The Effectiveness of Biogas Method from Rice Husks Waste: Liquid Anaerobic Digestion and Solid-State Anaerobic Digestion

S Syafrudin¹, W D Nugraha¹, H H A Matin², E S Saputri¹ and B Budiyono³

¹Department of Environmental Engineering, Faculty of Engineering, Diponegoro University, 50275 Semarang, Indonesia
²Environmental Science, Faculty of Mathematic and Natural Science, Sebelas Maret University, 57126 Surakarta, Indonesia
³Department of Chemical Engineering, Faculty of Engineering, Diponegoro University, 50275 Semarang, Indonesia

udin_syaf@yahoo.com

Abstract. Liquid Anaerobic digestion (L-AD) generally was operated in the total solid between 0 until 15%, while the Solid- State Anaerobic Digestion (SS-AD) operated at total solid higher than 15%. In this research, waste of rice husk were evaluated to determine the effect of biogas production of Liquid Anaerobic Digestion (L-AD) and Solid-State Anaerobic Digestion (SS-AD). This experiment was operated in batch system in the laboratory scale of anaerobic digestions and at room temperature, with C/N ratio was set at 25oC. Total solids (TS) was varied from 5, 7, 9, 19, 21 and 23%. Pretreatment of rice husk was needed to lower the high lignin content in the material, with added sodium hydroxide (NaOH). Biogas produced was measured by using the method of water transfer every two days for 60 days. The results showed the chemical pretreatment of sodium hydroxide increase the production of biogas, with the highest yield biogas difference between LAD condition and SS-AD by 14%. The highest yield biogas production in rice husk was obtained at TS 19%, with a productivity volume of 935.5 ml. Specific biogas production in TS 5, 7, 9, 19, 21 and 23% was 57; 56.64; 45.36; 24.62; 15.15; and 12.45 ml/g TS. The concentration of total solid to L-AD higher than SS-AD conditions. Further research needs to be studied is to optimize the yield of biogas with SS-AD system.

1. Introduction

The most of global energy needs are still using fossil fuel energy. Utilization of fossil fuels in Indonesia in the form of petroleum, natural gas, oil and renewables each of 51.66; 28.57; 15.34 and 4.43% . The lack of utilization of renewable energy source into weakness of the government in implementing energy policy equalization [1]. Biogas technology is the utilization of renewable energy using organic material is fermented in anaerobic conditions. In general, 60-70% of biogas is a mixture of methane (CH4), 25-30% of carbon dioxide (CO2), and residues such as another gas [2]. Materials that can be used as raw material for biogas that is biodegradable materials such as biomass, animal...
waste, domestic waste and wastewater [3]. One of the potential biomass feedstock for biogas is waste rice husk. Because availability is abundant in nature and a lot of carbon content available on the composition of rice husk in the form of lignocellulose makes it suitable as a feedstock for biogas production [4]. High content of lignin contained in rice straw make it difficult microorganisms to degrade substrat. required pretreatment is expected to break down the lignin content in rice straws. Pretreatment of possible biological and chemical pretreatment [5].

Chemical pretreatment of lignocellulosic biomass may increase higher biodegradation rate and overall product of yield biogas in any biological energy conversion processes, He et al. [6] reported NaOH pretreatment of rice straw increase biogas production SS-AD with the highest yield at an organic loading rate of 50 g/L, compared to the untreated rice straw. Further, NaOH pretreatment reduces the degree of inhibition during fermentation and provides a lower production cost compared to other pretreatment methods. Millet et al [7] concluded that the digestibility of NaOH treated hardwood increased from 14% to 55% with decrease of lignin content from 24-55% to 20%. Chandra et al. [5] cultivate rice straw with L-AD system (5% TS) and pretreatment with NaOH 3%. The treatment NaOH 3% succeeded in raising the production of biogas as much as 132% rather than rice straw without pretreatment.

