Biogas Production from Empty Fruit Bunch Waste

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Abstract: Title, Hypothesis, Method, Result and Conclusion.
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1. Introduction

Indonesia is the biggest palm oil producer in the world. The production of crude palm oil (CPO) in Indonesia rocketed to 48.3 million ton in 2020 [1] as shown in Figure 1. As a consequence, abundant wastes are generated. Every one ton of fresh fruit bunches produces huge number of solid wastes such as empty fruit bunch (EFB) around 23%, mesocarp fibre around 12% and shell around 5% [2]. Recently EFB waste is commonly used as compost fertilizer for oil palm plantations. However, there are huge quantity of EFB so that we need another method to increase economic value of EFB. Some efforts to utilize EFB have been investigated by applying it as raw materials for biomass power plant and biogas production.

Figure 1. Production volume of palm oil in Indonesia from 2012 to 2020 [1]

Burning an organic component or something in general causes smoke, which contains carbon monoxide, carbon dioxide and other dangerous substances that can harm the environment. This thing may cause several impacts both to the environment and health. If we burn those 4000 kilograms of empty fruit bunches, how much carbon monoxide and other dangerous compounds are released into the air?

Please add the EFB potential for organic material …………….

Energy is something we commonly use daily. Humans interact with all sorts of energy, from Heat to electricity. Some energy has a minimal amount that we someday will run out. Although we will eventually run out of resources that can produce energy, several alternatives may suppress the tremendous amount of usage from the limited resources. However, they might not be strong enough to replace the resources.

The purpose of this study was to ….

2. Literature review

a. Biogas

EFB is one of biomass types that can be a raw material for biogas production. Biogas, commonly containing CO_2 and methane (CH_4), is produced through Anaerobic Digestion (AD) process. The operating condition of AD process is the absence of oxygen for the degradation process using microorganisms. The scientific steps of making biogas are kind of straightforward. There are three steps of turning biomass into biogas (methane). The first step is hydrolysis which is the step of the bacteria reducing the amount of carbohydrate in the biomass (in this case, EFB). Reducing carbohydrate scientifically means the bacteria separate the carbohydrate electron chain while making a shorter chain consisting of protein and lipids.

The second step is acidification that generates a shorter chain from the hydrolysis. The bacteria now convert those into acetic acid (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). For extra information, to change these chemical bonds to methane at the last step, we need to put them in an anaerobic state (a situation where there is no air). Furthermore, lastly, the bacteria change all the low-density molecules to high-density molecules, resulting in all the bonds in acidification (hydrogen, acetic acid and carbon dioxide) to methane. However, not all carbon dioxide is converted to methane. So, the output of biogas is either methane or carbon dioxide.

b. Reactor

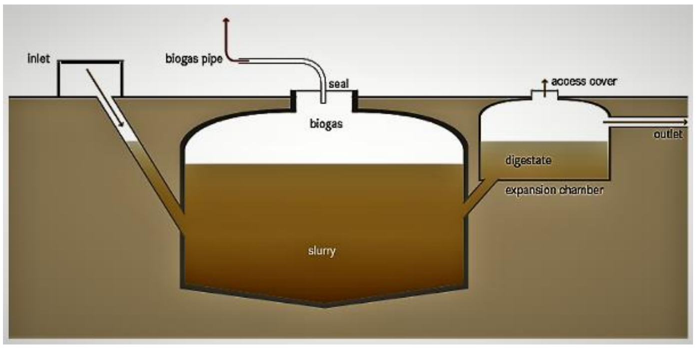

Figure 2. The reactor of biogas

The function of boigas reactor …….

The steps of making a biogas reactor are shown in the picture above. It compresses the biomass into a tube, and then we leave a hole at the top to withdraw the gas inside. However, the experiment's goal is to prove that it is possible to extract methane from biogas. Using an actual reactor is unnecessary. We decided to make a replica of a generator but more minor, which we call a mini-generator.

Part of reactor and its function

3. **Research Method**

3.1. Materials Research

The materials used in this research are:

3.2. Research Utilities

The production of biogas was conducted using a digester. Before continuing the experiment, we need to find a compound to boost and multiply the extraction process. We have found about four compounds that can be the booster. The first one is Bluegreen biotech, the second one is Urea, and the third one is EM4 and cow feces.

