Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2024, 11(7):235-240

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Assessement of the Potential of Biogas Production by the Bovines Stercorary and Visceral Matters in Cotonou's Slaughterhouse in Benin

Azim Mohamed Abibou[1], *Mickael Vitus Martin Kpessou Saizonou[2], Rosath Henock Gnanga[3], Acakpo Nonvignon Magloire Gbaguidi[1], Kayodé Elidja Babaliroko[1], Samson Ahognonhoun Agossou[1], Bertrand Hounsemon[1]

[1]Doctoral School of Exact and Applied Sciences, University of Abomey-Calavi, Benin
[2]Laboratory of Study and Research in Applied Chemistry, Polytechnical School of Abomey-Calavi
[3]Biogaz Bénin University of Abomey-Calavi, 01 BP 2009 Cotonou, Benin
Corresponding author: Mickaël Vitus Martin Kpessou Saizonou, Email: kpessou67@hotmail.com

Abstract Slaughterhouse waste decomposes quickly and can carry pathogens and other contaminants. Therefore they represent potential sources of major health and environmental problems, if they are not properly treated. The slaughterhouse of Cotonou generates large quantities of waste which management suffers from several inadequacies. This work evaluated the slaughterhouse waste quantity, quality and potential to produce biogas. Various samples of waste were taken and analyzed. The physical and chemical characterization of bovine stercorary matters (SB) and bovine visceral matters (VB) indicated, respectively, pHs of 6.50 and 7.50, dry matters contents (DM) of 13.94% and 20.49%, organic matters (OM) of 53.72% and 50.24%, carbon of 41.32% and 42.28%, humidity levels of 86.94% and 19.39% with ratios (C/N) of 22.22 and 19.39. The anaerobic digestion process was then implemented to evaluate the biogas production potential of (SB), (VB) alone mixed with water and in co-digestion. Three experimental devices were used for combinations of SB and water, VB and water and SB and VB and water for 30 days at 37°C. During the methanization process of these substrates, the evolution of the daily and cumulative biogas production kinetics was monitored. The cumulative biogas productions were respectively 1454 mL for SB, 1994 mL for VB and 3554 mL for co-digestion. The values obtained provided information on the types of management of stercorary and visceral matters from bovine that could be used in slaughterhouses for the optimization of biogas production.

Keywords animal waste, rumen contents, co-digestion, bovine, bioenergy, slaughterhouses

1. Introduction

Nowadays, the development of new types of energy has become a priority in the fight against climate change [1]. Bioenergy from biomass is attracting growing interest, particularly biogas from the methanization of organic matters. The controlled slaughter of animal, generates the production of mainly organic waste that can easily be mobilized by methanization [2]. Slaughterhouses therefore generate large quantities of waste and by-products which unfortunately are not always recovered and are thrown into public landfills (for solid waste), in sewers (for liquids), swamps and slums. They thus pollute the soil, groundwater, wadis and coastline [3]. The management of waste was, of course, an environmental problem but this activity could constitute an economic and social opportunity, making it possible to help reduce dependence on hydrocarbons and contribute to economic diversification. Although perceived as a source of environmental pollution, the waste represented biomass which, when recycled, produced biomethane that could be used as an energy source. Faced with the problem of waste management and the frequent power cuts that the Cotonou slaughterhouse due to its exclusive dependence on the Beninese Electric Energy Company, it was interesting to recover the solid waste from this structure into biogas to produce electricity. This study aimed to evaluate the quantity of organic solid waste produced in this slaughterhouse and to study their potential for producing biogas.

2. Material and Methods

2.1. Site description

The Cotonou slaughterhouse was located in Akpakpa at kilometer point 6 on the Benin-Nigeria interstate road, in the 1st district of the city in an urban area and constituted a source of odor nuisance and permanent pollution for local populations. This marshy settlement area presented difficulties in accessing the animal slaughter halls during rainy periods. It benefited from autonomous management [4].

2.2. Animal material

The solid slaughterhouse waste collected concerned bovine visceral contents (rumen contents) and bovine stercorary matters (dung).

2.3. Analysis equipment

Table 1 provided information on material.

