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| **RESEARCH ARTICLE**

Study on Processing of Animal Waste of Cattle Dung and Vegetable Waste of *Brassica rapa* in Continuous Anaerobic Digester

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| **ABSTRACT**

The purpose of this study was to understand the effect of addition vegetable waste interspersed into continuous anaerobic digestions that are normally operated with a substrate from cattle dung. The vegetable waste that was studied in this case is napa-cabbage (*Brassica rapa*). An anaerobic digester with a capacity of 200 liters was prepared for this study. In this study, the digester was operated with an input of 5 liters of a mixture of cattle dung and water (50%:50%) interspersed in 1 day with an input of 5 liters of a mixture of *Brassica rapa* waste and water (50%:50%). The methane content In the system with the addition of Brassica rapa is in the range of 9%-52%. The CO_2 content is in the range 15%-50%. The averages of pH is found 7.3 and average temperature inside the digester is 32.1°C

| **KEYWORDS**

Animal Waste of Cattle Dung; Vegetable Waste; Brassica rapa; Continuous Anaerobic Digester

| **ARTICLE INFORMATION**

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1. Introduction

Biogas plants are considered an optimal way to prevent water pollution and odor disturbances caused by uncontrolled livestock waste disposal into open water sources, which will affect the quality of integrated rural clean water supply and environmental sanitation [1]. Effluent, also known as leftover digestate, from digesters can be used directly as fertilizer because it is rich in nitrogen, potassium, and phosphorus [2,3]. Therefore, the development of biogas technology and biogas production to produce biomethane is being promoted by many countries as an alternative to cogeneration fuel for electric generator engines (4). Household-scale digesters can reduce environmental pressures such as decreased soil fertility, erosion, greenhouse gas emissions, and can prevent deforestation [2,5,6].

Various types of waste can be used in anaerobic reactors for biogas production. These include lignocellulosic waste, which can be obtained from markets, agriculture, municipalities, and various other large-scale activities. Other common types of waste include animal manure slurry, municipal waste, food scraps, and sewage sludge [7].

Animal manure contains methanogenic bacteria, making it easy to process in anaerobic digesters. Many projects have successfully processed various types of animal manure using anaerobic digesters, such as poultry [8], goat [9], elephant [10] and pig [11].

However, unlike animal manure, vegetable waste processing is more complex because it requires adjustments to the methanogenic bacteria that already present in the operating anaerobic digester.

Adding vegetable waste to a batch anaerobic digester is a common method for processing organic waste and producing useful products such as energy and fertilizer [12]. However, adding vegetable waste to the feeding system of a continuous anaerobic digestion system has not been practiced to date because the optimal route for achieving results is unknown.

This work specifically studies the processing of vegetable waste in a continuous anaerobic digester. This vegetable waste was added to an anaerobic digester that had previously been operating successfully using cattle dung waste. The addition of vegetable waste was done alternately with cattle dung to ensure the presence of methanogenic bacteria in the anaerobic digester.

2. Experimental

The source of cattle dung is Bali cattle (*Bos javanicus*) as presented in Fig. 1. This species is native to the island of Bali, Indonesia. Bali cattle are an important livestock species because they reproduce quickly and are highly efficient even when fed low-quality feed. This species also adapts well to tropical regions [13]. Vegetable waste used in this study was *Brassica rapa* as appearance can be seen in Fig. 2

(a) (b)

Figure. 1. (a) Bull of Bali cattle, (b) Cow and calf of Bali cattle

Figure. 2. Vegetable of *Brassica rapa*

An anaerobic digester (200 liter in volume) was prepared for this study, as illustrated in Fig. 3. This size of anaerobic digester was designed to facilitate easy transportation of the digester to the site [14]. The digester in this study was equipped with a stirrer to mix the substrates fed into the digester. Stirring in the digester aims to prevent sedimentation, facilitate the release of gas produced by bacteria into the biogas reservoir, prevent scum formation, and mix methanogenic bacteria with the substrates [15]. Stirring increases both biogas production and aids the degradation of organic compounds. This is due to the increasingly reversed hydrodynamics in the digester. Hydrodynamics have a significant influence on mass transfer phenomena [16]. The advantage of this small-scale construction is that it makes it easier for users to make repairs if something goes wrong during construction. The cost of producing a small-scale biogas digester is also relatively low. Thus, mini-sized biogas digesters are a solution to energy scarcity [17].

