International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 1, November-December 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Potentiality of Biogas Production in Mubi Slaughtering Houses, Northeastern Nigeria

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ABSTRACT
Intensive demand heat and electricity by slaughtering houses required an improve understanding of existing production of biogas in order to increase their efficiency, productivity, flexibility and to maintain balance of the ecosystem. It is important for this study to find out how potentially the biogas production is to be harvested for heat and electricity in Mubi slaughtering houses. It was found that the estimated volume of biogas, were viable for harvesting 167.47 KWh/m3 and 83.73 kWh/m3 of heat and electricity respectively for Mubi North, while 167.47 KWh/m3 and 10.11 kWh/m3 of heat and electricity for Mubi South daily. Therefore, authors recommends for further studies, if were implement to achieve maximum yield of biogas.

KEYWORDS: *Slaughter; House; Waste; Biogas; Abattoir; Animal*

How to cite this paper: A. S. Umar | N. W. Silikwa "Potentiality of Biogas Production in Mubi Slaughtering Houses, Northeastern Nigeria" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.674-677, URL: www.ijtsrd.com/papers/ijtsrd38019.pdf

IJTSRD38019

INTRODUCTION

Energy has been recognized as a major factor limiting economic growth, restricting socio-economic activities and adversely affecting the quality of life in Nigeria. Food processing factories, particularly slaughtering houses (SH), demand a large number of energy intensive processes that require heat and electricity. Due to the abundant biomass wastes generated by slaughterhouse, these biomass resources potential for biogas production by the process of biomethenation, this process use slaughterhouse waste for production of biogas [1]. The biogas is an environmentally friendly and one of the most efficient and effective renewable energy options [2]. Biogas can be stored and used when needed to produce heat or used to generate electricity for power supply. Benefits of biogas include financial benefits (i.e; cooking and lighting fuel saving house hold's health related expenditure), social benefits (i.e; fertilizer saving, employment generation and poverty reduction), environmental benefits (i.e; green house gas emission reduction, reduction of deforestation, improvement of air quality etc) [3]. The resultant energy in the biogas can be used directly as fuel to power electrical generator and cooking by burning it in the presence of oxygen. The generated energy could also be useful for rendering the slaughtered animals as a replacement for the current practice of open fire which can lead to fire disasters, respiratory problems and carbon monoxide generation [4]. Beside energy supplies, production of biogas eliminate or reduction of foul odors and harmful insects around SH. With that, there is no need in SH to seek for external energy for its usage.

Slaughtering houses (SH) are where animals such as cattle, goat, sheep and others are slaughtered for the purpose of food consumptions and it is also known as abattoirs. Most Nigerian abattoirs are situated close to surface water bodies in order to have access to water supply needed for slaughtered animal processing and to provide a sink for the run-off from meat processing activities [5]. The waste from slaughter houses have similar chemical characteristics as those of domestic sewage but are considerably more concentrated in general they are almost wholly organic [6]. This makes its disposal (as shown in Fig. 1) rather difficult because utilizing it not only lead to loss of potential environment but also lead to the added and increasing cost of disposal. A major contributing factor to high volumes of waste generation and difficulty in waste management at Nigerian slaughterhouses is the absence of preservation facilities such cold rooms [4]. Utilizing this waste on a large scale is the major challenge in urban areas throughout the world, poses serious health and environmental problems, due to inappropriate disposal of solid as well as liquid on landfills or open areas. Where abattoir effluent-polluted waters are used to grow salad crops and vegetables, transmission of infections is bound to occur because animal wastes are known to contain pathogenic organisms, causing Salmonellosis, Leptospirosis, Tularemia, Foot and mouth disease and many more [7]-[8]. Environmental problems have increased with improper management practices being largely responsible for the gross pollution of the aquatic environment with parallel increase in water borne diseases especially typhoid, diarrhoea and dysentery [8]. Modern research in the field of agriculture and livestock has revealed shortcomings in the direct use of waste from meat processing plants without appropriate treatment: the spread of soil pathogens and the transmission of diseases to animals, water pollution, and greenhouse gas emissions [9].

