Vol. 13(7), pp. 291-295, July 2019
DOI: 10.5897/AJEST2018.2549
Article Number: 3DA09D261220
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Full Length Research Paper

Residues of the transformation of halieutics products: An alternative substrate for energy valorization of wastes by methanisation for a local sustainable development (preliminary results)

N. N. Kebe[1*], P. A. Fall[2], D. Ndiaye[1] and D. Diouf[1]

[1]Laboratory of Electronics, Computer science, Telecommunications and Renewable Energy, Gaston Berger University, Senegal.
[2]Environmental consultant, Biogas specialist, Senegal.

Received 15 August 2018, Accepted 26 October 2018

The purpose of this study is to evaluate the biogas productivity potential of residues of the transformation of halieutics products. Experiments were conducted in two digesters of PUXIN model of 20 m^3, where the temperature is 35°C. Multirae analyser was used to know the composition of biogas produced. A gas counter was also used for counting the amount of biogas produced during the experiment. There was also a balloon of storage of 10 m^3 downstream from the digester, for storing the biogas produced. The total volume with 2970 kg of substrate was 9.67 m^3. The maximum daily volume of produced biogas was 1.561 m^3 at the 5th day after the installation of the gas counter. The potential biogas is then, 3.25 m^3/T of wastes. While the potential biogas found in earlier study is 53 m^3/T of wastes. For analyses of produced biogas, maximum percentages of methane, oxygen, carbon monoxide and hydrogen sulfide are, respectively 91%, 20.9%, 196 ppm and 44.7 ppm. Method of cooking halieutics products with biogas takes much time than that using wood of heating.

Key words: Substrate, biogas, potential biogas, digester.

INTRODUCTION

Since the crisis of agriculture caused by years of drought, fishing season occupies an important place in the economy of Senegal, in terms of export earnings. Thus, it strongly contributes to the reduction of the unemployment rate and the need for the animal protein populations. Conscious of this fact, the state of Senegal with the assistance of its partners sets up transformation units of halieutics products, in all regions where the

*Corresponding author. E-mail: kebendickou@gmail.com.

Abbreviations: %, Percentage; **°C,** degree Celsius; **kg,** kilogramme; **m^3,** cube meter; **m^3/T,** cube meter per ton; **ppm,** parts per million.

fishing season is practiced. These units currently employ many women, and make it possible to these last to take part in the development of our country.

In the region of St-Louis, 700 women work at the site of the transformation of halieutics products. They transform every day (that is to say 10 months out of 12) 6000 tons of fish per year, for obtaining different products like dried fermented products, dried salted fishes, dried braised fishes, and dried smoked fishes (Le Partenariat, 2015). This last, which is transformed the most, requires much energy at the time of the stage of cooking of fish. Generally, women use wood of heating and even, as of time, plastics. What created pollution of the atmosphere and in particular health problems for these women. Also, wastes coming from the transformation are not used, and then are most often dumped in the river or the sea, or exposed to free air. However, these wastes can be used as substrate for a biogas unit for example.

To meet the energy needs of the grouping, but also the need for cleansing for the site, “The Partnership”, technical partner of National Program of Domesticated Biogas of Senegal, accounts to help the transformer women to develop waste halieutics present in the site by the installation of a collective unit of methanisation. This project lies within the scope of the biogas project of St-Louis.

Biogas comes from anaerobic digestion of organic wastes from animal or vegetable origin. It is composed of methane CH_4 (50 to 75%), carbon dioxide CO_2 (25 to 40%), water H_2O, oxygen O_2, hydrogen sulfide H_2S (Abdoulaye Fall, 2013). This fermentation is done in the absence of air in a fermenter called digester. The digestate which is also a byproduct of digestion can be used as fertilizer for crops. Among the waste that can be methanized, we can cite cow dung, livestock effluents, sludge, cultures, etc (Chen and Neibling 2014). Cow dung is the most used substrate by National Program of domesticated biogas of Senegal, due to its availability across the country (Abdou Ndour 2014). The choice of the substrate used during anaerobic digestion is important. To maximize methane production, it is better to use products rich in lipids, carbohydrate and proteins. This is why we’re interested in residues of the transformation of fish products for biogas production; because they are substrates rich in lipids and proteins (Kaffe and Kim, 2012), which can speed up the process of forming methane during anaerobic digestion.

