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Minimalist Biogas Design from Cow Manure in Household Scale

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ABSTRACT

Biogas produced by the activity of anaerobic microorganisms will produce methane gas and continues to increase every day as long as the decomposing bacteria continue to grow and carry out their activities. To speed up the process, microbes (EM4) can be used as a starter. The purpose of this research is to produce a minimalist biogas design from cow dung on a household scale. This experimental research is to make a cow dung biogas device with the addition of inoculant bacteria (2% and 3%) as a starter in the digester with 3 units each. The parameters used are the volume of gas produced by the digester, temperature, pH, C/N ratio, biogas productivity, maturation time and flame test as well as the need for tools, materials and labor costs. The biogas design consists of a digester set of brick walls and light bricks measuring 0.7 x 0.8 x 6 m2, a biogas digester (plastic polytyline) 1.9 m3, a biogas reservoir 0.97 m3, a biogas stove and a distribution hose. Bioinoculant is 2 liters and 3 liters of EM 4. The biogas material is the dung of 2 cows. Obtained 20 kg of cow dung mixed with 40 liters of water. The cost of wall materials is brick = 5,289,000 rupiah and light brick = 3,957,500 rupiah. The biogas design consists of a brick wall, 2 liters of EM4 takes 24 days, and produces 0.93 m3 of biogas and 3 liters of light bricks EM4 takes 17 days.
Keywords: minimalistic biogas; cow dung; household

INTRODUCTION

Background

Biogas is the result of the activity of anaerobic microorganisms or fermentation of organic materials, including human and animal waste, domestic or household waste, and easily decomposed organic waste. The main content in biogas is methane and carbon dioxide (1).

The aerobic biogas process takes place through the stages of the hydrolysis process, the acidification stage and the methane gas formation stage. So that it produces biogas and continues to grow every day as long as the decomposing bacteria continue to grow and be active (2)

Biogas on a household scale with 2–4 livestock or a supply of approximately 25 kg/day of manure, it is enough to use a reactor tube with a capacity of 2500–5000 liters which can produce biogas equivalent to 2 liters of kerosene/day and is able to meet the energy needs of one house. rural ladder with 6 family members (3).

In a process of biogas formation in the digester that utilizes bacteria as a means to break down polymer compounds (in this case carbohydrates, fats, and proteins) additional media are needed to help speed up the process, and one of them is Effective Microorganism-4 / EM4 (4) . EM4 is a liquid medium containing microorganisms that can break down polymer compounds into monomer compounds. EM4 affects the fermentation process which in turn will affect the mass, calorific value, and speed of biogas formation. The addition of EM4 can reduce the C/N ratio and can accelerate the fermentation process so that it can accelerate the process of biogas formation (5). The faster the formation of biogas, the more sources of energy produced, so that biogas production will be higher. This will be very beneficial for the community because the higher the biogas production, the need for fuel oil as an energy source can be minimized.

Parameters that have an effect on increasing the volume of gas produced by the digester are digester volume, amount of EM, temperature, pH, C/N ratio and fermentation detention time (6)

Purpose

The development of an easy biogas technology with a relatively low cost that can meet daily cooking needs while producing renewable energy to replace LPG is an innovative work that cattle breeders have been waiting for. Digester made of polyethylene plastic planted in safe lightweight masonry and using a bioinoculant engineered bacterial fermenter will increase the quantity of biogas volume and can be profitable in the use of the gas. The use of lightweight bricks will be cheaper than ordinary bricks or concrete masonry. Apart from that, labor costs are also cheaper.

METHODS

This experimental study used a post-test only design, in which the researchers conducted research by making a cow dung biogas device with the addition of engineered bacteria inoculants as a starter in the digester. The raw material for cow dung was diluted with water in a ratio of 1: 2. This research was carried out through 2 treatments with the addition of fermenter bacterial bioinoculants (2% and 3%) with 3 replications each. Then each treatment was measured and analyzed using parameters, namely: volume of gas produced by the digester, temperature, pH, C/N ratio, biogas productivity, varying maturation time of 7, 14 and 21 days and flame test. The results of the biogas design are calculated in detail including the need for tools, materials and labor costs.

The procedure were:

1) Development of engineering model of biogas bioinoculant fermenter.
2) Making bacterial fermenter bioinoculants with EM4 as raw material which is cultured by giving glucose, agar, cow dung slurry and water media for 5 to 7 days until it is ready to be used for biogas fermenter starter
3) Designing a minimalist biogas model.

