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Application of Biogas with Fermenting Bacteria from Manure Raw Material on Stoves and Generators

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Abstract. The raw biogas from the digester is a gas produced by bacterial fermentation which has a composition of methane (CH4), carbon dioxide (CO2), hydrogen sulfide (H2S), water vapor, and various other gases. Gases other than methane in raw biogas can damage the combustion system if used directly. The digester that produces biogas is used to move the generator engine using raw materials, such as cow feces, goat feces, fowl feces, straw, husks, and clean water. In the mixing process, all the raw materials are stirred or mixed evenly in the digester. Next is the process with five stages, namely (1). In the first stage: on the 11th day, adding clean water and fermentation carried out for 21 days, (2). The second stage: adding starter, hormones, charcoal flour, cow feces, fowl fees, goat feces, straw, and husks, then fermented for 7 days. (3). The third stage: adding a starter and fermenting it for 7 days. (4). Fourth stage: ready-to-use compost or solid fertilizer is ready to produce. (5). Fifth stage: liquid fertilizer is ready for production. In the gathering stage: all raw materials are stirred or mixed evenly in the digester and fermented for 1.5 months to become biogas. The last stage is the distribution of biogas: for household needs, and generators. From this research, it can conclude that the water column height (h) is 10.42 cm, and the maximum water column height is 9 cm so that the reactor is safe and the maximum pressure that can be attained is 879.1918 $kg.m^{-1}.s^{-2}$. The heating rate for ratio A is 0.0600 ºC.s-1 and the heating rate for ratio B is 0.0640 oC.s-1. The calorific value produced from heating 1 liter of clean water using biogas from ratio A is 297.99315 kJ, and the calorific value of ratio B is 288.9174 kJ. With a compressor pressure of 8 psi, biogas can be inserted in this using a freon tube for a maximum of 6000 seconds with a mass of 6163 grams. In filling biogas, the biogas manometer should show the maximum number (between 16.50 – 25.50).

Keywords: biogas; digester; manure; raw material

INTRODUCTION

The results of biogas from animal dung, straw, and husks that are currently of biogas are alternative because there is no gas cylinder as a biogas storage that can be used by others as a substitute for LPG (*Liquified Petroleum Gas*), I hope for the biogas results Can be stored in a gas cylinder instead of LPG, due to the importance of the use of gas in the household. The object of research is to get the gas results obtained from biogas of animal dung, straw, and husk stored in used tubes that can be stressed so that animal dung, straw, and husk produced every day is not wasted. So that biogas energy is in waste, the biogas tube can store biogases of an animal, as husk utilized as needed.

The Composition of Biogas

The composition of the biogas depends on the type of raw material that is used. The main compositions of biogas are methane (CH_4) and carbon dioxide (CO_2), with a small amount of hydrogen sulfide (H_2S). Other components are found in a small concentration range, including organic sulfur compounds, halogenated hydrocarbon compounds, hydrogen (H_2), nitrogen (N_2), carbon monoxide (CO), and oxygen (O_2). In Table 1. Explaining biogas products consisting of carbon dioxide (CO2) 25-45 %, methane (CH4) 55-75 % Nitrogen (N_2) 0-0.3 %, hydrogen sulfide (H_2S) 0-3 %, hydrogen (H_2) 1-5 %, water vapor and oxygen (O_2) 0.1 to 0.5 %, and the heat value ranges from 4,800-6,700 kcal.m-3 (Masrukhi, 2017: 9).

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Table 1. Composition (%) of types of gas in biogas (Masrukhi, 2017:9)

No	Type of Gas	Product from Feces	Products from Mixture of Feces and Agricultural Waste
1.	Methana (CH_4)	65.70	55 - 70
2.	Carbon Dioxide (CO_2)	27.00	27 - 45
3.	Nitrogen (N_2)	23.00	0.5 – 3.00
4.	Carbon Monoxide (CO)	0.00	0.10
5.	Hydrogen Sulfide(H_2S)	Immeasurable	Exiguous
6.	Oxygen (O_2)	0.10	6.00
7.	Calorific Value (kkal/m^3)	6513	4800 - 6700

The Raw Material of Biogas Production

1. Cow Feces

Cow feces is the waste product of cow digestion. Cows have a special digestive system that uses microorganisms to digest cellulose and lignin from high-fiber grasses. Therefore, cow feces have a high cellulose content. Cow feces is very suitable as a source of biogas production and as a starter in the fermentation process because the cow feces already contain methane-producing bacteria found in the stomachs of ruminant animals (Sufyandi, 2001). Based on the results of previous research, it is known that every 1 kg of livestock feces has the potential to produce 36 liters of biogas.

