

## PAPER 112 – SUSTAINABLE SOLID WASTE MANAGEMENT AT GREGORY UNIVERSITY UTURU

A. C. Ekeleme<sup>1</sup>, C. E. Njoku<sup>2</sup>, B. N. Ekwueme<sup>3</sup>, C. Onuoha\*<sup>2</sup>, V. E. Amuluku<sup>3</sup>

<sup>1</sup>Department of Civil Engineering, Abia State University Uturu, Abia State, Nigeria

<sup>2</sup>Department of Materials and Metallurgical Engineering, Federal University of Technology Owerri, Imo State  
Nigeria

<sup>3</sup>Department of Civil Engineering, Gregory University Uturu, Abia State, Nigeria

\*Email: chukwudikeonuoha@gmail.com

### ABSTRACT

As man carries out his daily activities, waste is generated leading to pollution; and the associated challenges in the proper and sustainable management of the waste. The universities are in no wise exempted from the rapid pollution from municipal solid wastes. In this study, the wastes generated at the Gregory University Uturu campus were quantified and classified according to standards, and possible strategies suggested for sustainable waste management. During the study, an average of 449.8 kg/day (0.45 tons/day) were generated, with plastics and polythene wastes having the largest proportions of 35% and 25% respectively. Whereas other waste categories which include paper, organic, metal, e-waste, medical waste, textile, and others resulted in 15%, 12%, 4%, 2%, 1%, 1%, and 2% respectively. The campus generates waste at approximately 0.21 kg/capita/day and about 82% of the waste can be recycled. Using the waste-to-energy approach, a minimum of 22.kWh of electricity can be generated per day. The study recommends the adoption of the waste management hierarchy (reduction, reuse, anaerobic digestion, incineration, and landfilling) as a sustainable approach to managing waste in the University.

**KEYWORDS:** Solid waste management, Pollution, Sustainable approach, Universities

### 1. INTRODUCTION

The swift growth of the world population, perpetually growing living standards, and massive technological innovations are constantly increasing the multiplicity and quantity of solid waste. Virtually everything man does results in some form of waste (Saleh & Koller, 2019). In fact, global solid waste (SW) released in 2010 was estimated at about 10.4 billion tons and is envisaged to stand at 148 billion tons by 2025 (Alam & Qiao, 2020). Therefore, waste is inescapable as it is an outcome of daily human activities.

Waste is any solid, fluidy, gaseous, radioactive substance, the release, disposal, and throwing away of which may cause deadly changes to the environment (Ashikuzzaman & Howlader, 2019). Generation of municipal solid waste, coupled with the high organic content present in solid waste and its often inadequate disposal, results in extensive environmental pollution, via the emission of gases such as methane (CH<sub>4</sub>) and carbon monoxide (CO) that contribute to the greenhouse effect. As a result of this environmental menace, municipal authorities are presently charged with the responsibility of discovering and implementing techno-economic and political solutions of greater efficiency to manage the growing quantities of municipal solid waste (Saleh & Koller, 2019). Administration of waste encompasses the gathering, transporting, treating or dumping of rejected materials. Justifiable solid waste management is one of the fundamentals for workable environmental running as the careless disposal of solid waste contaminates the environment and endangers human wellbeing (Ashikuzzaman & Howlader, 2019).

In prehistoric cities, wastes were managed by discarding on top of unpaved streets and thoroughfares, where they were abandoned to accrue (Abdel-Shafy & Mansour, 2018; Briney, 2020). It was in 320 BCE in Athens that the first recognized law forbidding this exercise was instituted. In Greece and in the Greek-dominated cities of the eastern Mediterranean, in ancient Rome, and in most other parts of the world, methods of disposal were very rudimentary, which included open pits situated within the vicinity. As the number of residents increased, plans were directed towards conveyance of waste further away from the cities (Omang *et al.*, 2021). As at 2018, the speed of waste production in Nigeria was valued at 0.65-0.95 kg/capita/day which translates to an average of 42 million tonnes of wastes annually. This is more than half of 62 million tonnes of waste generated in sub-Saharan Africa annually and the problem is the where and how to channel these wastes.

