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Solid Wastes and Greenhouse Gas Emissions Management for Energy Derivation: Case Study of LAUTECH Ogbomoso and Environs

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ABSTRACT

Final disposal of solid wastes at Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, and its environs is by scavenging, dumping sites and open-air burning. This research aimed at studying the solid waste generation and greenhouse gas emissions management for energy derivation at LAUTECH and environs. The university was divided into sixteen zones based on Faculties and other prevailing activities on campus. Waste samples were obtained from bins and dumping sites, for 5 days (Monday, Tuesday, Wednesday, Thursday and Friday) in three years (2021, 2023 and 2024) for waste composition data. Sorted waste samples were taken to the laboratory to carry out moisture and energy content analyses. Methane (CH_4) and Carbon dioxide (CO_2) emissions from dumping sites and farm areas within LAUTECH and its environs were also measured using gas detectors. The collected primary data was analyzed statistically and discussed. Estimated waste generation in LAUTECH was 6161.47 kg/day, resulting in a daily waste generation rate of about 187 g per head, considering a university population of 33,000. The Energy content of daily wastes was 107.19 MJ, implying an electricity generation up to 0.02977 MWh (approx. 29.77 kWh) from daily steam production. Methane (CH_4) levels range from 75 ppm (Rabbit Unit) to 2,107 ppm (layer birds, Abogunde Farms) and CO_2 concentrations vary between 400 ppm and 470 ppm, across farms. However, methane levels recorded peak values e.g., 11,169 ppm at AA Rano, 8,763 ppm at college, and 6,900 ppm at ALICE. CO_2 is highest at college (1,171 ppm) and AA Rano (1169 ppm). TVOC and HCHO values remain low at farm sites, while elevated at dumpsites. Considering the high material recyclability, reusability and energy recovery potentials from solid wastes generated from LAUTECH Ogbomoso and environs, there is an urgent need for emissions control in high-risk dumpsites through methods such as methane capture and air quality filtration. These actions are critical for environmental protection and safeguarding public health.

INTRODUCTION

Population growth, urbanization and economic development are the factors that contribute to increasing waste generation in African Urban Cities and overburdening waste management systems (Scarlat *et al*., 2015). Advancements in science and technology, increasing consumption of resources have culminated to the accumulation of large amounts of solid waste ranging from domestic to agricultural and up to industrial activities, with increased toxicity and hazards that have threatened public health (Sangodoyin and Ipadeola, 2000; Oladejo, 2011).

Uncontrolled population, community density, consumption habits, standard of living, monthly wages, dwelling population, percentage of urban population, age, sex, ethnicity, size of housing units, geographical locations, land use patterns, productive activities and cost of living are some common factors that have the influence on waste generation, with population being the major factors influencing unit waste generation rate (Chung and Lo, 2008). Estimation of the quantity of solid waste generated in a city is very important for proper solid waste management. While most developed countries regarded their waste as a resource, poor waste management became a challenging issue with governments of developing countries, resulting in enormous tasks in terms of collection and disposal, making solid waste hazardous in most developing countries. Improper waste management has become a serious concern for experts from cities in developing states (Noor *et al*., 2013; Chung and Lo, 2008; Imam *et al*., 2008).

Waste management services, which involve collection of waste and transportation to final disposal, are carried out, in most developing countries, by the local authorities, but were stalled by inadequate financial assistance and human resource capacity. These hinder effective waste management services (Barton et al. 2008), amounting to serious problems that impair human and animal health and ultimately result in economic, environmental and biological losses (Shaholy *et al*. 2008). Some factors affecting effective municipal waste management in Nigeria are poor funding and uncontrolled population, lack of trained/professional waste managers (Okeniyi and Anwan, 2012), ineffective monitoring and control, inadequate maintenance culture towards the environment, and lack of modern technology/lethargy in the implementation of efficient waste management methods. Recovering energy from the waste can be a better means of managing environmental pollution caused by municipal waste disposal.

Urbanization in African countries is increasing annually, resulting in the generation of volumes of waste. Municipal Solid Waste (MSW) is one source of renewable energy resource that is replenished in African urban areas due to the poor waste management in these areas (Mwangomo, 2018). One of the waste management approaches is to convert waste into useful energy applications. According to Campos *et al*. (2015), the following technologies can be used to convert waste into useful energy applications these are pyrolysis process, gasification process, plasma arc gasification process, incineration/ filling, anaerobic digestion and refuse-derived fuel (Kumar, 2016; Jehangir, 2018).

Waste can be converted directly into energy in the form of biogas, syngas and heat. These conversions can be done through physical, thermal and biological methods. According to Jain *et al*. (2014) and Oladejo *et. al*. (2024), environmental impacts, technical aspects and socio-economic factors are the three factors that influence waste-to-energy technology. Solid waste management may also hold the key to reducing the rate of environmental pollution/degradation while improving the development rate. There exists ineffective waste management, inappropriate waste disposal methods, and value addition loss in the forms of material recovery, reuse and energy derivation. Jehangir (2018) stated that most of the municipal solid wastes in developing countries are left uncollected, so the first option would be to achieve a 100% collection rate prior to other waste-to-energy options. It was also mentioned that in most of the less developed countries, the facility of waste management is not available to all the people in the community.

A significant contributor to the generation of methane (CH4) gas is municipal solid waste (MSW) from open dumps (Chandra and Ganguly, 2023). Open dumping of solid waste has significantly increased greenhouse gas emissions in many developing countries. Much information is obtained about the contribution of these greenhouse gas emissions in cities and towns, but there is little from universities and other institutions of higher learning that now act like municipalities (Oladejo *et al*., 2020d, 2024b; Adeniran *et al*., 2017).

