http://heanoti.com/index.php/hn

RESEARCH ARTICLE

URL of this article: http://heanoti.com/index.php/hn/article/view/hn1320

Effective Microorganism (EM) from Modified Bioinoculant to Increase Biogas Quantity

Susi Nurweni[1], Karno[2], Beny Suyanto[3(CA)]

[1]Department of Environmental Health, Health Polytechnic of Surabaya, Indonesia

[2]Department of Environmental Health, Health Polytechnic of Surabaya, Indonesia; karnomagetan@yahoo.com

[3(CA)]Department of Environmental Health, Health Polytechnic of Surabaya, Indonesia; benssuy@gmail.com

(Corresponding Author)

ABSTRACT

Biogas is produced by non aerobic microorganism activity through stages: hydrolysis process, acidification, methane forming and grow everyday as decomposing bacteria continues growing and having activities. The objectives of the research was the usage of modified bioinoculant Effective Microorganism (EM) to increase the amount of biogas volume. The method used in this experimental research was to make biogas instrument using cow dung and fermentor bacteria in digestor with 6 Em and starbio treatment: 0 : 100; 25:75; 50:50; 75:25; 100:0; 0:0. Biogas with the capacity of 15 l (5 kg of cow dung and 10 l of water) using polytene plastic digestor fitted with fitting and PVC pipe accessories with measurement. Parameter C/N: 15 to 29; duration of gas forming process: 7, 14 and 21 days; gas volume: 1.55 to 6.85 l; biogas productivity: 0.07 to 0.33 l/day; pH: 6 to 7; temperature: 32 to 34; biogas flame: easy to flame in blue colour. The best result was using composition ratio of Em4 : starbio = 100 : 0 which can optimally produce 6.85 l of gas within 21 days and minimally produce 1.55 l within 21 days without bioinoculant. The result of the study can be implemented by, of and for the community, as a renewable energy substitution for LPG easily and in reasonable prize.

Keywords: Biogas, EM inoculants fermentation, Biogas volume quantity

INTRODUCTION

Biogas or gases produced by an-aerobic microorganism activities or organic materials fermentation, mainly containing of methane and carbon dioxide(1). Going through a phase of hydrolysis process, acidification and methane formation will continue increasing everyday as long as decomposing bacteria keep growing and activating(2). The process of forming biogas in the digester can be accelerated by adding EM4 which can break down the polymer compound into a monomerny compound(3). The faster the formation of biogas is, the more energy sources will be produced, so the biogas production will be greater. This will be very beneficial for the community because the higher biogas production, the need for fuel oil as an energy source can be minimized.

The parameters that influence in increasing the volume of the gas produced by the digester are the volume of digester, the amount of EM, the temperature, the pH, the C / N ratio and the fermentation detention time(4).

The purpose of this study was to analyze the effect of modified bio inoculant Effective Microorganism (Em) to increase the quantity of biogas volume. By an effective usage of the modified inoculant, hopefully, the quantity of biogas volume can increase.

METHODS

This experimental study used posttest only design, in which the researcher treats the raw materials of cow dung and water dilution in ratio 1:2, with an addition of bio inoculant of bacteria fermenter. This research was conducted through 6 treatments with 3 replications for each and each treatment will measure the result of its biogas volume afterwards.

Development of model of biogas type 1, the following is the procedure:

1. Preparing bio inoculant: main materials The Em (table 1) each will be multiplied by adding glucose (50 g), jelly (100 g), cow dung slurry (1000 g) and water medium (2000 ml) for 3 to 5 days and ready to use as biogas fermenter starter.

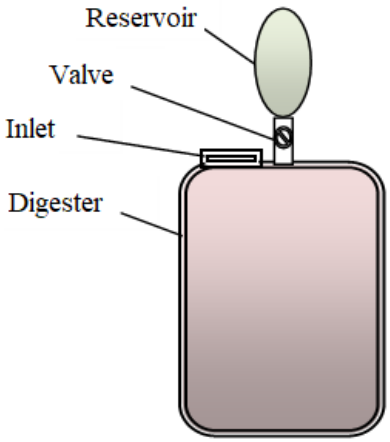

Figure 1. Biogas model of laboratory scale 20 l capacity

Table 1. Bio size of inoculant bacterial fermentation with EM4 and starbio materials

Treatment	EM4 (gr)	Starbio(gr)
1	0	1000
2	250	750
3	500	500
4	750	250
5	1000	0
6	0	0

