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EXPERIMENTAL APPROACH IN BIOGAS PRODUCTION FROM AGRICULTURAL SUBSTRATES – TEST RIG AND RESULTS

ADRIAN EUGEN CIOABLĂ[1], GABRIELA-ALINA DUMITREL[2], DORIN LELEA[1], ROXANA MILOTIN[1], MIHAI AUGUSTIN POPARAD [3]

1.Politehnica University of Timisoara, Mechanical Engineering Faculty, 300222, 1 Mihai Viteazu Avenue, Timisoara, Romania, phone: 0040-256-403748, adrian.cioabla@upt.ro

2.Politehnica University of Timisoara, Faculty of Industrial Chemistry and Environmental Engineering, 300223, 6 Vasile Parvan Avenue, Timisoara, Romania, phone: 0040-256-403073, alina.dumitrel@upt.ro

3.Transilvania University of Brasov, Faculty of Product Design and Environment, Colina Universitatii str., 1, 500068, Brasov, Romania, phone +(40)0721977292, poparad.mihai.augustin@unitbv.ro

Abstract: *Nowadays, the studies involving the use of renewable sources of energy are in a continuous stage of development in regard to different theoretical and experimental ways of approach. In the context of global crisis it is imperative to obtain solutions connected with new ways of capitalization of existing sources (wind, hydro, solar, biomass).*

Biomass residues are of great potential connected with different used technologies, one of them being biogas production in during the anaerobic fermentation process. Degradation is an important part during the process of obtaining biogas and because of this, the presented study underlines some of the characteristics of two different sorts of vegetal biomass, in regard to their physical and chemical properties and behavior during the anaerobic fermentation process in co fermentation with waste water for a treatment plant. Also in this paper is presented a small scale installation used for testing, which is located at the Mechanical Engineering Faculty, Politehnica University Timisoara. Conclusions will be traced relative to the obtained results in order to determine the possible applications of the produced biogas.

Keywords*: Agricultural biomass, waste water, biogas, degradation process*

1 Introduction

Biogas represents one of the oldest forms of clean sources of energy, but the used technologies have evolved in time, addressing different aspects connected with CO_2 and H_2S removal, process optimization, substrate testing, firing processes optimization and so on.

The use of biomass has for millennia helped human society to fulfill many of its fundamental energy needs, such as for the production of goods, cooking, domestic heating and the transport of people and goods [1].

Biomass is rich in carbon but is not yet a fossil material. All plants and animals in the ecological system belong to biomass. Furthermore, nutrients, excrement, and bio waste from households and industry is biomass [3].

One of the technologies used for energy recovery from biomass residues is the production of biogas through anaerobic fermentation.

Anaerobic digestion and biogas production are promising producing an energy carrier from renewable resources. Replacing fossil fuels with biogas normally reduces the emission not only of greenhouse gases, but also of nitrogen oxides, hydrocarbons, and particles [4].

Biogas could become one of the most important alternative fuels and can potentially replace natural gas and oil as it can contribute to maintain mobility, while other alternative sources of electrical energy and heat generation are available (wind, solar energy, etc.). No negative or limited environmental side effects are observed because biogas can be produced from all types of “green” biomass [5].

While new technologies such as fuel cells offer increased fuel conversion efficiency, improvements in the field of thermal engines are still pursued [6 – 9]. The use of alternative fuels is another important issue currently under study [10 – 12], as fuel availability will be an important aspect in the near future.

The present paper presents an experimental rig and an experiment carried out in regard to determine the potential of two different sorts of material (cereal mixture composed of 40% degraded wheat, 40% means of achieving multiple environmental benefits and degraded corn and 20%

degraded sunflower husks and degraded rye) for biogas production.

2 Experimental setup

2.1 Substrate choices and general information regarding the used materials

The base materials were:

- First glass vessel: 400 gr cereal mixture composed of 40% degraded wheat, 40% degraded corn and 20% degraded sunflower husks inserted in 5L of residual water from Timisoara treatment plant;

- Second glass vessel: 400 gr degraded rye in 5L of residual water from Timisoara treatment plant.

