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Analysis of the difference in biogas volume between continuous and semi-continuous systems

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Abstract: The increasing demand for energy, driven by population growth and reduced sources of oil reserves, puts pressure on every country to produce and use renewable energy as a substitute. One of the alternative energy sources is biogas, which is produced using EM4 bacteria that balance microorganisms. In this study, microorganism inoculants consisting of 90% Lactobacillus, produced from cow dung, were accommodated in an HDPE plastic container with a volume of 1 m3. Data collection was carried out from the first to the fourteenth day, with pressure data retrieved using a pressure gauge, temperature data retrieved using a thermometer gun, and the volume of biogas measured using an Arduino-based flow meter. The study found that a 1x1 meter HDPE polymer container can accommodate a maximum biogas volume of 208.12 liters. In the non-continuous system, the volume of biogas produced is not stable. The total volume of biogas produced before going through the filter for 14 days was 1075.12 liters with an average volume of 76.79 liters/day, while the total volume of biogas that had been through the filter for 14 days was 995.71 liters with an average volume of 71.12 liters/day.

Keywords*:* Biogas; HDPE; Volume; continue system; semi-continue system

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1. Introduction

The increasing energy demand is caused by population growth and reduced sources of world oil reserves as well as the problem of emissions from fossil fuels putting pressure on every country to immediately produce and use renewable energy as a substitute (Werkneh, 2022). One alternative energy source is biogas. Biogas comes from a variety of organic wastes such as biomass waste, human waste, food waste, and animal waste which can be used as alternative energy through the anaerobic digestion process (Purwanta et al., 2022). This process is a great opportunity to produce alternative energy that will reduce the impact of using fossil fuels. Biogas or often also called biogas is a gas that arises when materials such as animal waste, human waste, or garbage, are immersed in water and stored in a closed place or referred to as an anaerobic process (Afisna et al., 2022). The chemical process of gas formation is quite complicated, but the way to produce it is not as difficult as the process of its formation. Only with simple technology can this gas be produced properly (Aili et al., 2022).

Biogas is a form of bioenergy in the gas phase resulting from the fermentation or decomposition of organic matter under anaerobic (airtight) conditions with the help of methanogenic bacteria, such as livestock manure, liquid waste from the agricultural and plantation industries (Xie et al., 2023). Biogas is a form of energy that can be developed by providing sufficient available and environmentally friendly raw materials (Kabeyi & Olanrewaju, 2022). Biogas can be produced from the fermentation of livestock manure such as cows, chickens, buffalo, pigs and others, the main component is methane gas (Van et al., 2022). Cow dung is a substrate that is considered the most suitable source of bio-gas production because the substrate already contains methane-producing bacteria found in the stomachs of

ruminant animals (Iweka et al., 2021). The process of making biogas is by mixing dirt with water and then fermenting it (Kunatsa & Xia, 2021; Lahbab et al., 2021). The by-product of biogas in the form of mud or better known as sludge contains many nutrients that can be used as fertilizer for plants (Sharma & Suthar, 2021).

The cow dung waste produced from one cow can have an impact on global warming (Shaibur et al., 2021). This is because there is no proper treatment and the dirt is usually stored in an open area so that it is exposed to direct sunlight and causing the methane gas produced by the dirt to evaporate (Kaushal et al., 2022). Therefore, it is very important to use this cow dung in biogas. This study aims to reveal the volume of biogas before and after being filtered using HDPE polymer. In this study, the authors used HDPE polymer with a thickness of 0.5-0.7 mm. The elastic nature of the plastic, to increase the pressure of the biogas, a rope is used which functions as a tool to withstand the pressure of the biogas in the reservoir. The advantages of gas storage using polymers, the manufacturing costs are relatively cheap, easy to form, and easy to move anywhere (Datong, 1989).

