Solid State Anaerobic Digestion for Biogas Production from Rice Husk

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Abstract. Increased rice production in Indonesia not only brings good news socially and economically, but also brings bad news for environmental ecology. In each rice crop produces 50% rice straw and 50% grain. The grain is divided into two again, namely 80% rice and 20% rice husk. In 2018, counted the rice husk up to 10,379,625 tons, a fantastic number if cannot be managed properly so that it can pollute the environment. One alternative to deal with the high rice husk is through conversion to biogas. Biogas is an energy that is formed under anaerobic conditions with organic material so that it is also called renewable energy. The development of research on biogas production from rice husks based SS-AD has experienced a positive increase in hardness. Studies have been conducted on the pre-treatment to other influencing factors. But after the authors describe the latest development of biogas research from rice husk, there are still some variables that have not been tested such as physical treatment, the influence of temperature, pH and alkalinity. Based on this review, further research is needed to complete a number of variables that have not been carried out so that it is expected that the development of biogas production from rice husk based SS-AD can move toward larger scales such as pilot scale and industrial scale.

1 Introduction

As an agrarian country, Indonesia has a variety of activities in agriculture. One of the agricultural activities is rice farming. Rice plants produce rice where rice is a staple food for the people of Indonesia. Because of the high demand for rice, many farmers in Indonesia prefer to grow rice rather than other crops. Rice plants are very easy to live in Indonesia because of the climate and suitable soil. In general, rice is suitable for climates with little heat and contains a lot of water vapor and with soil content varies from sand to clay.

The agricultural industry has brought widespread social and economic improvement for the perpetrators. In 2018, Indonesia was able to produce 83,037,000 tons of rice with a harvest area of 15,995,000 hectares spread throughout Indonesia, with details of the

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development of the last four years presented in table 1 [1]. The rice harvest production data is a very good achievement and its productivity will continue to increase along with the Indonesian government's policy to become a country of self-sufficiency in rice. The policy will slowly suppress rice import activities and become a trigger for Indonesia to become a rice exporting country.

Table 1. Production, Harvest Area and Rice Productivity in Indonesia in 2014 – 2018

Commodity	Year				
	2014	2015	2016	2017	2018
Rice plants					
Production (000 Ton)	70,846	75,398	79,355	81,149	83,037
Harvested area (000 Ha)	13,797	14,117	15,156	15,712	15,995
Productivity (Ku/Ha)	51.35	53.41	52.36	51.65	51.92

Increased rice production in Indonesia not only brings good news socially and economically, but also brings bad news for environmental ecology. In each rice crop produces 50% rice straw and 50% grain. Of the grain itself is divided into two again, namely 80% rice and 20% rice husk [2]. All rice produced is sold by farmers and is a staple food for Indonesians. For rice husk, it will usually be used by brick craftsmen as fuel to burn bricks. Other uses are also carried out by plant sellers, which are used as planting media for plants. The results of the remaining rice in the form of rice husk have been used for several activities but not all of them have been utilized. Therefore, farmers burn the rice husk because they are confused about managing them. Whereas on the other hand, rice husk burning can disrupt human health and cause a decrease in air quality in the area and can reduce nutrients in the land where rice husk is burned.

The activity of burning rice husk can be stopped by making maximum use of these materials. Other utilization of rice husk in addition to raw materials for burning bricks and as a planting medium is to use them as raw materials for anaerobic biogas formation. Biogas is an energy that is formed under anaerobic conditions with organic material so that it is also called renewable energy [3-6]. Biogas is not only used directly for gas, but can also be converted into electricity and heat energy [7].

2 Rice Husk

Rice husk is one of the waste produced from agricultural activities, namely rice plants. Rice plants can be harvested every 3-4 months. In each harvest cycle, rice plants produce several kinds of by-products other than the main product, which is rice that is usually consumed by the people like in Indonesia. Rice plants at every harvest will produce side products such as rice straw and rice husk [8]. Rice straw is usually used as animal feed ingredients while rice husk is only used as a planting medium and as an additional fuel in making bricks. Every harvest, the rice plant will produce rice straw and grain as much as 1: 1, then the grain will be ground in the rice mill and produce rice and rice husk 4: 1 [9]. If you look at table 1 where the productivity of rice in 2018 in Indonesia can reach 83,037,000 tons, then the other side of it is the high rice husk that arises, if it is calculated to reach 10,379,625 tons of rice husk in 2018, a fantastic number if cannot be managed properly so that it can pollute the environment.

In its handling, rice husks are included in biomass which is difficult to be degraded by microorganisms. The physical characteristics of rice husk are hard and dry with a component of cellulose 59%, Hemicellulose 18%, Lignin 21%, and Ash about 2% [10-12]. Lignin

content in rice husk is believed to inhibit microorganisms in the decomposition process so that if the rice husk is left alone it is placed somewhere then the husk remains intact without experiencing decay. This is one of the variables that must be considered so that the aerobic biogas production process can run well, so preliminary treatment of rice husks is needed before entering the digester.

3 Pre-treatment of Rice Husk for Biogas

Anaerobic digestion technology has proven successful in producing biogas. Many researchers have produced biogas with various raw materials such as cow dung, goat dung, pig dung, poultry droppings, household organic waste, corncobs, sugarcane bagasse, and many more. This is inseparable from the initial treatment of each of these raw materials. There is a physics with enumeration, biologically with the addition of enzymes to accelerate the biochemical process, to chemically by immersing raw materials on several types of chemicals with various concentrations and length of time. [8, 13, 22, 23], [14-21].

