

# Don't Waste the Waste

## Objective:

The purpose of this lesson is to create a model digester to capture & measure biogas production, & to understand the anaerobic digestion process.

## Keywords:

- Renewable energy
- Manure management
- Environment
- Biogas
- Anaerobic digestion

## 21<sup>st</sup> Century Skills Represented:

- Environmental Literacy
- Economic & Business Literacy
- Critical Thinking & Problem Solving
- Communication & Collaboration
- Information Literacy

## National Science Education Standards:

- Physical Science: Matter and its Interactions
- Earth and Space Sciences: Earth and Human Activity
- Engineering, Technology & Applications of Science: Engineering Design; Links Among Engineering, Technology, Science & Society

## feedstocks

Livestock manure, food by-products and municipal solid waste

## processes

Biological – anaerobic digestion

## uses

Methane, heat and electricity

## Background

How can waste not be wasted?

Anaerobic digestion is the breakdown of organic matter by bacteria in the absence of oxygen. In the natural environment, this process takes place in deep soils, wetlands and lake bottoms. This process is getting more attention as environmental pressure focuses on the need to reduce waste in landfills, prevent runoff pollution and generate useful bioproducts.

The feedstocks (i.e. organic matter) used in the production of biogas can come from many sources: agricultural biomass, such as manure from dairy cattle, hogs, chickens and waste from crops; municipal waste from water treatment plants, such as biosolids; alcohol/ethanol biomass, which is leftover materials from producing alcohol and ethanol; or the waste from food manufacturers.

Biogas, one of the products of this process, is composed of approximately 60% methane (principal ingredient in natural gas) and 40% carbon dioxide. The biogas can be cleaned, compressed and burned to create heat and electricity or used as an automotive fuel.

## Materials

### For the teacher digester:

- 5 gallon sealed container with modified hose outlet to connect to a burner
- Cork or stopper
- Bunsen burner
- Blended organic material using the following ratios:
  - 10% blended organic materials (i.e. manure; food waste; food such as milk, eggs and bananas etc.)
  - 50% inoculum (starter fluid from a working digester; see *Resources* for additional information)
  - 40% distilled water

### For each student digester:

- 2 liter containers
- Latex balloon to fit over the container opening or modified lid, hoses and two additional 2 liter bottles for water displacement test (see Figure 1 under the *Resources* section below)
- Funnel
- Rubber or latex gloves
- Safety goggles
- Blended organic material using the following ratios:
  - 10% blended organic materials (i.e. manure; food waste; food such as milk, eggs and bananas etc.)
  - 50% inoculum (starter fluid from a working digester; see *Resources* for additional information)
  - 40% distilled water

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## ***Pre-Lab Preparation***

1. Prepare the teacher digester a few days prior to the lesson.
2. Modify the container's lid with a hose outlet that can be used to connect a Bunsen burner to the container. Place a cork or stopper in the end of the hose not attached to the container to prevent gas leakage.
3. Blend the solid organic material into a liquid slurry.
4. In a 5 gallon container, place your inoculum, distilled water and blended organic material using the following ratios: 50% inoculum, 40% distilled water and 10% blended organic material. If a blender is unavailable, combine the organic materials in zip-lock bag and mash and mix well.
5. Mix the contents and seal the container with the modified lid; be sure it is air-tight.
6. Place the digester in a warm area, but not directly in the sunlight, and monitor its progress.
7. To begin the lab, connect the container to a Bunsen burner.
8. Ignite the Bunsen burner and use the flame to roast a marshmallow or burn a piece of paper.
9. Allow students to observe the container and its contents.
10. Have students answer the following questions:
  - a. What materials are in the container?
  - b. What gas was produced that was capable of being burned?
  - c. What biological processes created the gas?
11. Allow the students to research these questions and use the new information to discuss the answers.

## ***Lab Procedures***

1. Divide the students into teams of 2-3.
2. Explain, in general, that they will be constructing a "mini-digester."
3. Each group should develop a plan that includes the design and construction of their digester using a 2 liter bottle, along with the type of organic material they will include, type of measuring apparatus, and how they will measure the gas production over a specified time (*Note*: you can provide the organic solids or you can have the students gather their own). The group should also develop a hypothesis and outline their experiment using the scientific method.
4. Be prepared to explain different measurement options, such as using a balloon or the water displacement method.
5. Instruct groups to take the fully developed plan, gather materials and assemble mini-digesters using the ratio 50:40:10 (see the *Pre-Lab Preparation* section). Be sure to mix the contents once they are placed in the container.
6. Place mini-digesters in warm area but not directly in sunlight.
7. Observe digesters and collect data for a pre-determined amount of time (few days to a few weeks). Record data in lab books.
8. At the end of the project, each group should prepare and present a report that includes the following elements:
  - a. A review of measurement data, including what did and didn't work.
  - b. An explanation of the scientific process taking place in the digester.
  - c. A suggested use for a real-world application.

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## Post-Lab Discussion/Questions

1. Have students answer the following questions:
  - a. How can the anaerobic digestion process address the problem of over-flowing landfills?
  - b. How can the anaerobic digestion process address the problem of increasing electricity demands?
  - c. What types of locations and what different feedstocks can be used in the anaerobic digestion process?
  - d. How can anaerobic digesters help create sustainable systems in urban and rural settings?
  - e. How and why can the anaerobic digester system be a viable option for both developed and developing countries?
2. Hold a class discussion over the above questions.