2. Preparing cow dung 5 kg and 10 l water stirred evenly until homogeneous and put it in lidded jug. 18 sampling media are made; 3 times replication of 6 treatments.
3. Mixing 2% bacteria fermenter to treatment 1-5. Treatment 6 as control, without bio inoculant.
4. From the 6 (six) treatments mentioned above are observed with the following parameters:
   a. Measurement of C / N Ratio
      To know the amount of C / N Ratio of each treatment in producing biogas.
   b. Duration of time of biogas formation
      The duration of the formation of biogas for 7, 14 and 21 days.
   c. Volume of biogas produced
      The volume of biogas produced by the fermentation process will be observed and measured to determine the biogas development by each reactor. The measurement is done by putting the gas volume placed in a digester into a full water tub. The amount of water coming out of the tub is measured, assumed that the volume of water coming out is equal to the volume of gas in the blimp. The biogas volume can be calculated by the formula:

      $$\text{Vol. biogas} = \frac{\text{Vol. biogas in plastic (ml)}}{\text{Day}}$$

   d. Biogas productivity.
      The gas productivity is measured at each treatment, by measuring biogas production for 7 days (first week), 14 days (week two) and 21 days (week 3). Productivity can be known by using the formula:

      $$\text{Production} = \frac{\text{Vol. biogas (liter)}}{\text{Amount (day)}}$$

   e. Degree of acidity (pH) (measured using pH meters)
   f. Temperature (measured using thermometer).
   g. Flame Test (performed to prove the produced biogas contains methane gas using a modified stove).

RESULTS

The Physical Condition of Bio Inoculant

1. Odor: After mixing EM4 and Star bio according to the above treatment the odor of cow dung predominates. There should be possibility that more EM4 and or star bio will reduce the typical smell of cow dung. After

being fermented for 5 days, the smell turns to typical fermentant (fermented cassava smell) followed by foam above the liquid.
2. Color: The color of mixed cow dung with EM4 and star bio according to the above treatment is blackish dark green which is dominated by cow dung color. The color of Em4 which is dark brown and star bio which is grey do not effect the color of the cow dung.
3. Texture: soft texture of the cow dung turns to dilution after being mixed homogenous.

Laboratory scale biogas product

The measurement results of C / N ratio, pH, Temperature, volume (production) of biogas for 7, 14 and 21 days are presented in the following table:

Table 2. Recapitulation measurement results C / N ratio, pH, temperature, volume (production) of biogas for 7, 14 and 21 days

Parameter / Time		Comparison of EM4 and Starbio (gr) and average measurement results from treatment					
		1	2	3	4	5	6
		0 : 1000	250 : 100	500 : 500	750 : 250	1000 : 0	0 : 0
7 hr	C/N rasio	26.88	22.23	24.41	22.38	28.47	16.76
	Vul biogas	1.17	0.23	0.80	0.25	1.27	0.12
	pH	6.97	6.53	6.63	6.40	6.97	6.43
	Suhu	33.33	33.00	33.00	32.67	33.67	32.67
14 hr	C/N rasio	26.74	22.43	24.54	22.38	28.54	17.65
	Vul biogas	2.33	1.33	2.10	1.38	2.93	0.53
	pH	6.90	6.47	6.73	6.53	6.93	6.40
	Suhu	33.33	33.33	33.33	33.67	33.67	33.00
21 hr	C/N rasio	26.43	22.78	24.88	22.27	28.55	16.96
	Vul biogas	2.45	1.90	2.13	1.77	2.65	0.90
	pH	6.93	6.50	6.80	6.50	6.97	6.57
	Suhu	33.67	33.67	33.33	33.00	33.67	33.00

DISCUSSION

C / N Ratio

The lowest cow dung C / N content ratio without the addition of bacterial bio inoculant is 17.65 (table 2) and the biogas produced 1.57 l is also less than cow dung added by bio inoculant. By a C / N ratio of 28.54 producing the greatest biogas volume, 6.85 l on treatment 5. The result in treatment 2-4 which is added by bio inoculant star bio and Em4 is less than treatment 5. This means that the synergy of the materials are less effective compared with treatment 1 and 5 which are without mixing the mentioned materials.

The C / N ratio difference in the fermentation process will affect the volume of biogas (treatment 1 to 5). The optimum C / N ratio for anaerobic digesters ranges from 20 to 30 and is one of the most important indicators for determining the quality of materials to be used as subtracts in the biogas formation process[(2)]. The content of nitrogen in the substrate has an important role in the amino acids formation. Too much nitrogen will increase ammonia causing stench. The carbon element used by bacteria during fermentation process as energy and Nitrogen (N) is used to build body structure cell[(5)].