This research is aimed at studying the solid wastes and greenhouse gas emissions management for energy derivation at Ladoke Akintola University of Technology (LAUTECH) Ogbomoso and environs, with the view of converting solid wastes generated into useful energy resources.

Description of study area

LAUTECH main campus is located in Ogbomoso, Oyo, Nigeria, with geographical coordinates 8° 8′ 0″ North, 4° 16′ 0″ East. This is where most of the University's teaching and research are carried out. The Ogbomoso Campus also houses the central administration of the University. The entire student body population of both undergraduates and postgraduates is presently about 30,000, with 3,000 dynamic and highly dedicated staff and faculty members. Source: https://lautech.edu.ng/ retrieved on 3rd March, 2025.

MATERIALS AND METHODS

The Works Department of the university, via the campus cleaners, collected the waste using the 'Portable Container System' waste bins and then transferred it to the nearest dumping location, where open-air burning takes place. The university was divided into sixteen zones based on Faculties and other prevailing activities on campus. Generated solid wastes samples were obtained from bins and waste disposal sites, for 5 days (Monday, Tuesday, Wednesday, Thursday and Friday) for consecutive three years (2021, 2023 and 2024) from the identified zones of study area to develop waste composition data for the specific zones to achieve a system of source generator-based study. Waste categories were weighed to obtain the weight-based characterization for the waste components. Sorting into major waste categories was in accordance with the College and University Recycling Council grouping system (CURC, 2001), with modifications to accommodate the peculiar waste stream generated in LAUTECH Ogbomoso. Afterwards, selected waste samples were taken to the laboratory to carry out necessary analyses according to Oladejo *et al*. (2020c). Methane (CH_4) and carbon dioxide (CO_2), and others such as total volatile organic compounds (TVOCs), and formaldehyde (HCHO) emissions from dumping sites and farm areas within LAUTECH and its surrounding areas were also measured to assess environmental health and ensure compliance with air quality standards. The collected primary data was analysed using the descriptive statistics method.

RESULTS AND DISCUSSION

The results and discussions of both exploratory field work, laboratory experiments, and greenhouse gas (GHG) were carried out within LAUTECH and its environs were presented as follows: The summarized Primary Data for Solid Waste Generated in Lautech Ogbomoso Campus within Years 2021- 2024 was presented in Table 1, while Table 2 showed the combustible components of solid waste generated in (g/day), energy content (MJ) and electricity generation potential (MWh). Table 3 presents the zero waste concept and analysis of value addition to waste generated in Lautech Ogbomoso. Figure 1 depicts the daily mean waste components generated from Lautech Campus, Ogbomoso, and Figure 2 shows solid waste components generated by percentage (%) from Lautech Campus, Ogbomoso, while Figure 3 presented the daily mean waste generated from activities zones within Lautech Campus, Ogbomoso, and Figure 4 showed value addition and electricity generation potential (MWh) from LAUTECH Campus, Ogbomoso.

Table 1: Summarized Primary Data for Solid Waste Generated in LAUTECH Ogbomoso Campus within Years 2021- 2024

Zones/ waste materials	Paper (g)	Plastic (g)	Nylon (g)	MetalsCan (g)	Flowers/Dry Leaves (g)	Food Wastes (g)	Glass (g)	Leather (g)	Wood (g)	Rags (g)	E-wastes (g)	Polystyrene (g)	Bones (g)	Dirt/Others (g)	Total Sum (kg)	Mean	% Mean
FET	2090	1140	820	182	716	992	380	50	294	20	160	390	70	2050	9.35	668.14	9.48
PAS	471.8	260.8	551.4	0	356.4	129.2	0	0	0	0	0	0	0	596	2.37	168.97	2.40
FES	300	1500	540	540	380	0	1300	40	320	80	0	164	0	300	5.46	390.29	5.34
FAGS	298	480	1030	74	184	124	120	10	50	50	20	92	10	98	2.64	188.58	2.68
FMGS	1250	1340	2020	550	780	637.5	375	140	347.5	637.5	20	6.25	50	400	8.55	610.98	8.67
FBMS	1760	1760	4020	0	1080	4294	100	0	200	270	0	610	2	1280	15.39	1098.29	15.61
ODL	322	420	340	11	300	440	0	0	4	0	0	0	21	1700	3.56	254.14	3.61
Senate Building	3140	840	1236	55	1030	0	254	0	0	0	115	12	0	1490	8.17	583.71	8.29
Car Park	170	330	230	0	132	0	0	0	50	0	0	0	0	106	1.02	72.71	1.03
SUB	410.8	428.8	110.4	200.4	120	309.8	76.8	66	0	90	0	0	0	171.2	1.98	141.73	2.01
Health Centre	752	2150	758	18	494	20	100	0	0	0	0	100	60	442	4.89	349.57	4.96
Bakery	500	620	808	284	3020	590	120	100	210	220	20	120	0	632	7.24	517.43	7.34
Sport Arena	1140	2730	1320	0	1435	0	0	0	2225	0	0	25	0	2680	11.56	825.36	11.73
Cafeteria	146	370	370	210	1920	3560	300	0	0	0	0	60	840	1390	9.17	654.71	9.30
Religious areas	130	206	836	11	0	442	120	0	0	40	164	161	0	751	2.86	204.36	2.90
Banking	800	410	320	296	490	990	0	0	22	0	0	0	0	1050	4.38	312.71	4.44
Total Sum (g)	13680.6	14985.6	15309.8	2431.4	12437.4	12528.5	3245.8	406	3722.5	1407.5	499	1740.25	1053	15136.2	98.58	6952.6	100
Daily Mean (g)	855.04	936.6	956.86	151.96	777.34	783.03	202.86	25.38	232.66	87.97	31.19	108.77	65.81	946.01	6161.47		
Std. Dev	844.06	761.04	949.97	186.07	794.04	1279.01	320.44	43.09	546.73	167.91	58.51	168.33	207.82	759.96	3981.74		
% Mean	13.88	15.20	15.53	2.47	12.62	12.71	3.29	0.41	3.78	1.43	0.51	1.77	1.07	15.35	100		

Table 4 shows the methane (CH4) and carbon dioxide (CO_2) concentrations measured at various dumpsites and selected farm areas, along with additional environmental parameters like temperature, humidity, Total Volatile Organic Compounds (TVOC), and Formaldehyde (HCHO).

