Biogas from Poultry Waste - a Source of Energy

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Abstract. The latest excessive industrial development has led to both the increase of the fossil fuel consumption and an excessive pollution. A saving solution would be the use of alternative, renewable energy sources, best based on wastes, which prove energy content. The current work focuses on a case study for the biogas production, using anaerobic digestion of poultry dejections, by means of a latest generation bio-processor. These dejections are presently and normally used only as fertilizer. The experiment was performed simultaneously in 6 digesters, which were loaded daily with a quantity of material resulting from the calculated recipe, based on the characteristics of the poultry litter. Preliminary analysis such as calorific value, humidity and volatile content were run. Following the results obtained can state that the poultry litter can be used as raw material for the anaerobic biogas production, in the future, as well.

1. Introduction

Together with the humankind evolution, the energy has become an important part of the economic development, significantly being generated by the increase of the population`s life standards [1]. This rapid economic development has come, up not only with benefits, but it also has brought a series of disadvantages. Thus, one can sustain that the energy constitutes a major factor in the evolution and the increase of the global economy [2].

As a result of the significant increase in electricity consumption, scientists are urging countries around the world to turn their attention to obtaining renewable energy [3].

Also, the use of renewable energy will generate lower production costs and will significantly contribute to solving the problem of global warming [4].

The climate changes, the increase of the fuel prices [5], the environment regulation and irreversible changes are facts, more and more demanding [6]. The rapid increase of the energy consumption, but also the fear of fossil fuels exhaustion, especially in the countries where the natural resources are reduced, have determined the community of the scientists to search alternative resources. Best of them are characterised by a low or neutral CO_2 emission, generally speaking a low exhaust of green gases, affecting the climate change.

An innovating solution would be the usage of recycling energy resources, as these being considered viable, cheap, ecologic, and avoidable for any state, poor in natural resources. The increase of the consumption of recycling energy by producing electrical energy and heat is at the basis of an ecological energetic transaction [7]. For the countries that are rich in biodegradable litter the designing of the biogas installation would be one option. This is a viable method to solve, not only the issue related to the energy, but also the issue of eliminating the litter, in an economic circle.

As for Romania, it provides a wide variety of biodegradable resources such as: biomass, the energy cultures [8], the litter obtained from the animal farms, the agricultural litter, the industrial litter, and the municipal solid litter.

Raising animals for slaughtering and meat processing and the large number of slaughterhouses, do not only have positive effects on the population, by creating new jobs and ensuring a fresh diet. These also lead to the generation of a large amount of waste, for the elimination of which solutions must be found urgently [9]. A suitable solution would be to capitalize this waste, and use it in a circular economy, by producing biogas, not before it has gone through a pre-treatment process (biological, physical, chemical and mechanical) [10].

The biogas is a gas, which is obtained through the biological decomposing of organic material in the absence of the oxygen [8]. Through technology the anaerobic mass digest is changed into biogas [11], while the organic substrate, resulted due to this process, is used in agriculture [12].

Concerning the methane production, the researchers are doing detailed tests to obtain bigger amounts using as raw the whey resulted after the process of milk manufacturing, the pig litter, the cow litter [13], the poultry litter.

Following the studies made, it was concluded that mixing several types of raw materials generates a much larger amount of methane, unless a single type is used [14].

2. The used material and the method of testing sampling

2.1. The experimental configuration

The lab installation used for this experiment is a bioreactor simulator (BRS). This is equipped with 6 graded glass digesters up to 1800 ml. Although digester has the capacity of 2000 ml during the experiment their charging rate was 1800 ml. Each of the 6 reactors has 3 orifices: an orifice is intended for feeding raw material supply, an orifice is used to evacuate the digestate in the reactor and an orifice can be used in continuous measurement of pH or temperature.

This installation was developed by Bioprocess Control Sweden AB (BPC) for the on-line monitoring and control in a continual way of the anaerobic fermentation of the experiment [15].

The installation has the capacity of calculating and of presenting in real time the rate of the organic charging (ORL), the hydraulic time retention (HRT) and significant gas production (SGP) [15].

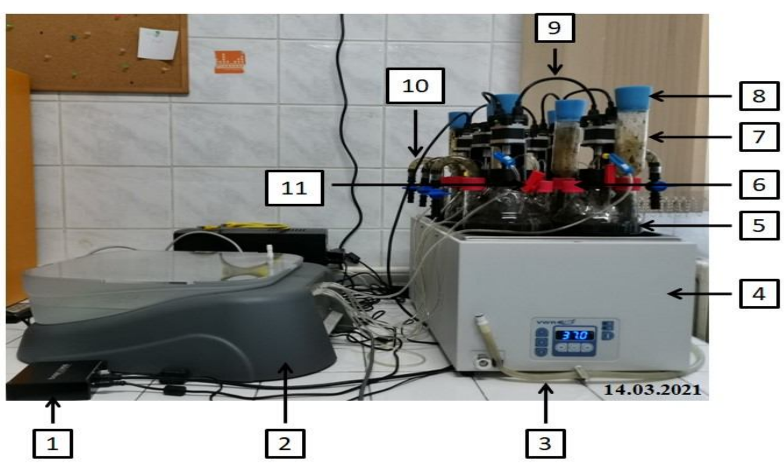

Figure 1. The schematic of the lab installation for the bio-gas production: 1- device for the motor control, 2- device of measuring the gas volume, 3- tube of water evacuation, 4- bath of thermostatic water, 5- six glass reactor with three holes, 6- plastic screw cap without hole, 7- funnel for charging, 8- silicon corks, 9- engine cable, 10- discharging tube, 11- plastic clamps for tubes [16].

