***Original Research Article***

# Critical Appraisal of Institutional Solid Waste Management: Case Study of Lead City University, Ibadan. Oyo State. Nigeria



**Abstract**

Implementing adaptive sanitary landfill for effective solid waste management system in any institutions leads to resource conservation and material recovery that promotes social inclusiveness and urban sustainability and also reducing the risk to public health and the environment. The economic implication of implementing a balanced structured municipal solid waste management is enormous; not only in terms of financial burdens on the government but also the revenue it generates for local economy and its macroeconomic effects. Lead City University, Ibadan experienced unprecedented student expansion, therefore had left the university scrambling to find workable solutions to its waste management issues since SDGs' main objectives of environmental sustainability and sustainable development depend on effective waste management. Therefore, the management of solid waste beneath the university system was the focus of this experimental study and adaptive sanitary landfill was designed on the principle of waste control which was characterized by the presence of a liner and a leachate collection system to prevent groundwater contamination and a capping system to prevent air contamination.

An experimental method after sorting, quantification and characterization of waste using Gas Monitoring Meter was used to measured four (4) major LFGs, that is, Methane ($CH_4$, measured in %), Carbon dioxide ($CO_2$, measured in %), Ammonia gas ($NH_3$, measured in PPM) and Hydrogen sulphide ($H_2S$, measured in PPM) before and after the construction of adaptive sanitary landfill.

The amount of Liquefied Gases (LFG) concentrations measured in the morning and afternoon, effect of addition of activated charcoal made the amount of liquefied gases (LFG) increased and finally, the amount of liquefied gases (LFG) generated after the addition of animal manures was higher compared to when not added.

The research work seeks to fortify the fundamental framework for inclusive waste management through construction of adaptive sanitary landfill in Lead City University, Ibadan as a planning mechanism for building a cohesive, economically stable, environmentally friendly and socially inclusive university environment through sustainable waste management.

**Keywords:** Effective institutional solid waste management, Open Dump Site, Adaptive Sanitary Landfill, Lead City University, Ibadan

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## 1. INTRODUCTION

Waste is a natural by-product of societal trends as life and population increase. After its first use, it happens to be unwelcome or unimportant material that can be gotten rid of or thrown away. Animals excrete, plants shed their leaves. Every day, people produce an infinite amount of waste that comes in many varieties. Any country's development requires industrialization. It results in increased production, consumption, and demand for a range of items that improve living conditions and habitat. This increases trash output in a variety of ways, many of which have a major negative impact on the environment. People with disabilities are more vulnerable to danger from improper trash treatment. Waste is frequently seen as a threat when suitable disposal and management systems are lacking. It not only degrades the beauty of living places but also contributes to pollution and poses a serious threat to the health and existence of all living things. Any country's ability to develop and maintain its citizens' health depends in large part on how effectively trash is managed. Nowadays, efficient waste management is a national concern.

therefore, government, non-governmental stakeholders as well non-governmental organization need to make every citizen aware, especially the young, and a collaborator in fostering a clean society nation[1].

As provided in Agenda 21, basic sanitation would be inaccessible to 2 billion people, and globally, half of the people would be without proper municipal solid waste management (MSWM) services[2]. Financial inefficiency in providing urban services, including solid waste management, has stressed the in-hand resources and deterioration in service quality[3]. Waste received at waste dumps, landfills and incinerators characterize the potential for recycling. Inorganic waste items are recycled because of growing demand but require a mechanism for their sale at competitive prices. Institutional-level recycling arrangements could take considerable quantities of waste out of the disposal system. The mixed waste storage challenge of material recovery and waste recycling directly impacts the quality and quantity of the product and the success of material recovery. This research paper will deliberate on existing practices of waste recycling, the potential of material recovery, and suggest measures for maximizing resource generation and waste reduction using waste recycling options. Present waste disposal options like open dumping and landfill sites have become a persistent apprehension to solve. Management of mounting quantities of MW spawned by the changing lifestyle is bestowing a challenge. The issue is how to deal with the waste quantities without changing the lifestyle. Spawned by public pressure, limited land dump development options, and changed local authorities' attitudes, it requires new initiatives. Preventing pollution is a key goal of EU waste management plans. waste generation and moderate its malice. The option of safe and secure waste disposal should be exercised when alternates like waste reuse, recycling, and waste recovery cannot be used. Researchers have viewed that the waste management approach needs to reduce waste quantities received at landfills and maximum material recovery to the possible extent[4,5]. It has been observed that "waste reduction is the most efficient method for minimizing the generation of waste and defecating many of the waste disposal problems[6]."

In both emerging and advanced cultures, the process of gathering, managing, and treating solid waste before disposal has become essential. But through time, the majority of garbage has grown to be seen as being of inferior value and capable of being recovered and repurposed for valuable things. But the price of building a sanitary landfill facility (SLF) have been a major barrier for its implementation, and these technologies also require considerable technical expertise, which is not often available in developing nations for the successful operation of the SLFs[7].

As results of increasing in the population of students, lecturers and others workers in the Lead City University Ibadan, due to the environmental risks and issues it generates for public health, waste management systems present a significant challenge to university management. The financial difficulties it throws on public and private universities are more significant. As a result, the volume of waste produced and the difficulty of waste management both increase as towns and cities around the world develop and their populations rise. Perhaps the United Nations' (UN) Millennium Declaration (September 2000) attention to this issue best captures the seriousness of the issue. The declaration's eight Millennium Development Goals (MDGs) include three that having to do with waste management or resource efficiency[6]

- Reverse the loss of environmental resources and ensure environmental sustainability by incorporating sustainable development ideas into national policies and programs.
- By decreasing the percentage of people whose income is less than $1 per day between 1990 and 2015, eradicate extreme poverty and hunger.
- Create a global partnership for development by addressing the unique requirements of landlocked nations, small island developing states, and least developed nations.