Volume and Production of Biogas

The bio gas production in treatment 1-6 in this research, the greatest cumulative product is in treatment 5, namely 6.85 l whereas the least is in treatment 6 (without bio inoculant addition) namely 1.56 l, each is for 21 days. Overall, the addition of bacteria from both EM4 and Starbio can increase the production of biogas compared with those which are without that substance (control or treatment 6). The mixture of EM4 and star bio (treatment 2 to 4) in this study not yet increasing biogas production synergistically because the most production is the addition of EM4 and Star bio. However, the addition of bacteria from bio inoculant produces more biogas than control (treatment 6). According to Teguh Wikan and Ahmad Asari (2011): Equivalent 1 m3 biogas is LPG (Liquified Petroleum Gas) source of 0.46 kg[(6)].

The above conditions are supported by the results of research[(3)], that the speed of biogas formation is influenced by the addition of EM4 to the organic material fermentation process in producing biogas compared to

that of without the addition of EM4. According to Shuler and Kargi (2002) that biogas production is influenced by the growth of methanogenic bacteria that convert volatile acid to methane and CO_2 and other products, so that the rate of methane gas formation goes along with the growth rate of methanogenic bacteria[7]. In this study, treatment 5 with a C / N ratio about 28 at temperature 34 and neutral pH (6.96) can produce the greatest biogas 6.85 l in 21 days compared with control and other mixed treatments. The amount of biogas volume is affected by the C / N ratio ranging from 20-30[2] and this occurs in treatment 1-5 with C / N ranges 22-29 (table 2). The result of biogas volume in treatment 6 which is without the addition of bio inoculant is less and C / N ratio is <20.

The amount of biogas volume is also influenced by pH content. To produce a productive biogas volume can be achieved at neutral pH 7[2]. This is reinforced by Yonathan's (2013) research that neutral pH can stimulate the development of bacteria to produce biogas[8].

In addition to pH, temperature also affects the amount of biogas volume. Temperature 31 to 34^0 C will facilitate bacteria to multiply so that methane gas formation will be faster[2]. While the temperature in this study ranged from 32 to 34

pH

The results of pH measurements in this study ranged neutral close to 7, while the lowest pH in the range of 6.3. According Melinda Mulyani, (2013) cow dung after being mixed with water pH ranges 6.58 and at a temperature of 30 to 35 ^{0}C will produce optimum biogas and also must consider about the duration of digestion process[9]. Neutral pH at about 7 effects ideally on the growth of anaerobic microbes in producing biogas, especially methane[10].

In this study, the addition of bio inoculant EM4 and star bio with pH 6.96 on treatment 5 produces optimum biogas of 6.85 l in 21 days while at pH 6.47 treatment 6 without bio inoculant (control) produces the lowest biogas 1.55 l. There is not significant changes from the addition of bio inoculant at 7, 14 and 21 days in each treatment, namely, in the range of 6.3 to 7. Anaerobic processes that occur in the former pH digester and the final digester process with raw materials of chicken and cow manure produce optimum biogas at neutral pH[2].

Temperature

The results of this study, temperatures during the anaerobic fermentation process ranged from 32 to 34^0 C. There is no significant difference in temperature during the fermentation process, with or without bio inoculant EM4 and Star bio. According to Megawati (2014) the temperature tends to be constant at ± 30 ^{0}C[3]. In that temperature a mezophysical type of microorganisms grow and develop optimally. Under these conditions, the reshuffling of organic materials will be well conditioned, accompanied by rising temperatures. Thus the temperature contributes to biogas production. The temperature fluctuates aside with the changes in ambient temperature and higher ± 2 °C than ambient temperature[4]. In the anaerobic fermentation process, reactions occurs during the degradation of organic matter do not have a great effect on the increase of digester temperature, since the energy produced by anaerobic fermentation is very small[11]. Therefore, temperature changes are more dominantly influenced by changes in ambient temperature

Relation C / N ratio, pH, Temperature and biogas production

To produce biogas anaerobic bacteria role in fermentation process in digester is needed. The addition of EM4 and star bio in in the treatment 1 to 5 produces more biogas than the control conditions without the addition of bio inoculant.

To increase the role of anaerobic bacteria operating temperature tends to be constant at ± 30^0 C is needed[3]. The good temperature is in the range of 20-40^0 C and the optimum temperature between 28-30 ^{0}C. In that temperature a mezophysical type of microorganisms grow and develop optimally. Under these conditions, the reshuffling of organic materials will be well conditioned, accompanied by rising temperatures. Thus the temperature contributes to biogas production.

Besides temperature, pH takes an important role in increasing biogas production. Ideal pH about 7 effects on the growth of anaerobic microbes in producing biogas, especially methane[10]. There is not significant changes by adding bio inoculant at 7, 14 and 21 days in each treatment (treatment 1 to 5), in the range of 6.3 to 7.

