BIOGAS YIELD FROM AEROBIC HYDROLYSIS USING BIOGAS PLANT DIGESTATE

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Abstract. To find out how full the conversion rate of biomass for biogas production process is if aerobic hydrolysis in anaerobic digestion technology is used, a study was conducted using laboratory equipment. 6 bioreactors were filling a batch mode at 40 ºC fermented digestate, which was taken from normal functioning of the biogas production plant. The same digestate was fermented and another 5 bioreactors at 18 ºC temperature. On average, 40 days fermentation at 40 ºC were obtained even 242 $l \cdot kg_{dom}^{-1}$ biogas (119 $l \cdot kg_{dom}^{-1}$ methane) and at 18 ºC – 43 $l \cdot kg_{dom}^{-1}$ biogas (9 $l \cdot kg_{dom}^{-1}$ methane). The study shows that the digestate is still possible to gain a significant amount of methane and appropriate to provide a heated post digester not only cover the lagoon.

Keywords: biomass, anaerobic digestion, biogas, aerobic hydrolysis, methane.

Introduction

One of the most advanced methods of energy production from biomass is anaerobic digestion [1]. Biogas is a product of great value and its production technology does not increase carbon dioxide emission and is environmentally friendly. Today in Latvia more than 50 biogas plants are running. They use technology developed in Germany [2] and German -built equipment. Many projects do not take into consideration the differences in climatic conditions and provide too optimistic biogas yield from raw materials. In order to achieve the designed capacity larger quantities of raw materials are used, but in many cases it destroys the anaerobic digestion (AD) process stability. It is believed that the importance of a rapid and as complete as possible raw material for hydrolysis is significant [3]. In the majority of working biogas plants in Latvia hydrolysis occurs in the bioreactor with other stages of AD. The methane -forming bacteria and hydrolytic optimal breeding conditions are different and therefore they can be usefully placed in different bioreactors. Such biogas production plants are also working in Latvia. Several of them use aerobic hydrolysis, which is fed to the air, according to the authors [6] it will be rapid and complete decomposition of organic matter .

For aerobic organic matter degradation oxygen is needed. The dissection performes aerobic bacteria that inactivate the absence of oxygen or die. The biochemical reaction is as follows:

$$CH_2O + O_2 \text{ ---- } CO_2 + H_2O + \text{bacterial cells (sludge)}. \quad (1)$$

Partition is intense and about 50 % of the weight of the filling can move the sludge. Organic compounds are rapidly mineralized and therefore this technology is well suited for wastewater treatment.

Anaerobic fermentation to produce methane requires gradual decomposition of organic matter by different types of bacteria [4]. First, a composite of organic material is broken down into simpler compounds. This is done by hydrolytic and acid -forming bacteria.

$$CH_2O \text{ ---- } H_2O + CO_2 + \text{acids} + \text{alcohols} + \text{cells}. \quad (2)$$

Then, the end products are used by other groups of bacteria that produce acetic acid. Acetic acid, methane -producing bacteria are used and it is the main way (78 %) how methane is produced.

$$CH_3COOH \text{ ---- } CH_4 + CO_2. \quad (3)$$

The second major pathway for methane production is connecting hydrogen with carbon dioxide directly. This is possible at low hydrogen partial pressure.

$$CO_2 + 4H_2 \text{ ---- } CH_4 + 2H_2O. \quad (4)$$

In anaerobic fermentation the bacterial cell mass is only about 5 % of the original substance.

In practice from stable working biogas plants using aerobic hydrolysis, digestate is obtained with relatively high dry matter content. The aim of this study was to find out how much of this digestate biogas can still be obtained under normal operating temperatures, as well as if it can be used in unheated capped lagoon.

Materials and methods

Investigations on laboratory equipment with different temperatures were carried out using one method. The digestate from a stable working biogas plant, which uses aerobic hydrolysis technology, was used for both investigations. The average digestate was taken and the Latvia University of Agriculture, Bioenergy Laboratory determined the composition of the substrate using ISO 6496:1999. The digestates were analysed for dry matter (total solids) (TS), dry organic matter (Dom), ash content and chemical composition. The analysis was measured by using standardized methods [5].

