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Study of the Activation Process of a 2 m³ Pilot Biodigester on a Microfarm Site

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Abstract

A domestic balloon-type digester with 1200 liters of substrate and a 700-litre gas reserve was installed at the Université Gaston Berger pilot farm, which has 4 cows. After an initial load of 1000 L of water, 90 L of bovine rumen and 145 L of cow dung, the functional parameters of the reaction medium, *i.e.*, temperature, pH, salinity and conductimetry, were regularly monitored at a rate of 3 tests per day until the thirtieth day, corresponding to the flame test and the start of analysis and daily loading of the biodigester. The analysis of the biogas obtained after the flame test showed us the considerable contribution of bovine hindquarters to the CH4 fraction, which reached 72.2% from the start of the production phase. As anaerobic digestion is both a complex and multiparametric process, microbiological analysis revealed the presence of several strains of bacteria in the substrate used. Among the most abundant were *Escherichia coli*, *Klebsiella* spp, non-fermentative Gram-negative bacilli and *Enterococcus sp*. However, the bacterial strain that interests us most in anaerobic digestion is the non-fermentative Gram-negative family. We see the identification and temporal monitoring of these families of bacteria as a major step forward in the control of anaerobic fermentation processes in the Sahelian context and in Senegal in particular.

Keywords

Pilot Digester, Activation, Bovine Belly, Conductimetry, Salinity, Microbiology Analysis

1. Introduction

The challenges of mitigating the greenhouse gas emissions that exacerbate global

warming and the consequent depletion of fossil fuels due to overuse characterize today's complex global energy issue [1] [2] [3]. According to the studies carried out by Global Carbon Budget in 2017, the strategies put in place from a scientific, social and cultural point of view have not achieved the desired changes. The world's biggest polluters, such as China, the United States and the BRICS, have not changed their energy consumption patterns, which are still dependent on fossil fuels. Furthermore, the 2015 Paris climate agreements seemed to offer a glimmer of hope, because of the ambitious targets set by the world's countries to keep the rise in the average temperature of the planet well below 2˚C compared with pre-industrial levels, and ideally below 1.5˚C. Despite these commitments, it is clear today that we are a long way from achieving these targets, which has led Antonio Guterres to say that the world is on a catastrophic path towards +2.7˚C of warming [4]. With most industrialized countries investing in renewable energy sources, it is important to emphasize that there is still a shortfall to be made up: such as anaerobic digestion technologies. The history of anaerobic digestion in Senegal began in 2009 with the promulgation of Ministerial Decree No. 12100 on the creation, organization and operation of Senegal's National Domestic Biogas Program (PNB-SN). This led to the emergence of five types of domestic biodigester on the market: The fixed dome model (GGC 2047 concrete dome), the Red MUUD Ballon model, the Biobolsa Geomembrane model, the Flexibiogaz model, the floating dome model, commonly known as the puxin model, installed by the NGO le Partenariat in Saint Louis, Senegal.

Of these models, the most widespread seems to be the GGC 2047 concrete dome model, with more than 2309 biodigesters installed by 2021 [5] [6]. But the major issues with these systems remain the control and maintenance of the system (gas pressure, substrate feeding, digester curing,) as well as the lack of scientific studies based on a well-defined protocol. To popularise this renewable energy source in sub-Saharan Africa in general and in Senegal in particular, we set ourselves the objective of studying the operating parameters of a new type of digester: the homebiogas marketed by Sustainable Business for All (SB2-4ALL), with the aim of providing users with the information they need to use and maintain it.

2. Materials and Methods

The chosen site is a micro farm, built up for educational and research purposes in the campus of Gaston Berger University, Saint-Louis, Senegal. This site hosts four cows, which produce on a Daly basis between 12 and 30 kg of manure.

The technology used in this study is the HOMEBIOGAS 2.0 (HBG 2), an Israeli-style biodigester with specific technical features. This specific version (2.0) was chosen in order to fit the capacity of manure production in the farm.

Made from UV-resistant polyethylene, polypropylene, PVC and ABS, Home-Biogas can be assembled in less than two hours, and thanks to its flexible, lightweight structure, it can be delivered as a simple parcel. The low-cost prod-

uct is currently distributed in 90 countries. The company offers four ranges of biodigesters: HOMEBIOGAS 1.0; 2.0; 4.0 and 7.0. But for economic reasons, we opted for the 2.0 model.

2.1. Technical Description of the HBG2 System

2.1.1. Dimensions

Like all anaerobic digestion systems, the HBG2 essentially comprises eight parts (see Figure 1):

Firstly, a digestion chamber, which forms the lower part of the system and has a volume of 1200 liters, where anaerobic fermentation takes place.

Then there is a biogas storage tank, which forms the upper part of the system and has a capacity of 700 liters.

This is followed by an inlet chamber for loading the substrate.

Then there's an outlet chamber, where the digestate is recovered and all the operating parameters are measured.

There is also an H_2S filter to reduce the concentration of hydrogen sulphide in the biogas for greater safety.

At the rear, there is a gas outlet where the pipework is connected to analyze the biogas and connect the system to the burner. Connected to this pipework are a water purge to sequester water vapor at the gas outlet, a single burner to use the biogas produced for cooking purposes and another outlet to connect the gas analyzer. It should be noted that the conventional distance between the single burner and the gas tank is 20 m, but we placed the burner in the practical room to isolate it from the rest.

