KEMAS 18 (3) (2023) 431-436

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Rice Husk Waste: Impact on Environmental Health and Potential as Biogas

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Article Info

Article History:
Submitted January 2023
Accepted January 2023
Published January 2023

Keywords:
Rice husk, environmental health, biogas energy

DOI
https://doi.org/10.15294/kemas.v18i3.42467

Abstract

Indonesia is an agricultural country with dry-milled grain production reaching 55.6 million tons in 2022. Besides producing an abundance of rice, milled dry rice also results in waste in the form of rice husks. The handling of rice husk waste is mostly by burning. The smoke from burning is toxic, so it has a poor impact on environmental health. This study is regarding the effect of improper management of rice husks on environmental health, the utilization of rice husks in biogas energy, and its potential in Indonesia. Air quality measurement in areas burning rice husks on the parameters SO2, CO, NO2, and PM10 regarding the method of the Indonesian National Standard. Then anaerobic laboratory-scale research to convert rice husk into biogas. Chemical pretreatment was carried out with 3% NaOH and the C/N ratio determined was 25. Condition variations were determined for L-AD with 7% TS and SS-AD with 17% TS. We found that burning rice husks harm on environmental health. It is indicated by the SO2 and PM10 parameters exceeding the quality standards, namely 167 and 132 µg/m3.The NO2 parameter almost reached the quality standard, namely 178 µg/m3. Generated rice husk can be converted into renewable energy in biogas with good productivity in SS-AD conditions, with biogas production reaching 75.2 mL.gTS-1. Biogas potential from rice husks reached 1.5 million liters. It can support energy security for Indonesia.

Introduction

Indonesia is an agrarian country, with most of the population working in the agricultural sector. According to the Official Statistical News No. 74/10/Th. XXV released on October 17, 2022, by the Central Statistics Agency (BPS), the harvested area of rice plants reached 10.6 million hectares with production in the form of dry milled grain (gabah kering giling/GKG) of 55.6 million tonnes. If converted into rice, rice production is estimated to reach 32.07 million tonnes (Statistik, 2022). Of course, it is good news that Indonesia has a staple food in the form of rice. So it can be fulfilled properly. However, it needs to understand that GKG does not completely turn into ready-to-cook rice. Rice obtained from GKG is 64.02%. The rest is waste in the form of rice husks. If calculated, in 2022, there will be an estimated generation of rice husk waste of 20 million tons.

Based on (Nugraha et al., 2018; Putri et al., 2019), the utilization of rice husks is still relatively low, usually used as a planting medium where some are made into charcoal first, and some are left intact in their original form. Other uses are as fuel for making bricks, cooking fuel, and made into briquettes, but the amount is very small. Research conducted by (Ningsih et al., 2012) stated that rice husks can be used as a mixture of cement raw materials where utilization can reach 5%. The research was carried out on a laboratory scale and needs to be scaled up and further developed. Most of the handling of rice husk waste is by burning

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pISSN 1858-1196
eISSN 2355-3596

it. Usually carried out directly by farmers after the main harvest period. Farmers note that burning rice husks can make paddy fields fertile and ready for replanting (Goodman, 2020). However, this is not per research conducted by (Glushankova et al., 2018), stating that burning rice husks can reduce nutrients in the area used to burn the rice husks. Besides having a poor impact on the soil, burning rice husks also causes air pollution. According to (Bodor et al., 2022; Zorena et al., 2022), the combustion process will release various pollutants such as SO2, NO2, CO, O3, Pb, PM10, and PM2.5 which can be detrimental to environmental health. Air pollution affects humans, animals, including plants.

Rice husk waste is included in the class of organic waste from agricultural activities (Achinas et al., 2017). Currently, biogas technology development uses agriculture waste (biomass) as raw material, whereas initially biogas technology only uses livestock waste (Matin et al., 2020). Of course, this trend is beneficial for agraria countries like Indonesia, where the generation of organic waste from agricultural activities is very high. Biogas is a technology that utilizes microorganisms anaerobically and converts organic waste into methane gas and other gaseous elements. Biogas is also renewable energy because the production process uses simple raw materials and does not require a long time (Budiyono et al., 2022, 2021; Sumardiono et al., 2022). This research studies the impact the impact of rice husk waste on environmental health if not managed properly. Furthermore, it is utilized as renewable energy in the form of biogas, and the potential of rice husk to become biogas energy in Indonesia.