All digesters were connected to the gas storage facilities and taps; the digesters were operating in batch mode. The data of gas volume and composition were registered every day. Also the digestate was weighed and the pH value, total solids (TS), ash content and dry organic matter composition (Dom) were determined. Fermented cow manure was used as inoculum in all reactors. All bioreactors were positioned in heated cameras Memmert having automatic temperature control at ±0.5 ºC accuracy. Fermentation was provided in a period up to 30 days or until no biogas was released from reactors.

Dry matter, ashes content and pH level were measured before and after the anaerobic fermentation process. Biomass weight was measured on the scales Kern16KO2 FKB having accuracy ±0.2 g. Measurement of pH level was provided by help of equipment PP-50. By help of specialized unit Shimadzu the biomass samples were dried for moisture and total solid content at temperature 120 ºC with mass weighting accuracy ±0.001 g.

Ashes for volatile solid content evaluation were measured by help of the oven Nabertherm at temperature 550 ºC. Biogas from every reactor was guided into external storage bags for gas volume measurement and analyses of gas composition. Gas composition, e.g., methane, carbon dioxide, oxygen and hydrogen sulphide content, was measured with the gas analyser GA 2000. Standard error was estimated by help of standardized data processing tools for each group of digesters.

1. Anaerobic digestion at 40 ºC

All 6 bioreactors (R1, 2, 3, 4, 12, 14) were filled with 500 g similar digestate each and positioned in the heating camera and anaerobic digestion temperature was 40±0.5 ºC.

Results and discussion

The results of analysis of raw materials are shown in Table 1, digested digestate in Table 2. Biogas and methane yields are shown in Table 3 and Fig. 1.

Table 1

Raw material analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
R 1,2,3,4,12,14	7.59	7.51	37.55	22.18	77.82	29.22	500

Table 2

Average results of digested digestate analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom digested, g
R1	7.45	4.45	21.04	22.29	77.71	16.36	473.0	12.86
R2	7.37	4.50	21.15	20.12	79.88	16.89	470.0	12.33
R3	7.57	4.49	21.35	23.81	76.19	16.27	475.4	12.95
R4	7.35	4.35	20.65	23.86	76.14	15.71	474.6	13.51
R12	7.34	4.30	20.30	22.20	77.8	15.79	472.0	13.43
R14	7.41	4.75	22.57	21.37	78.63	17.75	475.2	11.47

Table 3

Biogas and methane yield

Digester	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$ added	Methane, %	Methane, l	Methane, $l \cdot g_{dom}^{-1}$ digested	Methane, $l \cdot g_{dom}^{-1}$ add
Average R1,2,3, 4,12,14	7.07 ±2.43	0.242 ±0.068	49.04 ±4.3	3.467 ±1.2	0.264 ±0.11	0.119 ±0.043

Average methane yield was 0.264 ± 0.11 $l \cdot g_{dom}^{-1}$ digested.

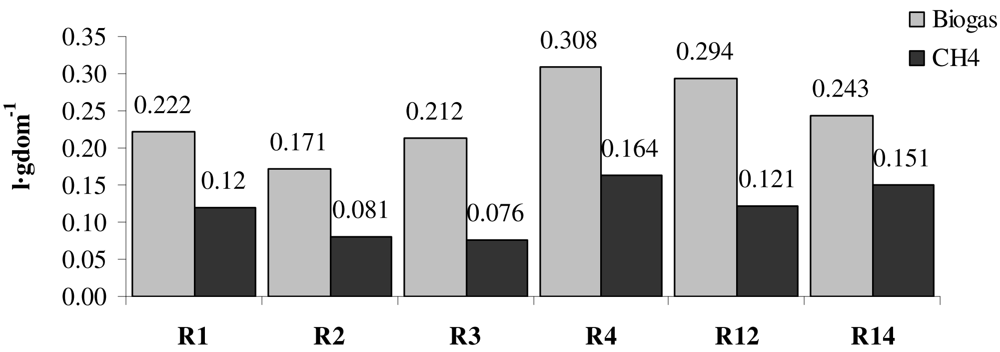

Fig. 1. **Biogas and methane $l \cdot g_{dom}^{-1}$ add from digestate digested at 40 ºC**

2. Anaerobic digestion at 18 ºC

All 5 bioreactors (R6, 7, 8, 13, 15) were filled with 500 g similar digestate each and positioned in the heating camera and anaerobic digestion temperature was 18±0.5 ºC.

