The Analysis Of Biogas Fermentation Time From Cow Manure On Fixed Dome Biodigester Batch Systems

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Abstract. Biogas technology from cow manure in Indonesia has been developing for a long time, but the application of its use as an alternative energy source is not yet widely developed, due to various unknown operations and processes. This research aimed to analyzed of biogas fermentation time in batch system of cow manure. This research used a Fixed Dome type biodigester that had a total volume of 500 litters with its operating system in batches with 80% of the slurry containing cow manure and the rest for the gas chamber. The biogas fermentation time were 5, 10,15,20 25 and 30 days. The raw material from cow manure had an organic COD content of 10.240 mg / l with a pH of 6.7. The C/N feed ratio was set in the condition of 25: 1 and the ratio of slurry of cow manure with water was 1: 1. From the results of the study in batch process, it was found that the longer the fermentation time the higher the methane gas content but the methane gas content decreases on the 30 th day from 59,12% on the 25 th day to 50,04% on the 30 th day of fermentation.

Keyword: Biodigester Fixed Dome, Biogas, Methane Gas and Cow Manure

1. Introduction
The excessive use of fossil fuels has become a global problem discussed both academically and socially, so that various parties concerned trying to find solutions for solving this problem. Diversification of energy sources by using renewable resources, one of which is biomass energy sources. Renewable resources from biomass are becoming major raw material for the energy supply. There are a number of biomass that can be energy sources such as wood, wood residues, agricultural crops and waste by products such as municipal solid waste and animal waste [1].

Animal waste has potential to be a source of biogas energy through anaerobic digestion process. Anaerobic digestion is a complex bioprocess and involves several groups of microorganisms which degrade organic material into a mixture of methane and carbon dioxide gas and other gases in the absence of oxygen. In anaerobic digestion to produce methane gas the process takes place in a four phase process, namely hydrolysis, acidogenesis, acetogenesis and methanogenesis. In each phase, microorganisms have different roles. Biogas can be used for various applications such as vehicle fuel and to generate electricity [2], but in Indonesia its application is still not well developed, among others, because the constraints of operations and processes have not been fully controlled.
Composition of biogas depends mostly on the type of decomposed material but generally as follows: 50-85% CH$_4$ (Methane); 20-35% CO$_2$ (Carbon Dioxide); H$_2$, N$_2$, and H$_2$S form the rest [3].

In the process of anaerobic digestion, water content is an important element for producing biogas. From several studies it is found that the effective ratio of cow manure and water for producing biogas is 1: 1 [4]; [5]. However, there are some researchers mixing 1: 1.5 [6] depending on the initial humidity conditions of cow manure.

The pH element is a parameter affecting bacterial growth, the optimum pH for the growth of methane gas producing bacteria is at pH 6.4 to 7.4. Under pH 6.4 bacterial activities of methanogenesis will decrease [7] and according to [1] best pH for anaerobic digestion is neutral pH.

The temperature also has a significant effect on biochemical reactions. Microorganisms are generally grouped according to their growth temperature, namely optimum thermophilic microorganism above 50°C, optimum mesophilic 30-40°C and optimum psychrophilic below 200°C [1]. For tropical conditions such as in Indonesia, generally the temperature for the anaerobic digestion process uses a temperature of 30-40°C. Temperature affects the metabolic activity of microorganism and the efficiency of anaerobic fermentation where the optimum temperature is at 35°C [8].

The main instrument for anaerobic digestion process is biodigester. Bio-digester is designed so that the anaerobic fermentation process running well. According to [9], there are several types of bio-digesters including the Fixed Dome Biodigester which has a fixed volume. In this digester along with the production of biogas, there will be an increase in pressure in the digester, so that the gas formed must be immediately flowed to the gas collection outside the reactor (biodigester). The other type is a floating drum bio-digester, in this digester there is a reactor section which moves with increasing pressure in the digester. The moving part functions as a gas collector. In Indonesia commonly use fixed dome type bio-digesters adapted from other countries such as Bangladesh, Cambodia, Laos, Pakistan, Nepal and Vietnam and are quite successful. In addition to the types of bio-digesters mentioned above, the other types of balloon / bag digester are widely used in Latin America. This type is usually made from a large, strong plastic bag connected to a piece of drainpipe at either end, these pipes being used to add feedstock and remove slurry, and gas is produced in the top of the bag. Gas pressure can be increased by placing weights on top of the bag [10].

The time influences the formation of biogas, the longer the fermentation process is carried out, the more biogas is produced. Biogas is formed within 10 to 30 days [11] and decreases after 30 days. According to [12] effective metabolic process of anaerobic digestion occurs within 20 to 30 days. Biomass materials containing a lot of lignocellulose and fat will have a longer fermentation time than those containing a large protein. Fermentation time is influenced by biomass, temperature, pH, and bio-digester models. Some researchers produced various optimum fermentation time, so this research aimed to analyze the fermentation time of cow manure into biogas in a fixed dome biodigester.

2. Methods and Experiment set-up

This research took place in several stages, starting by preparing a fixed dome type biodigester equipped with pH and temperature control devices and biogas container in the form of plastic bag. Before being used for this research, a leak test was carried out. In preparing the raw material for biogas by mixing cow dung and water with a ratio of 1: 1. After cow dung and water are mixed completely, methane bacteria are added and then this mixture is put into biodigester. The fermentation time is carried out for 30 days. The parameters analyzed are COD (chemical oxygen demand), TSS (total suspended solid), VSS (volatile suspended solid), pH and total Nitrogen. In this fermentation
process, the formed biogas was observed at intervals of 5 days for 30 days. During the research, the pH and temperature of the process were observed periodically. The biogas yield was analyzed for its composition. The detail research stages can be seen in Figure 1. below;

![Diagram of Research Stages](image)

**Figure 1. Research Stages**

The following Figure 2. is a fixed dome type biodigester used in this research. Biodigester has a total volume of 500 litters with 80% filled with cow manure slurry. This tools equipped with control panel.

