Anaerobic digestion potential of organic wastes from small farms

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Abstract

Food waste and organic residues are generated in substantial quantities on small farms. These include weeds, row clearings, diseased plants, culled fruits and vegetables, animal manures, and processing and market wastes. Current disposal practices include composting, spreading on uncultivated land, or sending to landfills. Although small farms may gain some benefit from these current practices (i.e. use of compost on planting beds), the farms are losing a substantial opportunity to generate bioenergy from their organic wastes. By utilizing anaerobic digestion, small farms can generate methane-rich biogas for on-site use. These uses can include cooking, space or water heating, gas lighting, gas-powered refrigeration, or electricity production. Additionally, nutrients in the feedstocks are conserved in the effluent of the digester and converted into plant-available forms (i.e. ammoniacal nitrogen). Thus the effluent, known as biofertilizer, can be a valuable commodity to the small farm as an organic fertilizer. This project is a case study of a local, organic small farm called Crones' Cradle Conserve located in Citra, Florida. A waste audit was conducted at the farm for three weeks during the summer season to determine the types and amounts of organic wastes produced on the farm. Samples from the audit were analyzed for moisture and organic content to estimate the methane potential if these wastes were anaerobically digested. Food waste from restaurants and schools in the surrounding community and glycerol and washwater from local biodiesel producers could also be brought onto the farm as additional feedstock for increased methane and biofertilizer production.

Introduction

Background

- Anaerobic digestion is a natural, microbial process that converts organic material into methane (Wilkie 2008).
- This process is harnessed by anaerobic digesters (Wilkie 2007).
- Biogas produced by the digester is comprised of mainly methane (60%-85%) and carbon dioxide (15%-40%).
- Nutrients in the organic waste are retained in the effluent, known as biofertilizer, and are mineralized into plant-available form.
- Anaerobic digestion represents a unique opportunity to treat organic wastes while producing renewable energy and organic nutrients (Wilkie 2006).

Project Overview

- Small farms are an ideal location to implement the anaerobic digestion of organic waste.
- Small farms generate a variety of different organic wastes that are potential feedstocks for an anaerobic digester (Fig. 1 and 2).
- Biogas produced from the digester can be put to many uses: cooking, water heating, barn or greenhouse heating, or electricity.
- Biofertilizer reduces the nutrient costs to the farm, particularly for organic fertilizer.
- Anaerobic digesters are fully scalable; therefore, small farms of all sizes can utilize an anaerobic digester.
- The small farm studied in this project was Crones' Cradle Conserve, an organic vegetable farm in Citra, FL. The farm has 2/3 acre under cultivation and raises small animals.

Materials and Methods

Waste Audits

- A waste audit was performed for three weeks.
- All on-farm organic waste was collected each day and separated into appropriate categories (Table 1).
- Waste in each category was weighed using an electronic balance.
- A representative sample of each waste type on each day was obtained for further analysis.

Waste Characterization

- Samples were chopped or ground to take a representative subsample during lab analysis.
- Total solids (TS) and volatile solids (VS) were measured on all samples using standard methods (APHA 2005).
- Methane production potential was estimated using total kg VS of each waste type and methane yield values from literature (Table 2).
- Daily values were summed for weekly waste generation and methane production.

Table 1: Organic waste categorization

Category	Description	Current practice
Row clearing	Unproductive or dead crop plants	Rotting pile
Weeds	Hand-pulled weeds with roots (high soil content)	Rotting pile
Greenhouse waste	Vegetative trimmings, dead plants, and potting medium	Rotting pile
Diseased plants	Infected plants that must be removed from property	Landfilled
Culls	Damaged, spoiled, or unmarketable produce	Composted
Processing waste	Waste from kitchen processing for canning, baking, etc.	Composted
Harvest waste	Unavoidable waste from harvesting activities	Rotting pile
Rabbit manure	Manure collected from 15 rabbits kept on the farm	Composted
Pig manure	Scraped manure plus bedding from the farm's pig	Composted

