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DIFFERENT WAYS TO PRODUCE BIOGAS

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Abstract: *Biogas is considered as alternative to conventional fuels. It is produced by anaerobic digestion of different organic materials. Generally, those materials include mostly manure and municipality waste. Our research focuses on the possibility to utilize new types of organic materials in combination with the traditional ones.*

In today world, humanity uses mainly oil, nature gas and coal, which are non renewable energy sources. Their usage throughout XXth century, have lead to economic prosperity, but also to a large scale pollution of the environment. Mostly that pollution is expressed by the carbon emissions, which have direct effect on global warming. The reason is that for a very short time scale, large amounts of fuels have been burnt. That leads to the release of the carbon, contained in those fuels for hundreds millions of years. According to The International Energy Agency[1], worldwide oil demand for 2023 is estimated to be around 100 mb/d (1 oil barrel is 159 liters). As the fuels are exhaustible, their depletion leading to economical, social and political consequences, it is important to research and develop new alternative fuels. Such fuels could be biogas, biodiesel, ethanol, hydrogen and others.

Keywords: Biogas*, Biomethane, Environment, Alternative non – fossil fuels*

INTRODUCTION

At the Institute of Chemical Engineering series of periodic experiments for the production of biogas from various waste materials have been carried. The first chosen type of waste was the waste glycerol from biodiesel production, then in the following experiment other materials have been used, such as coniferous material and straw. In all of the experiments, the cosubstrate material was mixed with manure. Pretreatment of the organic materials have been carried in all of the experiments. The pretreatment of the coniferous material and straw included shredding of them in a small chopper. Most commonly the following treatment of the plant material included acid hydrolysis of the coniferous material and straw (usually performed in autoclave for 20 min, at 121 °C). A solution of 1% H_2SO_4 was used to carry the acid hydrolysis. The manure was treated by applying electric current. After the treatment of both the organic materials was over, they were mixed and poured into small glass flask reactors. The flask reactors were kept at constant temperature, maintained by heaters. The resulting biogas was collected in biogas holders.

EXPOSITION

Methods of Producing Biogas

Method 1. The old traditional method of producing biogas is well known. It is mainly focused on cattle manure as feeding material. There are different in size bioreactors, from small ones – the size of a barrel, to large ones – the size of a large building. Usually they are made from concrete and build up in the ground (for better stability and thermal insulation). The accumulated biogas is used to produce heat, electricity or as a fuel for local vehicles.

Method 2. In the Institute of Chemical Engineering, research was carried to investigate alternative ways to produce biogas. The methods focused mainly on mixing the cattle manure with other materials, such as glycerol and organic material from plant origin such straw, coniferous

materials, garden grass. Different treatment of both feeding materials was also applied. Method 2 was focused on utilizing waste glycerol, which comes as a waste product in biodiesel production. Glycerol was mixed with cattle manure at specific ratio, the final product was biogas. A bioreactor with 8 chambers was used for the purpose. The accumulated biogas was collected in a gas holder. Samples were taken for pH and burning test.

Fig.1 Photo of the bioreactor

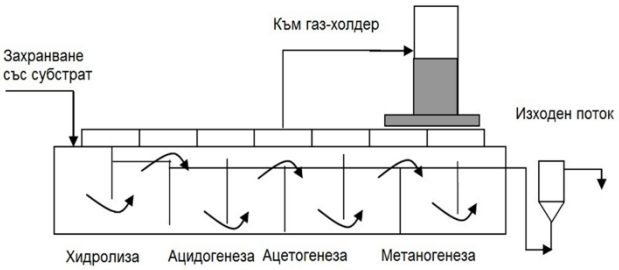

Fig. 2 Schematic view of the bioreactor

Four feedings were carried, each one with different concentration of glycerol – a) 6,3 g/L; b) 12,6 g/L; c) 18,9 g/L and d) 25,2 g/L. The reactor was let to work for 202 days, and 471 samples were taken. Positive in burning test were 444 of the samples and 27 were negative. The figure below shows the results for the accumulated biogas. As it can be seen from the figure, the process in the beginning had some fluctuations, and later it was stabilized. It showed us, that waste glycerol could be used as cosubstrate in anaerobic digestion bioreactor.

