Methane gas production from a mixture of cow manure, chicken manure, cabbage waste, and liquid tofu waste using the anaerobic digestion method

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Methane gas production from a mixture of cow manure, chicken manure, cabbage waste, and liquid tofu waste using the anaerobic digestion method

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Abstract. Biomass is valuable alternative energy worldwide as a substitute for fossil fuels can be converted into various forms of usable energy such as heat, steam, electricity, biogas, and liquid transportation biofuels. Cabbage waste, tofu liquid waste, cow dung and chicken manure is dangerous for the surrounding environment, which produces CH_4 gas and has quite high BOD and COD values. This liquid waste has an amount of COD, suspended solids, and a high total solids content. One solution to overcome this pollution is by processing the waste into biogas, especially methane gas. The material will be transformed into methane gas by fermentation through the anaerobic digestion method. Before converting into biogas, initial characterization will be carried out in total C content, total N, COD, and C/N ratio. Then, from the biogas produced, the maximum data obtained is in variable B4 (55% cow dung: 15% chicken manure: 15% cabbage waste: 15% liquid tofu waste) with a total amount of gas of 7140 ml. This shows that tofu liquid waste can increase the potential amount of biogas produced.

1. Introduction

The global issue currently being discussed by the Indonesian people and the world is global warming and the energy crisis [1]. BBM's consumption, which reached 1.3 million/barrel, was not balanced with the production, which was about 1 million/barrel, so a deficit had to be met through imports. A deficiency of 0.3 million/barrel can be obtained from alternative energy sources. The government has issued alternative energy sources like fuel oil through Presidential Regulation No. 5 of 2006 concerning national energy policies that emphasize renewable resources as an alternative to fuel oil such as hydrogen gas, geothermal, solar, biomass, and others [2].

Biomass is valuable alternative energy worldwide as a substitute for fossil fuels because it can be converted into various forms of usable energy such as heat, steam, electricity, biogas, and liquid transportation biofuels (biodiesel, ethanol, and methanol) [3]. The development of biomass-based biogas technology has increased rapidly, so it is necessary to research biomass production to biogas at an affordable cost, and it can be widely commercialized [4].

Component biogas consists of 50-70% methane, 30-40% carbon dioxide, and a small portion of other gases such as nitrogen, hydrogen, and oxygen [5]. Cabbage is one of the components of organic waste in traditional markets. The accumulation of cabbage waste can cause pollution due to the emergence of sulfuric acid gas and ammonia gas due to the decay process [6]. Cabbage also has a C/N ratio, which can become a pollutant in the environment if it reaches a high quantity because it has a high C/N ratio.

It also happens with the waste of tofu production, usually dumped into rivers or the surrounding environment. There are two kinds of tofu production waste, namely solid and liquid waste. Both types of waste contain high levels of amino acids and proteins. If disposed of in nature without proper treatment, they can be dangerous. According to Sally et al., high protein levels in tofu waste can contaminate soil and river ecosystems. Therefore, it is necessary to use tofu waste to minimize waste disposal in nature [7]. Livestock manure is one of the trash produced from livestock being raised and cultivated. Animal manure has great potential in its utilization and development in line with many livestock raised by the community and livestock companies also this study, using chicken manure and cow dung [8]. Chicken manure has high levels of nutrients and organic matter and low water content. Manure waste must be used because if it is left unchecked, it will cause air pollution. One of the acceptable uses of farmer waste is compost and biogas [9].

The process of forming biogas is carried out anaerobically. Bacteria decompose organic matter into biogas and organic fertilizer. The method of weathering organic matter is carried out by microorganisms in the anaerobic fermentation process [10]. This biogas formation process requires a particular installation called a digester to take place the anaerobic remodeling correctly.

