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Biogas from Mesophilic Anaerobic Digestion of Cow Dung Using Kaolin as an Additive

Mohammed Liaket Ali[1], Bodius Salam[2] and Sk M Fahim Shakil[3]

Bio-gas is produced due to bio-degradation of organic materials under anaerobic condition which means oxygen free environment. This research work was conducted to find out the production ability of bio-gas from mesophilic anaerobic digestion of cow dung (CD) using kaolin as an additive. Five laboratory scale digesters were constructed to digest cow dung. Each of the digesters had a capacity of 1 liter and made of glass conical flask. In the experiment 311 gm. of cow dung and 389 gm. water was used. Kaolin was added in four of the digesters with an amount of 0.4, 0.6, 0.8 and 1% (w/w). and one digester was used for digestion of cow dung without kaolin. The digesters were fed on batch basis. Total solid content was maintained 8% (wt.) in the slurry for all the observations. All the digesters were maintained at ambient temperature of 27 – 32℃. Retention time was maximum 54 days for the digestions. With the addition of kaolin total biogas production was found to be increased from 3 to 15% as compared to pure cow dung digestion with 0.6% kaolin gave maximum increase. Maximum 1373 ml/day.kg CD gas was produced on the 49th day and maximum total gas was produced 14373 ml/kg CD for addition of 0.6% kaolin. Whereas without kaolin maximum 608 ml/kg cow dung gas was produced on the 52th day with total gas of 12527 ml/kg cow dung.

Keywords: Biogas; anaerobic; mesophilic; cow dung; additive**.**

1. Introduction

Interest in biogas technology is increasing around the world due to the requirements for renewable energy production, reuse of materials and reduction of harmful emissions. Biogas technology offers versatile and case-specific options for tackling all of the challenges with simultaneous controlled treatment of various organic materials (Luostarien et al, 2011). It produces methane-rich biogas which can be utilized as renewable energy in various ways. It composes of 55-65% methane, 35-45% carbon dioxide, 0-3% nitrogen, 0-1% hydrogen, and 0-1% hydrogen sulfide (Milono et al., 1981). The residual material, digestant, contains all the nutrients of the original raw materials and offers a way to recycle them. Along the process steps, also emissions directly from the raw materials (storage, use, disposal) or from the replaced products (fossil fuels, inorganic fertilizers) can be reduced. By anaerobic digestion process the significant methane emission resulting from the uncontrolled anaerobic decomposition of organic waste into atmosphere would be stopped, where methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide.

[1]Mohammed Liaket Ali, Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh, Email: mohammedliaketcuet10@gmail.com
[2]Bodius Salam, Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh, Email: bsalam@cuet.ac.bd
[3]Sk M Fahim Shakil. Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh, Email: fahimmainam@yahoo.com

The paper is organized as follows. Section 1 presents the introductory basic things about the Bio-gas production and a lump-sum literature review on this issue. Section 2 describes the preparation for the experimental setup and the experimental procedure. Section 3 discusses the outcomes of this experiment, analyzing and optimizing the data to find out the best outcome. Section 4 presents final outcomes of the experiment and the effects of the new technique in the result in compare with the previous experiments as well as the future aspect of the experiment.

