LOGBOOK

Logbook

August 12:

I decided on a project

September 2: I typed up my introduction:

Carbon emissions have been a huge dilemma in today's society. Global warming and climate change are two words used frequently when describing the outcome of too much carbon in the atmosphere. Climate change is when the weather overtime slowly changes. Global warming is when the temperature warms overtime, or the earth starts to become hotter overtime. Pollution is another term to describe this matter, pollution is the term describing when toxins are released into nature, in this case the toxin is carbon. Currently only 1% of earth cannot inhabit life, but by 2050, it would potentially rise to about 20% due to climate change and global warming. Climate change is also endangering many species like polar bears, ringed seals, koala bears, monarch butterflies, etc. Many people are struggling to deal with this effect on our habitats and the drastic changes of weather. Electricity and heating through burning fossil fuels pay a big contribution to climate change. For our project, we are going to do biogas production. We want to inform consumers about the best way to produce biogas. Biogas production has been explained as an amazing alternative to many major issues having to do with fossil fuels. We wanted to know if the pH of the biogas will affect its production so we can understand if it speeds up production and works more efficiently.

Dec 4:

I got a partner (Sarah)

Dec 17:

We typed up our materials:

-glass jars with lids (4)*** -silicone tubing : 1/8"(3mm) ID x 3/16"(5mm) -lemon zest (optional to speed up the process) -strong tape -Infusion set (IV set) -lighter - grader -

Compost -syringe -pH strips -labels -Drill - stopwatch or phone stopwatch -vinegar (which will be our pH buffer) - plastic tubing

Dec 20:

We wrote our purpose:

Our purpose for our project is to figure out if biogas production is more effective with a more acidic factor (pH buffer) to comprehend if the pH of biogas jeopardizes or helps biogas production. We wanted to know this because consumers wanting a more sustainable alternative to the burning of fossil fuels could know the most effective way to create heat (biogas can be used for many purposes but we are demonstrating the heat production aspect).

Dec 22:

We wrote our hypothesis:

A hypothesis is your theory of the project's outcome. If there is a comparison between biogas without an added pH buffer and biogas with an added pH buffer, then biogas with the added pH buffer should produce the most heat because its production rate would be faster due to its acidity, causing it to have the most heat and heating up the water faster and for it to have a hotter temperature within 1 minute.

And we wrote our big question:

Does the pH of our biogas affect its production rate (how long it produces heat)?

Dec 24:

We wrote about what biogas is:

Biogas is a renewable energy source, natural and beneficial towards the environment. Biogas consists of broken down organic matter, exactly like the substances we are using (food waste: compost). It is broken down by microorganisms through this process called anaerobic digestion. It could be utilized for electricity production, heating or in our case, fuel for vehicles. Biogas contains around 65% of CH_4, and comprises trace gasses: H_2, N_2, and H_2S. Also, it disperses gasses such as CO_2 or methane. It is aiding the environment one step at a time and we feel it is our responsibility to spread the knowledge about this substitute.

Biogas can be used for many things; electricity, heat etc.

It can be transformed into biomethane by cleaning

it and removing traces of CO_2, so it can be used for fuel

(vehicles).

Jan 1

We wrote the benefits of biogas:

-**Biogas is eco-friendly:**Biogas assists with reducing the dependency on fossil fuels such as coal and oil. Biogas is also a much cleaner, renewable and sustainable source of energy.

-**Cheaper:** Technology used to produce and generate biogas is significantly cheaper, much simpler and accessible considering that things such as food waste and animal waste can be used to produce it.

-**Cleaner planet:** Biogas production may improve the quality of water and reduce waterborne diseases due to the way it is produced through anaerobic digestion. Anaerobic digestion will help deactivate harmful parasites and pathogens (organism that causes disease to its host). This can improve the water quality, environment, and the overall cleanliness of the earth.

-**Creates natural alternatives:** Through the generation of biogas(anaerobic digestion), organic digestate is created, which is a wonderful and healthier substitute for chemical digestate.

Jan 3

We wrote the disadvantages of biogas:

-**Temperature:**Similar to other kinds of renewable energy sources, biogas is affected by the temperature and weather. The optimal temperature that is required for bacteria to digest is around 37°C. This makes it difficult for biogas to become our main source of energy due to the changes in temperature.

-**Non-efficient:** An unfortunate disadvantage of biogas production is the fact that there isn't any new technology that has been created to produce large-scale amounts of biogas for large populations. This makes biogas far more inaccessible and expensive. Unfortunately many governments aren't willing to invest into this technology.