After gathering some information, we plan to make the Mini generator using a 50L size torrent/barrel. We also need to put an exhaust and pressure indicator in the 50L barrel. Therefore, a rough sketch was made to visualize the mini generator's design.

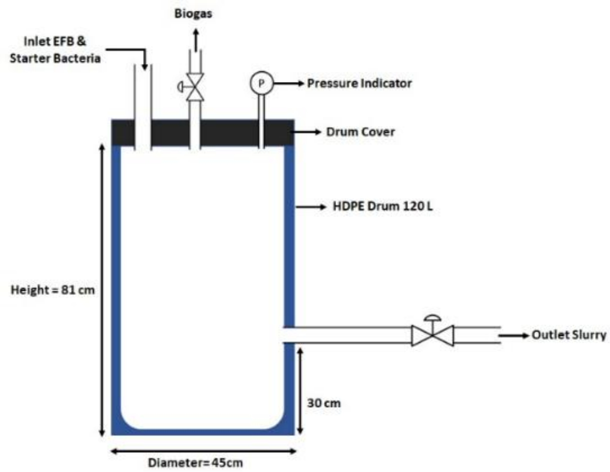

Figure 3. The sketch of experimental reactor

The amount of EFB being unused is the extent, while most of them is being burned to produce a lot of carbon dioxide (CO_2). So instead of burning them, why don't we reuse the palm waste and make it sound like something else? Even though there are several ways to solve the problem, there is one way to utilize the EFB effectively. It is by converting palm waste to biogas. Not only do we solve the problem of abundant palm waste, but we also reduce the carbon emissions and produce the renewable and sustainable energy. Nevertheless, is it possible to turn EFB into biogas? Moreover, is it possible for us to make a biogas powerplant in Indonesia?

Before anything else, the researcher plans to experiment with the question "What is the perfect ratio to extract the best amount of biogas" which will be discussed on the page 5. The variables will be the materials used in the experiment. This study aims to find the best compound used as the experiment's booster. The prediction for the best component that acts as a booster is a probiotic called "blue, green biotech", which is a consortium bacterium to produce biogas.

Please insert your own biogas reactor

4. Result and Discussion

Before proceeding to a bigger experiment, there are several things that still remain unknown. Like for instance **"What is the ratio of the components inside the reactor that produces biogas?"** this experiment will be testing and mixing materials that are used in process of making a biogas. the number of components that are being tested is water, Probiotic, EFB.

To answer that question, 4 mini reactors were made, an even smaller version of a mini-Reactor. The experiment is made it using paint canisters as the Barrel. The reason why there are 4 Mini-mini-Reactor is so there are several independent variables we can put. in this case, the ratios of components in each canister. There is a balloon stick in the canister cap, so when the gas is produced, it will fill the balloon, inflating. Moreover, a conclusion can be made by looking at the ratio that produces biogas the most. The hypothesis for this experiment it that the component called "Blue green biotech" will extract more methane than all the ratios I have created. The experiment run during two weeks (28th October – 7th November 2021).

Table 1. The parameters for mini reactor experiment

Experiment no	Water (mL)	EFB (gr)	Probiotic (mL)
1	50	100	10
2	100	100	10
3	50	100	20
4	100	100	20

Unfortunately, the experiment built a failure. We hypothesized that using a balloon would be too stiff, considering the amount of biogas is very little. Moreover, the probiotic is not working very well. But from this experiment, we can get the rough picture of ratio.

For the 2nd experiment, we tried to test the probiotic using sugar. Why sugar? Because according to Salman Zafar, "Sugarcane is one of the most promising agricultural sources of in the world". We tested the probiotic with sugar with the same materials as the experiment before. However, this time, the plastic bag is being used instead of using a balloon. Here is the ratio for my 2nd experiment.

Ratio
5 gr sugar 200 mL water 2mL of Probiotic blue green Time: 2 weeks 9 November 2021 - 23 November 2021

A couple of days have passed since the start of the 2nd experiment. It does not show the result we hoped for, and I wonder what seems to be wrong with my experiment. The article about how promising sugar would turn out stated that the promising material is sugar cane instead of kitchen sugar.