Estimated total solid waste generated from LAUTECH Campus, Ogbomoso

Estimated solid waste generation in LAUTECH Ogbomoso was 6161.47 kg, resulting in a daily waste generation rate of about 187 g per head, considering a university population of 33,000 (Table 1). Figure 1 shows solid waste characterization by weight and percentage (%) against sixteen (16) zones classified based on the Faculties and other prevailing activities on campus. By zones, FBMS, Sport Arena, FET, and Cafeteria have the highest waste generated (15.61%, 11.73%, 9.48% and 9.3%, respectively). The activities of students and the staff population around these zones were a major factor in the high waste generation. These zones were dominated by recyclable wastes such as plastic, nylon, paper, food wastes, glass and e-waste.

Generally, nylon (15.53%), comprising of Lautech bread nylon and water sachet, while plastic bottles (15.2%), papers (13.88%) from photocopying businesses, student notes, and offices, and food wastes (12.71%), from eateries formed the majority of highly generated wastes within Lautech campus. Flowers/ dry leaves (12.62%) were generated across all the zones within the campus, mostly due to the trees and flower gardens that beautify the university. These are eco-friendly and mitigation measures against global warming.

Babatunde (2013) reported a high volume of polythene bags as being the second largest waste after organics in some municipalities in Nigeria. The desire to have potable water at a moderate cost was also responsible for the high volume of sachet water, according to Dada (2009). There may be a need for a policy to localize the generation of plastic waste. Such as the use of water dispensers in cafeterias, commercial areas and offices and the strategic placement of plastic collection bins within the metropolis. Germany's 65% recycling rate (Eurostat, 2021) reduces landfill dependency. The high levels of plastic (936.6g mean) in this study reinforce the need for a structured recycling program.

Food wastes, flowers and dry leaves pose environmental and health challenges with the potential to release greenhouse gases and attract vectors, if not properly disposed (Symth *et al*., 2010). Westerman and Bicudo (2005) suggested three uses of organic wastes as composite production, energy generation and composting for soil nutrients, for effective organic waste management. Symth et al. (2010) reported a food waste composting programme at Camosun College, Victoria, British Columbia. Anaerobic digestion of food waste (Oladejo *et. al*, 2020c) has been reported to have approximately three times the methane production potential by volume than municipal wastewater solids (Adeniran *et al.,* 2017).

Among the least generated were metal wastes (2.47%), glass (3.29%), majorly from FES, possibly due to the Fine Art works, and e- wastes (0.51%) from FET due to electrical repair works; and textiles/rags (1.43%) and Leather (0.41%). Oladejo *et. al* (2020a) and Jikmika and Mirunalini (2017) reported that the use of leather waste materials in concrete for construction purposes has reduced pollution and disposal problems, resulting in less landfill pressure.

Physical combinations of solid wastes for energy recovery and recyclability potential

The combustible components of solid waste generated in LAUTECH Ogbomoso (g), energy content (MJ/kg) and electricity generation potential

(MWh) were presented in Table 2, while Figure 4 presents electricity generation potential (MWh).

As at present, when a daily waste stream (6.161 kg/day) in LAUTECH Ogbomoso is completely and thermally treated to produce steam, 0.02977 MWh (approx. 29.77 kWh) of electricity can be generated. This translates to an electricity consumption of a 1kW device running for 29.77 hours, which is enough to boil 300 litres of water.

Table 2: The combustible components of solid waste generated in LAUTECH Ogbomoso (g/day), energy content (MJ/day) and electricity generation potential (MWh)

S/N	Combustible Components	Moisture content	% Composition	Quantity of MSW generated (g)	Specific Energy Content (MJ/Kg)	Total Energy Content (MJ)	Electricity generation Potential (MWh)
1	Food Waste	35.9	12.71	**783.03**	5.36	4.20	0.0012
2	Bones	12.25	1.07	**65.81**	7.26	0.48	0.0001
3.	Papers	5.57	13.88	**855.04**	12.98	11.10	0.0031
4.	Plastic	1.80	15.20	**936.6**	31.25	29.27	0.0081
5.	Nylon	1.82	15.53	**956.86**	29.08	27.83	0.0077
6.	Polystyrene	-	1.77	**108.77**	35.34	3.84	0.0011
7.	Metals cans	-	2.47	**151.96**	0.56	0.09	0.00002
8.	Glass	-	3.29	**202.86**	0.47	0.10	0.00003
9.	E- waste	2.5	0.51	**31.19**	6.27	0.20	0.00005
10.	Textiles/Rag	15.25	1.43	**87.97**	17.45	1.54	0.0004
11.	Leather	25.37	0.41	**25.38**	16.72	0.42	0.00012
12.	Woods	35.48	3.78	**232.66**	15.08	3.51	0.0010
13.	Flower leaves	45.36	12.62	**777.34**	11.29	8.78	0.0024
14.	Other dirts	18.25	15.33	**946.01**	17.24	16.31	0.0045
	Total		**100%**	**6161.47**		**107.19**	**0.0298**

It is also similar to the energy content of 3 litres of gasoline (1 liter of gasoline contains approx.35MJ), and enough to power an average LED light bulb (10W) for about 3,000 hours. With the calorific value of waste in the present work, waste utilization as an alternative renewable energy source is reflected as a free source, and therefore it is economical to use waste as a source of energy. This proves to be a source of clean energy for electricity production. In the Arise News of Thursday, 4th March, 2022, Nigerian Federal Government put the country's total installed electricity capacity at 18,000MW, while it generated 8,000 MW for consumers, due to low water level at hydro dams in the country (arise.tv, 2022).

