

The Recovery of Municipal Solid Waste (MSW) into Biogas Using Accelerated Processing. The Case Study: Ouargla City in Sahara- Algeria

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Abstract

The study aims is to accelerator (reducing time) of the process of the digestion anaerobic and increasing the amount of biogas using accelerator; this technology allows for reduced the municipal solid waste (food) - based organic material (that is to say the achievement of zero food waste, especially after development urban digester in the neighbourhood and smart trash). In consequently, the study complemented the results of preliminary research, who to show the importance of proteins and fatty in municipal solid waste (MSW) to the production of biogas to the natural's deadlines in phase mesophile and thermophile for methanogens to function properly in 40 days. The obtained results through a reactor for anaerobic digestion (from the experimental condition at 37°C and 60°C), at representative sampling municipal solid waste of Ouargla city in Sahara –Algeria, in terms of quantity and quality, clearly show: 1. The impact of *Aspergillusniger* accelerator in reducing the extreme production biogas time in the digester in experience 1, recording respectively in 37°C and 60°C: 208.5 ml and 99.6 ml (in 19 days), compared experience 2 without accelerator in 37°C and 60°C: 140.3 ml and 207.5 ml (in 39 days). These results show (doubtless) the impact of accelerators of reducing time producing biogas in 37°C by 100%; on the other hand, the accelerator does not give significant results for increasing biogas production. 2. This result of reducing time producing biogas this will (undoubtedly allow) us the innovation of a digester household biogas digester in the residential neighbourhood and smart trash in homes (that is to say the achievement of zero food waste).

Keywords: anaerobic digestion; biogas; *Aspergillusniger*; MSW; methanation.

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Introduction

The recycling of municipal solid waste through the anaerobic digestion into biogas represents one of the current topics that address the issues for renewable energy (clean methane, municipal waste zero and massive production in city)[1].

The production of biogas is based on experience in anaerobic digestion and fermentation (methanogens)[2]. In this context, several researches have been developed the increase biogas extraction, in particular, on the questions of: (1) Laboratory ambience simulation to reality in CET. (2) Research into the most effective fermentation accelerators to shorten the duration of methanogens, and augmented biogas, (3) Development of urban and domestic reactors (that is to say the achievement of zero food waste, especially after development urban digester in the neighborhood and smart trash, that is to say the achievement of zero food waste[3], especially after reducing time of methanogens, which allows the development and realization urban digester in the neighborhoods and smart trash). Indeed, the policy of biogas production in Algeria represents an excellent solution the transition clean renewable energy and for the final elimination of MSW based on organic matter in cities. Algeria plans to install 50 technical landfill centers (CET) in 2025[4]. The project is very ambitious in terms of the quality and quantity of household waste (0.8 kg/inhabitants, 75% MO, rich in fat and protein), compared and international standard [5]. In this context, the present study in complemented the results of preliminary research, who revealed the impact of the proteins and fats in the food waste in Algeria (based on organic matter) on the augmented of the amount of biogas emitted[6].

In this framework, several researches (current topics) published very interesting results in with national[7,8,9,10,11,12], and internationals research's[13,14,15,16,17,18,19], especially, who are trying to develop the research into the most effective fermentation accelerators, that allow shortening the duration of methanogens, the augmented production biogas and Development of urban and domestic reactors (achieving virtually zero waste of organic materials); Especially the case of accelerator *Aspergillus niger* [20].

Therefore, the solid waste municipal of Ouargla city in Sahara –Algeria, is an exemplary case study in terms of quantity and quality (because dates constitute a medium rich in sugars for the "submerged" culture of an *A. niger* [21,22]. The Algerian date production (in 2021 is estimated 17 million date, product at 261,000 tons/year)[23]; which is a huge benefactor in and importance choice of the subject; especially to concretize the process in CET in city.

Materials and methods:

Biogas extraction and the revalorization experiments in the laboratory are usually done using fours steps components:

a. The assembly of a reactor digester on a laboratory scale:

The laboratory work, based on the experience anaerobic digestion (DA) in a reactors (i.e. the treatment DA based MO of two substrate samples in the absence of oxygen in 37°C-60°C), it is generally described by three phases between temperature 37°C-60°C: i). Mesophilic, ii). Thermophilic, and iii) Hyperthermophilic [24].