In response to the problem of waste in Lead City University Ibadan, recycling station (PET Bottle which stands for polyethylene terephthalate) was launched on campus. This serves as a symbol of the dedication to environmental sustainability in 2021. Reduce, reuse, and recycle are the three R's of waste management and environmental sustainability. In the university, there is a model of a PET bottle that serves as a recycle bin.

In many ways Lead City University, Ibadan is currently facing waste management problems because of its population that is over a million. Hospital wastes in Lead City University comprise 20% of the waste is hazardous or risky, and 80% of it is household waste components, often known as non-risk waste. Components that may be contaminated with diseases, chemicals, or radioactive substances make about 20% of the hospital waste stream, often known as risk waste (also known as infectious, medical, or clinical wastes). As a result, it should be handled and disposed of in a way that minimizes cross-contamination and potential human exposure. Hospital risk waste at Lead City University is broken down into the following seven broad categories: radioactive waste, sharps, infections, anatomical/pathological, chemical, pharmaceutical, and pressured containers. These garbage types are produced by university hospital. Therefore, this research is a case study of waste management in Lead City University using adaptive sanitary landfill of waste management.

Wastes are an expanding concern that have recently attracted more political attention. The management of Lead City University in Ibadan is presently concentrating on strategies to address the problems presented by municipal solid waste management because garbage generation at the university is rapidly rising. Due to the continuous influx of students to private colleges, there has been a need for rapid growth or high rates of student population, which has resulted in massive waste generation. Due to this waste management difficulty at Lead City University, it is crucial to evaluate the most affordable, environmentally friendly trash management choices for Lead City University.

For healthy ecosystems and human health, waste generation, disposal, collection, transport, and processing are crucial. There is a lot of material on the detrimental consequences of waste management on health. Cancer and congenital abnormalities are the two main health outcomes that have been demonstrated to be statistically related with trash exposure. Due to the presence of solid waste dumping sites near hostels on the campus's periphery, flies, mosquitoes, and rodents which act as disease-carrying vectors and compromise the population's health because their organic defenses are still developing and become a source of contamination for the students. The university management has not yet calculated the Lead City disposal site, which is not exceptional. However, because of growing populations, a booming economy, and higher living standards in the academic community, the rate of solid waste produced in the university and its surrounds has dramatically increased. If we don't act quickly to improve sanitation and solid waste management through development of adaptive sanitary landfill waste management system in Lead City University, Ibadan, the growing student population levels and rapid urbanization of the university community may further exacerbate the major urban environmental concerns of municipal waste management, sanitation, and associated detrimental health impacts.

**1.1 Main Objective**

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The research was aimed at developing a sustainable and effective waste management system for Lead City University, Ibadan.

**1.2 Specific Objectives**

The specific objectives are to;

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1. assessment of waste characterization and quantification at Lead City University, Ibadan
2. evaluation of biogas generation and microbial characterization from adaptive engineer sanitary landfill in Lead City University, Ibadan and
3. assess the influences of activated charcoal and animal manures on the generation of methane ($CH_4$)

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4. make recommendations for effective solid waste management in Lead City University, Ibadan.

## 2. MATERIALS AND METHODS

### 2.1 The Study area

Lead City University (LCU) is situated in the Nigerian city of Ibadan, which has a population between 1 million and 5 million. The location of the university is 7.3268° N and 3.8766° E.

Lead City University is a non-profit private higher education institution located in the urban setting of the metropolis of Ibadan (population range 1,000,000-5,000,000 inhabitants), Oyo State, Nigeria. It was founded on 16 February 2005. Officially accredited by the National University Commission. Lead city university is a small (unirank enrollment range: 3,000-3,999 students) co-educational Nigeria higher institution. Graduated more than 5,000 graduates. LCU also provides several academic and non-academic facilities and services to students including a library, housing, sports facilities, financial aids and as well as administrative services.

### 2.2 Target population

The study participants were both staff and students in Lead City University, Ibadan. The overall populations of the respondents were four hundred and eighty (480). The analysis took into account all of the recognized sources of garbage generation as well as the anticipated amount of waste generated each week at Lead City University, specifically;

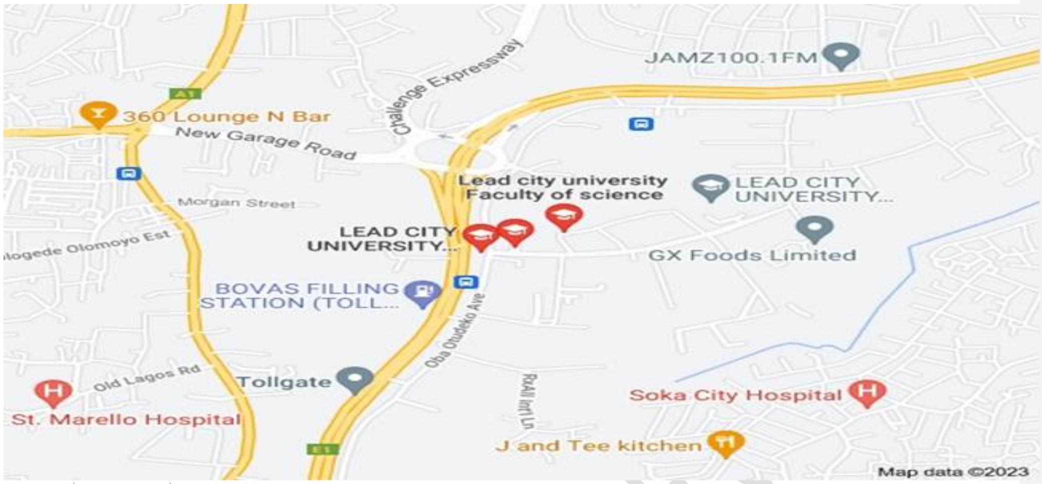


**Fig 1: Location of Lead City University, Ibadan**

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**Source: Google map**

**2.3 Waste Characterization and Quantification**

At each location in the university, investigations and sorting were done at least once every week throughout the duration of the project. A weighing balance was used to measure and record the weight of each composition that had been sorted. The individual weights were added at the conclusion of each sorting to determine the average daily total weight of municipal solid waste (MSW) at that location. The measured weight was divided by the number of days the waste remained at a place before sorting and quantification in those instances when it lingered longer than a day. Differences between biodegradable and non-biodegradable wastes were estimated, along with the percentage makeup of each component.