-**Contains impurities:**Even after refinement and compression biogas is still likely to contain impurities which would corrode the metal parts in a car if used for one. This would obviously lead to many issues and maintenance expenses. This is why biogas is better when used for smaller objects such as lamps, lightbulbs, and water boilers, etc.

-**Not accessible for many:** Industrial Biogas production is only available when the amount of materials required(food waste, manure etc.) are plentiful in supply. This is why biogas generation is better suited for rural areas with lower populations.

Jan 4

We wrote down how biogas and natural gas is different:

Many people think that natural gas and biogas are the same concept, when in reality, they differ greatly from each other. The biggest difference when it comes to the two sources of energy is that they are both perceived to be renewable. Natural gas is not a renewable energy source and consists of mainly methane (CH_4) which isn't renewable, as biogas contains a minimum amount, leading to less of an impact. Additionally, something that baffles many is that natural gas isn't as helpful towards the environment as it seems to be. Biogas helps lessen carbon emissions while natural gas seems to slightly help it grow, due to its methane content (It still allows CO_2 emissions to be reduced and still helps the environment). How does it contribute to carbon emissions? When the methane is burnt, it releases CO_2 into the atmosphere, leaving a remaining ecological footprint along the way and can be impactful overtime. Furthermore, natural gas has extensive availability while biogas has a restricted supply and is not so widespread (resources hard to produce in certain circumstances)**.

Jan 6

We wrote the difference between biogas and biomass:

Biogas and biomass are also often seen as the same thing, as most individuals are quite confused about their differences between them. Biomass is in the form of a solid and biogas is transparent and in the gaseous condition. Biomass utilizes organic substances and burns it in order to produce energy, whereas biogas goes through the anaerobic digestion process in order to give out energy.

We also wrote about the anaerobic digestion process:

The anaerobic digestion process has 4 phases: Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis.

1. Hydrolysis: Specific bacteria breaks down organic polymers and converts them into simple sugars. (First)
2. Acidogenesis: A specific category of bacteria called acidogenic bacteria turns simple sugars and amino acids into H, CO2 organic acids, organic acids and ammonia. (Second)
3. Acetogenesis:During the stage Acetogenesis, a particular bacteria named acetogenic bacteria turns the organic acids into H, CO2 and acetic acid. (Third)
4. Methanogenesis: Specific singular-celled named methanogens change the intermediate products created in the preceding processes into biogas (mainly methane and carbon dioxide). The digestate, a solid and liquid product of this process, contains substances that microorganisms cannot consume as well as deceased bacteria. (Fourth)

Jan 7

We wrote about what an anaerobic digester is:

A huge variable playing a role in our project is how can we produce the biogas? Anaerobic digesters are the very thing used for biogas production. Anaerobic digesters are tanks that are deprived of oxygen. It performs a process to make biogas called anaerobic digestion as we mentioned previously. Its main purpose is to transform organic matter into biogas and digestate (remainder of waste after the anaerobic digestion process).

Jan 8

We wrote about pH:

One of the biggest points we have to cover is what a pH is. The pH of fluid solutions is an objective indicator of their acidity or basicity. Acidity refers to the attribute to anything acidic; a chemical element, usually a liquid, that includes hydrogen and can combine with other chemicals to generate salts. Basicity is the condition of being a base; a substance that can counteract the acid by responding with hydrogen ions. In our project, we need to use a pH strip to observe if our biogas is ready. You may be wondering what is a pH strip? A pH strip is a strip of litmus paper used to determine the pH of a liquid. The material in the paper makes the strips represent different colors at different levels of acidity. There is a scale from 0-14 to determine different pH levels called the pH scale. On the scale, 0 is quite acidic and 14 being quite alkaline. Alkalinity is a measure of the water body's ability to balance acids and bases thereby keeping a relatively steady pH level.

We also wrote what a pH buffer is:

PH buffers are solutions that prevent large alterations in pH levels when an acid or base is added to it. It creates a stable pH for a solution by helping with maintaining it in a specific range. Buffer solutions are essential in various biological, chemical, and

environmental processes which require a stable pH level. Buffers don't only balance pH levels but can additionally change the pH level. Vinegar can act as a buffer since it's a weak acid and its ionization is less than 10%. Another term that's more fitting is an acidic pH adjuster but since we are combining it with water when we add it into the anaerobic digester, the pH lessons making the term pH buffer be a better description.