Here, hydrolysis is the rate-limiting step for the anaerobic digestion of solid wastes.

The preparation of laboratory assembly is based three bottles 1L:

The erlenmeyer flask of substrate, 2. Water Erlenmeyer flask colorful, 3. The graduated bottle for measuring biogas (to ensure the escape of the biogas produced).

The erlenmeyer flask of substrate is equipped with two holes syringe exit, one for taking liquid samples and the other for collecting and measuring the biogas produced (Fig.1).



Fig.1.Lab-scale anaerobic digestion reactor

b. Prepare a solid household waste sample:

The preparation of preventative sample of the mass of municipal solid waste (MSW) in Ouargla city (in southern Algeria), based food organic biomass has a surplus of fat, nitrogen and protein, is chosen, carefully, by the principles of the representative (referential composition) of household waste of Ouargla city, consist of organic matter 75%, after elimination of non-degradable substances (plastic, nylon...etc.), in the case of characterization of household waste in Algeria (Table 1)[25].

Table 1: Composition of household waste of Ouargla city.

Garbage type	Composition (%)
Food	75
Paper and cardboard	7
plastic	5
nylon	5
minerals	0.5
glass	2
VFG	5
another	0.5

This characterization (MSW) justifies our choice of case study of Ouargla city in Sahara –Algeria, either on a national or international level (Table 2, 3)[26].

Table 2: Composition level of household waste of Algeria city (national and international)

MWS chief city category	Ouargla %	Ténés %	Bourdjbouaridj %	Ghardaia %	Oran %
Food	75	72	61	58,5	69
Paper and cardboard	9	12	9	20	2,5
Plastic	7	12	9	20	2,5
Other	9	4	1,5	1,5	26
Total	100	100	100	100	100

Table 3: Composition level of household waste of Ouarglacity(national and international)

Countries and Maghrib	Organic Matter (OM)	Paper and cardboard	Plastic	Other
Algeria	67-89	7-9	2-3	1
Libya	42-48	16-19	2	3
Mauritania	4.6	3	17	44.5
Morocco	37-81	1-23	1-16	0-2

c. Preparing the environment anaerobes:

The experiment of anaerobic digestion takes place over a period of approximately 40 daily's, under specific operating conditions.

The laboratory parameter is defined by characterized four: temperatures, pH, humidity and Mass waste (MO).

The exemplary temperature of methanogens, in both experiments (37°C and 60°C), this referential temperature for to trigger it methanogen process: mesophililes and thermophililes: the favorable phase and activation of acceleration) (Fig.2)[27].

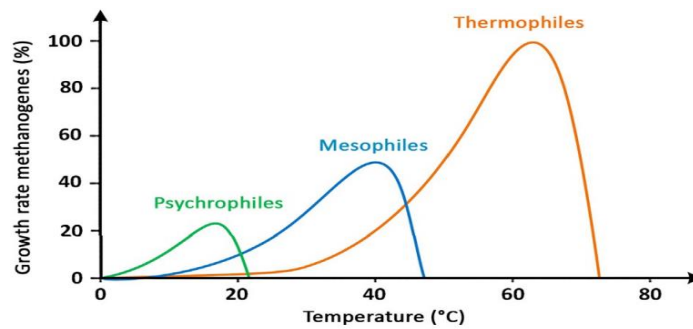


Fig.2.Relative growth rates of Kinetics

The pH is a very interesting indicator in the stabilization. Technically, the ketogenesis and methanogens phase requires a pH takes optimal value between 6.5 (37°C) and 7-8 (60°C) (Table 4)[27].

Table 4: Station laboratory.

Laboratory Station	Garbage type		types of household waste
	T (C°)	pH	-
1	37°	6-7	Food
2	60°	7-8	Food

The experience defined by characterized humidity with reference (of the total mass of the sample 100g), wetting doses by quantities of lightening water 40g (i.e. 40%) (Table5)

Table 5: Samples (mix of dry waste and wetting)

reactors	Mass waste (MS) %	mix dry (humidity) %
1	60	40

The present quantity recommended of samples: 100 g (MS and humidity-water), therefore, the recommended in this sampling organic mass is 60 g MS/l (or 60%)[28].

d. Adding accelerators constituent, mainly: of decomposing bacteria

Aspergillus niger it is a filamentous fungus that grows aerobically on organic matter; The molds, filamentous fungi, are ubiquitous and are also found on plants, products of plant origin, meats and products of animal origin, animal corpses and the droppings of herbivorous animals, etc[29].