2.1.2. Digestive Capacity

The substrate and cosubstrate inputs are detailed in the manufacturer's technical data sheet:

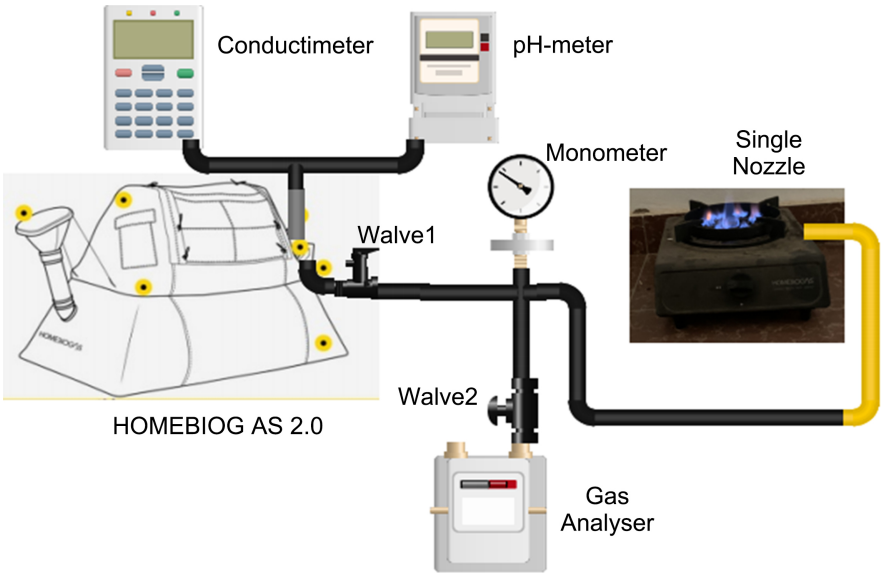


Figure 1. Microbiological schematic set up of the experimental rig.

The maximum input of organic waste is divided into two seasons.

In winter the input is 6 litres/day = 3 kg/day, while in summer it is estimated at 7.5 litres/day = 3.75 kg/day.

The maximum input of manure and slurry from the farm is 11 kg/day in winter and 14 kg/day in summer.

If we look closely at the composition of the mixture, 1 kg of organic waste is equivalent to 2 litres because the waste is mixed with water in a 1:1 ratio before being fed into the digester. This is due to the fact that manure also has to be diluted with water, in equivalent proportions.

2.1.3. Equipments (Single Burner)

The baking time (maximum duration for gas use) for HBG2 is two hours per day with normal loading and maximum production (https://www.homebiogas.com) [7].

To monitor the system's operating parameters on a daily basis, we use measuring equipment such as the OPTIMA7 biogas analyzer to determine the composition of the biogas produced, the multifunctional conductivity meter to monitor changes in conductivity, salinity and system temperature, the pen pH meter to monitor changes in pH and temperature of the reaction medium. The specifications of these equipmenents are reported in **Table 1**. The overall diagram of the system and the measuring equipment is shown in **Figure 1**.

2.2. Set-Up and Experimental Protocol

The HBG2 activation test began with the reception and installation of the system on Friday 16/12/2022 at the integrated mini-farm of the Gaston Berger University in Saint Louis, Senegal. Once the system was installed, we proceeded with the initial filling. The initial filling was done in three stages. To ensure that HBG2 was ready for use, we first introduced 1000 liters of water into the digester. Next, 90 L of bovine rumen was introduced into the reactor to make the medium richer in bacterial consortia with a view to activating the anaerobic digestion process.

Table 1. Characteristics of the equipment.

Analysis	Apparatus	Sensor	Measured	Range	Accuracy
Biogas analysis	MRU-OPTIMA7	NDIR	CH_4	0% - 100%	±0.3% or 5% reading
			CO_2		
		Electronical	H_2S	0 - 2000 ppm	±10 ppm
			O_2	0% - 25%	±0.2 Vol% abs
Substrate analysis	WTW Inolab Cond 7110	nd	Salinity	0 - 70 ppt	Nd
			Conductivity	0 - 1000 Ms/cm	±0.5%
			Temperature	−5˚C - 105˚C	±0.1˚C
	Hanna HI98127	Electrode HI73127	pH	pH 2.0/16.0	±0.1 pH

Finally, a 40 L mixture of cow dung and water was introduced into the medium to start the test. In addition to the input quantities, the Ph0 of all the inputs was also taken to have reference values, reported in Table 2. Thus, to complete the initial loading and start monitoring the functional parameters, the cow dung portion was reinforced with the addition of 105 liters of mixture on 17/12/2022. In addition, the input and output parameters of the substrate and digestate were initially taken and all listed in Table 2.

This allowed us to monitor the following parameters: ambient temperature, system temperature, pH, salinity, conductimetry and oxidation-reduction potential. On a daily basis, one measurement was performed in the morning, one measurement at midday and a third one in the evening.