Additionally, we wrote how biogas is different from other renewable energy sources:

Biogas has a few differences when it gets compared to its fellow renewable energy sources. Initially, the most noticeable difference is that biogas derives from organic waste, whereas other renewable energy sources utilize light from the sun (solar energy, wind (wind energy), heat from the depths of the earth (geothermal energy), etc. Also, biogas utilizing hydrogen has less carbon strength than another well known renewable energy source called solar energy (uses the sun to produce energy). Biogas is as well categorized as a fossil fuel unlike the majority of renewable energy sources. Also biogas has more availability than some other renewable energy sources. Biogas can be produced at any time you desire, whereas with solar energy and wind energy, it must be produced when there is enough sunlight or wind.

Jan 9

We wrote about the advantages and disadvantages of biogas production with compost:

For our biogas production, we used compost as our choice of organic waste, there are advantages and disadvantages that come with using compost for your biogas (we based it off of professional use of biogas as it's more complex than our experiment). Advantages:
-**Waste reduction:**Biogas production from compost(broken down food waste) will divert a

significant portion of organic wastes from landfills. **This will reduce and minimize the environmental impact t**hat's linked with the decomposition of organic matters in landfills, which releases methane (a potent greenhouse gas). Disadvantages: -**Time length:** Waiting for the breakdown and decomposition of your compost takes weeks, months or even years so the time length affects its production rate. Anaerobic digestion let alone takes several weeks (at mass production) so if you consider this alternative, **patience is required.**

We wrote about how biogas reduces greenhouse gas emissions:

-**Methane Capture:** Methane is a powerful greenhouse gas, with far higher global warming potential than carbon dioxide, it's responsible for over 25% of the global warming we are experiencing today. By seizing and utilizing methane produced during the anaerobic digestion of organic waste, biogas systems help with **preventing the release of methane into the atmosphere.**

-**Replaces fossil fuels:** Biogas can be a substitute for the traditional fossil fuels that we use today. By replacing fossil fuels with biogas, we will be able **decrease the overall carbon-footprint** and it reduces reliance on non-renewable sources of energy.

-**Returning Carbon to the soil:** Through the process of anaerobic digestion, you're left behind with a rich in nutrient slurry, which can be utilized as a fertilizer. When this fertilizer is used in agricultural land, it restores carbon back into the soil enhancing the soil's health. This helps **reduce greenhouse emissions by promoting carbon storage in soil.**

-**Waste management:** By properly and effectively managing organic waste through biogas production, methane release is lessened, resulting in the overall reduction of greenhouse

gas emissions.

Jan 10:

We wrote down our Variables.

Independent: The gasses that we are using (with pH and without pH), the pH buffer (vinegar)

Dependent: Which biogas will produce the most heat

Controlled: Silicone tubing brand, jar brand, iv set brand, what the compost was made of (orange peels, onions, kale, other vegetables), water temperature, same tap water, copper wire brand, lighter brand, silicone tubing brand, grader, iv set brand, plastic tubing brand.

Today we also just made our anaerobic digesters; these are the observations;

No pH buffer: Today nothing really changed due to us creating the anaerobic digester today.

pH buffer: Today nothing has changed much as it's the first day and we just made the anaerobic digester.

Jan 11:

We wrote down our Procedure to create the anaerobic digesters.

1. Gather compost (organic waste): our choice was food scraps that you can find at home, also add lemon zest (shave off some skin of a lemon with a grader)

2. Grab two mason jars

3. Drill a hole in both of the lids of the mason jars

4. Put water into one of the jars, we will call this jar #1 (not too hot not to cold)

5. In the other jar, put around 1 and a half cups of compost (375 ml) inside of it and add around 187 ml of water into the jar, we will call this jar #2

6. In jar #1, drill another hole to the left on the lid

7. Seal the lids tightly onto the jars (remember jar #1 has 2 holes) and tape around the lid seal so you can't open it, allowing no air to escape

8. Grab the silicone tubing and cut it in half (the rest we are going to use for the second anaerobic digester)

9. Place one end of the silicone in the first holes we made in jar #1 and #2 (the ones in the middle)

10. Cut the bottom part of the iv set off (make it as close or as far as you would like, the bottom part is the syringe with a cone at the end)

11. Put the new end of the iv set into the other hole in jar #1

12. Add a label onto one jar saying no pH

13. Repeat for the other anaerobic digester but this time add 80 ml of vinegar to the jar

with organic waste and label this one pH

We also wrote the testing procedure:

As we mentioned earlier, we advise you order a iv set with a needle, the steps we colored in red will be the steps we did but were not advisable and what we used instead of a needle.