Additionally, waste samples were sorted into different material kinds, such as newspaper and aluminum cans, and weighed separately in order to get data on waste characterization. Typically, samples were acquired from trucks transporting trash from residential, commercial, and self-haul sources to landfills and transfer facilities. In Lead City University, Ibadan, the characterization of municipal solid waste is crucial for building adaptive sanitary landfill and waste-to-energy systems. Wastes were gathered from waste-delivery trucks for the purpose of this project's activity and transferred to a station where waste characterization was taking place.

**Table 1:Sources of waste generation on campus**

| S/N | Sources of Waste | Amount generated per week (g/kg/tons) |
|---|---|---|
| 1 | University male and female hostels | 4 tons |
| 2 | University Guest house, halls and event centers | 980kg |
| 3 | University eateries | 6 tons |
| 4 | University shop operators/business centers | 890g |
| 5 | University microfinance bank | 230g |
| 6 | University hospital | 650kg |
| 7 | University faculties' buildings and classrooms | 450kg |
| 8 | University offices | 670g |
| 9 | University's building under construction | 880kg |
| 10 | University staff quarters | 2tons |
| 11 | University sporting unit and allied | 560g |
| | Total | 15.85146tons |

**Source: Research work 2023**

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All wastes were collected at the site of generation, labeled, and transported to a sorting facility for segregation and weighing. Each source generated records that gave an accurate estimate of the amount of solid waste that was produced, and a list of the different waste types produced across the entire university was also made.

**2.4 Identifying the Composition of the Waste**

The following steps are involved in determining the waste composition:

Step 1: List the sectors that need to be examined.

Making a list of the interested sectors is crucial if a waste composition analysis is to be carried out across many university departments. However, this stage can be avoided if the waste composition analysis is being conducted within a single home, place of business, or institution.

Step 2: Enlisting and educating participants

To obtain the information necessary, participants in a waste composition analysis may be located inside or outside of the institution. The participants should receive a thorough briefing on how the analysis will be performed and by whom. Due to confidentiality concerns, it may occasionally be challenging to recruit participants in the institution; therefore, an incentive may be helpful to encourage participation.

Step 3: Take waste samples and locate a site for sorting.

Step 4: Prepare the waste for measurement

To be sure that the analysis was performed on a representative sample, it is crucial to collect waste samples from the waste-generating units on their normal garbage collection days. Since most waste-generating machines lack the space to sort through huge amounts of waste, it may be possible to take a sample of the waste to a different location.

The following actions should be taken to prepare the waste samples for measurement:

- Place the waste from each waste-generating unit in a separate area (such as a table or a marked-off area of the floor) where it won't mix with other samples.
- Remove any food from the packaging, then group the packaging into a different pile.

- Classify the garbage according to the study's parameters.
- Sorting the non-decomposable trash into several categories, such as paper, plastic, metals, etc., might be interesting to the study.

Step 5: Weigh and note the information

Separately weigh each type of garbage. Based on the dietary categories chosen for the study, enter the weight data in a prepared spreadsheet.

Step 6: Get rid of the used-up samples.

The samples can be discarded after they have been sorted, weighed, and recorded. It can be required to hire a waste management business for a customized garbage retrieval if the study has a big scope.

Step 7: The data analysis

By multiplying the data by the number of days the unit operates annually, the waste composition analysis results that were collected for a single day from the waste-generating unit can be extrapolated to a whole year.

**2.5 Calculation of Waste Quantity**

Four ways can be used to measure the calculation: the proportion of material purchased, the percentage of material required by the design, the kg/m2 of gross floor area, and the m3/m2 of gross floor. The waste generation rates are discovered to range from 3.275 to 8.791 kg/m2, and the survey approach would be done by the composition of volume and mass.

**2.6 Landfill Gases (LFG) Measurement**

For the purposes of this study, four (4) major LFGs—methane ($CH_4$, measured in%), carbon dioxide ($CO_2$, measured in%), ammonia gas ($NH_3$, measured in PPM), and hydrogen sulfide ($H_2S$, measured in PPM—would be measured with a gas monitoring meter on a weekly basis, in the morning at around 9am and in the afternoon at around 5pm at four different sites before the construction of an adaptive sanitary landfill (i.e., The same four (4) major LFGs would also be measured after the building of the adaptive sanitary landfill and compared to the earlier measurement.

**2.7 Building a Sanitary Landfill**

Construction of adaptive sanitary landfill was categorized into six stages;

First stage: 15 feet in length, 6 feet in width and 3 feet in height of the topsoil was removed (at first, this created a significant depression or pit).

Second stage: From the standard 50 kg nylon rice bags, a non-perforated nylon sack was created. To act as an intended decomposable waste container that can stop waste materials from leaking, twelve (12) pieces of rice nylon bags were sewn together to form a large sack measuring 12 feet in length, 6 feet in width, and 2 feet in height.

In the third stage, biodegradable waste was deposited and thoroughly crushed using manual compressors (biodegradable wastes were dumped into the sack).

Fourth stage: Insertion of waste water pipes (Pipes were inserted to drain off waste water that is released after compression and into a separate, specially built deep pit for evacuation.