The results of biogas produced by the mixing material of cow dung and water hyacinth are not proper enough to be used as energy sources because it's only produced biogas with 7,9 ml/ day on average [11]. The mixing of cow dung and chicken manure as a raw material does not show good results in producing biogas [12]. In another way, there is another useless waste such as cabbage waste and tofu liquid waste, which contain high COD number and has big potential in producing biogas because the C/N ratio fulfill the standard of biogas material requirement, which is among 20-30:1. The researchers then took the initiative to provide additional raw materials in the form of cabbage waste and liquid tofu waste in the mixture of cow dung and chicken manure to find out how much biogas can be produced from the addition of these two ingredients.

2. Methodology

2.1. Research variable

The variable for this experiment consists of an independent variable, bound variable, and control variable. The independent variable is the raw material ratio variable. The control variable is incubator temperature 55°C, fermentation time 30 days, and the dependent variable is the amount of methane gas produced.

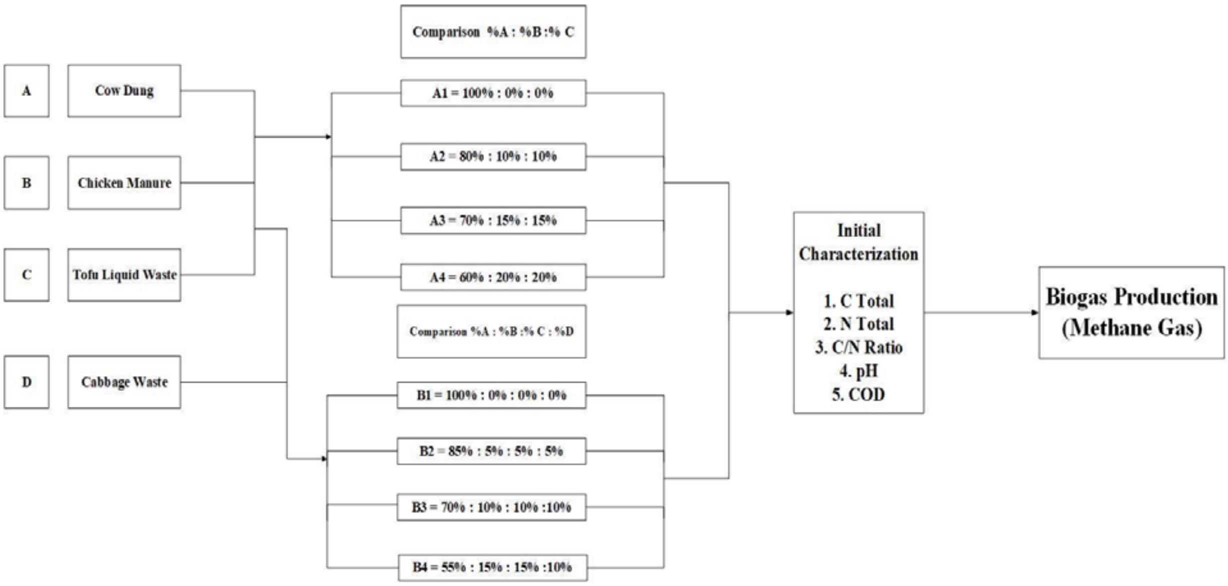

Figure 1. Research flowchart.

2.2. Tools and materials
The tools used in this research are pH meter, thermometer, cup, lab, oven, stirrer, bunsen, hose, stopwatch, digester, erlenmayer, measuring cup, thermometer, flowmeter, and the materials is used are cabbage waste, liquid tofu waste, activator (cow manure fermentation starter), H_2SO_4, 40% NaOH, 0.01 N HCl, 4% H_3BO_3, BCG-MR, nitrogen tube.

2.3. Procedure of experiment
First, the initial raw material was pre-treated for total C, total N, and C/N ratio. The Mixing cow dung, chicken manure, cabbage waste and tofu liquid waste work as a sludge activator. Then we analyze pH and COD. After that, the sludge can be put into the digester after ratio analysis, in which the volume input to the digester can be calculated by 70% x total volume of the digester. Then, shake the digester until homogeneous. Flow the digester with nitrogen gas for 2 minutes. Assemble the tool with a hose like figure 2.