The C / N ratio, is one of the most important indicators to determine the quality of materials to be used as subtracts in the biogas formation process[2]. Carbon / Nitrogen (C / N) The optimum ratio for anaerobic digesters ranges from 20 to 30. The carbon element C is used by bacteria during the fermentation process as energy and Nitrogen (N) is to build the body cell structure[5].

Thus it can be concluded that the speed of biogas formation is influenced the addition of EM4 to the process of fermentation of organic material in producing biogas compared with that of without the addition of EM4[3]. It should be understood, however, that anaerobic bacteria which take a role in fermentation to produce biogas must be conditioned at neutral pH, 20 to 40 and C / N temperatures of 20 to 30 in order to produce optimum biogas production.

Test flame

The biogas fire test is done by connecting the hose to the burner. Then the burner tip is ignited. The result is a blue flame and physically is same as an LPG flame and in this case, biogas produces methane gas. According to Iksan et al. (2013), if the gas produced from the anaerobic process can be burnt, it may contain 45% methane gas and generally, if methane gas is burnt, it will produce blue flame and not easily extinguished[12].

CONCLUSION

The results of this study can be summarized as follows:

1. Biogas tool with capacity 15 l (5 kg cow dung and 10 l water) with polythene plastic digester equipped with PVC pipe fittings and accessories, glucose and bacteria fermenter EM4 and star bio.
2. Results of C / N parameters measurements: 15 to 29; Duration of gas formation process 7, 14 and 21 days; Volume of gas: 1.55 to 6.85 l Biogas productivity: 0.07 to 0.33 l / day; pH: 6 to 7, temperature: 32 to 34, and test the biogas flame: easily burnt and blue.
3. Optimal biogas produced 6.85 l in 21 days using bio inoculant EM4, and minimum of 1.55 l in 21 days without bio inoculant.

The suggestion are: 1) it is necessary for a further investigation of modifying various bio inoculant so that an effective and efficient bio inoculant can be found. It should also be made of cheap local materials, easy to make and valuable, 2) the results of this study are recommended to be practiced in the social community because of appropriate technology, cheap and using local materials.

REFERENCES

1. Syamsuri, Suheni, Yustia W, Taufik. Biogas Stove Performance Analysis with Biogas 1 M3 Container Volume Produced from Reactor with 5000 Liter Volume (Analisa Performansi Kompor Biogas dengan Volume Penampung Biogas 1 M3 yang Dihasilkan dari Reaktor dengan Volume 5000 Liter). Seminar Nasional Sains dan Teknologi Terapan III 2015. Surabaya: Institut Teknologi Adhi Tama Surabaya; 2015. p. 151-162.
2. Sanjaya D. Biogas Production from Cow Manure Mixture with Chicken Manure (Produksi Biogas dari Campuran Kotoran Sapi dengan Kotoran Ayam). Graduate Thesis. Bandar Lampung: Universitas Lampung; 2015.
3. Megawati, Kontali WA. Effect of Addition of EM4 (Effectiveness Microorganism-4) on The Manufacture of Biogas from Water Hyacinth and Cow Rumen. Journals of Renewable Natural Materials. 2014.
4. Mujdalifah S, Dohong S, Suryani A. Effect of Fermentation Time on Biogas Production Using Two-stage Digester on Sharing of Palm Oil-mill Effluent and Active Sludge Concentration. Agritech Journal. 2014;34.
5. Siallagan NSR. The Influence of Residence Time and Composition of Raw Materials in The Process of Fermentation of Tofu Liquid to Biogas Production. Thesis. Medan: Faculty of Engineering, University of North Sumatra; 2010.
6. Widodo TW, Asari A. Biogas, Construction, Operation and Maintenance of The Installation. Tangerang: Agroinovasi Rays Farming Balitbang Agriculture; 2011.
7. Shuler MI, Kargi F. Bioprocess Engineering. USA: Pretice-Hall, Inc; 2002.
8. Yonathan AA, Petetya R, Pramudono B. Biogas Production from Eceng Gondok (*Eicchornia crassipes*): Consistency Review and pH on Biogas Produced. Journal of Industrial and Industrial Technology. 2013;2 (2):211-215.
9. Mulyani M. Design of Biogas Tools from Household Scale Dung. Palembang: Musi Engineering High School; 2013.
10. Saputro T, Suharjo T, Ambar P. Biogas Production from Mixture of Sapid Feces of Bagasse with Different C / N Ratio. Bulletin farm. 2010; 34.
11. Gerardi MH. The Microbiology of Anaerobic Digesters. New Jersey: John Wiley and Sons, Inc. Hoboken; 2003.
12. Iksan A, Bahri S, Musafira. Biogas Production Using Rumen Content of Cattle with Tempe Waste. Journal of Natural Science. 2013; 2(2):27-35.