The installation is a very high performance one, because it offers to the user the possibility to choose for each digester the type of substrate, as well as its concentration. The 6 digesters are running in parallel, but independent, main data (such as flow rate) being automatic measured and stored, according to a selected programm. Moreover, it offers the possibility to program the loading/unloading time of the digesters. With the help of a laptop or phone the user can overview, start, interrupt or even end the experiment [15].

2.2. Storing and pre-treating of the raw material

The poultry litter was collected from a poultry breeding farm and inoculums were provided by a biogas installation. Throughout the whole experiment the raw material was stored in a fridge while the inoculums were incubated at a temperature of 37°C for a week. Before being introduced in the digester the poultry litter was grounded with the help of a mixer, being afterwards diluted with warm water. Analysis concerning humidity, volatile content and heat value were simultaneously run, according to recommended procedures/standards EN 14774 Solid biofuels- determination of moisture content, EN 14775- Solid biofuels- determination of ash content, EN 14918- Solid biofuels- determination of calorific value, EN 15148- Solid bio fuels- determination of volatile matter content [17].

As a result of the preliminary tests, one concluded that for obtaining an optimal receipt one needs: 1065.7 g of inoculums, 620.79 g of warm water and 113.51 grams of poultry litter, in mixture, for each digester. During the experiment the daily rate of discharging of the 6 digesters was of 168.9 grams/digester, while the daily dose of their charging was of 26.1 grams of poultry litter and 142.8 grams of warm water/digester. In the last 13 days of the experiment, the loading rate of the digesters was doubled. During the whole experiment the digesters were kept in a thermostatic water bath at a temperature of 37°C. The samples used are showing specific characteristic that are turning it into a good biodegradable material, as it has pH of 6.8-7.3 and a specific proportion C/N= 15-20. Based on the information obtained from the farm owners, the use of antibiotics or phenols, or detergents in the practice is not usual.

To reach these results, there the following procedures/steps were accomplished: (a) The numbering and the weighing of six empty crucibles with a capacity of 100 ml; (b) The adding of 150 grams of wet material in every crucible; (c) The introduction of the crucibles in the oven and their keeping at a temperature of 105° C within 24 hours; (d) After 24 hours the dishes are removed from the oven and are left to cool down at the room temperature in several desiccators; (e) Then the six crucibles were weighed and their values marked, these values representing the amount of dried substance; (f) The weighed crucibles are introduced in a calcinatory for two hours at a temperature of 550°C; (g) After the two hours the six crucibles were removed from the calcinatory and introduced in the desiccators, to be cooled downs (h) After cooling down these were weighed, and the obtained valued represent the amount of the burnt substance; (j) The steps were repeated if necessary, until the final weight (mass) remained constant.

Based on the previously presented steps one could calculated the necessary amount of material to obtain an efficient receipt of the biogas production.

2.3. The supervision of the optimal environment of the microorganisms. Results

The pH value offers inseminated information about the acid and the basic measure of the digested. The studies have proved the fact that the bacteria develop better in neutral conditions up to light alkaline, where the optimal value of pH is between 7 and 8,5 [18]. Another important factor in the developing of the bacteria consists in the temperature that has to be stable. If for the mesophilic bacteria the temperature must be between 30-45°C, for the thermophilic bacteria this must be between 45-55°C [19, 20]. Within the whole experiment with the help of a portable pH-meter of high accuracy the pH value of the digestate was measured. The recorded values throughout the experiment varied between 7.35 and 7.87, this thing proves the fact that the optimal environment was offered to the bacteria.

Figure 2 represents the pH variation that was recorded during the experiment of anaerobic digestion. If in the first part of the experiment the pH value was higher, this oscillating between the values 7.56- 7.87, one can notice that towards the end of the experiment the pH value registered a slight decrease, varying between 7.36-7.49.