The fifth state is methane gas collection, which involves collecting the methane gas created by the anaerobic decomposition of waste into a separate pipe and directing it through an activated charcoal chamber to filter out contaminants including carbon dioxide ($CO_2$) and hydrogen sulfide ($H_2S$) before measuring the methane ($CH_4$). The methane can now be used to produce heat and energy, preventing explosions. In order to keep daily waste from being exposed to the air (which constricted the air), pests, and odors, layers of clay and top soil (2 inches thick) were placed on top of it.

Stage 6: To redirect and manage water runoff from rain and storms, specialized storm water pipes of 2mm are installed.

**3.0 Results and Discussion**

**3.1 Distribution of waste characterization in LCU,**

**Table 2: Distribution of waste characterization in LCU, Ibadan by %**

| Category | Dump Site | Office complex | Lecture Halls | Hostels |
|---|---|---|---|---|
| Biodegradable | 31.14 | 09.18 | 04.16 | 41.16 |
| Paper and cardboard | 42.12 | 74.26 | 83.10 | 24.14 |
| Plastics | 12.44 | 13.22 | 09.44 | 22.44 |
| Metals | 08.18 | 02.16 | 02.18 | 07.13 |
| Glass | 06.12 | 01.18 | 01.12 | 05.13 |
| **Total** | **100** | **100** | **100** | **100** |

Source: Researcher's field work (2023).

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Dump site and hostel have highest number of biodegradable wastes of 31.14% and 41.16% respectively, followed by paper and cardboard waste of 42.12 1nd 24.14. However, metals and glass waste have least number in all category sampled.

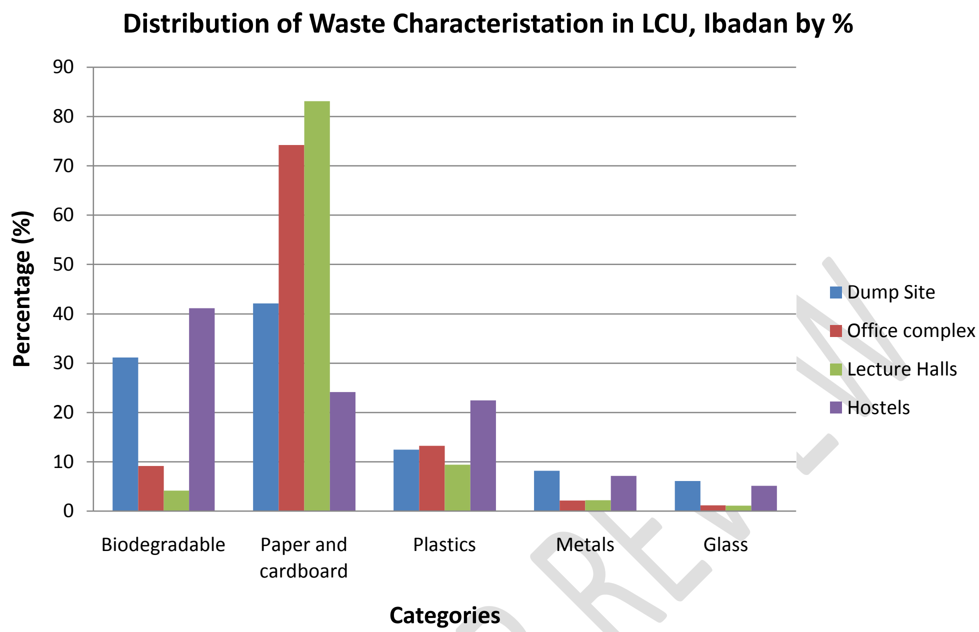


**Fig 2: Distribution of waste characterization in Location of Lead City University, Ibadan**

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**3.2Approximate Study of the Organic MSW produced at LCU**

**Table 3: An approximate study of the organic MSW produced at LCU, Ibadan**

| **Refuse component** | **Close Analysis (% by weight)** | | | | |
|---|---|---|---|---|---|
| | **Moisture Content** | **Volatile Matter** | **Fixed carbon** | **Ash** | **Total** |
| Food waste (mixed) | 65.2 | 26 | 4.0 | 4.8 | 100 |
| Wood/ Leaves | 19.2 | 65 | 15 | 0.8 | 100 |
| Paper | 6.9 | 78 | 9.1 | 6.0 | 100 |

| | | | | | |
|---|---|---|---|---|---|
| Plastics | 0.3 | 95 | 2.4 | 2.3 | 100 |
| Textiles/rubber/leather | 7.8 | 69 | 16.2 | 7.0 | 100 |

**Fieldwork conducted by researchers in 2023.**

Moisture content has the highest percentage of 65.2% in food waste (mixed) and fixed carbon have the least percentage of 4.0%, volatile matter has the highest percentage of 65% in wood/leaves and ash have the least percentage of 0.8% volatile matter have the highest percentage of 95% in plastic and moisture content have the least percentage of 0.3% while volatile matter has the highest percentage of 69% in textiles/rubber/leather and ash have the least percentage of 7.0%.