These functional parameters were monitored for the first thirty days before the ignition test and the first analysis of the produced biogas. On the thirtieth day, we carried out the ignition test and the first analysis of the biogas. The ignition test is used to check the flammability of the biogas produced during the first 30 days of anaerobic fermentation in order to decide how to proceed with the process. As the test went well (successful ignition), we proceeded to load the system daily with the cow dung available at the university's integrated mini-farm, at a rate of 6 loads per week. These loads corresponded to the working days of the week, *i.e.*, Monday to Saturday. The test phase lasted four and a half months, from 16 December 2022 to 01 May 2023. This enabled us to verify three possible scenarios:

The behaviour of the digester during the cool period in Senegal from December to mid-February; the behavior of the environment during the transitional period from mid-February to early March; and the behavior of the system during the hot season, which is the longest period of the year in sub-Saharan Africa.

It is important to emphasize that the loading was carried out with an accepted variability in the quantity of daily substrate, due to natural collecting issues including the absence of a weighting device in a similar installation, or to the use of some of the dung as occasional fertilizer (+/− 7 kg). We call this variability the farmer's method.

The so-called "farmer's method" consists of varying the quantity of substrate to be used per day between 15 and 22 kg in order to verify the impact of a daily load variation on the quantity of biogas produced per day, the quantity of digestate to be produced and the behavior of HBG2.

A microbiological study was also carried out on the fresh cow dung and on the digestate extracted from the system to gain an overall idea of the families of

Table 2. Input parameters for cosubstrates.

Designation	Amount of cow dung	Amount of Belly	Initial amount of water	pH of water	pH of Cow Dung Mix	pH of Belly	Output pH	pH of digest ate
Values	145 L	90 L	1000 L	8.2	7.3	7.2	7.0	7.8

microorganisms present in aerobic environments and those that characterize anaerobic environments. Throughout the test phase, the functional parameters of the biodigester and the elemental composition of the biogas produced were monitored using our measuring equipment. The collected data provided us with a dataset enabling us to plot the evolution curves of each parameter over time; hence the results that follow.

The Purpose of Microbiology Analysis

Microbiological analysis in anaerobic digestion makes it possible to isolate and identify each family of bacteria involved in the degradation of organic matter in order to produce biogas by going through the phases involved in this process. The isolation and identification of bacterial strains are both technologically and technically complex processes, the samples were sent to the bacteriological unit of Regional Laboratory of Saint-Louis for analysis. The aim was to culture on chromogenic medium, fresh cow dung on one hand and mixture of cow dung with the contents of a cow belly sampled from the HBG2 digestor at the start of digestion. After incubation at 37˚C for 24 hours, the colonies obtained were identified by studying morphological, cultural and biochemical characteristics in accordance with current procedures.

3. Results and Discussion

The results that follow describe the complexity of the anaerobic digestion process, in terms of the parameters that characterize the process and, above all, in terms of the bacterial fauna responsible for the reactions observed.

3.1. Comparative Microbiological Analysis of Samples

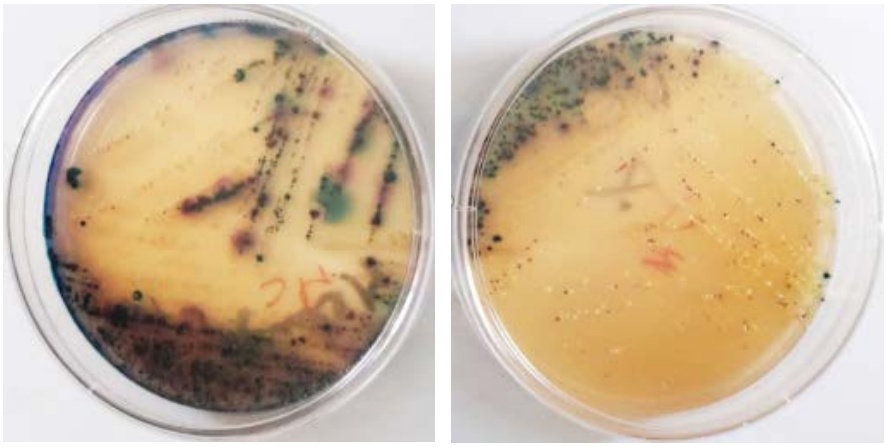
The results of the analyses revealed that both samples had been successfully characterized in the chromogenic media with evidence of several families of bacteria in the media *i.e.*, polymicrobial media.

The fresh cow dung (**Figure 2(a)**) contained the following strains:

- *Escherichia coli* +++, the predominant strain in aerobic media with a wild phenotype (**Table 3**). It also has a pink coloration, as shown in **Figure 2(a)**.
- *Klebsiella spp* ++ is a family that ranks second after the *E. coli*. This family has a bluish coloration, as shown in **Figure 2(a)**.
- Non-fermentative Gram negative, with its whitish coloration (**Figure 2(a)**), it is one of the strains least present in fresh dung because it has not yet undergone transformation in a biodigester. Its presence could therefore be due to the adaptation of strains from the cow's microbial fauna.
- *Enterococcus* ++ are still in seconde place.

The digestate from HBG2 (**Figure 2(b)**) has the opposite characteristics to cow dung.

- Non-fermentative bacteria, which were rare in fresh cow dung, become predominant in the mixture from the digester (**Table 3**). This is clearly shown in



(a) (b)

Figure 2. Microbiological analysis of Fresh Cow dung samples (a) and Cow dung + belly (b) White colonies = Non-Fermentative, Pink colonies = *E. coli*, Blue colonies = Enterobacter.

