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Optimization of biogas production from lignocellulosic materials by different methods of substrate treatment

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Biogas is considered a possible alternative to the 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 (e.g. ground coffee residue, coniferous vegetation) in combination with the traditional ones. We believe that adding new materials will enhance the process of biogas production and will contribute to higher range of waste treatment. The final product is biogas with higher methane content which makes it useful for heat and power generation. Therefore we focused on utilizing of coniferous material mixed with other organic materials in anaerobic digestion reactor.

Keywords: Biogas, Coniferous materials, Waste treatment, Biotechnology

INTRODUCTION

Biofuels play an important role in our efforts to reduce CO_2 emissions and keep the environment cleaner. As we depend more and more on fuels to power our economies (by generating electricity, producing chemical products, as fuel for planes, ships and vehicles), it becomes more difficult to reduce the pollution of the environment.

Biogas is a widely used fuel in economically developed countries, as well as in the countries from the 3rd world. It has many applications. Among the most important ones are as a fuel for thermal power plants, addition to the 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 disadvantages of producing biogas are the low content of methane (50% – 60%) and 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.

During the experiments, we used a coniferous material from the 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 (cattle manure) was taken, and was mixed with water. After that, the slightly liquefied manure was treated in various ways. One of them included passing 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 a water bath, where the temperature was kept at 32 to 35 °C. Each experiment included different ways of treatment, mixing and autoclaved material.

Three series of experiments were conducted. They are all part of a long-term scientific research which focuses on producing biogas by utilizing coniferous material mixed with other waste organic materials. Each of the experimental series included 2 samples.

MATERIALS AND METHODS

Experiment 1

Experiment 1 (which included samples A1 and B1) used coniferous material treated with 1% H_2SO_4. Then the material was mixed with residues of ground coffee waste (sample A1) and manure. The mixture was poured into a glass bottle tank and kept at 32°C in a water bath. The bottle was connected to a gas holder which collected the produced biogas. Then the biogas was analyzed. Sample B1 was treated in the same way, with one difference, that instead of coffee, the coniferous material was mixed with waste glycerol. The substrate compositions are shown in Table 1. Some results for the biogas yield of this experiment are shown in Figs 1 and 2. It is obvious that glycerol is more efficient as addition to the coniferous material. It is because of the high stoichiometric methane yield.

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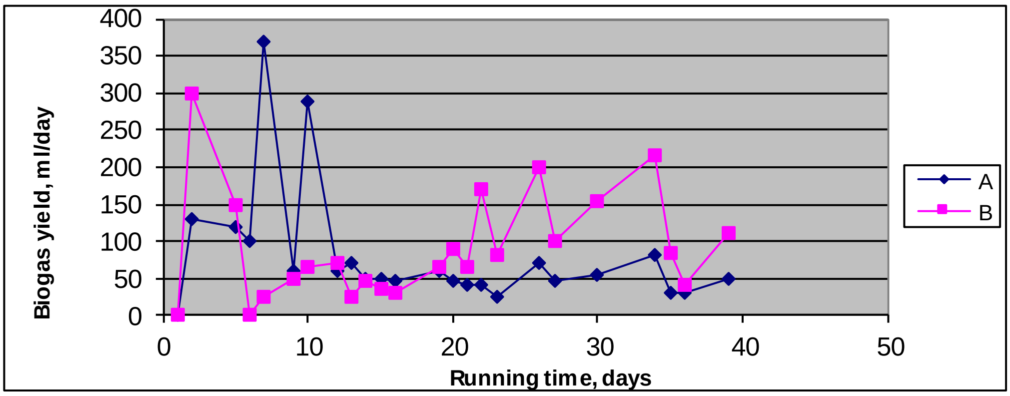

Fig. 1. Daily biogas yield. Samples A1 and B1

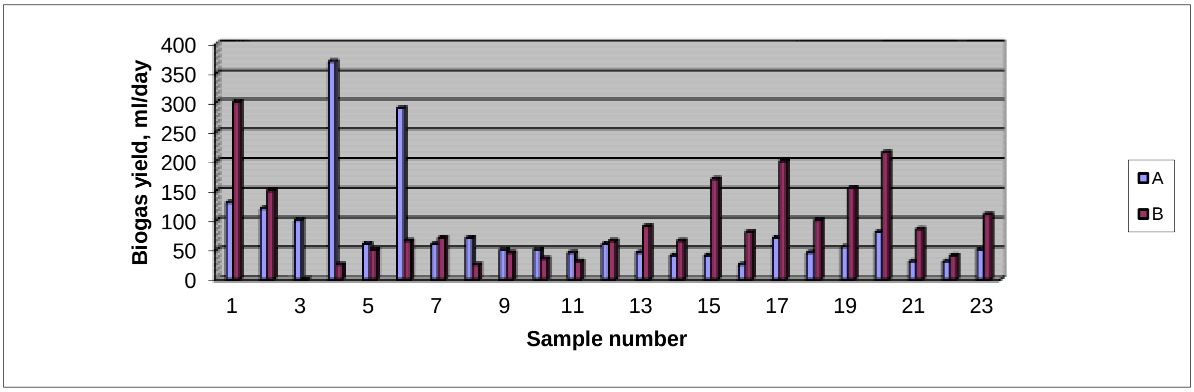

Fig. 2. Biogas yield for longer period of time (experiment 1).

