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Experimental Study on Key Factors Affecting Dairy-based Gas Production

Jian Lv [a], Yang Liu [a]*, Hongxing Yang [b] and Shengfeng Ren [a]

[a]*Tianjin Chengjian University, Jinjing Road No.26, Xiqing Distric, Tianjin, 300384, China*
[b]*Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China*

Abstract

Fermented cow dung as raw material can be used for biogas generation from cattle ditch bottom sludge inoculum. In a small homemade device, cyclical experiments have been conducted to study the effects of temperature and concentration of the material on cow dung anaerobic fermentation and gas production. The results show that at lower temperature fermentation methane gas production as feed concentration increases. With increasing temperature, the concentration of the biogas changes as well. When the concentration is about 7%, the optimum temperature of biogas fermentation is 34℃, with a total gas production of 2290ml and 2594ml. When the concentration is 10%, the biogas fermentation optimum temperature is 40 ℃, and the total gas production is 3757ml. The research will provide a preliminary result for further studies in this area.

Keywords: cow dung anaerobic fermentation; temperature; concentration; gas production

Introduction

Biogas originally was used for cooking and lighting, and now it is used for tri-generation and attracts more and more people's attention. A lot of factors would affect the anaerobic fermentation, including feed type and concentration, temperature, pH value, inoculums and stirring [1,2,3]. Biomass fermentation temperature should not be lower than 10℃, the maximum temperature should not exceed 65℃ [4]. It is studied that if anaerobic fermentation is in a constant temperature, the temperature fluctuations within an hour should not exceed 2℃~5℃. If short time temperature change exceed 5℃, biogas production decreased significantly. Once volatility is too large, gas production may cease [5, 6,7].

Cow dung is used as raw material and cattle sludge is used as inoculum in this study. The effects of temperature and concentration on gas production performance are observed.

Materials and Experimental Designation

1.1. Materials

The raw material of this experiment is fresh cow dung, taken from the fourteen dairy farm of Tianjin Jia Li He Animal Husbandry Limited Company. Before the experiment, the material was placed in an oven in the constant temperature of 120℃, and then the water concentration is calculated. According to

* Yang Liu.Tel.: 13820172757
*E-mail address:*liuyang1126_tj@163.co

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the different concentrations of this experiment, then the weigh calculated. Inoculum is also from the dairy farm, the sludge from the rodeo gutter.

Fermentation devices are saline bottles with the volume of 250ml. In the experiments, the bottle is filled to the line of 250ml with configured fermented liquid to ensure that the raw material for fermentation experiments in each group have the same amount. The bottles are sealed with glove and vacuumed with a syringe to ensure the strict anaerobic environment. The method of gas collection is drainage, and infusion tube is used to guide the gas to a bottle which is filled of water. To reduce the influence of the gas pressure, gas production is collected twice a day, 9 a.m. and 9 p.m. respectively.

1.2. Experiment

After retrieving the raw material, it is put in the laboratory for 10 days to pre-treatment. The fermentation temperature is 31℃, 34℃, 37℃, 40℃ and 43℃ respectively, and the concentration of fermentation are supernatant of sedimentation tanks. The sample with sedimentation and the concentration of 6%, 8% and 10% are named as No.1, No.2, No.3 and No.4 respectively. The Supernatant is the fermentation material of the dairy farm, and it is set as control group. Shock the fermentation bottles every three hours to make the fermentation liquid mix uniformly and to prevent the obvious delamination.

Then the devices mentioned above is put in the thermostat to conduct the fermentation experiment, and the fermentation period are 26 days. The fermentation gas productions of all devices are measured from the third day.