Table 3. Microbiological analysis of cow dung samples.

	Fresh cow dung	Cow dung + belly content at the start of anaerobic digestion
Isolation medium	Chromogenic medium	Chromogenic medium
Culture results	Polymicrobial +++	Polymicrobial +++
Isolated bacteria	Escherichia coli +++ Klebsiella spp Enterococcus +++ Non-fermentative Gram negative	Non-fermentative Gram negative +++ Enterococcus++ Escherichia coli rare
Antibiogram of Escherichia coli strain	Wild phenotype	n.d

Figure 2(b), with its almost whitish appearance. This family of bacteria is responsible for anaerobic fermentation.

- Enterococcus ++ are still in second place, with a disparate presence compared with fresh dung.
- *Escherichia coli* with a wild phenotype do not seem to resist anaerobic conditions, hence their rarity.

These microbiological analysis results give us a glimpse of the characteristics of two different culture media: fresh dung and digestate from an anaerobic environment. However, we are still limited by the failure to identify the sub-families of non-fermentative Gram-negative bacilli.

These results highlight that the fact that Escherichia coli which are majoritarian in cow dung becomes rare at the start of digestion.

3.2. The Impact of Ambient Temperature on the System's Inner Temperature

Temperature is one of the most influential parameters in anaerobic digestion. In order to study the evolution of temperature in HBG2, we considered it necessary to simultaneously study the variations in ambient and system temperature to see the correlation between the reaction medium and its most immediate environment.

To do this, the ambient temperature was taken from the water in the pond located two meters away from the biodigester, since the substrate mixture introduced into the reactor is almost liquid.

As with all the parameters studied in this test, the temperature was taken three times a day. In fact, the ambient temperatures throughout the day seem to be divided into two phases. The midday and evening temperatures vary in a similar way, with a notable difference on 20/06/2023, when the midday temperature reached a maximum value of 33.6˚C while the evening temperature was 27˚C, Figure 3. The similarity of the two temperatures over time can be explained by the fact that the cement pool has the capacity to transfer the heat stored during the day to the water in the evening. The maximum value recorded on 20 February can be explained by the fact that this is a month of transition between the cooler and warmer periods.

On top of that, this year the date of 20/02/2023 coincided with a heatwave that swept across the country. Ambient evening temperatures were lower than at any time during the test period. However, the low morning temperature of 17.1˚C was recorded on 17/02/2023, *i.e.*, two days before the midday peak in Figure 3. This differential behavior of temperatures in February can be explained by the adverse weather conditions, which lead to unprecedented variations during the day. So, what will be the impact on system temperatures? Compared with ambient

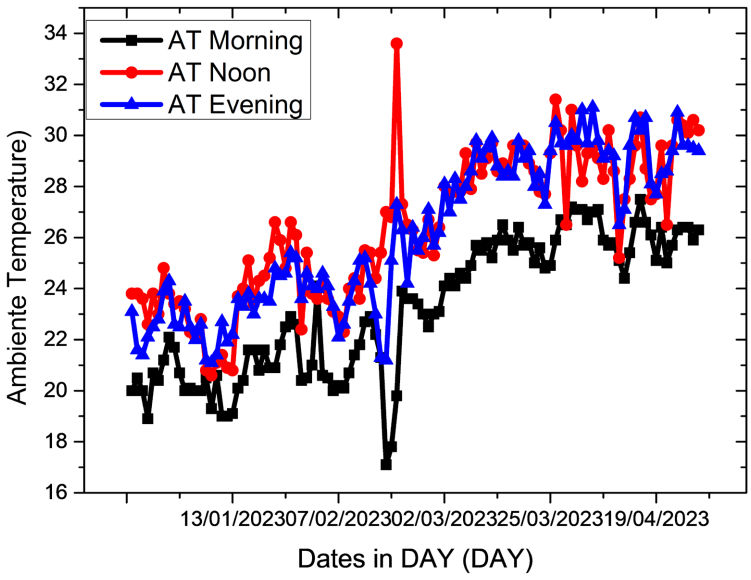


Figure 3. Variation curve of ambient temperature as a function of time.

temperatures, biodigester temperatures are rather disparate, with a differential distribution between morning, midday and evening temperatures (**Figure 4**). The lowest temperatures are recorded in the morning with a minimum value of 17.6˚C on 02/02/2023 and the maximum temperature in the morning is recorded on 15/04/2023 with a value of 33.2˚C **Figure 4**. Average temperatures are recorded in the evening with values varying between 23.1˚C and 43.7˚C respectively on 24/03/2023 and 01/04/2023.

Maximum temperatures are recorded at midday, with a peak of 46.2˚C observed on 27/03/2023. Overall, HBG2 temperatures vary between 17.6˚C and 46.2˚C without heating up the system. This means that our biodigester is operating in a mesophilic regime [8] [9] [10]. The fact that we can record system temperatures of up to 46.2˚C not only increases bacterial activity in the reactor but also, and above all, saves energy in semi-industrial and industrial reactors. This makes the system more efficient and even more profitable, as there is no need to supply heat for a large part of the year. Hence the climatic advantage of countries south of the Sahara. It is important to emphasize that obtaining these temperatures depends on the material used.

