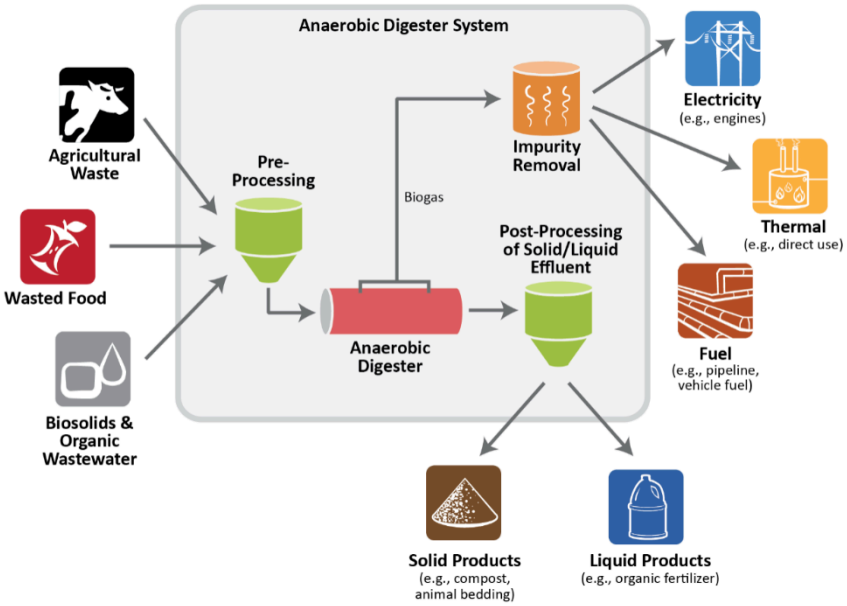
Measuring Methane
Earth Science/Environmental Science

Name: _____ Class Section: ____

Background

Anaerobic digestion means microbes break down organic materials in the absence of oxygen. The biogas produced has methane which can be used as a fuel source, just like propane. Cow stomachs (and ours) can release methane gas. Anaerobic digestion also happens at the bottom of swamps and lakes where organic wastes such as dead leaves and plants slowly break down. Thawing permafrost also releases this gas. Anaerobic digestion is used by engineers all over the world to break down complicated organic wastes such as garbage, and food, yard and human waste. 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 for new plant growth. Anaerobic digestion is a form of *Resource Recovery* – it can help recover energy and nutrients from food waste.

The United Nations Framework Convention of Climate Change estimates that the global warming potential of methane gas is 21 times more than that of carbon dioxide over a 100-year period. Methane is already being used by many large farms to power their operations and produce electricity from generators. During the combustion of one mole of methane, one mole of carbon dioxide is produced. Therefore, the greenhouse gas effect is reduced by 21 times by combusting the methane. On top of this benefit, the amount of energy that can be harnessed from this combustion is staggering.



Procedure

1. Find out which Station you and your partner will be working at. This Station corresponds to a recipe in the table below.
2. Label the bottle to indicate which substrate you are testing and your initials:
    a. Control
    b. Milk
    c. Donuts
    d. Manure
3. Put on gloves! Transfer all of the ingredients indicated according to the recipe at your Station to the bottle. Be careful not to spill the effluent. This effluent is the "starter" bacteria.
4. Attach a balloon to the top of the bottle, being careful to avoid damaging the neck of the balloon. Tape in place.
5. Place the bottle in the glass tank indicated to you. Adjust the bottle so that it is partially buried in the sand to help maintain a temperature above the room temperature.
6. Wash your hands with soap and water after handling the effluent and food or manure.

7. Each day for 4 more school days, record your observations of the balloon and measure its circumference with a string.

Station	Substance	mL of Effluent (bacteria starter)	mL of Milk	g of Donut	g of Manure
A, B, C, D	Control	200	0	0	0
E, F, G, H	Donuts or other food	200	0	60	0
I, J, K, L	Manure	200	0	0	60
M, N, O, P	Milk	200	60	0	0

Pre-Lab

Milk is mainly composed of protein and sugar, donuts are mainly composed of complex carbohydrates, sugar, and oils/fats, and manure is undigested food material. Predict which of the three substances will produce the largest volume of biogas (CH_4 and CO_2). Use your knowledge of biology and chemistry to justify your prediction.

1. Predictions:

2. Below, write the balanced equation for the combustion of methane, CH_4. (convert the sentence, "burning methane consumes oxygen and yields water and carbon dioxide" to a chemical equation):

3. How could reducing food going to landfills or manure decomposing reduce global warming?_____

   _____

   Why is burning methane better for the environment than having it released into the atmosphere?

4. Draw a sketch graph of how you expect carbon dioxide is changing over time and another of how methane is changing over time:

Data

Table 1 – Qualitative observations of appearance, balloon size, odor, etc.

Date	**Observations**
Monday	
Tuesday	
Wednesday	
Thursday	
Friday	

Table 2 – Volume of gas produced, measured by circumference of balloon

	Circumference of Balloon
Balloon 1	
Balloon 2 (if balloon breaks)	

Biogas Analysis

Table 3 – Average gas produced by each type of food

Substrate	**Average diameter of balloon**	**Estimated volume of gas produced (high, low, medium)**		
Control				
Donuts				
Manure				
Milk				

Analysis

1. Which substrate produced the most biogas? Why did this substrate produce the most?

2. What was the reason for including bottles in the experiment that only contained the effluent bacteria?

   Why did we include multiple bottles for each substrate?

3. A mature dairy cow weighing 1,400 pounds can generate around 112 pounds of manure per day. How many pounds of manure is this per 30-day month?

4. There are 94,400,000 cattle in the United States. If each cow releases 8 kg of methane in a month, how much methane is this? Since methane gas can be burned for heat or to produce electricity in a generator, discuss how this methane could be used:

5. During the 60 day period from January 7, 2019 to March 6, 2019, Canton High School collected 67 pounds of food waste in the clear bins destined for the methane digester. How many pounds is this per day?

6. During the 5 day period from March 11 to March 15, 194 pounds of food waste was collected in the clear bins destined for the digester from both the middle school and high school. How many pounds is this per day?

7. Explain whether you think it is the case that the high school just doesn't waste a lot of food, or whether people are throwing their food waste into the trash instead?

8. Using the amount of methane produced by the milk and donuts in this experiment, estimate how many balloons of methane could be gathered from the food collected from the cafeteria. Since every pound of food equals 454 grams and you used 60 grams of material in your bottle digesters, **estimate** based on these numbers.