The *A. niger* strain is implemented and inoculated sterilely on 2 petri dishes containing 10 ml at the biology laboratory level, in order to recover as many spores as possible. After 7 days of incubation at 37°C, spores appear on the surface of the mycelial mat[30].

The color of the colonies, the colonies appears white then yellow then blackish (Fig.3).



Fig.3. Photograph of *Aspergillus niger* accelerator.

Results:

The experiment 1 (Fig.4) shows the impact of high temperatures (37°C, 60°C) in degrees of mix wetting (humidity- water 40%) on the production of biogas emitted from the digestion anaerobic of the sample without accelerator, respectively expressed by the extreme amounts emitted of biogas: 140,3 ml and 207.5 ml (in 39 days).

This result shows the similarity of the biogas production in the preliminary study. It was also noted that the beginning of the extraction of biogas began significantly from 19 to 40 days, in the natural's deadlines for methanogen.

The decline in the quantity emitted recorded after 40 days in (37°C and 60°C): 77.9ml and 78.1ml.

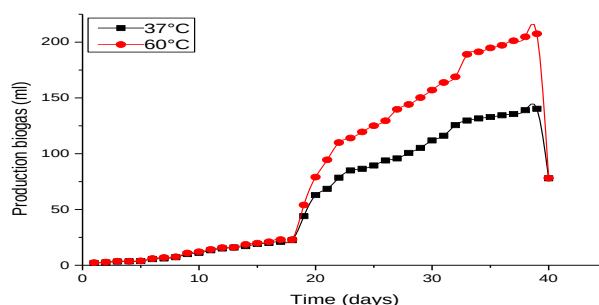


Fig.4. Kinetics of days biogas production (without accelerator).

By the experiment 2 (Fig.6) we see that the methanogen phase is triggered from the 4th day, it considerably changes the extreme results until the 19th day when it reaches, from the maximum value at 37°C: 208.5 ml (in 19 days), compared with to 60°C (99.6 ml) (in 19 days). Therefore, the result exactly shows the impact of *Aspergillusniger* accelerator an reducing the time of Kinetics of biogas production (or 100% time reducing). This explains the acceleration of the fermentation process of fatty acids and proteins (VFA) into biogas. On the other hand, the curve of kinetics of time biogas production in the case of 60° is similar to that of experiment 1 (without accelerator), which explains the inactivation of *Aspergillusniger* in temperatures above 40°C, So, the important values of methanogens within the natural's deadlines in phase mesophiles and thermophiles between 19-40 days). The curve shows the production in decline until maintained in zero until the 40th day. These results show (doubtless) the impact of accelerators of reducing time producing biogas

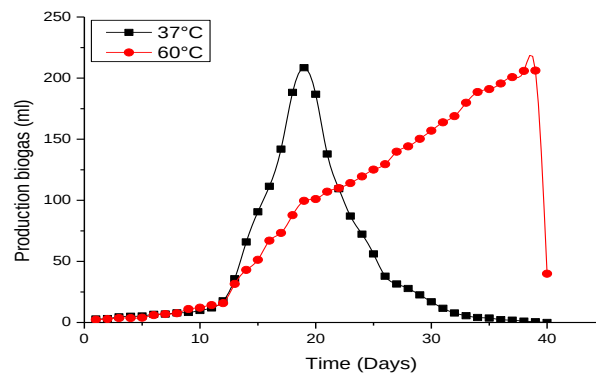


Fig .6. Kinetics of days biogas production (with accelerator).

Discussion:

Two result obtained discussion:

1. The impact of *Aspergillusniger* accelerator reducing the extreme production biogas time:

The curve of biogas production kinetics is divided into three main phases:

- a. Latency phase: This phase is observed in the production of biogas by using accelerator, during the first days (more significantly, from 4 days), compared to the sample without accelerators (which started in 10 days). Production in this area begins with minimum biogas production in hydrolysis phase (this phase precedes methanol production which is responsible for biogas production).
- b. Exponential phase: concretely (and undoubtedly) we distinguish in experiment 2, the impact of the *Aspergillusniger* accelerator reducing the extreme time of biogas production by 19 days, in maximum value in 37°C: 208.5 ml (i.e. 100% time reduction) in the digester.