Cow feces is one of raw materials's sources for biogas production. Furthermore, the content of methane gas (CH4) in cow dung is 65.7% (Wulandari & Labiba, 2017). The high content of this gas from cow feces can be used as raw material for making biogas (Wulandari and Labiba, 2017). The composition of the gas produced from cow dung is shown in this table.

In addition to the high cellulose content in cow feces, the thing that must be considered for the raw material for making biogas is the content of the C/N ratio. The following contains the C/N ratio of animal feces: Cow feces as livestock waste is used as a source of C and N in methane gas formation. Cow feces as the primary stuffing item has a C/N ratio of 22.12 to 25 (M. Quraish Shihab, 2020).

Table 2. Composition of cow feces (Wardana et. al, 2021)

No	Type of Gas	Percent (%)
1.	Methane (CH_4)	54 - 70
2.	Carbon Dioxide (CO_2)	27 - 45
3.	Nitrogen (N_2)	0.3 – 3
4.	Carbon Monoxide (CO)	0.1
5.	Oxigen (O_2)	0.1
6.	Hydrogen Sulfide (H_2S)	Exiguous

Table 3. C/N ratio in some animal feces (Iriani et.al., 2011)

No	Type of Feces	Ratio C/N
1.	Cow	22.12 – 25
2.	Buffalo	18
3.	Horse	25
4.	Pig	25
5.	Goat / Sheep	30
6.	Fowl	15

2. Rice Husk

Rice husk is a hard layer that includes caryopsis and consists of two sections called lemma and palea that are interconnected. Husks categorize as usable biomass which can be used for various needs such as industrial raw materials, animal feed, and energy or fuel. The rice milling process usually obtains 20-30% husks, 8-12% bran, and 50-63% milled rice.

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Tabel 4. Chemical composition of rice husk (Eryani et.al., 2018)

No	Component	% Weight
1.	Water Content	9.02
2.	Coarse Protein	3.03
3.	Fat	1.18
4.	Coarse fiber	35.68
5.	Crude carbohydrates	33.17
6.	Ash	17.71
7.	Hydrogen	1.54
8.	Oxygen	33.64
9.	Silica	16.98

3. Rice Straw

Rice straw is used to produce biogas by fermenting it in a vacuum tank (anaerobic). Every 1 kg rice straw can produce 0.20 - 0.38 m^3 of biogas. The energy produced by biogas can be used for cooking, lighting, and cooling the motor drive. The energy from 1 m3 of biogas can be used to run a 1 HP engine for 2 hours; provide 1.25 kWh of electricity; provide energy to cook three meals for five people per day; provides the equivalent of 60 watts of illumination for 6 hours; Turn on the refrigerator for 1 hour. The process of making biogas with rice straw through inserting rice straw and cow feces into the digester tank with as much as 8 kg of dry materials with a ratio between rice straw and cow feces is 2: 1. Next is adding water so that the water content's substrate becomes 90%. The fermentation process was carried out for 35 days. Every five days, before using it, stirring is carried out so that all substrates are perfectly mixed, and the formation of scale will be avoided. Stirring is moving the iron pendulum in the digester through a connecting rope made of steel wire. The substantial component of rice straw is cellulose (35 -50%), hemicellulose (20 - 35%), lignin (10 - 25%), and other substances. The two polysaccharide materials (cellulose and hemicellulose) can be hydrolyzed into simpler compounds. The results of the hydrolysis can be fermented into methane (CH_4), which is the main component of biogas. One of the factors that influence the formation of biogas from biomass is the C/N ratio. The higher the C/N, the slower the decay time, while the lower the ratio increases the production of ammonia which is toxic to bacteria, caused by excess nitrogen residue. A good C/N ratio is 30, this is because bacteria consume carbon (C) 30 times faster than nitrogen (N). Table 5 below shows the C/N's comparison of several agricultural wastes (Ihsan, A Bahri, S., Musafira. 2013).

Table 5. C/N ratio of some agricultural waste (Ihsan, A., Bahri, S., Musafira. 2013)

No	Type of Material	C/N Ration
1.	Green Grass	12
2.	Vegetables	11 - 19
3.	Straw	150
4.	Sawdust	200 - 500

Biogas for Stove and Generators

Biogas is a fuel from an anaerobic process using a digester often used for cooking and can be used as fuel for generator sets ((Ningrum, et. al., 2017). Methane gas has a very high calorific value of 4800 kcal/ m3 to 6700 kcal/m3, while pure methane gas has an energy of 8900 kcal/m3 so that biogas can be used for lighting, cooking, and driving machines Equivalence between biogas and other energy sources, that is, for every 1 m3 biogas is equivalent to liquefied petroleum gas (LPG) 0.46 kg, 0.62 liter diesel, 0.52 liter gasoline, 0.80 liter kerosene, 3.5 kg firewood (Irawan & Ridhuan, 2017).