The digester tank in this study was constructed using low-carbon steel plate. Because biogas produces hydrogen sulfide (H2S), a by-gas that is highly corrosive to steel [3,6,18], to address this issue, the steel tank was equipped with a corrosion prevention system consisting of small pieces of magnesium attached to the outside of the tank. This magnesium acts as a sacrificial anode to provide cathodic protection [19,20).

There is a slurry inlet section (1) where the substrate is fed into the anaerobic digester. The digester tank section (2) is filled with substrate in the form of slurry. The digester tank in this study is equipped with a manual stirrer (3) which functions to rotate the agitator section (4) to mix the substrate well and helps flow the substrate from the inlet section (1) to the outlet section (6) when filling the digester. The produced biogas released from biogas outlet (5) and was collected in a floating drum (9) by opening the inlet valve (7) and closing the biogas outlet valve (8). Furthermore, if the biogas in the floating drum will be used as fuel, either for cooking fuel or engine fuel, the inlet valve (7) is closed and the outlet valve (8) is opened.

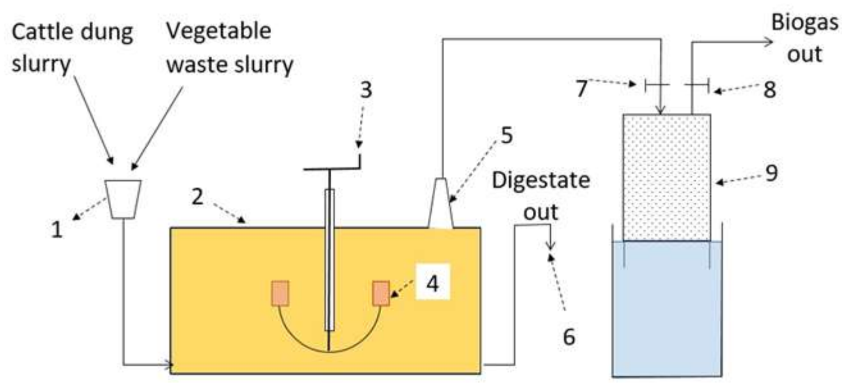

Figure 3. Schematic of anaerobic digester. 1. Substrate inlet, 2. Anaerobic digester tank, 3. Stirrer, 4. Agitator, 5. Biogas outlet 6. Digestate out, 7. Inlet biogas valve, 8. Outlet biogas valve, 9. Floating drum for biogas storage

For the initial process, the anaerobic digester was operated with a batch system for 1 month. The digester was then operated with a continuous system by filled with 5 liters of a mixture of cattle dung and water (50%:50%) to the digester alternately in a day with 5 liters of a mixture of *Brassica rapa* (50%:50%). The purpose of adding the substrate to the digester alternately in 1 day was to continue supplying methanogenic bacteria as inoculum [21, 22]. Slurry from *Brassica rapa* was prepared using a blender.

In this study, the parameters measured were the rate of biogas formation and the composition of methane and carbon dioxide in the biogas. The pH of the digester was also measured. The temperature inside and outside the digester was also recorded to understand the processes occurring within the digester.

