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Comparative Study for Biogas Production from Different Wastes

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Abstract

The bulk of our work was performing the anaerobic digestion of wastes rich in organic matter in a laboratory prototype. The two different substrates: the biodegradable waste from landfill and sludge from the wastewater treatment plant by natural lagoon.

We surveyed the evolution of the degradation of organic matter of both experiments which are carried in a digester with a capacity one liter, sealed. During the experiments we followed themeasure of the COD (chemical oxygen demand), the volume of biogas formed during the digestion, the temperature and the pH.The biogas produced from the anaerobic digestion of the two substrates is flammable with a percentage of CH_4 more than 64%.

Comparing the volume of biogas produced during the digestion of the two substrates of digestion we found that the volume collect from the sludge waste is greater than 10 times relative to thevolume of biogas produced with organic matter in the landfill. The volume of biogas produced is always a function of the residence time of digestion and the concentration of organic matter in the experiment. The percentage of decrease in COD of the sludge was estimated at 87.3% and the substrate of the landfill is 82.44%.

***Keywords**:Anaerobic Digestion, Biogas, biodegradable, COD.*

1. Introduction

Biogas is a clean renewable energy produced from organic wastes using anaerobic digestion as a method. The anaerobic digestion is a biological degradation of organic matter by bacteriological flora in anaerobic mode [1]. The products of the digestion are biogas and residue. Biogas is a mixture of methane (CH_4) with percentage over than 65% and carbon dioxide (CO_2). CH_4 is the highest component of natural gas. The digestate is the liquid residue containing non-degraded materials.

The anaerobic digestion is carried out in four phases [2].

• Hydrolysis: macromolecules are cut gradually soluble monomers by extracellular enzymes (cellulases, hydrolases, amylases, etc. ...)

• acidogenesis: monomers derived from the hydrolysis step, are converted to organic acids and alcohols with a release ammonium (NH_4^+), carbon dioxide (CO_2) and hydrogen (H_2),

• acetogenesis: the products of acidogenesis are converted into acetic acid (CH_3COOH), but also CO_2 and H_2, the main substrates of methanogenesis

• Methanogenesis: final step in which the methane is formed as two separate channels and main, the acetate and the mixture of H_2/CO_2 [3].

The anaerobic fermentation can take place between 5℃ and 65℃. It defines three conventionally ranges of temperatures around an optimum value qualified [2].

• The area psychrophile, from 4 to 25°C

• Themesophilic zone, from 35 to 45°C

• The thermophilic zone, from 55 to 65℃.

The first zone encompasses the fermentations present in marine sediments but also the septic tanks. The most widely studied is the area mesophilic. Differences are observed

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between bacterial populations. As well, the acetones are the most sensitive to variations in pH (optimum growth of 7, 2 then that the methanogenesis bacteria may accept variations of pH between 6 and 8. The acid bacteria can easily adapt to the pH in the vicinity of 4.

Generally, it is considered that the variations must be maintained in a range between 6, 4 and7, 8 for the fermentations are stable [4].

The biogas produced from the anaerobic digestion is flammableand can be used such as: heating, cooking, power generation, lighting and as a biofuel.

The biogas production will normally be in the range of 0.3 - 0.45 m^3 of biogas per kg of solid substances for a well-functioning process with a typical retention time of 20-30 days [5].

Biogas plant has a self-consumption of energy to keep the sludge warm.

This is typically 20% of the energy production for a well-designed biogas plant. For example if the biogas is used for power and co-generation, the available electricity will be 30-40% of the energy in the biogas, the heat will be 40-50% and the remaining 20% will be said self-consumption [6].

2. Materials And Methods

2.1. Experimental Procedure

The anaerobic digestion is carried in the digester with a capacity 1 L. before the start of the digestion reaction waste we must control strictly the anaerobic condition. The digester must be sealed and closed effectively. The experiments were conducted for residence time of 20 to 30 days.

The physic-chemicals parameters observed during the anaerobic digestion of substrates are pH, temperature, the volume of biogas produced and the chemical oxygen demand COD.