In this second phase, we note the regular daily more than increase of 50 ml up to 19 days, compared to the experiment without accelerator at 37°C and 60°C: 140,3 and 207.5 ml in 39 days.

c. Declination phase: This phase where the production of biogas in experiment1: without accelerator on suddenly decreasing in 40 days.

In the second accelerator experiment, the decline in production results falls from 19 days to zero in 40 days.

2. The innovation of a digester household biogas digester in the residential neighborhood and smart trash in homes:

The results obtained (reducing time in biogas production time) will subsequently allow us to develop of a digester household biogas digester in the residential neighborhood (left) and smart trash in homes(right) (Fig.5).

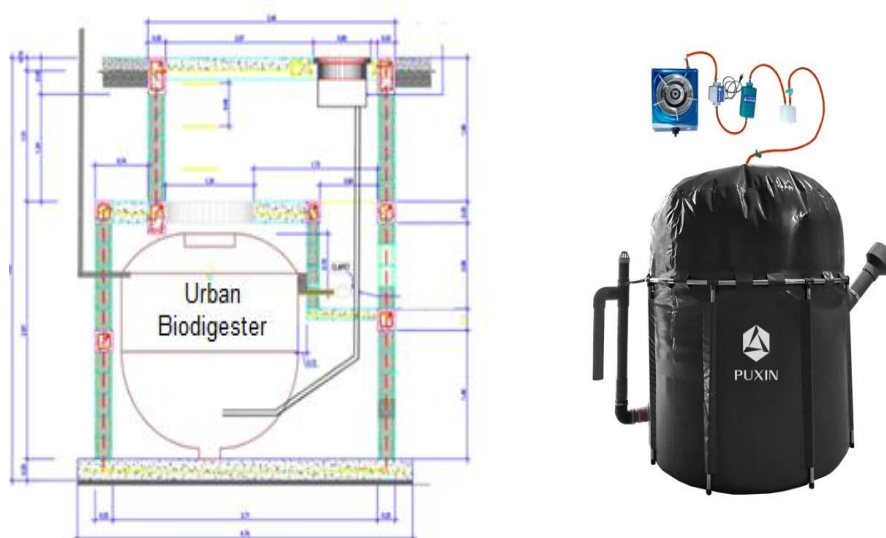


Fig.5. Urban biodigester and smart trash and commercial prototype.

Conclusion

The study complemented the results of preliminary research, who to show the importance of proteins and fatty in municipal solid waste (MSW) to the production of biogas to the natural's deadlines for methanogen (40 days in 60°C). In consequently, the study aims of this study is to accelerator (reducing time) of the process of the digestion anaerobic and increasing the amount of biogas using biochemical accelerator.

First, the experience 1 (without accelerator) shows the impact of high temperatures (37°C, 60°C) in degrees of mix wetting (60g MS/l or 60% and humidity 40%) on the extraction of biogas emitted from the anaerobic digestion of the sample of organic matter of MSW, respectively expressed in 37°C and 60°C by biogas production (in 39 days): 140.3 ml and 207.5 ml, we see that natural's

deadlines for the methanogen phase is triggered from the 11th day. This result is very similar to the results of preliminary research. It was also noted that the beginning of the production of biogas began significantly from 19 days. In addition, it took its maximum value from 33 days to 39 days, at through a small, non-regular increase spread from 19 days to 40 days).

Secondly, according to experience 2 (with accelerator *Aspergillus niger*), we see that the methanogen phase is triggered from the 4th day. The impact of the *A. niger* accelerator reducing the extreme time of biogas production by 19 days, in maximum value (in 19 days) at 37°C: 208.5 ml (i.e. 100% time reduction), compared with to 60° (99.6 ml)(in 19 days), which explains the inactivation of *A. niger* in temperatures above 40°C (so, in 60°C the important values of methanogens within the natural's deadlines in phase mesophiles and thermophiles is recorded between 19-40 days). The curve shows the production in decline until maintained in zero until the 40th day. These results show (doubtless) the impact of accelerators of reducing time producing biogas by 100%.

Finally, this result of reducing time producing biogas this will undoubtedly allow us the innovation of a digester household biogas digester in the residential neighborhood and smart trash in homes accordingly for reduced the municipal solid waste (food) - based organic material (that is to say the achievement of zero food waste).

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