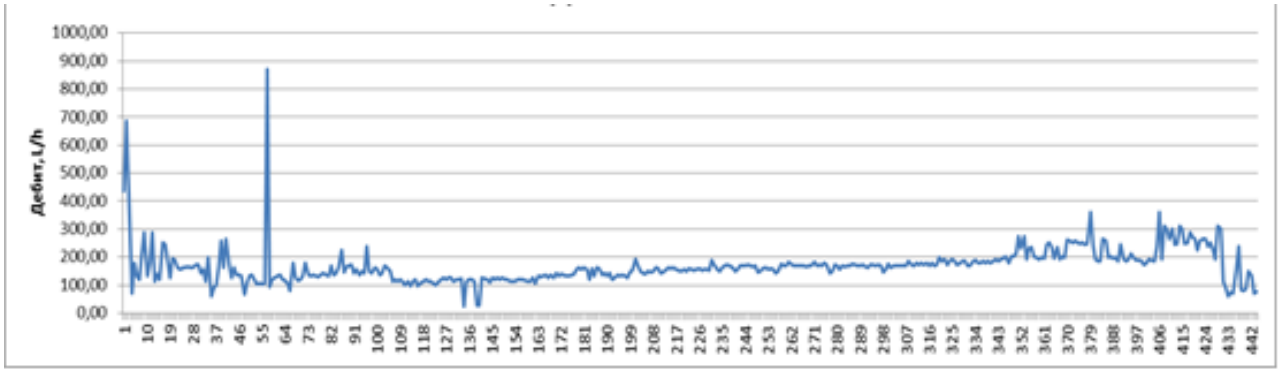

Fig. 3 Biogas yield Method 2

Method 3a. Agricultural and nonagricultural organic waste material. Method 3a was focused on using coniferous material as a main substrate for biogas production. Most common type of first treatment is milling with chopper. It aims to increase the surface contact between the material and the bacteria in the reactor.

Fig. 4 Coniferous material used as a feeding material in Method 3a

Method 3b was focused on using straw as feeding material. It required some pretreatment of the feeding material (milling in chopper machine), then it was mixed with cattle manure and loaded into the reactor.

Fig. 5 Straw used as feeding substrate in Method 3b

Method 4 was focused on researching how different temperatures influence the production of biogas. Two temperatures were tested: Method 4a used 32 °C (mesophilic digestion), which is the most common temperature range for anaerobic digestion. It is widely used, because the methanogenic bacteria present at this temperature range is consuming less energy for bioreactor heating, it is more tolerant to changes in temperature and pH levels and feeding schemes. Method 4b used 55 °C (thermophilic digestion), a rare temperature level for anaerobic digestion. It consumes a lot of energy in order to maintain the temperature at the desired level. The bacteria present at this temperature was also less tolerant to changes in pH levels and temperature.

Method 5 was focused on organic material pretreatment. Another way to produce more biogas is by treatment called steam explosion, which converts the solid plant waste into liquid, thus transforming the nutritious compounds in a more accessible form for the bacteria in the reactor. The liquid is mixed with other materials and injected into the reactor. The plant material was subjected to steam explosion treatment. By using this method of treatment, the plant material was turned into semiliquid porridge. Then it was mixed with cattle manure and loaded into the reactor vessel. Biogas samples were taken for analysis.