3.3. pH Variation

After temperature, pH is one of the functional parameters to be monitored during an anaerobic digestion test. The pH tells us something about the nature of the reaction medium, which can be acidic, neutral or basic. For the anaerobic fermentation process to function properly and remain stable, the pH must vary between 6 and 8, with an optimum around 6.8 and 7.2 [11] [12] [13]. In the specific case of our study, the pH seems to evolve in blocks over the course of the day, with consistency in most cases at intake times. In fact, the evolution of pH reveals three parts or blocks.

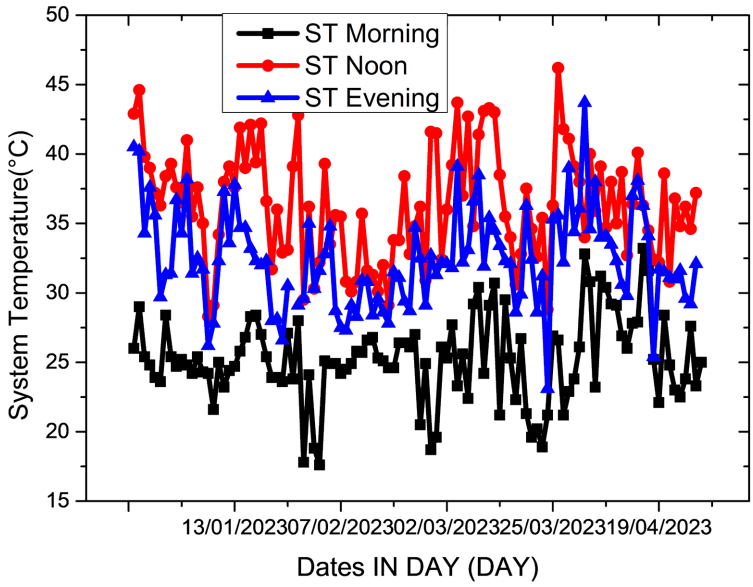


Figure 4. System temperature variation curve as a function of time.

Firstly, there is the phase from the first loading to 24/02/2023, with pH values varying between 5.9 and 6.1 (Figure 5). These low pH values can be explained by the fact that the initial loading of the digester contained a large quantity of water, a total of 1000 liters. As the system is not loaded for the first thirty days prior to the ignition test phase, the digestate produced by the reactor during the initial loadings is less consistent. This could explain these pH values.

We then observe another phase starting from 25/02/2023 to 30/03/2023 with pH values fluctuating between 6.2 and 7, which is the maximum pH value during this HBG2 activation phase (Figure 5). After the ignition test and the first analyses of the biogas produced, the biodigester is loaded each day with 15 to 20 kg of cow dung, which corresponds to 60 liters of cow dung plus water, for a ratio of 1/3. So, after a month and a half, the initial quantity of water is completely removed from the reactor, making the reaction medium increasingly consistent, resulting in a denser digestate. This explains the higher values.

And finally, a last phase from 31/03/2023 to 29/04/2023 with pH values varying between 6 and 6.3, Figure 5. This phase corresponds to the modification of the cow's diet during this period as detailed in the next section.

3.4. Changes in Conductimetry and Salinity

Conductivity and salinity are two new parameters in the study of anaerobic digestion processes, as there are virtually no studies linking their evolution to that of pH. To meet the needs of a parallel educational project on the cows' feeding, their diet was changed from fodder to a mixture of fodder, maize silage and concentrate. This has changed the nature of the cow dung: from a solid, compact dung to a semi-liquid dung as the cows adapted to this new type of feed. However, the values are still higher than in the first phase. Overall, the pH of HBG2

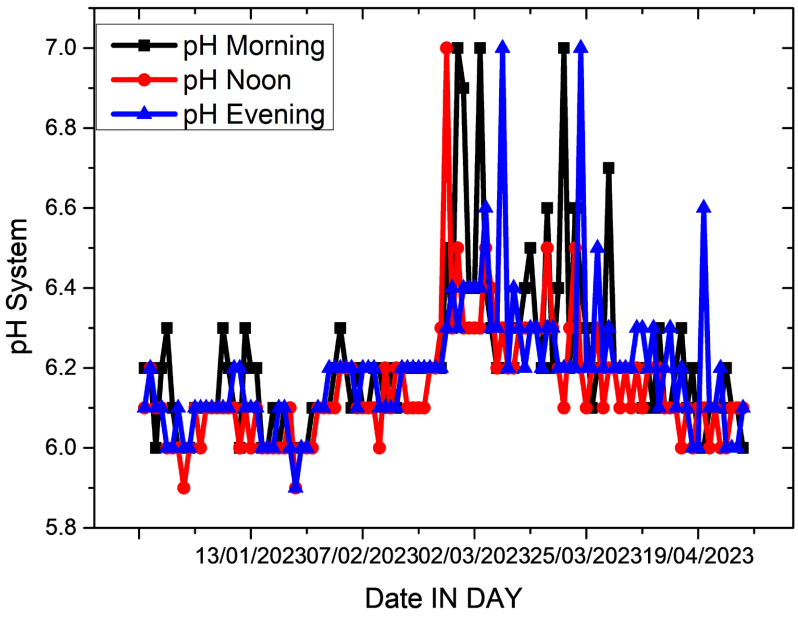


Figure 5. pH variation as a function of time.

during this experiment varied between 5.9 and 7, with a preponderance around 6.2 and 6.4. Hence the difference with most of the pH values of conventional anaerobic digestion systems known to date. These digesters often have a pH that varies around the optimum [11] [12] [13] [14]. Moreover, the evolution of pH in HBG2 during this activation phase seems to deviate from the rule. This allows us to put forward the hypothesis that the pH is a function of the consistency of the reaction medium and therefore of the consistency of the digestate! To verify this hypothesis, let's look at the changes in the following two parameters.

