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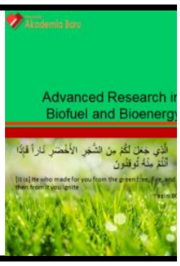

Treatment of Cow Dung Waste by using Monitoring and Controlling Oxygen Gas in the Biogas Reactor

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ABSTRACT

This study discusses a brief analysis of cow manure waste treatment by using monitoring and controlling oxygen gas in the biogas reactor to determine the minimum amount of oxygen gas concentration for biogas production. The six liters of biogas reactor was used for treating cow manure waste. The initial condition was the biogas reactor contains oxygen gas with a concentration of 22% (v/v) according to the level of oxygen gas in the air. The 2% (v/v) of nitrogen gas was injected into the biogas reactor to reduce the oxygen level into 0% (v/v). The result showed that the retention time of biogas production was found 10 days of reaction time, which reached 0.5% (v/v) of oxygen gas concentration in the reactor. The highest biogas production was achieved by 0.6% (v/v) of oxygen gas concentration at 15 days of reaction time. The methane gas concentrations were 85.8% which corresponded to 85,800 ppm. The minimization of oxygen gas concentration along reaction times was achieved 0% up to 0.6% (v/v), which required to optimize biogas production.

Keywords:
Biogas; controlling and monitoring; methane; oxygen; waste reactor

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1. Introduction

In recent years, global warming caused by environmental damage has become a hot topic of discussion [1,2] . One of the causes of environmental damage is fossil energy which is a non-renewable resource, such as the use of diesel and gasoline. The exploitation of fossil resources is most widely used in petroleum because most industries use fossil fuels to support the production process. Therefore, in addition to reducing global warming, alternative energy is needed to diversify energy sources' availability in the future [2–4].

One of the environmentally friendly alternative energy is biogas [3,5]. Biogas is called environmentally friendly because it is produced from processing household waste, animal waste, human waste, organic waste, which undergo decomposition or fermentation by microorganisms [6-9] The breakdown of organic materials by anaerobic bacteria into biogas occurs in a digester.

Therefore, the digester is one of the main components in the process of making biogas. In order the biogas production process to take place optimally, the digester must be well designed. Several

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types of biogas digester are being developed, including fixed-dome digester, floating drum, balloon digester, a horizontal type, and soil hole type. Of the six types of biogas digester, the most commonly used types are fixed-dome and floating digester types [10-12].

In general, a biogas digester is specially made with a single stage placed in the soil. This will cause problems in the maintenance of biogas reactors [3,11,13]. Therefore, in this study, a special digester was made that could be placed without being in the soil to simplify the maintenance process through the biogas control process. The digester used is made of stainless steel and is two-stage. A two-stage digester is a digester whose process is carried out in two digesters that work in series. In the first digester, the process of hydrolysis, acetogenesis, and acidogenesis takes place. Whereas in the second digester, the methane gas formation process takes place, namely the methanogenesis reaction.

Apart from the digester, another factor that affects the biogas formation process is the presence of oxygen gas. In the biogas digester, some gases affect methane gas. Oxygen is not needed in the biogas formation process because it is anaerobic fermentation that does not require oxygen [1,5], [14-16]. The greater the oxygen content in the anaerobic digester, the more it will inhibit methane gas production by bacteria. Therefore, this study aims to determine the range of oxygen gas concentrations needed to achieve the maximum biogas product.

2. Methodology

2.1 Design of Biogas Reactor with Monitoring and Controlling of Oxygen Gas

Figure 1 shows the biogas reactor with the installation of any censorship. The biogas reactor was designed and constructed by the laboratory scale, with the diameter in the reactor is 6 inches, and the height is 33 centimeters [17]. This biogas reactor is equipped with a thermal jacket for keeping the internal environment completely psychrophilic. Therefore, the temperature of the biogas reactor upper than 20 ° C. The acidity (pH) level of the substrate in the reactor was conditioned at pH 6.8–7 [3,18]. The exact volume of 3 liters of cow dung and 1.5 liters of liquid tofu waste was supplied in each biogas reactor. The biogas reactor was operated with/without oxygen maintenance, with hydraulic retention time (HRT) of 30 days, with daily monitoring of methane gas production.

2.2 Flowchart of the Experiment

Figure 2 shows the detail flow chart of the experiment. The experiment began with designing a laboratory-scale digester, data characterization, making biogas, cow dung, and liquid tofu waste. The measurements taken were measuring oxygen concentration and methane levels in a controlled / uncontrolled biogas reactor. In the next step, the data is processed and analyzed about the effect of oxygen on biogas production with a substrate mixture of cow dung and tofu liquid waste.

