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# Estimation of Methane Emission Potentials in Landmark University Open Dump Site, Omu-Aran, Kwara State Nigeria

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## Abstract
*Most of the increasing quantity of wastes in institutions of higher learning, are disposed of through open dumping. The decomposition of these wastes has been identified to be a source of methane emissions. This study estimated methane emissions from the open dumpsite in Landmark University. An exploratory study design was adopted. The study involved physical characterization of solid wastes at the Landmark University for a period of three months and the estimation of methane emission potentials of the dumpsite for the years 2011 to 2031 using IPCC Default Method (DM) and the Landfill Gas Emission (LandGEM) Model Version 3.02.The study revealed the percentage composition of waste to be 48, 16, 12, 10, 5 and 3% for plastics, garden trimmings, paper, metal, food waste and textile respectively. The maximum methane emission is 11.65 and 2.48 Mg/year for DM and LandGEM respectively in the year 2021 while the methane emissions will decline to 7.06 and 1.50 Mg/year for DM and LandGEM respectively in the year 2031. The contribution of methane emissions in the University is still little as reflected in the values of 11.65 and 2.48 Mg/year although there is a tendency to increase as population increases. Further studies should be carried out to provide methane specific properties of the solid waste generated in Omu-Aran in order to build an inventory of methane emission parameters.*

**Keywords**: Solid waste Characterization, Methane emissions potentials, Open dump site, Landmark University

## Introduction
In our present world, many institutions of higher learning communities can be taken as ‘‘mini cities” with large expanse of land bigger than many towns, with activities of various dimensions by humans which have numerous effects on the total environment (Alshuwaikhat and Abubakar, 2008). Many Nigerian Universities have been said to act as their own municipalities (Adeniran, 2014; Adeniran, 2015). As experienced in many developing Countries and Nigeria inclusive, the consequence of the management of rapidly expanding municipal solid waste (MSW) is one of the major challenges. The situation is also not different in institutions of higher learning as the waste management systems is not an integrated one. Most of the solid waste are collected, dumped and burned openly in a secluded place (Kaushal and Sharma, 2016; Adeniran *et al*., 2017). This is responsible for the waste not to be properly managed, thereby creating environmental problems such as water and soil contamination, thus affecting human and animal health and ultimately agricultural productivity (Staley *et al*., 2009). The quantities of solid waste are increasing as the University is expanding and this leads to the release of significant quantities of greenhouse gases such as carbon dioxide and methane which are recognized to cause global warming. The Global Warming Potential (GWP) of methane is reported as 21 times of carbon dioxide for a period of 100 years (Kumar *et al.,* 2004). According to Kumar and Sharma, (2014), greenhouse gas emissions are greatly contributed by the uncontrolled generation of municipal solid waste. A lot of information has been obtained about the contribution of greenhouse gases emission in cities and towns (Babel and Vilaysouk, (2015) with

little from Universities and other institutions of higher learning in developing countries. Hence, this paper deals with methane emission potential of the open dump site in Landmark University, Omu-Aran.

## Materials and Methods

The study area is an open dump located inside Landmark University. Landmark University is a private University established in 2011 by the Living Faith Church World Wide (Oladejo *et al.,* 2018). The University is situated in Omu-Aran, an indigenous town which lies at 8 ° 8′00′N latitude, 5 ° 6′00′′E longitude and 564 m above sea level (Elemile *et al.,* 2020). The University has four Colleges namely College of Pure and Applied Sciences, College of Engineering, College of Business and Social Sciences and College of Agricultural Sciences. There are also facilities such as senate building, halls of residence, chapel, staff quarters, orchard, cafeteria, secondary and primary schools, commercial farm and so on

### Waste characterization and/physical composition

The determination of the weight of the physical components was carried out daily for a week for three months (December, March and April (2017-2018)). This was from Monday till Friday (five days). The average value for each waste component was now multiplied by 365 days to estimate the quantity of waste generated for a year. The wastes were manually sorted and weighed using a 20kg capacity camry kitchen weighing scale (Oladejo *et a*l., 2018).