2. Literature Review

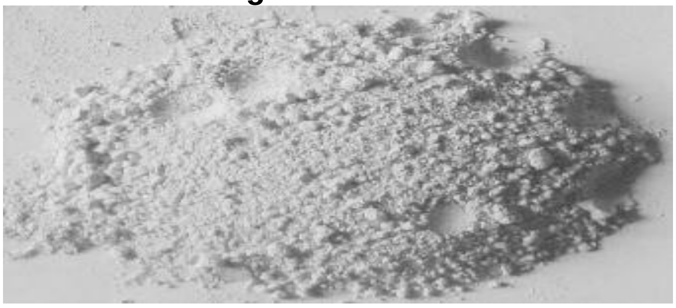
The production of biogas will reduce the use of fossil fuels, thereby reducing the carbon dioxide emission. This is thus in accord with Kyoto Summit agreement (Mata-Alvarez et al., 2000). Anaerobic digestion is in principle possible between 3ºC and approximately 70ºC. Differentiation is generally made between three temperature ranges: the psychrophilic temperature range lies below 20ºC, the mesophilic temperature range between 20ºC and 40ºC, and the thermophilic temperature range above 40ºC (ISAT). The biogas production under meshophilic condition found to be maximum between 37 and 40ºC (Patel and Madamwar, 2002; Desai et al., 1994). But when the digester is operated at atmospheric condition the gas generation goes down when the ambient temperature goes down. One way of increasing gas production is the inclusion of additives. Patel et al. (1992) used kaolin to see the effect of it on gas production from water hyacinth and cattle dung. Osueke et al. (2013) investigated the effect of kaolin on biogas production from cow dung. McCrory and Hobbs (2000) showed the use of additives to reduce odor and ammonia (NH_3) emissions from livestock wastes. Herrmann et al. (2011) demonstrated an experiment on biogas production capability of a plant by using silage as an additive. Effect of resin addition on biogas fermentation were esteemed using resin with similar specific surface area and different electric charge to elucidate mechanism of resin addition (Wang et al., 2010-1). Unlike the other research in this project the increase of bio-gas from anaerobic digestion of cow-dung by using an additive named kaolin was investigated. The maximum gas production was obtained by using optimum amount of kaolin. The scope of the present work was to conduct research in the laboratory scale to produce biogas from mesophilic anaerobic digestion from cow dung using kaolin as additive.

3. Materials and Methods

3.1 Source of Cow Dung and Slurry Preparation

The cow dung (CD) for this research work was collected from the area inside Chittagong University of Engineering and Technology campus. The total solid content of cow dung was determined by heating cow dung at 115ºC in oven for 42 hours (Salam et al., 2015). And the total solid (TS) content was found to be 18%. Normally total solid content of fresh cow dung varies between 15 – 19% (Shyam, 2001). For preparing the slurry 8% of total solid content was maintained by adding water. Solid contents in the range 7 – 9% were considered to be optimum by many researchers (Madamwar et al., 1990; Santana and Pound, 1980; Otaraku and

Figure 1: Kaolin

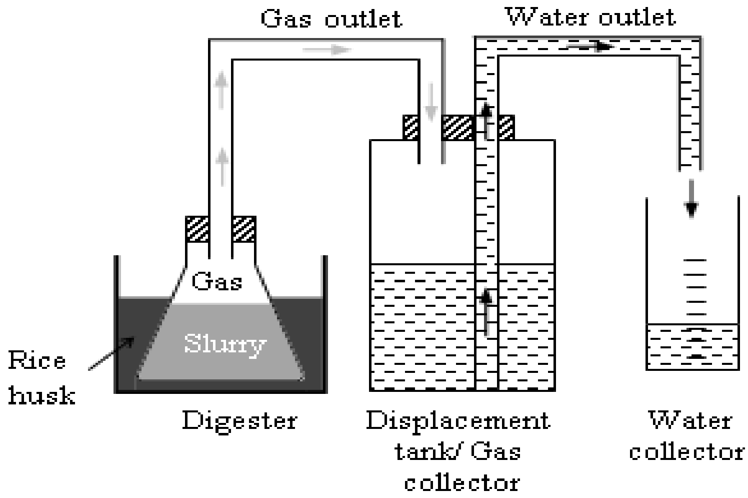


Ogedengbe, 2013). For each experiment 700 gm. slurry was prepared from 311 gm. of.cow dung and 389 gm. of water. Kaolin was added with an amount of 2.8, 4.2, 5.6 and 7 gm. in the four digesters to get kaolin concentration with respect to slurry 0.4, 0.6, 0.8 and 1% respectively and one digester was used without adding kaolin. Figure 1 shows picture of kaolin used.

