Biogas Technology on Supporting “Sustainable” Coffee Farmers in North Sumatera Province, Indonesia

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Abstract. A study has been conducted in an area of coffee plantation in Samosir District, North Sumatera Province. The study was conducted in August until September 2016. The objective of this study is to investigate the benefits of using biogas technology in supporting coffee farmers’ productivity to be sustainable, i.e. methane as energy source for coffee roasting proceed instead of fired wood and slurry as organic fertilizer. Coffee cherry causes environmental problem when it is dumped openly, hence it is used to mix with buffalo feces in biodigesters to produce methane and organic fertilizer. Five biodigesters were used with 5 different designs of composition: T1) 100% buffalo feces, T2) 75% buffalo feces + 25% coffee cherry, T3) 50% buffalo feces + 50% coffee cherry, T4) 25% buffalo feces + 75% coffee cherry, and T5) 100% coffee cherry. The key parameters measured were methane production and slurry chemical compositions including NPK, pH, and C/N. It is found that designs T1 and T2 were superior in methane production, and about 400 liters of methane were used in roasting 3 kg coffee bean as opposed to 6.6 kg fired wood. Designs T1 and T2 were also better in slurry chemical compositions than the other 3 designs. It is recommended that local coffee farmers utilize coffee cherry based biogas technology in order for their productivity to be sustainable. It is noteworthy that this study is continued with the next one in which the resulting slurries are implemented to foster the growth of the coffee plants during the period of October until December 2016.

1. Introduction
Department of Agriculture North Sumatera Province has 4 (four) programs, i.e. (1) improving farmer’s welfare program, (2) technology application program, (3) improving production program, and (4) Bukit Barisan Plateau Aeropolitan Area Development Program. In coffee industry, the department has been successful in improving production, however there is an impact on the environment, as coffee cherry has been dumped onto the environment. Coffee cherry could be easily seen scatters in coffee producer districts, for example Karo, Sidikalang, HumbangHasundutan, Toba Samosir, North Tapanuli and South Tapanuli. Aesthetically and environmentally, a scattered of coffee cherry create a nuisance. Associates with this condition an effort has to be taken. This research is tried to use a technology which is bio gas in supporting coffee industry thus coffee farmers to be environmentally.

In this research, coffee cherry is used as input for bio gas unit experiment. Benefits are methane as energy source for coffee roasting proceed instead of fired wood and slurry as organic fertilizer.
According to Calise et.al [1] 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. Prior to Calise et.al [1], Ginting [2] mentioned that bio gas technology could help scarcity of energy and fertilizer especially in agricultural area.

2. Method

The study lasted from August until September 2015. The tools used in the research were five-unit installation of biogas 500 litres 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 buffalo feces, coffee cherry, and rumen of buffalo as a starter.

The experimental design used in this research is Completely Randomized Design (CRD) with 5 treatments and 4 repetitions. The treatment in this research is T1 = 100% buffalo feces ; T2 = 75% buffalo feces and 25% coffee cherry; T3 = 50% buffalo feces and 50% coffee cherry; T4 = 25% buffalo feces and 75% coffee cherry; T5 = 100% coffee cherry. Buffalo feces and coffee cherry diluted with water in ratio of 1:2. Parameters researches were methane production, pH, temperature. Methane production was measured by using a 3 inch PVC pipe with 1 atm pressure (Figure 1). pH was measured by using pH meter on slurry in outlet. Temperature was measured by inserting thermometer from inlet onto bottom of digester. The research of biogas done by filling the bio gas digester according to treatment and left for 25 days of HRT (Hydraulic Retention Time) 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.

3. Results and Discussions

3.1. Gas Production

Gas production from this study was dominated by T2; gas production was significantly different (5%) from other treatments. High gas production in T2 is related with nutrient content of coffee cherry. As a waste, coffee cherry contains a good percentage of protein and more over the middle part of coffee cherry which is a fruit flesh contain a lot of sugar. This is why animal such as Civet (Paradoxurus hermaphroditus) likes to eat fresh coffee bean which in fact Civet only consume the cherry part and the bean is excreted.

**Table 1. Nutrient Content of Coffee Cherry**

| Nutrient Content | (%)  |
|------------------|------|
| Dry Content      | 90,52|
| Fat              | 1,31 |
| Crude Fiber      | 34,11|
| Protein          | 6,27 |
| Ash              | 7,54 |

Source : Animal Fed Laboratory, Agriculture Faculty, University of North Sumatera (2016)

Nutrient content of coffee cherry stimulates metabolism of microorganism. Simple carbohydrate such as molasses or sweet material like in this research sweet fruit flesh in coffee cherry will give an access for acidic bacteria to be formed. As the result a lot of acetat is produced which is an energy source for methan bacteria to be formed. This is in concordance with Zhang et. al [3] which stated that high glucose of biomass is easy to be hydrolized and followed by degrading into Volatyle Fatty Acids and Hydrogen. More over, coffee cherry contains of N, P, K, Ca, Mg, Mn, Fe, Cu, and Zn [4]. Microorganism in its formed stage need a light percentage of mineral although high percentage is harmed.
3.2. **Temperature**

Temperatures in this research are about 19°C which is more like the temperature of environment. Temperatures in this research are not different from each treatment. Cantrell et al. [5] mentioned that 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; 3) 45 - 60°C or thermophilic. The temperature difference in biomethanisation process is more affected by the environment temperature than the digestion itself. As research location is in a highland area, where ambient temperature around 22 – 23°C in August and September so temperature of underground where biodigester were placed is below 20°C and this temperature affected temperature inside biodigester.