Results and discussion

The results of analyses of raw materials are shown in Table 4, digested digestate in Table 5. Biogas and methane yields are shown in Table 6 and Fig. 2.

Table 4

Raw material analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g
R 6,7,8,13,15	7.61	5.76	28.8	15.41	84.59	24.36	500

Table 5

Average results of digested digestate analyses

Raw/digester	pH substr.	TS, %	TS, g	Ash, %	Dom, %	Dom, g	Weight, g	Dom digested, g
R6	7.36	5.35	25.17	17.15	82.85	20.85	470.4	3.51
R7	7.43	5.24	25.02	18.37	81.63	20.42	477.4	3.94
R8	7.40	5.41	25.60	19.18	80.82	20.69	473.2	3.67
R13	7.36	5.43	25.78	18.46	81.54	21.02	474.8	3.34
R15	7.41	5.52	26.03	18.33	81.67	21.26	471.6	3.10

Table 6

Biogas and methane yield

Digester	Biogas, l	Biogas, $l \cdot g_{dom}^{-1}$ added	Methane, %	Methane, l	Methane, $l \cdot g_{dom}^{-1}$ digested	Methane, $l \cdot g_{dom}^{-1}$ add
Average R6, 7, 8, 13, 15	1.18 ±0.3	0.048 ±0.012	20.09 ±5.3	0.239 ±0.19	0.069 ±0.055	0.009 ±0.003

Average methane yield was 0.069±0.055 $l \cdot g_{dom}^{-1}$ digested.

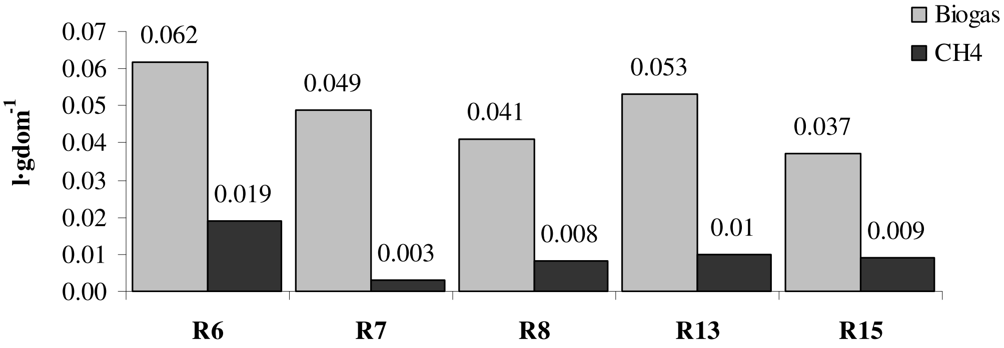

Fig. 2. **Biogas and methane $l \cdot g_{dom}^{-1}$ add from digestate digested at 18 ºC**

Conclusions

1. From aerobic hydrolysis-using biogas plant digestate fermentation at 40 ºC much methane is produced (an average of 0.119 $l \cdot g_{dom}^{-1}$ add).
2. From aerobic hydrolysis-using biogas plant digestate by fermentation at 18 ºC even little methane is produced (an average of 0.009 $l \cdot g_{dom}^{-1}$ add).
3. Digestate methane extraction potential constitutes about 35-45 % of the raw material potential of methane.
4. At low temperature (18 ºC) of digestate only 3 % of methane was produced, so the collection of an unheated tank will not be useful.

References

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