Food Waste Module Teacher Resource Sheet

Key Questions:

- How much food waste is produced annually in the US? Globally?
- What happens to food waste after it enters the waste stream?
- Which food groups do you think will produce the most biogas? Why?
- How will the results from the whole food samples differ from the chopped food samples?

Useful Videos to Share:

1. Landfills and Garbology Landfills and Garbology - Into the Outdoors episode (4:35) available at https://www.youtube.com/watch?v=K7cz9WPntfw
2. CleanWorld promotional video about large-scale food-to-energy project in Sacramento, California (5:15) available at http://www.cleanworld.com/
3. Anaerobic digestion video from Purdue University available at https://www.westlafayette.in.gov/topic/index.php?topicid=12&structureid=188

Vocabulary/Definitions

Variable: Any component of the experiment that can be altered; in this experiment, the variable will be the 'substrate' that is placed in the reactor to provide food for the microbes (bacteria).

Experimental group: The experimental set-up or group that includes the independent variable being tested.

Control group: The experimental set-up or group that does not have the independent variable. The purpose of the control group is to make sure the independent variable is causing the results.

Substrate: Organic matter that is broken down or digested by bacteria.

Anaerobic: An environment or condition that lacks oxygen

Anaerobic digestion: A process through which bacteria break down organic matter (substrate) — such as manure — without oxygen.

Biogas: A gas mixture produced during anaerobic digestion that contains methane and carbon dioxide. Biogas can be burned as an energy source. Biogas contains 55%-75% methane and 44%-24% carbon dioxide, with the other gases making up 1% or less of the mixture.

Bioreactor: An artificial environment in which organisms are encouraged to accomplish a particular task, essentially the microbes' workplace.

Effluent: Liquid waste from anaerobic digesters, farms, factories, or households that sometimes flows into bodies of water.

Manure: Solid wastes from animals (dung).

Organic material: All living or once-living things or items produced by living things. These carbon-based items include food waste, yard scraps, plant material, sugar, animal wastes, human wastes, and animals and people themselves. Also called 'organics.'

Background Knowledge

Overview: 5 Waste disposal options (from 'Where Does the Trash Go?' activity)

There are approximately 60 million metric tons of food wasted in just the United States annually. Where does it go? Roughly 32 million metric tons of food waste ends up in municipal landfills (see below). Modern landfills are often designed to prohibit contact between the waste that gets deposited and the surrounding environment (land, water, or air) – this means that the waste materials, whether biodegradable or not, often sit for many decades unchanged. This is not an economical use of landfill space!

When organic materials do decompose in a landfill it is often in the absence of oxygen. This anaerobic decomposition produces greenhouse gases, which are emitted into the atmosphere causing global warming. Methane is the main greenhouse gas that is emitted from landfills. Decomposition of organic matter in landfills accounts for 7% of the total global methane emissions.

Methane is also a valuable source of energy - it can be burned to create heat and electricity. Sometimes a modern landfill will capture the landfill gas to either flare it off (converting it to CO2) or collect it for an energy resource. Instead, we could avoid using the landfill to dispose of our organic material.

Below is a summary of different options for disposing various items, including organics, in our waste stream.

1. COMPOSTING *(or Aerobic Digestion)*

Composting is the rotting of organic material such as grass trimmings, leaves and food waste into a nutrient-rich material that can be used on gardens as fertilizer or soil enhancer. Yard and food wastes typically account for 20-30 percent of the waste stream. This means there is an opportunity to divert a large part of the waste stream to be composted. Many communities have started or are evaluating setting up a composting facility. Also, many families are setting up composting bins in their backyards and mulching grass clippings from their lawns.

Unlike a landfill, where garbage is tightly packed and covered with soil, a compost pile is mixed and aerated to help the organic material biodegrade – air makes the process happen more quickly, generating heat (that's why a compost pile is often warmer than the surrounding air). To make compost, air, water, heat and soil microbes must be present. Compost piles are turned frequently so these factors will work. Although composting has several advantages, such as producing a useful product and being inexpensive, it also has some disadvantages. Only organic materials can be composted. Also, no one wants to live next to a large compost facility. As compost decomposes, it may smell like rotting garbage, which is quite unpleasant for those people living close by.