Fig. 1: Weeds and row clearings left to rot onsite away from beds

Fig. 2: Food waste from kitchen processing activities

Table 2: Methane yield estimates from literature

Category	Methane yield (m^3 CH_4/kg VS)	Source
Row clearing	0.143[a]	Owens and Chynoweth 1993
Weeds	0.143[a]	Owens and Chynoweth 1993
Greenhouse waste	0.143[a]	Owens and Chynoweth 1993
Diseased plants	0.143[a]	Owens and Chynoweth 1993
Culls	0.405[b]	Graunke and Wilkie 2008
Processing waste	0.405[b]	Graunke and Wilkie 2008
Harvest waste	0.143[a]	Owens and Chynoweth 1993
Rabbit manure	0.213	Aubart and Bully 1984
Pig manure	0.278	Aubart and Bully 1985

a: Value is for mixed yard waste
b: Value is for food waste

Results

- Each week showed great variability in types and amounts of waste produced (Fig. 3).
- The majority of organic waste was row clearings and weeds.
- The different types of waste showed very different TS and VS content (Fig. 4).
- Total organic waste (wet weight) and methane potential per week ranged from 379 to 545 kg and 8.98 to 10.12 m^3, respectively (Fig. 5).

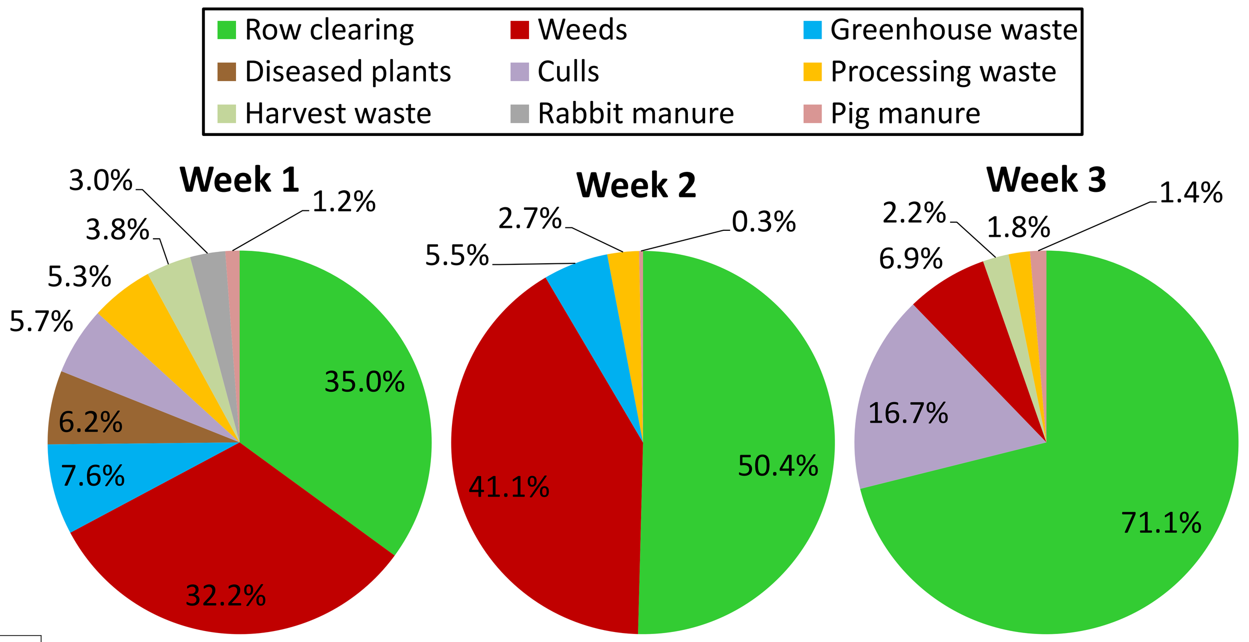

Fig. 3: Weekly composition of organic waste

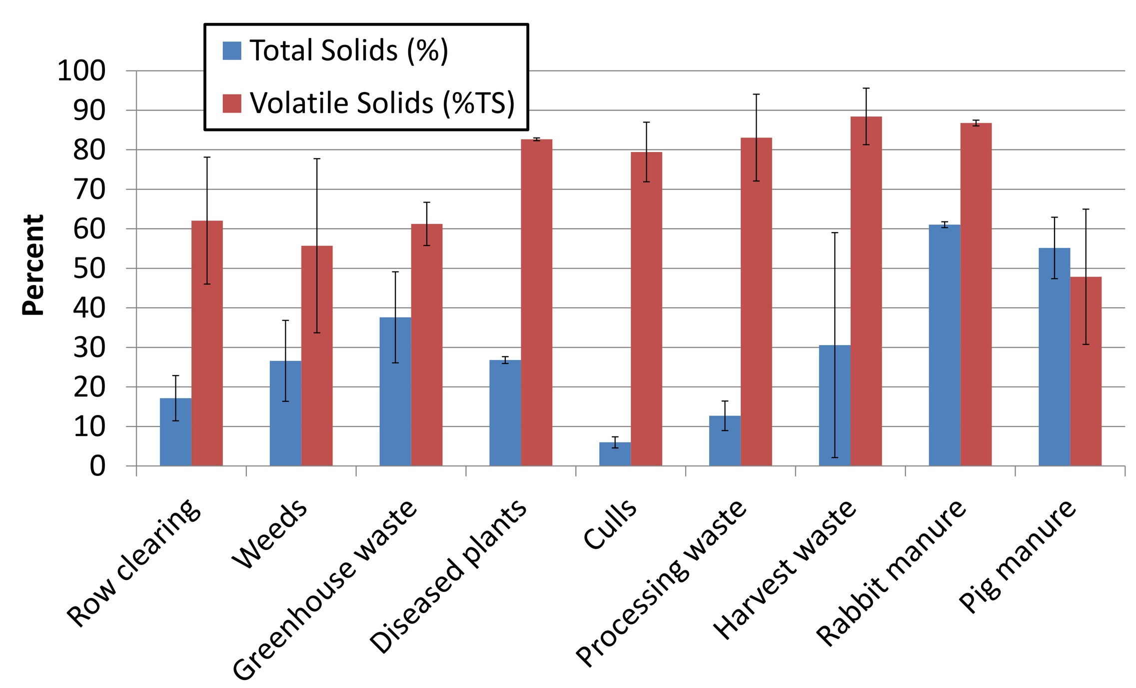

Fig. 4: Average total solids and volatile solids of each type of waste

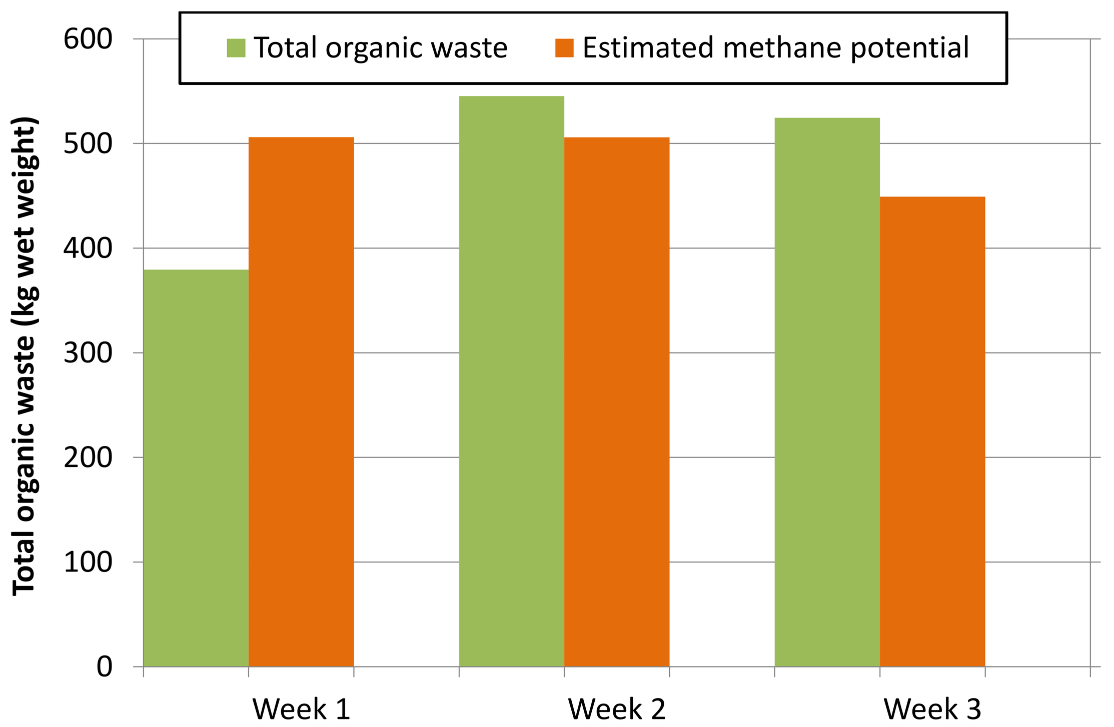

Fig. 5: Total organic waste and estimated methane potential for each week

Discussion

- An estimated 9-10 m^3 of methane could be generated per week which corresponds to 318,000-353,000 BTUs per week.
- Greater mass (wet weight) did not correspond to greater methane; measuring moisture content and organic matter content is crucial.
- Determining the digestibility of each type of waste is critical for digester feedstock selection.
