Modification Reactor Biogas With Isolation Water And Scrubber To Increase Biomethane Production

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Abstrak : Biogas is alternative energy produced through the process of fermenting organic materials in anaerobic conditions to produce methane gas (CH4). The quality of the biogas depends on the concentration of the CH4, the higher the content, the better the quality. One way to improve the quality of biogas so that the content of methane gases in biogases increases and can reduce gases such as CO2, H2S, and other gases is by using a scrubber that contains compound fertilizer as its purification. The objective of this research is to reuse organic waste into useful biogas as alternative energy, and to apply water as a methane gas isolator so as not to be wasted on batch and scrubber reactor processes for the purification of H2S content. The old test results of the biogas flame and the color test of the flame on the 20th and 28th days could not be done, because of the little gas formed to the pressure of the gas generated 0 atm. On the 40th day where the gas pressure generated 5 atm, but the results of the biogas fire test did not come out because the gas produced was still small so the flow of gas to the stove did not reach. Biogas production needs to be increased so that the long-standing test of flame and flame color of biogas can be done well. This research also was explored step by step to producing biogas using organic waste. In addition, consideration should be given to the use of other methods to increase gas production so that these alternative energy applications can run optimally.

Keywords : Organic Waste; Modification Digester; Water Isolation; Scrubber; Biomethane

1. Introduction

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Indonesia is estimated to produce 64 million tons of garbage every year. According to data from the Ministry of Environment and Forestry (KLHK), the composition of garbage is dominated by organic waste, which accounts for 60% of the total waste (Widowati, 2019). Organic waste has the characteristics of rapid degradation and, when not managed immediately, could potentially become a source of disease. Due to the high-water content of organic garbage, improper management leads to the spread of dirt water from the waste and causes water and soil pollution (Akhtar et al., 2021). Garbage management, with the concept of collecting cargo-waste, needs to be transformed into management from the point of view of garbage as a source of energy (Akhtar et al., 2021). To drive a positive change in the waste management system in Indonesia, the government has set a target for the monthly amount of waste managed into renewable energy in 380 cities of 1.460,000 tons by 2019, as focused on the Ministry of Environment and Forestry Strategic Plan 2015-2019 (Romianingsih, 2023).

To date, garbage has been handled through the application of simple technologies to advanced technologies, from land collection, composting, and incineration to incinerators (Akhtar et al., 2021; Ding et al., 2021). However, this method does not yield satisfactory results. For instance, the daily volume of garbage is disproportionate to the capacity of disposal, resulting in premature degradation that can lead to odor pollution, groundwater contamination, spills, and sources of disease. The smell pollution will cause discomfort to the population.

Biogas energy is one of the waste management and alternative energy technologies that have great development opportunities in Indonesia. Biogas energy is produced by the fermentation process of organic materials with the help of anaerobic bacteria (Archana et al., 2024; Dhull et al., 2024; Terziev et al., 2024). The energy component of biogas consists of methane gas (55%–75%), carbon dioxide (25%–45%), and some gases in small quantities (Archana et al., 2024; Terziev et al., 2024). The methane gas, including the greenhouse gas, along with the carbon dioxide gas (CO2), can provide a greenhouse effect that causes global warming (Slingo & Slingo, 2024; Uda et al., 2024). This local reduction of methane gas can play an active role in efforts to solve global problems. Basically, only by mixing the EM_4 substrate with the organic garbage inside the anaerobic digester can biogas be produced.

Previous research has focused on biogas production using anaerobic bioreactors (Paramitha & Ikhsan, 2012; Ramandani et al., 2023). Nevertheless, there was a leak of methane gas produced. This study refers to a bioreactor from this previous study, which is an anaerobic bioreactor but does not use water as insulation. The bioreactor is modified into a batch system bioreactor using water as its insulation. The device design of the biogas bioreactor uses a batch system with water as its insulation to efficiently produce biogas so that no leakage occurs during the production of methane gas. The batch system reactor will also be equipped with a scrubber. This scrubber is intended to purify the methane gas from the HS_4 content. This research is expected to be able to contribute to the management of organic waste into biogas fuels as an alternative energy source to fossil fuels.