Today the use of biogas is not only used as fuel for stoves but can also be used to generate electricity using a generator. However, in its development, the application of power plants using biogas fuel is still limited (Aisyah & Herdiansyah, 2015). Household-scale biogas power generators are a promising technology for supplying electricity to remote and isolated areas in Indonesia. The components of a small-scale biogas power plant system

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consist of a digester anaerobic to produce biogas, generator engines that have been modified to be able to use biogas fuel, desulfurized units to reduce H2S levels which are corrosive to generators, and water trap units to reduce biogas water content (Haryanto, et.al., 2020).

METHODS

The research method and flowchart that describes the stages of the activity are as follows: a. Flow diagram of the biogas production process until household needs and generator distribution; b. Digester installation components until household stoves and generator distribution; c. Functional testing of design and construction results; d.Testing the drying system and drying characteristics of rice.

Tools and Materials

- Tools

  The tools used in this study are as follows:

  a. A digester equipped with a stirrer is used to make biogas from mixing, and fermentation until storing the biogas;
  b. Manometer used to measure biogas pressure in the fermentation process of the sample;
  c. Thermocouple is used to measure sample temperature in the digester;
  d. Litmus paper or pH paper is used to measure the pH of the sample before starting the fermentation process;
  e. Stopwatch used to measure the time of sample stirring and biogas flame testing time;
  f. Scales are used to weigh the mass of the sample;
  g. Measuring cup is used to determine the volume of water;
  h. Second-hand Freon tubes are used to store biogas before using it to fill the stove and generator;
  i. Biogas stove used for testing the biogas flame;
  j. Genset is used for household lighting backup if the lighting from PLN goes out.

Materials

The raw materials used are cow feces, goat feces, fowl feces, straw, husks, clean water, charcoal flour, starter, and hormones, and they will be mixed until evenly distributed in the digester.

Formula

This research use this specific formula below :

$$P = \rho.g.h \quad \ldots.. (1)$$

Which:

P = maximum pressure (1018.19 kg/m.s2)

ρ = polyethylene plastic density (995.8 kg/m3)

g = gravity acceleration (9.81 m/s2)

Standard Operating Procedures

The research will be carried out as follows:

a. Prepare all the necessary raw materials, such as cow feces, goat feces, fowl feces, straw, husks, and clean water;
b. Freshly harvested rice straw with 65% moisture content and cut it into 10 - 15 cm long. Then, stack them in a place with a height of 20 cm. Sprinkle urea and probiotics evenly with a dose of 5 kg of rice straw;
c. Second-hand rice husks from milling rice are weighed around 5 kg;
d. Cow feces, goat feces, and fowl feces are weighed around 5 kg;
e. 10 liters of clean is measured using a measuring cup;
f. Mix the raw materials, such as straw, husks, cow feces, goat feces, and goat feces, and mix them thoroughly until evenly for 10 minutes with a rotating speed of 340 rpm, and repeat it one more time in 2 days for 10 minutes with speed 340 rpm;
g. Store the mixture in a fermentation reactor (anaerobic process) for 45 days.