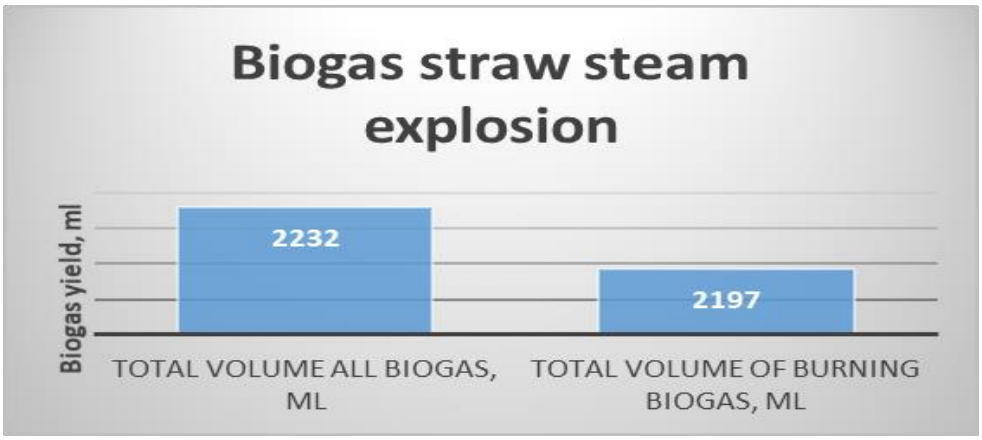

Fig.6 Comparison of the obtained total and burning biogas in Method 5

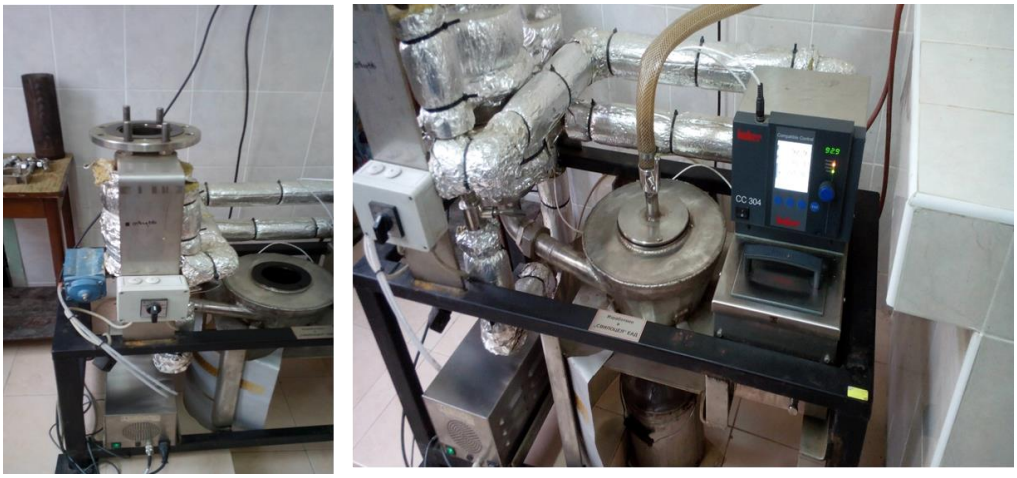

Fig. 7 Photos of steam explosion method

Table 1. Results from biogas experiment with straw treatment

Loaded material / Biogas Results	**250 ml liquid straw extract**
Total accumulated biogas volume, ml	2232
Total burning biogas volume, ml	2197
Burn ratio, %	98.48
Running time, days	215

