Start-up of a Small-Scale Anaerobic Digester

Blaze Walsh[1] and Ann C. Wilkie [2]

[1] Environmental Science Major

[2] Faculty Mentor, Soil and Water Sciences Department, University of Florida-IFAS, Gainesville, Florida

Abstract

Anaerobic digestion involves the fermentation, breakdown, and stabilization of organic materials in the absence of oxygen, resulting in renewable fuel (biogas) and solubilized nutrients (biofertilizer). The process design can be relatively simple and inexpensive, with minimal maintenance. A small-scale (55-gallon) anaerobic digester was designed and constructed for treating food wastes. The purpose of the self-contained unit is to generate cooking fuel and produce organic biofertilizer for gardening. Organic loading rates (2g COD/L/day) were established for two primary feedstocks, namely sweetpotato culls and spoiled ground corn. Critical operational parameters including pH and temperature were monitored closely during the start-up period, and the biogas yield and composition were measured daily to determine methane productivity. Temperatures were in the mesophilic range, while the pH decreased from 6.61 to 6.16 on day 4 due to increased volatile fatty acid production. The total biogas production followed the pH trend during the start-up phase and reached steady-state conditions by day 5, producing approximately 34 L biogas/day. The methane composition of the biogas consistently increased over time, reaching 40% by day 9. This small-scale, low-cost digester design promotes recovery of methane gas and biofertilizer from food waste, and facilitates diversion of organic residues from landfills.

Introduction

Food waste is a significant fraction of municipal solid waste in the US, which means energy is used to haul it to the landfill where it becomes a burden rather than a valuable resource. However, this organic waste can be anaerobically digested in order to produce renewable energy in the form of biogas and biofertilizer in the form of liquid effluent. A household digester has no minimum volume requirement, demands no advanced methodology, and minimal effort is needed for it to successfully produce energy and nutrients. The recycling of organic materials and the use of their multiple nutrients not found within industrial fertilizers can improve soil characteristics [1].