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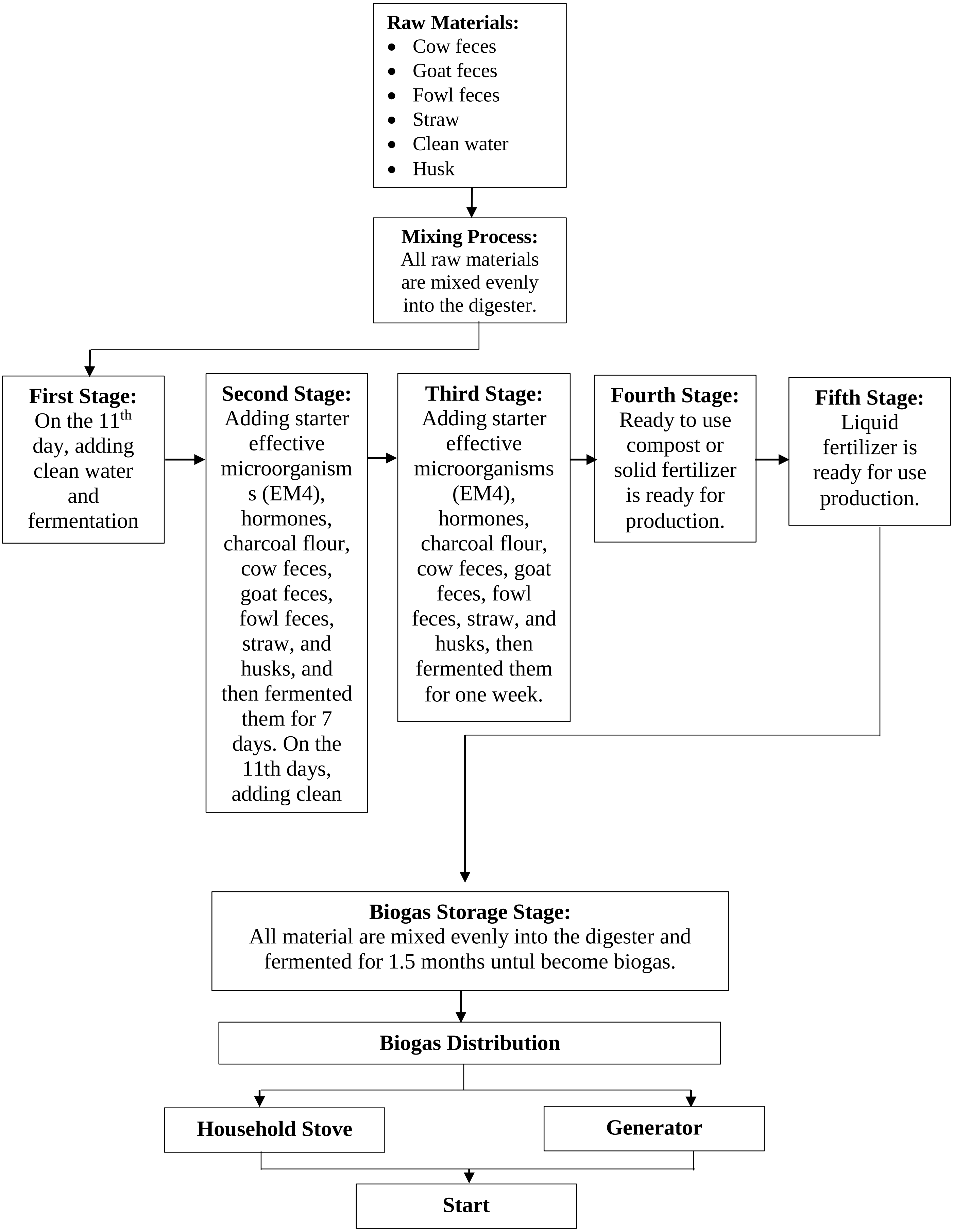

Figure 1. Flow chart of the biogas production process until distribution to household stoves and generators.

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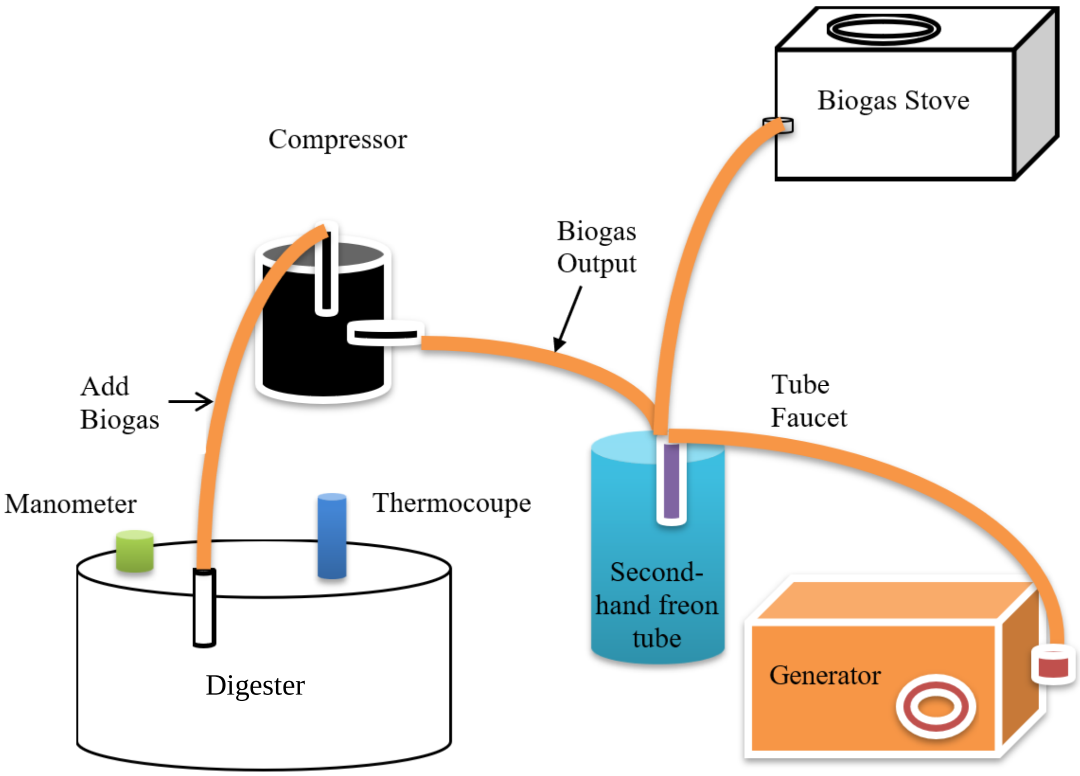