The Effect of Temperature on The Fermentation Gas Production at The Same Concentration

Under the same concentration mentioned above, with different temperature, gas productions are also different. Processed experimental data and the daily gas production of supernatant when the concentration is 6%, 8% and 10% is shown below:

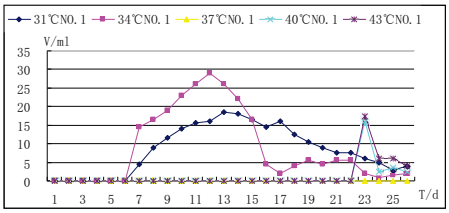


Fig.1 Daily gas production of supernatant

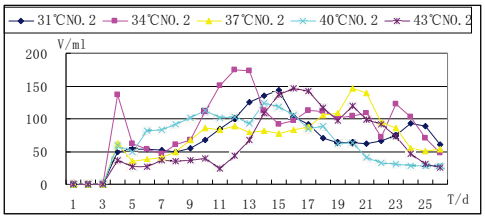
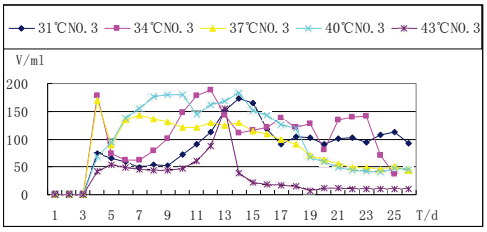


Fig.2 Daily gas production of 6% concentration

As can be seen from Figure 1, the supernatant at 31 ℃ and 34 ℃ had more gas production and the gas production peak occurred on the 12th day of fermentation; it has very little gas production at the temperature of 40℃ and 43℃, and the time of gas generation was relatively later; on the contrary, at the temperature of 37℃ there was no gas production. As can be seen from Figure 2, at the concentration of 6%, while gas production did not change regularly every day, but at the same temperature the change of gas production had the same trend each day. At the temperature of 34℃, the gas production was maximum and gas production peak was the earliest and had a long duration. At the temperature of 31℃, 40℃ and 43℃, gas production peak appeared almost at the same time, the 15th day of the fermentation. While at the temperature of 37℃, the gas production peak was on the 20th day, relatively lag. In the case of sufficient materials, it can be fermented to produce more methane in a short period of time at 34℃.



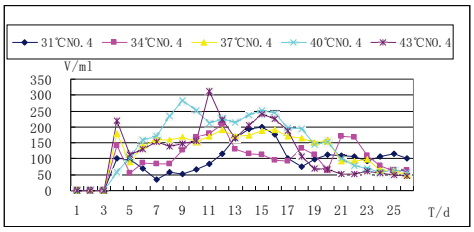
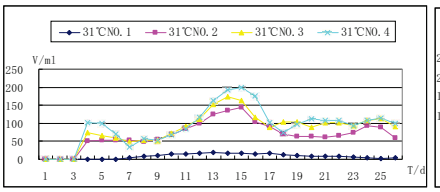


Fig.3 Daily gas production of 8% concentration Fig.4 Daily gas production of 10% concentration

From Figure 3 it can be found that at the concentration of 8%: on the 6th day of fermentation, the device of 37℃ had reached peak gas production, while the gas production was less. The device of 34℃ and 40℃ had the maximum peak gas production, although it declined quickly. But it can be maintained for a longer time with higher gas production. The peak of the device of 31℃ and 43℃ came on the 14th day, however, the peak duration is too short, and gas production is less. As can be seen from Figure 4, at the concentration of 10%, it had the shortest time to reach the maximum gas production at the temperature of 40℃, and it can sustain larger gas production in a long time, the fermentation is the most satisfying. If it is continuous fermentation, the 16th day was the best feeding time. It produced more gas at the temperature of 43℃, but the peak time is shorter, what is more, the pre-fermentation had less gas production. For the rest temperature, the peak gas production came relatively later, and the daily gas production was relatively small.

The Effect of Concentration on Gas Production at The Same Temperature

At temperature of 31℃, 34℃, 37℃, 40℃ and 43℃, gas productions of different fermentation concentrations were studied. The results were shown in the following figures, respectively:



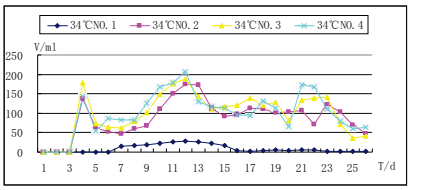
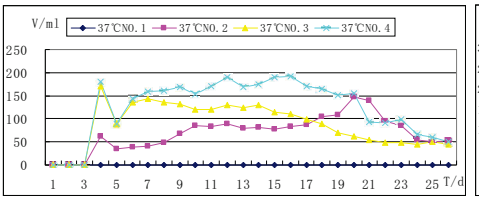


Fig.5 the gas production of 31℃ Fig.6 the gas production of 34℃

As was shown from Figure 5, the daily gas production was increased with the increasing of the concentration, and the peak gas production occurred on the 15th day approximately. The gas production of supernatant was far lower than the other concentrations and the concentration of 8% and 10% almost had the same gas production. As can be seen from Figure 6, it has the same trend of daily gas production with different concentrations. All gas production peak occurred on the 12th day, and they had the same daily gas production except for supernatant.