This work was done within the framework of technical, social and organizational feasibility of project of installation of digesters at the site of transformation of halieutics products

MATERIALS AND METHODS

Substrate

Residues of the transformation of halieutics products are the substrate used for anaerobic digestion in this experimentation. They were collected at the site of transformation of halieutics products of Hydrobase at St-Louis. The components of fish wastes are nonfresh fish, head, internal organs, and guts. They decompose themselves rapidly due to their high composition of lipids and proteins. These wastes come from the transformation of fishes by women who constitute themselves in small enterprises. Women who work in the site, can transform around 20 cases per day according to the woman, that is, 1000 kg of fishes per woman and per day, and this generates 500 kg of wastes per day in period of strong season (Le Partenariat, 2015). All this to say that the amount of fish wastes generated in the site is very important and would allow to develop biomethanisation using fish wastes.

Experimental setup

For having biogas using residues of transformation of halieutics products, the experimentation took place on two digesters of PUXIN model, which has been developed by a Chinese society named PUXIN (Figure 1).

The volume of each digester is 10 m^3. In each digester, we have a mixture of residues of halieutics products with water in the same proportion. And when the gas is produced, it leaves the digester, passes by the gas pipes and arrives at the balloon of storage, which has a volume of 10 m^3. If the amount of biogas in the balloon is sufficient, to be used for the transformation of halieutics products, furnaces will be connected to the balloon. And the biogas from residues of halieutics products will be tested by women who work in the site, to compare it with their old cooking method.

For a first filling of the digesters, on 18th May 2017, each of them were placed in 1000 kg of residues of halieutics products, mixed with the same amount of water. Which represents on the whole, 2000 kg of residues of halieutics products in the two digesters. Nineteen days after the first filling, it was noticed that there was no gas in the balloon. This is due to the fact that with Puxin model, water must be above the gasometer to avoid gas leakage. It was then necessary to increase the amount of water, to have a change of state of the balloon.

RESULTS AND DISCUSSION

Volume of biogas produced and its composition

After the first filling of the two digesters with 2000 kg of substrate, the gas generation has not started at once. It was then necessary, at the 19th day after the first filling, to increase the amount of water until it reaches the bell. And the gas starts to pass in the balloon of storage at the 19th day and gas generation continues then 63 days later.

According to the work of Salam et al. (2009), the gas generation started on the 7th day with anaerobic digestion of fish waste, and fish waste in co digestion with cow dung. Which means that much gas was lost during the time of first filling and on the 19th day.

At the 28th day, the gas counter was installed. Figure 2 shows the volume of produced gas for residues of transformation of halieutics products during the 63 days. The total volume of produced gas is 9.67 m^3.

The filling has been repeated during the experience on different dates. Table 1 shows some information

Figure 1. 2 Digesters of PUXIN model.

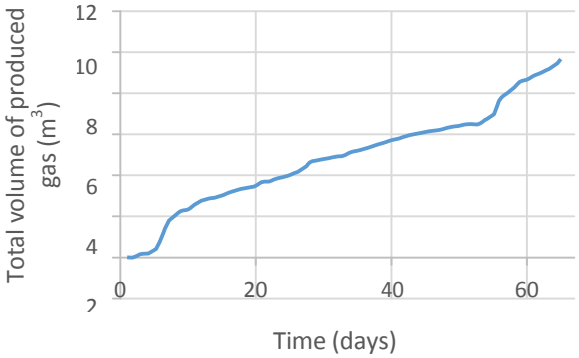

Figure 2. Total volume of produced gas.

Table 1. Quantity of susbstrate put into the disgester.