3.2 Experimental Set-Up and Procedure

For this experiment five laboratory scale experimental set-up were fabricated for investigating the effect of kaolin on anaerobic bio-gas production. In the set-up digesters were made of glass conical flask with capacity of 1L. In four of the digesters kaolin were added as additive with different amounts (2.8, 4.2, 5.6, 7 gm.). And in one digester no kaolin was added. All the set-ups were placed in the Heat Engine Laboratory of Mechanical Engineering department of CUET. The schematic diagram of the set-up is shown in Figure 2. The digesters were connected with displacement tank / gas collector and water collector. As methanogenic micro-organisms were very sensitive to temperature fluctuation the digesters were kept in the containers and covered with rice husk to keep the digesters temperature stable. Plastic pipes were used to connect the digesters and the displacement tanks. The gas produced in the digester passed through the pipe to the displacement tank. Another plastic pipe was used to take the displaced water from the displacement tank to the water collector which fitted air tight in the displacement tank and inserted up to bottom part of it. Digestion was done at ambient temperature. During the investigation the volume of the produced gas was measured with the help of water displacement method (Salam et al., 2011), considering the volume of the produced biogas was equivalent to the displaced water in the water collector. The digesters were operated in batch mode and fed manually. At the time of experiments, these were ensured that the digesters were fully gas tightened. M-seal was used to make the digesters perfectly gas tightened.

Figure 2: Schematic Diagram of the Experimental Set-Up for Anaerobic Digestion of Cow Dung.



4. Results and Discussions

Figure 3 shows that total gas yields for both anaerobic digestion of cow-dung without kaolin (WOK) and with kaolin (WK). Four of the curves in the graph are for the anaerobic digestion of cow dung with kaolin as different amount of kaolin was added to prepare the samples. Data were taken for collected gas and room temperature for the digestion set-ups between 23/04/2015 and 21/06/2015. During the data taking period ambient temperature varied from 27 – 32^oC with average temperature 29.5^oC. From the Figs. 3 and 4 these are shown that in every cases gas productions started from the 3rd day. The gas production continued for maximum up to 54 days. Without using kaolin maximum 608 ml/kg cow dung gas was produced on the 52th day, Fig. 4, and total gas produced was 12527 ml/kg cow dung. Using 0.4% kaolin resulted maximum of 740ml/kg cow dung gas produced on the 49th day and total gas produced was 12862 ml/kg cow dung. In case of 0.6% kaolin maximum 1373 ml/kg cow dung gas was produced on the 49th day and total gas produced was 14373 ml/kg cow dung. Adding 0.8% kaolin resulted maximum of 772 ml/kg cow dung gas produced on the 53th day and total gas produced was 13633 ml/kg cow dung. And 1% kaolin addition produced maximum of 450 ml/kg cow dung gas on the 49th day and total gas produced was 13164 ml/kg cow dung. From Fig. 4 it is shown that no significant differences were found from the digestions of five different samples for daily gas production except some fluctuation in the last part. This part is from 46 days to 53 days. All the maximum gas production took place between 49 and 53 days. Figure 5 shows the effect of kaolin amount on total gas production. With the increase of kaolin addition total gas production was found to be increased as compared to that of without kaolin addition up to 0.6%, but after that increase of kaolin addition resulted in decrease of total gas production. At 0.6% kaolin addition 15% enhancement of total gas was observed as compared to that of without kaolin. Patel et al. (1992) found 7 gm/litre kaolin addition to be the optimum for gas production when they digested water hyacinth and cow dung at 37±1^oC. Osueke et al. (2013) used 0.8% kaolin additive to enhance biogas generation from cow dung. They obtained 48% enhancement of total gas production as compared to control.

Figure 3: Production of Total Gas at Various Observed Day for Different Condition of Digestion

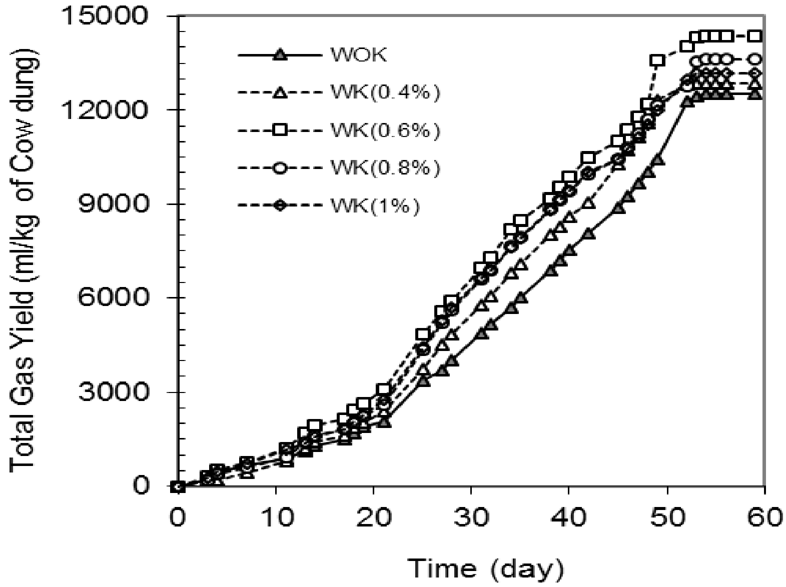


Figure 4: Production of Gas Produced Per Day at Various Observed Day for Different Condition of Digestion