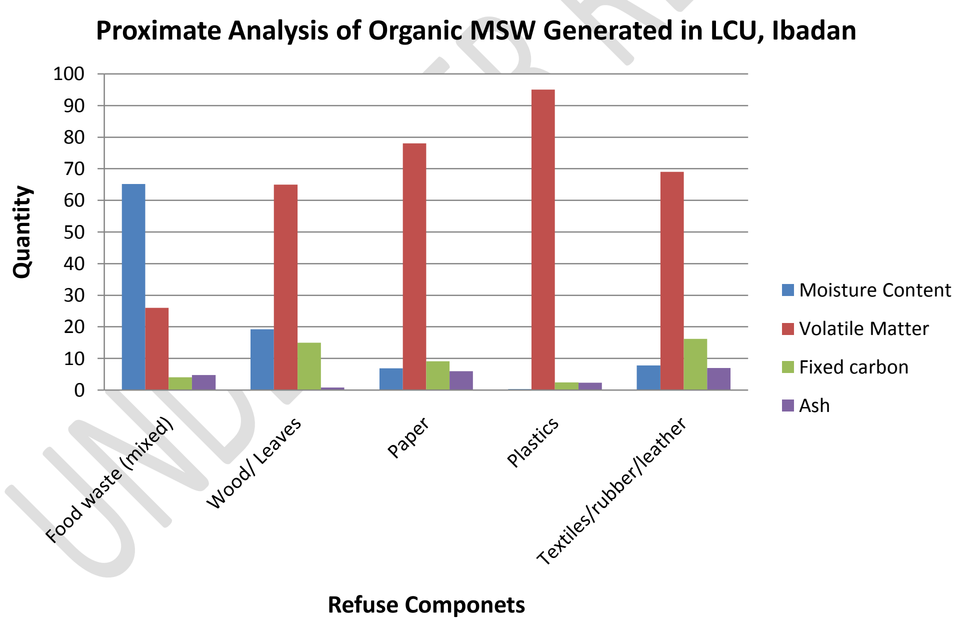


**Fig 3: Proximate Analysis of Organic Solid Waste Generated at Lead City University**

### 3.3 Overall Composition of Waste at LCU

**Table 4: Overall Composition of waste at LCU**

| **Fractions** | **Average (%)** |
|---|---|
| Wood | 0.72 |
| Rubber | 0.69 |
| Paper | 9.96 |
| Gravel | 0.81 |
| Metal | 1.36 |
| Plastic | 8.24 |
| Textiles(leader & cloth) | 4.16 |
| Glass and ceramics | 1.23 |
| Organic matter | 72.74 |
| Hospital waste | 0.08 |
| **Total** | **100** |

**Fieldwork conducted by researchers in 2023.**

There are three main forms of solid waste at Lead City University in Ibadan:

Domestic garbage is the solid waste produced by households, grocery stores, marketplaces, and business establishments like hotels, shops, and restaurants. This is responsible for the LCU's larger percentage of organic matter (72.74%).

Institutional waste includes the solid garbage produced by hospitals, classrooms, recreation centers, public development initiatives, and other office buildings. This is responsible for other waste fractions with the lowest percentage.

Industrial waste is anything that isn't toxic or hazardous and needs specific care, treatment, or disposal. Ibadan's Lead City University does not apply this.

According to a few variables, waste content varies at Lead City University in Ibadan:

- Season: Waste has a higher organic composition during the rainy season since there is a higher volume of food, fruit, and vegetable waste.
- Richness - Similar to the majority of developing countries, rural areas with poorer populations produce solid waste with a larger percentage of organic matter, between 70 and 80 percent. Contrary to urban regions with wealthy residents, the garbage has a lower percentage of non-biodegradable elements including plastic, metal, and glass, with an average organic content of 72.74%.
- Location: Hostels produce more organic garbage than commercial spaces.
- Cultural Activities: It is noteworthy that not only has the composition of waste changed, but the amount of waste generated also varies in Lead City University, Ibadan, with Women's Day, Christmas, and New Year celebrations and other celebrations resulting in more organic waste generation due to the amount of flowers, trees, etc. bought for the occasion.

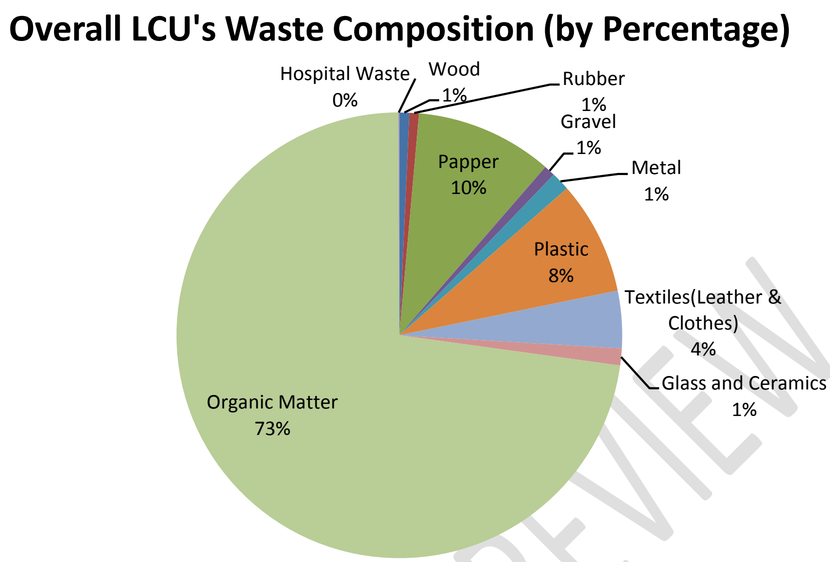


**Fig 4: Overall Lead City University waste composition**

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**3.4 Estimated Quantity of deposited waste at the LCU dump sites.**

**Table 5: Estimated Quantity of deposited waste at the LCU dump sites.**

| **Months** | **Years** | |
|---|---|---|
| | **2021** | **2022** |
| January | 1400 | 1578 |
| February | 1330 | 1460 |
| March | 1289 | 1367 |
| April | 1256 | 1298 |
| May | 1178 | 1246 |
| June | 1098 | 1167 |
| July | 2389 | 2478 |

| | | |
|---|---|---|
| August | 2505 | 2617 |
| September | 2878 | 2988 |
| October | 3234 | 3389 |
| November | 3689 | 3856 |
| December | 1407 | 1566 |
| **Total (Tons)** | **23,653** | **25,010** |
| **Yearly Average** | **1.97** | **2.08** |

Source: Researcher's field work (2023).

From the table 5 above, it was revealed that as the population of the Lead City University, Ibadan increases yearly so also the waste generated also increased. Also wastes generated during the rainy season is greater than that of dry session because there is a high amount of food, fruit and vegetable waste in rainy session compared to that of dry session.