Similarly, according to Nigerian Electricity Regulatory Commission, NERC, the average energy consumption per residential household in Nigeria was reported to be around 50 – 60 kWh per month (approximately, 2 kWh per day) in 2019, including urban and rural areas connected to electricity grid (Published June 6, 2023 by Newsletter, Energy Independence).

Table 3: Zero waste concept and analysis of value addition to waste generated in LAUTECH Ogbomoso

Value Addition	Waste components	Ave Waste (g) generated	% waste generated	Electricity generation Potential (MWh)	Zero Waste Concept
Compost and Bio fuel Production	Paper	855.04			
	Food wastes	783.03			
	Flower leaves	777.34			
	Sub total	**2415.41**	**39.31**	**0.0067**	
Recyclables	Plastics (water bottles)	936.6			Material Recyclable
	Polythene (water sachet, nylons)	956.86			**76.31%**
	Metals (tins, cans bottles)	151.96			**(0.0226 MWh)**
	Glass	202.86			
	E- waste	31.19	**37.00**	**0.0159**	
	Sub total	**2279.46**			
Incineration	Textiles/ Rags	87.97			
	Polystyrene	108.77			
	Woods	232.66			Energy Recovery
	Leathers	25.38			Material
	Bones	65.81			**23.69%**
	Sub total	**520.59**	**8.36**	**0.0027**	
Reuse	Residuals (ashes, sand, etc)	**946.01**	**15.33**	**0.0045**	**(0.0072 MWh)**
	Total	**6161.47**	**100.00%**	**0.0298**	**100%**

From the fore going, estimated electricity potential from waste incineration, 0.02977 MWh (approx. 29.77 kWh) matches with the national grid electricity generation and can provide electricity (2 kwh/ day) for over 15 residential households in Nigeria.

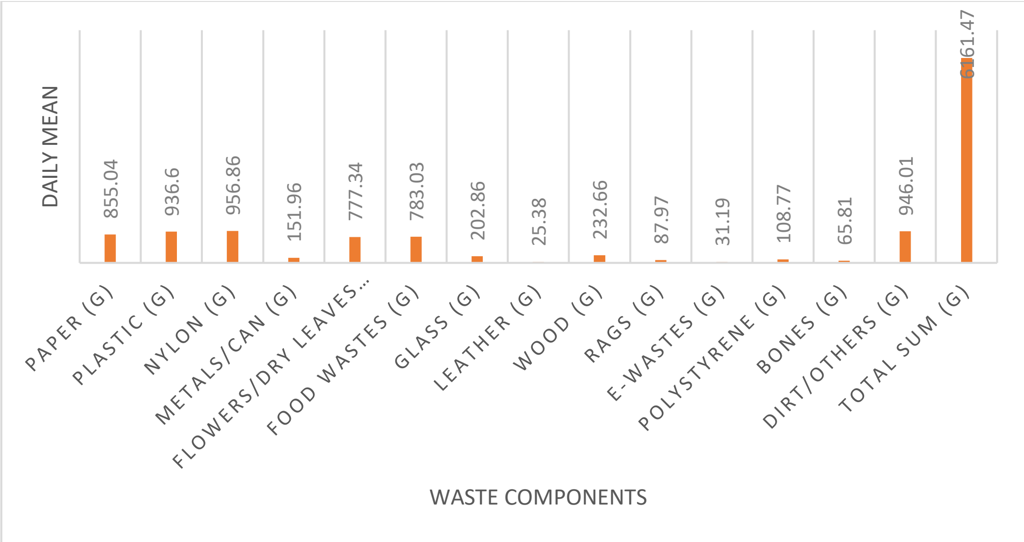

Figure 1: Daily Mean waste components generated from LAUTECH Campus, Ogbomoso

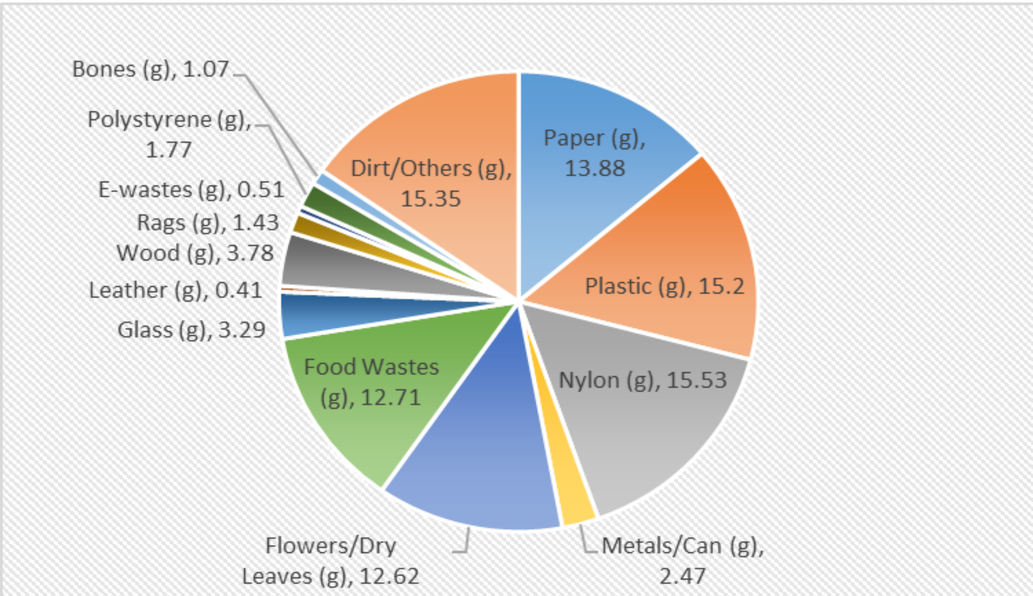

Figure 2: Solid waste components generated by percentage (%) from LAUTECH Campus, Ogbomoso

