food, and trimmings.
- Food waste from surrounding community has potential to boost biogas and biofertilizer production.
- Previous research found significant food waste generation from an on-campus dining hall (Graunke and Wilkie 2008).
- ~1.7 million tons of food waste is disposed in landfills annually (FDEP 2008).
- Food waste digestion creates a synergistic relationship between small farms and urban centers.
- This process helps meet Florida's 75% Recycling Goal (FDEP 2009).

Materials and Methods

Waste Audits

- Waste audits were conducted for two weeks at three local schools and three local restaurants (Table 1) to determine food waste generation from both kitchen and dining areas.
- Student and customer counts were collected for normalization.
- Each day food waste was weighed and ground through either an in-sink food disposal or manual meat grinder (Figs. 2 and 3)
- A 2 kg representative sample was obtained for further analysis (Fig. 4).

Waste Characterization

- Total and volatile solids (TS & VS) were measured on all samples using standard methods (APHA 1998).
- Chemical oxygen demand (COD) were measured on a sub-set of samples using standard methods (APHA 1998).
- Methane potential was based on stoichiometric COD ratio (0.35 L CH_4/g COD @ STP) (Speece 2008).
- Total Kjeldahl Nitrogen (TKN) and total phosphorous (TP) were measured using standard methods (APHA 1998).

Table 1: Waste Audit Locations

J.J. Finley	Public elementary school
Lofton	Public high school
Oak Hall	Private K-12 school (no cafeteria)
The Top	Full-service restaurant
Satchel's	Pizza restaurant
Rolls ' n Bowls	Quick-service sushi/Asian restaurant

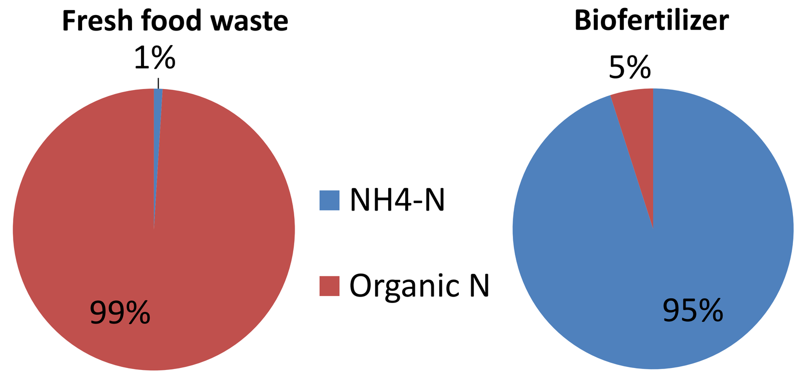

Fig. 1: Nitrogen form in fresh food waste and biofertilizer

Fig. 2: Food waste collected during audits

Fig. 3: Grinding food waste

Fig. 4: Obtaining a representative sample

Results

- Daily school food waste production showed less variability, than restaurants (Figs. 5 and 6).
- Per capita food waste varied significantly (Fig. 7).
- Table 2 shows monthly methane, nitrogen, and phosphorus available in the food waste from each location.
- Average food waste characteristics from all locations:
  - TS: 28.5 ± 13.0 %
  - VS:COD ratio: 1.49 ± 0.21
  - TKN: 2.42 ± 0.11 % dw
  - TP: 0.361 ± 0.092 % dw