We Gather information by reading more journals and articles about Biogas and biomass. Interviewed several experts who then got beneficial information. He (Professor Pramujo Widiatmoko) stated that using cow feces may boost the probiotics inside to produce more gas. Then the attempt on creating the third pre-experiment Ratio started, in which 2 of the subjects used cow feces and two others did not (just probiotic). MM Reactor is upgraded by replacing balloons with plastic and concealing them more tightly. The ratio for this experiment is shown below. The experiment run during two weeks (03^{rd} December – 17^{th} December 2021).

Table 2. The parameters for mini reactor experiment with cow feces

Experiment no	Water (mL)	EFB (gr)	Cow Feces (gr)	Probiotic (mL)
1	80	40	10	-
2	80	40	20	-
3	80	40	10	10
4	80	40	20	10

After a week, the plastic at MM reactor number 4 started to expand. Thus, we have found the Ratio of the big experiment.

Table 3. Non -Experimental Observation

Experiment	**Water (L)**	**EFB (kg)**	**Cow feces fresh (kg)**	**Cow Feces after 1-2 weeks (kg)**	**Urea (gr)**	**EM4 (mL)**	**Reactor (L)**
1	0,6	3	0.6	-	210	30	20
2	0,6	3	-	0,6	210	30	20

Using the information gathered. A table that consists of 2 experiment plans was constructed. Both of them are pretty similar. However, what differentiates it is the timeliness of the cow feces. The first one is fresh from the cow, while the other is held for a week or 2.

Two experiments are done because information regarding what is the most suitable cow feces is being used in the biogas is limited. How does it affect you? So, the quality of bacteria from the cow feces that is new or we have to wait for them to “grow up” a bit to produce more is yet to be unknown.

Question: Can we extract methane from palm oil waste (EFB) using biogas?

Hypothesis: based on my research, with the right material to boost the production rate, I think we can extract methane from EFB.

The chemical is used in this project is EM4, Urea 46% (CH_4N_2O), Bluegreen biotech. These components are used as a booster. To make the reactor device, the first thing to attach the pipes in all the places meant. And then seal every opening with a glue gun. Attach a pressure indicator to have safety measures if things go wrong.

Then put all the components into the barrel according to the table above. Then stir it. Then the reactor is sealed using duck tapes to maintain it in an anaerobic state. After the reactor have been secured, the reactor will be left untouched for two weeks. After two weeks, attach those to the lid, then open the area inside the hose to make the biogas inside flow inside the hose. Put a fire at the edge of the lid.

After two weeks of the experiment, the process of "waiting" is over. The experiment almost came to an end. Since it is a mini reactor, the flames that showed up are not as huge as expected, making the experiment unobtainable. Though, the real goal for this experiment is to prove that the EFB can produce biogas.

5. Conclusion

The result of the experiment is quite what we had presumed, but we do get several pieces of information from the experiment. The first analysis regarding the result of small flame is that the components are lacking. To produce more excellent flame, we hypothesize raising the components and the actual size of the reactor.

The second analysis regarding the result of small flame is that the boosters are not very compatible with complex substances such as shells. This matter will be continued in the conclusion section. The third analysis regarding the result of the small flame is that the reactor might have leaked a bit of the gas. However, this theory is not as strong as the ones above. The reactor is sealed with the glue gun and duck tapes in all the openings to prevent leakage and preserve the anaerobic state.

It is very likely to create a biogas power plant using palm waste because of the number of resources and its potential. Using EM4 urea and cow feces will be less effective in mass production since fulfilling the proportion of those materials in a more significant ratio is impractical.

That is where consortium bacteria work. Consortium bacteria is biotech developed to do certain things. In this case, it can be programmed to make palm EFB unleash its methane content. However, the author's knowledge for this matter is quite incapable of explaining it yet because of shallow understanding.

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2. Keywords (min 3)
3. Introduction
4. Literature review
5. Research Method
6. Result and Discussion
7. Conclusion
8. Reference