Table 1: List of material

Material	Roles
Plastic bags	Sampling
Analytical balance	Weighing of samples.
Multi-parameters	In situ pH measurement.
Oven	Dying samples at 105°C
Muffle furnace at 600°C	Calcination of samples.

2.4. Methods

2.4.1. Evaluation of annual quantities of visceral and stercorary matters

According to data collected at the Cotonou slaughterhouse, on average 91998 bovines are slaughtered per year and the quantity (Q) of solid waste is calculated by the formula:

$Q = N_t * P_m$ with N_t : number of bovines and P_m : average mass of solid waste per animal

2.4.2. Physico-chemical parameters

- **Determination of humidity level and dry matters contents**

The samples are dried in an oven at 105°C until constant mass. The difference in mass between the mass before drying and after drying made it possible to obtain the water and dry matters contents. The humidity level and the quantities of dry matters were determined according to standard NF V 03-909 (1988). To get results, weighing capsule was previously dried in an oven at 105°C for 15 min until constant weight (m_0). After cooling in a desiccator, 1g of crushed sample residue was added and the whole was weighed (m_1). The capsule containing the crushed residue was dried in an oven for 12 h at 105°C then cooled in desiccator and weighed (m_2). The operation was repeated until obtaining constant mass m_2. The moisture content (T_H) and dry matters content (D_M) were determined according to the following formulas :

$T_H = \frac{m_1 - m_2}{m_1 - m_0} * 100$ and $D_M = \frac{m_2 - m_0}{m_1 - m_0} * 100$

- **Determination of organic matters content**

The organic matters content was determined according to standard NF V 03-909 (1988). The sample was calcined at 600°C and maintained at this temperature until obtaining constant mass. The organic matters content was calculated from the mass of the residue after calcination. A capsule was dried in an oven at 105°C for 1 hour and weighed (m_0). After removal and cooling in a desiccator, 1 g of waste was introduced and the whole placed in an oven at 105°C until the water was eliminated. The crucible containing the dehydrated sample was placed in the oven at 600°C until ashes were visibly free of carbonaceous particles. The capsule was cooled in desiccator to room temperature and weighed quickly (m_3). The organic matters (OM) content was determined by the following formula [5]:

$OM = \frac{m_3 - m_0}{m_S} * 100$ with m_0: mass of the empty crucible; m_s: mass of dry matters and m_3: mass of the crucible and ashes

- **Evaluation of the volume of biogas**

The volume of biogas produced was measured using the liquid displacement method [6] (Figure 1). The biogas produced lowers the water level in the burette by pressure difference. The volume of water displaced corresponded to the volume of biogas produced. The experimental device was designed using plastic graduated cylinders, digesters (500mL bottles), infusers, a thermostat bath and a metal support [7] as shown on figure 1.

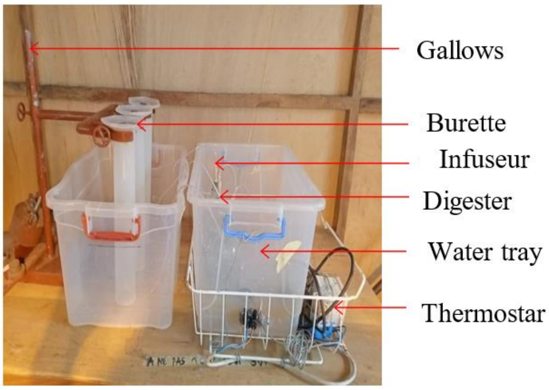

Figure 1: Expérimental apparatus

The digesters are anaerobic, discontinuous, mesophilic type (37°C). They were ¾ full and the experiment lasted 30 days. The Table 2 below mentioned the composition of the contents of each of the digesters.

Table 2: Compositions of digesters

Digester 1	Digester 2	Digester 3
0,5 kg (SB) + 200 mL of water	0,5 kg (VB)+200 mL of water	0,25 kg (SB) +0,25kg (VB) +200 mL of water

3. Results and Discussion

3.1. Results

3.1.1. Estimated quantity of solid waste per year

Table 3 provided informations on the mass of bovine stercorary matters produced annually

Table 3: Yearly quantiy of stercorary matters

	Number of animal/year	Average mass of stercorary matters/year
Bovine	91998	3645.885 kg

3.1.2. Physico-chemical parameters of stercorary matters and bovine visceral contents

The physicochemical characteristics of both substrates are presented in Table 4.