Methods

Measurement of ambient air quality was carried out in Rowosari Village, Tembalang District, Semarang City. Measurements were made twice during the main harvest, and many farmers burned rice husks. The measurement method is based on the Indonesian National Standard (SNI) under Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management. The parameters tested included: Sulfur Dioxide (SO2) with SNI 7119-7-2017, Carbon Monoxide (CO) with SNI 7119-10-2011, Nitrogen Dioxide (NO2) with SNI 7119-2-2017, and Particulate Matter 10 (PM10) with SNI 7119-15-2016. In measuring SO2, CO, and NO2 parameters using Impinger and for PM10 parameters using High Volume Air Sampler (HVAS).

The raw material used for biogas production is rice husk from the Rice Milling House in Rowosari Village, Tembalang District, Semarang City. Another ingredient used is cow rumen liquid taken from the Penggaron Animal Slaughterhouse. Cow rumen liquid is used as a starter. 3% NaOH was used for chemical pretreatment for 24 hours. The C/N Ratio parameter was determined to be 25 and adjusted by adding technical urea. Total Solid (TS) parameters are set in two conditions, namely Liquid State Anaerobic Digestion (L-AD) and Solid State Anaerobic Digestion (SS-AD). In L-AD with 7% TS and in SS-AD with 17% TS.

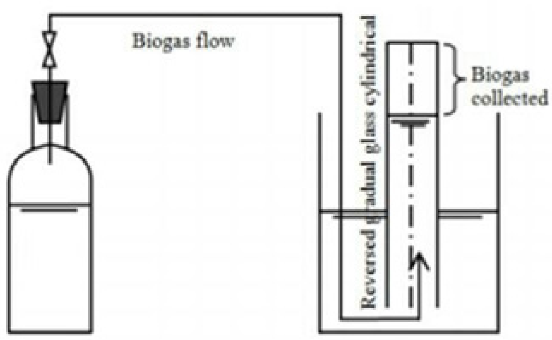

Figure 1. Series of Research Tools in the Laboratory

The research was on a laboratory scale. The biogas reactor is assembled from a polyethylene bottle with a volume of 1 liter, with a top made of rubber equipped with a valve that can be opened and closed for the process of measuring biogas production. Biogas measurements were carried out using the water displacement method (Budiyono et al., 2022; Sumardiono et al., 2022) and also carried out every other day for 60 days (biogas was no longer formed significantly). The series of biogas reactors and their measurements are in Figure 1.

Results and Discussions

Ambient air quality measurements were carried out twice to obtain accurate data and also follow the SNI method for each parameter.

The results of ambient air quality measurements can be seen in Table 1. Two parameters exceeded the quality standards, namely SO2 167 μg/m3 and PM10 132 μg/m3. Then the parameters for CO 200 μg/m3 and NO2 178 μg/m3 are still below the quality standard. But for NO2 it is at the upper limit, so it almost reaches the quality standard.

Table 1. Ambien Air Quality Measurement

Parameters	Measurement Results (μg/m^3)	Quality Standard (μg/m^3)
Sulfur Dioxide (SO_2)	167	150
Carbon Monoxide (CO)	200	1,000
Nitrogen Dioxide (NO_2)	178	200
Particulate Matter 10 (PM_{10})	132	75

The process of burning rice husks openly and at uncontrolled temperatures included incomplete combustion resulting in significant high air pollutants. Perfect combustion only produces CO2 and H2O (Oluwoye et al., 2020). Rice husk has a high lignin content, so when placed and allowed to stand in an open space, it will retain its shape due to the difficulty of being degraded by microorganisms (Nugraha et al., 2020; Syafrudin et al., 2020). The lignin content in rice husk forms the outermost layer so that the contents, such as cellulose and hemicellulose, are difficult to decompose naturally (Matin & Hadiyanto, 2018). The utilization of rice husks, such as being used for planting media, then used as fuel for making bricks, is still very low and has not been able to reach all of the rice husks, especially during the main harvest. (Ahmed et al., 2015) states that socio-economic factors also play a role in the behavior of farmers in managing rice husk waste. Farmers who have quite a lot of livestock choose to use this waste as one of the raw materials for animal feed, but on the contrary, farmers who do not have livestock tend to burn the remaining agricultural waste directly. In addition, rice field areas that are worked directly by their owners will have different handling of rice husk waste compared to rice field areas that are worked on by land tenants, one of the indications is due to significant economic factors in the rice field cultivators.

Burning rice residue has many negative effects including local air pollution, an increase in black carbon, and a contribution to regional and global climate change (Ahmed et al., 2015). The smoke from burning rice husks is toxic to humans and animals. Air contaminated with pollutants from combustion can cause eye and nose irritation, difficulty breathing, coughing, and headaches. People with heart disease, asthma, emphysema, or other respiratory ailments are particularly sensitive to air pollution. Other health problems exacerbated by burning waste include lung infections, pneumonia, bronchiolitis, and allergies (Budhy et al., 2021). Exposure to these SO2, CO, NO2, and PM10 substances and consuming food contaminated with ash and smoke in the long term has the risk of causing certain types of cancer, liver disorders, immune system disorders, and reproductive system disorders (Hu et al., 2020; Sunarsih et al., 2019).

