OPTIMIZATION OF BIOGAS PRODUCTION FROM LIGNOCELULOSIC MATERIALS BY DIFFERENT METHODS OF SUBSTRATE TREATMENT

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Abstract: *One of the most used types of biofuels is the biogas, produced during the process of anaerobic digestion of organic waste. The current project aims utilization of plant biomass waste, used to produce energy in the form of biogas, after proper pretreatment, in order to enhance energetic value and yield. Proper resource and method of pretreatment will be chosen, in order to obtain high biogas yields. The chosen technology will be tested in a plug-flow bioreactor to optimize the technical parameters.*

Keywords: BIOGAS, ANAEROBIC DIGESTION, BIOMASS, LIGNOCELULOSIC MATERIAL, BIOREACTOR

1. Introduction

Biofuels represent a great share of the energy carriers of the modern developed society. They are considered an alternative to the traditional energy sources such as oil, coal and nature gas. Biofuels stands for ethanol, produced from plants, biodiesel, produced from nature lipids and biogas, produced through anaerobic digestion of plant and animal waste.

Biogas is widely used fuel in economically developed countries, as well as in the countries from 3rd world. It has many applications. Among the most important ones are as fuel for both thermal power plants, national gas grid and as a fuel in various types of vehicles, including passenger cars, trucks, small and midsize boats and aircrafts. The main source to produce biogas is manure. Some of the disadvantage of producing biogas, is the low content of methane (50 60%), as well as the presence of sulfuric compounds. In the current case, our aim is to investigate the possibilities of optimizing the methods and conditions for biogas production from vegetal waste.

Series of periodic experiments on biogas production from vegetal waste have been carried out in the Institute of Chemical Engineering (BAS). In each one of them, coniferous material was mixed with manure. Pretreatment of manure and coniferous material was conducted in some of the experiments. Most commonly, the treatment involved acid hydrolysis of the coniferous material, autoclaving applying electrical field in the reactors containing coniferous material and manure. After both materials were treated in the corresponding way, they were subjected to mesophilic anaerobic digestion in sealed glass vessels. Biogas was collected and stored above water in gas-holders. Biogas yields were checked and samples for analyze were taken daily.

During the experiments, we used a coniferous material from type *Picea excelsa L*. The first part of treatment focused on the lignocellulosic material. The branches and leaves were shredded and then collected in a beaker. After that, their weight was measured. In the next step, the material was mixed with water or acid. Then, the material was autoclaved for 20 min at 121 °C. In the meantime, the second part of the treatment was carried out. A specific amount of organic waste (cow/cattle manure) was taken, and then it was mixed with water. After that, the slightly liquefied manure was treated in various ways. One of them included passing an electrical current through the mixture for some time. After that, the lignocellulosic material and the organic waste were mixed. Then the mixture was poured in air insulated glass vessels. The vessels were installed in water bath, where the temperature was kept at around 35 °C. Each experiment included different ways of treatment, mixing and autoclaved material.

Experiment 1 has no additional treatment of the two materials used (coniferous and manure). It serves as a base experiment.

Experiment 2 Sample A contains cattle manure only. Sample B includes coniferous material mixed with acid and autoclaved. Then it was mixed with cattle manure.

Experiment 3 Sample A contains coniferous material mixed with water and then cattle manure was added. Sample B contains coniferous material treated the same way, but before adding, the cattle manure was treated with electricity for ½ hour.

Experiment 4 Sample A contains coniferous material mixed with acid and autoclaved, then before adding, the manure was treated with electricity for ½ hour. Sample B contains coniferous material mixed with water and then autoclaved. Before adding, the cattle manure was treated with electricity for 1 hour.

Experiment 5 Sample A contains coniferous material which was treated by method called "steam explosion". Then it was mixed with manure. Sample B has the same treatment, only before adding, the manure was treated with electricity for ½ hour.

Fig. 1 *Outlook of the small scale bioreactor*

2. Results and Discussion

During the first part of the project, it was investigated the possibility to produce biogas by using different waste materials, which include lignocellulose, pretreated in various ways (including hydrolysis, enzymes, electrochemical processes) and kept in defined conditions (temperature – 35 °C). The materials used were mainly from plant, animal, and/or industrial waste (wasted glycerol from biodiesel production). Their treatment included different schemes of mixing, use of digestion compounds (acid hydrolysis, water autoclave, electrical treatment).

Table 1: *Biogas daily yield – Samples A and B. Results from burning test.*

	Biogas yield Samples A, mL	Biogas yield Samples B, mL	Total amount of burning biogas, mL
Experiment 1	2285	1691	A-2075; B-1691
Experiment 2	70	325	A-0; B-325
Experiment 3	3345	210	A-0; B-210
Experiment 4	2100	1005	A-0; B-1005
Experiment 5	328	388	A-0; B-303

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%). It is important, as the higher methane content in the produced biogas, means better fuel properties. Therefore, the accumulated biogas (containing 95 – 98% methane), could be directly used as a

fuel in public transport, or to be supplied into the national gas grid system without additional treatment, as it is in the case with biogas with lower methane content. Then additional treatment is required, when the biogas will be used as fuel in public vehicles or the injection into the national gas grid. The treatment includes compressing, drying the biogas and separating the remaining CO_2 and sulfuric compounds (hydrogen sulfide and mercaptans). This leads to higher energetic and economic expenditure and therefore producing less amount of methane.

