Nigerian Research Journal of Engineering and Environmental Sciences 3(1) 2018 pp. 280-286

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

ADOPTION OF A LANDFILL SYSTEM IN NIGERIA AND THE ROLE OF MUNICIPAL SOLID WASTE SEGREGATION ON ITS PERFORMANCE

[1]Ukwaba, S.I., [2]Ikpe, A.E. and *[3]Orhorhoro, E.K.

[1]Department of Mechanical Engineering, Petroleum Training Institute, Effurun, Nigeria.
[2]Department of Mechanical Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria.
[3]Department of Mechanical Engineering, College of Engineering, Igbinedion University, Okada, Nigeria.
*ejiroghene.orhorhoro@iuokada.edu.ng

ARTICLE INFORMATION

Article history:
Received 18 April, 2018
Revised 27 April, 2018
Accepted 30 April, 2018
Available online 30 June, 2018

Keywords:
Municipal solid waste
Landfill
Segregation
Disposal
Dumpsite
Solid waste management

ABSTRACT

Municipal solid waste disposal is one of the major environmental problems in Nigeria due to lack of landfill systems and as such; the populace is left with no option than waste disposal at open dumpsites. This study focuses on the decomposition period of municipal solid waste and the viability of such materials when disposed at landfill. 10,000 kg (10 tonnes) each of municipal solid waste was collected randomly from Olusosun dumpsite in Ojota, Lagos state, Nigeria and Lucky four way dumpsite in Benin City, Edo State, Nigeria. Hand sorting was used to segregate the collected waste materials according to its composition. The segregated municipal solid waste was measured with a weighing scale and left to decompose in an open environment for a period of 120 days of which visual observation was used to determine the rate of decomposition of each category of waste. It was observed that food leftovers (2,900 kg) and vegetables (1,900 kg) had the least decomposition time and constituted the highest number of waste collected from Olusosun dumpsite, while food leftovers (2,100 kg) and vegetables (2000 kg) also decomposed with the least time frame and constituted the highest number of waste collected from Lucky Four Way dumpsite. Decomposition time for plastics, metals, ceramics and glass was undetermined, as the 120 days observation period elapsed without decomposition of these materials. Segregation of municipal solid waste before disposal at dumpsite will yield more biodegradables for biogas production.

1. INTRODUCTION

Municipal Solid Waste (MSW) is one of the major challenges faced by Nigerian cities in recent times as a result of its rapidly increasing trend which has outgrown the existing waste management practice. Omole and Akinlade

(2013) reported that Nigeria among other developing countries is witnessing an unprecedented growth of human population and urbanization which are some of the factors responsible for increasing rate of MSW.

In recent years, there has been a phenomenal increase in the volume of wastes generated daily in Nigeria (Olanrewaju and Ilemobade, 2009; Orhorhoro, et al., 2017). Oladepo et al. (2015) attributed the recent upsurge in solid waste generation in Nigeria to population growth, low budget on solid waste management which has translated into open dumping of refuse on any available land space. Furthermore, Nigeria is the 6th most populous country in the world with estimated population of about 178 million (HDR, 2016). Some areas such as Lagos has a relatively high population density with relatively small landmass (Komolafe, 2015). Generally, Lagos State is one of the areas known to be facing great challenges of MSW (Adejoro, 2015; Komolafe, 2015). Currently, the commonly practiced waste management option in Nigeria involves the collection of mixed waste materials and subsequent dumping at dumpsites without separation (Orhorhoro, et al., 2017). Moreover, it is not a practice to separate waste materials at source or any point of its management (Adekunle et al., 2011). According to Taopo (2013), recycling and biogas production are more efficient (in terms of the quantity and cost) when the waste materials are properly segregated. However, the waste management practices in Nigeria contradicts the concept of integrated solid waste management (Reduction, Recycle, Reuse, Energy Recovery, Final disposal) by intensifying the severity of MSW challenges in Nigeria.