Several research works have investigated municipal solid waste management, (Abdel-Shafy & Mansour, 2018; Oji Iheukwumere *et al.*, 2020; Omang *et al.*, 2021; Ugwu *et al.*, 2021; Zadawa *et al.*, 2015). Challenges and conceivable panacea to the municipal solid wastes management in Nigeria was investigated by (Amuda *et al.*,

2014), They discovered that, with the global population explosion, unplanned urbanization, climate change, combined with existing un-sustainability features; cities in developing countries are certainly going to encounter difficulties in proficiently dealing with municipal solid waste which will undeniably lead to enormous glitches on They further recommended combined efforts of local, state and federal government, the stakeholders, non-governmental organizations and the private sector in tackling this menace. The research focused on the need for efficient solid waste management. However, (Sembiring & Nitivattananon, 2010) that studied the integration of the informal sector in sustainable solid waste management, posited that effective and efficient waste management will lead to unemployment of the scavengers and waste pickers who also need to survive in the society.

Due to lax environmental regulations, insufficient resources, and unchecked rapid urbanization and industrialization, indiscriminate dumping is the primary disposal method in developing countries such as Nigeria (Ugwu *et al.*, 2021). More so, the Federal Government of Nigeria has promulgated various laws and regulations to safeguard the environment. This effort of the Federal Government is left on the shoulders of the Federal Ministry of Environment, empowered to administer and enforce environmental laws in Nigeria. However, in Nigerian universities, waste composition and generation patterns have received little or no attention. Universities are tasked with the critical responsibility of promoting safe and friendly environments by adopting responsible waste management policies.

Gregory University Uturu (GUU) is sited at Uturu, Abia State in Nigeria. It is a Private University named after Pope Gregory I. The staff and students' population as at the period of this study (in the year 2022) is about 2100. Gregory University, Uturu (GUU) has about eight colleges and fifty-seven departments. The colleges include; College of Medicine and Health Sciences, College of Law, College of Engineering, College of Agriculture, College of Environmental Sciences, College of Humanities, College of Natural and Applied Sciences, Joseph Bokai College of Social and Management Sciences, and College of Education. The appalling situation in Nigeria is exactly what is obtainable at Gregory University and other Nigerian universities in terms of waste management. Most tertiary institutions in the country lack data on the quantity and composition of waste generated, making it difficult to design a waste management system. Thus, this research is intended to identify the causes of waste generation, determine the amount of waste generated daily and design an effective waste management model for Gregory University; so as to provide the needed data for efficient solid waste management.

## 2. MATERIALS AND METHODS

The materials used for this study comprise weigh balance (200kg scale) for weighing samples, spade for mixing and leveling waste during sorting, personal protective equipment (nose mask, coverall, safety boots, hand gloves, eye protection) worn during field work, oven for drying the waste to get some of the generated waste's chemical and physical properties. Others include litter pickers for picking and sort the waste, plastic containers for collecting samples and for sorting and polythene bags for samples packaging after weighing.

In this study, solid waste were collected from selected sites which include each faculty, hostel, and cafeterias. Sampling and analysis were performed as stipulated by (*ASTM D5231-92(2016) - Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*, n.d.). The sampling of the waste was done day-to-day in a space of eight days. In order to find out the quantity of waste produced, waste was taken and retained in large bags. Labels of activity area and dates were placed on the large bags, and kept outside the building for a while, to resume taking of weight later. The average weights of each component were added to determine the total amount of solid waste at each waste dump point. The weight of waste generated at each dump point was recorded for all the eight days. The different waste components were characterization by sorting and separating into several categories (leaves, food waste, paper, cardboard, plastics, metal, and others). Quartering method was used in reducing the homogeneously mixed waste to a size that can be tested in the laboratory. The obtained sample was placed plastic bags, closed and taken to the laboratory for tests.

Furthermore, the solid wastes were differentiated into recyclable and non-recyclable categories. The recyclable wastes for which there is a market include metals, polythene bags, paper, and plastic while those for which there is no market are e-waste, glass, leather, organic waste, and textile. Non-recyclable category includes wastes such as sanitary waste. Food scraps, garden wastes, wood, textiles, newspaper, packaging material, magazines, office paper, and cardboard were classed as recyclable organics. Animal excreta, miscellaneous paper, cellophane, miscellaneous cardboard, waxed paper, and plasticized paper were classed as non-recyclable organics.