## Expansion Ideas

- Compare the anaerobic digestion process to the enteric fermentation process in ruminant animals.
- Consider how this process can be used as part of a livestock manure management plan.
- Develop a community plan using waste water treatment plant biosolids and/or waste from food manufacturers as a biomass source.
- Create an “issues forum.” Students read a newspaper article about a manure spill and possible EPA action. Establish stakeholder roles (i.e. farmer, EPA, community member, etc.), conduct research, and share their different points of view.

## Evaluation of Learning

- Students successfully create a digester and gather biomass.
- Students share results, observations and answers.

## Resources

- Water displacement: see Figure 1 below. Also, visit: <http://chemed.chem.purdue.edu/genchem/lab/techniques/gascollect.html>

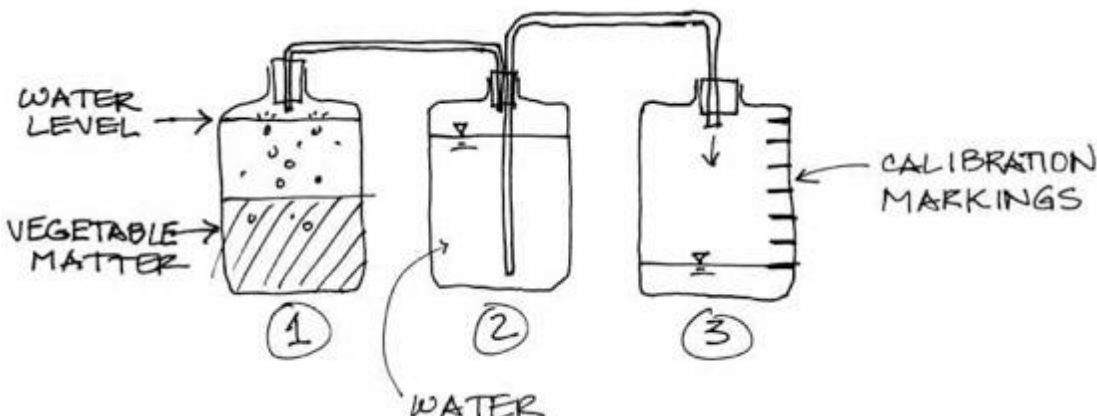
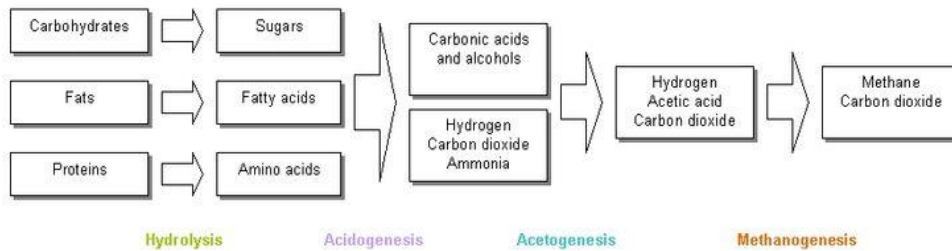


Figure 1 Set-up for measuring gas using water displacement

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- Anaerobic digestion process:



- Inoculum: “starter fluid” from a working digester that already contains microbes. It can be obtained from a functioning digester or a local wastewater treatment facility and may also be referred to as sludge or effluent. It is important that the sludge or effluent still have microbes in it and not be completely treated. The digesters should still produce gas if inoculum is unavailable, but it will take a longer amount of time.
- Videos
  - [quasar](#) from YouTube by The Ohio State University-OARDC
  - [Growing Ohio's Economy: quasar](#) from YouTube by The Ohio State University-OARDC
  - [Partnering for Green Energy Solutions](#) from YouTube by The Ohio State University-OARDC
  - [Power from organic wastes](#) from the quasar energy group
  - [Dairy Farm: Methane Digester](#) from YouTube by New York NRCS
  - [Biogas and How to Make a DIY Anaerobic Digester](#) from treehugger
- Websites and Articles
  - [Anaerobic Digesters for Farms and Ranches](#) from the U.S. Department of Energy
  - [Science Fair Digester](#) from the University of Adelaide
  - [Anaerobic Digestion on Farms Could Turn Agriculture Green](#) from ScienceDaily
  - [The process of anaerobic digestion](#) from the Science Fair Project Encyclopedia
  - [Power From Poop: Putting Manure to Use](#) by Jessica Marshall from the Discovery Channel
  - [Panda poop may be a treasure trove of microbes for making biofuels](#) from American Chemical Society
  - [Alternative & Advanced Fuels: Natural Gas](#) from the U.S. Department of Energy
  - [Interactive map of BioPower Application in the United States](#) from the U.S.E.P.A.
  - [National Biodigester Programme](#) (international connection)

## Contacts

- quasar energy group Headquarters, Cleveland, OH: <http://www.quasarenergygroup.com/>
  - quasar Laboratory & Engineering, Wooster, OH
  - Operational Digesters: Wooster, Columbus, and Zanesville
  - Commissioning Digesters: North Ridgeville

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