![Fixed Dome Biodigester](image)

**Figure 2. Fixed Dome Biodigester**
3. Results and Discussions

The following in Table 1 shows the results of the analysis of the biogas raw materials derived from cow dung.

| No. | Parameters | Content     |
|-----|------------|-------------|
| 1.  | COD        | 10.240 mg/l |
| 2.  | TSS        | 11.675 mg/l |
| 3.  | VSS        | 9.930 mg/l  |
| 4.  | pH         | 6.7         |

The cow manure had high organic content of 10.240 mg/l. The total suspended solid content of 11.675 mg/l, and volatile solid of 9.930 mg/l. The substrates then were regulated with C/N ratio of 25:1, where ini anaerobic digestion of cow manure C/N ratio usually around 20-30:1. For its pH the value was 6.7, it was close to neutral pH so it did not need initial treatment to increase the pH of cow manure.

Observation of pH during the fermentation process in fixed dome biodigester as shown in following Figure 3. Observation were carried out every 5 days for 30 days.

![Figure 3. Observation of pH in Biodigester](image)

From the figure above, at the beginning of the fermentation process until the 10th day, the pH was still relatively low it was between 6.7 to 6.9, but continued to increase to the value of 7 on day 15th in reaches 7.1 on the 25th day. However on the 30th day, the pH dropped again. These results were in accordance with the research conducted by [13], where the optimum pH in the formation of methane gas was between 7 – 7.2.

For the observation of temperature, it was shown in Figure 4, the observations were made for 30 days of fermentation. The following is an overview of the temperature profile in the biodigester.
Figure 4. The Observation of Temperature in Biodigester

From Figure 4 above, the temperature in the biodigester from the first day to the 25th day tent to increase indicating the activity of microorganisms continued to grow. On the first day, it was recorded that the temperature in the biodigester was 26ºC, then it continued to increase to 35ºC on the 20th day and the 25th day, but on the 30th day the temperature declined to 29ºC. As stated by [14] that the time of the fermentation process by \textit{mesophilic} in producing methane gas was between 20 to 30 days with temperatures between 30-40ºC.

From the results of biogas fermentation with cow manure slurry, which was carried out for 30 days of fermentation in \textit{fixed dome} type biodigesters with a range of 5, 10, 15, 20, 25 and 30 days after analysis to determine the gas composition or gas content produced from the biodigester using \textit{Gas Chromotography} (GC) analysis, the data were obtained as shown in Table 2. This analysis was carried out at PT. Pupuk Sriwidjaja Palembang.

| Day | Biogas Composition | (%) |
|-----|--------------------|-----|
| 5   | Oxygen (O\textsubscript{2}) | 0   |
|     | Nitrogen (N\textsubscript{2}) | 0   |
|     | Methane (CH\textsubscript{4}) | 0   |
|     | Carbon Dioxide(CO\textsubscript{2}) | 0   |
| 10  | Oxygen (O\textsubscript{2}) | 21.01% |
|     | Nitrogen (N\textsubscript{2}) | 70.20% |
|     | Methane (CH\textsubscript{4}) | 8.41% |
|     | Carbon Dioxide(CO\textsubscript{2}) | 0.38% |
| 15  | Oxygen (O\textsubscript{2}) | 16.96% |
|     | Nitrogen (N\textsubscript{2}) | 43.78% |
|     | Methane (CH\textsubscript{4}) | 37.42% |
|     | Carbon Dioxide(CO\textsubscript{2}) | 1.84% |
| 20  | Oxygen (O\textsubscript{2}) | 14.27% |
|     | Nitrogen (N\textsubscript{2}) | 33.41% |
|     | Methane (CH\textsubscript{4}) | \textbf{48.27%} |
|     | Carbon Dioxide(CO\textsubscript{2}) | 4.05% |
| 25  | Oxygen (O\textsubscript{2}) | 4.75% |
|     | Nitrogen (N\textsubscript{2}) | 10.97% |
|     | Methane (CH\textsubscript{4}) | \textbf{59.12%} |
|     | Carbon Dioxide(CO\textsubscript{2}) | 25.16% |
| 30  | Oxygen (O\textsubscript{2}) | 3.27% |
|     | Nitrogen (N\textsubscript{2}) | 14.98% |
|     | Methane (CH\textsubscript{4}) | \textbf{50.04%} |
|     | Carbon Dioxide(CO\textsubscript{2}) | 31.64% |
Based on data from Table 2 on day 5th from the fermentation of methane gas had not been formed. After 10 days, the results were 8.41%. On day 15th, it was 37.24%, day 20th was 48.27%, on day 25th was 59.16% and day 30th was 50.04%. Thus the longer the time, the larger the methane gas formed. However, the optimum condition in the formation of methane gas (CH\textsubscript{4}) occurred on day 25th with concentration of 59.16%. After 25 days the fermentation of the methane gas produced began to decrease. The reduction of methane gas was due to the carbon substrate was converted into biogas decreased, as stated by [14] that the time for fermentation process by mesophilic microorganisms was between 20-30 days with a temperature of 30-40\textdegree C. This biogas after the flame test produced adequately large flame.

4. Conclusion
The research on the production of biogas from cow manure using a fixed dome biodigester with batch process showed that time greatly influences the process of making biogas, the longer the fermentation process, the more methane gas produced increases. However, the optimum condition for fermentation time was 25 days with methane gas produced at 59.12%.

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