3. Results and Discussion

Biogas production pattern in 1 month operation is found following trend line of polynomial order 4 with R^2= 0.996 as can be seen in Fig. 4 with the substrate used is cabbage waste alternately with cow dung, The regression modelling follow the Equation 1

$$Y = -0.0225X^3 + 0.8629X^2 + 4.8457X + 61.258 \quad (1)$$

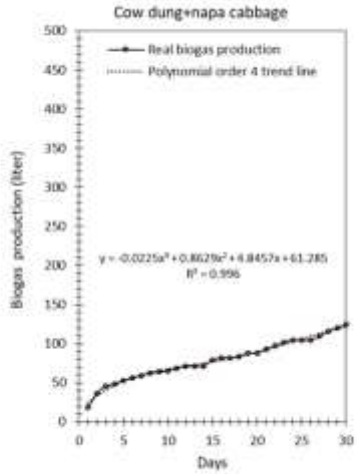

Figure 4. Biogas production in continuous anaerobic digestion feeding with cattle dung and waste of *Brassica rapa*

This condition can occur because the proximate compositions of *Brassica rapa* as dry matter basis are 2.35% of moisture content, 22.51% of crude protein, 21.60% of crude lipid, 4.35% of crude ash, and 49.19% of carbohydrate [23]. The main composition of cabbage is carbohydrates, protein, and lipids, which causes the hydrolysis process to be longer, thus delaying the formation of CH_4 gas and increasing the range for CO_2 gas formation (Fig. 5 and Fig. 6) [24,25]. If the addition of *Brassica rapa* alternately continues until after the 20th day, the hydrolysis process is washed out [24]

Methane is the target to be obtained as a good characteristic of biogas quality [3]. It turned out that adding *Brasica rapa* alternately with cattle dung resulted in lower methane levels in the biogas during the 30-day observation (Fig. 5). The CH_4 content in biogas when filled only with cattle dung ranges from 41-52 %, and in the first 20 day which is suitable for use as fuel [4, 27]. But then reduced gradually until reach the lowest at 9 %. This condition is much lower than previous research [16] using a batch system with a floating drum of the same volume, which only produced biogas with a maximum CH_4 content of 60.9%. This result indicate that addition of *Brassica rapa* after 20th days should be stopped until the methane content increase again by filling only with cow dung.

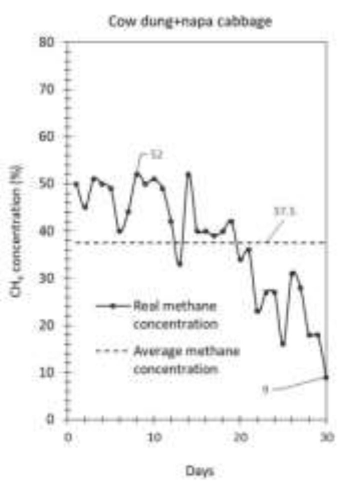

Figure 5. The methane composition in biogas that was produced in continuous anaerobic by filling the digester with cow dung and *Brassica rapa* interspersed every 1 day and observed in 30 days

The CO_2 Composition in the biogas during 30 day observation is found steady around the average values of 26.6%. The highest value is 30% and lowest value is 15%. There is no found extreme CO_2 content during the 30 day of Inspection meaning by addition of *Brassica rapa* in the system is not affecting the process of acidogenesis, and acetogenesis but indeed the addition of *Brassica rapa* affecting the production of CH_4 contend that can be understood by decreasing value of CH_4 content after 20 days. By observation of this sign, the addition of *Brassica rapa* should be terminated after 20 days and the system should keep filled with cow dung only until rising of CH_4 content to be observed [24].

