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Biogas Productivity, Financial Analysis, Livestock Mix Pasture Influenced by Biogas Input and Slurry

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ABSTRACT

The research was conducted at the Laboratory of Animal Biology, Animal Husbandry Program, Faculty of Agriculture, University of North Sumatra, in November 2014 to November 2015. This study is a series of studies, the first study was biogas productivity influenced by proportion of goat feces and bagasse as biogas input. The purpose is to determine the productivity of biogas. The design was completely randomized design (CRD) with treatments, T1 (100% feces goat), T2 (75% feces goat + 25% bagasse), T3 (50% feces goat + 50% bagasse), T4 (25% feces goat + 75% bagasse) and T5 (100% bagasse). Parameters were methane production, pH and temperature. The next study was financial analysis of biogas technology utilization with Analysis of Profit and Loss, Revenue Cost Ratio parameters. The series of subsequent research is to determine effects of fermented biogas slurry with various of livestock urine on production and quality of mixed pasture. The design used in the study was Split Plot Design. The treatments consisted of two factors and three replications. Main plot (A): Various of pasture; A1 = *Brachiaria decumbens* and *Stylosanthes guyanenesis*; A2 = *Brachiaria ruziziensis* and *Stylosanthes guyanensis*. Subplot (B): fermented biogas slurry with various of urine; B0 = Without urine, B1 = With goat urine, B2 = With rabbit urine, B3 = With cattle urine. Parameters observed were fresh weight production, dry weight production, crude protein content and crude fiber content. The result showed that the highest gas production ($P<0.01$) was on T3; *i.e.* 124.5 liter of CH_4 with a pH 7.1, temperature 27.2°C. Financial analysis of the utilization of bio gas technology showed the highest profit is on treatment T3, this is due to bio-gas generated higher than other treatments, the best value of revenue/cost Ratio was on T3 treatment; *i.e.* 1.90. Application of slurry added with fermented cow urine gives the best result compared to other treatments.

Key Words: Biogas, Bagasse, Feces, Financial, Pasture, Slurry

INTRODUCTION

The supplies of fossil fuel sources dwindling while the human needs for energy are constantly increasing. In 15 to 20 years into the future, Indonesia is predicted having energy crisis threat. Large populations in Indonesia correlated with large energy needs. The fuel prices that have been subsidized by the government still burden the people, especially the lower middle class society. Commonly in Indonesia the lower class economic generally domiciled residing in both rural and suburbs. Generally they are farmers and also a laborer too. In addition they raise a livestock, mostly poultry and goat because they do not require a large capital for maintenance and were savings for life community environment. Goat population in North Sumatera Province is 866,763 (BPS 2015). Feses production per day is about 563 kg as every goat produce about 0.63 kg feces per day. Feces could be a potential source of rural energy as Li et al. (2016) in China found that energy from manure is equivalent to 20% of natural gas used.

All this time there are many untapped waste such as bagasse. This waste comes from the communities work to provide water cane which is one of people's favorite beverages.

There are about 1,000 kg bagasse per day is produced from water cane small business in Medan as capital city of North Sumatera Province (BPS 2015).

Bagasse waste and livestock manure, both were potential organic waste used as raw ingredients for biogas. According to Calise et al. (2015) either livestock manure or agro by-product which are utilized for example through biogas technology is ecologically promoting as cleanliness of the environment is one of biogas technology production.

Utilization of organic waste with biogas technology as a raw energy is one of the answer to the energy crisis. This is due to high oil prices and sometimes the amount is limited. Biogas technology can be used to produce slurry which is in the form of liquid fertilizer that ready to use (Ginting & Mustamu 2012). If people use the slurry to fertilize agricultural commodities, the community will get savings because they do not need to buy chemical fertilizer as they did during this time. The purpose of this study is to find alternative source to generate energy, *i.e.* from combination of bagasse and goat feces. In addition, to find alternative source for organic fertilizer on pastures.

MATERIAL AND METHODS

The research has been conducted at the Laboratory of Animal Biology, Animal Husbandry Program Faculty of Agriculture University of North Sumatra. The study lasted from November 2014 until November 2015.

The tools used in the biogas research were five-unit installation of biogas 200 liter capacities, a scale to weigh ingredients which will be used in accordance with the treatment, a thermometer to measure the temperature of the slurry, plastic to accommodate gas and five units of gas volume measuring device with a 1 bar pressure.