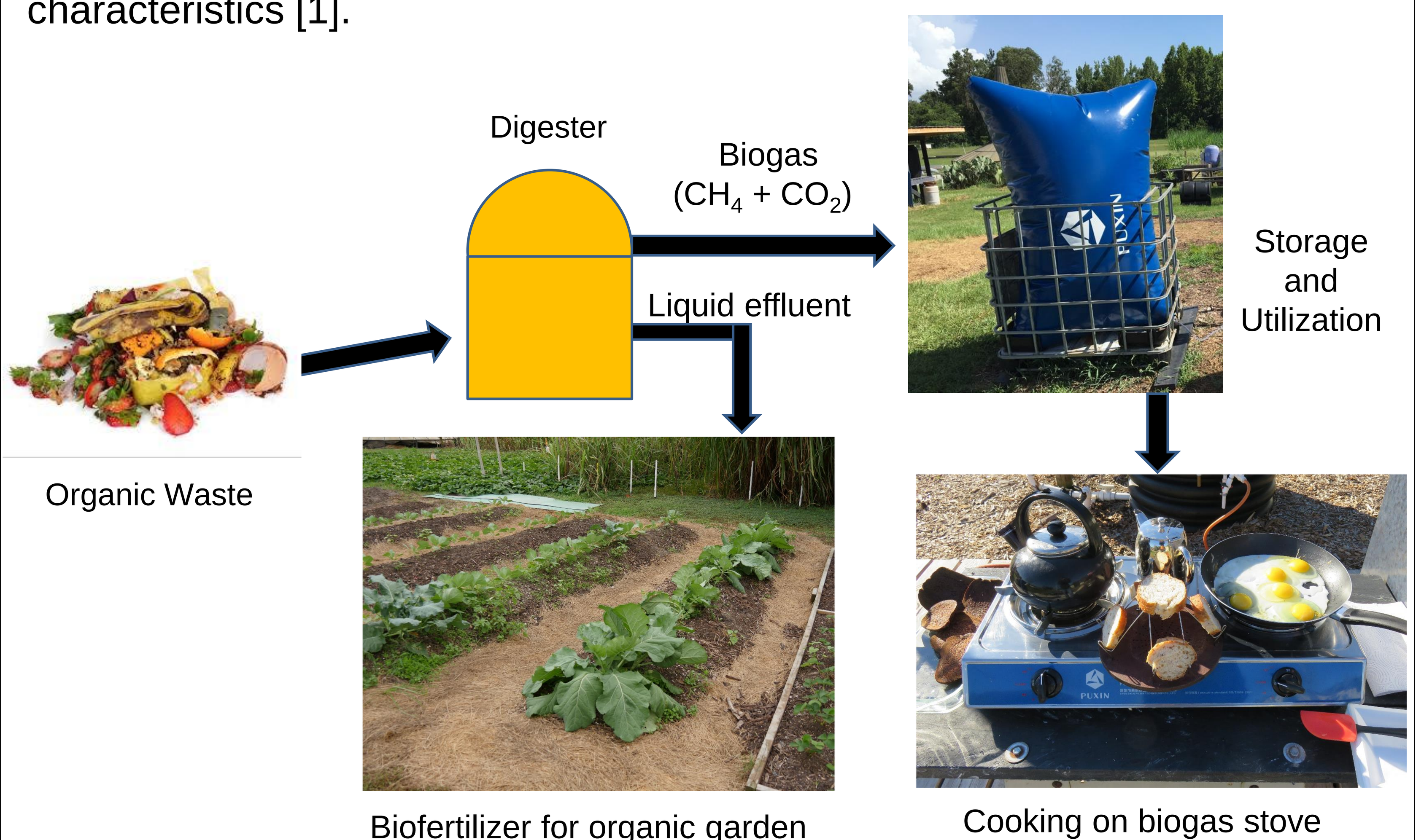

Figure 1. Potential Applications for Household Digesters

Objectives

- Construct a small-scale digester for household applications that can reduce waste, produce energy and provide a nutrient-rich fertilizer for organic gardening.
- Collect pertinent data during start-up to determine when steady-state conditions are established.

Methods

Digester Construction:
- Digester constructed of 55-gallon drum
- Gas collector consisted of inverted 40-gallon drum with open-ended bottom to allow for gas collection
- Inlet pipe to add feedstock
- Outlet pipe/valve to collect effluent for garden
- Baffle for mixing

Figure 2. Digester Construction

Digester Composition:
- Available feedstock consisted of sweetpotato culls
- Feedstock was initially characterized for total and soluble chemical oxygen demand (COD) [2]
- COD values were used to establish appropriate loading rates for digester
- Inoculum consisted of digested flush dairy manure from Alliance Dairies

Figure 3. Laboratory Analyses

Digester Start-up Period:
- July 25 – August 3, 2016

Daily Monitoring:
- pH
- Temperature
- Volume of biogas
- Composition of biogas using Landtec Gas Meter

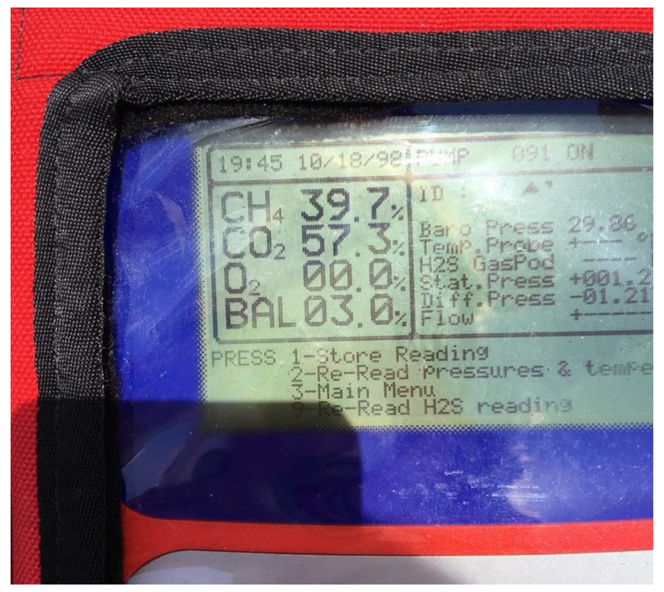

Figure 4. Biogas Composition

Results

Table 1. COD Concentrations of Feedstock

Total COD (g COD/ kg sweet potato cull)	342 ± 11
Soluble COD (g COD/ kg sweet potato cull)	150 ± 4