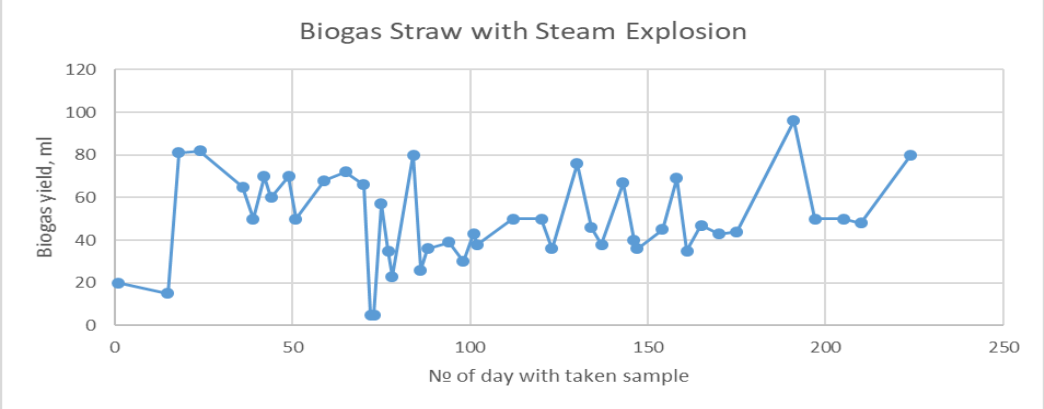

Fig. 8 Biogas yield from Method 5

Method 6 was focused on treatment of the cattle manure with electricity. DC was applied to the cattle manure for 30 min and 1 hour. In the conducted experiments, we have found out that, the treatment of the waste material with electric current leads to improvement in the ingredients of produced biogas, expressed mainly in higher methane content (reaching in some cases 95 – 98 % (vol.) in a comparison with most commonly observed 50 – 75%).

Table 2. Number of experiments and the corresponding feeding and treatment scheme

№ of Experiment	**Type of treatment**
A1	No pretreatment
B1	No pretreatment
A2	Manure only
B2	Manure + conf. material + acid treatment

A3	Conf. material + cattle manure
B3	Conf. material + cattle manure + DC ½ h
A4	Conf. material + 1% H_2SO_4 + cattle manure + DC ½ h
B4	Conf. material + 1% H_2SO_4 + cattle manure + DC 1 h
A5	Conf. material + steam explosion + cattle manure
B5	Conf. material + steam explosion + cattle manure + DC ½ h

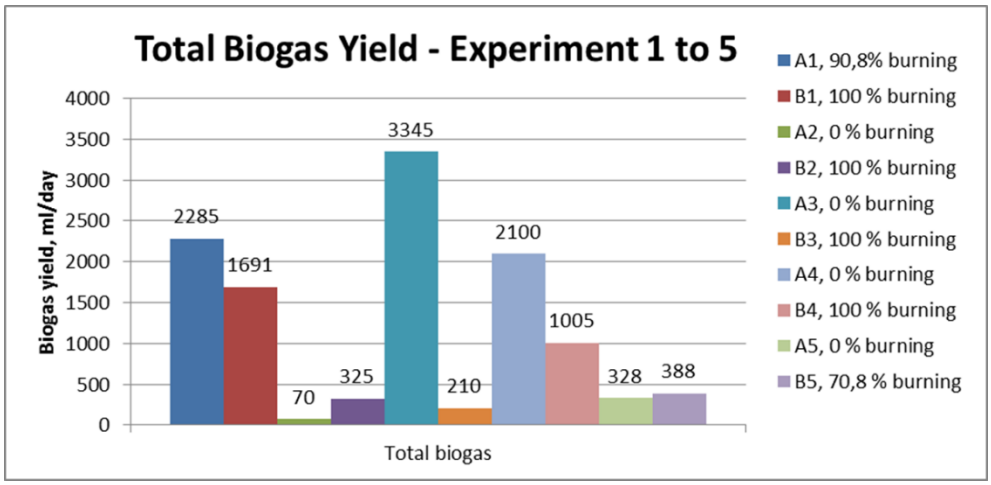

Fig. 9 Comparison of biogas yields in Method 6

Fig. 10 Photo of the electric pretreatment of the cattle manure in Method 6

CONCLUSION

The use of other materials for biogas production in anaerobic digestion bioreactor is possible. Some of the materials require pre-treatment, which in some of the cases, leads to better yield of biogas. Milling in chopper increases the substrate contact surface with the microorganisms, the application of electric current of the cattle manure increased the speed of the process. The type of treatment depends on various factors, such as type of feeding material, type of cosubstrate, temperature range of the bioreactor and etc. The use of waste materials, helps to lower the amount

of organic waste, which in turn would led to lower emissions and lower pollution of the environment. It is also beneficial for the local economy, as it creates additional jobs for the locals – bioreactor construction and maintenance, waste collection and transportation, biogas utilization. The produced biogas could be used to generate electricity, heat, and as a fuel in biogas running vehicles. Today not only private cars are made to run on biogas, but also buses, light and heavy trucks, ships and even planes (prototypes and testing phase).

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