1. Grab your anaerobic digester

2. Grab the end of the iv set

3. Place around 5cm of extra tubing onto the mouth of the iv set (make sure the holes align)

4. Tape it together (once again make sure the holes align)

5. Turn on the lighter and set the new mouth of the iv set ablaze (you can just light up the needle on the iv set on this step)

6. Use stopwatch to observe how long it remains on fire

Today is the second day of the anaerobic digestion, here are our observations:

No pH buffer: Today the organic waste began to sink into the water that was added into it but nothing too different.

pH buffer: Much earlier than the anaerobic digester with no pH buffer, a little bit of condensation is developing in the jar with water only, and the compost is more sunken.

Jan 12

Today is the third day of the anaerobic digestion, here are our observations:

pH buffer: Much earlier than the anaerobic digester with no pH buffer, a little bit of condensation is developing in the jar with water only, and the compost is more sunken.

pH buffer: The compost began to lose color and the water in the organic waste jar is turning a mix of yellow and green. Also some bubbles are starting to form.

Jan 13

Today is the final and fourth day of the anaerobic digestion, here are our observations:

No pH buffer: Today the bubbles started popping and the number of bubbles has increased. Brown spots also began to develop in the jar with water only. Additionally, today we are going to test our biogas to see how long it will hold its flame once we test it.

pH buffer: Brown dots started to develop and noticeably so. It has more spots than the anaerobic digester with no pH buffer. Today we are going to see how long it will hold the flame when we test it.

Today we tested our anaerobic digesters and wrote our times on scrap paper. We did three attempts for both digesters.

After we did that, we tested our pH levels of our anaerobic digesters and took photos of the pH strips.

Jan 14

We made a slide on the pH levels of our anaerobic digesters, this is the information on the

slide:

We tested the pH of our anaerobic digesters to represent the difference of acidity. It might not be noticeable but the anaerobic digesters pH's were slightly different. The pH level of the anaerobic digester without a pH buffer was a 6 and the anaerobic digester with a pH buffer was a 5, showing that the anaerobic digester with a pH buffer is more acidic.

Jan 15

We made a graph and wrote our data analysis:

First, we wanted to quickly go over how the experiment went and some thoughts we had on it:
We initially thought that the results were just from the plastic burning and we were worried, but we went a step further and tested the remainder of the extra tubing after we were done and the plastic held the flame barely and instantly burnt out in less than one second without the lighter. Moreover, the flame with the anaerobic digesters was really high when it was put with the lighter, and the extra tubing alone didn't achieve the height as with the anaerobic digesters.

For our first attempt on the anaerobic digester with no pH buffer held the flame for 4.15 seconds, the second attempt held it for 3.26 seconds and the third held it for 5.37 seconds. The average was 4.26 seconds (we calculated this for comparison reasons). For our first attempt on the anaerobic digester with no pH buffer held the flame for 3.21 seconds, the second attempt held it for 3.04 seconds and the third held it for 2.51 seconds. The average was 2.92 seconds. The anaerobic digester with no pH buffer noticeably held the flame for a longer span of time. This was very shocking towards us as we anticipated the anaerobic digester with the pH buffer to hold the flame the longest.

Jan 16

We wrote our sources of error:

There were various potential sources of error that we need to address. One of the potential sources of error was that we should have replaced the water with the vinegar (pH buffer). I think that since there was more moisture in the anaerobic digester, (or the vinegar became more diluted) it might have affected the outcome. Additionally, we could have used a iv set with a needle, we initially thought that the iv sets were accompanied with a needle, but we were mistaken. That might have slightly affected the results, whereas we used extra plastic tubing as a replacement that was dangerous. Furthermore, we had the anaerobic digesters go through the digestion process for only 4 days. Usually, people do at least a week, but we thought that since there was less space since we are just making smaller anaerobic digesters, although it might have affected our end results and made them shorter.

And our conclusion:

In conclusion, our **hypothesis was proven wrong** which stunned us. We expected the anaerobic digester with the pH buffer would hold the flame for longer than the anaerobic digester without the pH buffer. After conducting the experiment and performing the test, we were left with the result that biogas that hasn't had pH buffer added, holds a flame for a longer period of time. The results for our multiple trials at testing the biogas had all left us with similar outcomes, biogas without a pH buffer is superior. This experiment gives us an idea on how to assist with the production of biogas by figuring out the better average pH level for biogas generation which is an important variable in its production.
Throughout the experiment we came across various challenges and difficulties, such as missing materials and having to substitute certain things, which led to attempting many

trials. Our results are a crucial part of the future of biogas, with our results we know the most efficient way to produce biogas which can help turn biogas into a more accessible and well-known resource.