In the past 5 years, there are several researchers who conducted research on biogas production with rice husk raw material. Pre-treatment is needed as an effort to increase biogas production. The pre-treatment techniques that have been used are physics, chemistry and biology. First, [24] states that biological treatment by adding 5% enzyme and chemical treatment using 3% NaOH can increase biogas production. Then by [25] states that biological treatment using 5% enzyme can increase biogas production. Furthermore [6] also stated in his research, conducted research on the effect of chemical treatment with NaOH in the range of 3-9%, the best results obtained were 6% NaOH. In addition, research was conducted on the effect of biological treatment with enzymes in the range of 5-11%, the best results were obtained on enzymes of 11%. Another study is [21], conducting research on chemical treatment using CH_3COOH in the range of 3-5%, the best results were obtained at 3% CH_3COOH. Then an experiment using 3-5% range HNO3 was carried out, but the biogas yield was low, lower than the CH_3COOH treatment experiment and without treatment at all. Then [9], stated that chemical preliminary treatment using 3% NaOH could increase biogas production 4.5 times higher and biological treatment with enzymes in the range of 3-9% obtained the best biogas productivity at 6% enzyme. More concisely, the preliminary treatment of rice husks for biogas production can be seen in Table 2.

Table 2. Pre-treatment for Biogas Production

Treatment	Substrate	Condition	Result
NaOH	Rice husk	SS-AD TS 21%, C/N ratio 20-35, NaOH 3%	3% NaOH increases biogas production
	Rice husk	SS-AD TS 21%, C/N ratio 25, NaOH 3-9%	The best biogas production is in variables with 3% NaOH, which is 497 ml
	Rice husk	SS-AD TS 15-40%, C/N ratio 20-50, NaOH 3%	3% NaOH increases biogas production 4.5 times higher than variables without NaOH
CH_3COOH	Rice husk	SS-AD TS 21%, room temperature, CH_3COOH 3-5%	Biogas production with 3% CH_3COOH is higher than 5%, which is 45.86 ml/gr.TS

HNO_3	Rice husk	SS-AD TS 21%, room temperature, HNO_3	Biogas production with 3% HNO3 is higher than 5%, which is 21.85 ml/gr.TS. This pre-treatment results are very low, because it is lower than the variable without treatment
Enzyme	Rice husk	SS-AD TS 21%, C/N ratio 20-35, Enzyme 5%	5% enzyme can increase biogas production
	Rice husk	SS-AD TS 21%, F/M ratio 6-24, C/N ratio 25, Enzyme 5%	5% enzyme can increase biogas production
	Rice husk	SS-AD TS 21%, C/N ratio 25, Enzyme 5-11%	The best biogas production is in variables with 11% enzyme, which is 667.5 ml
	Rice husk	SS-AD TS 15-40%, C/N ratio 20-50, Enzyme 3-9%	The best biogas production results are seen in variables with 6% enzyme following other variables such as CN ratio and TS concentration using response surface methodology (RSM)

4 Factors Affecting Biogas from Rice Husk

There are factors that can affect biogas production from anaerobic digestion. Whatever the raw material for biogas, the influencing factors are the same. Because the biogas production base is biologically, these factors are the same as the factors that influence the growth of anaerobic bacteria, including C/N ratio, total solid (TS), pH, temperature, alkalinity, F/M ratio [26, 27], [36-38], [28-35].

So far there has been research on biogas production from rice husk on these factors. In research on the effect of CN ratio conducted by [24] in the range of 20-35, obtained the best biogas productivity at a CN ratio of 35. Furthermore [25] in his research on the effect of FM ratio in the range of 6-24, obtained the best biogas productivity on CN ratio 10. For the effect of TS, [39] in his research on TS in the range 17-23% (SS-AD conditions), obtained the best biogas productivity at TS 23% per unit volume and TS 17% per unit weight (grams). Furthermore, [9] also conducted a study on the effect of CN ratio in the range of 20-50 with the help of Response Surface Methodology, in the study it was found that the best biogas productivity was CN ratio 35. Experiments were also conducted on TS with a range of 15-40% (SS-AD conditions), the best biogas productivity is obtained at TS 27%. More concisely, the results of research on the factors that influence biogas production from rice husks can be seen in Table 3.

Table 3. Factors Affecting Biogas Production

Factor	Substrate	Condition	Result
C/N ratio	Rice husk	SS-AD TS 21%, C/N ratio 20-35, Pre-treatment NaOH 3% and enzyme 5%	The best biogas productivity in the variable C/N ratio 35
	Rice husk	SS-AD TS 15-40%, C/N ratio 20-50, Pre-treatment NaOH 3% and Enzyme 6%	The best biogas productivity at C/N ratio 35 with TS 27%
F/M ratio	Rice husk	SS-AD 21%, C/N ratio 25, F/M ratio 6-24, Pre-treatment Enzyme 5%	The best biogas productivity in the variable F/M ratio 10
Total solid	Rice husk	SS-AD on TS 17-23%, C/N ratio 25	The best biogas productivity at TS 23% per unit volume and TS 17% per unit weight (grams)
	Rice husk	SS-AD TS 15-40%, C/N ratio 20-50, Pre-treatment NaOH 3% and Enzyme 6%	The best biogas productivity at TS 27% with a C/N ratio of 35

5 Conclusion

The development of research on biogas production from rice husks based SS-AD has experienced a positive increase in hardness. Studies have been conducted on the pre-treatment to other influencing factors. But after the authors describe the latest development of biogas research from rice husk, there are still some variables that have not been tested such as physical treatment, the influence of temperature, pH and alkalinity. Based on this review, further research is needed to complete a number of variables that have not been carried out so that it is expected that the development of biogas production from rice husk based SS-AD can move toward larger scales such as pilot scale and industrial scale.

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