2. Methods

This research uses the experimental method. The biogas that has been produced from the fermentation of cow dung is accommodated in a container made of HDPE plastic. The dimensions of the reservoir are 1 m^3. The data taken are pressure (P), volume (V) and temperature (C). Data collection was carried out starting from the first day to the fourteenth day. Retrieval of pressure data using a pressure gauge, temperature data retrieval using a thermometer gun and measuring the volume of biogas using an Arduino-based flow meter. The filter is a place to store the adsorbent used for biogas purification. The function of this 4-stage filter is to filter the H_2O, H_2S, CO_2 elements in the biogas that has been produced before being accommodated to the main reservoir.

3. Results and discussion

3.1 Comparison of biogas volume before and after the filter

On the first day the volume of biogas has not been obtained so there is no difference in volume. On the second day, the volume of biogas obtained is 10.32 litres and after going through the filter the volume is 9.1 litres, the difference on the second day is 1.22 litres. On the third day, the volume of biogas obtained was 25.56 litres and after going through the filter the volume obtained was 25.31 litres. The difference on the third day was 0.25 litres. On the fourth day, the volume of biogas obtained was 14.59 litres and after going through the filter the volume obtained becomes 12.69 litres. The difference on the fourth day is 1.9 litres, On The fifth day the volume of biogas obtained is 26.38 litres and after going through the filter the volume obtained is 17.03 litres. The difference on the fifth day is equal to 9.35 litres. On the sixth day, the volume of biogas obtained was 54.85 litres and after going through the filter the volume obtained was 46.39 litres max. The difference on the sixth day is 8.46 litres, On The seventh day the volume of biogas obtained is 130.43 litres and after going through the filter the volume is 122.53 litres. The difference on the seventh day is 7.9 litres. On the eighth day, the volume of biogas obtained is 204.71 litres and after going through the filter the volume obtained is 180.32 litres. The difference on the eighth day is 24.39 litres. On the ninth day the volume of biogas obtained is 208.12 litres and after going through the filter volume which is obtained to 203.25 litres. The difference on the ninth day is 4.87 litres. On the tenth day, the volume of biogas obtained is 165.7 litres and after going through the filter the volume obtained is 157.65 litres. The difference on the tenth day is obtained by 8.05 litres.

On the eleventh day, the volume of biogas obtained was 84.63 litres and after going through the filter the volume obtained was becomes 82.42 litres then the difference obtained on the

eleventh day of 2.22 litres. On the twelfth day, the volume of biogas obtained is 49.54 litres and after going through the filter the volume obtained becomes 47.05 litres. The difference is obtained on the twelfth day of 2.49 litres. On the thirteenth day, the volume of biogas obtained was 52.47 litres and after going through the filter the volume obtained was 48.78 litres. The difference on the thirteenth day was 3.69 litres. On the last day, the volume of biogas obtained was 47, 82 litres and after going through the filter the volume is 43.2 litres, so the difference on the last day is 4.62 litres.