3.1.3. Kinetics of daily and cumulative biogas production

The evolution of the volume of biogas produced per day is shown in Figure 2.

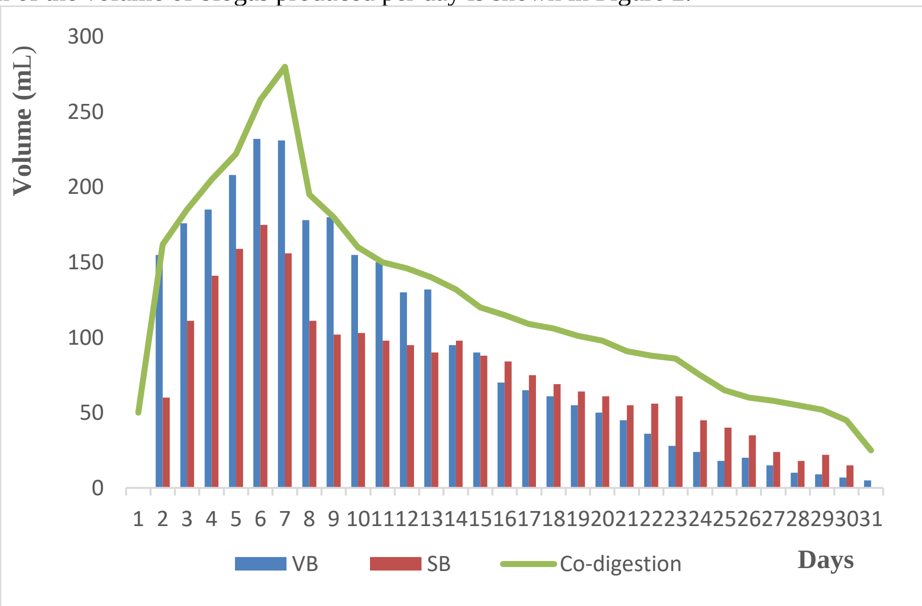

Figure 2: Variations in daily volumes of biogas from substrate digestion

3.1.4. Kinetics of the cumulative biogas production

Figure 3 represented the accumulation of biogas produced by the substrates.

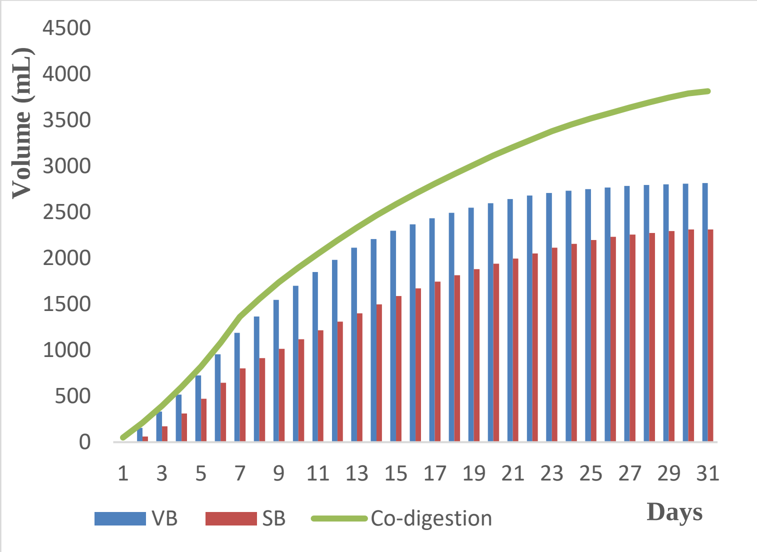

Figure 3: Variations of biogaz cumulated volumes producted by substrates

3.2. Discussion

According to the results mentioned on Table 3, the quantity of bovine stercorary matters was estimated on average at 3645.88 (kg/year). The importance of this quantity of organic waste, sufficiently demonstrated the necessity and importance of their recovery.