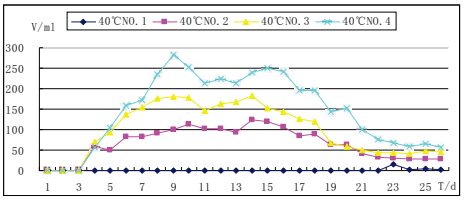


Fig.7 the gas production of 37℃ Fig.8 the gas production of 40℃

It can be found from Figure 7 that at 37℃ the device with concentration 10% was the first to reach peak gas production and lasted for the longest time. The yield was significantly greater than the other gas concentration. After the device of 8% reached peak gas production, the daily gas production tended to decline. The device with concentration of 6% had become a rising trend until the 20th day on which it was the peak gas production. The reason for this phenomenon may be that the number of methanogenic bacteria was in constant number, the greater the concentration, the more organic matter, the greater the gas production. Figure 8 showed that all the devices with concentration of 6%, 8% and 10% reached peak gas production on the 9th day with the same gas production. The higher the concentration is, the bigger daily gas production is. While the supernatant produced little gas on the later period of the experiment.

As seen from Figure 9, the peak gas generation of the concentration of 6% occurred later , but the duration time was relatively longer to the concentration of 8% (only three days) , and the gas production

was also more than that of 8%. The gas production of 10% concentration from the 5th to the 18th day was higher than 100ml, and had a relatively higher gas production.

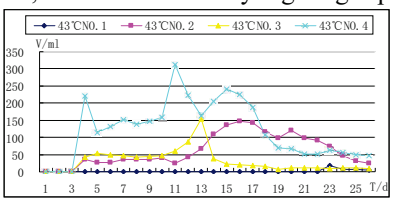


Fig.9 the gas production of 43℃

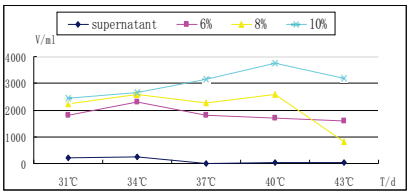


Fig.10 The total gas production comparison chart

Overall, the supernatant used for fermentation had less gas production and wasted fermentation of raw materials, which in theory was not scientific and desirable in engineering.

Comparison of The Total Gas Production

Analysis the amount of the biogas generated by the fermentation process, the curve shown in Figure 10 can be obtained.As shown in the chart, the higher gas production was not because of the higher temperature or the bigger concentration. The effects of temperature and concentration on gas production were a mutual restraint factor. But it was not difficult to find the match case between them: the optimal temperature of the device with 6% concentrate to produce biogas was 34℃; the gas production of 8% concentrate was almost equal at the temperature of 34℃ and 40℃, while between them the gas production was a little decline. From the viewpoint of economy and the consumption of energy, 34℃ was the optimal temperature. The device with 10% concentrate had the maximum gas production at the temperature of 40℃, that is, 40℃ was the optima temperature for 10% concentrate.

Conclusion

From the experiment of temperature and concentration, it can be obtained that:

① The dairy farm anaerobic fermented with supernatant, which can obtain very little biogas and is a waste of fermentation material. This experiment has a value of reference on the factor of temperature and concentration.②The optimal temperature of caw dung with concentration of 6% and 8% is 34℃, both of them can reach peak gas production on the 12th day. All the projects are continuous fermentation, if this temperature and concentration are used, the refueling cycle is 12 days, which can promise the maximum gas production.③The optimal temperature of caw dung with concentration of 10% is 40℃, and the peak gas production occurs on the 9th day. Because of its long duration, the refueling conducts on the 16th day, which can promise the largest gas production.

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