So, their evolution over time provides information about the movement of ions in a similar way in the reaction medium but also, and above all, in the digestate.

The two parameters, conductivity and salinity, evolve in the opposite direction to the pH. In other words, when the pH evolves towards low values, the other two parameters evolve towards higher values and vice versa.

In **Figure 6** and **Figure 7**, we see exactly the same behavior for conductivity and salinity. And these similar behaviors are reflected in the division into two parts of each characteristic curve for the two parameters. A first phase starting from the initial loading to 24/02/2023, characterized by an exponential increase in conductivity and salinity, which reach values of 4000 µS/cm and 2.1 respectively. This is followed by a final phase that begins immediately afterwards, characterized by a sawtooth progression of the two parameters as a function of the consistency of the reaction medium and the digestate (**Figure 6** and **Figure 7**). And this consistency depends intrinsically on the nature of the substrate used to load the biodigester. This strongly supports our hypothesis that the consistency and compactness of the reaction medium influences the variation in pH and the mobility of ions in solution.

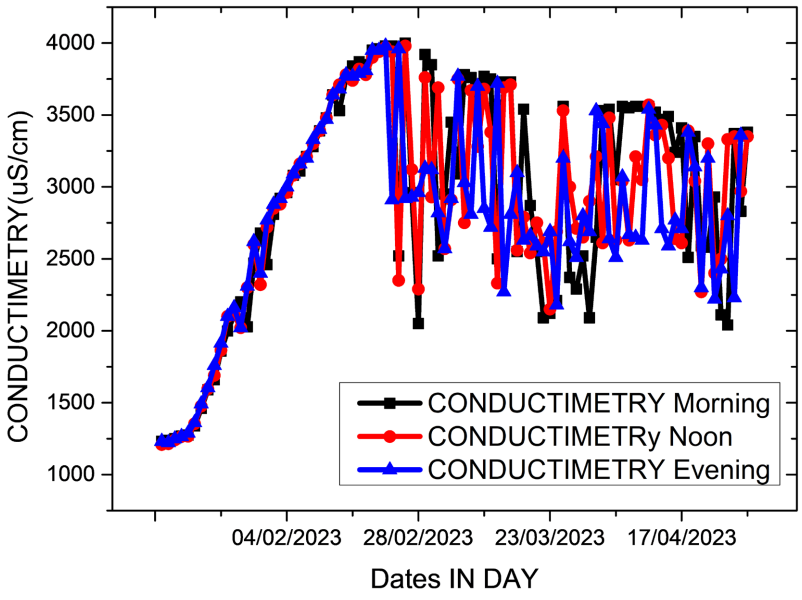


Figure 6. Variation curve for conductimetry as a function of time.

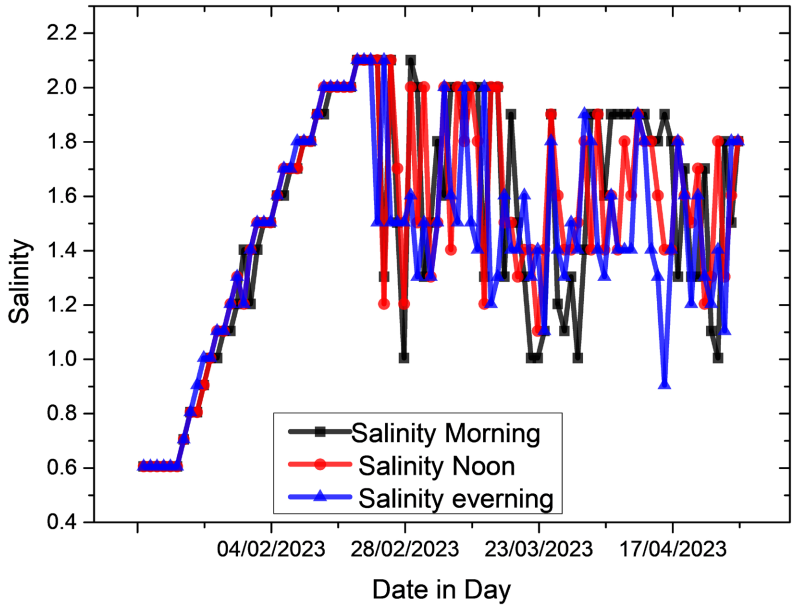


Figure 7. Salinity variation curve as a function of time.