The ingredients used in research of biogas productivity were 324 kg goat feces, 162 kg of bagasse, and rumen of cattle as a starter. Ingredients needed in research of slurry fertilization on mix pasture are grass pols and legume seeds of *Brachiaria ruziziensis, Brachiaria decumbens* and *Stylosanthes guyanenesis*, measuring 1×1 m land plot with a total of 24 plots and nine plants per plot.

Research methods

The experimental design used in biogas research was completely randomized design (CRD) with 5 treatments and 4 repetitions. The treatment in this research was T1 = 100% feces of goat; T2 = 75% feces of goat and 25% bagasse; T3 = 50% feces of goat and 50% bagasse; T4 = 25% feces of goat and 75% bagasse; T5 = 100% bagasse. Goat feces diluted with water in ratio of 1:2. Parameters researches were methane production, pH and temperature. Methane production was measured by using a 3 inch PVC pipe with 1 atm pressure. pH was measured by using pH meter on slurry in outlet. Temperature was measured by inserting thermometer from inlet onto bottom of digester.

In the research of financial analysis, the parameters were profit/loss and revenue cost ratio. In the research of the utilization of biogas slurry on fertilizing mix pasture, parameters were fresh ingredients production, dry weight production, crude protein content and crude fiber content. The research of biogas done by filling the biogas digester according to treatment and left for 25 days of hydraulic retention time (HRT) for the gas produced maximum output. Refilling raw ingredients per day is necessary. Data collection was performed by calculating the volume of biogas, pH, the temperature after 25 days of HRT. Slurry fertilization on mix pasture was designed in a split plot design with 2 treatments and 3 repetitions. Subplots were slurry with various of urine; *i.e.* goat (B1), rabbit (B2) and cow urine (B3). Each plot given doses of slurry 200 ml. Main plot were mix pasture; *i.e.*: A1. *B. decumbens* + *S. guyanensis* and A2. *B. ruziziensis* + *S. guyanensis.* Sample was compiled from mix pasture on the mid quadrant of plot with size 60×60 cm. As there were 52 weeks/year, it was assumption there were 13 times mix pasture cutting.

RESULTS AND DISCUSSION

Biogas production

The results of biogas research with input of goat manure and bagasse proportion can be seen in Table 1. The data was processed by the method of SAS and then continued with Duncan test so that it is known that the treatment T3 where there is a similar percentage between the volumes of goat feces with bagasse is 50% produced CH_4 significantly different compared to the other treatments ($P<0.01$). As T3 contained with goat feces where goat feces has smaller particle size, diversity of microorganisms and high nutrient content, they support microorganism metabolism in biogas digester as well as leftover sugar on bagasse.

Table 1. Volume of gas, pH and temperature generated by the input of goat feces and bagasse proportion/day

Treatment	Volume CH_4 (l)	pH	Temperature °C
T1	70.3^d	7.4	27.2
T2	99.1^b	7.4	27.2
T3	124.5^a	7.1	27.2
T4	84.9^c	6.9	27.7
T5	55.7^e	6.9	27.5

T1: 100% feces of goat; T2: 75% feces of goat + 25% bagasse; T3: 50% feces of goat + 50% bagasse; T4: 25% feces of goat + 75% bagasse; T5: 100% bagasse

Ward et al. (2008) which states that the size of large particles will be difficult for microorganisms to reach the interior of the particles. Smaller particle size will cause microorganisms easier to degrade because pieces of the substrate become more wide open instead. Goats as one of the animals that have multiple stomachs have a diversity of microorganisms to aid with their digestive process in accordance with a variety of feed they consumed. By Abdullah et al. (2011) stated that goat feces as a result of metabolism still consist of high nutrient. This is because goats are animals that require high-quality feed and in this regard, goat is choosers for their feed. Smaller gas production in P5 possibly because T5 consist only bagasse so that population and various of microorganism is limited. Deublein & Steinhauser (2008) stated that the substrate that contains lignin better crushed first, before the cut. Bagasse in this research had previously been through the crushing process, but the result of the gas production still remains lower. According to Avicenna (2015) lignin physically protects the cellulose and hemicelluloses parts cause substrate more resistant to anaerobic digestion and if a substrate is well enclosed in lignin structures, a slow hydrolysis might occur and biogas production could become low with a long retention time required.

