VOL. 11, NO. 20, OCTOBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EFFECT OF MIXTURE RATIO OF COW FAECES WITH WATER ON BIOGAS PRODUCTION

C. Rangkuti, Salman Ahmad and Rosyida Permatasari
Mechanical Engineering Department, Universitas Trisakti, Grogol, Jakarta, Indonesia
E-Mail: chalil@trisakti.ac.id

ABSTRACT

Biogas is one alternative solution to overcome the energy crisis occurred in Indonesia. The cattle populations are 13.13 million in 2013. It is very potential to use the cow faeces to produce biogas as an alternative fuel for domestic use and to run internal combustion engines to produce electricity. This work has been done on mixing ratios of the cattle faeces with water to produce optimum biogas using a single type of batch digester with a capacity of 20 litres each. The faeces were used as the form of cattle faeces mixing with water of weight ratios of 1:1; 1:1.4; 1:1.7; 1:2 and 1:2.5 (kg/kg). The gas chromatograph identifies its gas components produced by biogas and the calorimeter tests its calorific value. This study aims to determine the biogas composition which the highest methane contained therein. The results showed mixing cow faeces and water at the ratio of 1:1.7 produces biogas with the highest methane concentration of 61.78% vol and calorific value of 5498.54 kcal/m^3.

Keywords: biogas, cow faeces, digester, mixing ratio, renewable energy, methane.

INTRODUCTION

Scarcity and the rising fuel prices have become a global problem, especially in Indonesia. The energy crisis has become an important concern, and it is impossible to disregard. Biogas can be one alternative solution for the problem that is very likely to develop its utilization, especially in Indonesia. The gas can be renewable and easy to make as well as the raw materials not difficult to get in abundance in the country.

According to statistic data of 2013, there are 13.13 million cow populations in Indonesia, is very potential to use the faeces to produce biogas as an alternative fuel for domestic use and to run internal combustion engines to produce electricity. Manure waste, especially cow or goat faeces are usually collected and just stacked by farmers. This is a serious problem to the environment of the farm, because the foul odour as well as other health problems it causes. Supposedly, the wastes can be used as raw materials for biogas and also dreg (slurry) by the digester can be used for organic fertilizer, rich in nutrients needed by plants.

Biogas is a combustible gas (flammable gas) and the end product of digestion / degradation of the decomposition of organic materials by the activity of bacteria in conditions without air (anaerobic) or an aerobic fermentation. Biogas can be used properly as fuel because it has a high calorific value. Biogas calorific value ranges between 4800-6700 kcal/m^3 (pure methane gas at a concentration of 100% has a calorific value of 8,900 kcal/m^3). Biogas has a composition consisting of methane (CH_4), carbon dioxide (CO_2), nitrogen (N_2), hydrogen (H_2) [1]. The composition as the gas contained in the biogas is shown in Table-1.

Methane producing bacteria growth would be good if the alkalinity - pH is in a state (base) of 6.5 - 7. The best pH for a digester is about 7.0. If the pH value is below 6.5, the activity of methanogenic bacteria will be reduced and if the pH is below 5.0, the fermentation stops. When the fermentation process takes place in the normal condition and anaerobic, then automatically pH range between will be 7 - 8. If the pH is higher than 8.5, will result in a negative impact of the population of methanogenicic bacteria that will affect the yield of methane gas into the reactor [3].

Biogas composition varies with the origin of the waste materials used and the anaerobic process that occurs. The biogas can be used as an alternative fuel if its system can produce a high enough percentage biogas of the composition of 55-75% CH4 [4].

Biogas will be formed on day 7 of the start of the digestion; in day 14 biogas produced will be at its highest yield of methane in general and on day 21 the value of methane biogas began to decline [5].

Table-1. Biogas composition [2].

No	Biogas Composition	Volume (%)
1	Methane (CH_4)	50 - 70
2	Carbon Dioxide (CO_2)	25 - 45
3	Hydrogen (H_2)	0 - 1
4	Hydrogen Sulfide (H_2S)	0 - 3

In the making of biogas, the raw material composition faeces, and rumen fluid (starter) should be balanced in order to generate maximum volume of biogas. If the ratio is unbalanced, e.g. rumen more than faeces and water, then biogas produced will be less, because the raw material mixture is only a source of bacteria without the presence of the substrate, so that the bacteria will be a shortage of food and become unproductive. Starter that can be used includes activated sludge and cow's rumen [6].