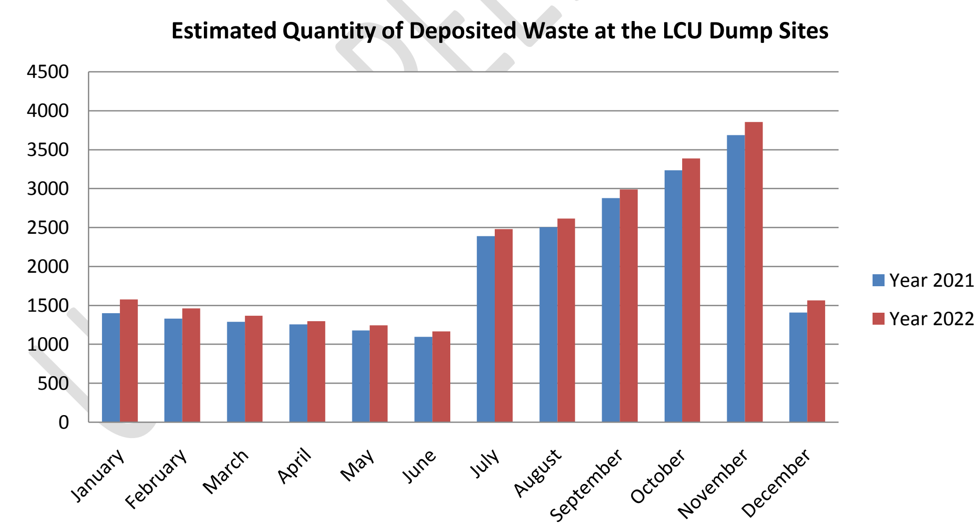


**Fig 5: Estimated Quantity of Deposited Waste at the Lead City University Dump Site**

### 3.5 Waste quantification.

Self-reported waste generation rates at the campus ranged from 0.14 to 1.4 kilograms per day for students and an average of 1.7 kilograms per day for vendors, which is comparable to estimates for waste generation rates in sub-Saharan Africa[2]. In contrast, National Polytechnics have the lowest per capita trash creation at 0.28 kg/week/student, while Institutes of Technology generate the most garbage per capita at 0.71 kg/week/student[3]. These rates are lower; according to data on global solid waste generation by region, the Sub-Saharan Africa region produces between 0.5 and 0.65 kg per person per day. In sub-Saharan Africa, trash generation rates per person are generally modest, averaging 0.65 kg per person per day, although they can vary greatly depending on economic position, from 0.09 to 3.0 kg per person per day. The rate of 0.5 kg/capita/day was chosen in order to further calculate the campus's waste generation rates because there was a lack of reliable data on waste collection and to minimize any conflicts with earlier research. For instance, the overall enrollment at Lead City University in Ibadan has increased, as reported by the university administration, from 23,653 students during the academic year 2020–2021 to 25,010 students during the following year (see table 5). In the event that this pattern persists, Lead City University in Ibadan will generate a similarly greater amount of waste.

**Fig 6: Loading and weighing of waste**

**Fig 7: Open dump site practice @ LCU and Cleaning of sanitary landfill prototype**

**Fig 8: Researcher weighing the decomposable waste after sorting before loading and using herbicide to control weeds at the Adaptive sanitary landfill**

**Fig 9: Researcher testing the flame coming out of the methane chamber with lighter**

**Table 6: Quantification of Waste**

**LEAD CITY UNIVERSITY WASTE QUANTIFICATION**

| Year | Population | Formulation (GRXMX0.001X365) | Amount (Ton/Year) |
|---|---|---|---|
| 2020/2021 | 23,653 | 0.625 x 23,653 x 0.001 x 365 | 5,395.840625 |
| 2021/2022 | 25,010 | 0.625 x 25,010 x 0.001 x 365 | 5,705.406250 |
| | **Average** | | **5,550.623438** |
| **FORECAST STUDENT POPULATION (3% GROWTH RATE)** | | | |
| 2022/2023 | 25,760.30 | 0.625 x 25,760.30 x 0.001 x 365 | 5,876.568438 |
| 2023/2024 | 26,533.11 | 0.625 x 26,533.11 x 0.001 x 365 | 6,052.865719 |
| | **Average** | | **5,964.717079** |