- Additional organic waste, such as food waste from local schools and restaurants or waste products from biodiesel production could be brought to the on-farm digester for additional bioenergy production.
- Utilization of anaerobic digestion can create a closed-loop cycle of organic waste management with energy and nutrient recovery on small farms (Fig. 6)

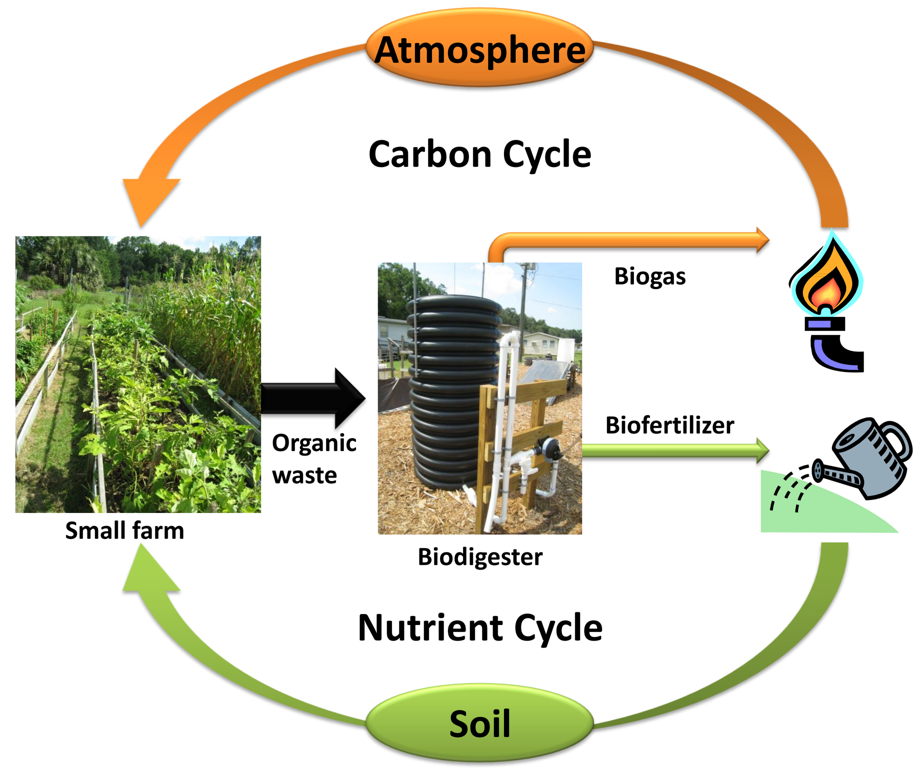

Fig. 6: Closed-loop cycle of small farm organic waste recovery and reuse

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Acknowledgements

- Jeri Baldwin, Lee Soloman, and the staff at Crones' Cradle Conserve
- The 2011 BioEnergy Internship food waste team: Chelsea Brown, Jacquelyn Neal, and Tim Sink
- This work is funded by a grant from Southern SARE (Sustainable Agriculture Research and Education).