going, estimated electricity potential from waste incineration, 0.02977 MWh (approx. 29.77 kWh) matches with the national grid electricity generation and can provide electricity (2 kwh/ day) for over 15 residential households in Nigeria. Table 3 and Figure 4 showed the zero-waste concept and analysis of value addition to the waste generated in LAUTECH Ogbomoso campus, Ogbomosho. About forty percent (39.31%) amounting to 2.415 kg of waste generated were derived from paper, food wastes and flower leaves. These categories of waste could be aerobically or anaerobically digested to produce compost (organic fertilizer) or bio-fuel, respectively.

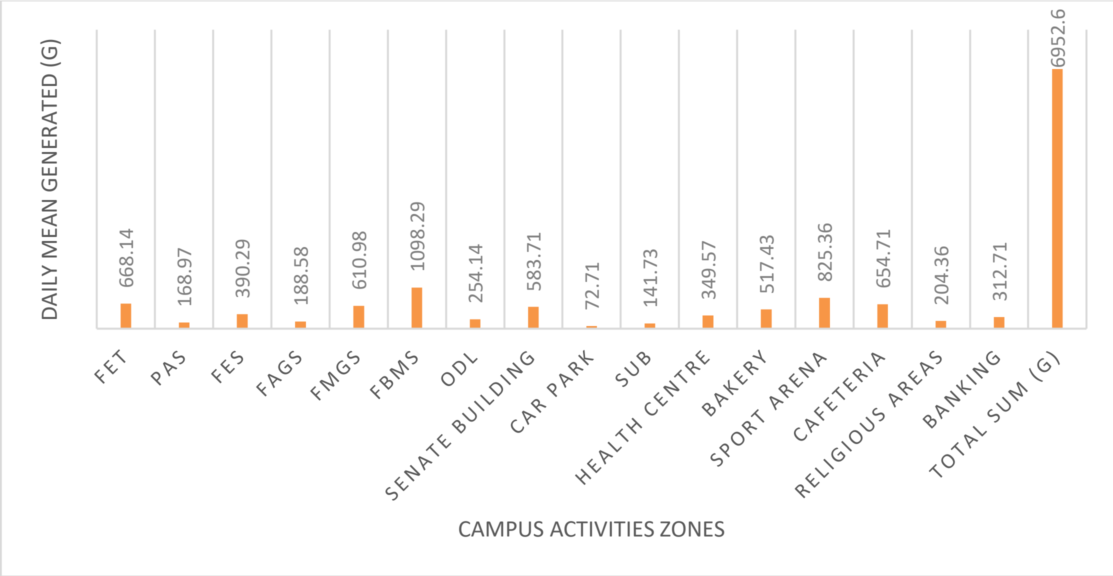

Figure 3: Daily Mean waste generated from activities zones within LAUTECH Campus, Ogbomoso

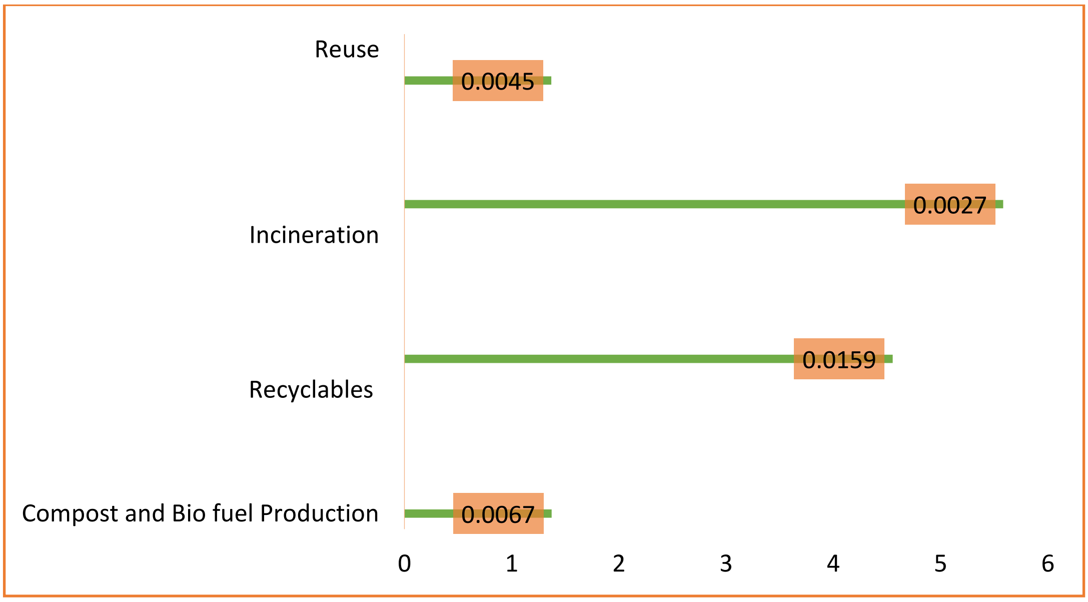

Figure 4: Value addition and Electricity generation Potential (MWh) from LAUTECH Campus, Ogbomoso

