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Evaluating the Quantity of Sewage Disposal for Biogas Production in University of Maiduguri Students Hostels, Nigeria

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Abstract

The price rise of fuels has stimulated a trend towards the use of alternative energy sources like biomass, solar, wind, geothermal, etc. Global energy crisis has generated interest in the use of human and animal waste which is a biomass source, as a substitute to fossil fuel for biogas generation. There is now a consensus in Nigeria, that renewable energy can play a significant role in the overall energy development of the nation. This study presents the quantity of sewage generated and deposited at the University of Maiduguri for biogas production. The sewage deposit is situated behind the works department of the university. This waste is channel to the deposit site from the student hostels of the University by a well designed sewage system. The total number of persons on the sewage system of the University of Maiduguri is obtained from the Student Affairs Division of the University as the sewage system connects only the students hostels but the actual number of students that used the hostel toilets and the quantity of water used in the toilets are obtained using a questionnaire. The data obtained in this study were recorded, analyzed and presented using Microsoft Excel application. The results of the study revealed that this sewage line serving 8272 students from the hostels generated a total quantity of 235870.38L (235.87m^3) sewage per day which has pH value between 6.864 and 6.75. The study confirmed that sewage generated at University of Maiduguri has the potential to be used as resource to produce biogas which is sustainable, safer and cheaper. Use of the sewage for biogas production will also serve as a waste management source for the University.

Keywords: Biomass, Biogas, Energy, Waste, Sewage

INTRODUCTION

Nigeria is presently grappling with a substantial energy crisis due fuel subsidy removal; however, many households possesses organic waste which has notable potential for biogas energy production owing to its high biodegradability and calorific value thereby reducing the dependence on fossil fuels (Ismail, 2025).With increasing demand and rapid decline of fossil fuels, a global imperative to explore alternative sources of energy is essential. Sewage sludge stands out as a viable option for clean energy generation (Wani and Parveez, 2025). The management of sewage sludge at student hostels is a very important technical, economic and environmental issue. One of the popular environmental friendly methods of processing

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sewage is by methane fermentation which is a complex biochemical process through which organic matter present in the sewage undergoes biochemical decomposition in anaerobic conditions to produce biogas (a valuable source of energy). The residue (digestate) constitutes an excellent organic fertilizer (Peres *et al*., 2019). As energy poverty pervades across West Africa, the demand for access to alternative energy is on a steady rise. However, this demand is not matched with adequate supply, as successive Biogas technology in West Africa remains underdeveloped and underutilized. With a population of about 362 million, West Africa has the capacity to produce as much as two billion cubic meters of biogas annually, a quantity that is capable of enhancing electricity generation with over two million megawatts hour added to the sub-regional grid (Ogwus, 2019).

The demand for sustainable energy in Nigeria is increasing due to population and developmental growth. Unfortunately, the available infrastructures for providing and extending this required energy especially to rural areas have continued to diminish and have become grossly inadequate in recent times. The realization of this fact necessitates the need for the nation to identify and promote the development and utilization of alternative sources of energy such as biomass to augment the existing ones for the socio-economic development of the unreached rural areas of Nigeria (Onuoha et al., 2019).

There is now a consensus in Nigeria, that renewable energy can play a significant role in the overall energy development of the nation. These views were well articulated in the National Energy Policy (NEP) of the country which was promulgated in August 2002 and further amplified by the Renewable energy Master Plan (REMP) of the country which was developed by the Energy Commission of Nigeria (ECN), in conjunction with the United Nations Development Programme (UNDP) in November 2005 (Diji, 2013). According to the Co-founder of African Environmental Action Network, Dr. Victor Fodeke, the EANet-Africa National Strategic Road map will bring on board home-based and community-based biogas digesters in each of the 774 local government area of Nigeria, primary health centres and agriculture communities to produce two to five megawatts of electricity in five years in a public-private participatory and focused international support strategy (Femi, 2018).