Date	Amount of susbstrate (kg)
18th May 2017	2000
13th June 2017	600
02nd July 2017	40
10th July 2017	20
02nd August 2017	200
10th August 2017	35
16th August 2017	75
Total	2970

about the quantity of substrates put in the digesters during the experiment.

To have the amount of gas produced during the experience, upstream of the balloon of storage, has been installed a gas counter. That allows us to know with precision, the amount of gas that have passed through the balloon of storage.

The produced gas needs to be analyzed to know its composition in different gas. This is why a MULTI RAE ANALYSER, which gave the rate of four gases found in

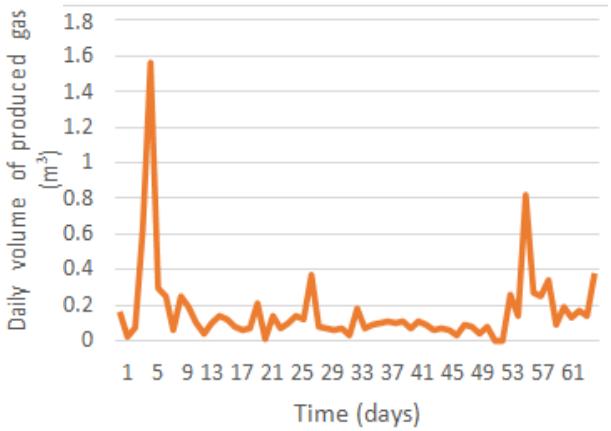

Figure 3. Daily volume of produced gas.

the biogas, was used. These gases are carbon monoxide (CO), methane (CH_4), dioxygen (O_2) and hydrogen sulfide (H_2S) with different proportion in the biogas.

After the gas has been produced, tests of cooking have been done by two women to compare two manners of cooking: one using biogas and the other using wood of heating. It is clear that cooking with biogas respect more the environmental procedures and is more ecological than using the wood of heating. But we have searched for the manner of cooking that takes less time between biogas and wood of heating.

Figure 3 shows the daily volume of produced gas with residues of transformation of halieutics products. Figure 3 shows greater production at the 5th day with 1.561 m^3 and at the 54th day with 0.82 m^3.

For Figures 2 and 3, time is counted starting from the assembly of gas meter. These information could not be obtained only after the installation of gas meter. The greater gas production was obtained at:

(1) 5, 6, 7 and 9th day: at the beginning of the experiment, the balloon of storage was not installed. The biogas which was in the gasometer have passed thus in the balloon of storage.
(2) 19 and 26th day: there was a filling of the digesters with the residues of the transformation of halieutics products.
(3) 52, 54, 55, 56 and 57th day: there was also a filling of the digesters with more than 200 kg of residues of the transformation of halieutics products.

During the experiment, without counting the gas lost, the amount of gas produced is about 9.67 m^3. The potential biogas is then, 3.25 m^3/T of wastes. However, the potential biogas found in the work of Tomczak-Wandzel et al. (2013), is 53 m^3/T of wastes. There is a great difference between these two results; this could be due to the fact that much gas was lost during the

Table 2. Comparison of two methods of cooking, with biogas and wood heating.

Method of cooking	Biogas	Wood heating
Water to be heated (L)	15	15
Quantity of fish (kg)	25	25
Time of heating of water (min)	37	30
Time of cooking of fish (min)	164	41
Quantity of biogas for all the transformation (m^3)	2.491	-
Quantity of wood heating for all the transformation (kg)	-	4

experiment.

The biogas obtained after fermentation of residues of transformation of halieutics products was analyzed in order to know its composition in different gas such as methane (CH_4), carbon monoxide (CO), oxygen (O) and hydrogen sulfide (H_2S).

For many analyses that were done, different rate of gas was found composing of biogas. For each gas, different values were found varying:

(1) Methane: 80 to 91%
(2) Carbon monoxide: 22 to 196 ppm
(3) Oxygen: 10 to 20.9%
(4) Hydrogen sulfide: 0 to 44.7 ppm.

These values proved that the biogas produced with residues of transformation of halieutics products is rich in methane. And the other gas like hydrogen sulfide is not an important component due to their low rate.

