Pre-treatment of Food Waste to Facilitate Anaerobic Digestion

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Abstract

Increasing fossil fuel use and waste disposal in landfills have led to a situation where society must develop sustainable energy and waste solutions. Use of synthetic fertilizers derived from fossil fuels has increased substantially, placing further demand on natural resources and the environment. Anaerobic digestion of organic waste can simultaneously alleviate these problems. Through anaerobic digestion, organic material is decomposed by microbes to produce sustainable bioenergy (biogas) and biofertilizer for organic agriculture. Anaerobic digestion maintains overall carbon and nutrient balances by recycling these resources from waste rather than using fossil fuels and raw materials. One excellent organic feedstock for anaerobic digestion is food waste. In Florida, 1.7 million tons of food waste was produced in 2006, representing 6% of the municipal waste stream. By diverting food waste from landfills to anaerobic digestion, many problems associated with landfills will be alleviated, including methane emissions, leachate treatment, space availability, odor, and nutrient lock-up. Anaerobic digestion can also help meet Florida's 75% recycling goal. The purpose of this project is to develop methods of pre-treating food waste to facilitate anaerobic digestion. By solubilizing food waste prior to digestion, the overall process efficiency increases due to improved microbial processes. Treatment methods will be selected with particular attention to sustainability, such as enzymatic and/or bacterial treatment and mechanical grinding. The solubilized COD pre- and post-treatment will be measured to determine the effectiveness of the treatment. Treatments will be assessed for large-scale applicability and feasibility to increase the widespread adoption of food waste digestion.

Introduction

Background

•Anaerobic digestion harnesses the power of microbial metabolism to decompose organic material and capture methane gas (Wilkie 2008)

•It is a sustainable technology for energy production and waste handling

•Captures both energy (as biogas) and nutrients (as biofertilizer) from waste products

•Helps maintain natural carbon and nutrient cycles (See Fig. 1)

•Food waste is a large source of organic waste in Florida, ~1.7 million pounds annually (FDEP 2007)

•Digestion of food waste can be an integral part of Florida's 75% Recycling Goal (FDEP 2009)

•A study at the University of Florida Broward Dining Hall found that food waste produces 320 L methane per dry kg food waste per day in a trial-scale digester (See Fig. 2) (Graunke and Wilkie 2008)

Project Overview

•By pretreating and solubilizing food waste prior to digestion, nutrients can be made more available to the anaerobic consortium, expediting its conversion into biogas

•Literature shows that using enzymes as pretreatment will increase soluble chemical oxygen demand (COD) of food waste (Kim et al. 2005).

•By using a bacteria and enzyme mixture, the process may by more effective and self-sustaining

Materials and Method

•Food waste studied was a represented sample of household food waste including both cooked and raw food

•Material was homogenized using a paint mixer attached to electric drill

•Five 100 g samples of homogenized food waste were obtained and placed in flasks

•Treatment regime is detailed in Table 1.

•Samples were held at 25°C in a water bath.

•At 0, 1, 2, and 3 days, sub-sample was obtained from each treatment and centrifuged to separate suspended solids and solubilized material

•Soluble COD analysis was performed using standard methods (APHA 1998)

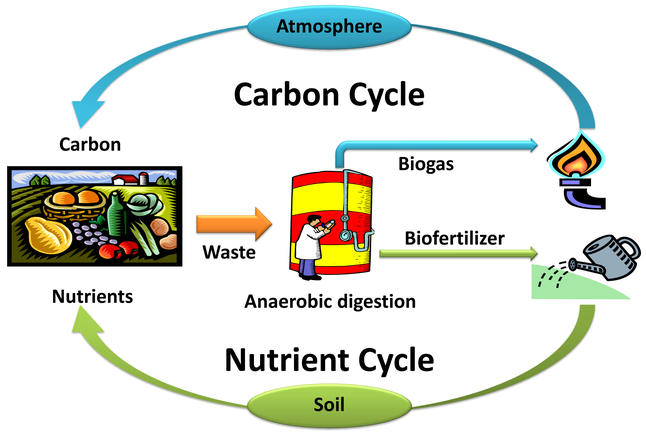

Fig. 1 Anaerobic digestion in the carbon and nutrient cycles

Fig. 2 Trial-scale food waste anaerobic digester

Results

•Visually all treatments appeared significantly more liquefied than prior to treatment (Fig. 4&5)

•Figure 3 shows the soluble COD over three days for each treatment and control

•Treatment with enzyme/bacteria mixture shows an initial increase in solubilization

•Rate of solubilization is similar for all food waste treatments

•Blending seemed to have little effect on solubilization

Table 1: Treatment regime to study soluble COD

Label	Treatment
Control	100 g food waste & 25 mL water
Blended	100 g food waste & 25 mL water (blended for 30 sec.)
1 g	100 g food waste, 25 mL water & 1 g enzyme/bacteria mixture
5 g	100 g food waste, 25 mL water & 5 g enzyme/bacteria mixture
10 g	100 g food waste, 25 mL water & 10 g enzyme/bacteria mixture
1g Control	1 g enzyme/bacteria mixture & 100 mL water
5g Control	5 g enzyme/bacteria mixture & 100 mL water
10 g Control	10 g enzyme/bacteria mixture & 100 mL water

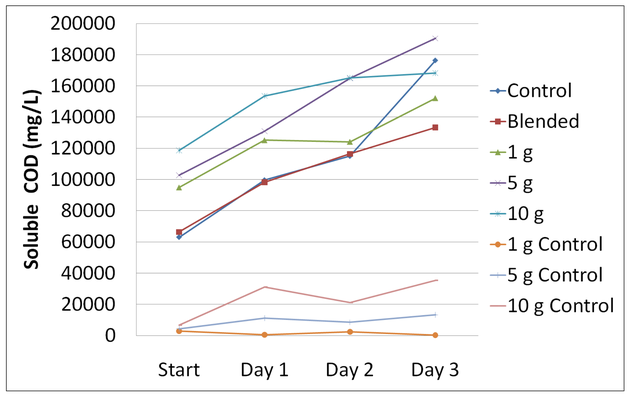

Fig. 3 Soluble COD over three days of treatment

Fig. 4 Food waste prior treatment

Fig. 5 Food waste post-treatment ("5 g" shown)

Discussion

•Soluble COD was increased by pretreating food waste with the bacteria/enzyme mixture

•Pretreatment using this material shows potential to increase efficiency of anaerobic digestion

•A shorter pretreatment period is ideal, pretreatment with enzyme/bacteria mixture for one or two days may be sufficient

•Field trials will need to be implemented to determine actual increase in digester loading rate and performance

•Material may be self-inoculating and self-sustaining, meaning the mixture will only need to be added once to a continuous-fed system

•Cost of material will need to be compared to gain in efficiency

•Further studies will look at potential increase from blending/enzyme-combination and looking at other enzyme and microbially-active materials

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