2. Materials and method

Drums of 220 liters serve as water insulation containers, drums of 25 liters of 2 pieces are then connected into one serves as a digester, drums of 175 liters serving as digester covers, 1 inch PVC pipe, 3⁄4 inch PVC pipes, 6 inch PVC tubes, 1 set of iron wire pads, small limestone hose, water flow, ball valve 3⁄4 inches, inlet socket 3⁄4 Inches, outer hose socket, water mur 3⁄4inch, water cranes 3⁄4Inches, ordinary water slide, 6 Inch pipe dop, digester wire holder, elbow 3⁄4 INCH, tee 3⁄4INCH, blue hose water, wooden board 100 x 40 cm, scrubber seal. The materials used were 25 kg of organic waste (vegetable

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garbage) and cattle debris, 25 liters of water, 5 kg of iron powder, 5kg of compost, 500 ml of EM4, pipe glue, small drill blades, silicon glue (sealer), 100 ml molasses, and 100 x 40 cm banners.

2.1 *Pretreatment and preparation of organic waste*

Organic waste was collected from cafeteria polytechnic country Lampung vegetables or leaves that do not contain onion skin and oil, because if it contains onion skin and oil, it will inhibit the growth of microbes in the biogas fermentation process. Then sort the organic garbage that will be subjected to the process of scaling down by means of a knife or a blade. Then add 25 liters of water to 25 kilograms of organic garbage and cattle dirt (1:3), then insert it into a biogas reactor and mix it evenly. The raw material has been inserted into the biogas reactor and then added 500 ml of EM4, then added molasses as microbial feed ingredients, and mixed evenly. Then wait for the process of forming the methane gas according to the specified time variables (20 and 28 days), and after that the result is obtained and purified with a scrubber, and the pressure of the resulting methane gas is measured with a water flow made by itself based on the law of hydrostatic pressure.

2.2 Modification bioreactor

The reactor is shaped like a plastic drum with a size of 220 liters as a water insulation place, the drum with the size of 50 liters of two pieces is then connected to one serves as a digester, the drum with a dimension of 175 liters as a container for the digester's cover, and is equipped with a ball valve to open and close the flow of gas from the reactor to the scrubber with water to isolate the gas produced so that it is not wasted. The reactor will be filled with a substratum consisting of organic garbage, cattle dirt, water, and there are catalysts that use EM4, as well as added molasses as food for microbes. After that, the methane gas that still contains HS4 will be purified using a scrubber. As for the contents of the scrubber, it's compost.

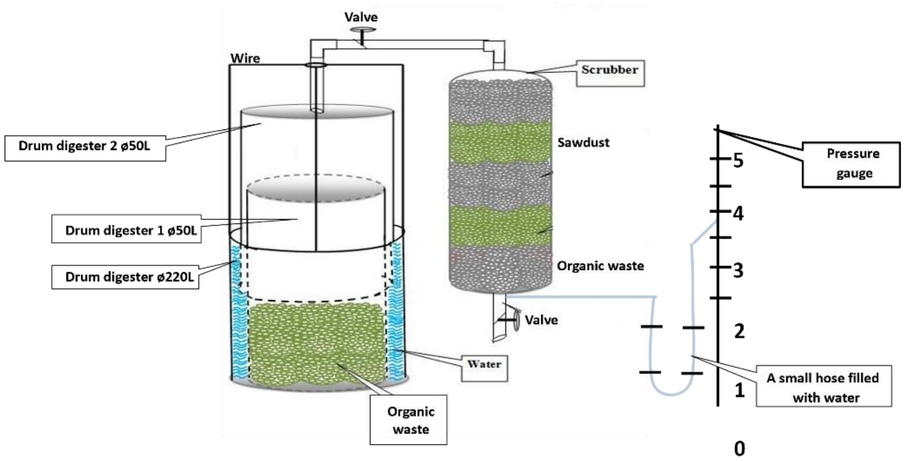

Figure 1. Modification reactor digester using isolation air and scrubber for biomethane production