This result is in line with the findings of (Oladejo et. al., 2018, 2020a, b and c); Jehangir, 2018 and Salam et al., 2012); that a large portion of solid wastes is composed of organics (fruit wastes, vegetable and food wastes). The derivable electricity potential is 6.7 kWh. The recyclables (polythene bags, plastic bottles, metal cans, glass and e-waste) constituted 37.00% (2.279 kg) of the solid waste generated. This agreed with studies by Armijo de Vega et al. (2008) and Smyth et al. (2010) of 34% and 28.2% respectively, and Oladejo *et. al.* (2020a). It showed that the community has better recyclability and an electricity generation potential of 15.9 kWh. About 8.36 % (520.59 g) of the total solid waste could be incinerated. These were leather, textiles/ rags, polystyrene, bones and wood. Thermal energy generated could be converted and reused, with an electricity potential of 2.7 kWh. Ash produced from incineration process could be combined with residuals ash from cafeteria and bakeries (15.33%, 946.01 g) and disposed of to landfill or for reuse as alkaline solution to address soil acidity and other soil enhancement and treatment for agrarian policy, as non- recyclable waste (Anon, 2004; Aubert, 2004). Bottom ash has the potential to be used in various applications, after specific treatments for each application, as depicted in It is presently used for certain applications such as in road construction, cement production as an additive, concrete production as aggregate, etc.

Arising from Table 3, an integrated solid waste management concept adaptable to LAUTECH campus, Ogbomoso has zero waste concept of about 76.31% waste material recyclable (composting, bio-fuel production and recyclables), with electricity generating potential of 22.6 kWh and 23.69 % energy recovery (electricity generation, incineration-derived ash and residual ash for landfilling or soil enhancement) of about 7.2 kWh.

Greenhouse Gas (GHG) Emissions Analysis from Farm and Dumpsite Locations

The dataset reveals stark differences in GHG levels between farm and dumpsite locations as shown in Table 4. Dumpsites consistently exhibit higher methane and CO_2 emissions, indicating more intense organic decomposition and anthropogenic activities. Farm sites show more moderate emissions, with exceptions like layer birds at Abogunde Farms.

A. Farm Sites Analysis

Methane (CH_4) levels range from 75 ppm (Rabbit Unit) to 2,107 ppm (Abogunde Farms). This varied comparatively, with the highest levels recorded at Abogunde Farms (2107 ppm) and the Sheep and Goat Unit (454 ppm). The elevated methane at Abogunde Farms may be due to inefficient waste management practices and higher organic material breakdown rates. The Piggery Unit also displayed moderate methane levels (174 ppm), likely due to anaerobic conditions created by pig waste. CO_2 concentrations vary between 400 ppm and 470 ppm, relatively moderate across farms. TVOC and HCHO values remain low at farm sites, showing lesser air quality risks compared to dumpsites.

In contrast, CO_2 levels at these farm sites were relatively low, peaking at the Broiler Unit (470 ppm). This difference suggests that methane emissions from animal waste management and decomposition activities are more dominant than CO_2 emissions, which are more directly linked to respiration processes. The CO_2 emission pattern also indicates possible adequate ventilation or natural dispersal across units, which limits CO_2 buildup from animal respiration.

B. Dumpsites Analysis

Methane levels recorded peak values, e.g., 11,169 ppm at AA Rano, 8,763 ppm at College, and 6,900 ppm at ALICE. CO_2 is highest at College (1,171 ppm) and AA Rano (1169 ppm). Volatile Organic Compounds (TVOCs) and Formaldehyde (HCHO) concentrations are also significantly elevated.

Methane emissions were prominently elevated at the Abattoir (621 ppm) and the Low-cost Area Dumpsite (552 ppm). These high methane levels likely result from waste decomposition processes where organic materials break down anaerobically, releasing methane as a byproduct. In contrast, certain sites, such as Behind Highrise I and Beside Laboratory, registered no methane emissions. These areas, located within the school premises, primarily contain non-biodegradable waste, such as paper, polyethylene, plastic bottles, and wrappers, which do not decompose anaerobically and therefore do not emit methane.

Table 4: Greenhouse Gas Emissions Readings from selected farm areas and dumpsites