Loading Rate:

2 gCOD/L → *1.2 kg Sweetpotato culls / day*

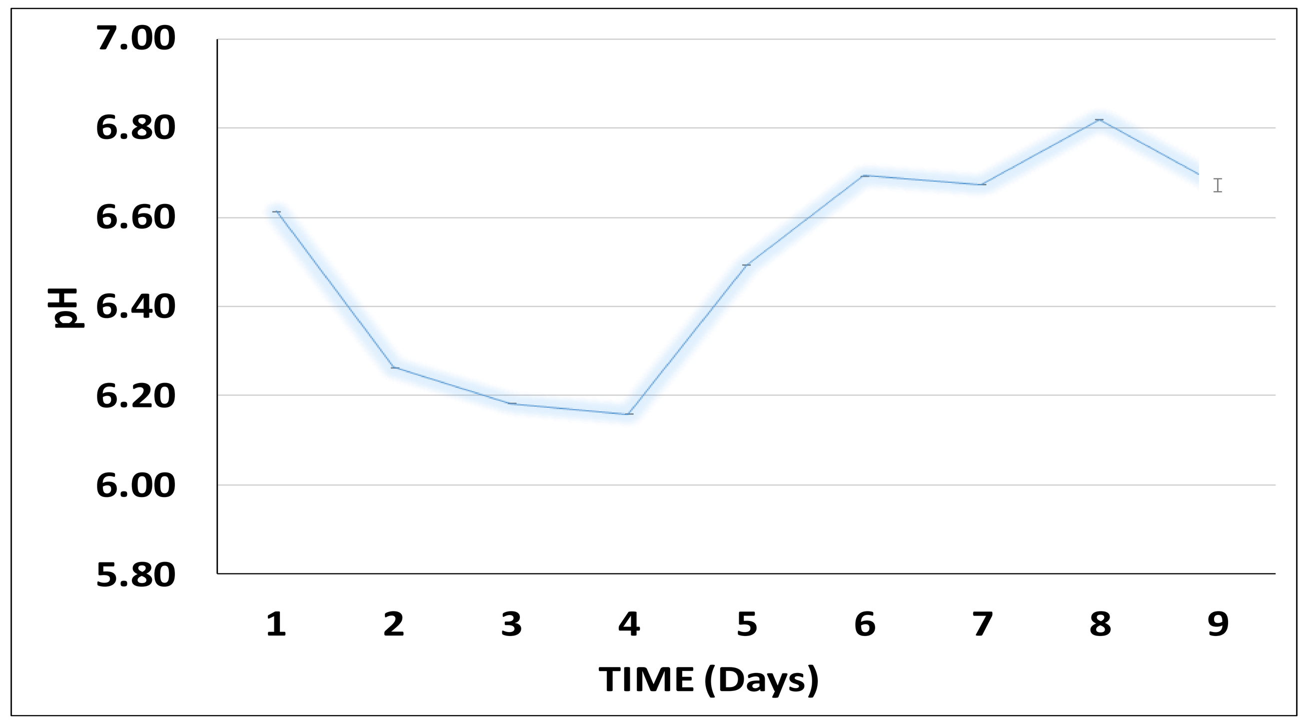

Figure 5. pH changes

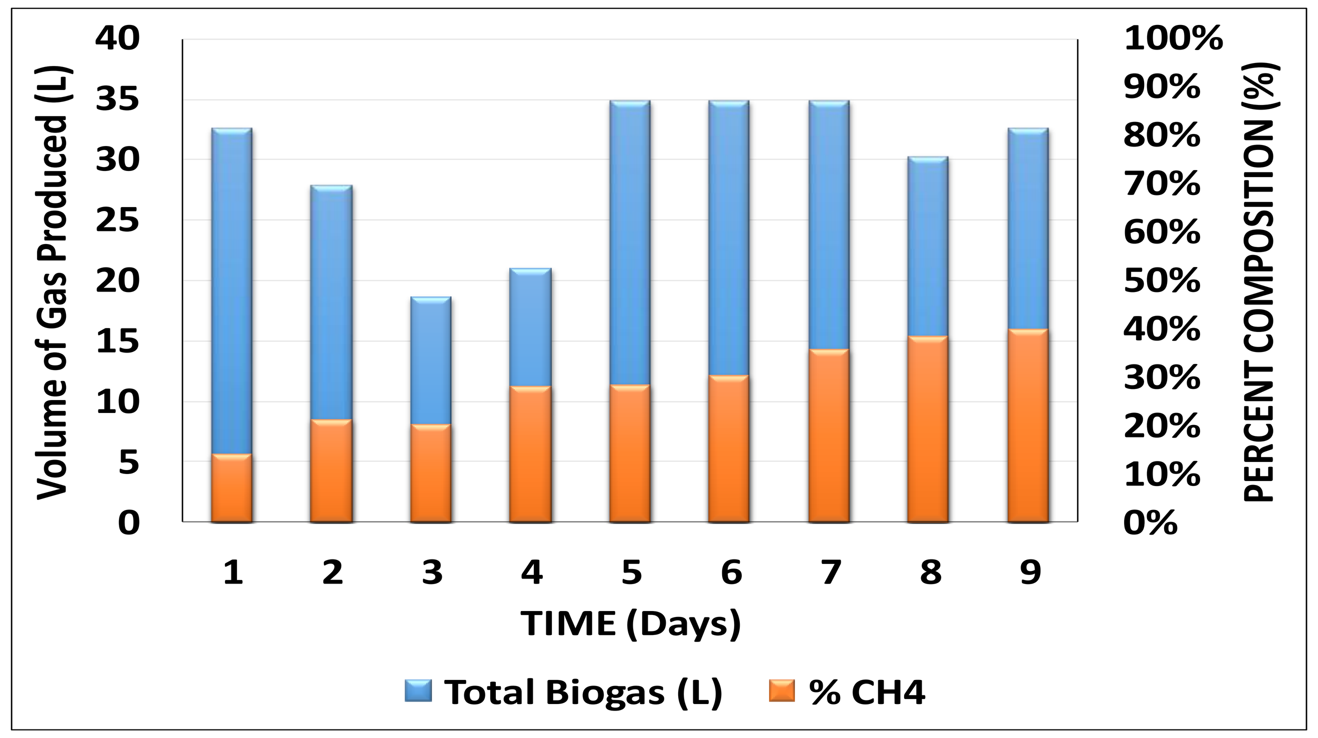

Figure 6. Biogas and Methane Production

The pH trend initially declined due to the rapid production of volatile fatty acids. However, within one week, pH stabilized and composition of methane in biogas reached 40% by Day 9. Temperature ranged from 30 to 35°C with no external heating requirements.

Conclusions

- Approximately 44% of the organic component of the feedstock was in soluble form.
- The pH and methane composition of the digester stabilized after a 9-day start-up period in mesophilic conditions using a loading rate of 1.2 kg sweetpotato culls/day.

References

[1] Firoza Akhter, Zakaria Ahmed, Hasina Banu and M. Shamsul Haque (2003). Utilization and Feasibility of Retting Effluent as Fertilizer in Vegetable Crops Production. *Pakistan Journal of Biological Sciences*, 6: 341-343. DOI: 10.3923/pjbs.2003.314.343

[2] APHA (2012). *Standard Methods for the Examination of Water and Wastewater*. 22nd ed. Washington DC: American Public Health Association/American Water Works Association/ Water Environment Federation.

Acknowledgements

This research was conducted as part of the 2016 BioEnergy and Sustainability School (BESS), a summer research internship program for undergraduates funded by the Florida Agricultural Experiment Station, UF– IFAS.