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Anaerobic Digestion of Vegetable Wastes to Produce Biogas as a Substitute for LPG

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Abstract. There are abundances of vegetable wastes in a traditional market, these easily degraded wastes could polluted the environment if not treated wisely. Vegetable wastes could undergo anaerobic digestion process to produce biogas and minimise the wastes. Biogas is an alternative energy source to replace LPG, a fossil energy source widely used in Indonesia. The waste from anaerobic digestion may be further treated to produce organic fertiliser. This study aimed to examines anaerobic digestion of vegetables wastes collected from a traditional market in Makassar, Indonesia, to produce biogas. In this research, three vegetable wastes, namely, cabbage, spinach and kangkoong were shredded, mixed with a starter of cow dungs and water, then fed to the anaerobic digester with ratios of a starter to organic waste of 1:3. The process was left for several days. The biogas produced from the process was collected and analysed for its characteristic. It was found that cabbage and spinach wastes yielded biogas with quite similar pressure ca 120 KPa, whereas kangkoong yieldedd quite lower biogas pressure. The biogas produced from the digestion of vegetable wastes from a biodigester with a capacity of 150 liters for 20 days could be combusted for 1807 s with a blue-clear flame.

INTRODUCTION

Organic wastes, such as vegetables wastes, from traditional markets if not well-treated could create a problem to the environment [1–3]. The vegetable wastes could be anaerobic digested with the help of suitable microorganisms to produce biogas and the remaining wastes could be further treated to produce organic fertilisers [4]. Biogas produced from anaerobic digestion of vegetables wastes is one of solutions to solve energy shortages in Indonesia. LPG is widely used as domestic fuel for cooking in Indonesia. For a lower economy class, the high price of LPG is a burden. Therefore, it is important to educate communities to convert energy from organic wastes which are widely available. Anaerobic digestion could be chosen to treat organic wastes, especially organic wastes, to produce biogas as a substitute for LPG.

There are at least three (3) advantages in treating vegetable wastes to produce biogas, namely (1) Waste reduction, treating the wastes to produce biogas is reducing the amount of waste piles, (2) Energy reliability, by providing anaerobic digestion facility to the community, they could provide easy and clean energy for themselves, (3) Reducing household spending, if the community could provide energy for themselves, they could reduce the energy cost. Through anaerobic digestion, carbohydrates in vegetable wastes could be hydrolysed to sugars which will be further digested by methanogenic microorganisms to produce methane (CH_4) and carbondioxide (CO_2) [5].

Previous research on an anaerobic digestion of vegetables wastes and cow dung showed that CH4 composition in biogas was 54.03% with digestion times of 21 days [6]. Another study on the anaerobic digestion of vegetable wastes showed that the biogas was produced from day 1 to day 35, however the best biogas with the highest energy content (10.081 KJ/day) was produced at day 18 [7].

The content of CH4 in biogas varies, it depends on the anaerobic digestion process, operation conditions, microorganisms, substrates, etc. Arnold et al (2013) reported that the biogas contains 0,3mol/100gr water hyacinth [7]. While Badrussalam (2011) found that in biogas the contents of CH4 was 60- 70% and CO2 30-40% [8].

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The current research examines anaerobic digestion of vegetables wastes collected from a traditional market in Makassar, Indonesia, to produce biogas. The research is not only solving the problems related to the organic waste piles in Indonesian traditional markets, but also to provide biogas as renewable and alternative energy for the community. Utilising biogas as energy is also helping in tackling the global warming since if CH4 and CO2 are not utilised, they are considered as greenhouse gases [9,10].

METHODS

Material and Equipment

Biodigester is a tool used for the process of biogas formation by anaerobic and permanent in nature. Based on the method of filling, there are two types of digesters (digestive units) or biodigesters, namely batch feeding and continuous feeding. Batch feeding is a type of biodigester in which organic matter is filled once full, then waits for biogas to be produced. After the biogas is no longer produced or the production is very low, the contents of the digester are dismantled and then filled with new organic matter. Continuous feeding is a type of biodigester in which the organic matter is filled every day in a certain amount, after the biogas begins to produce. At the initial filling, the digester is fully filled, then wait for the biogas to produce. After production, organic matter filling is carried out continuously every day with a certain amount.