S/N	Location	coordinate (N)	coordinate (E)	Temperature	Methane (ppm)	(ppm)	TVOC (mg/m^3)	HCHO (mg/m^3)	Humidity
Readings From Farm Sites									
1	Broiler Unit	8°10'21"	4°16'15"	30°	132	470	0.014	0.019	65.9
2	Rabbit Unit	8°10'23"	4°16'14"	30°	75	411	0.015	0.001	65.2
3	Piggery Unit	8°10'25"	4°16'14"	31°	174.4	448	0.041	0.008	58.3
4	Sheep & Goat Unit	8°10'17"	4°16'20"	35°	454	428	0.024	0.004	55.9
5	Abogunde Farms (layers)	8°11'11"	4°14'49"	26°	2107	400	0.024	0	85.3
Readings From Dump Sites									
6	Behind Highrise I	8°10'04"	4°16'07"	87°	0	524	0.124	0.022	70.5
7	Behind Highrise II	8°10'13"	4°16'08"	87°	0	647	0.063	0.011	64.9
8	Beside Laboratory	8°09'14"	4°15'28"	87°	0	723	0.862	0.118	52.4
9	waso market	8°09'52"	4°15'26"	35°	469	406	0.072	0.009	53.3
10	river side waso market	8°09'52"	4°15'20"	32°	551	442	0.001	0.023	50.1
11	main dumpsite (wazo)	8°09'53"	4°15'25"	37°	302	770	0.359	0.07	55.5
12	abattoir	8°14'46"	4°24'24"	33°	621	680	0.241	0.05	57.1
13	Low-cost area dumpsite	8°07'55"	4°12'32"	32.3	552	702	0.313	0.062	54.3
14	UnderG	8°09'49"	4°16'00"	31°	0	504	0.064	0.01	55.9
15	G71 Petrol Station	8°09'38"	4°15'51"	33°	5393	831	0.278	0.013	53.3
16	ALICE	8°09'14"	4°15'33"	32°	6900	872	0.774	0.095	56.9
17	Stadium	8°09'11"	4°15'22"	30°	4000	774	0.362	0.064	57.6
18	Ragarey	8°09'11"	4°15'17"	31°	3500	978	0.579	0.09	55.4
19	AA Rano	8°09'28"	4°15'25"	38°	11169	1169	1.434	0.202	48.7
20	College	8°09'36"	4°15'28"	34°	8763	1171	1.159	0.187	51.2
21	NNPC	8°09'58"	4°15'38"	32°	3785	971	0.665	0.118	55.4
22	Main School Gate	8°10'12"	4°15'46"	34°	2504	985	0.693	0.121	52.1
23	Opp Metal Workshop	8°09'59"	4°16'06"	32°	943	941	0.685	0.124	66.1
24	UnderG School Gate	8°09'54"	4°16'04"	33°	872	643	0.195	0.048	53.5
25	roundabout waso	8°09'48"	4°15'32"	31°	360	402	0.023	0.001	70.3
26	salawu petrol station	8°09'20"	4°15'19"	31°	853	975	0.642	0.06	69.0
27	LTH	8°09'05"	4°15'12"	33°	432	703	0.262	0.059	61.4

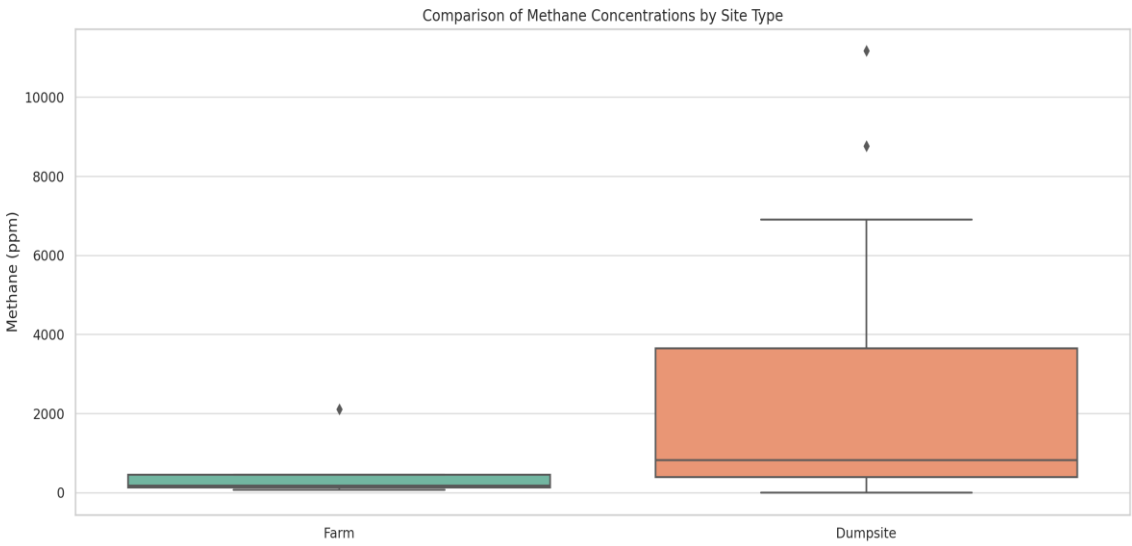

Figure 5: Difference in methane levels between farm sites and dumpsites

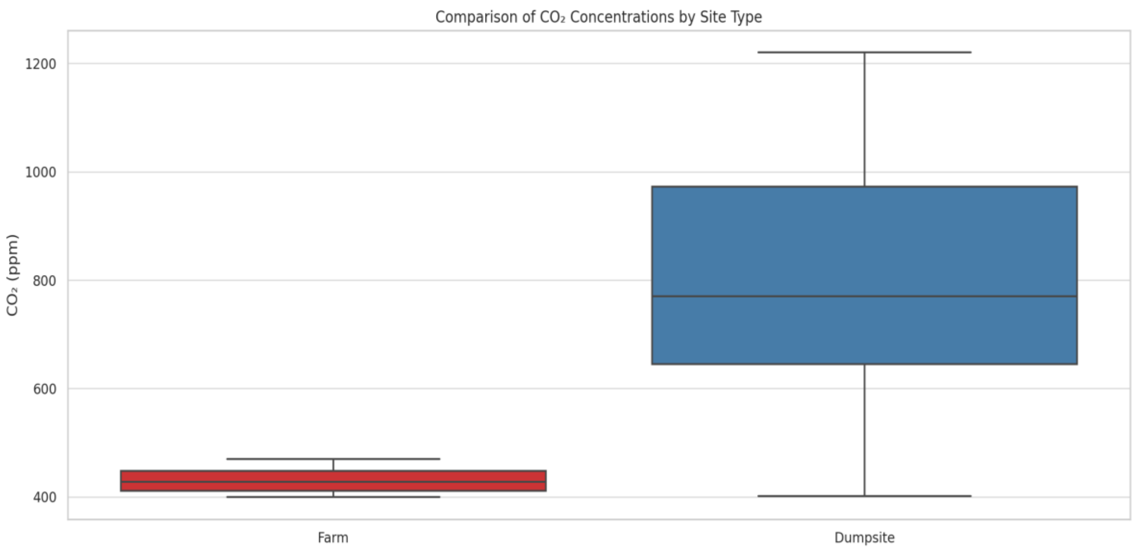

Figure 6: Difference in CO_2 levels between farm sites and dumpsites

Temperature and humidity also play roles in emission variations; for instance, higher temperatures can accelerate microbial decomposition, thereby increasing methane emissions. Sites like Inside Wazo Market showed high CO_2 levels (770 ppm), likely due to increased microbial respiration in decomposing organic materials. These dumpsites also recorded higher volatile organic compounds (TVOCs) and formaldehyde (HCHO), indicating potential chemical breakdown of synthetic materials.