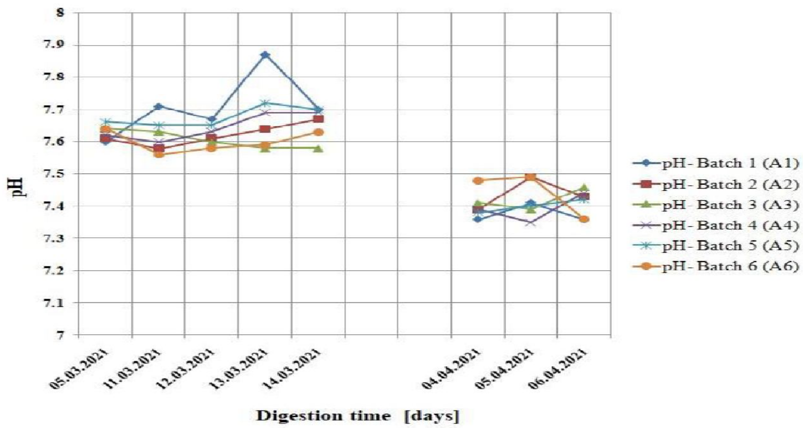

Figure 2. The pH value for the six digesters.

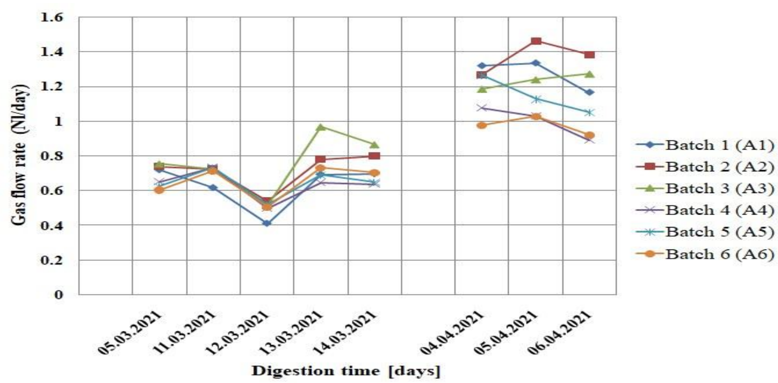

Figure 3. The days with the most relevant gas flow.

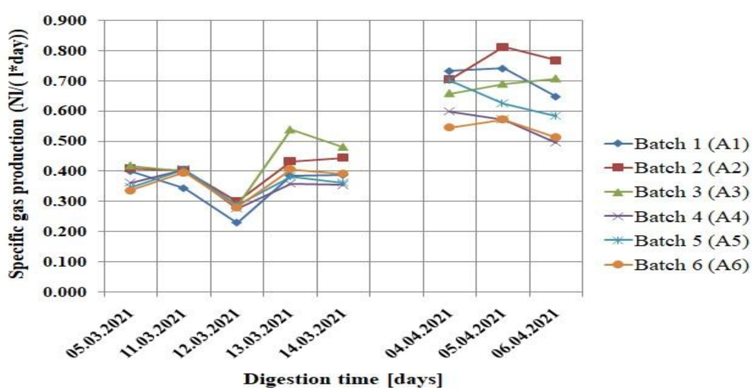

Figure 4. The specific gas production.

The results, covering the most relevant gas flows, are presented in the figure 3. If in the first part of the experiment the 6 digesters were loaded with 168.9 g (water + poultry manure), during this period the lowest value of the gas flow was recorded at line 1 (A1), while the value of the highest was recorded at line 3 (A3). Towards the end of the experiment, the loading rate of the digesters doubled. During this period the lowest gas flow was recorded at line 4 (A4), and the highest gas flow recorded at line 2 (A2).

Figure 4 represents the amount of biogas (daily specific gas production) obtained at the beginning and end of the experimental period. At the beginning of the experiment, the amount of gas generated was reduced and stable. After that, one can observe a slight increase, followed by a sudden decrease and then finally an increase in the specific gas production. By analyzing the final stage of the experimental period, fluctuations were as well registered, but in comparison to the beginning of the experiment, they were not so sudden. The highest amount of gas recorded was on line (A2) and took place at the end of the experimental stage.

3. Conclusions

This research was carried out to determine the energy properties of the poultry litter in the biogas production, using as method the anaerobic digestion. The experiment was accomplished with the support of an ultramodern installation made up of 6 digesters, filled preliminary with the same amount of material and of inoculums. The main first two advantages of this installation consist in the fact that it has the capacity to store the measured data and information on a computer and that it can be supervised, in real time, from a laptop or a mobile.

Within the whole experiment the pH was measured, thus having the possibility to conclude if the bacteria were provided a proper environment for developing and supporting the CH_4 generation, under anaerobic conditions, in mesophilic conditions.

Even though the 6 digesters were daily fuelled with the same dose of under-layer, the biogas amount generated in the 6 lines was different. An explanation consists of the differences on the raw material, as even one mixed very well each batch, the variety of the original poultry manure being variable, the composition could be slightly different. Another explanation is connected to the sensibility of the process versus the pH value hat must be controlled and corrected. In the case of this experiment no corrections were needed, because during the whole experiment the pH value was between 7.35 and 7.87.

Based on the results obtained following the experiment one can sustain that this new source of recyclable energy, based on poultry manure, can be easily implemented worldwide, and in Romania, being an important source of “clean energy”.

Due to the great diversity of biodegradable waste, which are found in our country, it is desired that in the future to determine the recipes for biogas production, using various mixtures of waste.

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