Figure 2. Digester installation components until distribution to household stove and generator

Time and Place of the Research

The research was conducted from December 2021 to June 2022 in Sranten village, Karanggede sub-district of Boyolali district, Central Java Province.

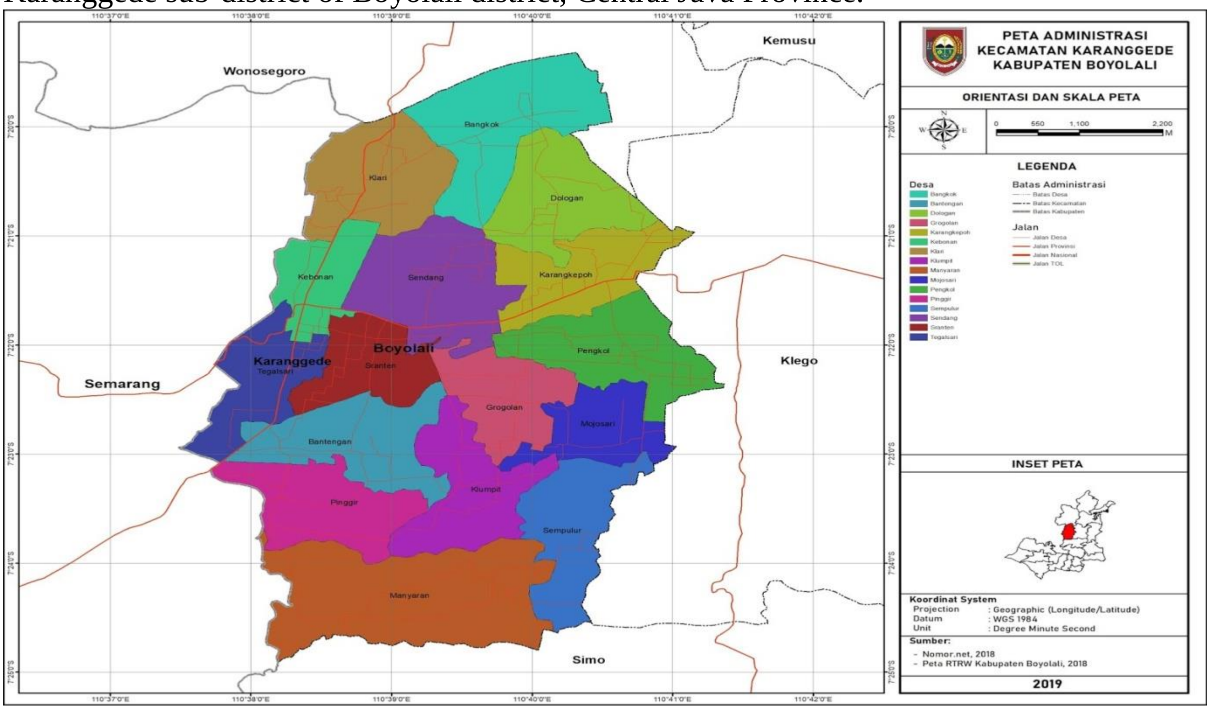

Figure 3. Sranten village, Karanggede sub-district of Boyolali district, Central Java Province.

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RESULTS AND DISCUSSION

The results of biogas from two types of reactors are as follows.

Table 6. Data of environment temperature, biogas temperature, and slurry temperature from the research

