Evaluation of Main Parameter Process of Anaerobic Digestion of Cow Dung in Fixed Dome Biodigester on Methane Gas Quality

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Abstract. Methane gas produced from anaerobic digestion has been widely studied through some of the researches, but the quality of methane gas produced is still a problem because the concentration of methane gas produced is generally low. Biogas formation is a complex process involving several process parameters that must be controlled such as temperature, pH, and fermentation time. Therefore the use of biogas is still problems and it has not been widely used. This study aimed to evaluate the main parameter process of anaerobic digestion of cow dung in fixed dome biodigester on methane gas quality. The research was carried out for 30 days and every 5 days the quality of methane gas (CH_4), organic content (COD) and total solids (TSS) were analyzed. From the results of the study, it was found that temperature, pH, and fermentation time greatly effect on biogas produced. at high methane gas concentrations (59,12%) occur at pH 7.1, temperatures 35_0 C and fermentation time of 25 days. Besides that the longer the fermentation time, the COD and TSS content decreases and the concentration of methane gas increases.

Keyword: Organic content, total solid content, biogas, gas methane, cow dung

1. Introduction

Waste material including biowaste is a product that cannot be avoided from human activities. Various techniques have been used to manage and reduce the amount of biomass. Some technologies such as gasification, pyrolysis, inceneration and land filling are among the most widely used in various countries to convert solid waste such into energy, but there are still effects on the environment that are difficult to avoid [1].

Anaerobic digestion is a biochemical process in which several groups of microorganisms degrade organic matter into a mixture of gases that mainly consists of methane gas and carbon dioxide called biogas in an oxygen-free environment. Anaerobic digestion is usually used for animal dung

management for two reasons where emissions of methane related to the atmosphere will be reduced. Anaerobic digestion consists of four stages [2]:

(1). Hydrolysis: In this step serves the purpose rendering organic macromolecules into its smaller components (carbohydrates, fats, and proteins) into monomers (sugars, long chain fatty acids, and amino acids);

(2). Acidogenesis: In this step, the dissolved compounds present in cells of fermentative bacteria convert simple monomers into volatile fatty acids (VFAs), alcohols, lactic acid, CO_2, H_2, NH_3, and H_2S;

(3). Acetogenesis (intermediary acid production): In this step, digestion products (higher volatile fatty acids) are transformed into acetate, H_2, and CO_2, as well as new cell material;

(4). Methanogenesis: In this stage, acetate, hydrogen plus carbonate, formate or methanol are converted into methane, CO_2 and new cell material.

Acoording to [1], anaerobic digestion are conducted by various groups of microorganisms. Complex organic compounds are first hydrolyzed through enzymatic reactions to monomers, such as glucose, amino acids, and long chain fatty acids (LCFAs), and they are subsequently converted in the acidogenic pathway to volatile fatty acids, H_2, and acetic acid. During the metabolic pathway of β oxidation, LCFA break down in multiple stages to H_2. The acetogenic bacteria convert volatile fatty acids to H_2, CO_2, and acetic acid in acetogenesis stage. In homoacetogenesis, hydrogen is used to reduce carbon dioxide to acetate. In the last, methanogens convert H_2, CO_2, and acetate to CH_4 and CO_2. These pathways are shown in Figure 1.

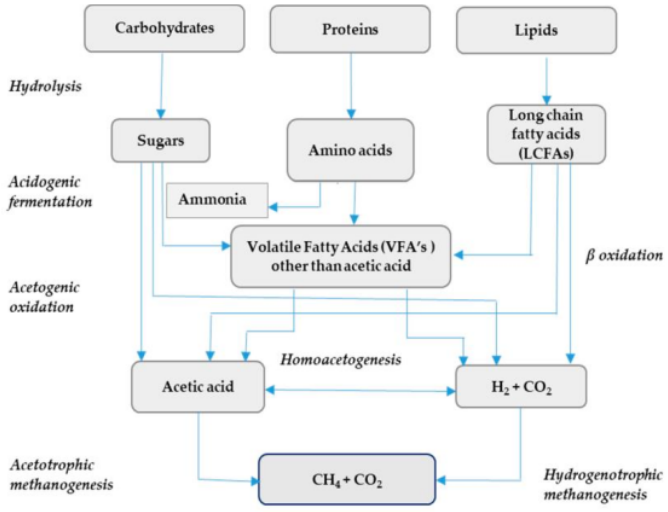

Figure 1. Pathway of anaerobic digestion for biomethane production

Global energy supply is still very dependent on fossil fuel sources such as crude oil, coal and natural gas. The fuel source is non-renewable and is limited because it cannot be renewed. To cope with