Inference and Trends

A. GHG Concentration Patterns

Urban waste dumpsites show higher emissions of both methane and carbon dioxide than animal farms. High TVOC and formaldehyde levels correspond to areas with intense organic decomposition or fossil fuel proximity (e.g., petrol stations). Temperature does not directly correlate with methane concentration. E.g., G71 Petrol Station with 33°C recorded 5,393 ppm methane, while “Behind Highrise I” with 87°C had 0 ppm methane. Zhang et al. (2019) reported a temperature threshold (~40°C) beyond which CH_4 emissions decline due to microbial activity inhibition. The dataset supports this, showing a non-linear CH_4 trend at higher temperatures (>42°C). Studies by Bogner et al. (2007) suggested that landfill methane emissions increase with rising ambient temperatures, aligning with the present findings.

B. Environmental and Public Health Implications

Locations like AA Rano, College, ALICE, and Stadium show higher values of GHG and VOCs, potential climate and respiratory risks. Farm emissions, though higher in some units (e.g., Sheep and Goat Unit and Piggery), are far lower than dumpsites, implying less urgent mitigation needs.

Comparison with Related Works

Methane from Waste

According to Bogner et al. (2007), landfill sites are among the largest anthropogenic methane sources globally due to anaerobic decomposition of organic waste. This aligns with the extremely high methane levels seen at sites like the layer birds at Abogunde Farm and College. Also, according to Bogner et al. (2007), methane emissions from landfills contribute 11% of global anthropogenic CH_4. The high organic waste fraction (food waste: 821.2 g mean) suggests potential for methane recovery. Studies like Themelis and Ulloa (2007) indicated that landfill methane emissions range from 400–1200 ppm, aligning with dataset (360–1197 ppm). The correlation between CH_4 and CO_2 emissions is also consistent with results from Themelis and Ulloa (2007), who highlighted that landfill gas compositions are influenced by both microbial activity and environmental conditions. High methane levels suggest anaerobic decomposition, which could be mitigated by landfill gas recovery systems (Bogner et al., 2007).

CO_2 in Urban Environments

Chen et al. (2015) highlighted those urban centers, particularly in proximity to traffic and industrial zones, experience elevated CO_2 and VOCs, consistent with AA Rano, College, and G71 Petrol Station. Lombardi et al. (2015) found CO_2 emissions from uncontrolled dumpsites ranging from 500–1400 ppm, consistent with our findings (400–1356 ppm). Efficient waste-to-energy (WTE) conversion (e.g., incineration) can reduce direct emissions by up to 70%. (Lombardi et al., 2015) showed incineration can achieve 65-80% efficiency in energy recovery. With plastics, nylons, and paper forming a major proportion, combustion-based energy derivation is feasible.

Air Quality & Health

World Health Organization (2018) noted that formaldehyde and VOCs at elevated levels are linked to increased asthma, cancer risk, and developmental issues, reinforcing the concern at high-HCHO sites like Beside Laboratory and College.

Methane and CO_2 Concentration Comparison

The boxplot (Figure 5) illustrates the difference in methane levels between farm sites and dumpsites. Dumpsites show dramatically higher concentrations, with extreme values observed in locations such as AA Rano and College. Similar trends are seen in CO_2 emissions, where dumpsites consistently record higher concentrations (Figure 6). The environmental and public health implications of these elevated values are considerable, especially in urbanised or industrial zones.

CONCLUSIONS

Campus waste in LAUTECH Ogbomoso is not well managed. There is no integrated waste management method of collection, transportation, recycling and waste-to-energy processes. The disposal of waste by open dumps is not effective as it pollutes the environment and does not explore the full recycling potential of the campus's solid waste. The huge quantities of solid waste generated are all alternative sources of clean energy and electricity generation; the recyclable material and energy recovery potentials of solid waste for LAUTECH Ogbomoso are very high. Dumpsites present higher GHG emissions than farm areas. Methane levels are dangerously high in urban waste sites, indicating an urgent need for landfill gas recovery systems. Formaldehyde and TVOC levels point to air quality hazards in select zones.

RECOMMENDATIONS

The following measures are recommended for the integrated approach towards waste management in LAUTECH campus, Ogbomoso:

In order to improve the solid waste management situation in LAUTECH campus, Ogbomoso, there should be proper strategies in the future for reduction, recycling, long-term waste management policies, involvement of the private sector and a proper formal waste management system in which all the stakeholders are involved.

i. Public campaigns and awareness among the university community about waste management should be created.
ii. Government should provide subsides on waste to energy plants in order to invite foreign investors.
iii. Specific waste to energy technologies should be compared and the one that suits Lautech campus, Ogbomoso should be applied.
iv. There should be proper monitoring so that there is accurate data and record keeping, collection, storage, transport of waste and there is no leaching from the landfills and the emissions from waste to energy projects are safe.
v. Implement methane flaring or biogas recovery in major dumpsites.
vi. Install VOC and HCHO filtration or remediation near petrol stations and labs.
vii. Use these findings to guide GHG mitigation policies, urban planning, and public health interventions.

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