Days	Environment temperature (°C)	Ratio A Biogas Temperature (°C)	Slurry Temperature (°C)	Ratio B Biogas Temperature (°C)	Slurry Temperature (°C)
1	27.50	27.00	26.50	27.00	28.00
2	28.00	27.00	26.50	28.00	28.00
3	27.50	27.00	26.00	28.00	27.50
4	29.00	29.00	28.00	30.00	29.50
5	28.00	27.50	27.00	28.50	28.50
6	28.00	27.50	26.50	28.50	28.00
7	27.50	27.00	26.50	27.00	28.00
8	27.00	26.50	26.00	25.50	25.50
9	27.50	27.00	26.50	27.00	27.00
10	27.50	26.50	25.50	27.50	28.00
11	27.50	26.50	26.00	27.50	28.00
12	28.50	27.50	27.00	28.50	29.00
13	28.50	28.00	27.50	28.00	28.50
14	29.50	28.50	29.00	29.50	30.00
15	27.50	27.00	26.00	27.50	28.00
16	27.50	26.50	26.00	27.50	28.00
17	28.00	27.00	27.00	28.00	28.50
18	28.00	27.00	26.00	27.50	28.00
19	29.00	29.00	28.00	29.00	29.00
20	28.50	28.00	28.00	28.50	28.50
21	27.50	27.00	26.50	27.00	28.00
22	28.00	27.00	26.50	28.00	28.00
23	27.50	27.00	26.00	28.00	27.50
24	29.00	29.00	28.00	30.00	29.50
25	28.00	27.50	27.00	28.50	28.50
26	28.00	27.50	26.50	28.50	28.00
27	27.50	27.00	26.50	27.00	28.00
28	27.00	26.50	26.00	25.50	25.50
29	27.50	27.00	26.50	27.00	27.00
30	27.50	26.50	25.50	27.50	28.00
31	27.50	26.50	26.00	27.50	28.00
32	28.50	27.50	27.00	28.50	29.00
33	28.50	28.00	27.50	28.00	28.50
34	29.50	28.50	29.00	29.50	30.00
35	27.50	27.00	26.00	27.50	28.00
36	27.50	26.50	26.00	27.50	28.00
37	28.00	27.00	27.00	28.00	28.50
38	28.00	27.00	26.00	27.50	28.00
39	29.00	29.00	28.00	29.00	29.00
40	28.50	28.00	28.00	28.50	28.50

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Days	Environment temperature (°C)	Ratio A Biogas Temperature (°C)	Slurry Temperature (°C)	Ratio B Biogas Temperature (°C)	Slurry Temperature (°C)
41	27.50	27.00	26.50	27.00	28.00
42	28.00	27.00	26.50	28.00	28.00
43	27.50	27.00	26.00	28.00	27.50
44	29.00	29.00	28.00	30.00	29.50
45	28.00	27.50	27.00	28.50	28.50

Note: Slurry contains a ratio of liters of cow feces, fowl feces, and 10 liters of clean water

- Ratio A: volume of slurry without husk and straw
- Ratio B: slurry + husk + straw with 0.1 volume from slurry's volume divided by slurry

Based on the table above, it is seen that the addition of a larger ratio of rice husks does not directly increase the productivity of methane gas, because the addition of 0.10% volume of slurry in the digester shows a decrease in the methane gas productivity and an effect on a decrease in biogas temperature at ratio A. with the slurry temperature, and will be the same with the decrease in methane gas productivity and affect the decrease in biogas temperature in the ratio B to the slurry temperature.

Table 7. Data of pressure on the gas

Days	Ratio A Pressure (Pa)	Ratio B Pressure (Pa)
1	101355.75	101358.86
2	101378.42	101381.55
3	101401.13	101404.74
4	101424.55	101427.16
5	101447.25	101451.37
6	101470.75	101473.43
7	101493.48	101496.26
8	101516.75	101519.12
9	101539.38	101542.26
10	101562.23	101565.41
11	101585.47	101588.73
12	101618.38	101621.45
13	101641.67	101644.66
14	101664.22	101667.38
15	101687.35	101690.52
16	101700.78	101703.29
17	101723.19	101726.43
18	101746.35	101749.67
19	101769.48	101773.76
20	101792.27	101795.31
21	101815.51	101818.84
22	101838.73	101841.25
23	101842.35	101845.42
24	101865.41	101869.73
25	101888.18	101891.39
26	101911.65	101914.16
27	101934.92	101937.49

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Days	Ratio A Pressure (Pa)	Ratio B Pressure (Pa)
28	101957.73	101960.62
29	101980.42	101983.36
30	102003.15	102006.27
31	102026.63	102029.43
32	102029.48	102032.67
33	102052.24	102055.16
34	102085.45	102088.27
35	102108.18	102111.52
36	102131.61	102134.31
37	102154.25	102157.49
38	102177.44	102180.27
39	102200.72	102203.26
40	102223.19	102226.83
41	102246.37	102249.18
42	102269.35	102272.47
43	102292.28	102295.32
44	102315.47	102339.08
45	102339.72	102343.19

From the table 7 above from the first day to the 45th day of the biogas pressure data for ratio B increase from 3.14 to 3.47 Pa from the pressure in ratio A.