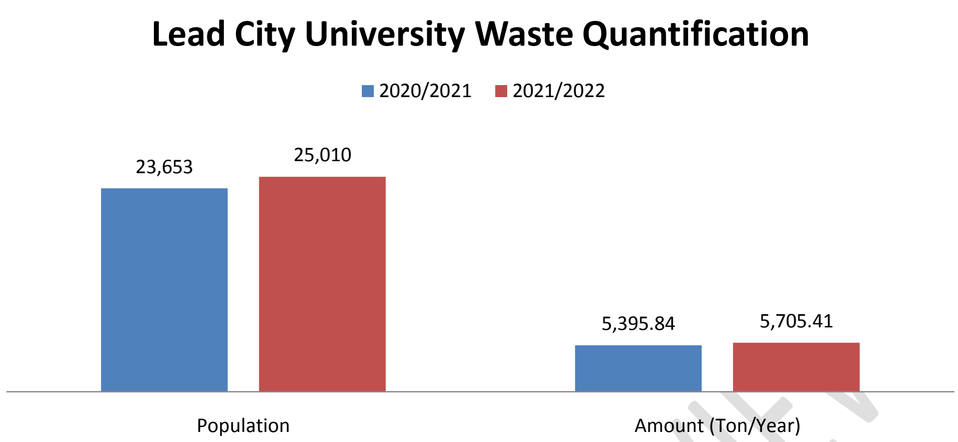


**Fig 10: Waste Quantification at Lead City University**

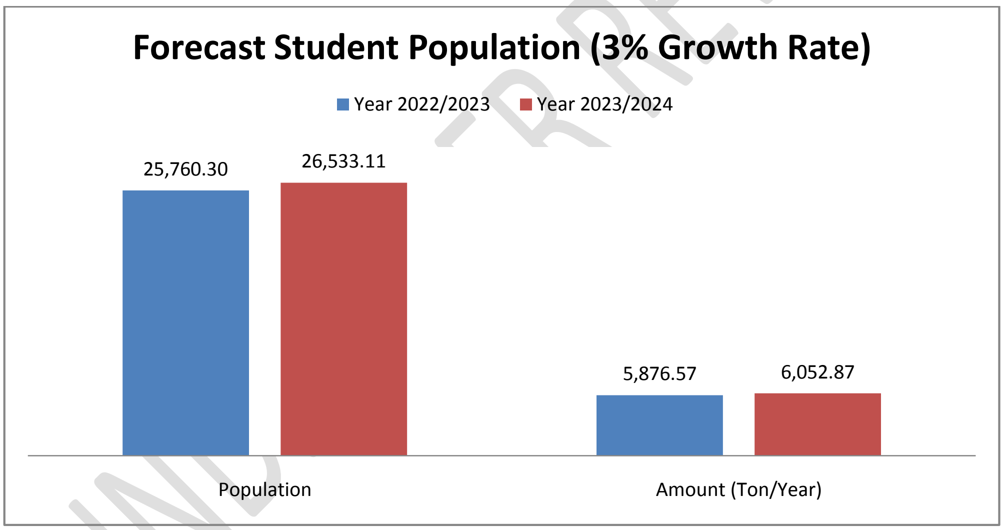


**Fig 11: Student Population (3% Growth Rate) Forecast at Lead City University, Ibadan**

### 3.6 Liquefied Gases (LFG) concentrations

For the purpose of this research work, four (4) major LFGs, that is, Methane (CH4, measured in %), Carbon dioxide ($CO_2$, measured in %), Ammonia gas ($NH_3$, measured in PPM) and Hydrogen sulphide ($H_2S$, measured in PPM) was measured with Gas Monitoring Meter before the construction of adaptive sanitary landfill.

**Table 7:Liquefied Gases (LFG) concentrations measured before construction of LCU Landfills**

| Sampling Date | Morning $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) | $H_2S$ (PPM) | Afternoon $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) | $H_2S$ (PPM) |
|---|---|---|---|---|---|---|---|---|
| 6/03/2023 | 08.34 | 18.24 | 608 | 1020 | 08.54 | 18.56 | 890 | 1030 |
| 7/03/2023 | 08.56 | 18.35 | 656 | 1032 | 08.78 | 18.68 | 898 | 1038 |
| 8/03/2023 | 08.65 | 18.50 | 678 | 1034 | 08.82 | 18.78 | 902 | 1040 |
| 9/03/2023 | 08.72 | 18.68 | 688 | 1036 | 09.94 | 18.82 | 922 | 1054 |
| 10/03/2023 | 08.88 | 18.78 | 692 | 1042 | 09.98 | 18.98 | 942 | 1066 |
| 13/03/2023 | 09.08 | 18.86 | 698 | 1054 | 10.54 | 19.10 | 954 | 1072 |
| 14/03/2023 | 10.22 | 18.98 | 702 | 1064 | 10.83 | 19.22 | 968 | 1076 |
| 15/03/2023 | 10.34 | 19.12 | 718 | 1068 | 10.98 | 19.30 | 988 | 1088 |
| 16/03/2023 | 10.56 | 19.22 | 722 | 1072 | 11.10 | 19.42 | 1002 | 1092 |
| 17/03/2023 | 10.68 | 19.34 | 734 | 1088 | 11.22 | 19.54 | 1020 | 1096 |



Table 7 revealed that Liquefied Gases (LFG) concentrations measured in the afternoon was lower compared to the one measured in the afternoon before construction of LCU Landfills and this was due to increase in temperature in the afternoon and decrease in relative humidity in the afternoon.

**Table 8:Liquefied Gases (LFG) concentrations measured after construction of LCU Landfills**

| Sampling Date | Morning $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) | Afternoon $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) |
|---|---|---|---|---|---|---|

| | $H_2S$ (PPM) | | | | $H_2S$ (PPM) | | | |
|---|---|---|---|---|---|---|---|---|
| 3/07/2023 | 21.72 | 41.23 | 1202 | 3450 | 23.45 | 40.67 | 2390 | 3470 |
| 4/07/2023 | 23.24 | 44.56 | 1428 | 3560 | 24.30 | 42.34 | 2786 | 3678 |
| 5/07/2023 | 24.65 | 46.50 | 1546 | 3670 | 26.40 | 44.35 | 2986 | 3690 |
| 6/07/2023 | 26.23 | 48.89 | 1654 | 3750 | 28.30 | 46.78 | 3245 | 3760 |
| 7/07/2023 | 28.56 | 49.20 | 1858 | 3789 | 32.30 | 48.24 | 3456 | 3792 |
| 10/07/2023 | 30.09 | 50.56 | 1956 | 3840 | 33.20 | 49.80 | 3578 | 3865 |
| 11/07/2023 | 32.90 | 51.20 | 2021 | 3868 | 34.55 | 50.67 | 3978 | 3872 |
| 12/07/2023 | 34.39 | 52.50 | 2467 | 3920 | 36.30 | 51.34 | 4200 | 3950 |
| 13/07/2023 | 39.30 | 53.45 | 2645 | 3960 | 41.40 | 52.45 | 4278 | 3980 |
| 14/07/2023 | 40.20 | 54.70 | 2982 | 4002 | 42.50 | 53.67 | 4560 | 4022 |

Table 8 revealed that Liquefied Gases (LFG) concentrations measured in the afternoon was lower compared to the one measured in the afternoon after construction of LCU Landfills and this was due to increase in temperature in the afternoon and decrease in relative humidity in the afternoon. It was also deducted that Liquefied Gases (LFG) concentrations measured after the construction of LCU Landfill was higher in both morning and afternoon compared to before construction of LCU Landfill and this was due to assembled of Liquefied Gases (LFG) at the adaptive sanitary landfill.