the depletion of the world fossil fuel reserves, efforts are needed to diversify energy sources. The excessive use of fossil fuels has an impact on the environment because it causes CO_2 emissions of greenhouse gases into the air. One source of energy that can be renewed and can be used for gas fuel is biomass. There are many of biomass that can be utilized as biogas including livestock waste such as cow dung. Utilization of cow dung into biogas is also one of the solutions to sanitation and environmental health problems, especially around the livestock area [3]. By processing organic waste such as cow dung into biogas, uncontrolled methane gas emissions from anaerobic decomposition can be avoided. Methane is about 21 times more powerful at warming the atmosphere than CO_2 and Methane chemical lifetime in the atmosphere is approximately 12 years, compared with approximately 100 years for CO_2 [4].

According to [5], biogas technology is not a new technology in Indonesia, but until now there has not been an encouraging development. The use of biogas as a source of energy so far has been aimed at people who have not yet received adequate fossil energy services such as far from urban areas and in an area where people have a cow so they need to use cow dung into energy. The use of biogas as an energy source has good potential because of the abundant amount of raw materials and energy needs that also continue to increase. The composition of biogas produced in a biodigester varies depend on feedstock types, even though it usually contains CH_4 50 - 75% , CO_2 25 - 45%, H_2 <1%, O_2 < 2%, N_2< 2, water vapor 2-7% and H_2S <1% [6].

To produce biogas from cow dung a biodigester that needs a well-controlled process such as temperature, pH, fermentation time and substrate conditions of biogas feedstock must meet a C/N ratio between 10-30 [6]. Based on [7] The environmental factors that are important in the process of anaerobic digestion include temperature, pH, buffering systems, retention time, process configuration, solubility of gas, avaliability of nutrient and the precence of toxic component in the process. In the present study temperatur, pH, time of fermentasi has been investigated for 30 days in fixed dome biodigester using cow dung as substrat and evaluated methan gas production. COD and TSS controlled during the process.

2. Research Methods

The study was conducted in fixed dome biodigester as the principles reactor as shown in Fig.2 The capacity of the biodigester was 500 liters. Biodigester was equipped with inlet, outlet, temperatur control, pH control, pressure control and gas holder.

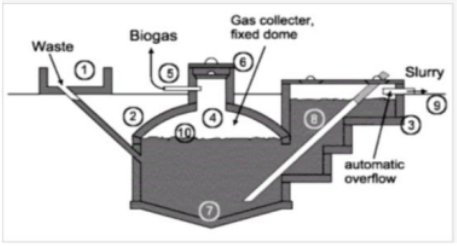

Figure 2. Principles of Fixed Dome Biodigester

Cow dung sampless were collected from cattle farm in Palembang city. The cow dung was blended with water at the ratio 1:2 and loaded to biodigester. Before cow dung is feed into a biodigester, the raw material analyzed includes pH, temperatur, COD, TSS, Nitrogen and water content. C/N ratio of raw material was setting at 25:1 that it was commonly used as characterization of nutrients. Anaerobic digestion process was carried out for 30 days. In the period of five days, an analysis of pH, temperature, COD, TSS and biogas composition was analyzed. The effective biodigester volume used is 80% of the total volume and the remaining space is 20% for biogas space.

Laboratory equipment used in this study includes COD refluks, ovens, furnaces, porcelain cups, pH meters, and gas chromatography (GC). While the materials used are cow dung, water, $K_2Cr_2O_7$, H_2SO_4, FAS, $HgSO_4$, $AgSO_4$, NaOH, HCL, K_2SO_4, boric acid, and HgO. Parameter analyzed were COD and TSS according to SNI methods. COD using SNI method No:06-6989.15.2004 and TSS using SNI method No: 06-6989.3.2004. Biogas composition is measured using Gas Chromatography (GC) equipment.