Table 8. Data of gas volume accumulation from to day

Days	Ratio A Volume (m^3)	Ratio B Volume (m^3)
1	0.0000	0.0000
2	0.0071	0.0075
3	0.0084	0.0093
4	0.0098	0.0110
5	0.0112	0.0137
6	0.0179	0.0222
7	0.0245	0.0309
8	0.0312	0.0396
9	0.0378	0.0484
10	0.0445	0.0571
11	0.0512	0.0638
12	0.0580	0.0670
13	0.0647	0.0735
14	0.0715	0.0803
15	0.0779	0.0893
16	0.0845	0.0961
17	0.0912	0.1051
18	0.0979	0.1136
19	0.1051	0.1230
20	0.1115	0.1366
21	0.1183	0.1428
22	0.1250	0.1490
23	0.1317	0.1575

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Days	Ratio A Volume (m^3)	Ratio B Volume (m^3)
24	0.1385	0.1643
25	0.1459	0.1733
26	0.1525	0.1821
27	0.1592	0.1911
28	0.1659	0.1996
29	0.1731	0.2132
30	0.1795	0.2268
31	0.1863	0.2329
32	0.1930	0.2397
33	0.2007	0.2482
34	0.2075	0.2560
35	0.2041	0.2650
36	0.2108	0.2738
37	0.2175	0.2828
38	0.2242	0.2913
39	0.2309	0.3049
40	0.2376	0.3185
41	0.2443	0.3321
42	0.2510	0.3457
43	0.2577	0.3593
44	0.2644	0.3729
45	0.2711	0.3865

In Table 8 above regarding data on the accumulation of gas volume from the first day to the 45th day, the gas volume has an increase from the A ratio from 0.0000 to 0.2711 m^3, and the gas volume accumulation data from the first day to the 45th day the gas volume has an increase from the ratio B ranges from 0.0000 to 0.3865 m^3.

- **Pressure safety valve**

The data obtained from the two biogas reactors is the maximum pressure (P) from the difference between reactor B minus reactor A on the 45th day, which is (102343.19 - 101325) = 1018.19 Pa = 1018.19 kg/m.dt2, with polyethylene plastic density (ρ), is 995.8 kg/m3 (Indartono,

2005). By using the equation below, the height of the water column used to maintain the pressure in the reactor so as not to exceed the strength of the polyethylene plastic is:

$$P=\rho.g.h \; ..... (2)$$

Which:
P = maximum pressure (1018.19 kg/m.s2)
ρ = polyethylene plastic density (995.8 kg/m3)
g = gravity acceleration (9.81 m/s2)
it is obtained that the height of the water column (h) is:

$$h = \frac{P}{\rho.g} = \frac{1018.19\ \mathrm{kg/m.s^2}}{995.8\ \mathrm{kg/m^3} \times 9.81\ \mathrm{m/s^2}} = 0.1042\ \mathrm{m}$$
$$= 10.42\ \mathrm{cm}$$

For the maximum height of water column to be made is 9 cm, so that the reactor is safe and the maximum pressure that can be achieved is (995.8 kg/m^3 x 9.81 m/s^2 x 0.09 m) = 879.1918 kg/m.s^2 = 879.1918 Pa.

- **Fire safety valve**

The fire safety valve has a function to prevent fire from returning to the biogas installation by placing the fire safety valve in the line after the reservoir before the stove and the generator. The valve is made with plastic tape wear for the water reservoir and 0.5” = 1.27 cm PVC pipe for the line.

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- **Biogas Combustion**

Test of data retrieval for the calculation of the heating rate using 1 liter of clean water heated with a fire produced by the reactor from the slurry. The composition is with a ratio of 1:1 (for cow feces, goat feces, and goat feces with clean water) without rice husks and the addition of straw with a 0.20 ratio and the slurry volume with a 0.25 ratio.