3.5. Changes in the Concentration of CH_4 and CO_2

The composition of biogas always shows two main components: methane CH_4 and carbon dioxide CO_2. In most cases, these components account for an average of 98% of the overall composition of the biogas. However, it has to be said that these components vary from one system to another or from one substrate to another, and in opposite directions. In other words, when CH_4 is high, CO_2 is at a minimum, and when CH_4 is at a minimum, CO_2 reaches a maximum. Thus, in the context of our study, the analysis shows us that the biogas obtained during the first analysis phase is richer in CH_4 than the rest. This first phase began on 16/01/2023 with the ignition test and ended on 21/02/2023 with the total disappearance of the bovine rumen ratio. CH_4 values during this phase varied from 53.28% to 72.2% in a decreasing manner with a peak recorded on the 7th day (21/01/2023) Figure 8. It is important to remember that 72.2% CH_4 is a limited concentration rarely reached in most anaerobic digestion studies After this first phase, we note that CH_4 varies in an almost linear manner throughout the rest of the activation time with a decrease on 27/03/2023 where we recorded the minimum CH_4 value which is equal to 48.94%. This day is marked as an HBG2 blackout because such a high percentage of CH_4 is difficult to obtain in a mechanization process operating normally after an all. The biogas produced by HBG2 is used by staff at the integrated mini-farm to heat water, make tea and cook dog food. And the date of 27 March coincided with the practical work day for the students on the animal and plant production course. During their anatomy classes, they used substances that made the meat of the slaughtered sheep unfit for human consumption. So, the person in charge of feeding the dogs used biogas to cook the meat for the dogs. This completely emptied HBG2, resulting in the blackout shown in Figure 9.

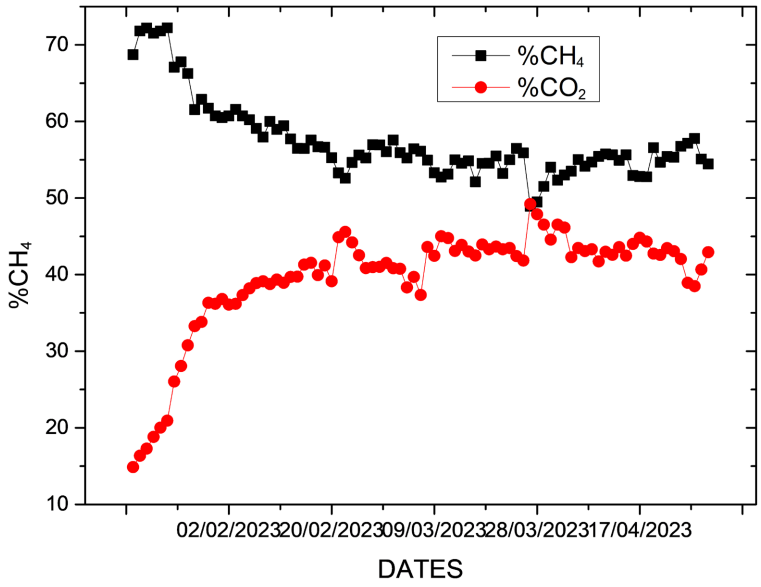


Figure 8. CH_4 and CO_2 variation curve as a function of time.

Figure 9. HBG2 tank completely emptied by uncontrolled use of biogas.

As for CO_2, it varies increasingly from 16/01/2023 to 21/02/2023, becoming almost linear throughout the rest of the activation period, peaking at 49.21% on the day of the blackout. This is explained by the theory of the inverse evolution of these two major components of biogas.

3.6. Variation in the Minority Components of Biogas (O_2, N_2 and H_2S)

The composition of biogas includes so-called minority elements because of their low percentage in the final product. Depending on the type of analyzers used, different elements can be detected. In most cases, these are O_2, H_2S and the rest

of the N_2. In the case of our study here, we can see a wave-like variation in these components. First of all, we have oxygen with a low concentration varying between 0 and 0.8. Then we have N_2, which peaks on the first day of analysis with a concentration of 16.37%. This concentration will decrease over time, reaching an average value of 1.37% on 14/03/2023 (**Figure 10**). Its variation will then take on an undulating form throughout the rest of the monitoring period, with the lowest point recorded on 19/04/2023, when the concentration was 0.67%. The N_2 concentration appears to fall with the disappearance from the reaction medium of the quantity of rumen initially charged to activate bacterial activity and initiate the anaerobic digestion process. So, we can put forward the idea that the concentration of N_2 is a function of the substrate used. And finally, we have hydrogen sulphide which, despite its very low concentration of around one ppm, attracts the attention of all experts in anaerobic fermentation because of its harmful effects on the health of users. This justifies the use of filters to considerably reduce its concentration to almost zero. Given that our filter is working properly, its concentration in the biogas varies from 0 to 59 ppm (**Figure 10**). The peak of 59 ppm recorded on 17/03/2023 coincides with the change in feed for the cows with the introduction of maize silage and concentrate. The concentration of H_2S varies according to the nature of the substrate, which is also a function of the crop soils.

3.7. Variation in HCV and ICV

The Higher Calorific Value (HCV) and the Lower Calorific Value (LCV) are two parameters that provide information on the capacity of biogas to produce heat. This allows it to be compared with conventional fuels such as firewood, charcoal, butane gas, propane and natural gas. If we refer to the conversion factor, which is: 1 kWh = 3.6 MJ, by taking the maximum value of PCI and PCS, we can make a comparison with some of the fuels listed in **Table 4**.