Moreover, due to inadequate coverage of most urban areas and rural areas by the waste management agencies during waste collection services, residents resort to dumping of refuse along the road and any available space where it is often set on fire to reduce the large stockpile (Ogwueleka, 2009). World Bank (2003) reported that waste generation can be an asset when managed properly in terms of wealth creation and job opportunities but can also be a curse when managed improperly in terms of constituting hazards to public health and surrounding environment. For example, some dumpsites are located near streams and rivers while wastes are sometimes dumped in rivers which serve as major sources of drinking water to residents, particularly in the rural areas (Sabejeje et al., 2014). By so doing, the liquid content generated by biodegradable waste during decomposition can migrate into or percolate through the soil to contaminate surface and ground water, thereby making it unfit for drinking. Moreover, PET bottles and other non-biodegradable materials from dumpsites end up blocking drainage systems during the raining season, while open dumpsites also serve as breeding ground for vectors, insects, rodents and other disease spreading animals. This can result in outbreaks such as lassa fever which the cause is attributed to rodents habituating in unsanitary environment as is currently the case in Nigeria (Odijie, 2016).

Furthermore, MSW is generated on daily basis, and when discarded, the biodegradable content of the waste decomposes to generate biogas which contains methane (CH_4), carbon (IV) oxide (CO_2), hydrogen sulphide (H_2S), siloxane etc. in composition, and CH_4 and CO_2 are the dominant composition in biogas of which CH_4 is 21 times more of a potential GHG than CO_2 when released into the atmosphere (Orhorhoro et al., 2018). Consequently, these are major GHGs responsible for climate change and global warming which the entire world is fighting towards minimizing. In addition, biogas is a renewable energy resource that can diversify the energy options in Nigeria, offset the cost and dependence on fossil fuel and as well serve as alternative source of energy if harnessed for consumption (Orhorhoro, 2014). Biogas is produced from a process known as anaerobic digestion (AD). The major by-products of anaerobic digestion include biogas and leachate, whereas, the substrates which allows the process of anaerobic digestion are mainly biodegradables (Ebunilo et al., 2015).

Therefore, it is important for biodegradable MSW materials to be separated from the non-biodegradable in order to maximize the rate decomposition and biogas generation in landfills. However, decomposition time of biodegradable waste materials varies according to the type of materials (Oseni, 2012). While open dumping

exists as the primary means of waste practice in developing countries such as Nigeria, landfill system is primarily used in Germany and Europe where approximately 1.8 million tons of methane gas produced from MSW landfill is used to generate 2.5 million gigajoules (GJ) of heat energy and over 650 giga watts per hour (GWH) of electricity (Green Gas, 2013). However, landfill fill system remains the simplest land method for disposing municipal solid waste (Barrett and lawlor, 1995). Landfill is a well-designed system with liners, leachate collection system and gas collection system and monitored to ensure the protection of public health and environment from the hazards associated with MSW (Jimenez and Oakley, 2012). Considering the hazards that the populace has been exposed to due to waste generation and poor management policies in Nigeria, it is important to look in-depth into an alternative way of controlling these hazards by finding sustainable solution (such as generation of biogas from landfill system) that is viable in our local environment. This study is aimed at the determination of the decomposition period of municipal solid waste and the viability of such materials when disposed at landfill. The results obtain from this study will serve as a guide for design of a suitable energy landfill system in Nigeria.

2. MATERIALS AND METHOD

2.1. Materials

The materials used in this study include wheel barrow, bucket, weighing balanced, hand gloves, and nose mask.

2.2. Description of Study Area

Lagos is the biggest city in Nigeria, and in addition on the African landmass. It is one of the quickest developing urban areas on the planet and furthermore a standout among the most crowded urban agglomerations in the world (HDR, 2016). It is a port city; this metropolitan territory started on islands, including Lagos Island that was shielded from the Atlantic Ocean by sand spits. The city has a population density of 13,000 persons per square kilometer, and estimated population of over 22 million persons (HDR, 2016). Figure 1 shows the map of Lagos State.

Figure 1: Map of Lagos State, Nigeria

Benin City is a city and the capital of Edo State in southern Nigeria. It is situated approximately 40 kilometres (25 mi) north of the Benin River and 320 kilometres (200 mi) by road east of Lagos. It has an estimated population of 2 million persons (HDI, 2016). Benin City is a commercial city just like every other commercial city in Nigeria such as Lagos, Calabar, Onitsha, Portharcourt, Warri, etc., where industrial and commercial activities that results in generation of large quantity of MSW takes place daily. Figure 2 shows the map of Benin City, Nigeria.

Figure 2: Map of Benin City

2.3. Methods

In this study, the MSW used was collected within a period of one week. The managements of the open dumpsite were contacted, and arrangement was made for every MSW coming to the site within that period. The MSW was weighed, properly sorted and reweighed. 10,000 kg (10 tonnes) each of MSW was collected randomly from Olusosun open dumpsite in Ojota, Lagos state, Nigeria and Luck Four Way open dumpsite in Benin City, Edo state, Nigeria. Hand sorting was used to segregate the collected waste materials according to its composition. The segregated MSW was measured with a weighing scale and left to decompose in an open environment for a period of 120 days of which visual observation was used to determine the rate of decomposition of each category of waste.