The experiments of anaerobic digestion of two organic substrates are carried out in adigester with a capacity of 1 L equipped with a sampling, placed in water bath set to the temperature at 37 ° C (fig 1). this digester is associated with a system for measuring the volume of gas produced (volume measurement by the method of the displaced liquid) [7].

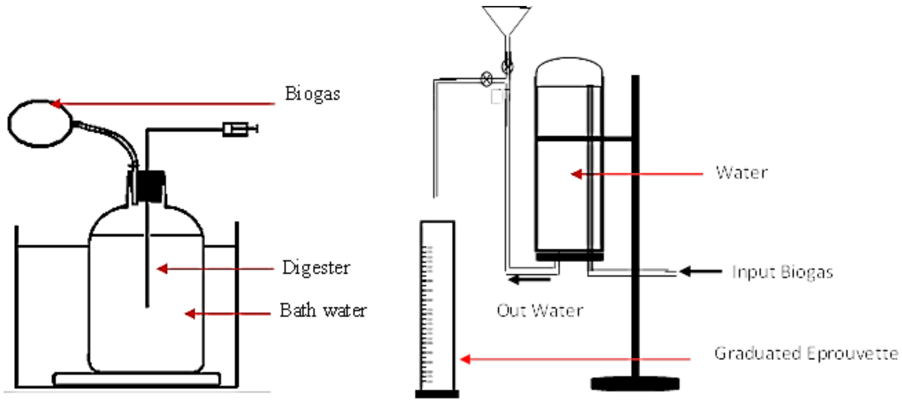

Figure 1. Experimental Digester

2.2. Analytical Method

The chemical analyses are:

- *pH*

The measurement of pH (±0.1 pH unit) is done directly by reading on a pH-meter.

- *Dry Matter (%)*

The measure must be determined as quickly as possible, to limit the losses through evaporation. The standardized method Afnor NF U 44-171, consists of a levy of a maximum quantity of sample, preferably a mass greater than 100 ±0.1 g, placing in the oven at 105 ± 2 ℃ until constant weight, approximately 24 hours. The dry matter (MS %) is the supplementary rate degree of humidity[8].

- *Dry volatil Matter (%)*

A mass around 50 ±0.1 g is calcined at 550 ℃, for 2 hours in a furnace (NF U 44- 160) [9].

- *Chemical oxygen demand (COD)*

Measurement with the aid of a equipment and by spectrophotometry UV-VIS [10].

- *NTK (Nitrogen Kjeldahl)*

5 ml of the sample are place in the flask of Kjeldhal.
Add 7,5 g of catalyst ($CuSO_4$ + K_2SO_4).
Add 10 ml of H_2SO_4.
Add 10 ml of hydrogen peroxide 30% (H_2O_2).

- *Biochemical oxygen demand (BOD)*

The value of this measure allows you to assess the amount of oxygen that the environment must be able to provide to ensure the aerobic degradation of the effluent which is will to be rejected. Measurement of the oxygen consumed in five days by a sample diluted with saturated water into oxygen, sown with the seeds, and then placed in a thermostatic chamber at 20℃ [11].

2.3. Substrates

2.3.1. Landfill

When they have a high water content, Organic waste are not intended to be stored in landfills, or even be incinerated. It thus requires a strong limitation of the landfill of biodegradable waste. This objective requires significant efforts include: reducing waste, increasing the recycled hand and development of composting, anaerobic digestion followed or not. The important treatment of this organic matter is the recovery to energy from waste through anaerobic digestion process. It is a renewable energy source as we produce waste, the cost is low. The composition of the landfill wastes is various (table 1).

Table 1. Classification of the Landfill Waste,

Parameter	Percentage (%)
Organic matter	61,86
Plastic	10,50
Cardboard and paper	11,58
Métaux Metals	8,75
Glass	4,50
Rags and other	2,83

2.3.2. Sludge of Wastewater

The natural lagoon is the most widely used biological treatment stations for medium-sized (more than 2000 inhabitant equivalents). The sample of the plant wastewater sludge is taken from the treatment plant and especially from the settling tank. The composition of the sludge is reported in Table 2

Table 2. Composition of the Wastewater Sludge,

Parameter	Composition
Dry Matter (%)	18
Dry Volatils Matter (%)	80
Azote (mg/L)	4
Phosphorus (mg/L)	1,2
CDO (mg/L)	1500
BDO5 (mg/L)	750
pH	8

2.4. Procedures

The experiment was conducted at a digester with a capacity of one liter. The substrate is dilute at 80% with the water. Then we placed the digester in the bath water adjusted at the temperature 37℃.