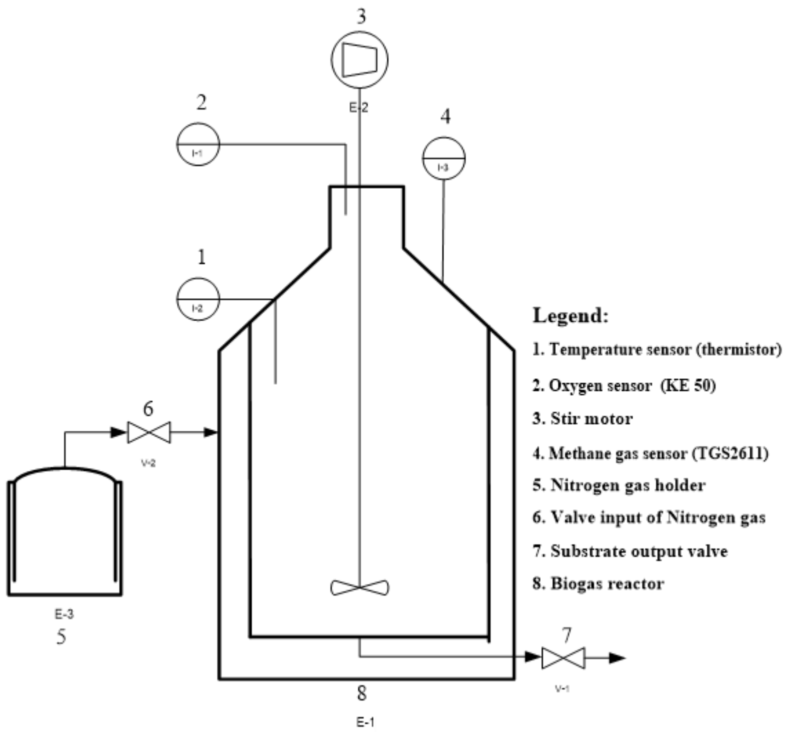

Fig. 1. The biogas reactor with monitoring and controlling of oxygen gas

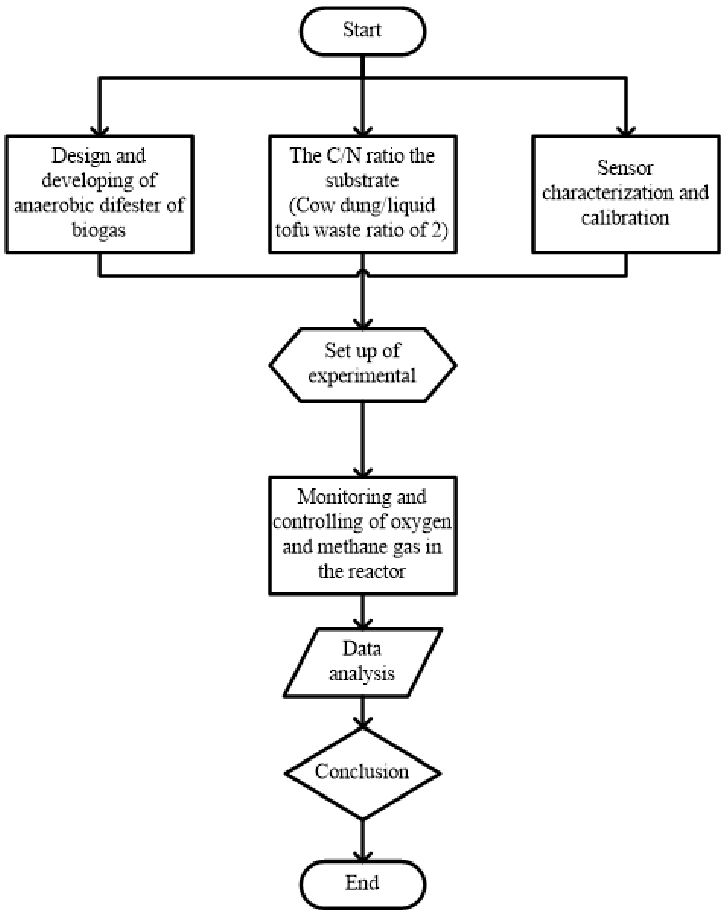

Fig. 2. The detail flowchart of experiment

3. Results

3.1 The C/N Ratio of the Substrate

The Kjeldahl test was applied in Solid Waste Laboratory and B3 Labtek IX C at Bandung Institute of Technology. This test aims to examine the composition of the substrate on the C/N ratio of the substrate. This ratio shows the capability of substrate for food consumption of the bacteria producing biogas. The results of the ratio test C/N in this research shown in Table. 1.

Table 1
The C/N ratio of the substrate

Substrate	C (%)	N (%)	C/N Ratio
Cow dung/liquid tofu waste ratio of 2 (v/v)	37.09	0.49	75.69

According to the best our knowledge, the best C/N ratio to produce methane gas on biogas substrate is 25 [10]. However, Table 1 shows the C/N ratio of substrate causing the production of biogas was less optimal. The reason is the tofu liquid waste affected more robust than the cow dung content. Therefore, the reaction condition required another factor to boost the biogas productivity up, such as controlling oxygen gas concentration, pH, temperature, substrate level, and others, in the biogas reactor as a treatment [17].