Inside the two vessels / reactors there were not used any inoculums, catalysts or other enzymes for increasing the quality or quantity of the produced biogas.

The general properties of the two materials and residual water from Timisoara treatment plant are presented below. The determinations were made according to standard methods [13-18].

Table 1, General characteristics of the used materials (part 1)

No.	Material	Hygroscopic moisture content, [%]	Ash content (dry basis), [%]	Net calorific value (dry basis), [J/g]
1.	Cereal mixture	10.5	1.5	16800
2.	Degraded rye	10	1.67	17300
3.	Residual water from Timisoara treatment plant	5.9	36	14100

Table 2, General characteristics of the used materials (part 2)

No.	Material	Carbon content [%]	Nitrogen content [%]	Volatile content (dry basis) [%]
1.	Cereal mixture	40.5	1.12	85
2.	Degraded rye	40.3	1.45	84.5
3	Residual water from Timisoara treatment plant	32.2	5.1	38

From the point of view of the calorific value, the materials present a real energetic potential which can be capitalized during the process. The C/N ratio is between 27.6 and 36 which indicates that both materials can be used for biogas production through anaerobic fermentation.

2.2 Experimental set-up

The fermentation process was held for 30 days in order to observe the pH and gas quantities and composition in terms of CH_4 and CO_2 percentages maintaining a constant temperature between 35 and 37 °C.

In order to correct the pH values during the process, it was used a solution of chaustic soda, 1g/liter

The general overview of the small-scale installation is presented in figure 1.

The components of the small-scale installation are:

1 – thermal glass vessels with a total volume of 6L used for dark fermentation;

2 – magnets positioned at the bottom of the glass vessels used for magnetic stirring of the used material suspensions; this system allows also the manual stirring / agitation;

3 – device used for heating the suspension inside the glass vessels;

4 – thermocouple used for temperature control inside the fermentation vessels;

5 – system for sampling and pH correction of the concentration.

6 – syringe used for sampling and pH correction system;

7 - pH controllers connected to pH sensors inside the glass vessels in order to determine in real time the pH value of the suspension;

8 – temperature controller connected with the suspensions inside the vessels;

thermocouple inside the glass vessel for temperature control to a determined range;

9 – gas bags with a total volume of 2L dedicated for sampling the obtained biogas from the fermentation process.

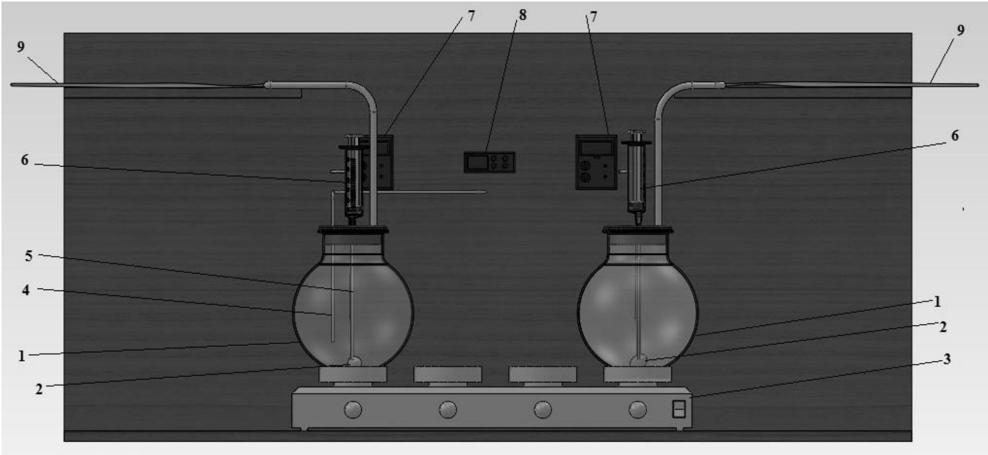

Fig. 1. Overall view of the small-scale installation

3 Results

The time variation for pH is presented in figure 2.

