Anaerobic Digestion for Sustainable Development

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Abstract

Anaerobic digestion is the breakdown of organic material by anaerobic bacteria, decomposing it into biogas and nutrient-rich slurry. The biogas is primarily composed of methane and carbon dioxide, and can be used in heating and cooking applications. The remaining slurry can be diluted and used on crops as a nutrient-rich fertilizer to promote growth and restore nutrients to the soil. Processing of human and animal waste by anaerobic digestion results in pathogen reduction, due to the pathogens' inability to compete for food in the oxygen-free conditions inside the digester. Anaerobic digesters can be built from low-cost materials, and require little to no technical knowledge for construction, operation and maintenance, making them an ideal technology to be used in rural settings. This technology has been used in developing regions to treat and manage waste, create a sustainable fuel source for heating and cooking, and create a biofertilizer for agriculture. The focus of this study is to determine the optimal conditions for anaerobic digestion with respect to temperature, pH, and feedstock loading rate and retention time. Establishing these conditions enables the user to maximize biogas production, creating sustainable energy and relieving an important need to any society. The study also sets out to create an operating manual that covers basic construction and operating parameters.

Background

Anaerobic Digestion Process

- Three main phases:
  1. Hydrolysis: hydrolytic bacteria break down large molecules into smaller, more usable molecules
  2. Acid Digestion: smaller molecules are digested by acidogenic bacteria to form short chain fatty acids, H_2 and CO_2
  3. Biogas Digestion: fatty acids are digested by methanogenic bacteria to form CH_4

Types of Digesters

- Anaerobic digesters can vary from large, centralized units to personal home units
- Can be constructed from inexpensive, basic materials
- Designs can vary to adapt to local climate and weather conditions
- Two main types of digesters:
  1. Batch: Digester is filled once and allowed to degrade over time.
  2. Continuous: Feedstock is added and removed incrementally.

Design Conditions

- pH: Anaerobic bacteria operate optimally at a neutral (7) pH.
- Temperature: Most anaerobic bacteria operate between 21 and 40 °C
- Loading Rate: The amount of feedstock to be added to a digester at a time, dependent on the feedstock's volatile solid content and digester volume
- Retention Time: How long the contents remain in the digester, also varies with volatile solid content and digester volume

Benefits of Anaerobic Digestion

- Biogas can be used as a sustainable, renewable energy for as heating, cooking, lighting, etc.
- Effluent from the digester is a nutrient-rich fertilizer that can be used to boost soil fertility
- Anaerobic digester is a practical waste treatment method, being 99% efficient in pathogen reduction
- Anaerobic digesters are easy to build, operate and maintain

Methods and Materials

- Digester is constructed using inexpensive readily available materials (Fig. 2, 3, 4)
- The digester is designed to be a continuous flow digester
- 9 L of swine manure mixed 1:1 water is mixed and aged for 1 day to make fresh slurry
- 18 L of digested slurry is removed from digester
- Fresh slurry is fed to digester
- The digester is fed consistently for a steady flow of biogas
- Agitation is applied to prevent slurry layering and inhibit biogas formation
- Agitator is a simple, manually-powered design (See Fig. 5)
- To maintain anaerobic conditions, a layer of oil is applied on top of slurry

Fig. 2 Digester barrels

Fig. 3 Constructing frame

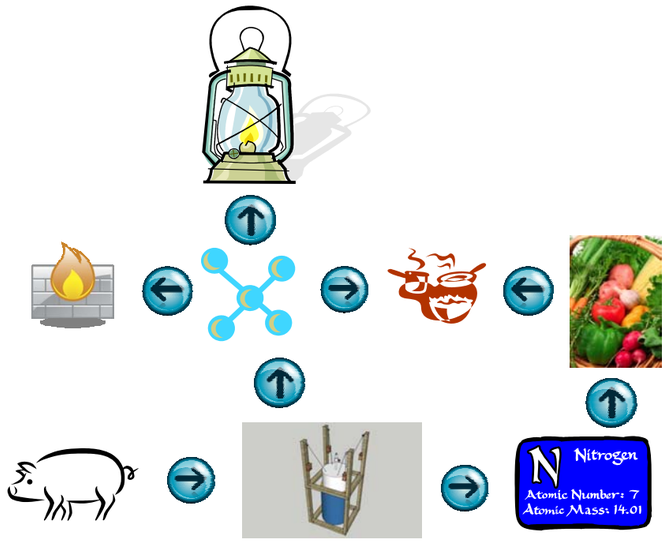

Fig. 1 Nutrients and biogas from swine manure

Results and Discussion

- Once the digester was constructed and fed it started producing gas within the first couple days.
- The initial gas had a low methane content. This is due to initial start-up stabilization.
- Further research will seek to optimize operating conditions
- Anaerobic digesters are very useful for developing nations where combustible energy is not an abundant resource
- Digester design is ideal for developing nations due to simple design and materials
- It has been used to replace the practice of burning wood for cooking, which has effectively reduced deforestation and incident of lung disease in rural areas
- The building of digesters can also stimulate a local economy in areas of low employment
- Biogas is a "green energy" and helps to reduce accumulation of greenhouse gases

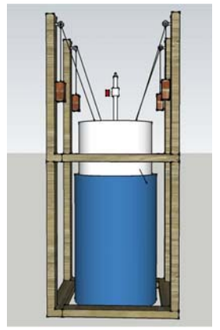

Fig. 4 Final digester design

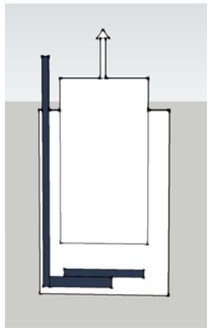

Fig. 5 Agitator design

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