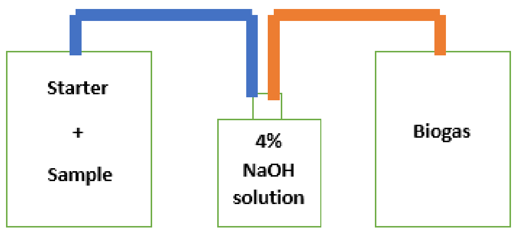

Figure 2. Series of experiment tools

After the series of the experiment tool is ready, cover the digester tightly, then put the digester series in the incubator, as shown in figure 3, and do a volume review every two days using the tool, as shown in figure 4.

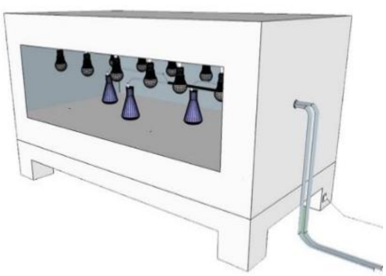

Figure 3. Incubator design for biogas production.

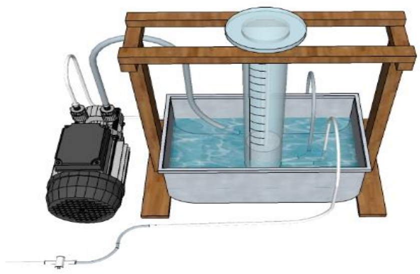

Figure 4. Design of a gas volume gauge.

3. Results and discussion

3.1. Results of the initial characterization of raw materials

From the raw material characterization results to determine the levels of C Total, N Total using the Kjeldahl method, and the C/N ratio, the results are shown in table 1. Where the results of the C/N ratio will later be used as a reference in determining the feasibility of raw materials for producing biogas or, in this research is the methane gas reactor.

Table 1. Results of raw material characterization.

No.	Material	C Total (%)	N Total (%)	C/N ratio
1	Cow dung	27.31	1.69	16.15
2	Chicken manure	19.51	1.27	15.36
3	Liquid tofu waste	0.28	0.04	7
4	Cabbage Waste	42	0.7	60

3.2. Methane gas production results

The amount of methane gas production for variable A, which produces the most gas, is on the variable A3 (70% cow dung: 15% chicken manure: 15% cabbage waste) with a total methane gas of 6380 ml for 30 days of production. The amount of methane gas production for variable B, which produces the highest amount of methane gas, is on the variable B4 (55% cow dung: 15% chicken manure: 15% cabbage waste: 15% liquid tofu waste) with a total methane gas of 7140 ml.

Table 2. Methane gas production results.

	Volume Day (ml)															
Sample	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	Total
A1	20	30	50	80	150	200	200	320	380	480	550	630	710	800	900	5500
A2	30	40	50	100	150	200	250	330	450	530	610	700	810	890	980	6120
A3	30	60	80	120	150	250	280	350	430	510	600	730	840	920	1030	6380
A4	30	50	70	100	150	200	230	320	390	450	490	550	770	820	970	5590
B1	20	30	50	80	140	190	200	340	400	480	500	630	710	810	900	5480
B2	50	50	100	180	230	250	270	280	340	440	520	540	680	800	880	5610
B3	50	50	120	180	230	270	300	360	460	550	640	700	790	880	940	6520
B4	60	60	130	190	260	290	340	370	470	580	690	780	890	980	1050	7140

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3.2.1. Raw materials for cow dung, chicken manure, and cabbage waste

Figure 5 shows that the highest production of methane gas is on days 10-16, where anaerobic fermentation of bacteria occurs here or often referred to as the exponential phase. After passing through this phase, gas production will be static before finally decreasing and not producing gas anymore. For variable A itself, the highest amount of gas is in variable A3 by reaching a total production of 6380 ml after 30 days. This means a 70% cow dung ratio: 15% chicken manure: 15% cabbage waste. Tofu liquid waste is the best comparison among all the other comparisons in variable A. For the production of the gas produced is methane gas because, in a series of experiment tools, there is NaOH to absorb CO_2 gas content, which a component of biogas is also.

