Small Scale Anaerobic Digestion in an Urban Environment

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Abstract
Climate change is quickly impacting the environment. Humans are an active contributor to the increasing rates of climate change; food waste contributes to 8% of greenhouse gasses. At Loyola University of Chicago there is a need to work towards reducing this carbon footprint, this can be done utilizing Loyola’s food waste. The food waste can be captured and utilized in the processes of anaerobic digestion to create biogas. Anaerobic digestion follows four steps, hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Introducing this program to Loyola will help eliminate food waste and benefit the environment. In order to accomplish Loyola’s net carbon goals, we have experimented with small-scale anaerobic digesters to test this beneficial program.

Introduction
The small batch anaerobic digesters resemble the reactors that could one day be used on Loyola’s campus. Some investigations have already been conducted to find how much carbon the inoculum could undergo. The pretreatments help determine what would be most effective in producing methane gas. Experiments have also been conducted to understand how the system stays healthy. A list of previously conducted experiments can be seen below.

• Different levels of Dilution
• Different levels of Aeration
• Caps kept off for extended periods of time
• Different amounts of feed
• Number of feedings

An explanation of the basic set up, and an example experiment can be seen in the Methods Section

Definitions
Anaerobic Digestion: A four step process in which waste is broken down by anaerobes to produce methane
Hydrolysis: When a molecule of water breaks one or more chemical bonds. The lipids, carbohydrates, and proteins in food waste break down to become fatty acids, glucose, and amino acids [1]
Acidogenesis: When the fatty acids, glucose, and amino acids ferment to become volatile fatty acids [1]
Methanogenesis: The process in which anaerobes consume volatile fatty acids to produce CO₂ and CH₄ [1]
Substrate: The food that anaerobes consume
Influent or Inoculum: The digester drawl used as the base for the experiments
Effluent: The different gasses collected, as well as the remain drawl
Automatic Methane Potential Test System (AMPTS): The system used to conduct experiments from BPC instruments

Materials
In order to conduct an anaerobic digestion experiment to gather data on methane production at a small-scale level the AMPTS must be utilized. AMPTS experiments all follow a similar procedure. Preliminary to an experiment being conducted the following materials must be gathered.
• Automatic Methane Potential test system
  • The AMPTS Scrubbers are filled with 2M NaOH
  • Figure 1 shows the different pieces to the AMPTS that are needed
• Crucibles
• Tongs
• Furnace
• Incubator
• Dresser
• Influent: Digester drawl from Metropolitan Wastewater Reclamation District
• Substrate
• A scale
• A funnel
• Ethanol
• Gloves, goggles, lab coats
• Water

Once the materials have been gathered the methods below can be followed to collect data

Methods: TS/VS
• Total solids versus volatile solids tests are carried out to determine how much inoculum and substrate is needed
  • First the crucibles are burned at 550 °F in the furnace for 30 minutes, this is to ensure that anything that was in the crucibles is now gone
  • Place crucibles in the desiccator. Be sure to use tongs and oven mitts to ensure safety. Let the crucibles cool for 30 minutes
  • Once the crucibles are cooled weigh them. Be sure to keep track of the order that the crucibles are in to properly conduct TS/VS. This is the dry crucible mass.
  • Then fill each crucible with either inoculum or substrate. It is best to have three of each. Record the weights.
  • Once all the crucible's weights have been recorded place each one into an incubator set to 105 °F for 20-24 hours
  • After the time in the incubator weigh the samples again. This is the dry sample weight. All of the water in the crucibles has evaporated. While the crucibles are cooling keep all others in a desiccator to prevent any evaporation
  • Next, place the crucibles back into the furnace for 2 hours at 550 °F. After the two hours weigh the crucibles again to get the burned weight of the samples.
  • Once all the weights are taken use the AMPTS software to determine the amount of inoculum to substrate needed to start the experiment.

How to Read AMPTS Data
The following experiment was conducted in 2022. The experiment was used to see how the different sizes of microbe populations effected methane production. The inoculum was diluted at various amounts. Both the volume of total gas, carbon dioxide, methane and other gasses, and just methane were collected. Each dilution was fed an initial amount of substrate, then two more times. Although AMPTS software does produce a graph, it is easier to understand the trends if the data is put into MATLAB. The following figures show the trends in each replicate.

Future Outlook
There is still plenty to investigate when it comes to advancing anaerobic digester knowledge, and how it can be applied to an urban campus setting. The following items are suggested for further research.
• Three of the fifteen reactors were used to collect gas into gas bags. No data was taken from these, but the collected gas can be experimented on. Gas chromatography can be used to determine the contents of the “other gases”
• More feeding experiments can be carried out to determine how often the reactors should be fed to create maximum gas production
• Feeding experiments should be conducted to determine an effective ratio of liquids, carbohydrates, and proteins
• Gene sequencing can be utilized to determine the microbes that are more fit for the systems

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