To study the anaerobic digestion, samples of the mixture were taken from the substrate for determination of COD at suitable time intervals and analyzed by a UV–visible spectrophotometer. The biogas product is collected in balloon and measured by the method of the liquid displacement. The experiments were performed at the pH that resulted the methanogenesis phase, if the pH is coming below 6,5 an adjustement of the pH with the $CaCO_3$ is recommended.

3. Results And Discussion

3.1. Anaerobic Digestion of Waste from Landfill

The anaerobic digestion of organic waste from the landfill is carried out in a digester with a capacity of 1 L. The organic waste is shredded and finely divided into small pieces. The dilution ratio used is 80%. We followed the pH, temperature, COD and measured the volume of the recovered biogas which is passed through a Bunsen burner to examine its flammability.

The evolution of the volume of biogas formed during the anaerobic digestion of organic materials from the landfill over time is shown in Fig 2. From this figure, it appears that the amount of biogas formed increases with increasing residence time in the digester. These results clearly show that methanogen bacteria transform organic matter into biogas.The methanation or anaerobic digestion is a biochemical phenomenon rather anaerobic fermentation of organic matter under the action of microorganisms. The transformation of organic matter in gas is the work of myriad bacteria. Indeed, it appears that using the methanation may be an interesting solution to provide energy from organic waste, while contributing effectively to clean up the effluent.According to data from this table, the substrate is rich in organic matter and thus could easily promote anaerobic digestion.

Differences are observed between bacterial populations. As well, the acetones are the most sensitive to variations in pH (optimum growth of 7,2 then that the methanogenesis bacteria may accept variations of pH between 6 and 8. The acid bacteria can easily adapt to the pH in the vicinity of 4. Generally, it is considered that the variations must be maintained in a range between 6,4 and7,8 for the fermentations are stable. After these phases of acidogenisis and acetonegesis the production of biogas is initiated by the final phase which is the methanogenesis.

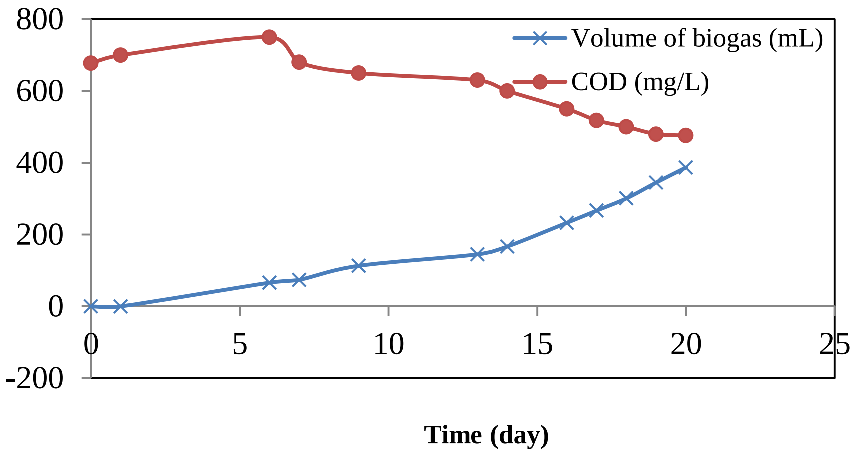

Figure 2. Anaerobic Digestion of Organic Matter from Landfill Wastes

The temperature during digestion was maintained around 37 ° C. We observe from Fig 2 that becomes flammable biogas from the day 9 of the digestion, neutral pH around 7, and the degradation of organic matter is more readable because the curve corresponding to the evolution of COD begins to decrease. We notice a slight decrease in the pH of the first day of the digestion until the fifth day of digestion when the pH was lowered from 8.01 up to 6.76, when the pH increases this tells us that acidogenesis phase is exceeded and the degradation of organic matter during methanogenesis and which is reflected in the production of biogas.