3. Result and discussion

3.1 Reaction of fermentation anaerobe

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Organic waste in this study will be converted into biogas or biomethane following the processes of hydrolysis, acidogenesis, acetogenesis, and methanogenesis, as shown in Figure 2. The biogas or biomethane produced can then be used as a renewable energy source. The biogas or biomethane produced can then be used as a renewable energy source for electricity generation, heating, or transportation (Francisco López et al., 2024; Loboichenko et al., 2024; Najafi & Acaroğlu, 2024).

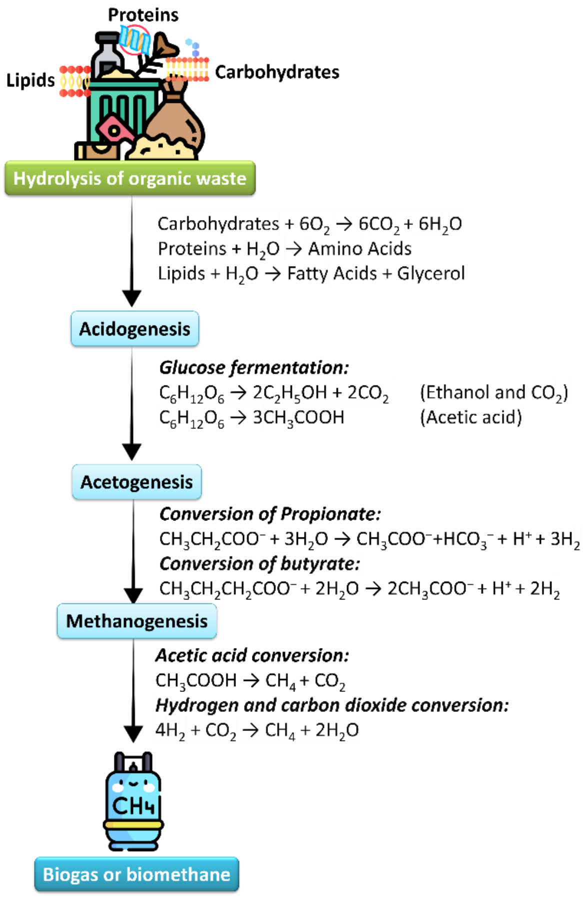

Figure 2. Processing organic waste through anaerobic digestion to produce biogas or biomethane

Hydrolysis is breaking down complex organic compounds into simpler molecules (i.e., glucose) (Fitri et al., 2023; Karthikeyan et al., 2024). This process is essential for the efficient production of biogas. Without hydrolysis, biogas production would be significantly reduced (Karthikeyan et al., 2024). Acidogenesis and acetogenesis follow hydrolysis, further breaking down the simpler molecules into volatile fatty acids, alcohols, and acetate (Urfi et al., 2024; Wang et al., 2024) . These intermediate products are then converted into methane and carbon dioxide during methanogenesis, resulting in the production of biogas. Overall, the anaerobic digestion process is a crucial method for converting organic waste into renewable energy. By efficiently breaking down complex organic compounds through a series of steps, biogas production can be maximized, providing a sustainable source of energy. Furthermore, the byproducts of anaerobic digestion can also be used as nutrient-rich fertilizers for agriculture, closing the loop on waste management. This process not only helps reduce greenhouse gas emissions but also contributes to a more circular economy. In addition, the utilization of biogas as a renewable energy source helps reduce reliance on fossil fuels, further mitigating the impact of climate

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change. By promoting the adoption of anaerobic digestion technology, we can move towards a more sustainable and environmentally friendly approach to waste management and energy production. This can lead to significant environmental benefits and help create a more resilient and sustainable future for generations to come. It is crucial for governments, businesses, and individuals to prioritize the implementation of anaerobic digestion technology in order to address pressing environmental challenges.