The results from Table 4 indicated that the dry matters rate of bovine visceral contents was 13.94% and that of stercorary matters was 20.49%. The results were close to those obtained by Marillier and *al*., (2007) [4], M'Sadak and *al*., (2012) [8] which were respectively 16% and 21% on the same substrates. The organic matters rates were respectively 53.72% and 50.24% and corroborated the results of 55% reported by Ait-Brahim and *al*., (2013) [9]. The carbon contents of the substrates were 41.32% and 42.28% respectively for VB and SB and were in the carbon content ranges of 20 to 70% that favoring the increase and growth of microorganisms in these substrates. The ratios between the rate of carbon and that of nitrogen (C/N) were respectively 22.22 and 19.39 for VB and SB. They were located in the optimal range for biogas production which were 20 to 30 [10]. The humidity levels were 86.94% for SB and 79.51% for VB. These humidity levels were included in the recommended range of 60% to 90% humidity levels [10] and Petitclerc [11].

The initial average pH values before digestion were 6.50 for VB and 7.50 for SB. These results corroborated those obtained by M'Sadak and *al*., (2012) [10] who indicated that for the production of biogas, the pH of VB cold be between 6.50 and 7.50 and by Yadvika and *al*., (1984) [11] who indicated 7.2 for SB.

The results recorded for biogas production indicated that during 30 days of digestion at 37°C on average, the maximum specific biogas production for bovine visceral contents was recorded on the 3rd day with a volume of 2500 mL. From 4th day, the production decreased gradually until to the 30th day, for minimum of 15 mL. For bovine stercorary matter, there was a rapid increase from the 2nd to the 4th day with maximum volume of 1550 mL recorded on the 4t^{h} day. From the 5th to the 30th day the production decreased sharply with minimum of 7 mL. For codigestion as well as bovine stercorary matters, there was a rapid increase in production from the 1st to the 4th day, with maximum of 3950 mL recorded on the 4th day. From the 4th to the 30th day, a decrease in production were observed with minimum of 25 mL recorded on the 30th day. It was noticed that the fermentation kinetics were faster for the codigestion. Comparing the kinetics of biogas production by the different substrates, Figure 2 indicated that, from the 1st to the 2nd day, the codigestion and VB curves were superimposed and that of SB was below both. From the 2nd to the 4th day, the curves of VB and codigestion had almost the same appearance, with a greater amplitude for codigestion compared to VB. These daily production kinetics were consistent with the results of M'Sadak and *al*., (2012) [10] and Rouez (2008) [13].

The curves represented by Figure 3 had the same appearance. From the start of digestion it was noticed a low production of biogas, then growth and finally a slowdown towards the end. These kinetics were consistent with the results of Zerrouki and *al*., (2017) [14] and Traore and *al*., (2017) [15]. It presented the following three phases:

- First phase: latency phase, the duration of this phase depended on the nature of the substrate. It was 4 days for SB with a production of 412 mL; 5 days for the codigestion substrate with 1500 mL and 5 days for VB with 881 mL. This period corresponded to liquefaction with phenomena of hydrolysis, acidogenesis and acetogenesis.
- Second phase: exponential phase, it corresponded to the central part of the production curves. This phase lasted 13 days, from the 5th to the 18th day for SB and 13 days, from the 4th to the 16th day for VB; for codigestion, it lasted 21 days, from the 5th to the 26th day. The maximum biogas volumes were obtained during this second phase: 1994 mL for VB, 1454 mL for SB and 3554 mL for codigestion. This period corresponded to methanogenesis.
- Third phase: it corresponded to low biogas production due to the exhaustion of substrat [16]. It began from the 18th day for VB; 16th day for SB and 26th day for codigestion, until digestion were completed.

4. Conclusion

This work, focused on the physical, chemical parameters as well as the ratio (C/N) of the contents of stercorary and visceral matters of bovines from the Cotonou slaughterhouse. The volumes of daily biogas produced by these substrates were also measured using three experimental devices at approximately 37°C. The cumulative biogas production of the three substrates showed that co-digestion had a higher biogas production potential than the VB and SB substrates. It followed that for better valorization of these substrates, it was preferable to carry out co-digestion. In short, waste from oxen could potentially be used for the production of biogas. In perspective, the combinations of waste analyzed with wastewater from the slaughterhouse will allow to optimize the production of biogas using slaughterhouse waste in general in order to better exploit them.