Burning rice husks in paddy fields which are considered to be able to fertilize it, is another reason farmers do this. Whereas according to (Glushankova et al., 2018), rice husks burned in rice fields can cause nutrients to be lost, especially volatile nutrients. Loss of nutrients without being accompanied by the return of these elements into the soil will result in an imbalance of nutrients in it. It will reduce the level of soil fertility and lead to a decrease in crop production and productivity. (Ezyan & Hanuni, 2019) states that rice husk ash has benefits for the soil. Rice husk ash can accelerate the process of weathering and composting through the efficient absorption of nutrients. The total rice husk ash is only 7.5% and the composting process takes 48 days. In this condition, sample C achieved a ratio of N:P:K 3:8:9, 57.72% water content, and 69.86% water holding capacity. It should be noted that the total rice husk ash above 7.5% is ineffective and interferes with the composting process. As stated by (Glushankova et al., 2018), burning rice husks to ashes on agricultural land in large quantities can harm on soil nutrients.

In this section, a study on the effect of L-AD and SS-AD on the production of biogas made from rice husk. In the L-AD variable, biogas appeared starting from the 8th day of 19 mL. This L-AD variable was recorded to produce a maximum daily biogas production of up to 56 mL on the 32nd day. Furthermore, on the SS-AD variable, biogas has appeared since the 2nd day of 25 mL. This SS-AD variable was recorded to produce a maximum daily biogas production reaching 107 mL on the 46th day. Cumulatively, biogas production at L-AD and SS-AD variables for 60 days was 433 mL and 1,278 mL. Cumulative biogas production in detail is in Figure 2.

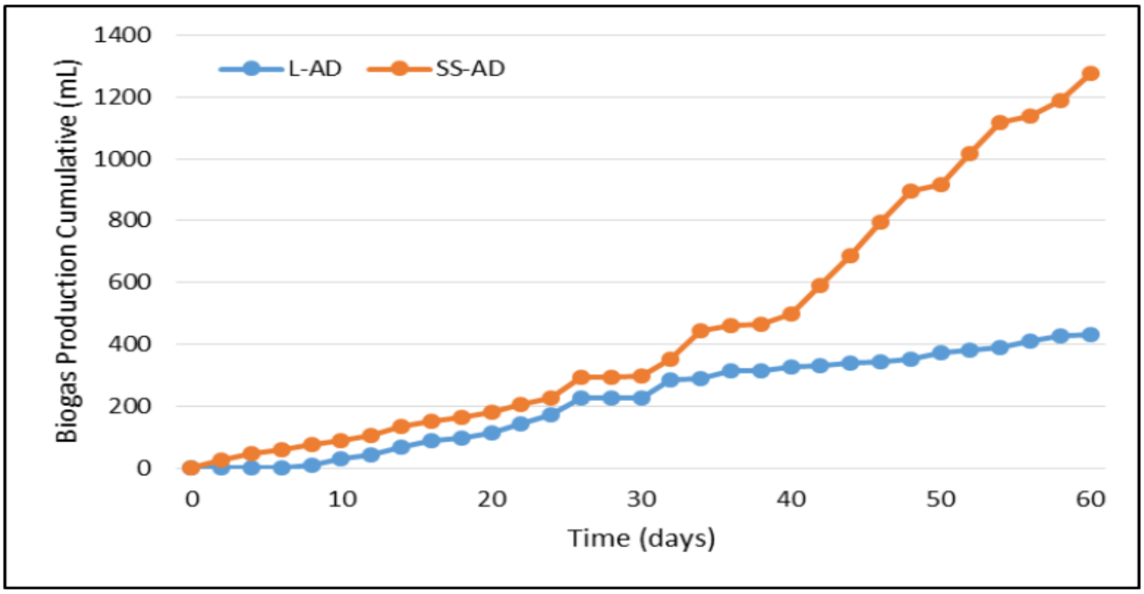

Figure 2. Biogas Production Cumulative on TS 7% (L-AD) and TS 17% (SS-AD)

When viewed cumulatively, as presented in Figure 2, the SS-AD variable shows significant biogas productivity compared to L-AD, with a biogas difference of up to 845 mL. However, if we examine deeper, the study of calculations per unit-TS, it is found that between L-AD and SS-AD, the difference in productivity is not too high. It can be seen in Figure 3, the cumulative biogas production on the L-AD variable is 61.8 mL.gTS-1 and on the SS-AD variable is 75.2 mL.gTS-1. The difference between the two is only 13.4 mL.gTS-1.