3.Result and Discussion

3.1 The Main Parameter in Anaerobic Digestion

According to [8-9] in most cases, the anaerobic transformation of organic matter is achieved most efficiently at a netral pH and at low value of pH (5-6) will inhibit the growth of methanogenic bacteria. From the results of the study it can be seen that during the anaerobic digestion pH the process is in the range of 6.7 to 7.1. The following in Table 2 is the relationship between temperature, pH and time of fermentation to methane gas produced.

Tabel 1. Relation between the main parameter to CH_4 concentration

Time (day)	Temperature ($_0$C)	pH	CH_4 (%)
0	26	6,7	0
5	30	6,8	5
10	30	6,9	8,41
15	33	7,0	37,42
20	33	7,0	48,27
25	35	7,1	59,12
30	29	6,9	50,04

At a low pH of 6.8 methane gas produced 5% and at a high pH of 7.1 methane produced 59,12%. However fermentation time is very influential where the longer the fermentation time the methane gas concentration increases. It can be concluded that the highest concentration of methane gas is achieved at a neutral pH of 7.1.

Temperature during the anaerobic digestion process in this study was in the range of 26$_0$ C to 35$_0$ C. As temperatur increases, the biochemical reaction takes places at heigher rate. The optimum temperature achieved in producing the largest methane gas was 35$_0$ C. The type of microorganism in this anaerobic digestion is mesophilic microorganisms, base on [8] optimum temperature of mesophilic in range of 30$_0$C-40$_0$C.

Fermentation time or Retention time (also known as Hydraulic retention Time, HRT) is the average period that a given quantity of inputs remains in the digester to be acted upon by the methanogens. In this study, the fermentation process was carried out for 30 days and base on the data on Tabel 1 the optimum time of fermentation was obtained at 25 days with methane gas concentration was 59,12%.

3.2 Organic Content (COD)

Chemical oxygen demand (COD) reflects the number of organics compound present in the slurry of cow dung. COD content at the beginning of fermentation of cow dung in the fixed dome biodigester was 30.800 mgl /l and on the 25th day it became 7.400 mg /l. The efficiency of anaerobic digestion can also be evaluated using COD, COD reduction can be reflective of the amount of degradation taking place within anaerobic digester [9]. Anaerobic digestion stabilizes the organic matter and reduced patogens, odor, total solids by converting part of volatile solid fraction into biogas [10]. COD content at the time of fermentation can be seen in Figure 3. Based on Figure 4, the longer the fermentation time, the lower COD content.

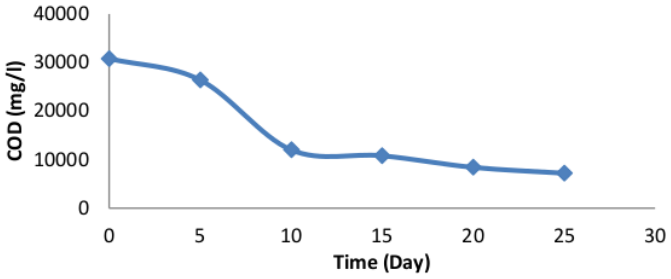

Figure 3. COD Content Versus Fermentation Time

3.3 Total Suspended Solid Content (TSS)

Total suspended solids (TSS) in this study was measured dry matter in the slurry of cow dung. TSS is the attribute of digester operation. TSS content at the time of fermentation can be seen in Figure 4. It is can be seen that the longer the fermentation time the TSS content will decrease. The decrease in TSS shows the decomposition performance of organic compounds in the biodigester.

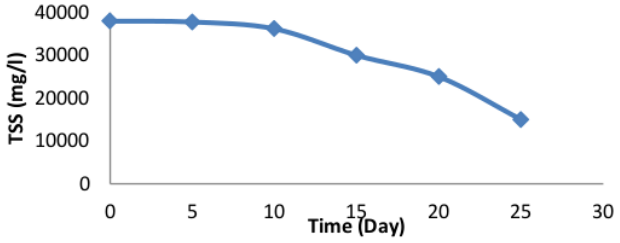

Figure 4. TSS Content Versus Fermentation Time

4. Conclusion

The main parameters of anaerobic digestion for pH, temperature ,fermentation time and organic content greatly influences the production of methane gas. The optimum condition in the formation of methane gas is at pH 7.1, temperature 35$_0$C and fermentation time of 25 days. The heighest methane gas concentration at the optimum condition is 59,12%. The degradation of organic content of cow dung into biogas can also be seen in decrease in content of COD and TSS on the fermentation time.

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