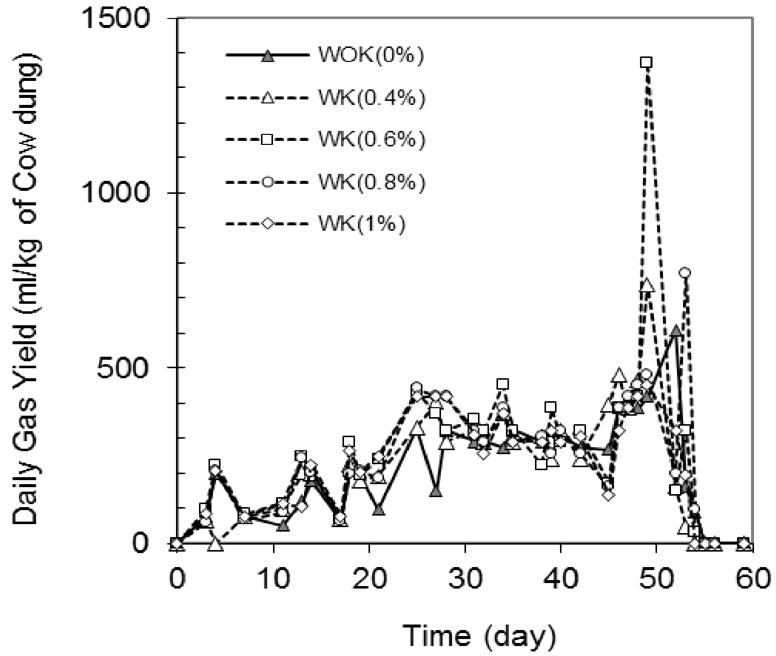
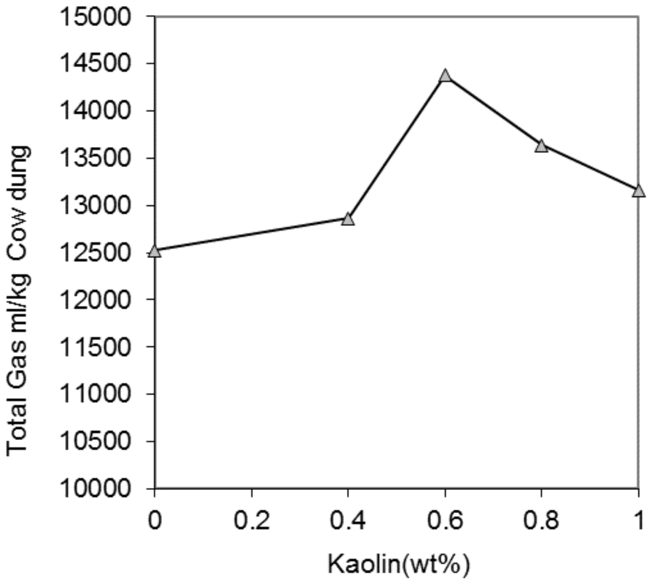


Figure 5: Effect of Kaolin on Total Gay Yield



5. Conclusions

The effect of kaolin additive on anaerobic mesophilic digestion of cow dung was investigated using batch type 1 liter digesters. Digestions were done at ambient conditions of temperature 27 – 32^{o}C with average temperature 29.5^{o}C. The maximum enhancement of 15% total gas production for using 0.6% kaolin additive as compared to control was observed. In industrial production of biogas the outcome of this experiment can be implemented for increasing the gas production. The outcome of this work can grow the interest on further study of biogas production using cow dung and kaolin as additive. Temperature has significant effect on biogas production from anaerobic digestion. Desai et al. (1994) reported maximum gas production at 40^{o}C. Further research should be done to see the effect of temperature on biogas production from cow dung using kaolin as additive.

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