In the present case electric current as pretreatment method avoids the necessity of additional treatment of the produced biogas.

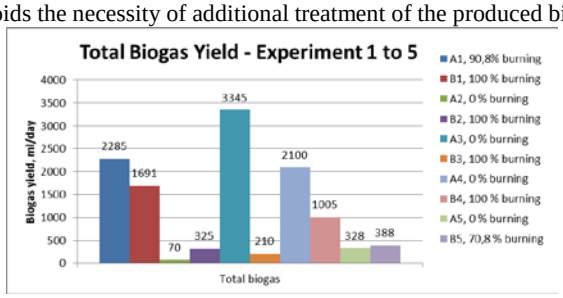

Fig.2 *Biogas yield in experiments 1 to 5*

Fig. 2 shows the combined results from 5 experiments. Each experiment contains two samples, named A and B. In the some of the samples, the burning is 100 %, which means that all the collected for the day biogas burnt. In others, the percentage is lower, because not all taken samples were burning (when the methane content in the taken sample drops to below 50 %, vol). Sample A3 gave the highest quantity of biogas, but there was no burning, while B3 gave much less biogas quantity, but with 100 % burning.

Fig. 3 to Fig. 6 show the corresponding biogas results for each experiment. It can be noticed that in most of the experiments, Samples A show higher amount of biogas, but has lower content of methane, while Sample B show lower amount of biogas, but higher methane content.

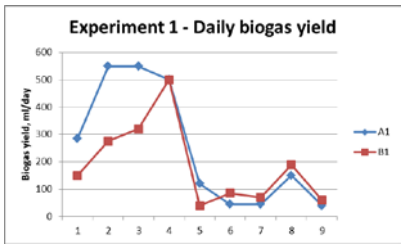

Fig.3 *Biogas yield Experiment 1*

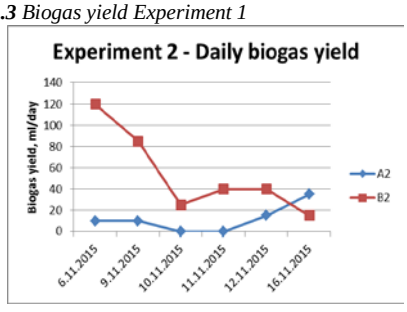

Fig.3 *Biogas yield Experiment 2*

In Experiment 2, Sample A contains manure only, while Sample B contains acid hydrolyzed (with 1 % H_2SO_4) coniferous material mixed with manure. (Acid treatment was applied to the plant material only.

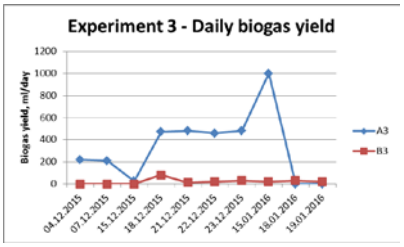

Fig.4 *Biogas yield Experiment 3*

In Experiment 3, Sample A contains water autoclaved coniferous material, later mixed with manure, and Sample B contains the same way treated coniferous material, plus additional treatment of the manure – charged with electrical current for 30 min.

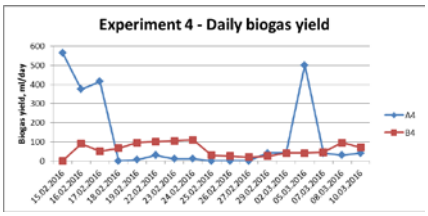

Fig.5 *Biogas yield Experiment 4*

In Experiment 4, the coniferous material was treated with 1% H_2SO_4 and the manure was treated with electrical current for 30 min (Sample A). Sample B was treated the same way, with the only difference – the manure was treated with electricity for 1 hour.

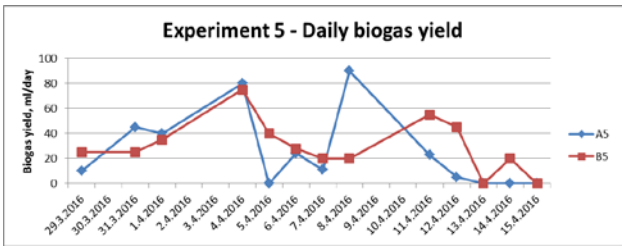

Fig. 6 *Biogas yield Experiment 5*

In Experiment 5, the coniferous material from Sample A and B was treated by method called steam explosion. It was believed that such treatment would make the organic compounds more accessible for the microorganisms present in the anaerobic digestion process. Then the exploded coniferous material was mixed with untreated manure (Sample A), and a treated with electrical current for 30 min manure.

3. Conclusion

According to the results obtained from our experiments, we have noticed that treatment did improve the quantity and quality of the collected biogas. While some of the treatments gave more biogas quantity with slightly less amount of CH_4, others gave slightly lower amount of biogas, but with higher content of CH_4.

4. Reference

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