There were no differences in the pH of each treatment. pH of substrate will be stable at around 7.2-8.2 when the whole process of decomposition of the substrate has been completed and the process will take about 30 days in mesophilic conditions.

Temperatures in this research were not different from each treatment. According to Cantrell et al. (2008) there are three temperature ranges in the anaerobe digestion process which are: (1) The range of low temperature/psychrophilic *i.e.* <20°C; (2) 20-45°C or mesophilic; and (3) 45-60°C or thermophilic. The temperature difference in biomethanisation process is more affected by the environment temperature than the digestion itself. The research conducted in Costa Rica by Lansing et al. (2008) result biodigester temperatures average 26.2±0.2°C and the environment temperature in Costa Rica is relatively equal to Medan where this research was located.

Financial analysis

Financial analysis with the utilization of goat feces and bagasse on biogas technology are presented in Table 2.

Table 2. Financial analysis with goat feces and bagasse substrates

Treatment	Profit (Rp)	R/C Ratio
T1	11,180	1.19
T2	25,816	1.51
T3	39,652	1.90
T4	33,969	1.89
T5	11,898	1.23

Total production consists of the manufacturing cost of the biodigester and equipment as well as the cost of raw materials consisting of goat feces, bagasse, starter (rumen). Table 2 can be seen the analysis of income from the provision of bagasse gives different effects on each treatment. The highest profit is on treatment T3, this is due to biogas (Table 2) generated higher than other treatments, so that the total yield, *i.e.* total production of bio-gas in a month that is converted to kerosene added with total production of slurry in a month converted to NPK fertilizers have a higher value than the total cost of making the biodigester and raw ingredients costs. Rajakovic et al. (2006) mentioned that every 1m^3 biogas is equal to 0.62 litre kerosene. Ginting & Mustamu (2012) found that application of biogas slurry as 250 ml could be an alternative of 2.5 g NPK as early fertilizer on the growth of Spinach Plant (*Amaranthus tricolor*).

Table 3. Production of bio gas and slurry/month on different ratio of feces/bagasse

Treatment of ratio feces/bagasse	Production		Conversion results		Saving	
	Biogas (liter)	Slurry (liter)	Kerosene (liter)	NPK (kg)	Kerosene (Rp)	NPK (Rp)
T1	2,109	389	1.31	3.89	20,960	46,680
T2	2,973	389	1.84	3.89	29,440	46,680
T3	3,735	389	2.32	3.89	37,120	46,680
T4	2,547	389	1.58	3.89	25,280	46,680
T5	1,671	389	1.04	3.89	16,640	46,680
Total	13,035	1,944	8.09	19.44	129,440	233,400

T1: 100% feces of goat; T2: 75% feces of goat + 25% bagasse; T3: 50% feces of goat + 50% bagasse; T4: 25% feces of goat+75% bagasse; T5: 100% bagasse

Pindyck et al. (2007) mentioned that income statement shows the results obtained from the sale of goods and services, and the costs incurred in the process of achieving those results. The amount of profit is determined based on the difference between the values of sales with the total costs (fixed costs plus variable costs) at a certain level of volume production. When profits consistently positive, then the activities worth for further action.

Analysis of R/C ratio

Analysis of R/C ratio that obtained in Table 2 indicates T3 is considered to be very efficient way to proceed because its value is better. This is consistent with the statement Pindyck et al. (2007) states that to determine the level of work efficiency, can used parameters which by measuring the amount of income divided by the amount of outcome, which if R/C ratio >1 = efficient. The larger the value of R/C ratio, the more efficient the work and the smaller the value of R/C ratio, the more inefficient the work is. In accordance with the statement Nachrowi & Usman (2006) an attempt is said to provide benefits if the value of R/C ratio >1. The larger the value of R/C ratio, the more efficient the work, and the smaller the value of R/C ratio is, the more inefficient the work is.

Mix pasture production

Fresh ingredient production

Production of fresh weight from the research of slurry utilization on mix pasture can be seen in Table 4. Table 4 shows slurry with fermented cow urine has a significants interaction (P<0.05) with mix pasture either A1 or A2 on fresh weight. Improvement in production of fresh material, for example *B. decumbens* and *S. guyanensis* possibly due to better in nutrients absorption contained in the slurry so that they can put good use to support its growth. This is in line with the statement of Shehu et al. (2001) which states that fertilization on soil improves soil structure, making it easier for plants to absorb nutrients contained inside.