### Estimation of methane emission potential at the dumping site

To estimate the Methane Emission Potential of the dump site the Intergovernmental Panel on Climate Change (IPCC) Default Method (DM) and The Landfill Gas Emission Model Version 3.02 were used.

### IPCC Default Methodology

The annual $CH_4$ emission estimation was calculated from Equation (1) (IPCC, 2006).

The default method (IPCC, 2006) is based on the main equation:

$$\boldsymbol{CH_4\ Emission\ Gg\ Yr^{-1}} = [\left\{\boldsymbol{MSW_T\ x\ MSW_F\ x\ MCFx\ DOC\ x\ DOC_F\ x\ F\ x\frac{16}{12} - R}\right\}\ \boldsymbol{x\ \{1 - OX\}}] \quad (1)$$

Where:
$MSW_T$: total MSW generated (Gg/yr)
$MSW_F$: fraction of MSW disposed to solid waste disposal sites (Default value 70%)
MCF: methane correction factor (fraction) Default Value 0.4
DOC: degradable organic carbon (fraction) (kg C/ kg SW) giving as 0.4A + 0.17B + 0.15C + 0.3D
$DOC_F$: fraction DOC dissimilated (IPCC default is 0.77)
F: fraction of CH4 in landfill gas (IPCC default is 0.5)
16/12: conversion of C to $CH_4$
R: recovered $CH_4$ (Gg/yr) which is 0 for an open dump
OX: oxidation factor (fraction – IPCC default is 0)

### The Landfill Gas Emission Model Version 3.02

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} KL_0 \left[\frac{M_i}{10}\right] e^{-kt_{ij}} \quad (2)$$

Where:
$Q_{CH4}$ = Annual methane generation in the year of calculation ($m^3\ yr^{-1}$)

i = The yearly time increment
n = Difference: (year of the calculation) – (initial year of waste acceptance)
j = 0.1-year increment
Lo= Methane generation potential ($m^3$/Mg)
Mi= Mass of waste accepted in the $i^{th}$ year (Mg)
k = Methane generation rate ($yr^{-1}$)
$t_{ij}$ = Age of $j^{th}$ section of waste mass Mi accepted in the ith year.
The important parameters of the LandGEM equation for the generation of methane gas are Lo (methane generation potential) and k (methane generation rate).
Methane generation potential ($L_O$)
The methane generation potential is determined from the equation (IPCC, 2006):

$$L_o = DOC \; x \; DOC_F \text{ x F x } \frac{16}{12} \; x \; MCF \quad (3)$$

DOC = (0.4 x A) + (0.17 x B) + (0.15 x C) + (0.3 x D) (4)

Where:
DOC = degradable organic carbon

A= fraction of MSW that is paper and textiles wastes, B = fraction of MSW that is garden park waste, C= fraction of MSW that is food waste and D= fraction of MSW that is wood or straw.
$DOC_f$ = fraction of assimilated degradable organic car-bon (DOC)is obtained from the IPCC default value of 0.77 (IPCC, 2006).
MCF = Methane correction factor. This is based on the category of the solid waste disposal site (SWDS) management as presented by IPCC:
Managed sites MCF = 1.0
Unmanaged, deep sites (≥ 5m) MCF = 0.8
Unmanaged, shallow sites (< 5m ) MCF = 0.4
Unspecified SWDS - default value: MCF = 0.6
F = fraction of methane in landfill gas (0.5 default)
16/12 = stoichiometric factor.