Acknowledgements:
The authors thank the World Bank for financing the study through the College of Engineering in Energy, Infrastructure and Environment of the Polytechnical School of Abomey-Calavi for its financial contribution.

References

[1]. Marillier, F. (2007). Energy crisis: it is not too late to get out of it. *New Fondations*. 6 (2): 63-69.

[2]. Hounkanrin, A. (2015). Contribution to the production of electrical energy at the Cotonou Slaughterhouse through the valorization of rumen waste. End of training Memory. Polytechnic School of Abomey-Calavi, p 48

[3]. Farinet J.L. (2017). In: Roose, Eric (ed.). *Restoration of the productivity of tropical and Mediterranean soils: contribution to agroecology*. Marseille, IRD, 315-317

[4]. Salifou, C.F.A., Youssao, A.K.I., Salifou, S., Kpodekon, T.M., Tougan, P.U., Ahounou, G.S., Boco, C., Farougou, S., Mensah, G.A., & Clinquart, A. (2012). Evaluation of the cattle slaughter process at the Cotonou-Porto-Novo slaughterhouses in the south from Benin. *Int. J. Biol. Chem. Sci*, 6(6): 49-61.

[5]. Lacour J. (2012). Valorization of agricultural residues and other organic waste by anaerobic digestion in Haiti. Doctoral thesis. National Institute of Applied Sciences of Lyon, Chemistry Doctoral School of Lyon, p 62.

[6]. Lacour, J., Bayard, R., Emmanuel, E., & Gourdon, R. (2011). Assessment of the potential for valorization by anaerobic digestion of deposits of organic waste of agricultural and similar origin in Haiti. *Environment, Engineering & Development*, (60) :31-41.

[7]. M'Sadak, Y., Ben M'barek, A., Zoghlami, RI., Baraket, S. (2012). Quantitative and qualitative characterization of the energy productivity of pilot animal manure digesters. *Revue de génie industriel*, (7): 46 - 55

[8]. M'Sadak, Y., Ben M'Barek, A., & Baraket, S., (2012). Physico-chemical and energetic monitoring of experimental biomethanization applied to bovine biomass. *Nature and Technology*., (7) 81-86

[9]. Ait-Brahim, R., Amazigh, A., & Mahach, H. (2013). Biogas digester. Professional project dissertation. Poly-disciplinary Faculty of Ouarzazate, p 25

[10]. M'Sadak, Y., Ben M'barek, A., Zoghlami, R.I., & Baraket, S. (2012). Quantitative and qualitative characterization of the energy productivity of pilot animal manure digesters. *Industrial Engineering Review*, (7): 46 - 55

[11]. Petitclerc, A., & Leclercq, S. (1984). Research on the production of methane and compost from slaughterhouse waste: case of the slaughterhouses of Dakar and Thiès. National University Higher School of Technology. Dakar Senegal, p 9.

[12]. Yadvika, S., Sreekrishnan, T.R., Sangeeta, K., & Vineet, R. (2004). Enchantment of biogas production from solid substrates using different techniques. *Bioresour. Technol*., 95 (1): 1-10

[13]. Rouez, M. (2008). Anaerobic degradation of solid waste: characterization, influence factors and modeling. Doctoral thesis. University of Lyon, p 159.

[14]. Zerrouki, S., Rihani, R., & Bentahar, F. (2017). Study of the anaerobic digestion of effluents from the agro-food industry. *Nature and Technology Algeria, Environmental Sciences.*, 17 (C): 25 - 30

[15]. Traore, D., Dianou, D., & Traore, A. S. (2017). Biomethane Potential of Some Agroresources in Burkina Faso: Case Study of Vegetable Residues, Pig Manure, Mango Waste and Bovine Manure. *Journal of Advances in Biology & Biotechnology*. 15 (2): 1 - 11

[16]. Afilal, M.E., Elasri, O., & Merzak, Z. (2014). Characterization of organic waste and assessment of biogas potential, J. Mater. *Environ. Sci*., 5 (4): 1160 – 1169