The weight of the solid waste generated within the campus per day was determined by subtracting the weight of the empty collection tank or the previous weight recorded from the weight of the waste generated on a particular day. The waste generated per capita per day was the obtained by dividing by the population of students and staff in the university.

Samples were analyzed for moisture content, in that a portion of the waste was placed in a clean and dry container weighing  $W_1$  and the weight of the sample and container,  $W_2$  was recorded. The container with the sample was then oven-dried at a temperature of about 110 degrees Celsius for about twelve hours until a constant mass was reached. The sample was taken out of the oven, cooled, and then re-weighed ( $W_3$ ). The percentage moisture content was obtained using equation (1) (HAYAKAWA & TSUBAKI, 1998).

$$M = \frac{W_2 - W_3}{W_2} \times 100\% \quad \dots\dots\dots(1)$$

where M is the moisture content,  $W_2$  is the initial weight and  $W_3$  is the final weight.

**3. RESULTS AND DISCUSSION**

**3.1 Waste characterization**

The essence of waste composition is to predict the waste management strategy to be adopted in a particular location. For example, organics served as food for pests, insects and rodents and hence need to be disposed of regularly since controlled biological treatment facilities for its conversion to wealth are lacking. Figure 1 shows the waste composition by weight of municipal solid waste generated at Gregory University Uturu. Plastics make up most of the waste generated on campus, accounting for 38 percent (Figure 2(a)). Polythene ranks with 25 percent (Figure 2(b)), followed by paper (Figure 2(c)) and organic materials with 15 percent and 12 percent, respectively. Others include textile waste materials (2 %), E-waste (2 %), medical waste (1 %) and metal trash (Figure 2(d)) (4 %). The quantity of the recyclables like paper and plastic is an indication of immediate monetary value to the collectors. (Ranjith Kharvel Annepu Advisor & Themelis Stanley-Thompson Professor Emeritus, 2012) made similar observations in their work on sustainable solid waste management in India. The reason for this high percentage of plastics is because Gregory University Uturu is a Private University where the main food types as provided by the school cafeterias are such foods and drinks that are contained in plastic disposable containers. Polyethylene bags ranked second due to their high use for sachet waster due to scarcity of drinkable water on campus. Paper is also a prevalent waste category in universities due to massive administrative and academic activities. Metal waste consist of aluminium tin, can drink containers, and other metal scraps from the mechanical metal workshop located at the school.

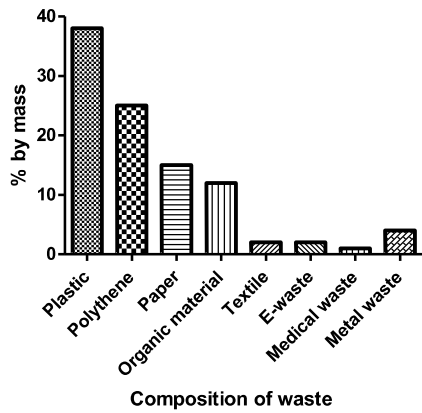


Figure 1 Composition of the waste in percentage      Figure 2 Grouping of major waste materials (a) plastic (b) polythene (c) paper and (c) metal waste

**3.2 Estimation of daily waste generated**

The average waste generation of 449.8 kg/day (0.45 tons) was obtained from this investigation, giving a per capita generation rate of 0.21 kg/capita/day. Most of the organic waste was from staff quarters, cafeterias, and garden waste, while the inorganic waste was primarily plastic waste from the hostels and paper waste from educational and administrative activities. Table 1 is a display of the average waste generated from different dump sites in the campus. The hostel and residential areas generated the highest amount of waste with 324.2kg/day, followed by the academic zones with 52.7kg/day and the cafeterias with 48kg/day. Other supporting areas like the security posts, sport area and university clinic generated 11.4kg/day, school auditorium area 7.5kg/day, and the religious area generating the least amount of waste, 6kg/day. The quantity of waste generated in a particular area is largely dependent on the degree of human activities in that area, as can be seen from the result.