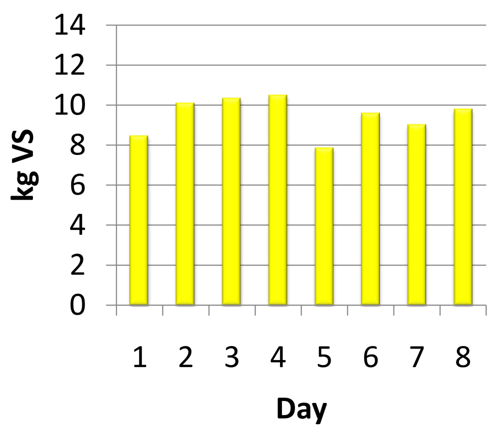

Fig.5: Daily food waste generation (kg VS) from J.J. Finley

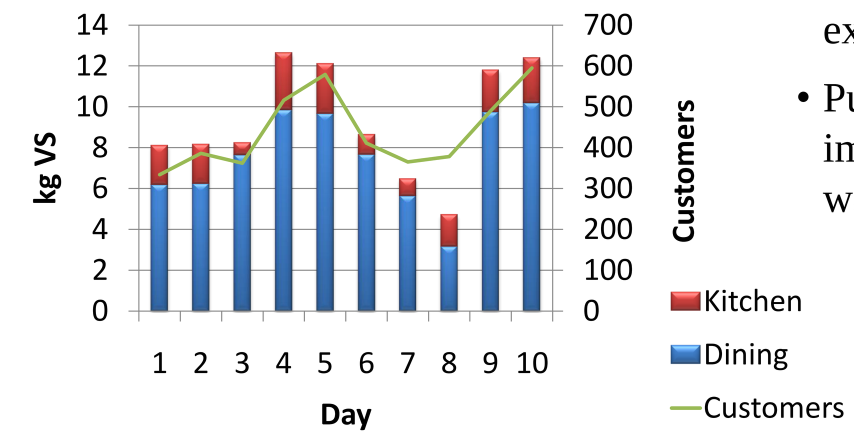

Fig. 6: Daily food waste generation (kg VS) from Satchel's

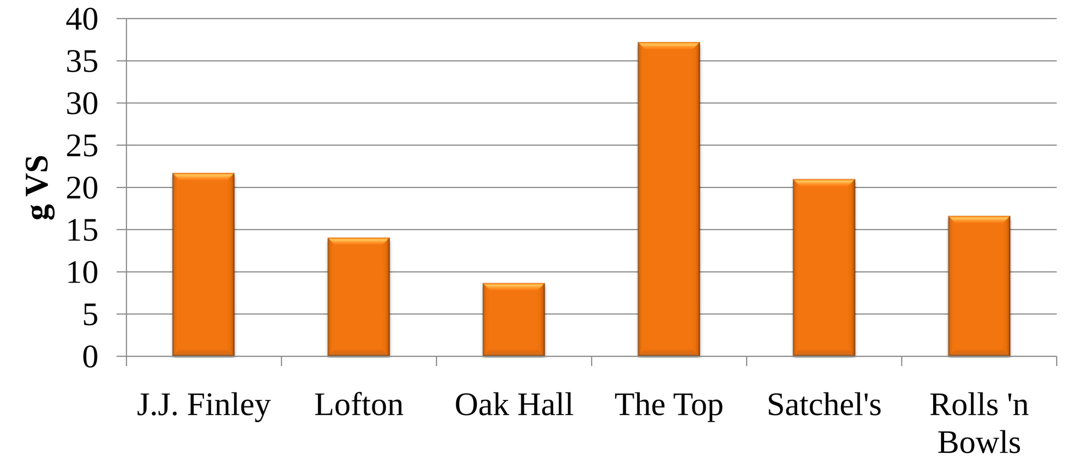

Fig. 7: Average daily per capita food waste generation (g VS)

Table 2: Bio-resources available from food waste

	m^3 CH_4/month	kg N/month	kg P/month
J.J. Finley	155.48	7.52	1.12
Lofton	62.04	3.05	0.45
Oak Hall	43.24	2.67	0.40
The Top	204.09	9.04	1.35
Satchel's	137.43	7.43	1.11
Rolls ' n Bowls	61.02	3.39	0.51

Fig. 8: Demonstrating food waste digestion to small farmers in Live Oak, FL

Discussion

- Schools and restaurants produce significant quantities of food waste, representing the majority of municipal solid waste from these sites.
- Food waste generation between locations depended more on school or restaurant type than student/customer count.
- Food waste has a high COD content and therefore high methane potential (relative to other organic feedstocks).
- Through anaerobic digestion, Florida's food waste could generate:
  - 219 million m^3 of methane
  - 11.2 million kg nitrogen
  - 1.67 million kg phosphorus
- Current research is focused on how to effectively treat food waste to expedite digestion.
- Public demonstrations and involvement (Fig. 8) are critical in implementing sustainable energy and nutrient production through food waste digestion on small farms (Fig. 9).