Biogas production using anaerobic digestion (AD) has two advantages, i.e. treating waste and generating biogas which can be used as an alternative energy source. In addition, other advantages was obtained such as reducing greenhouse gas emissions, and producing another economically viable fertilizer [8-9]. AD process based on the solid content of the are classified into liquid anaerobic digestion (L-AD) and solid-state anaerobic digestion (SS-AD). L-AD operates at a total solids (TS) content of less than 15%, while SS-AD generally used for the TS content higher than 15% [10].

Numerous researchers had been conducted several studies of these lignocellulosic biomass sources tested production from SS-AD systems [6-7] However, the suitability of lignocellulosic biomass form of rice husk and effectiveness of biogas production during L-AD have not been studied. The study concern of present was to understand the effective productivity based on method L-AD and SS-AD. Then, studied the kinetics of the rate of biogas production using modified Gompertz equation [8].

2. Materials and methods

Rice husk obtained from an agricultural land in the area Rowosari, Tembalang, Indonesia. The rumen fluid was used as inoculum. In this study, rumen fluid that was in fresh condition was obtained from slaughterhouse in Pedurungan, Semarang, Indonesia. Rice husk was pretreated by 3% NaOH. First, 500 g of dry rice husk was placed into container. Then added NaOH with dose 3%, followed by the addition of 500 ml of distilled water. Then stir until evenly and rice husk was neutralized until normal pH, for the next dried overnight. Anaerobic digester reactor made of polyethylene with a volume of 600 mL. Reactor equipped with a rubber plug mounted valves for measuring biogas operated in a batch system and at room temperature.

![Figure 1. Schematic batch anaerobic digestion of experimental laboratory](image)

Substrate pre-treatment had been conditioned with TS 5, 7, 9% (L-AD) and 19, 21, 23% (SS-AD). Then added rumen fluid as a provider of methanogenesys bacteria in the digester and homogenized
with glass stirrer. Biogas formed was measured every two days and stopped after 60 days. Biogas production kinetic based on the modified Gompertz equation was assumed had a correspondence specific growth rate of methanogenic bacteria in digester [8, 11].

3. Result and discussion

3.1. Effect of pretreatment to biogas production

The first aim of this research is to know the influence of pretreatment NaOH on rice husk. The study was conducted by soaking rice husk in 3% NaOH solution for 24 hours after is filtered and washed with running water until the normal pH, then dried rice husks for one night. Then the rice husks have been added pretreatment introduced into the reactor with the existing TS concentration ratio, ie 7% (L-AD) and 21% (SS-AD) for anaerobic conditioned with the help of cattle rumen rumen weight ratio:water is 1:1.

Figure 2a shows a graph between of biogas yield TS 7% with substrat the pretreatment and substrates without pretreatment. substrat with pretreatment produces the biogas yield more higher than total substrat without pretreatment, respectively 793 and 404.5 ml. With addition NaOH 3% in a concentration ratio TS 7% on L-AD increase the yield biogas more than 95%. The results conducted in accordance with research of Chandra et al. [5] which states that addition of NaOH increases hydrolysis process which increases the amount of biogas production.

As well as the conditions of the L-AD, on condition SS-AD with TS 19% shown in figure 2b that yields biogas cumulative per unit TS without pretreatment lower than the pretreatment with the acquisition of each at 542.5 and 636.5 ml. In SS-AD conditions of the concentration ratio of 21% TS biogas yield increased by 17%. It was due to the addition of NaOH pretreatment could accelerate the process of degradation of lignocellulose content, due to the presence of lignin compounds can inhibit the fermentation process conducted by the microorganisms so that the required pretreatment with a chemical solution in the form of the addition of NaOH solution. in addition, NaOH pretreatment can also multiply the results of biogas [5-7].

Based on the research results, it can be stated that with the addition of a chemical pretreatment with NaOH given effect to the production of biogas in condition L-AD as well as SS-AD than without pretreatment.

![Figure 2. Cumulative biogas yield per unit TS during 60-days AD in (a) L-AD and (b) SS-AD](image-url)
3.2. Effect of pretreatment to biogas production

The next goal in this study, to determine the effect of the concentration of TS on biogas production from rice husk, which is observed with a variation of TS levels of 5%, 7%, 9%, 19%, 21% and 23%. Data are presented as yield biogas during the 60 day study period, as shown in the following figure 3.