3.2 Effect of modification digester biogas

In this study, there was a change in the composition of the contents of the scrubber, where they were filled only with compost. The preliminary test results showed that when a scrubber is filled with iron powder and compost, the gas filtered inside the scrubbers takes a very long standby time when compared to a compost-only Scrubber. The time-out test results with a powdered iron and compost scrubber took over an hour, while a composted scrubbers only took less than a second. Based on the preliminary test results, a compost-containing scrubber was considered for use in this study, due to its more effective and efficient time-out on a gas that would be filtered or cleaned of unwanted gas particles. From the results of the study in Figure 3, it shows that the methane gas has already begun to form on the eighth day.

On the 8 days, there was an increase in the digester on drum 1 with a height of 1.0 cm and a gas volume of 1.808.64 cm3, while on drum 2, there was a result of a drum height of 0.5 cm and a gas volume of 904.32 cm3. However, the newly formed gas is so small that the pressure value at the time of measurement has not been read by the device (at pressure of 0 atm).

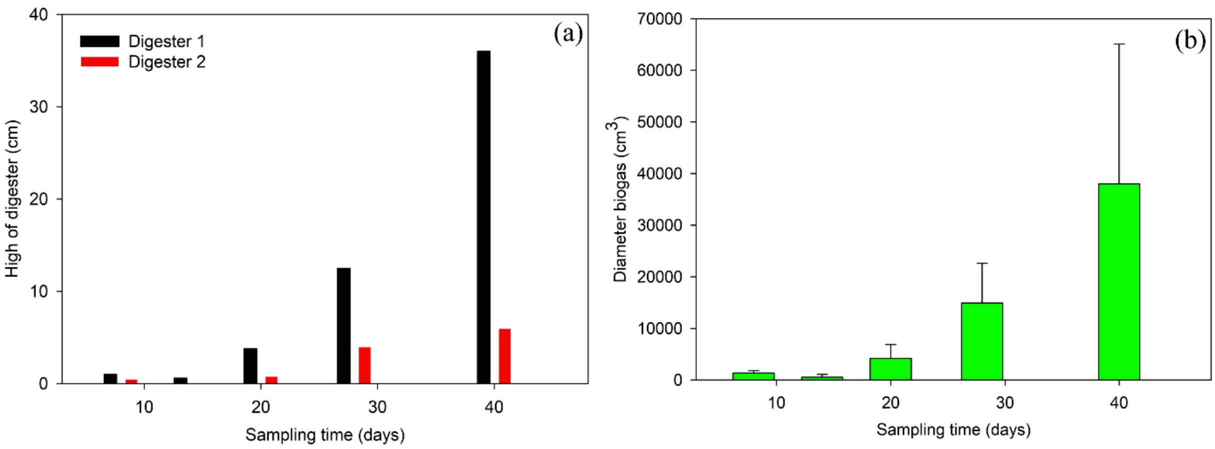

Figure 3. Trial and error in the modification digester reactor of (a) high of digester (cm) and (b) diameter biogas (cm^3)

On the 14th day, there was a decrease in height and volume of gas obtained: a height of 0.6 cm and a gas volume of 1.085.18 cm3 on the 1st drum, while the height was 0.0 cm, and the gas volume was 0.3 cm3 in the 2nd drum. The decrease in the volume of gas on the 1st and 2nd drums is due to a gas leak on the digester and scrubber. The cause of the leakage in the digester and scrubber is the connection of the drum digester with a poorly designed pipe, which triggers the gas leak through the gaps of the connection. The leakage in the cracks of the scrubber pipe also caused the gas to come out through the gap. The gas leak resulted in it not being read at the time of the measurement. Therefore, the attempt to prevent leakage is done by adding glue to the connections of the digester drums with the pipes. Efforts