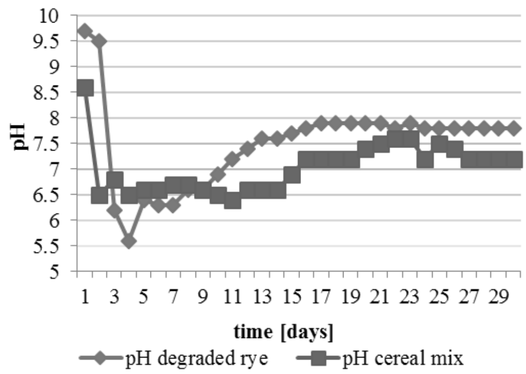

Fig. 2. pH variation

It can be observed that during the process, the batches started with a relatively high pH value and, with the help of pH corrections, they were maintained in the range 7 – 8 during the fermentation period.

During the tests, the produced biogas was measured both in terms of quality and quantity.

The gas analyzer used for this task was a DELTA 1600 S IV type, which allows determination of methane and carbon dioxide composition up to 100% by volume.

The CH_4 and CO_2 concentrations are presented in figure 3.

The material was already partly degraded, which had a great impact over the initial period when biogas is formed. It can be observed that the initial methane concentration for both batches is about 20 % which means that actually the first step – initializing anaerobic fermentation was after about 3 days. This aspect is due to the fact that the waste water was a catalyst in terms of microorganisms which provided support in accelerating the degradation process.

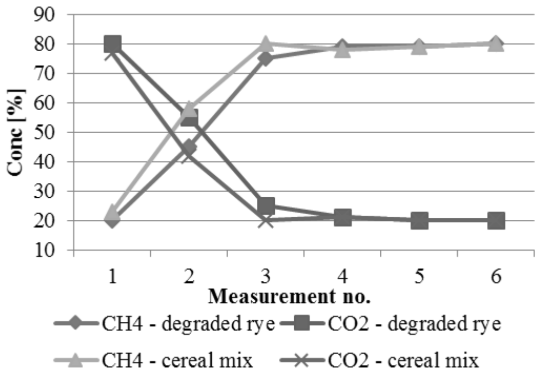

Fig. 3. CH4 and CO2 concentrations for the first and second vessels

The produced quantities were about 15 L of gas for the degraded rye batch and about 18 L for the cereal mix batch. Relative to the initial material volume used for the study (5 L) the obtained biogas quantities are large, which is a good indicator for further studies and analysis for process optimization. Also, the methane content is high for both batches, having in mind that no dedicated enzymes or other inoculums were used.

4 Conclusions

Both batches of materials presented good results in terms of biogas production and methane concentration during the process. The cereal mix batch had a better indicator in biogas quantity but the final methane concentration was the same for both substrates, indicating that both have the same potential in terms of biogas quality relative to its methane volume percentage.

One of the main ideas which can be extracted from the present work is that that the residual water from the treatment plant has a good potential relative to further usage at larger scale with possible applications for biogas production with usage in firing processes.

Acknowledgements

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STUDII PRIVIND PRODUCȚIA DE BIOGAZ DIN SUBSTRATURI AGRICOLE

Rezumat

In prezent, domeniul legat de utilizarea surselor regenerabile de energie este într-o continuă dezvoltare. În contextul crizei globale, este extrem de important să se găsească soluţii de valorificare a surselor de energie existente (eoliană, hidro, solară, biomasă). Reziduuri de biomasă reprezintă o materie primă cu un mare potenţial în producerea de biogaz prin procesul de fermentaţie anaerobă. Deoarece degradarea este un fenomen important in timpul procesului de obţinere a biogazului, prezentul studiu prezintă proprietăţile fizico-chimice a două tipuri de biomasă vegetală şi comportamentul lor în timpul procesului de co-fermentare anaerobă cu apă reziduală de la o staţie de epurare. Concluziile desprinse în urma rezultatelor obţinute vizează identificarea posibilelor aplicaţii ale biogazuui produs.