ANAEROBIC DIGESTION TECHNOLOGIES FOR DRY BIOMASS

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Abstract. Anaerobic treatment of relatively dry biomass (W>30 %) has some advantages compared with traditionally used wet biomass due to lowered expenses for transportation of raw and finished materials. the possibilities for using of some technologies of dry anaerobic digestion by help of self-made laboratory equipment were investigated. As raw material energy crops (sorghum, galega, amaranths) were used. The results from the garage type digester were lower than from wet digestion and from the batch type digester with recirculation of infiltrate. Higher methane content (56.4 %) and yield was from the digester with recirculation of infiltrate.

Key words: dry digestion, biogas, methane, batch type digester.

Introduction

Agricultural production technologies require heat and power energy for heating of homes, drying of harvest, heating of greenhouses, powering of electric equipment, etc. Heat energy obtained in the burning process of fossil fuels and biomass causes the greenhouse gas (GHG) emissions. Unused biomass residues can produce gases that contain up to 50 % methane (CH_4) during its natural degradation or 5-10 % CH_4 during its open burning. In a global scale, biomass was burned within an area of 8 million ha yearly, and carbon dioxide (CO_2) or methane emissions are estimated to account for 40 % and 10 % of global emissions respectively [1]. Another investigation shows that in tropical deciduous forest fires CH_4 emission ratios were 1.29 % and 1.59 % of all emissions at the two sites investigated [1]. Controlled combustion in a power plant converts virtually all of the carbon in the biomass to CO_2. As CH_4 is a stronger greenhouse gas than CO_2, shifting CH_4 emissions to CO_2 by converting biomass residues to energy significantly reduces the greenhouse warming potential of the recycled carbon. Renewable biomass (wood wastes, straw, grain wastes, etc.) controlled burning (in burners or furnaces) produces a small amount of GHG compared to fossil fuels.

However, biomass burning causes emissions of solid particulates and poisonous gases (dioxides, nitrous oxides, and others). Emission of particles increases for biomass having a high content of ashes [2]. The most environmentally friendly technology is biogas (mixture of CH_4 and CO_2) production from biomass in the anaerobic fermentation process, as it is usable for a relatively "clean" heat and power energy production, as the biogas contains no ashes. Methane produces more heat (891 kJ mol^{-1}) per mass unit (16.0 g mol^{-1}) than other complex hydrocarbons. In this context, methane is usually known as a natural gas, and has an energy content of 39 MJ m^{-3}. The anaerobic digestion process has an environmental advantage compared to burning of waste, for example, digestion of poultry manure is preferred, due to the increased risk of emissions of nitric oxides and other harmful substances if burned. The previous investigations revealed possibilities of methane production from sawdust or peat in the anaerobic digestion process [3]. Further investigations should be aimed at biogas production from relatively dry biomass (W>30 %) in order to minimize the expenses for both raw material and anaerobic treatment residue transportation. The purpose of this study is to investigate the parameters of biogas released during the anaerobic fermentation of relatively dry forest and agricultural waste.

Materials and methods

The biogas yield was investigated by help of self-made laboratory equipment. Each digester was equipped with heating devices for automated regulation of temperature 38±1 ºC in digesters. The digesters were equipped with sensors for automated registering of pH and gas volume data in the computer. To assess the outcome of biogas production in 5 L digesters from dry fermentation1 plant "Sorghum" and dry fermentation2 "Amaranths" (Figure 1 $B3_2$) also was "Sorghum" traditional/wet anaerobic fermentation (Figure 1. $B3_4$) study (50 days).

Fermented cow manure was added to all digesters in the ratio 20 %, to provide methanegenous microbial inoculums for a successful anaerobic fermentation process.

The substrates were analyzed for organic matter, total solids, organic solids and moisture content before filling in the digesters. The accuracy of the measurement was ±0.02 for pH value, ±0.0025l for the volume of gas and ±0.1 ˚C for the temperature.

The experiments were carried out periodically during the analysis of released biogas determining the methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), and hydrogen sulfide (H_2S) concentration of the reactor gas through specialized isolates of manufactured and certified instrument "GA2000 Plus".

Figure 2 shows the invented and built garage-type bioreactor arrangement, the first dry-fermentation study in Latvia. The digester was equipped with heating devices for automated regulation of temperature 38±1 ºC in the digesters. Biogas production was investigated from „Galega" garage-type biomass in anaerobic fermentation in the batch process study (200 days).

Laden solids were determined by drying the sample at 1200 C to dry weight "SHIMADZU" automatic mode. Organic solids determined by drying in an oven at 5500 C "Nabertherm" automatic modes.