Vegetable wastes used in the research were wastes of cabbages, spinaches and kangkoongs which were collected from Terong traditional market, Makassar, indonesia. The starter was cow dungs collected from a slaughter house in Makassar, Indonesia. A set of biodigester presented at Figure 1 was used. To support the experimental, mixing buckets, a tunel, pipes and gas bags were also used.

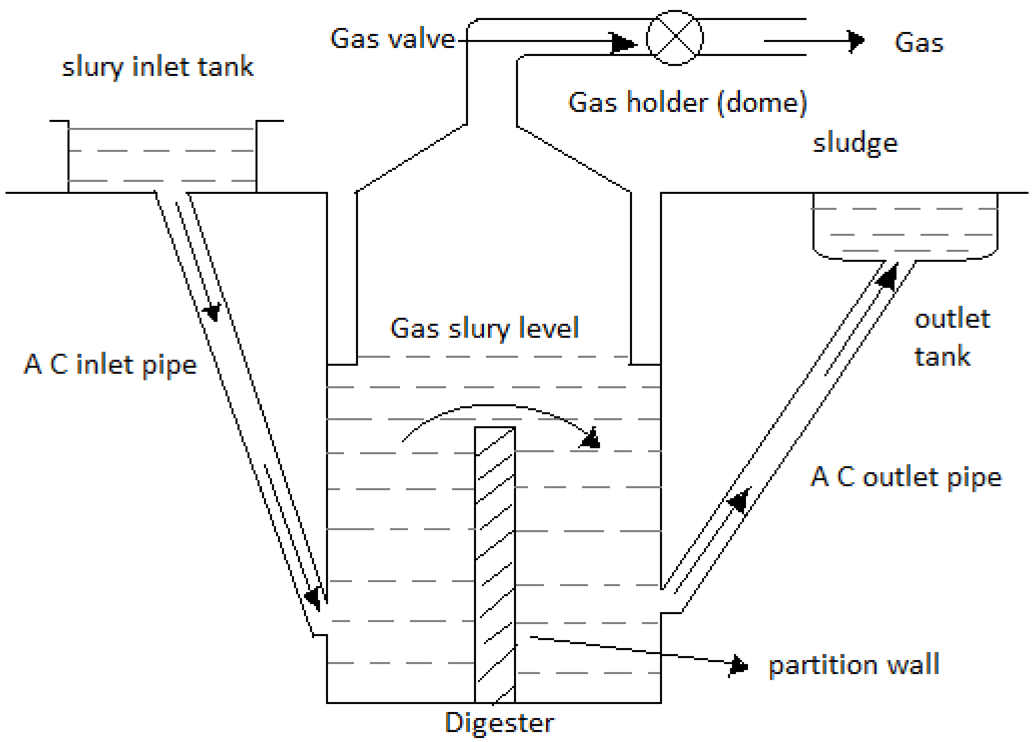

FIGURE 1: A set of biodigester

Vegetable wastes were shredded and weighed. The wastes were mixed with a starter and water at various ratios. The mixture then was poured into a biodigester which was closed tightly and digested for 25 days.

RESULTS AND DISCUSSION

Effect of fermentation times on biogas pressure

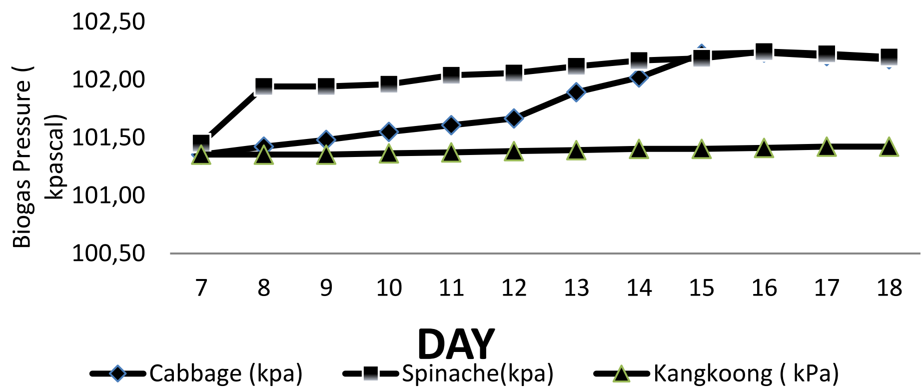

FIGURE 2. Effect of fermentation times on biogas pressures for various vegetable wastes