3.2. Anaerobic Digestion of Sludge

The anaerobic digestion of sludge from the treatment plant by natural lagoon is performed using a substrate concentration of 100 g / L. The evolution of the volume of biogas formed and degradation of the organic load of the sludge are exposed in Fig 3. We note a production of biogas from the 2nd day of anaerobic digestion and this is the very necessarily in that biodegradable sludge character. We also note that the sludge treatment plants are more productive in the landfill biogas. This is evidenced by the volume of biogas produced during each experiment. The anaerobic digestion degrades the organic matter in the sludge produced efficiently a flammable biogas. Thus, the more sludge is loaded with organic matter; the more methane will be effective.

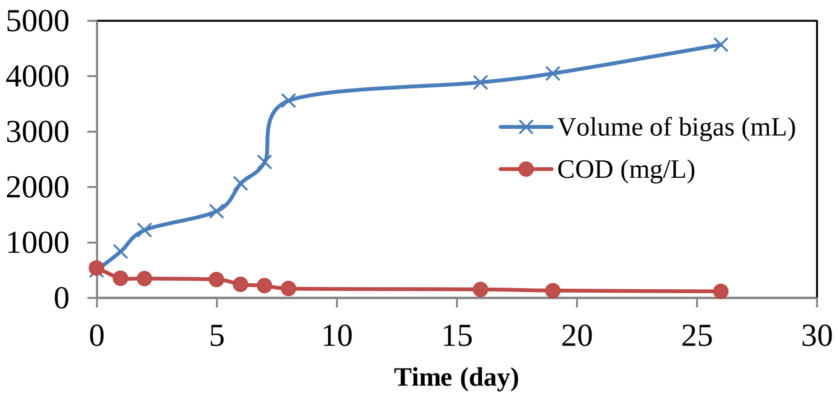

Figure 3. Anaerobic Digestion of Waste Water Sludge

The anaerobic digestion with the substrate as sludge from sewage treatment plants is readily biodegradable and form of biogas from the 2nd day of the process. Sludge from sewage treatment plants gives a very good performance in biogas production. This is inevitably the biodegradable nature of the sludge. The volume produced is ten times more than the experience of the anaerobic digestion of organic waste from the landfill.
The pH does not decrease significantly from 7.17 to 6.68, biology and biodegradability of sludge from municipal wastewater anaerobic digestion makes them easy to do.The main cause of a decrease in the pH is the accumulation in the middle of the intermediaries of fermentation (volatile fatty acids, lactic acid, etc.).
This accumulation may be due to different phenomena, such as the inhibition of the subsequent stages or the biodegradation too fast of an organic substrate.
This phenomenon can appear quickly and led to an imbalance of the irreversible fermentation in the absence of a regulating process.

If we compare the test anaerobic digestion of two substrates, we note that for the substrate resulted in the production of biogas which% CH_4 is greater than 70%. This was confirmed by the flammability of biogas produced. It was also noted that the sludge treatment plants are more productive in the landfill biogas. We realized this fact, a comparison experiment between the two substrates digestion which was launched in the same operating conditions two anaerobic digestion tests, one with the sewage sludge and other organic waste with the landfill. We followed the variation of COD and we measured the volume of biogas each bottle. Fig 4 shows the degradation of the two substrates and indicates that both substrates digestion are biodegradable and can be valuable in a renewable and inexhaustible.