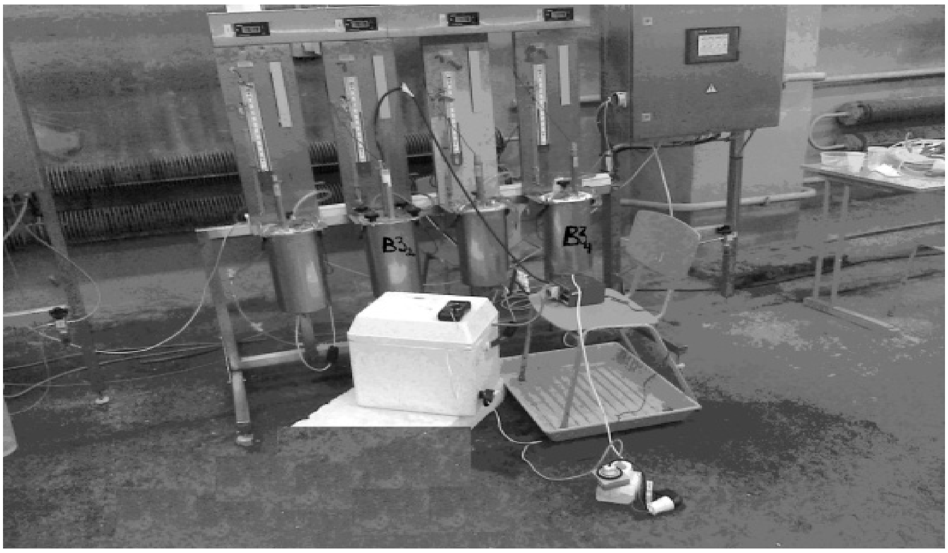

Fig. 1. **Laboratory reactors, biogas yield from biomass study**

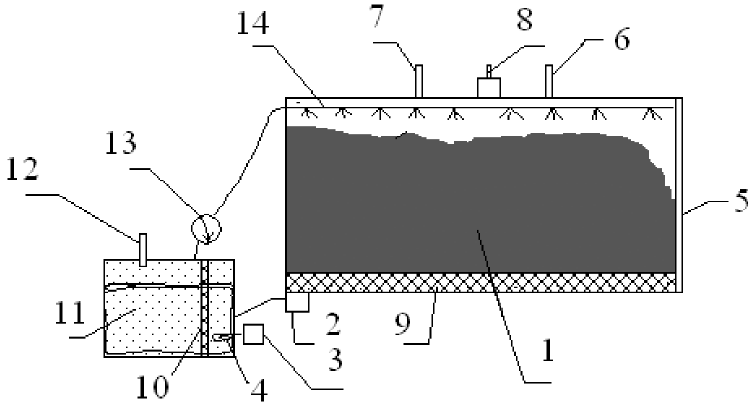

Fig. 2. **Invented and built garage-type bioreactor arrangement:**
1 – Biomass, "Galega"; 2 – leachate collection; 3 – automatic; 4 – heating device; 5 – door, biomass loading; 6, 7 – temperature gauge; 8, 12 – biogas output; 9, 10 – grid; 11 – container with leachate; 13 – leachate pump; 14 – injector

Results and discussion

The fermentation process was provided in batch mode without mixing (apart the initial mixing) or recirculation of the liquid part of substrates in all digesters. The results of the anaerobic fermentation of biomass for all digesters are shown in Table 1 study 50 days.

Table 1

Results of the anaerobic fermentation of biomass

Title	Units	Dry fermentation1	Dry fermentation2	Wet fermentation
Biogas	Litres	64.29	35.05	21.95
Average CH4 content	%	56.40	55.20	53.30

The fermentation process was provided in batch mode without mixing dry anaerobic fermentation garage-type bioreactor. The result of the anaerobic fermentation of "Galega" is 1394 L biogas during the process of the study that was 200 days and the average methane yields were 50.2 %.

The methane yields from "Sorgo" dry fermentation1 were higher by 5.5 %, compared to the methane yield from "Sorgo" wet fermentation (Table 1).