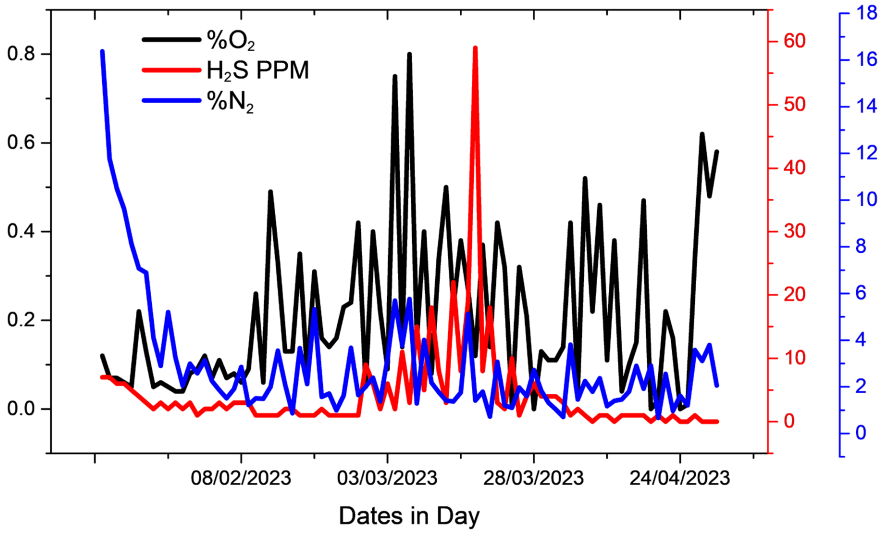


Figure 10. Variation curve for N_2, O_2 and H_2S as a function of time.

Table 4. Some data for Lower heating Value of common fuels [15].

Fuels	LPG	Natural gas	Hydrogen	Biogas	UGB Biogaz	Producer gas
Lower heating value (MJ/kg)	45.7	50	120	17	21.5	5

[a]LPG: Liquide petroleum gas; [b]UGB: Gaston Berger University of Saint Louis.

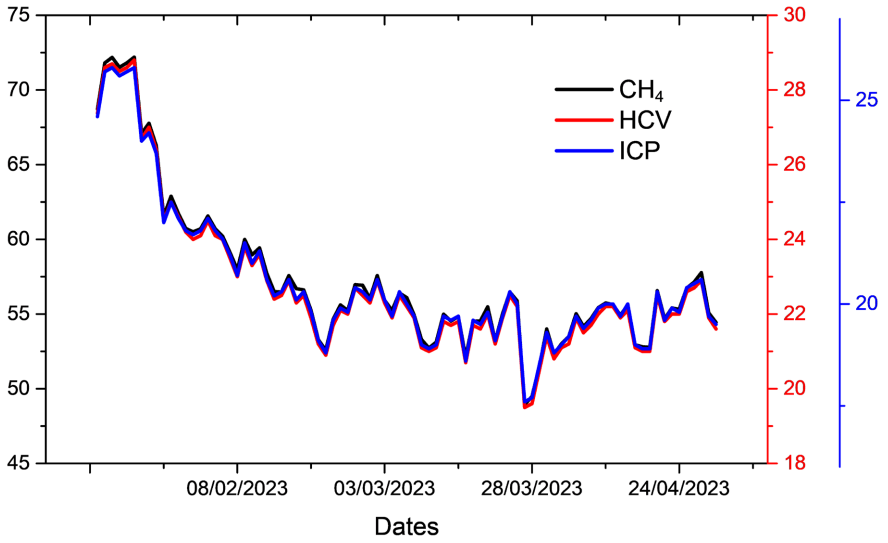


Figure 11. Variation curve for CH_4, HCV and ICP as a function of time.

Even if the values of the other fuels higher than those of the UGB biogas, it is important to remember that the UGB biogas has not been purified, but the values are taken at the peak of the PCI and PCS recorded on 21/03/2023 as shown in **Figure 11**. Both parameters vary according to the CH4 concentration of the biogas produced. In other words, the maximum CH_4 concentration of 72.2% corresponds to the peak of ICP and HCV, which are 25.8 and 28.8 MJ/m^3 respectively. The minimum values for ICP and HCV were also recorded on the day of the blackout, so the correlation is perfect.

4. Conclusion

This study enabled us to follow the entire activation process of a new type of digester commonly known as HOMEBIOGAS (HBG2). This highly efficient model enabled us to achieve a CH_4 concentration of 72.2%. As well as being highly efficient, this type of digester is mobile, so it can be installed anywhere: on a terrace or on the ground… Studying the functional parameters of HBG2 gave us another idea of the optimum and stable pH, which has always been estimated at between 6.8 and 7.2. But with HBG2, we realized that this depends not only on the type of biodigester but also, and above all, on the type of substrate. As a result, other parameters such as conductimetry and salinity provide a better explanation of the stability of the reaction medium. This allows us to redirect our thinking towards other parameters that, until now, have been set aside or even ignored by anaerobic fermentation specialists. This makes our case study specif-

ic, because over and above the classic parameters of anaerobic digestion, we have introduced other parameters into the equation to explain the process in its entirety in a different way. And this includes the mobility of ions in the reaction medium.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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