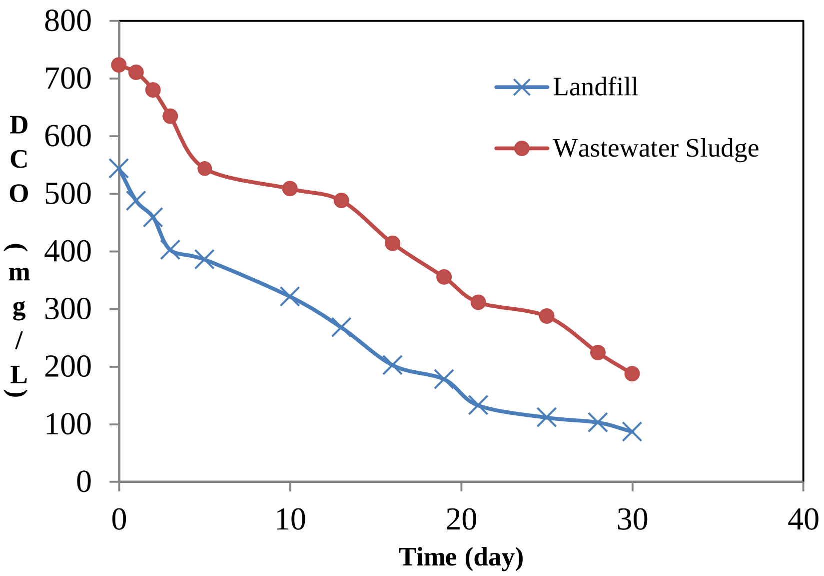

Figure 4. Variation of the COD of the Two Substrates Digestion

The volume of biogas increases with residence time and substrate concentration. Only high concentrations require time to stay very long for digestion. For the two different substrates we found flammable biogas with different volume production as shown in Fig 5.

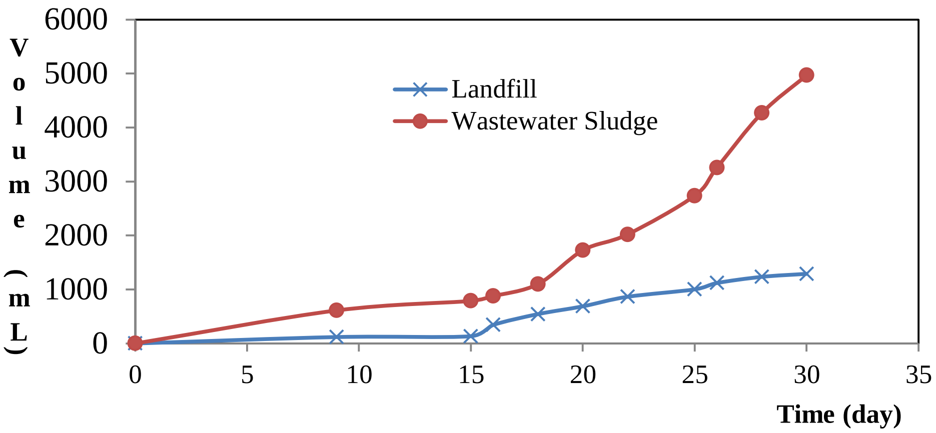

Figure 5. Biogas's Volume of the Two Substrates Digestion

4. Conclusion

The anaerobic digestion process offers the possibility of combining the treatment of waste and the production of renewable energy is biogas rich in methane CH_4 [12, 13].

The biogas produced in the two substrates is flammable, especially since the second day of the digestion of the substrate sludge [14].

Substrate for the landfill, the onset of methanogenesis is detected on day 9. Phase methanogenesis was not inhibited the pH decreased to 6.68 for the substrate of the discharge for the substrate and 6.76 for sludge off waste water treatment.

This slight decrease in pH shows that the substrate used for the two tests is readily biodegradable. Digestion temperature remains between 35 ° C and 37℃ [15].

The rate of reduction in COD (chemical demand in oxygen) of the sludge was estimated at 87.3% and the substrate of the landfill is 82.44%.

Methanogenesis is the specific step of the methane fermentation. It leads to the reduction of carbon in methane and is carried out by highly specialized microorganisms.

During this phase, the chemical oxygen demand decreases to produce biogas against party over the substrate is concentrated biodegradable organic material the more it produces biogas and this was confirmed by comparing the two types of substrate digestion in our study.

The energy and environmental systems analyses presented in this thesis indicatethat the environmental impact of biogas production can vary greatly depending onthe raw materials digested and the system design.

Anaerobic digestion is a method of treating organic waste materials effectively, easily and economically exploitable. This method reduces the use of fossil fuels especially in the regions were the connection of natural gas and electricity is very expensive as well as the production of recoverable energy which is biogas. Also, this process contributes to the cleanup of organic loads. Another advantage is the production of a residue that can enhance the soils poor in organic matter16].

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