Differences in levels of water uses mixing with the cattle faeces will affect the rate on the biogas

VOL. 11, NO. 20, OCTOBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

production. The water content is the very important ingredient for the production during biogas fermentation process, but if it is too much will inhibit the activity of methanogenic bacteria. This is due to the addition of water will increase the concentration of oxygen that is toxic to anaerobic bacteria. Conversely, if the water level is too low will result in acetic acid, which causes fermentation directly, which in turn affects the levels of biogas produced [7].

EXPERIMENTAL

Fresh cattle faeces that were used were taken from a dairy farm at Mega Kuningan in South Jakarta.

This research was conducted at the Mechanical Engineering Laboratory, Department of Mechanical Engineering, Trisakti University, Jakarta. Biogas making process using a single batch digester type reactor with a capacity of 20 liters each with anaerobic system. The research was done by creating five different mixing compositions of cow faeces and water of the weight ratio of 1:1; 1:1.4; 1:1.7; 1:2 and 1:2.5. Biogas sampling and calculation on the pH value were conducted on day 17.

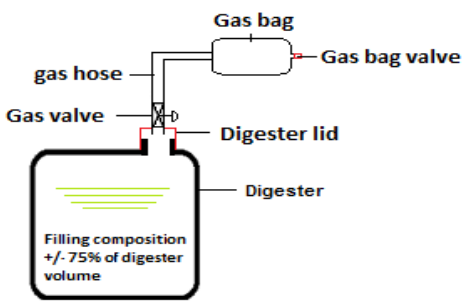

Figure-1. Schematic of the testing equipment.

Figure-1 shows a schematic testing equipment used. Cow faeces mix with water and rumen fluid (starter) was added to the digester and sealed so that no incoming air in (anaerobic). This digester then left alone at the ambient temperature until biogas began to be generated. Using the gas valve produced biogas flows through the gas pockets collectors. Biogas samples for analysis are carried in the sample bag and then were analyzed in Chemical laboratory, University of Indonesia, Jakarta to measure its composition and concentration. Alkalinity - pH measurement of the mixtures of cow faeces and water is done by inserting a pH meter sensor into the mixture inside the digester.

Biogas produced for this study were tested using a gas chromatograph (GC). The data below is the result of the tested and calculated for the components of methane, carbon dioxide and hydrogen contained in the biogas produced.

RESULTS AND DISCUSSIONS

Here are the results as the value percentage (volume/volume) of hydrogen(H_2), methane(CH_4) and carbon dioxide (CO_2) in the mixing ratio of:1, 2, 3, 4, and 5, are shown in Table2. The percentage (volume/volume) of methane and carbon dioxide gases shown in Figure-2 and pH value is shown in Figure-3.

Table-2. Biogas components for each mixing ratio.

Mixing ratio	Biogas Component produced (%) (volume/volume)		
	Methane (CH_4)	Carbon Dioxide (CO_2)	Hydrogen (H_2)
1	42.27	57.73	0.0087
2	46.11	53.89	0.0093
3	61.78	38.21	0.0151
4	59.81	40.18	0.0164
5	34.35	65.65	0.0080

The mixing ratios of the cow faeces and water described as follows:

1. Mixing ratio 1 (cow faeces: water = 1:1)
2. Mixing ratio 2 (cow faeces: water = 1:1.4)
3. Mixing ratio 3 (cow faeces: water = 1:1.7)
4. Mixing ratio 4 (cow faeces: water = 1:2)
5. Mixing ratio 5 (cow faeces: water = 1:2.5)

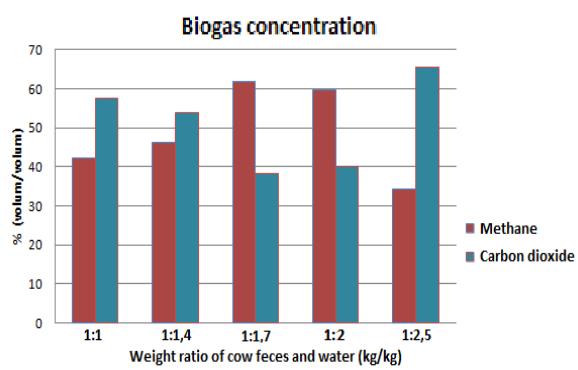

Figure-2. Percentage (volume/volume) of Methane and Carbon dioxide gases on mixing ratio of cow faeces with water.