**3.7 Utilizing activated charcoal to remove pollutants, such as carbon dioxide ($CO_2$) and hydrogen sulfide ($H_2S$),**

In order to eliminate pollutants like carbon dioxide ($CO_2$) and hydrogen sulfide ($H_2S$) before measuring the methane ($CH_4$), an activated charcoal chamber was added to the adaptive sanitary landfill. Now that the explosion risk has been reduced, methane can be burned to provide heat and energy.

**Table 9: Effects of activated charcoal on Liquefied Gases (LFG) concentrations**

| Sampling Date | Morning $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) | $H_2S$ (PPM) | Afternoon $CH_4$ (%) | $CO_2$ (%) | $NH_3$ (PPM) | $H_2S$ (PPM) |
|---|---|---|---|---|---|---|---|---|
| 3/07/2023 | 45.46 | 40.01 | 250 | 3120 | 46.56 | 40.04 | 340 | 3208 |
| 4/07/2023 | 45.56 | 40.22 | 268 | 3134 | 48.20 | 40.08 | 356 | 3212 |
| 5/07/2023 | 45.86 | 40.34 | 278 | 3138 | 48.24 | 40.12 | 365 | 3216 |
| 6/07/2023 | 45.14 | 40.65 | 287 | 3142 | 48.56 | 40.34 | 378 | 3219 |
| 7/07/2023 | 45.68 | 41.10 | 292 | 3148 | 48.86 | 40.56 | 386 | 3304 |
| 10/07/2023 | 45.86 | 41.15 | 298 | 3150 | 48.92 | 40.66 | 398 | 3308 |
| 11/07/2023 | 46.22 | 41.20 | 302 | 3158 | 49.24 | 40.68 | 402 | 3312 |
| 12/07/2023 | 46.64 | 41.50 | 314 | 3162 | 49.86 | 41.12 | 410 | 3318 |
| 13/07/2023 | 47.30 | 41.52 | 320 | 3168 | 50.40 | 41.24 | 422 | 3322 |
| 14/07/2023 | 48.20 | 41.60 | 332 | 3172 | 50.50 | 41.34 | 432 | 3328 |

Table 9 showed the effect of addition of activated charcoal which made the amount of liquefied gases (LFG) to increased compared to when no activated charcoal was added.

**3.8 Influence of Animal Manures added on Liquefied Gas production in LCU Landfill**

Animal manure and other composted organic materials, such as cow dung, boost nutrient content and bioavailability. This encourages microbial activity and the production of complex organic polymers and chemical metabolites, which act as ties and bonding agents to cement flocculated clay particles into aggregates.

**Fig 12: Animal manure added to the waste to hasten the digestion and decomposition**

**4.0: Summary of Findings**

Lead City University in Ibadan (LCU) conceptualized the organizational structures of the municipal waste management systems, and this conceptualization suggests a research framework for the advancement of sustainable waste management in higher education. According to the analysis of study findings at LCU, adequate university community engagement and a sense of participation are essential for effective and sustainable waste management. As a result of the liquefied gases (LFGs) produced at the sanitary landfill, increased university community involvement not only reduces the likelihood of conflicts that have hampered the economic and environmental effects of waste management, but also lowers capital expenditures for waste management and boosts internal university generated revenues. Waste streams at LCU have enormous resource potential. Not all of the waste generated by hostels, restaurants, guest houses, and institutions is disposed of in the same container. Findings make it clear that the majority of biodegradable waste produced at the university is produced by the hostels, restaurants, and guest houses, and that when this waste is disposed of in a sanitary landfill, it often results in the production of biogas.

In the course of designing and constructing an adaptive sanitary landfill for the university, a significant amount of liquefied gases was produced at the sanitary landfill at Lead City University in Ibadan and this was supported by a research carried out in India[8].

The amount of methane generated increased when adding activated charcoal in a chamber and this was supported that carbon filters (Activated carbon) can remove hydrogen sulphide and siloxanes from landfill gases[9]. Adding of animal manures to organic waste in landfills has a positive effect by increasing the amount of methane produced and it was confirmed that pretreatments often enhance the anaerobic digestion of the lignocellulosic content of animal manure and thus raise methane yield[10].



**5.0 Conclusion**

By building an adaptive sanitary landfill at Lead City University in Ibadan, the research project aims to strengthen the inclusive waste management structural model and serve as a planning tool for creating a cohesive, financially secure, environmentally friendly, and socially inclusive university environment through sustainable waste management.

**6.0 Recommendations**

1. The Nigerian government must acknowledge solid waste management as a serious issue and commit sufficient financial and other resources to finding an effective solution. Additionally, university management may research the costs and advantages of outsourcing waste collection and disposal operations to private operators if the available resources at the university are insufficient.

2. Environmental Impact Statements (EIS) for the proposed sanitary landfill sites at Lead City University in Ibadan are crucial to produce. Not only should the environmental and material components of development be taken into account in the EIS, but also the groups in university contexts that are likely to be impacted by the development proposals.

3. Intentional landfill sites should be planned and run in accordance with the relevant engineering and physical planning requirements. These requirements cover the movement of solid waste, accessibility, disposal, the amount and depth of sand (15 cm) that must be spread within 24 hours of disposal, and the installation of fencing around the sites.

**7.0 Contribution to the Knowledge**

With the completion of this project work, most of the universities in West Africa Countries and world at large will now understanding how to manage their waste in sustainably manners.

**8.0 Suggested areas for further research**

Management of healthcare waste in university can also be carried out in the nearest future.



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