The exploration of biogas in Nigeria began in 1982 (Efurumibe *et al*., 2014). Subsequently, research efforts have been ongoing, albeit not with sufficient intensity to achieve the commercial viability of the technology within the nation. Currently, there are fewer than twenty pilot projects for biogas in the nation (Umeh et al., 2024).

Sewage is a combination of liquid wastes which may include chemicals, house wastes, human excreta, animal or vegetable matter in suspension or solution and which is discharged from a building, dwelling or other structure (Ajibade, 2013). Sewage sludge management is a problem of growing importance. Anaerobic sewage sludge stabilization is commonly used technology, where organic matter contained in primary and activated sewage sludge is converted into biogas, so both pollution control and energy recovery can be achieved (Dokulilová *et al*., 2018). Sludge is widely considered as favorable byproduct of wastewater treatment but it can be used as a raw material for energy production. Generally, the specific daily sludge production per person is 80g TS (total solids), i.e., 56g VS (volatile solids), considering the typical pollution of sewage, the use of common secondary treatment and the average VS/TS ratio of 70%. This is equivalent to a yearly organic matter production of 20.4kg VS/person (Jenicek *et al*., 2012).

Many countries are adopting environmental policies promoting the production and consumption of alternative, sustainable and renewable energy sources. Among these sources is green energy production through the anaerobic digestion of agricultural feedstock, like animal manure and food industry by-products, mainly aimed at producing biogas. Nevertheless, only a very small part of the biogas potential is currently used, while many European countries are facing huge problems caused by the overproduction of organic waste from industry, agriculture and households. Biogas production is an excellent way of using organic waste for energy generation, followed by the recycling of the digested substratum (digestate) as fertilizer (Comparetti *et al*., 2013).

The sewage deposited at the University of Maiduguri has not been investigated on its potential for biogas production despite its possibilities. This waste deposit will serve as a source of fuel and reduce the dependency on fossil fuels which is challenged with environmental issues.

METHODOLOGY

Area of the Study

The study area is University of Maiduguri, Maiduguri Borno state. University of Maiduguri is located at latitude$11^{\circ}30'00''N$, longitude $13^{\circ}00'00''E$ and houses about 40,000 people; students, staff and business owners (Oumarou *et al*., 2012). The sewage deposit is situated behind the works department of the university. This waste is channel to the deposit site from the student hostels of the University by a well designed sewage system shown in Figure 1.



Figure 1: Deposit site of the sewage (Imam *et al*., 2024)

Materials used for Study

The materials for this research designed to provide the anaerobic environment essential for the bacterial activity that produces the biogas are: 500ml glass container, Cork, 500ml measuring cylinder and Digital pH meter.

Data analysis

The data obtained in this study are recorded, analyzed and presented using Microsoft Excel application.

Methods

The quantity of the sewage is determined as follow:

Used water from toilets, showers, baths, kitchen sinks, laundries and industrial processes is known as wastewater. Domestic households produce an average of 200–300L of wastewater per person every day (Queensland, 2003). Ninety-nine percent of this wastewater is water and the other one percent is the contaminating waste (Queensland, 2003)**.** Hence, the total quantity of sewage (TQS) generated and deposited at the study area can be obtained as stated by (Queensland, 2003) using the equation 1:

$$TAVH = AVH\ per\ person\ (L) \times Total\ number\ of\ students \quad (1)$$

$$TAVU = AVU\ per\ person\ (L) \times Total\ number\ of\ students \quad (2)$$

$$TAVW = AVW \times Total\ number\ of\ students \quad (3)$$

$$TQS = TAVH + TAVU + TAVW \quad (4)$$

Where TQS is the total quantity of sewage generated at the study area, $TAVH$ is total average daily volume of human excreta per day, $TAVU$ is total average daily volume of urine per day and $TAVW$ is total average daily volume of water per day.

The total number of persons on the sewage system of the University of Maiduguri is obtained from the Student Affairs Division of the University as the sewage system connects only the students hostels but the actual number of students that used the hostel toilets and the quantity of water used in the toilets are obtained using a questionnaire.