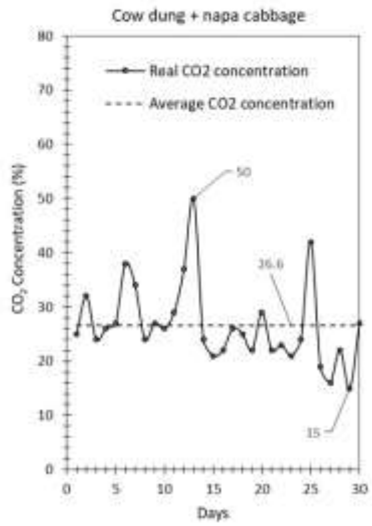

Figure 6. Carbon dioxide content in the biogas that was produced in continuous anaerobic digester feed with cattle dung with interspersed mixed with *Brassica rapa*

The pH for the system is found in the range of 6.8-8.5 with average value 7.3 as can be seen in Fig. 7. But if it is analyzed in detail, after 20 days of addition *Brassica rapa*, the pH Increase drastically to above value of 8. This condition yield in decrease of CH_4 value (Fig. 5) which is give clue to stop the addition of *Brassica rapa* and the system should keep filled with only cow dung until pH system reach about neutral as required. The nitrogen will be released and accumulate into ammonia which can raise the pH of the substrate [17]. By addition of *Brassica rapa* makes the pH in the range of about neutral until the day of 20th that indicate acidogenesis process does not occur and process hydrolysis is washed out [24]. Methanogens thrive in neutral to slightly alkaline conditions and die in acidic environments. The optimum pH of the system is 7 for optimal activity when the anaerobic digestion process is stable.

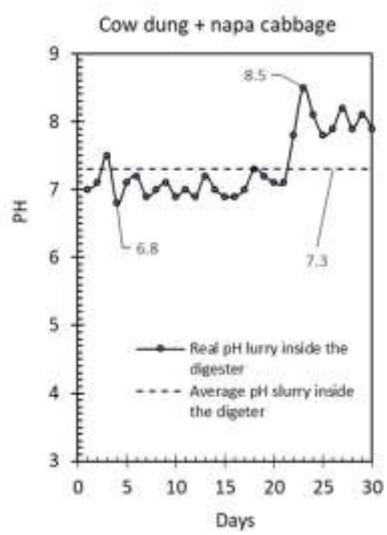

Figure 7. The pH of slurry inside an anaerobic digester filled with cow dung and *Brassica rapa* interspersed

The temperature inside the digester for 30 days is presented in Fig.8. The lowest is 30°C and the highest is 34°C for feeding with cattle dung and waste of *Brassica rapa*. In this work, the temperature inside the digester never reached 38°C which is a condition that reportedly destroys 99.9% of pathogens [28]. It is to be noted that the digester was operated in summer or dry season of tropical region of the year, therefore there was a bit of difference in ambient temperature outside the digester. Temperatures inside the digester is found in the range of mesophilic process [24]. To increase the temperature, the concept of a greenhouse coupled with a digester should be introduced for future work. The one-year study revealed almost a 100% increase in biogas yield when applying a digester inside a greenhouse [29].

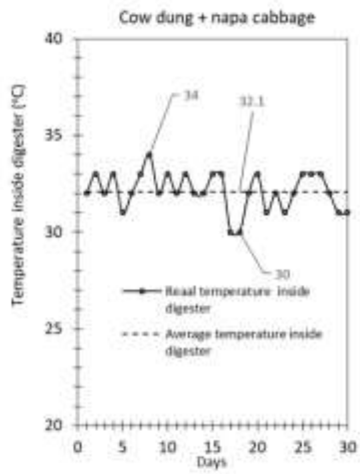

Figure 8. The temperatures inside continuous anaerobic digester filled with cow dung and *Brassica rapa* interspersed

4. Conclusion

Animal waste of cow dung and waste of vegetable of *Brassica rapa* can be processing inside continuous anaerobic digester. The process is conducted by filled the 2 types of the waste interspersed in 1 day. The result indicate that CH_4 and CO_2 are still yield in the process that indicate the anaerobic process is carried out. To be noted that the addition of *Brassica rapa* should be stopped and controlled after 20 day because the pH increase and the CH4 content decrease. For the future work the pretreatment and acclimatization of *Brassica rapa* should be conducted for better anaerobic process to occur.

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