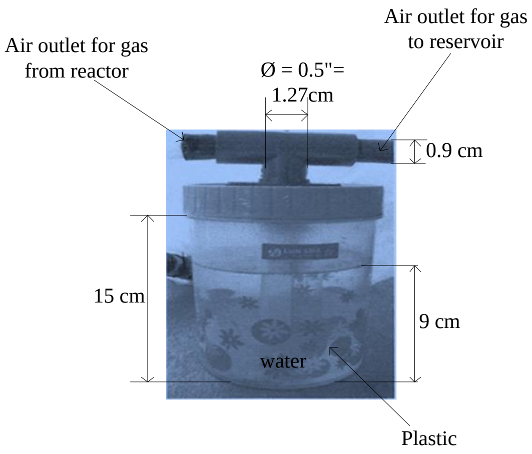

Figure 3. Pressure safety valve

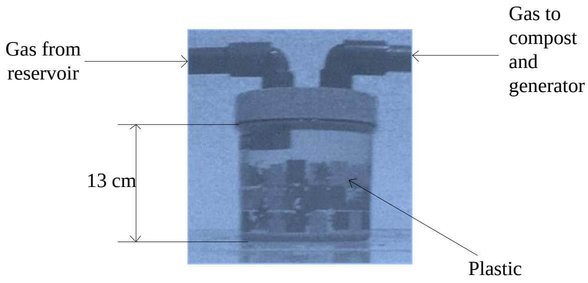

Figure 4. Fire safety valve

Table 9. Data of water temperature test from both biogas ratio

Testing	Time (second)	Ratio A Temperature (^{o}C)	Ratio B Temperature (^{o}C)
1	0	27.50	27.50
2	120	42.32	43.56
3	240	49.32	43.56
4	360	27.50	27.50
5	480	42.32	43.56
6	600	57.38	59.14
7	720	71.65	72.29
8	840	84.75	88.67
9	960	91.34	92.47
10	1080	98.75	96.58

- **Heating rate and calorific value of biogas**

The heating rate for 1 liter of clean water is to be calculated using the following equation:

$$\text{Heating rate} = \frac{T_2 - T_1}{t} \quad ..... (3)$$

Which:

T_1 = 27.50 ℃

T_2 = 98.75 ℃

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t = 1080 second

Obtained:

Heating rate $= \frac{(98.75-27.50)°C}{1080\ \text{second}} = 0.06\ {°C}/{s}$ ..... (3)

Tabel 10. The heating rate is obtained from 1 liter of water

Reservoir Gas	Heating rate (°C/second)
Rasio A	0.0600
Rasio B	0.0640

The calorific value produced by heating 1 liter of clean water using biogas from each ratio is:

$Q = V_{water} \times \rho \times C_p \times \Delta T$ ..... (4)

$$Q = 0.001 m^3 \times 995.8\ kg/m^3 \times 4.2\ kJ/kg.K \times (371.75 - 300.5)K$$

$Q = 297.99315\ kJ$

Furthermore, the calculation of the other ratio is shown in **Table 11**.

Table 11. The calorific value for ratio A and B

Reservoir Gas	Calorific value (kJ)
Rasio A	297.99315
Rasio B	288.9174

- **Gas filling test**

Table 12. Data of gas filling test

Test	Temperature (°C)	Compressor Pressure (psi)	Biogas Manometer	Time (second)	Mass (gram)	ρ (kg/m^3)
1	27.50	8.00	25.50	600	785	95.80
2	27.50	8.00	24.50	1200	1238	192.29
3	27.50	8.00	23.50	1800	2317	202.31
4	27.50	8.00	22.50	2400	3383	267.56
5	27.50	8.00	21.50	3000	3821	310.19
6	27.50	8.00	20.50	3600	4474	359.25
7	27.50	8.00	19.50	4200	4924	405.58
8	27.50	8.00	18.50	4800	5583	487.56
9	27.50	8.00	17.50	5400	5924	405.58
10	27.50	8.00	16.50	6000	6163	487.56

- **Testing to usage of biogas**

Table 13. Gas usage test

Test	Temperature (°C)	ρ (kg/m^3)	Time (second)
1	27.50	95.80	300
2	27.50	192.29	600
3	27.50	202.31	1200
4	27.50	267.56	1800
5	27.50	310.19	2400
6	27.50	359.25	3000
7	27.50	405.58	3600
8	27.50	487.56	4200
9	27.50	405.58	4800
10	27.50	487.56	5400

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- **The result of test analysis**

Table 14. The result of the test analysis

Test	Mass (gram)	Pressure (psi)	Time (second)
1	785	386.33	600
2	1238	406.12	1200
3	2317	431.55	1800
4	3383	521.37	2400
5	3821	545.19	3000
6	4474	621.87	3600
7	4924	673.38	4200
8	5583	715.24	4800
9	5924	759.62	5400
10	6163	827.08	6000

CONCLUSION

From the results and discussions above, it can be concluded: First, the height of the water column (h) is 0.1042 m = 10.42 cm and the maximum water column height to be made is 9 cm so that the reactor is safe and the maximum pressure that can be achieved is 879.1918 $kg.m^{-1}.s^{-2}$ = 879.1918 Pa. Second, the heating rate for ratio A is 0.0600 $^oC.s^{-1}$, and the heating rate for ratio B is 0.0640 $^oC.s^{-1}$. And then, the calorific value produced by heating 1 liter of clean water using biogas from ratio A is 297.99315 kJ and ratio B is 288.9174 kJ. Fourth, with a compressor pressure of 8 psi, you can enter biogas in this freon tube for 6000 seconds at maximum with a mass of 6163 grams. Last, when filling biogas, the biogas manometer should show the maximum number (between 16.50 – 25.50).

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