3.3. **pH**

pH in this research is range from 5.2 to 7. pH is influenced by combination of substrates materials. pH of biogas slurry is a critical point because slurry could be used as fertilizer. In this research slurry from T 1, T2, T3 and T4 could only be used as liquid fertilizer as pH are range from 6 to 7. pH standard for a material classified as fertilizer is 4 until 9 (SNI). However, it is better to serve slurry with pH close to pH of soil which is 6 to 7 in order to give suitable habitat for a wide range of good microorganisms hence create a competition of microorganisms in soil.

3.4. **NPK**

Ginting [2] mentioned that there were three major benefits by using biogas technology, e.i. CH4 as source of renewable energy, slurry as liquid fertilizer and clean environment. Slurry as fertilizer had been proven by research which was conducted by Ginting and Mustamu[6] and they 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 (Amaranthustricolor). Nutrient content of this research is presented in Table 2. In this research, as the biodigester has a continues feeding, every day about 9.2 liters substrates were inserted, which means that everyday too 9.2 liters slurry were produced or equal to about 92 g NPK. Besides NPK as macro nutrients, slurry also contains micro nutrients such as Ca, Mg, Fe, Mn, Cu dan Zn [7]. Bougnomet. al [8] stated that slurry as fertilizer in liquid form provide nutrition for plant easily.

![Figure 1. Gas Metre Prototype](image-url)
Table 2. Chemical Quality of Biogas Slurry

| NO. | Chemical Quality Unit | Slurry | Total Liquid Fertilizer Standard (SNI) [12] |
|-----|-----------------------|--------|------------------------------------------|
| 1   | N-total (%)           | 1.22   | 1.25                                     |
| 2   | P2O5                  | 0.073  | >0.05                                    |
| 3   | K2O                   | 0.098  | >0.05                                    |
| 4   | C-organic (%)         | 26     | 20-25                                    |

Source: Central Laboratory, Agriculture Faculty, North Sumatera University 2016

3.5. C/N
C/N indicates nutrient content and how far degradation process has already taken place on materials which in this research cow feces and coffee cherry. C/N in this research in T1 until T4 were around 21 until 25 and T5 was 29. As in T5 percentage of buffalo feces was zero, thus population of microorganisms was less than the other treatments. Ruminant feces such as buffalo feces contains tremendous population of microorganism with the function to degrade material/substrate. In this research, sugar content in cherry flesh facilitated methane microorganism to be formed. This is the reason why gas is fast in forming while degradation on the cherry is still in process. That is why C value is still high thus C/N is high. According to Ginting and Mustamu [6], slurry with C/N is high, i.e. more than 20 was suggested to get maturity by keeping the slurry in a container for at least one month. In this time, N value was getting better as population of microorganism still in form. Microorganism itself contains of amino acid.

3.6. CH4 as an energy alternative in coffee roasting
In roasting processed, farmers use fire wood, for example old coffee wood. However, this practice harm the environment as wood burning produces greenhouse gas, i.e. CO2. This research was try to provide energy alternative for roasting. A simple research was conducted by roasting 3 kg of coffee beans used fire wood. Farmers with land size 1000 m2 cultivate 3 kg coffee beans weekly. Roasting was used a thick iron pan which will produce slow heat as perfect roasting only could be achieved if coffee is done until the inner part of bean by slow heating. For roasting 3 kg bean, it was used 6.6 kg of fire wood. Another 3 kg coffee bean than was roasted by using CH4 and how much CH4 was used than was calculated. Gas container was a plastic tube. Gas was calculated by formula $V = \pi r^2 \cdot t$ and for roasting 3 kg coffee beans, CH4 was used about 400 litres.

Combustion of CH4 produces much less CO2 than combustion of fire wood [9] thus it was suggested to use biogas in order to reduce greenhouse gases. Moreover, as biogas is a renewable energy, it serves energy consumption widely. IPCC (Intergovernmental Panel on Climate Change) predicted that in 2050 global energy consumption from biomass become 180 EJ (Eksa Joule) or 30% from total energy consumption and in 2100 become 325 EJ (Eksa Joule) or 45% from total energy consumption [10]. It means that energy from biomass is significantly supported energy consumption. Li et.al [11] in China found that energy from manure alone is equivalent to 20% of natural gas used.

4. Conclusions
Instead of dumped on the environment, utilized coffee cherry by bio gas support coffee farmer to be sustainable. Farmers were allowed to get benefits such as methane/CH4 which could be used by farmers in roasting coffee beans. 3 kg coffee beans could be roasted by 400 liters CH4. Moreover, farmers get slurry which a good liquid fertilizer. From this research, it could be suggested for coffee farmers to use bio gas in their farm practices.

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