The source of raw material required for biogas formation is the waste from slaughtered animals. The biogas production process involves multiple related biochemical processes with microorganisms that work together to achieve the degradation of organic matter into methane and carbon dioxide [10]. The first stage is hydrolysis, in which the complicated components and molecules are converted into simpler molecules and components [11]. The second stage is the acidogenic fermentation of organic slurry is an impressive way to inaugurate valuable intermediate chemicals [12]. The third stage is acetogenesis. This again refers to a process of conversion of volatile fatty acids (VFA) into acetic acid, carbon dioxide and hydrogen which is a chemical reagent for production of chemical compound [13]. The last stage is methanogens production of methane from slurry. In this process acetic acid is converted into methane having a high potential that can be used for electricity, cooking food etc [14]

With abundant waste resource in SH, production of biogas is cheaper, simpler and has been implemented successful with the advancement technology. Therefore, it is important for this study to find out how potentially the biogas production is to be harvested for heat and electricity in Mubi. Estimation in this study was based on the average size of the cattle, sheep, and goats and expected quantity of biogas, heat and electricity were adopted from other scholar contexts.

METHODS AND MATERIALS

A. Description of Study Area

Mubi is located at the coordinates of 10°16′N 13°16′E / 10.267°N 13.267°E in Northeastern, Nigeria. The Mubi consist of 2 local government, including Mubi North and South. The major tribes of the town are: Gude, Nzanyi, Fali, Kilba, Marghi, higgi and Fulani. Mubi is the commercial center of Adamawa State and has an international cattle market, which biggest in region. Most of their communities engage in farming, both local and international businesses and cattle rearing. Their planting crops includes groundnut, maize, yam, cassava, guinea corn, millet and rice.

Figure 1 Dumped slaughtered waste at Mubi North SH

B. Estimation of Slaughtering Houses Waste

The SH considered in this study are from Mubi North and South L.G.A in Adamawa state. Animals slaughtered in Mubi SH include cows, sheep, goat, as shown in Table 1. Primary data were collected through personal interview with people who work in main SH (excluding the number of livestock slaughtered around homes or outside the selected SH).

The potential of biogas volume produced depends on available waste. Effluent from slaughterhouse is moderate to high strength complex wastewater containing about 45% soluble and 55% coarse suspended organics [6]. Approximately 50–54% of each cow, 52% of each sheep orgoat, 60–62% of each pig, 68–72% of each chicken, and 78% of each turkey end up as meat consumed by human beings with the remainder becoming waste after processing [15]-[16]. According to Rao et al, 1Kg of abattoirs waste can produce 0.053m^3 of Biogas, and the quantity waste in an average size of animal by [17], was adopted to estimate the volume of biogas in this study as shown in Table 2. The data was used to estimate quantity of waste and volume biogas generated per day, using the following equations:

Slaughtered waste = Number of animals × Quantity of slaughtered waste per head (Kg) (1)

Volume of biogas (m^3) = Quantity waste × 0.053 (m^3) (2)

Table 1 The average number of animals slaughtered in Mubi North and South per day

Stations	Cattle	Sheeps/goats
Mubi North	26	45
Mubi South	3	7

Table 2 The mass waste per slaughtered animal according to Aniebo et al, 2009

S/No	Waste Categories	Cow	Sheeps/Goats
1	Blood per head (kg)	12.6	0.72
2	Intestinal content per head (kg)	8.0	1.25
3	Waste tissue per head (kg)	6.4	0.80
4	Bone per head (kg)	11.8	2.06

Source: Aniebo et al, 2009.

The Slaughtered waste was a combination of all animals including blood, intestinal content and waste tissues. This study did not include bone, because it is useful for something else (not waste). Therefore, it was estimated that the weight of average cow and sheep/goat slaughtered waste were respectively 27 and 2.77Kg.

C. Estimation of Energy From Biogas

The potential energy from slaughtering waste were determined through energy analysis. Energy analysis was used to examined how much energy is available for utilization of biogas exhausted in generating a unit of energy. According to [18] the net energy analysis indicated that both the thermal and electrical demand of the slaughtering facility could be met from the energy generated through combustion of the biogas in a CHP unit with electrical and thermal efficiencies of 41% and 49% respectively. Ultimately, 85% of the waste accumulated during the slaughter

process is converted into 2700 MWh thermal and 3200 MWh electrical energy in a biogas combined heat and power (CHP) plant [19]. However, in this study conversion of biogas into electric and heat energy are estimated, according to [20], where 1 m^3 of biogas can result in the production of 1.9 kWh of electricity and 3.8 KWh of heat, as shown in equation (3) and (4).