Minimalist biogas with 2% bacterial fermenter biounikolant:

1) All fresh cow dung is put into the inlet mixer tub (the cage will be clean from cow dung); make a mixture of cow dung and water ratio (1:2) and stir until evenly distributed in the mixer tub.
2) Adding bioinoculants of fermenter bacteria as much as 2% (point 3.3.b) mentioned above.
3) Flow the mixture (in the form of mud) in this mixer tub into the digester.
4) The volume of the digester can accommodate for 21 days (amount of cow dung and water for 21 days).
5) From the 21st (twenty-first) day onwards, the valve at the slurry outlet tub (sludge without biogas) can be opened every day with the same amount of sludge removed = as much as the amount of mud that is added every day in the mixer tub.
6) Perform measurement indicators according to the procedure (point 3.3.4) mentioned below.
7) Repeat for the 3%

Measurement of minimalist biogas parameter indicators:

1) Measurement of the volume of biogas from the gas reservoir at the age of 7, 14 and 21 days
2) Measurement of C/N ratio
3) Biogas formation time
4) Biogas productivity
5) pH measurement
6) Temperature measurement
7) Flame test

Data collection and analysis techniques

Primary data is obtained from the results of examination and direct observation of the object studied in the laboratory. The research data are presented in tabular form.

RESULTS

Table 1. Results of minimalist biogas volume measurement for households for 7, 14 and 21 days

Formula	Comparison of bioinoculants	Total volume of biogas (M3) for 0 to 7 days on replication to:				Total volume of biogas (M3) for 7 to 14 days on replication to:				Total volume of biogas (M3) for 14 to 21 days on replication to:				Maximum volume (m^3)
		1	2	3	Mean (l)	1	2	3	Mean (l)	1	2	3	Mean (l)	
1	2 l	0.18	0.17	0.20	0.183	0.40	0.50	0.55	0.48	0.75	0.70	0.70	0.73	0,96
2	3 l	0.20	0.20	0.30	0.23	0.70	0.75	0.80	0.75	0.95	0.95	0.95	0.95	

Table 2. The results of measuring the temperature of a minimalist biogas design for households for 7, 14 and 21 days

Formula	Comparison of bioinoculants	The results of measuring the biogas temperature on the 7th day of replication to:				The results of measuring the biogas temperature on the 14th day of replication to:				The results of the biogas temperature measurement on the 21st day of replication to:				Total
		1	2	3	Mean (l)	1	2	3	Mean (l)	1	2	3	Mean (l)	
1	2 l	32	33	34	33.33	33	33	34	33.33	34	33	34	33.67	33.44
2	3 l	32	34	34	33.67	34	34	33	33.67	33	34	34	33.67	33.67

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Table 3. The results of measuring the pH of a minimalist biogas design for households for 7, 14 and 21 days

Formula	Comparison of bioinoculants	The results of measuring the pH of biogas at 7 days of replication to:				The results of measuring the pH of biogas at 14 days of replication to:				The results of the measurement of biogas pH at 21 days of replication to:				Total
		1	2	3	Mean (l)	1	2	3	Mean (l)	1	2	3	Mean (l)	
1	2 l	6.9	6,5	7	6.8	6.8	6.9	7	6.90	6.9	6.9	7	6.93	6.93
2	3 l	7	7	7	7	6.8	7	7	6.93	7	6.9	7	6.97	6.96

Table 4. The results of the measurement of the C/N ratio of minimalist biogas design for households for 7, 14 and 21 days

Formula	Comparison of bioinoculants	The results of the C/N measurement of biogas material for 7 days on replication to:				The results of the C/N measurement of biogas material for 14 days on replication to:				The results of the C/N measurement of biogas material for 21 days on replication to:				Total
		1	2	3	Mean (l)	1	2	3	Mean (l)	1	2	3	Mean (l)	
1	2 l	25.23	25.54	25.36	25.38	25.7	24.55	25.57	25.27	25.1	24.26	25.1	24.82	25.16
2	3 l	27.23	27.6	27.58	27.47	27.8	27.75	28.1	27.80	29.3	28.22	28.3	28.61	27.96

DISCUSSION

Minimalist Biogas Model

The minimalist biogas model for households is basically the same in terms of the size of the digester, biogas reservoir and biogas stove. But what makes the difference is the bioinoculants, namely group 1 using 2 liters of EM4 with a brick digester, while group 2 bioinoculants with 3 liters of lightweight brick digester. From the results of field monitoring, data obtained from cow dung using a 3-liter bioinoculant takes an average of 17 days to produce 0.93 m3 or 930 liters of gas. Meanwhile, a mixture of water and cow dung using a 2 liter biouniculant takes an average of 24 days. It should be explained that the gas reservoir indicator is said to be full if the household's daily use of biogas does not experience a shortage for daily use.