**Methane generation rate constant**
The methane generation rate constant or decay rate k, is determined based on USEPA (2004):

$$k = 3.2 \times 10^{-5} (x) + 0.01 \quad (5)$$

Where x is annual average precipitation

**Results and Discussion**

**Waste composition**
The composition of the solid wastes at the dumpsites located within the campus of Landmark University in December, March and April (2017-2018) is shown in Figure 1. The percentage composition by weight was 48, 16, 12, 10, 5, 3, 3, 2 and 1% for plastics, garden trimmings, paper, metal, food waste, glass, sand, wood and e-waste respectively. This was in agreement with Adeniran *et al.,* (2017) who reported that plastic bottles and plastic packaging bags represent the largest stream of waste generated on campus representing 34% of the total waste generated. Also, the food waste represented about 10% of the waste generated in comparison to 5% in this study. Oladejo *et al.,* (2018) observed that about one-third (33.69 %) of waste generated within Landmark University were derived from food wastes, paper and paper products and these categories of waste could be aerobically or anaerobically digested to produce compost (organic fertilizer) or bio-fuel. It was also added that, the recyclables (polythene bags, plastic bottles, metal cans and glass) constituted 52.29 % of the total wastes in the University. These findings revealed that although large quantities of

these wastes are generated, most of these plastics are collected by the cleaners for reuse. This shows that there are enough materials if the University decides to establish a waste recycling plant. In a related work on Omu Aran community waste management, Oladejo *et al*., (2020) reported that the total amount of material recyclable was about 44 % and energy recovery material, to attain zero-waste was 56 %.

**Estimation of methane emission from the Landmark University open dump:**

The methane generation potential ($L_o$) and generation rate constant (k) (Table 1) revealed that the $L_o$ was 0.021m$^3$/Mg while the k was 0.018 y-$^1$. This was low compared to the values of 76.94m$^3$/Mg and 0.041 y-$^1$ in a study for dumpsites in Kano (Daura *et al*., 2014), the reason is because the University is a small community compared to the city of Kano which is one of the most populous cities in Nigeria. The estimated methane emission from the study area (Table 2) revealed that the estimated annual methane emission by the default method ranged from 2.55Mg/year in the year 2012 which would peak to 11.65Mg/year in the year 2021 and would drop to 7.06 Mg/year in the year 2031whereas using the Landfill Gas Emission Model Version 3.02 method, the methane emission was ranged from 0.01Mg/year in the year 2012 which would peak to 2.48Mg/year in the year 2021 and would drop to 1.50 Mg/year in the year 2031. The quantity of methane generated was little compared to the amount of 248.22 and 8.85Gg/year for the Default Method and The Landfill Gas Emission Model Version 3.02 method respectively for the year 2013 from a study conducted in Akure (Elemile, 2019). The quantity of methane is little but as stated that the predicament of solid waste management is a regional one but it has an impact on the global scenario (Lou and Nair, 2009). As reflected in the results the estimations by the empirical methods were not different. This was in agreement with Kumar *et al*., (2004) who argued that the values of the default method were higher due to the assumption that all potential methane is emitted in the same year in which the solid wastes were disposed.