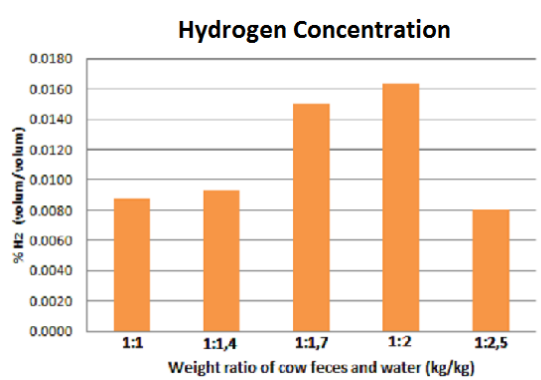

Figure-3. Percentage (volume/volume) of hydrogen gas on mixing ratio of cow faeces with water.

Table-2 implied that the biogas produced by mixture 3 with a mass ratio of cow faeces and water of (1: 1.7) has the highest percentage of volume of 61.78% methane, 38.21% carbon dioxide and 0.0151% hydrogen. Biogas generated by mixture 3 has a calorific value of 5498.54kcal/m^3. Figure-2 shows, the higher the methane composition in the biogas the less the composition of CO2 and vice versa. The results indicate that in the range of faeces and water mixtures among 1:1.7 to 1:2 are the ideal mix of cow faeces and water to produce optimum biogas. From the graph in Figure-3 above shows that the pH value was instrumental in the formation of methane gas in biogas. Condition in mixture 5 is not too acidic with a pH value of 6.84. So that the growth of methanogenic bacteria is better, and the methane produced is more than the composition of mixtures 1, 2, 4and 6. It shows that the pH value is comparable with faeces mixing with water. In a mixture with low pH values, the biogas produced is lower and with higher mixture ratios the pH values are also lower and so with the biogas produced. The maximum highest pH value is in the range of1:1.7and1:2 mixture ratios. Similarly, it is the same with methane gas generated as shown in Figure-4.

CONCLUSIONS

From this study, it can be concluded that the quality of the yielding biogas was affected by the composition of the cow faeces and water mixtures. Alkalinity - pH greatly influences the formation of methane in the biogas production. The mixture of raw material i.e., cow faeces mixing with water are best for producing biogas in the weight ratio of 1: 1.7. Biogas with cow faeces produces methane levels that most (61.78% vol) and the calorific value of 5498.54 kcal/m3.

ACKNOWLEDGEMENTS

The researchers would like to thank Trisakti University for providing the research grant for conducting this research.

REFERENCES

[1] Syaharuddin, Ibrahim, *et al*. 2008. Produksi Gasbio Dari Bungkil Jarak Pagar (Jatropha Curcas). Kelompok Studi Biodiesel, Institut Teknologi Bandung. Indonesia.

[2] Hambali, E, *et al*. 2007. Teknologi Bioenergi. Biodiesel, Bioetanol, Biogas, Pure Plant Oil, Biobriket, dan Bio-oil. PT Agromedia PustakaJaka.

[3] Yani M Darwis AA. 1990. Diktat Teknologi Gasbio. Pusat Antar Universitas Bioteknologi-IPB, Bogor.

[4] Juniper 2012, Gasbio Yield Companion. http: //www.basic informaton.-gasbio.com/

[5] Selamet, Agus. 2005. Memanfaatkan Limbah Cair Industri Tepung Aren Menjadi Energi Alternatif. Teknik Mesin, Politeknik Negeri Semarang.

[6] Saputro, RR 2004. Pembuatan Gasbio Dari Limbah Peternakan. Undip Press. Semarang.

[7] Firdaus, I.U. 2009. Energi Alternatif Biogas.http://www.migas-indonesia.com/index.php