This questionnaire is administered to all the twelve (12) hostels connected to the sewage system and the completed questionnaires are collected for analysis.

It is important to determine the sample size of the students to whom the questionnaires will be administered. Sample size refers to the number of elements selected from a given population. This study adopted Taro Yamane Formula (Yamane, 1973) (Uakarn *et al*., 2021; Yerima et al., 2019) sample size formula (Equation 4) with 95% confidence level to calculate the sample size (Ansong *et al.*, 2023).

$$n = \frac{N}{1 + Ne^2} \quad (5)$$

Where:

n = Sample size required

N = number of people in the population

e = allowable error (%) between (1-10%)

RESULTS AND DISCUSSION

Evaluation of the Quantity of Sewage Produced at University of Maiduguri

The quantity of the sewage generated and deposited at University of Maiduguri is calculated using Equations 1, 2, 3 and 4.

The total number of students connected to the sewage line is presented in Table 1.

Table 1: Number of students in hostels connected to the sewage line

S/NO	Name of Hostel	Number of Students		
		Conventional	**Non-conventional**	**Total**
1	Aisha Hall	1200	168	1368
2	Murtala Mohammed Hall	1000	60	1060
3	Aisha Annex	710	64	774
4	New Female Hostel	284	0	284
5	Dr. Shettima Ali Monguno Hall	284	0	284
6	Aisha Muhammadu Buhari Hall	600	0	600
7	Sardauna Hall	1000	44	1044
8	Tafawa balewa Hall	1000	46	1046
9	Ibrahim Imam Hall	1000	63	1063
10	Ado Bayero Hall	710	0	710
11	New Male Hostel A	600	0	600
12	New Male Hostel B	600	0	600
Total Number of students				**9433**

The sewage system of the University of Maiduguri is designed to be used by 9433 students but to determine the actual number of students that used the sewage system, a questionnaire is administered.

The sample size of this study of 9433 students is 320 students using Equation 5. Therefore, the questionnaires will be administered to 320 students to determine the number of students that actually use the hostel toilets and the average volume of water used in the sewage system per day. The questionnaire distribution of respondent is shown on Table 2 with female hostel (F) and male hostel (M).

Table 2: Distribution of Respondent

S/NO	**Name of Hostel**	**Hostel Symbol**	**Total Number of Students**	**%**	**No. of Questionnaires to be issued**
1	Aisha Hall	F1	1368	14.5	45
2	Murtala Mohammed Hall	F2	1060	11.2	36
3	Aisha Annex	F3	774	8.2	26
4	New Female Hostel	F4	284	3	10
5	Dr. Shettima Ali Monguno Hall	F5	284	3	10
6	Aisha Muhammadu Buhari Hall	F6	600	6.4	21
7	Sardauna Hall	M1	1044	11	35
8	Tafawa balewa Hall	M2	1046	11.1	35
9	Ibrahim Imam Hall	M3	1063	11.3	36
10	Ado Bayero Hall	M4	710	7.5	24
11	New Male Hostel A	M5	600	6.4	21
12	New Male Hostel B	M6	600	6.4	21
	Total		**9433**	**100**	**320**

The actual number of students that use the student's hostel is 8272 students as presented in table 3 and the total average volume of water (TAVW) in liters per day in the sewage system

is 222826.30L as presented in table 4 as obtained from the questionnaires administered using equation 3.