Table 4. Fresh weight production of mix pasture with various animal urine with biogas slurry fertilization (ton/ha/year)

Treatments	Mix pasture	
	A1	A2
B0 (without urine)	101.58[d]	102.90[d]
B1 (goat urine)	131. 97[b]	135.41[b]
B2 (rabbit urine)	114. 90[c]	123.55[c]
B3 (cow urine)	152.29[a]	149.64[a]

A1: *B. decumbens + S. guyanensis*; A2: *B. ruziziensis+S. guyanensis*; B0: Slurry without urine; B1: Slurry with fermented goat urine; B2: Slurry with fermented rabbit urine; B3: Slurry with fermented cow urine; Different superscript in different row and coloumn indicate significantly different (P<0.05) with other treatments by Duncan Test

The interaction between factors A and B in production of dry ingredients utilization of slurry with fermented cows, goat and rabbit urine is not significant (Table 5). It has resulted in the highest average production of dry matter compared with slurry without fermented urine. Slurry with fermented cows urine shows the highest production of dry matter and significantly different (P<0.05) with other treatments. In addition, different mix pasture; *i.e. B. decumbens + S. guyanensis* (A1) resulted higher dry matter production significantly different (P<0.05) compared to *B. ruzizizensis* and *S. guyanensis* (A2). According to Ginting & Mustamu (2012) biogas slurry which contains nutrients like N, P and K can be absorbed and put to good use by plants which support its growth. Animal urine contains N ±10 g l-1 which mostly in the form of urea. Urine also contains macro nutrients (S, P, K, Cl, and Na) in various numbers which depends on kinds of animal feed, fisiologis condition and climat. Nutrition is needed due to plant growth.

Table 5. Production of dry ingredients utilization of fermented various animal urine with biogas slurry (ton/ha/year)

Treatments	Mix pasture		Mean
	A1	A2	
B0	23.35	20.62	21.98[d]
B1	29.72	26.60	28.16[b]
B2	25.73	24.54	25.13[c]
B3	34.30	29.58	31.94[a]

The interaction between factors A and B in production of crude protein content is not significant (Table 6). Slurry with fermented cows, goat and rabbit urine resulted in the highest average production of crude protein content compared with slurry without fermented urine. Slurry with fermented cows urine shows the highest crude protein content and significantly different (P<0.05) with other treatments. Moreover, protein content in *B. decumbens + S. guyanensis* (A1) is higher significantly (P<0.05) compared to *B. ruzizizensis + S. guyanensis* (A2). This is due to *B. decumbens + S. guyanensis* have better growth proportion than *B. ruziziensis* and *S. guyanensis*.

Table 6. Crude protein content (%) of mix pasture utilization of fermented various animal urine with biogas slurry

Treatments	Mix pasture		Mean
	A1	A2	
B0	17.53	15.57	16.55[d]
B1	18.36	16.23	17.29[b]
B2	17.82	16.23	17.02[c]
B3	18.92	17.04	17.98[a]

Nutrient content in fermented animal urine plus biogas slurry, especially when it is in a liquid form, provide nutrition for plant easily. Metabolism process then produced nutrition content in plant include either crude protein or crude fiber (Bougnom et al. 2012).

Table 7. Crude fiber content (%) of mix pasture utilization of fermented various animal urine with biogas slurry

Treatments	Mix pasture		Mean
	A1	A2	
B0	43.81	43.33	43.57[a]
B1	39.40	39.81	39.60[c]
B2	40.97	40.58	40.77[b]
B3	38.16	38.64	38.4[d]

CONCLUSION

Biogas utilization, balance of goat manure and bagasse with a composition of 50% goat manure and 50% bagasse provides the highest gas production, *i.e.* 124.5 litres and gives a profit of Rp. 39,652 and R/C ratio 1.90 with the main results of biogas and slurry. Application of slurry from such composition added with fermented cows urine produced higher fresh weight of *B. decumbens* + *S. guyanensis*, *i.e.* 152 ton/ha/year, and dry weight, *i.e.* 34 ton/ha/year. In addition, it also improved mix pasture quality; *i.e.* higher crude protein and lower crude fiber. Application of slurry added with fermented cow urine gives the best result compared to other treatments.

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