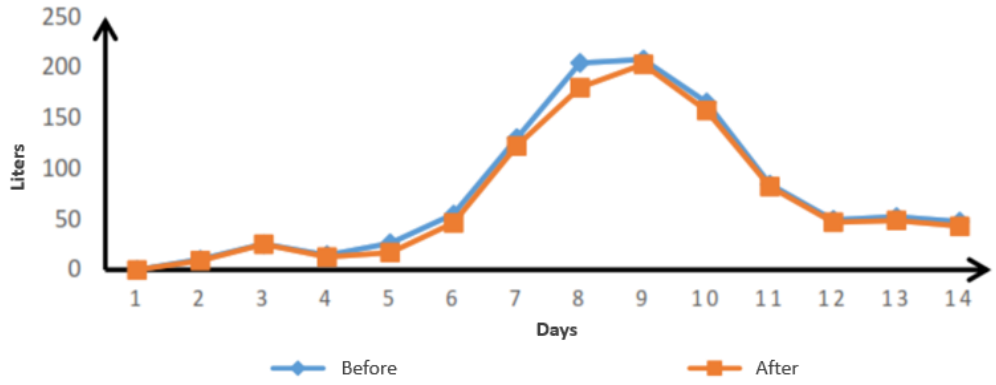

Figure 1. Comparison of biogas volume before and after the filter

3.2 Comparison of non-continuous and semi-continuous biogas volume

Figure 2 shows non-continuous and semi-continuous systems. The non-continuous system is a discontinuous slurry filling system where the slurry is filled once at the beginning and is waited until the anaerobic process occurs, while the semi-continuous system is a continuous slurry filling system where 75 litres of slurry is replaced every day in the digester. In the graph in figure 2, it can be seen that the biogas volume differs where in the semi-continuous system the volume of biogas produced is more and more stable due to the daily replacement of the slurry. As for the non-continuous system, the volume produced was less, not very stable, and experienced the highest peak on days 8 and 9.

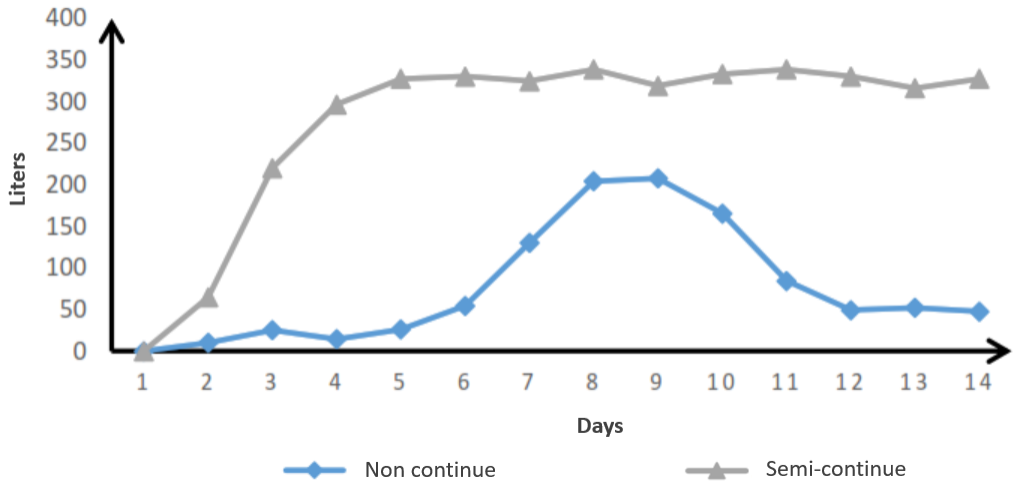

Figure 2. Comparison of non-continuous and semi-continuous biogas volume

This is because when the drum has reached its maximum height, the gas must be removed to accommodate the gas that will be formed. It is the same with pressure where on day 20 the

volume begins to decrease until day 37. This means that the gas formed in the holding drum has decreased (Singh et al., 2021). The amount of biogas formed can be calculated by the accumulation of gas formation from the first to the last day so that the amount of gas formed is 2721 litres or the average gas formation is 74 litres/day. The development of a fibreglass model biogas reactor using cow dung waste by mixing cow dung and water in a ratio of 1: 1 Fermentation time from day 15 to day 30 resulted in 50% biogas production (Glivin et al., 2022). After the 29th day of fermentation, biogas production tends to decrease and produces a volume of 160.1 litres of biogas with a volume of 92 litres of stuffing material.

4. Conclusions

The manufacture of biogas reservoirs using HDPE polymer material is formed with a size of 1x1 meter and can accommodate a maximum biogas volume of 250 litres, and there are no leaks. In a non-continuous system, the volume of biogas produced is not stable with the total volume of biogas before going through the filter for 14 days is 1075.12 litres with an average volume per day produced is 76.79 litres/day while the volume of biogas that has been through the filter for 14 days day is 995.71 litres with the average volume per day produced is 71.12 litres/day.

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Declarations

Author contribution

Lathifa Putri Afisna was responsible for conceptualizing and analyzing the data, while Bagas Nugroho Jati Rahadi collected and analyzed the data and wrote the article.

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Conflict of interests

The authors declare no conflict of interest.

Ethical clerance

There are no human subjects in this manuscript and informed consent is not applicable.

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