Table 3: Total Number of Students Using the Hostel Toilets Daily

Hostels	Number of students daily toilet use
F1	1217.52
F2	1060
F3	580.5
F4	227.2
F5	284
F6	600
M1	678.6
M2	1046
M3	967.33
M4	518.3
M5	522
M6	570
TOTAL	**8271.45**

Table 4: Total Average Volume of Water (TAVW) per day in the Sewage System

Quantity (L)	0-10	11-20	21-40	41-60	TOTAL
F1	54.520	54.52	368.01	790.54	
F2	349.80	180.20	530	0	
F3	147.06	178.02	448.92	0	
F4	0	28.40	198.80	56.80	
F5	0	28.40	198.80	56.80	
F6	60	114	342	84	
M1	104.40	198.36	595.08	146.16	
M2	0	62.76	387.02	596.22	
M3	85.04	467.72	446.46	63.78	
M4	269.80	92.30	319.50	28.40	
M5	114	84	114	114	
M6	60	288	252	0	
Total Frequency	1244.62	1776.68	3021.30	1936.70	
AVW(L)	5	15	30.50	50.50	
TAVW(L)	**6223.10**	**26650.20**	**97803.35**	**97803.35**	**222826.30**

The quantity of sewage is evaluated using the parameters in table 5 which was obtained from tables 3 and 4 above.

Table 5: Parameters for the Determination of Quantity of Sewage

Total Number of Students that Use the Hostel Toilets Daily	8272	Source: Present study
Total Average Volume of Water used per day in Sewage System (L)	222826.30	Source: Present study
Average Daily Volume of Human Excreta per person (L)	0.377	Source: (Maurya, 2012)
Average Daily Volume of Human Urine Per person (L)	1.2	Source: (Maurya, 2012)

Total average volume of human excreta in the sewage system is obtained from equation 1as 3118.34 liters and total average volume of human urine in the sewage system is obtained from equation 2 as 9925.74 liters.
Therefore, the total quantity of sewage TQS from equation 4 is:

$$TQS = 235870.38l$$
$$TQS = 235.87m^3$$

It is observed that this sewage line serving 8272 students from the hostels generates an average total quantity of 235870.38L (235.87m^3) sewage per day. It is also observed that at the time of

this report, the volume of sewage at the deposit site is 13933.44m^3 over a long period of time. This value could not be used in the calculation due to contamination by rain, long time of deposition, etc., among others. The total capacity of the main sewage system is 33933.60m^3. Claribelle *et al.,* (2020) used a hostel with a capacity of 696 students which generated a total quantity of 139200L (139.2m^3) of sewage per day. The capacity of students and total quantity sewage per day do not confirm with the present study even though the method of estimating the total quantity differs.

Checking Initial pH Value

Three samples of the sewage were collected and the pH values were checked and recorded in Tables 6.

Table 6: Average pH value of the samples

Sample	pH value
A	6.864
B	6.776
C	6.75

Tables 6 present the average pH values of the three samples collected. The pH values of the sewage samples from the study area is between 6.864 and 6.75 which is a best-optimized condition for biogas production, where the methane producing bacteria exist and will not have a toxic effect on the methanogenic bacteria since it is above 6.4 as stated by (Weinstein, 2009).

CONCLUSION

The study successfully assessed the amount of sewage produced at the University of Maiduguri and its potential for biogas production. It was estimated that approximately 235.87 m^3 of sewage is generated every day. That data is useful for alternative energy biogas production. From questionnaire analysis, the study established the number of students who actually use the sewage system and their water usage habits, furnishing precise information for sewage volume calculations. In addition, the pH test of the sewage samples revealed an ideal range for anaerobic digestion, which means that there were good conditions for biogas production.

These results bring forth the feasibility of harnessing sewage as an energy renewable source at the university campus and probably beyond. With easier access to such volatile waste, the university is bound to reduce its waste management issues, reliance on fossil fuels, and move towards the more sustainable energy production paradigm. The high quantum of sewage generated offers an unmistakable prospect of applying biogas technology that is compatible with national renewable energy policy and redressing Nigeria's increasing energy needs. Design and installation of a pilot biogas digester system for proving the actual utilization of the observations and measurement of the recoverable biogas yield is suggested for future study. This would not only legitimize the findings of the study but also open up avenues for large-scale application of sewage-based biogas technology in such locations elsewhere in West Africa, and promote energy security and environmental sustainability.

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