For more detailed information on composting, see the Teacher Resources for Lesson 06, 'What Happens to your Food when it gets Composted?"

2. **RECYCLING**

One very popular way to divert materials from the waste stream is recycling. Recycling is the remanufacture of a material after it's been used. It may be turned into the same thing or something different. Recycling efforts have reduced the amount of material going into landfills. Of course, many waste products are not recycled.

It isn't practical to collect and recycle everything, especially considering that the reason we recycle: to save resources. If it takes more resources to recycle an item than to produce a new one, the item should not be recycled.

Recycling has become very popular in the past few years. Unfortunately, recycling has frequently grown faster than recycling facilities can handle it, manufacture it into new products, and find markets for the products.

Collecting items for recycling isn't effective if no one is willing to buy the recycled materials and make new products. Unless people are willing to buy the recycled products, companies won't produce them. For example, most plastic bottles are recyclable, yet when was the last time you looked at a bottle to make sure it had recycled content?

Some products, such as paper, cannot be recycled indefinitely. The wood fiber in paper gets shorter as it goes through the recycling process, and eventually it cannot be further recycled. Some materials may require too much energy to be recycled effectively.

This is especially true if the materials to be recycled are too far away from collection or manufacturing facilities. Does it make sense to ship glass 1,000 miles to be recycled and use more fuel to get it there than is saved by recycling?

The bottom line is that recycling has many advantages. It reduces the amount of garbage going to waste facilities, and in many instances, it can save energy and not create pollutants.

But recycling is not a cure-all. It is a process like any other, in that it uses energy, creates its own pollutants and has its own costs. All of these factors must be weighed when deciding how best to reduce waste disposal.

3. **INCINERATION (***or Waste to Energy)*

Modern incinerators burn garbage and nearly all of the plants generate electricity from the heat. An incinerator burns trash such as paper, plastics and broken furniture, turning them into electricity instead of sending them to a landfill. This seems like a better way to make electricity than damming rivers or burning coal or oil. Unfortunately, these plants are very expensive to build and run, and no one wants to live next to them.

Earlier incinerators produced a lot of smoke and pollution. Now, they burn at very high temperatures

and have special equipment that eliminates most of the pollution. Incinerators produce ash just like a fireplace does. Typically, the burned trash is reduced to one-tenth its volume and one-fifth its weight. The ash is tested for hazardous materials, and if the hazardous content is too high, it must be disposed of in special landfills. Fortunately, most ash isn't found to be hazardous. **By the way, batteries are sometimes listed as hazardous waste that cannot be incinerated and must be sent to expensive toxic waste facilities**.

4. **LANDFILLS**

A landfill is more than a big hole in the ground.

New landfills are designed with special clay and plastic liners to trap liquids, such as rain, which might seep through. Older landfills (often called dumps) had no liners and water and other liquids would soak down through them, sometimes polluting nearby wells and bodies of water.

Regulations now prohibit the disposal of hazardous material in a landfill. When the landfill is filled, it is covered with a membrane and dirt and often turned into a park or golf course.

We often read that we are running out of landfills. For example, we used to have more than 15,000 landfills in the United States, but as of 2023 we have only about 1,250. But these numbers do not tell the whole story - many of the landfills were old, were designed improperly, and should have been shut down. Also the new landfills that replaced them can be very large. In one case, three regional landfills had a greater capacity than the 500 "dumps" that had been closed. So it's not the number of landfills, but their capacity that's important.

The biggest problem for new landfills is the same as for incinerators and compost facilities– no one wants to live next to one. This is called the NIMBY (Not In My Back Yard) syndrome. Coupled with the high cost of building and maintaining new facilities, the NIMBY syndrome could lead to landfill shortages in some communities in the future.

5. ANAEROBIC DIGESTION (*or Waste to Energy)*

Anaerobic digestion is a process in which bacteria break down or "digest" organic material in the absence of oxygen to produce "biogas" as a byproduct of their metabolism. The process occurs naturally in the digestive systems of termites and animals (that includes you), water-logged soils, and deep water bodies, where naturally occurring bacteria break down dead leaves and other organic material in the absence of oxygen. The biogas that is released in swamps is often called "swamp gas."