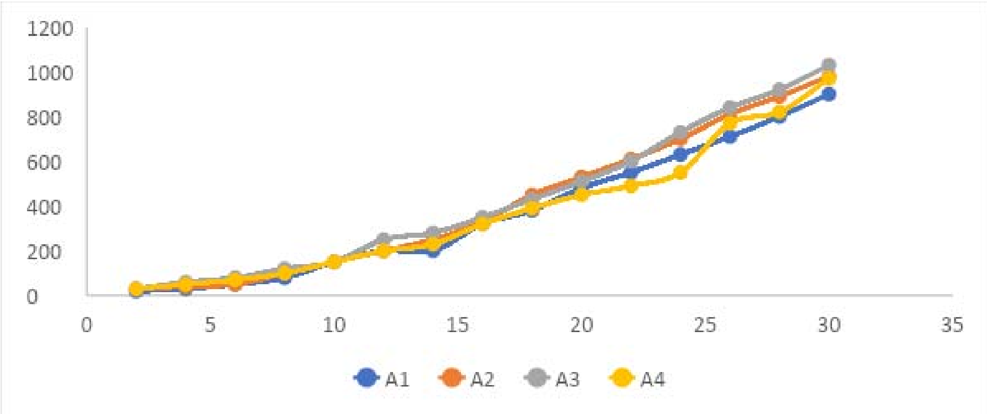

Figure 5. Total methane gas production variable A.

3.2.2. Raw materials for cow dung, chicken manure, and cabbage waste

Figure 6 shows that the highest production of methane gas is on days 10-16, where anaerobic fermentation of bacteria occurs here or often called the exponential phase. After passing through this phase, gas production will be static before finally decreasing and not producing gas anymore. For variable A itself, the highest amount of gas is in variable B4 by reaching a total production of 7140 ml after 30 days. It means that the ratio of 55% cow dung: 15% chicken manure: 15% cabbage waste: 15% tofu liquid waste is the best ratio among all the other comparisons in variable B.

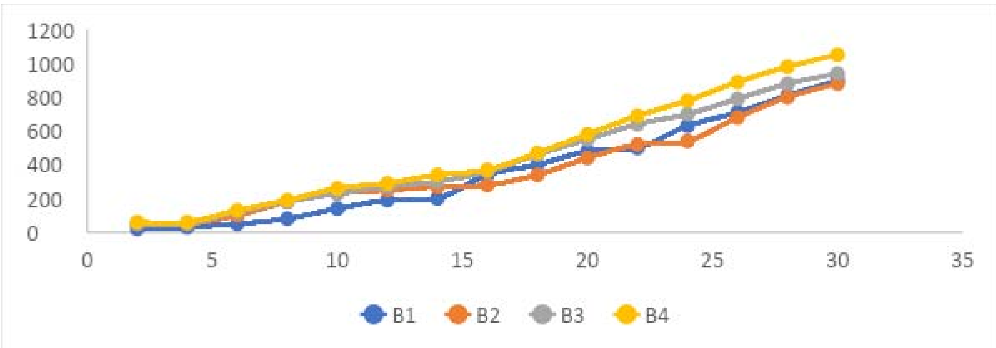

Figure 6. Total methane gas production variable B.

4. Conclusion

Cow manure, chicken manure, cabbage waste, and tofu liquid waste are types of waste that have high COD levels that have the potential to pollute the environment and must receive further processing. On the other hand, this waste can be processed into biogas, and after initial characteristics, it has a ratio of c/n, which is suitable for processing into biogas. Production results for 30 days show that the A3 variable with a ratio of 70% cow dung: 15% chicken manure: 15% cabbage waste produce the highest number of methane gas, which is 6380 ml, and for variable B, the highest number of methane gas production by variable B4 with a ratio of 55% cow dung: 15% chicken manure: 15% cabbage waste: 15% tofu liquid waste with a total production of 7140 ml gas methane after 30 days.

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