Table 1 Average waste generation from different dump sites

Dump site	Average generation/day	waste	Percentage by weight
Academic areas; colleges, administrative buildings, library	52.7		12
Residential area; hostels, staff quarters, chancellor villa	324.2		72
Cafeterias	48		10
Religious areas	6		1
School auditorium/ amphitheatre	7.5		2
Other areas; security post & clinic	11.4		3
Total	449.8		100

### 3.3 Optimization of collection points

The reconnaissance survey carried out to determine the current number of collection points in GUU showed that the current number of primary collection points is inadequate to cater for the amount of waste generated by the university. The result showed that currently, we have 25 primary collection points in GUU and these primary collection points were also found to be unevenly distributed over the university area leading to waste being indiscriminately dumped and open-burnt in certain areas, actions that harm the environment. The number of primary collection points was increased to an optimized value of 97 collection points with an addition of 55 extra collection points to the existing number currently in the university. The primary collection points were placed at not more than 15m apart in areas where there are a lot of activities and to enhance the ease of access to the collection points as well as the route for transportation to the secondary collection points. Figure 3 is the map of GUU showing optimization of waste collection points.

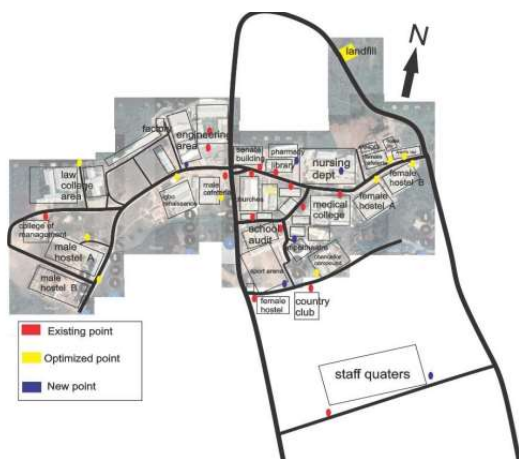


Figure 3: Map of GUU showing optimized collection points

### 3.4 Moisture content of the waste

The moisture content of a waste stream is a crucial parameter for the degradation of biodegradable waste in landfills, and it is also a key determinant in the production of landfill gas like methane. Moisture content is also used to determine the calorific value of waste applied in incineration and waste-to-energy generation. In this work, the average moisture content of the waste stream was obtained to be 16.15% (using Equation 1) which is slightly less than the average moisture content in waste streams in Nigeria (20%) as stated by (Zadawa et al., 2015) and even lower than observed by other researchers (Ranjith Kharvel Annepu Advisor & Themelis Stanley-Thompson Professor Emeritus, 2012), (Ugwu et al., 2021).

### 3.5 Recyclable potential of waste

A reasonable proportion of the waste generated in the GUU campus is recyclable or is potentially recyclable. It shows that 82% of the waste streams are recyclable while 15% are potentially recyclable. The GUU campus has a lower non-recyclable waste of 3%. GUU is not able to recycle, reuse or recover energy from any of its waste categories. Figure 4 shows the potential recycling rating for waste generated in the university; it shows that 82% of the waste can be recycled, 15% has the potential of being recycled, while as 3% cannot be recycled. Thus, a

large percentage of the waste stream can be recycled if proper channels are put in place to segregate waste at the source.

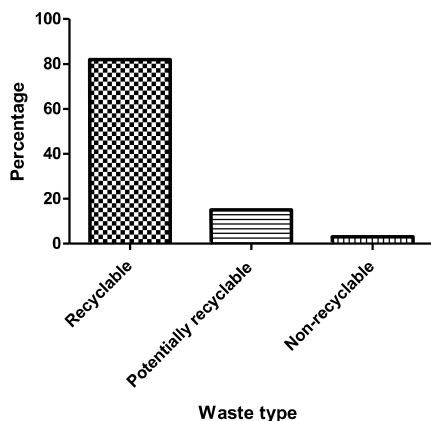


Figure 4 Level of recyclability in percentages

### 3.6. Sustainable management strategies

Universally, the initiative for workable measures and approaches to solid waste management is on the increase. Appropriate sustainability measures are necessary in order to prevent the attendant health implications of indiscriminate dumping of waste in the society. Conventionally, the most prevalent sustainability measures in use include the 3Rs (i.e. reduce, re-use and recycle), composting, open burning, anaerobic digestion (incineration) sanitary landfilling, etc. Most of these measures are capital intensive and can only be efficiently practiced in advanced economies. This study has revealed that there is high percentage of recyclable waste at the university but at present, the University has no existing recycling facilities probably due to lack of funds and expertise. Hence, the best approach remains reduction at source and re-use.