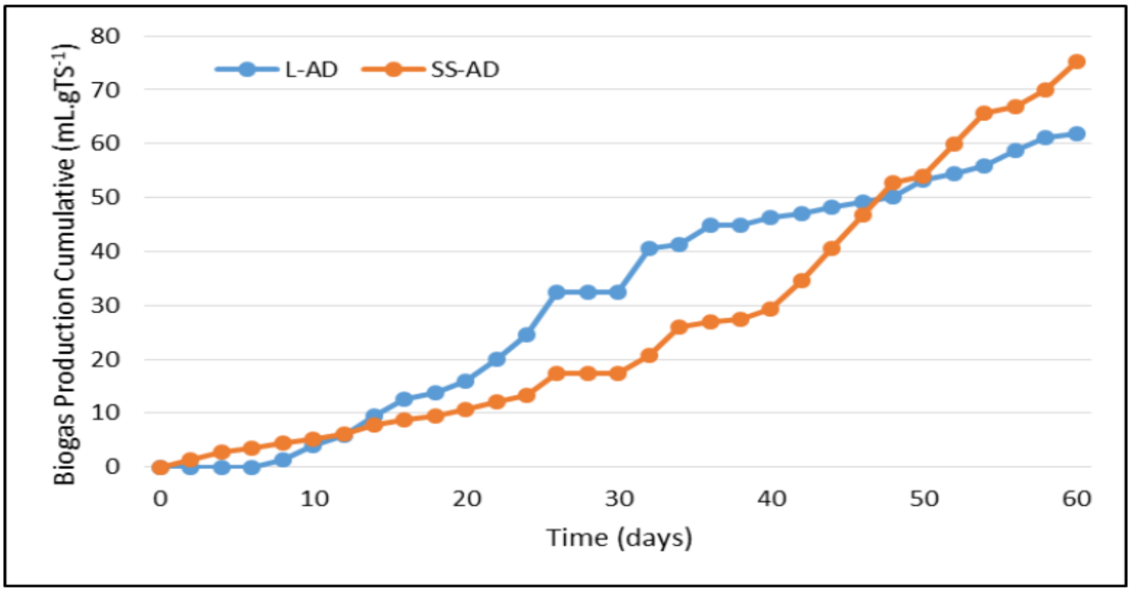

Figure 3. Biogas Production Cumulative per unit-TS on TS 7% (L-AD) and TS 17% (SS-AD)

When compared between the two, the difference in biogas production per unit-TS is not significant, but SS-AD has various advantages, so this variable is superior. Based on (Brown et al., 2012; Budiyono et al., 2021; Li et al., 2011; Matin & Hadiyanto, 2018; Yang et al., 2015), SS-AD has better biogas productivity, thus in one period of anaerobic fermentation, SS-AD can accommodate more solid waste so it can degrade more organic solid waste, and has a by-product in the form of organic fertilizer which is also more many.

The potential of rice husk waste as renewable energy in the form of biogas is very large, especially in an agricultural country like Indonesia (Nugraha et al., 2020). In Indonesia, in 2022, it will produce 55.6 million tons of dry-milled grain (GKG). From the GKG data, 64.02% goes into the rice, and the rest is rice husk waste. So the calculation is 35.98% become rice husks and its emergence in Indonesia in 2022 will reach 20 million tons. It is a big problem if not managed properly. If all of this waste is burned, what will happen is a massive degradation of health and environmental quality. However, if it is converted into renewable energy as biogas, the potential obtained is 1.5 million liters of biogas. If all generated rice husk waste can be managed properly, it can support energy security for Indonesia. On the other hand, sources of air pollution from agricultural activities, especially burning rice husks, can be significantly reduced.

Conclusion

The results of burning rice husks harm environmental health. It is indicated by the SO2 and PM10 parameters exceeding the quality standards, namely 167 and 132 µg/m3, and the NO2 parameter almost reaching the quality standard, namely 178 µg/m3. Generated rice husk can be converted into renewable energy as biogas with good productivity in SS-AD conditions, with biogas production reaching 75.2 mL.gTS-1. Rice husk to be used as biogas is very potent and can be done. Utilizing rice husk to become biogas can suppress the emergence of air pollutants from agricultural activities and can also be a source of energy security support for Indonesia.

Acknowledgement

We acknowledge Universitas Diponegoro for the World Class Research University Program 2021-2023 No: 118-19/UN7.6.1/PP/2021 for supporting this research.

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