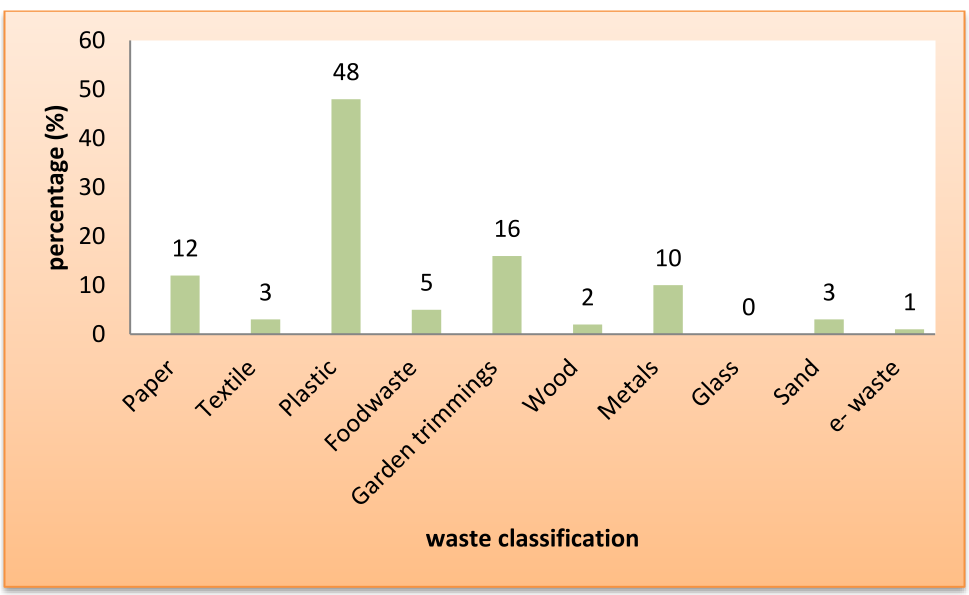


**Figure 1:** Percentage composition of waste generated in Landmark University, Omu-Aran, Nigeria

**Figure 2:** Open Dump in Landmark University, Omu-Aran

**Table 1:** Methane generation potential and methane generation rate

| Dumpsite | $K(y^{-1})$ | $L_o(m^3/Mg)$ |
|---|---|---|
| Landmark University | 0.018 | 0.021 |

**Table 2:** Annual Methane Emission using IPCC Default Method and Landfill Gas Emission Model Version 3.02 (2012-2031)

| Year | IPCC DM Methane Emissions (Mg/Year) | LandGEM Methane Emissions (Mg/Year) |
|---|---|---|
| 2011 | 0.00 | 0.00 |
| 2012 | 2.55 | 0.01 |
| 2013 | 4.37 | 2.65 |
| 2014 | 6.91 | 5.21 |
| 2015 | 8.47 | 8.26 |
| 2016 | 9.26 | 1.15 |
| 2017 | 8.06 | 1.41 |
| 2018 | 8.97 | 1.69 |
| 2019 | 9.23 | 1.96 |
| 2020 | 10.47 | 2.23 |
| 2021 | 11.65 | 2.48 |
| 2022 | 11.08 | 2.36 |
| 2023 | 10.54 | 2.24 |
| 2024 | 10.00 | 2.13 |
| 2025 | 9.54 | 2.03 |
| 2026 | 9.07 | 1.93 |
| 2027 | 8.63 | 1.84 |
| 2028 | 8.21 | 1.75 |
| 2029 | 7.81 | 1.66 |
| 2030 | 7.43 | 1.58 |
| 2031 | 7.06 | 1.50 |

An attempt has been made to apply a convenient generally acceptable method by IPCC (2006) although different countries still use different methods for collecting and reporting their methane production from landfill sites. Thompson *et al*., (2009) have compared various models for methane emission from various landfill sites and concluded that LandGEM model estimated methane emission with better accuracy as compared with other models. This method Kumar *et al* (2004) proposed assumes that the decomposition of organic matter takes place in two phases. Large differences in methane estimations from open dumps from developing countries are found in the literature. The estimations have to be handled with care as a lot of uncertainties exist because, regarding open dumps, there are several factors that have to be considered such as the specific microorganisms which hinder or enhance the anaerobic decomposition of organic waste. Furthermore, climatic conditions, age, and gas migration lead to a wide variation of measurement results. Thus, uncertainties are associated with the degree of factors affecting the methane emission estimation (Doorn *et al,* 2000).

## Conclusion

The emission estimates calculated with the two methods of IPCC Default Method and the Landfill Gas Emission Model Version 3.02 method reveals that there is a vast difference. The values for IPCC Default Method ranged from 2.55Mg/year in the year 2012 which would peak to 11.65Mg/year in the year 2021 and would drop to 7.06 Mg/year in the year 2031whereas using the Landfill Gas Emission Model Version 3.02 method, the methane emission ranged from 0.01Mg/year in the year 2012 which would peak to 2.48Mg/year in the year 2021 and would drop to 1.50 Mg/year in the year 2031 reflecting a variation. Although the values are little compared to values of similar studies, there is a tendency of increase in the emissions as the University becomes bigger and the population increases leading to the generation of more and various kinds of solid waste. Therefore, it is recommended that further studies should be carried to provide methane specific properties of the solid waste generated in Landmark University and other Institutions of Higher Learning in order to build an inventory of methane emission parameters.

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