3.2 The Calibration of KE50 as Oxygen Sensor

The oxygen sensor KE50 needs to be characterized to see the linearity of the sensor reading. Therefore, the precision of the measurement of the oxygen gas concentration on the biogas reactors was calibrated. The calibration and the characterization of KE50 was carried out at the Ujung Berung Work Safety Centre in Bandung using a Tiesto device. As a result, the linear regression obtained from the equation:

$$y = 1.0003x - 0.0255 \quad (1)$$

Figure 3 shows that each sensor has a line equation of change in oxygen levels against the voltage on the 50th oxygen sensor, which will be entered into the program for reading oxygen levels. The x-axis value is the value of the read's oxygen level, and the y-axis value is the value of the ADC voltage read at a certain oxygen level.

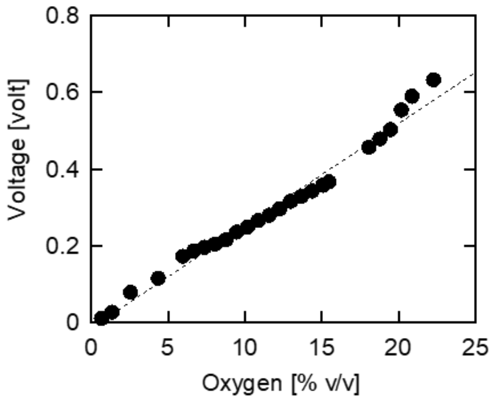

Fig.3. The calibration of KE50 as oxygen gas sensor

3.3 The Calibration of TGS2611 as Methane Sensor

The methane gas sensor TGS2611 needs to be characterized to see the sensor reading's linearity. Therefore, the precision of the measurement of the methane gas concentration in the biogas reactors was evaluated7]. The methane sensor's characterization was carried out by equalizing the voltage of the signal controller's voltage with the methane gas levels. Therefore, the linear regression obtained from the equation:

$$y = 1.0004x - 5.0183 \quad (2)$$

Figure 4 shows that the methane gas levels' output voltage has been quite linear along with the range of measurement.

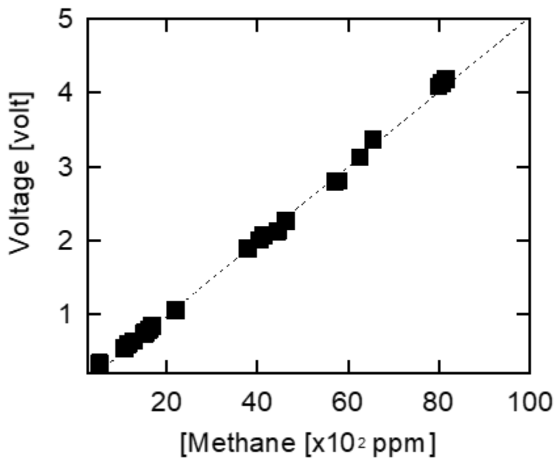

Fig.4. The calibration of TGS2611 as the methane gas sensor

3.4 The Effect of Oxygen Concentration on the Methane Production

Figure 5 below shows that oxygen gas affects methane gas productivity. The first digester shows that the initial of oxygen gas levels was 21.57%. It decreased by 30 days at 2.62%, and the highest of methane gas with levels of 43.94% among the reaction time. In the second digester, it was seen that the optimal oxygen content was around 0% up to 0.6%. The methane gas produced was the greatest with a level of 85.80%. In the second digester, the resulting methane concentration is greater than the first digester. The lower the oxygen level in the second reactor than the first reactor is caused by the monitoring and controlling oxygen gas by adding nitrogen gas. Nitrogen gas significantly affects methane gas because it can help the growth of anaerobic bacteria on the substrate to produce methane gas optimally in this biogas process.

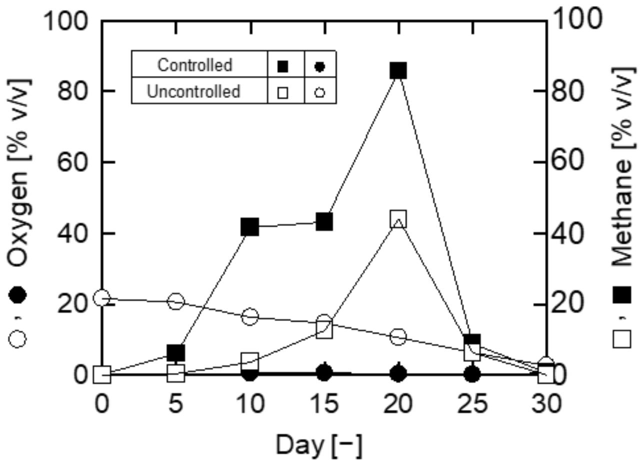

Fig.5. The correlation of oxygen gas and the methane gas production for 30 days

4. Conclusions

Monitoring the biogas production process is the most effective step to ensure effective and efficient biogas production. The key to ensuring an effective and efficient production process is early warning indicators in a system. Current research is an early warning that could be applied to biogas reactors with parameter indicators focused on metabolic processes. Despite this considerable achievement on a laboratory scale, the widespread application of online monitoring methods is still hindered by the high cost of instrumentation. In the future, parameter monitoring studies and biogas reactor design for biogas production have great potential to help reduce production costs in biogas plant installations.

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