The Results of the Calculation of the Needs and Costs of Materials and Tools and Labor

There are differences in the production of minimalist household-scale biogas for biogas units. It costs 5,280,000 rupiah for a design using bricks, cement, sand and longer and more expensive labor costs; while the cost of 3,957,500 for the design using lightweight bricks is efficient, cement and labor.

The use of bricks in the digester needs to be plastered while light bricks with smooth surfaces do not need to be plastered. To strengthen lightweight bricks, iron is needed so that the series of structures is stronger.

From these data, technically, the community does not experience difficulties with digesters of bricks and lightweight bricks. However, in terms of affordability, of course, they choose lightweight brick digesters because they are cheaper.

The Results of the Calculation of the Results of Biogas Products

<u>Measurement of biogas volume, processing time and biogas production</u>

a). Biogas volume

From the results of measuring the volume of biogas, it can be seen that in the first week the volume of biogas produced is lower than in the second and third weeks. It is predicted that in the first week the number of bacteria is still small and needs adjustment, while in the second and third weeks there are more so that the anaerobic fermentation process runs better to produce biogas. The highest volume of biogas was produced using a 3-liter biouniculant compared to a 2-liter bioinoculant from week 1 to week 3.

Based on the difference in the volume of biogas, it can be concluded that the addition of biouniculants into the digester can increase the volume of biogas because the role of anaerobic bacteria is getting more real. The role of bacteria in producing biogas in the digester is influenced by nutrients, temperature, pH and C/N ratio.

The volume of biogas is influenced by the content of C/N ratio ranging from 20 to 30 (2) and this occurs in formulas 1 to 2 with C/N ranging from 22 to 29. In the results of research by Nurweni & Karno (4) the volume of biogas without the addition of biouniculant (pure bacteria from cow dung) the yield is less and the C/N ratio is below 20.

The volume of biogas is also influenced by the pH content. To produce a productive volume of biogas it can be achieved at a neutral pH of 7 (2). This is reinforced by Yonathan's research (7) that a neutral pH can stimulate the development of bacteria to produce biogas.

In addition to pH, temperature also affects the volume of biogas. A temperature of 31oC to 34oC will make it easier for bacteria to breed so that the formation of methane gas will be faster (2). While the temperature in this study ranged from 32 to 34

b). Biogas production

The cumulative biogas production results in this study were the highest with the addition of 3 liters of EM4 bioinoculant compared to 2 liters both in the 1st to 3rd week. This is in line with the research of Nurweni & Karno (4) that the production of biogas in the control without using a bioinoculant yields less biogas than using a starbio bioinoculant in the biogas digester. The use of EM4 as a starter in the digester is able to produce more biogas products than the starbio bioinoculant.

The above conditions are supported by research results (5), that the speed of biogas formation is influenced by the addition of EM4 for the fermentation process of organic matter in producing biogas compared to without the addition of EM4.

Temperature

The results of this study the temperature during the anaerobic fermentation process ranges from 32 to 34 oC, which means that during the biogas formation process there is only a difference of 2 oC. There was no significant difference in the temperature during the fermentation process, both using 2 liters of biouniculant and 3 liters of EM4.

According to Megawati (5) the operating temperature tends to be constant at ± 30 oC. This temperature is a condition for mesophysical types of microorganisms to grow and develop optimally. Under these conditions, the overhaul of organic matter will take place well, accompanied by an increase in temperature. Thus, temperature plays a role in biogas production.

The temperature value fluctuates following changes in environmental temperature and is ±2 °C higher than the ambient temperature

CONCLUSION

1. The biogas design consists of a digester set of brick walls and lightweight bricks measuring 0.7 x 6 m2, a biogas reservoir for 0.933, a biogas stove and a distribution hose. 2 liter and 3 liter bioinoculants from EM4.
2. The cost for biogas design consisting of brick walls is 5,289,000 rupiah and for lightweight bricks is 3,957,500 rupiah.
3. The biogas design consists of a brick wall, 2 liters of EM4 takes 24 days to produce 0.93 m3 of biogas and 3 liters of light bricks EM4 takes 17 days to produce the same biogas which is sufficient for daily household cooking needs.

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