3. RESULTS AND DISCUSSION

Table 1 and Table 2 show a list of MSW collected randomly from Olusosun open dumpsite in Ojota, Lagos state, Nigeria and Lucky Four Way open dumpsite in Benin City, Edo state, Nigeria and segregated according to their compositions. From the results obtained, it was observed that food leftovers (2,900 kg) and vegetables (1,900 kg) had the least decomposition time and constituted the highest number of waste collected from Olusosun dumpsite. Also, food leftovers (2,100 kg) and vegetables (2000 kg) also decomposed with the least time frame and constituted the highest number of waste collected from Lucky Four Way Open Dumpsite. This shows the trend in consumption pattern of the people in these areas (i.e., Benin City, and Lagos State). Moreover, there is no single landfill system in the study area for waste disposal, as such, all the waste materials generated are dump at dumpsites where they constitute nuisance to the well-being of human existence and the environment.

Table 1: Result for Oloshosun open dumpsite

Type of Waste	Quantity (kg)	Decomposition Period
Food leftovers	2900	7-14 days
Vegetables	1900	5-10 days
Paper	1100	10-30 days
Ply wood	800	60-120 days
Cellophane	1100	Undetermined
Ceramics	600	Undetermined
Glass	500	Undetermined
Empty Cans and Tins	1,100	Undetermined
Total	10,000	

Table 2: Result for Lucky four way open dumpsite

Type of Waste	Quantity (kg)	Decomposition Period
Food leftovers	2100	7-14 days
Vegetables	2,000	5-10 days
Paper	1,100	10-30 days
Ply wood	800	60-120 days
Cellophane	1700	Undetermined
Ceramics	600	Undetermined
Glass	700	Undetermined
Empty Cans and Tins	1000	Undetermined
Total	10,000	

Waste segregation plays a vital role in the waste management system as it makes the process of collecting waste much more convenient in terms of giving the collectors an idea of the type of waste involved and the tools required for collection. However, integrated solid waste management system suggests segregation of waste from source in order to make other waste management stages (such as reduction in waste volume, recycling, energy recovery and disposal) easier. From the study, waste management is incapacitated by a number of factors such as lack of infrastructures and lack of trained staffs who have little or no knowledge on the importance of waste segregation, as such, collecting and dumping of MSW at dumpsites unsegregated. Biodegradable materials are some of the principal sources of biogas which can offset Nigeria's dependence on fossil fuel and serve as alternative energy source in Nigeria. Therefore, with such amount of biodegradables waste obtained, it is important to adopt a landfill system to control the hazards associated with MSW management practice in Nigeria, diversify energy resource and as well create employment. Furthermore, decomposition time for other solid wastes (such as plastics, cellophanes, ceramics, glasses, tins and cans) collected from each of the dumpsites was undetermined as the 120 days duration set for the study elapsed without decomposition of these materials. This further emphasizes the need for segregation before disposal at landfill because most of these materials take more than a thousand years to decompose, and when disposed at landfill, remains un-decomposed for as long as it remains in the landfill without adding any value (in terms of biogas generation) and consuming the available space that would be used to dispose biodegradables for biogas recovery. However, the fact that waste materials such as plastics and metals require more than a thousand years to completely decompose is enough reason why segregation and recycling is more important, rather than disposal at landfill. On the basis of that, Taopo (2013) reported that the collection, recycling and biogas production are only efficient and cheaper when waste is properly segregation.

4. CONCLUSION

Considering the challenges of waste management practice in Nigeria, there are need to promote source segregation of MSW and segregation of waste from every stage of its management. This will create room for

sustainable change in the waste management system in Nigeria by recovery of valuable items for reuse and recycling and as well recover biodegradable materials for biogas production. Hence, landfill system should be adopted in Nigeria for proper use of biogas resource and environmental protection.

5. ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of the managements of Lucky Four Way Open Dumpsite, Benin City, Edo State, Nigeria.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Adejoro, L. (2015). Feeding from the Dumpsite: The Olusosun Story. Daily Times. [online] available from http://www.dailytimes.com.ng/feeding-from-the-dumpsite-the-olusosun-story/ [30 November 2017]

Adekunle, I.M., A.A. Adebola, K.A. Aderonke, O.A. Pius and A.A. Toyin (2011). Recycling of organic wastes through composting for land applications: A Nigerian experience. *Journal of Waste Management Research*, 29 (6), pp. 582-93

Barrett, A and Lawlor, J. (1995). The Economics of Waste Management in Ireland. Economic and Social Research Institute, Dublin. [online] available from http://www.ucc.ie/research/crc/publicatin/conf_proceedings/Rio_Landfill.pdf [10 January 2017]

Ebunilo, P.O., Aliu, S.A., Orhorhoro, E.K. (2015). Performance Study of a Biogas Pilot Plant using Domestic Wastes from Benin Metropolis. *International Journal of Thermal and Environmental Engineering,* 10(2), pp. 135-141

Green Gas (2013). Yearly Generated Electricity. [online] available from <www.greengas.net/green-gas-germany.html> [2 January 2017]

Human Development Report (HDR) (2016). Work for Human Development; Human Development Report 2016, Retrievedfrom http:// http://hdr.undp.org/en/2016-report, [Accessed 12th January, 2017]

Jimenez, R. and Oakley, S. (2012). Sustainable Sanitary Landfill for Neglected Small Cities in Developing Countries: The Semi-Mechanized Trench Method from Villanueva, Honduras. *Journal of Waste Management*, 32 (12), pp. 2535-2551

Komolafe, T. (2015). Olusosun: Beyond a Dumpsite. [online] available fro<http://hallmarknews.com/olusosun- beyond-a-dumpsite/> [27 December 2017]

Odijie, M (2016). Taraba State Government Confirms the Outbreak of Lassa Fever in the State. [online] available from <http://www.goldmyne.tv/2016/01/taraba-state-government-confirms-the-outbreak-of-lassa-fever-in-the-state/> [10 January, 2017]

Ogwueleka, C. (2009). Municipal solid waste characteristics and management in Nigeria. *Iranian Journal of Environmental Health Science & Engineering*, 6(3), pp. 173-180

Olanrewaju, O. O. and Ilemobade, A. A. (2009). Waste to Wealth: A Case Study of the Ondo State Integrated Wastes Recycling and Treatment Project, Nigeria. *European Journal of Social Sciences*, 8(1), pp. 1-12

Oladepo, O. W., Ilori, M. O., and Taiwo, K. A. (2015) Assessment of the waste generation and management practices in Nigerian food industry: towards a policy for sustainable approaches. *American Journal of Scientific and Industrial Research*, 6 (1), pp. 12-22

Omole, F.K. and Alakinde, M.K. (2013). Managing the Unwanted Materials: The Agony of Solid Waste Management in Ibadan Metropolis, Nigeria. *International Journal of Education and Research,* 1(4), pp. 1-12

Orhorhorhoro, E.K. (2014). Performace Study of a Biogas Pilot Plant using Domestic Waste from Benin Metropolis. Masters thesis, Department of Mechanical Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria

Orhorhoro, E.K., Ebunilo, P.O., Sadjere, E.G. (2017). Determination and Quantification of Household Solid Waste Generation for Planning Suitable Sustainable Waste Management in Nigeria. International *Journal of Emerging Engineering Research and Technology*, 5(8), pp. 1-9

Orhorhoro, E.K., Orhorhoro, O.W., Victor, E. (2018). Atumah, Performance Evaluation of Design AD System Biogas Purification Filter. *International Journal of Mathematical, Engineering and Management Sciences*, 3(1), pp. 17–27

Oseni, B. (2012). Municipal Solid Waste Management in Developing Countries (Part II), Environment of Nigeria. [online] available from <http://nigeriaenvironment.blogspot.com.ng/2012/12/municipal-solid-waste-management-in_11.html?m=1> [30 January, 2017]

Taopo (2013). 8 Reasons Why Waste Segregation is Important. [online] available from <http://www.taopo.org/microsites/wastedma nila/collection/8-reasons-why-waste- segregation-is-important/> [15 November, 2017]

Sabejeje, A. J., Oketayo O.O., Bello, I.J and Sabejeje, T. A. (2014). Elemental analysis of leachates from open-dump-solid wastes in Ondo State, Nigeria: Implication on underground water and surface water safety. *American Journal of Research Communication*, 2 (10), pp. 287-296

World Bank (2003). Thailand Environmental Monitor 2003. A Joint publication of the pollution Control Department, Royal Thai Government. The World Bank, US Asia Environmental Partnership.