The BioEnergy Project

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UNIVERSITY OF CALIFORNIA Carbon Neutrality Initiative

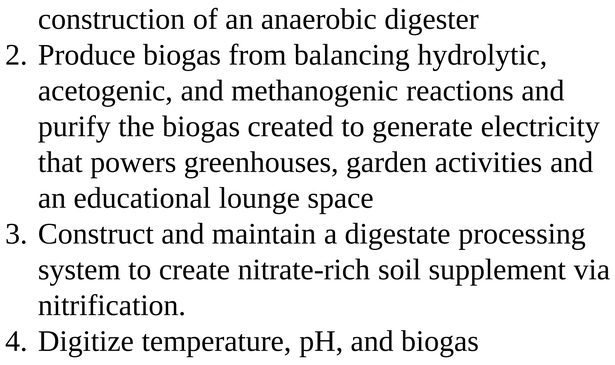
Introduction

Anaerobic digestion can provide a technical solution to the trilemma of overfilling landfills, greenhouse gas emissions, and the need for renewable energy sources by diverting food waste from landfills for practical use, sequestering CO2, and generating a baseload renewable energy supply. This is accomplished through the generation of biogas, which can be converted into electricity, and anaerobic digestate, which can be processed to produce organic soil supplement. Throughout the course of this fellowship, the creation of a sustainable method of operating, constructing, and maintaining a small scale off-grid food repurposing system including anaerobic digestion, biogas purification, and anaerobic digestate treatment was developed through collaboration with Roger's Community Garden, Engineers for a Sustainable World, and Engineers Without Borders.

Project Goals

1. Offset Carbon dioxide and methane emissions and initiate landfill diversion through the construction of an anaerobic digester
2. Produce biogas from balancing hydrolytic, acetogenic, and methanogenic reactions and purify the biogas created to generate electricity that powers greenhouses, garden activities and an educational lounge space
3. Construct and maintain a digestate processing system to create nitrate-rich soil supplement via nitrification.
4. Digitize temperature, pH, and biogas composition readings using Arduino microcontrollers and Raspberry Pi
5. Use soil supplement to grow edible plants, bringing the food life cycle full circle and generating carbon sinks.

What is Anaerobic Digestion?



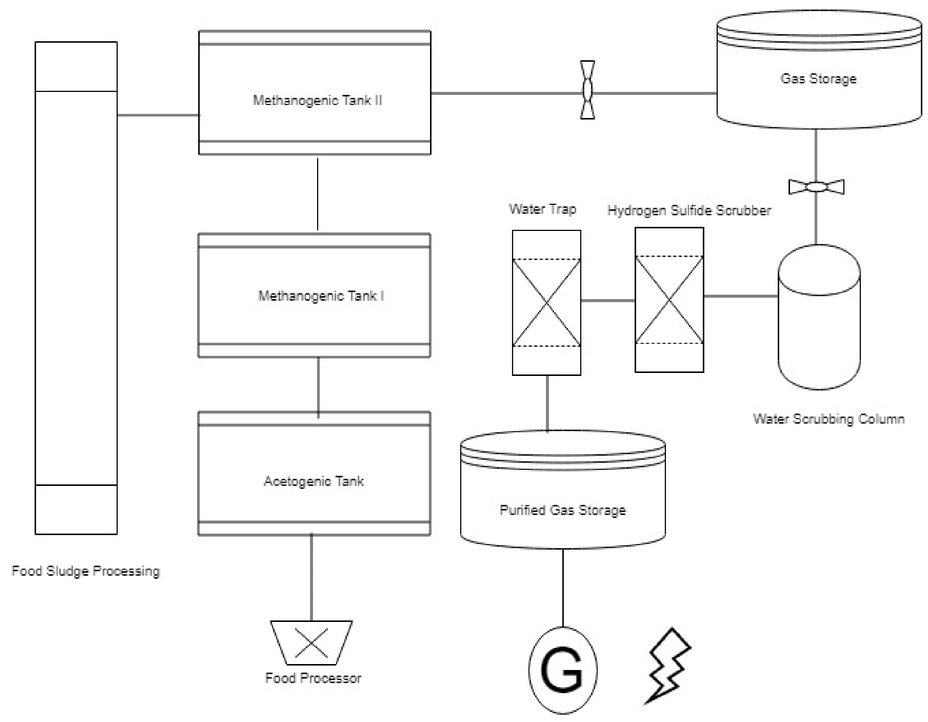
Biochemical Steps of Anaerobic Digestion

Hydrolysis - Enzymes from bacteria break down complex molecules into simpler ones

Acidogenesis - The simpler compounds in bacteria converted to intermediary products

Acetogenesis - Intermediary products consumed by acetogenic bacteria form acetic acid and hydrogen gas

Methanogenesis - Methanogenic bacteria convert acetic acid and hydrogen gas to methane, carbon dioxide, hydrogen sulfide, trace gases



Methods

Initially, designs for the anaerobic digestion system, digestate processing system and biogas purification system were created and constructed.

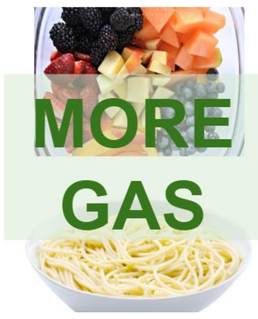
Soon after, project members and volunteers began pre-consumer food waste collection from six vendors at UC San Diego 's Price Center to be delivered to Roger's Community Garden using weekly standard procedure. Once collected and delivered to the garden, food waste bins were weighed and catalogued using a Google Sheet to allow for easy input from any volunteer via smartphone.

As the anaerobic digester filled, the digestate treatment system was constructed using porous media to filter residual solids and aeration to initiate nitrification. The food waste preparation system was then designed and constructed to pulpify food waste with an Insinkerator garbage disposal and Saniflo sewage pump.

The system efficiency was observed and recorded by periodically monitoring pH, ammonia, and nitrate levels of the digestate.

Results

1. **2,704 lbs** of food waste diverted from landfills totaling **2.2 tonnes CO2eq** using combined composting and anaerobic digestion.
2. Composting is better suited to food waste high in fibrous materials, which are low in energy density and more difficult to preprocess. Anaerobic digestion is more suitable for food waste high in simple carbohydrates and micronutrients such as grains and fleshy fruits.
3. Anaerobic digester was constructed and food waste added but limited biogas was collected due to acidifying methanogenic tanks, high solids percentage, and variable food waste loading rates.



Future Goals

- Fully automate process and sensor operations using Arduino and Raspberry Pi
- Collect biogas and use to generate electricity via methane fuel cell technology
- Improve the efficiency of biogas collection and food waste processing by balancing the hydrolysis and methanogenesis stages
- Test digestate samples using GC-MS Techniques

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RCG ROGERS COMMUNITY GARDEN

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Engineers for a Sustainable World

UC San Diego SUSTAINABILITY

ENGINEERS WITHOUT BORDERS-USA UNIVERSITY OF CALIFORNIA-SAN DIEGO STUDENT CHAPTER

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