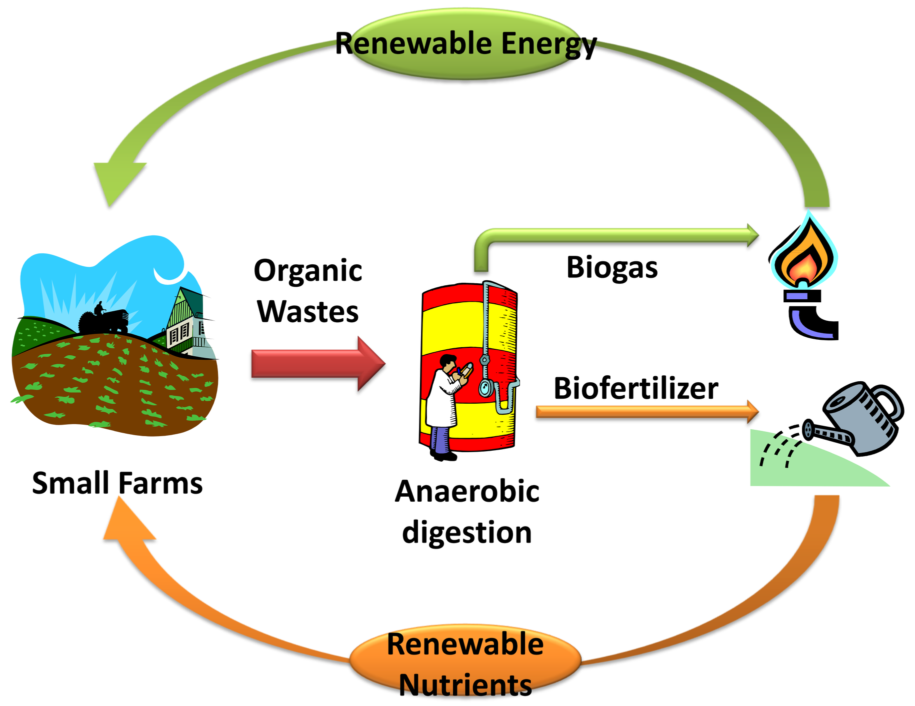

Fig. 9: Closed-loop energy and nutrient cycle for small farms

References

APHA (1998). Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Association, Washington, DC.

Biogas – A Renewable Biofuel. Available from: http://biogas.ifas.ufl.edu/

Florida Department of Environmental Protection (FDEP) (2008). Recycling – 2008 Solid Waste Annual Report Data. http://www.dep.state.fl.us/Waste/categories/recycling/SWreportdata/08_data.htm.

Florida Department of Environmental Protection (FDEP) (2009). Florida's 75% Recycling Goal. http://www.dep.state.fl.us/waste/recyclinggoal75/default.htm.

Graunke, R.E. and Wilkie A.C. (2008). Converting Food Waste to Biogas: Sustainable Gator Dining. *Sustainability – The Journal of Record*, 1 (6), 391-394.

Speece, R.E. 2008. *Anaerobic Biotechnology and Odor/Corrosion Control for Municipalities and Industries*. Archae Press, Nashville, TN.

Wilkie, A.C. (2006). The other bioenergy solution: The case for converting organics to biogas. *Resource: Engineering & Technology for a Sustainable World* 13(8):11-12. October 2006. American Society of Agricultural and Biological Engineers (ASABE), St. Joseph, Michigan.

Wilkie, A.C. (2007). Eco-Engineering a Sustainable Society. R*esource: Engineering & Technology for a Sustainable World* 14(6):19-20. August 2007. American Society of Agricultural and Biological Engineers (ASABE), St. Joseph, Michigan.

Wilkie, A.C. (2008). Biomethane from biomass, biowaste and biofuels. In: *Bioenergy.* p.195-205. J.D. Wall, C.S. Harwood and A. Demain (eds,). American Society for Microbiology Press, Washington, DC B

Acknowledgements

This work is funded by a grant from the Hinkley Center for Solid and Hazardous Waste Management.