Table 1. Biogas yield. Combustion test results. A1: 8 g con. matter (100 ml 1% H_2SO_4) + ground coffee waste (4 g) + manure (317 g). B1: 8 g con. matter (100 ml 1% H_2SO_4) + glycerol (4 g) + manure (304 g)

Total volume of biogas	Sample A1 = 1915 ml	Sample B1 = 2170 ml
% Burning of biogas	47 %	79.26 %

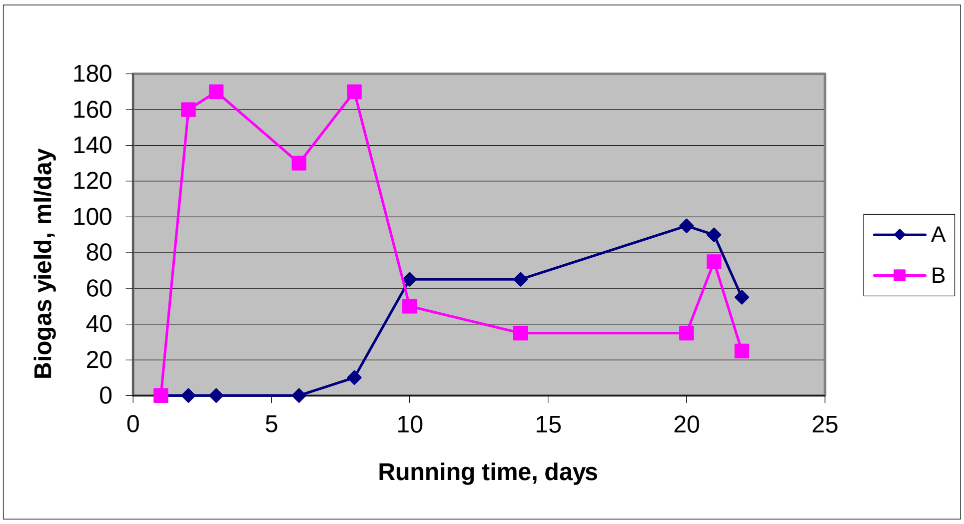

Fig. 3. Biogas yield. Samples A2 and B2

Experiment 2

Experiment 2 (samples A2 and B2) contained coniferous materials treated with 1% H_2SO_4 acid. Coffee residues were added in sample A2 and wasted glycerol was added in sample B2. Then cow manure was treated with constant voltage for 30 min. After the treatment it was added to the reaction vessels. There is also better effect of glycerol on the combustion capacity of the produced biogas, being additionally enhanced by manure after the electrical treatment.

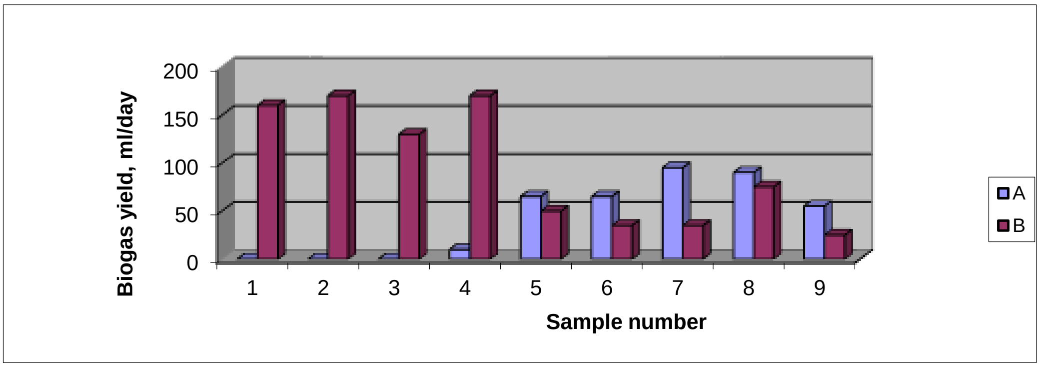

Fig. 4. Biogas yield for experiment 2

Table 2. Biogas yield. Combustion test results. A2: 8 g con. mat. (100 ml 1% H_2SO_4) + coffee (4 g) + manure (300 g, electric field for ½ h). B2: 8 g con. mat. (100 ml 1% H_2SO_4) + glycerol (4 g) + manure (300 g, electric field for ½ h)

Total volume of biogas	Sample A2 = 380 ml	Sample B2 = 850 ml
% Burning of biogas	0 %	81.17 %