It can be seen that different vegetables show different patterns of gas pressures, although generally the pressure increased with increase in fermentation times. The gas pressure started to decrease at day 17. This could be related to the reduction of the ability of methanogenic microorganisms in digesting the substrates. This finding is in accordance with previous research on anaerobic digestion of vegetable wastes with EM4 bacteria [11].

Optimal Biogas Pressures of Various Vegertable Wastes

Figure 3 shows optimal pressures of biogas from different vegetable wastes.

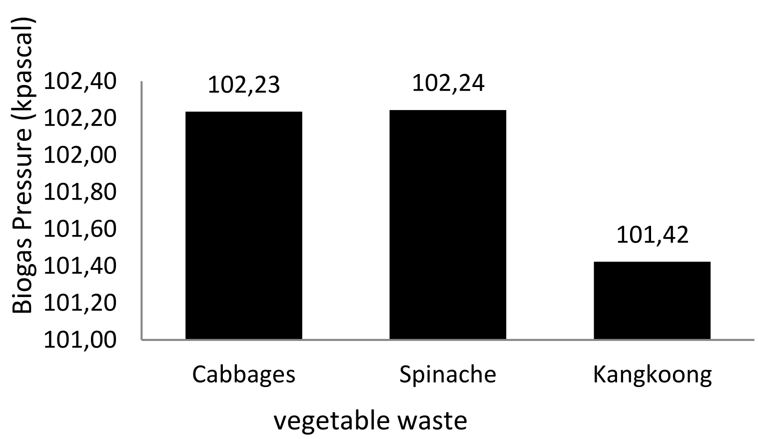

FIGURE 3. Optimal biogas pressures of various vegetable wastes

It can be seen that cabbages and spinaches had similar optimal pressure of ca 102 KPa, whereas kangkoong had quite low pressure. The optimal pressure relates to the biogas produced and this could be related to the content of readily digested carbohydrates in substrates.

Combustion Test

To confirm that the biogas produced from this research could be applied as a renewable alternative energy for the community, a combustion test was performed. The test was performed to the biogas anaerobically produced from a biodigester with a capacity of 150 L as shown in Figure 4 [12]. It was confirmed that the biogas produced from the reactor with a ratio of vegetable waste to starter of 3:1 which digested for 20 days could be combusted for 1807 s with a blue-clear flame. Amaru (2006) found that using a biodigester with a capacity of 2.5 m^3could provide fuel for a gas stove for 4-5 hrs. [13-16].

FIGURE 4. Biogas combustion test

The anaerobic breakdown process of organic matter for biogas production is influenced by two factors, namely biotic and abiotic factors [17-19]. Biotic factors in the form of microorganisms and active bodies, while abiotic factors include stirring, temperature, pH, substrate, water content of the substrate, the ratio of C/N and P in the substrate and the presence of toxic materials [20]. If the elements in food are not in a balanced or reduced condition, it is certain that the production of enzymes to decompose complex carbon molecules by microbes will be inhibited. Several compounds that can inhibit the decomposition process in a biogas unit include antibiotics, disinfectants, and heavy metals [19].

CONCLUSIONS

The biogas started to be produced at day 7 and decreased at day 17. The optimal pressures of biogas from wastes of cabbages, spinaches and kangkoong were 102.23 kPa, 102.24 kPa, and 101.42 kPa, respectively. The biogas from vegetable wastes could be combusted for 1807 s with a clear-blue flame. Based on the results of this study, it is recommended for further research using more types of vegetable waste. So that research is more developed and the results can be on a large scale.

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