#### 3.6.1 Reduction, Re-use and recycle

Source reduction focuses on minimization of generation of waste. Efforts should be made to prevent unnecessary waste generation. This could be achieved by enhancing public awareness on the dangers of municipal solid waste, which will in turn change the consumption pattern of the citizens. Again, the essence of the re-use strategy cannot be over-emphasized. As uncovered in the Gregory University Uturu, there is large proportion of plastic containers generated as a result of the feeding pattern in the university. Staff and students should be encouraged to go for returnable and re-usable containers. Secondary usage of waste is also to be encouraged as far as it can be done in a hygienic manner. Since, the university does not have facilities for recycling, the informal sector can be engaged for the collection of recyclable wastes while market for recyclables are explored for sale of such items. This will go a long way in tackling the menace.

#### 3.6.2 Utilization of Bio-Gas

Energy can be derived from the enormous waste generated on campus. This can be obtained by the decomposition of organic waste anaerobically to generate methane gas. This gas can be used as fuel to power automobiles, generate electricity and also serve as cooking gas for domestic use. Though the waste generated by Gregory University contains a low proportion of organic waste (12 percent), the waste to energy prospects of the school can be increased by considering other energy-generating management methods like incineration. The campus can produce at least 225 kWh of electricity per day from its 0.45 tons of waste generated daily. When this amount of energy is properly harnessed and distributed to campus users, significant savings on-grid electricity can be realized in addition to a cleaner environment. Additionally, methane can be produced via anaerobic composting of agricultural and human wastes in digesters. In biogas digesters, waste can be fermented to produce a gas rich in methane. The gas can be harnessed to generate enough energy for electricity, cooking, lighting, and a variety of other energy-intensive applications.

#### 3.6.3 Incineration

Incineration is primarily the process of destroying waste in a furnace by controlling combustion at high temperatures to generate steam, which is then used to generate electricity via steam turbines. By incinerating waste, approximately 70% of the total waste mass and 90% of total volume can be reduced, leaving a small residue of waste to be disposed of in a landfill. If this is done, the pressure demand on landfills will be removed and the huge cost associated with waste disposal will be saved. The waste stream in GUU is rich in combustible materials like paper (15%), polythene (25%), plastic (38%) and medical waste all of which can easily be taken care of by incineration. Incineration not only reduces waste volumes but also provides alternative energy sources. However,

incineration plants are typically among the most expensive SWM options, requiring highly skilled personnel and meticulous maintenance. Hence, it is recommended that incineration be used only when other simpler and less expensive options are unavailable.

#### 3.6.4 Landfilling

Sanitary landfilling is the most common method of disposing of municipal solid waste globally and the cheapest and most convenient method adopted by developing countries, where 65 to 80 percent of collected solid waste is disposed of. Other methods cost largely more than landfilling and as such, landfilling is no longer the preferred option only in developing countries. After considering all other options in the waste hierarchy system, the final point of disposal of the waste generated in GUU should be an engineered landfill. An engineered landfill also known as a sanitary landfill which the school is currently using should be improved to manage the waste generated in the school.

#### 4. CONCLUSION

The status of waste generation on campus, its composition, and the possibility for sustainable management was determined in this study with Gregory University as case study. The amount of waste generated by various parts of the university and the associated student and staff population were also estimated. During the study period, Gregory University generated an average of 449.8 kg of solid waste per day, with polythene and paper waste accounting for the largest proportions at 26 percent and 24 percent, respectively. The waste generation was approximately 0.21 kg/capita/day. The university can generate approximately 225 kWh of electricity per day if appropriate waste-to-energy (WTE) technologies are implemented. The in-depth understanding of waste generation trends in GUU and how this should result in more sustainable waste management strategies on campus is expected to spur similar studies in Nigerian universities.

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