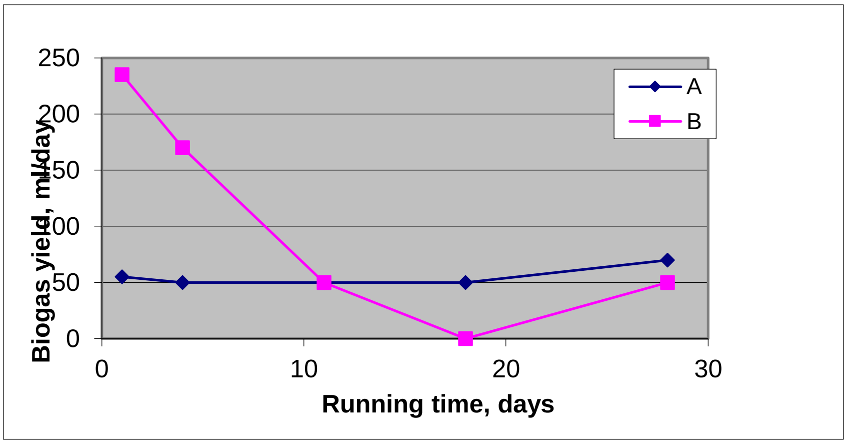

Fig. 5. Biogas yield. Samples A3 and B3

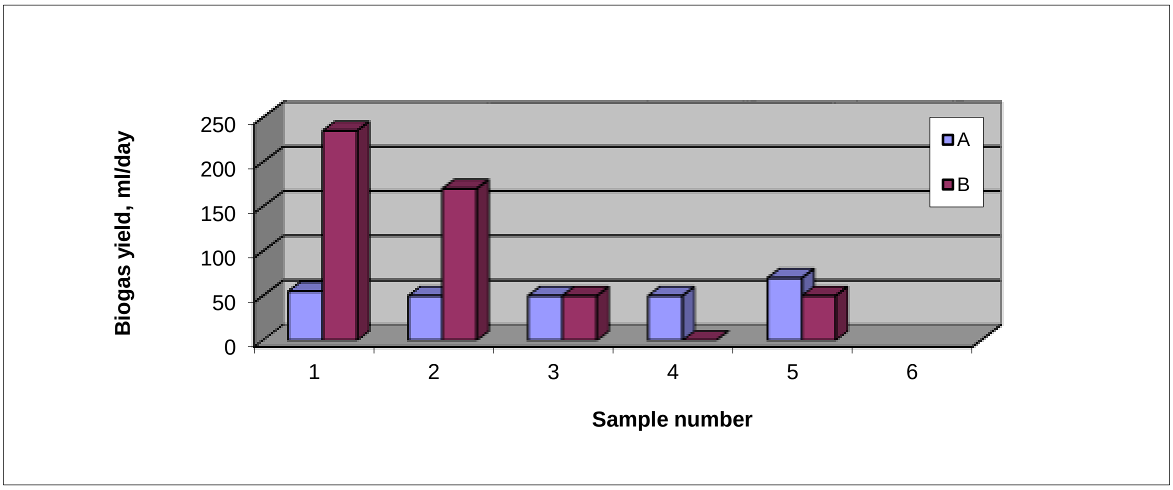

Fig.6. Biogas yield for experiment 3

Table 3. Biogas yield. Combustion test results. A3: 8 g con. mat. (100 ml 1% H_2SO_4) + coffee (4 g) + manure (300 g, electricity for 1 h), B3: 8g con. mat. (100 ml 1% H_2SO_4) + glycerol (4 g) + manure (300 g, electricity for 1 h)

Total volume of biogas	Sample A3 = 275 ml	Sample B3 = 505 ml
% Burning of biogas	43.6 %	90 %

Experiment 3

Experiment 3 (samples A3 and B3) contained coniferous materials treated with 1% H_2SO_4 acid. Coffee residues were added in sample A3 and wasted glycerol was added in sample B3. Then the manure was treated with electricity for 1 h. After the treatment, it was added to the reaction vessels.

RESULTS AND DISCUSSION

Throughout the series of experiments, the aim of our research was to investigate different types of substrate combinations (as mixing with food waste) and the influence of electricity charge in the complex biochemical reactions of anaerobic digestion. For that purpose, the electricity applied in experiment 2 was ½ h and in experiment 3, it was 1 h. As a conclusion, according to the results we obtained from our experiments, we have noticed that coniferous material can be used as a substrate for biogas production if mixed with cattle manure, as well as the treatment of manure with electricity improved the quantity and methane content of the collected biogas. We have also noticed that the used food waste (which in our case was ground coffee waste), was hardly used by the microorganisms in the bioreactor. On the other hand, the addition of waste glycerol gives better effect on biogas yield and combustibility. In all cases, the treatment of manure by DC enhances the methane content and the biogas combustibility.

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