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to add glue were successful in dealing with the leakage. On the 20th day, there's a rise in the height of the drum digester. In drum 1, the height of the drum is 3.8 cm, and the gas volume is 6.872.83 cm3, while in drum 2, the drum height is 0.8 cm, and the volume of the gas is 1.446.91 cm3. The pressure is stable at 0 atm because the gas is still forming a little. That's why it's not possible to test the flame on biogas or the color of the flame. On the 28th day, there has been a significant rise, where on drum 1, a digester height of 12.5 cm with a gas volume of 22.608 cm3 has been obtained. On drum 2, a digester height of 4.0 cm and a gas volume of 7.234.56 cm3 were obtained. The pressure on the 28th day is still stable at 0 atm because the gases formed are still small and difficult to read by the instrument at the time of measurement.

On the 40th day, there was a very high increase in the drum digester. The result obtained on drum 1 had a height of 36 cm with a gas volume of 65.111,04 cm3, while on drum 2, it had a height of 6 cm and a gas volume of 10.851,84 cm3. From all the data obtained, it was the 40th day that produced the highest methane gas, and the 40th day for measuring the pressure values was already measurable. The pressure value obtained is 5 atm; it can be done for long-term flame and flame color testing on biogas. The results of the long-term test of the flame of biogas were that the fire in the stove could not be lit because the methane gas produced was still small. So that the methane gas to be delivered to the stove doesn't reach the oven and the methane gas is very little, the gas is still left in the scrubber. The test of the flame color on biogas could not be done since the fire could not ignite on the stove and the methane gas obtained little. Based on this, the length of the fermentation or the formation of gases greatly affects the result of the gases obtained, so the longer the process of fermentation, the more gases will be formed, and the more methane gases can be used for the needs of the community, like lighting the stoves for cooking. Comparison study in the biogas production using waste sources, as shown in Table 1.

Table 1. Comparison study biogas production based on waste sources, composition, processing, and biogas yield.

Waste Sources	Composition	Digester Type	Anaerobic Rermentation Time	Biogas Production	References
Banana stem and rice straw	50 grams of banana stems, 100 grams of rice straw, 500 mL of water, and 500 grams of cow feces	The biogas digester uses the volume of a balloon to determine the gas produced	7 days	1531.24 mm^3	(Ramandani et al., 2023)
Domestic waste	Substrate: spinach, leaves, rice, fish, papaya and banana	Digester of 100 mL	6 days	1993.6 L/mol	(Murniati, 2024)

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	Inoculum: 110 mL cow feces				
Vegetable waste	4 kg of banana peel and 4 L water	Reactor digester (30 x 30 x 75 cm)	7 days	1.03325 bar	(Sutanto & Supriyanto, 2019)
Vegetable waste	10 kg vegetable waste, 5 L water, and 500 mL EM4	Digester biogas 20 L	7 days	950 mg	(Rhohman, 2021)
Vegetable waste	Vegetable waste, water and cow dung	Digester glass	30 days	48.40 cm^3	(Fitri & Dhaniswara, 2018)
Vegetable waste	120 mL inoculation and 500 g rabbit droppings	Digester reactor 400 mL	60 days	280 mL	(Septiariva et al., 2023)
Vegetable waste	150 grams of mixed vegetables mustard greens, cabbage, tomatoes, cassava leaves and banana peels and 350 mL EM_4	Digester reactor 5 L	25 days	13 mL	(Siboro et al., 2013)
Cafeteria waste	25 liters of water, 25 kilograms of organic garbage, and 500 mL EM_4	Digester reactor of 320 L	40 days	65.111,04 cm3 and a pressure of 5 atm	This study

4. Conclusion

Organic waste can be used as biogas as fuel or renewable energy. The results obtained on the 20th and 28th days showed a slight increase in the volume of methane gas. And on the 40th day there was a high rise in the volume of methane gas obtained a volume of 65,111.04 cm3 and a pressure of 5 atm. The results of the old flame test and the flame color test on the biogas have not yet been seen because the gas produced has little to do with the test, if the fermentation process has a strong influence on the result of the gas formation, the longer the process, the more gases are obtained.

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