![Figure 3. Cumulative biogas yield per unit TS during 60-days](image)

Figure 3 shows the cumulative biogas yield of rice husk per unit TS. The succession in biogas yield per unit of TS with concentration variations TS 5, 7, 9, 19, 21, and 23% is 57; 56.64; 45.36; 24.62; 15.15 and 12.45 ml/gTS. Content of TS 5% by produce biogas pretreatment which is higher than the TS content of the other conditions in conditions L-AD or SS-AD. According to Brown and Li [10] the higher contains TS has a minimal effect on the efficiency of the TS and the reduction in the production of biogas so that in this study L-AD situation more favorable for the cumulative biogas yield per TS will be higher if the amount of solids slightly. Because the TS content is too high can lead to inhibition of the hydrolysis stage disebakan limited by mass transfer between microbes and raw materials. The products of hydrolysis stage has been accumulating on the surface of the substrate for mass transfer limited, ultimately inhibits the absorption of hydrolytic enzymes. Limited mass transfer makes the amount of hydrolysis products are available for a limited acidogenic microbe thereby reducing the number of products produced on stage acidogenesis to be converted into biogas at the stage of methanogenesis [12].

3.3. Production rate of biogas from rice husk

Based on the aim of this study include to determine the production rate of biogas. On table 1 and figure 4 shows the effect of the concentration of total solids (TS) with the addition of NaOH to give a significant effect on kinetic constant production of biogas. In successive kinetic constant of biogas formed by this treatment are as follows. With (A) was the production of biogas daily, (U) the rate of biogas production, and (λ) minimum time of formation of biogas. For TS 5% was 61.26 (ml/gTS); 1.32 (ml/gTS.hari); and 3.12 days. While TS 7% was 63.62 (ml/g TS); 1.30 (ml/g TS.hari); and 5.08 days. Then for TS 9% was 51.71 (ml/g TS); 0.99 (ml/gTS.hari); and 3.94 days. And for TS 19% was 66.74 (ml/g TS); 0.42 (ml/gTS.hari); and 7.21 days. For TS 21% was 54.79 (ml/gTS); 0.26 (ml/g TS.hari), and 11.90 days. the last of TS 23% was 30.24 (ml/gTS); 0.18 (ml/g TS.hari), and 0.99 days.
Table 1. Kinetic constants on effect of total solids concentration in biogas production

| Variable | A (ml/g TS) | U (ml/g TS.day) | λ (days) |
|----------|-------------|-----------------|----------|
| TS 5%    | 61.26661    | 1.3203577       | 3.117642 |
| TS 7%    | 63.62472    | 1.303298        | 5.076153 |
| TS 9%    | 51.70581    | 0.992509        | 3.942701 |
| TS 19%   | 66.73804    | 0.421644        | 7.214215 |
| TS 21%   | 54.78709    | 0.257652        | 11.90406 |
| TS 23%   | 30.23699    | 0.181583        | 0.979987 |

Figure 4. Connection between data experiment and research results effect concentration calculations on the total solids (TS) of the biogas production

Based on the calculation, the maximum biogas yield was at TS 7% with (A) was the production of biogas daily, (U) the rate of biogas production, and (λ) minimum time of formation of biogas was 63.62472 (ml/gTS); 1.303298 (ml/gTS.hari); and 5.076153 day achieved at day 140 (figure 5).
4. **Conclusion**

In this study showed that NaOH pretreatment is very influential to increase the biogas yield, with condition of L-AD and SS-AD. While the solids concentration effect on the biogas the less total solid, the higher yield of biogas produced. Based on a calculation rate of biogas production from waste rice husk showed the maximum at a concentration of TS 7% had been added to the pre-treatment chemicals (NaOH), with a value as follows: (A) is the production of biogas daily, (U) the rate of biogas production, and (λ) the minimum time the formation of biogas; 63.54 ml/(g TS); 1.303298 (ml/g TS.day), and 5.0762 days.

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