In anaerobic digesters, naturally-occurring biological processes are exploited in an engineered system to treat and dispose of waste materials, stabilize end products, destroy pathogens, and generate biogas, a valuable product (see Figure 1). Biogas is the mixture of gases produced by the microbial communities within anaerobic digesters, and usually consists of 50-80% methane, 20-50% carbon dioxide, around 1% water vapor, and trace levels of other gases such as hydrogen sulfide, hydrogen, and ammonia.

Anaerobic digestion changes a waste management problem into an income generating enterprise. Biogas is an energy resource that can be used – just like propane or natural gas – for heating or

generating electricity. The effluent and gas (when combusted and utilized) is almost odor-free. Not only does anaerobic digestion create biogas, but it also releases all of the nutrients in the organic "waste" making them available again as raw resources (fertilizers) for new plant growth.

In summary, anaerobic digesters create biogas that can be used as an energy source for electricity, heating, or transportation fuel and reduce the amount of greenhouse gases emitted to the atmosphere. Overall, anaerobic digesters create energy and fertilizer resources while also helping to reduce odors, pathogens, waste, and the emission of harmful gases.

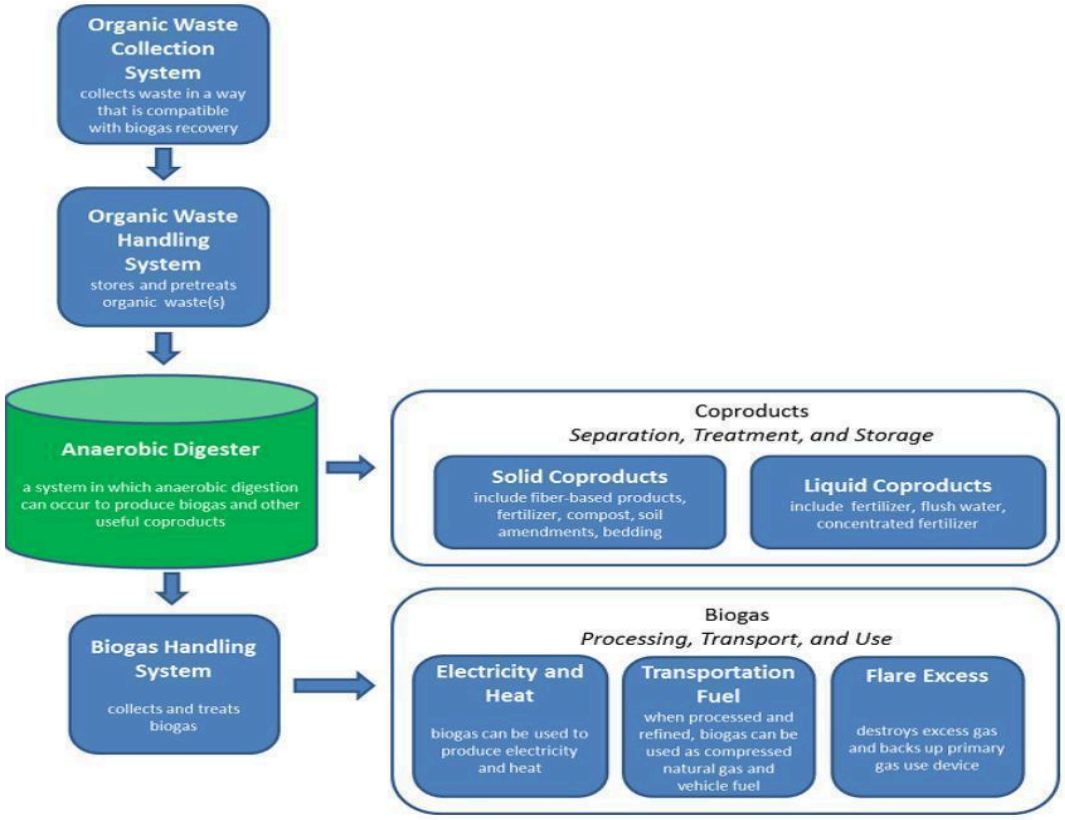

Figure 1: Anaerobic Digestion Cycle

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