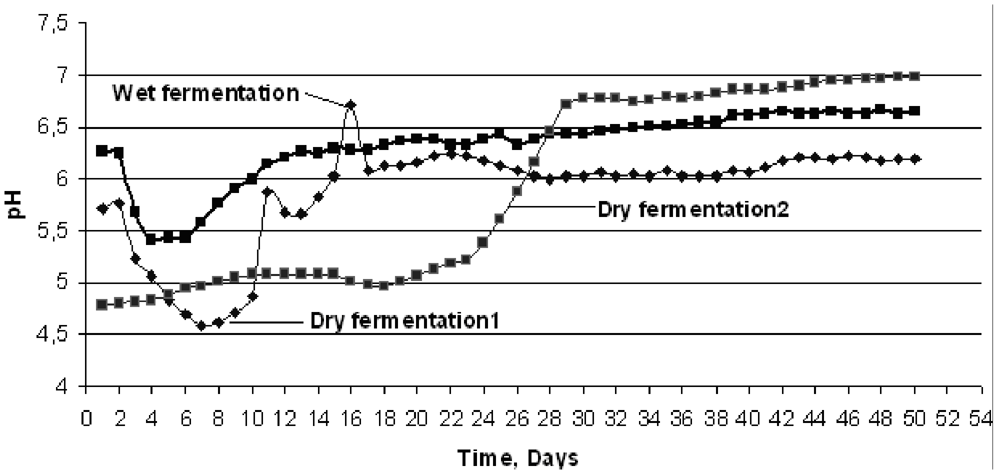

Fig. 3. **Variable pH, dry and wet fermentation**

In Figure 3 it can be seen that at the starting point dry fermentation 1 was pH 5.71, and then fell over the 10 days up to pH 4.87. From 13 days to 22 days pH climbed to the top of pH 5.67 to pH 6.25 and on the 22nd day pH was lower than pH 6.00. Figure 3 shows that wet fermentation the first day of pH 6.27 and from day one started to fall to pH 5.41 4th day. In the fourth day to the 20th day pH climbed to 6.39, then back to the 23rd day fell to 6.33. On the whole wet fermentation period of 50 days the minimum and maximum pH 5.41 and pH 6.66.

The evolution of gas, dry and wet fermentation is shown in Fig. 4 of the period from 1 to 50 days.

It was observed that all reactors isolate the biogas composition for methane concentrations, which are practically usable energy (about 50 % and higher methane concentrations).

The concentration of methane was within the range of 50.2-56.4 % in biogas from all of the investigated biomass that is satisfactory in relation to biogas usage for production of heat and power after preliminary treatment aimed to increase methane in the final gaseous fuel. The anaerobic fermentation of relatively dry (W>30 %) biomass is a feasible method for biogas extraction degradable.

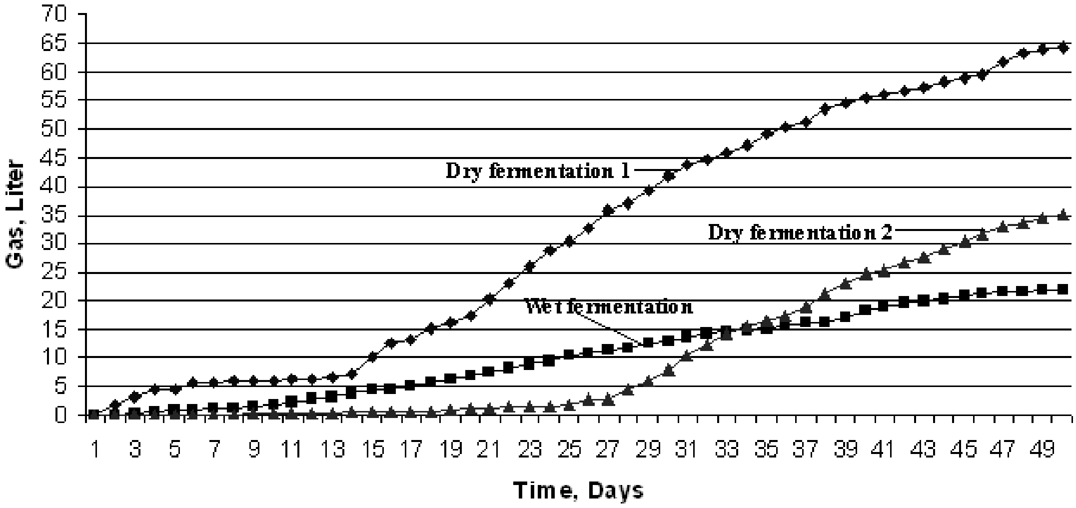

Fig. 4. **Evolution of gas per day, dry and wet fermentation**

Conclusions

1. The lowest yields of biogas 21.95 L were obtained from wet fermentation and the highest yields of biogas 64.29 L were registered from the "Sorgo" dry fermentation1.
2. The methane yields from "Sorgo" dry fermentation were higher by 5.5 %, compared to the methane yield from "Sorgo" wet fermentation bioreactor respectively.
3. Anaerobic fermentation of relatively dry (W>30 %) biomass is a feasible.
4. The methane yield from "Galega" dry anaerobic fermentation garage-type bioreactor is 1394 L biogas.
5. The investigated methane content in biogas was in the range of 50-56 % from all reactors that is satisfactory for biogas usage for the production of heat and power.

References

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