All this to say that anaerobic digestion using fish waste as a substrate is quite possible, but the volume of gas produced is not sufficient compared to the experiments made previously with fish wastes or co-digestion of fish wastes with other substrates.

Test of cooking

Biogas produced by fermentation of residues of transformation of halieutics products was tested by two transformers women. The purpose of these tests was to evaluate the cooking time and the volume of gas used and to compare the method of cooking of halieutics products with biogas and using wood of heating.

Table 2 gives information about the two methods of cooking of halieutics products. A difference was observed between the two methods of cooking; transformation with biogas being too slow. This would not be due to a low pressure of biogas, because during the transformation, a pump was used for recording the pressure of gas. This slowness would then be due to the stove used for the transformation of fish with biogas. The design of the stoves should then be remade to improve the output of the transformation with biogas.

Conclusion

The production of biogas with residues of the transformation of halieutics products is possible. With this substrate, the amount of gas for cooking test was 9.63 m^3 during the experiment.

These tests were done at the site of transformation of halieutics products to test the capability of the residues of transformation of halieutics products to produce biogas. During this test, some information were collected, such as the amount of total biogas produced and the daily biogas produced, and the composition of the biogas produced. Tests of cooking were also done to know if it is possible to use this gas for cooking halieutics products. The total retention time in this study is about 65 days.

But these information are not sufficient scientifically. Different parameters like the temperature of the digesters, the composition of the substrate, the pH, the pressure of gas, and the composition of the digestate were not determined.

This is the reason why subsequent studies will be carried out for more information on this. And these parameters are essential for increasing the anaerobic efficiency of residues of the transformation of halieutics products. Co-digestion of residues of halieutics products with other substrate will also be done soon to enhance the anaerobic efficiency of this substrate (Kassuwi et al., 2012; Serrano et al., 2013).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This work was done with the support of “The partnership”, an association that promotes the development of biogas in north of Senegal. It was also done within the framework of technical, social and organizational feasibility of project of installation of digesters at the site of transformation of halieutics products of Hydrobase at St-Louis. The authors express deep gratitude to the

CEA MITIC for granting permission to attend the conference Casamansun 2018 at Ziguinchor (Senegal) and to present this work.

REFERENCES

Abdoulaye Fall P (2013). The biogas-definition, principles and applications, Senegal.

Abdou Ndour (2014). La méthanisation au Sénégal : biogaz domestique et semi-industriel. INFORSE International Network for Sustainable Energy 28 April – 01 May 2014 Lome Togo.

Chen L, Neibling H (2014). Anaerobic Digestion Basics. University of Idaho Extension. 6. http://cals.uidaho.edu/edcomm/pdf/CIS/CIS1215.pdf

Le Partenariat (2015). Potential and limits of the valorization of halieutics wastes at Hydrobase, Saint-Louis.

Kaffe GK, Kim SH (2012). Evaluation of the biogas Productivity Potential of Fish Waste : A lab Scale Batch Study. Journal of Biosystems Engineering 37(5):302-313.

Kassuwi SA, Mshandete AM, Kivaisi AK (2012). Anaerobic co-digestion of biological pre-treated nile perch fish solid waste with vegetable fraction of market solid waste. ARPN Journal of Agricultural and Biological Science 7:12.

Salam B, Islam M, Rahman MT (2009). Biogas from anaerobic digestion of fish waste, Proceedings of the International Con- ference on Mechanical Engeneering 26-28 Dhaka, Bengladesh.

Serrano A, Siles JA, Chica AF, Martín MÁ (2013). Agri-food waste valorization through anaerobic co-digestion: fish and strawberry residues. Journal of cleaner production 54:125-32.

Tomczak-Wandzel R, Levlin E, Ekengren Ö (2013). Biogas production from fish wastes in co-digestion with sewage sludge. InIWA Specialist Conference Holistic Sludge Management 6-8 May 2013 Västerås Sweden 2013 May. Svenska miljöinstitutet (IVL).