Electricity (KWh/year) = biogas (m^3/year) × 1.9 KWh/m^3 (3)

Heat (KWh/year) = biogas (m^3/year) × 3.8 KWh/m^3 (4)

RESULT AND DISCUSSION

The purpose of this section is to discuss the results obtained from the Slaughtered waste in the SH, by considering the volume of biogas and expected energy output.

Table 3 Quantity of waste and volume of biogas generated in Mubi North and South SH per day

Parameters	Waste (Kg)		Biogas (m^3)	
Stations	Cows	Sheeps/ goats	Cows	Sheep/ goats
Mubi North	702	129.47	37.21	6.86
Mubi South	81	19.39	4.29	1.03

From Table 3, the estimated daily slaughtered waste of cows and sheep/goats, are responsible for producing 702 and 129.47 Kg respectively in Mubi North, and 81 and 19.29 Kg for Mubi South. While an estimated daily biogas generated are 37.21 and 6.86 m^3 for Mubi North and 4.29 and 1.03 m^3 Mubi South respectively. The result also shows that the number of slaughtered sheep/goats were high in the Mubi SH compare to cows. However, the availability of this resource ensures the continuous supply of biogas, as far as the SH is existing.

Table 4 Estimated energy from biogas generated per day

Stations	Total Slaughtered waste (Kg)	Total Volume of biogas (m^3)	Heat Generated Energy (KWh/m^3)	Electric Generated Energy (KWh/m^3)
Mubi North	831.47	44.07	167.47	83.73
Mubi South	100.39	5.32	20.22	10.11

Table 4 represent the daily estimated quantity of waste, volumes of biogas, and expected energy output. The results shows that, 44.07 m^3 biogas can yield of heat and electricity respectively per day for Mubi North, while 5.32 m^3 of biogas yield 167.47 KWh/m^3 and 10.11 kWh/m^3 of heat and electricity per day for Mubi South.

This expected amount of biogas estimated could run the generator to produce heat and electricity. The utilisation pathway consisted of the combustion of the raw biogas with a Lower Heating Value (LHV) of 37 MJ/m3 CH4 in a CHP unit with a total net efficiency of 90%, 41% generated as electricity and 49% as heat [21]. Also, the energy generated by the biogas CHP-plant can cover a significant share of the energy requirement of the abattoir corresponding to 50% of heat and 60% of electric demand, respectively [19].

The expected heat is used for preparing meat (as shown in Fig. 2, where mostly they are use to firewood, charcoal and used car tyre to prepare meat and skin, locally called pomo), while electricity is mainly used in the cold rooms, offices and the lighting of the SH. With that, SH waste has the potential to partly replace its energy demand by converting slaughtered waste into heat and electricity. Hence, the remaining subtract is also useful as organic fertilizer. The application of such an organic fertilizer improves the physical condition of the soil, increasing the soil porosity and reducing the bulk density, which allows for smooth root penetration and growth in the soil [22]. Thus, implementing bio-digester in Mubi SH will fetch considerable profit in terms of energy savings, air quality, agriculture, potable water supplies, and aquatic life.

CONCLUSION

The outlook for this study is to find out how potentially the biogas production is to be harvested for heat and electricity. Accordingly, Mubi can potentially benefit from installations of 44.07 m^3 and 5.32 m^3 daily biogas production fed with slaugtererd animals waste of 831.47 and 100.39 Kg respectively for Mubi North and South. Thereby, harvesting daily 167.47 KWh/m^3 and 83.73 kWh/m^3 of heat and electricity for Mubi North SH, while 167.47 KWh/m^3 and 10.11 kWh/m^3 of heat and electricity for Mubi South SH. Implementing this will go a long way towards solving their energy demand. It is, however, strongly recommended for further details study and to seek for skilled labour and experienced experts, if were to implement to achieve maximum yield of biogas.

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