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Life-Cycle Assessment of Municipal Solid Waste in Selected Landfills in Ibadan

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Abstract

Increased municipal solid waste generation due to rapid urbanization of Africa cities is contributing to global warming. Life-cycle assessment of municipal solid waste was carried out in two selected landfills in Ibadan, Nigeria. The environmental impact index of Global Warming Potential (GWP100) for two waste management scenarios: landfill and incineration were evaluated using $GaBi_6$ package. Biodegradable components of the MSW constitute approximately 47%. The GWP for landfilling and incineration are 24.33 and 15.20 kg (CO_2-equivalent) respectively. In order to reduce global warming impact, incineration waste management technique is preferred to landfilling in the area of study. The methane gas emitted from landfilling could be tapped as alternative energy source for small and medium enterprises in the locality.

Introduction

Many cities in Africa are experiencing a steady rise in municipal solid waste (MSW) generation due to urbanization, economic growth and increase in population. The rapid urbanization is reported to likely raise the rate of production of waste by as much as 1.0kg per capita in 2020. It is reported that Accra, Ibadan, Dakar, Abidjan and Lusaka generate waste in the range of 0.5 to 0.8 kg/capita per day (Simelane and Mohee, 2012); waste density ranged from 280 to 370 kg/m^3 (Ogwueleka, 2009). This is likely to raise the daily rate of production of waste by as much as 1.0 kg per capita in 2020. The increase in waste generation will further increase the challenges presently being faced by the African cities in effective waste management.

Innovative management techniques and strategies should therefore be employed to promote proper management and disposal of MSWas already being practised in many developed nations.

Life cycle assessment (LCA) is a management technique that is gradually being used in sustainable municipal solid waste (MSW) management. LCA technique considers the entire life cycle of products and services from cradle to grave, in other words, from acquisition of raw materials, going through production and use until the disposal of the residues (Al-Salem and Lettieri, 2009). LCA assesses the use of resources and the release of emissions to air, water, land and the generation of useful products (Abeliotis, 2011). Over the past years, many LCA models have been developed for addressing MSW management. Most of the computer models are used to facilitate the modelling of the waste management systems and the calculation of environmental emissions and impacts (Banar *et al.*, 2007;Cleary, 2009; Ojoawo *et al.*, 2013).

The LCA models are also used as tools to aid waste management practitioners in the collection, organization and analysis of data. Opportunities for environmental improvements are also identified through the use of LCA models (Finnveden *et al.*, 2005). In this study, comparison of municipal solid waste management strategies of Apete and Lapite dumpsites in Ibadan metropolis was carried out using the life cycle assessment (LCA) approach.

Materials and Methods

The data on MSW generated and disposed in the community was determined through a field survey. Representative samples of MSW were collected randomly from Apete and Lapite landfills in Ibadan in September, 2013. Field visits and reconnaissance survey showed that Apete and Lapite landfills lie approximately on 25 and 20-hectare land respectively. However, large portions of the two sites are not utilized. The two landfills serve four local government areas: Ido, Ibadan North, Akinyele and Ibadan North-East.

Characterization was carried out based on ASTMD 5231-92 (Standard Test Method for Determination of Composition of Unprocessed Municipal Solid Waste. The MSW sample was homogenized by dividing the sample into four portions and discarding two portions then repeating the procedure until a significant

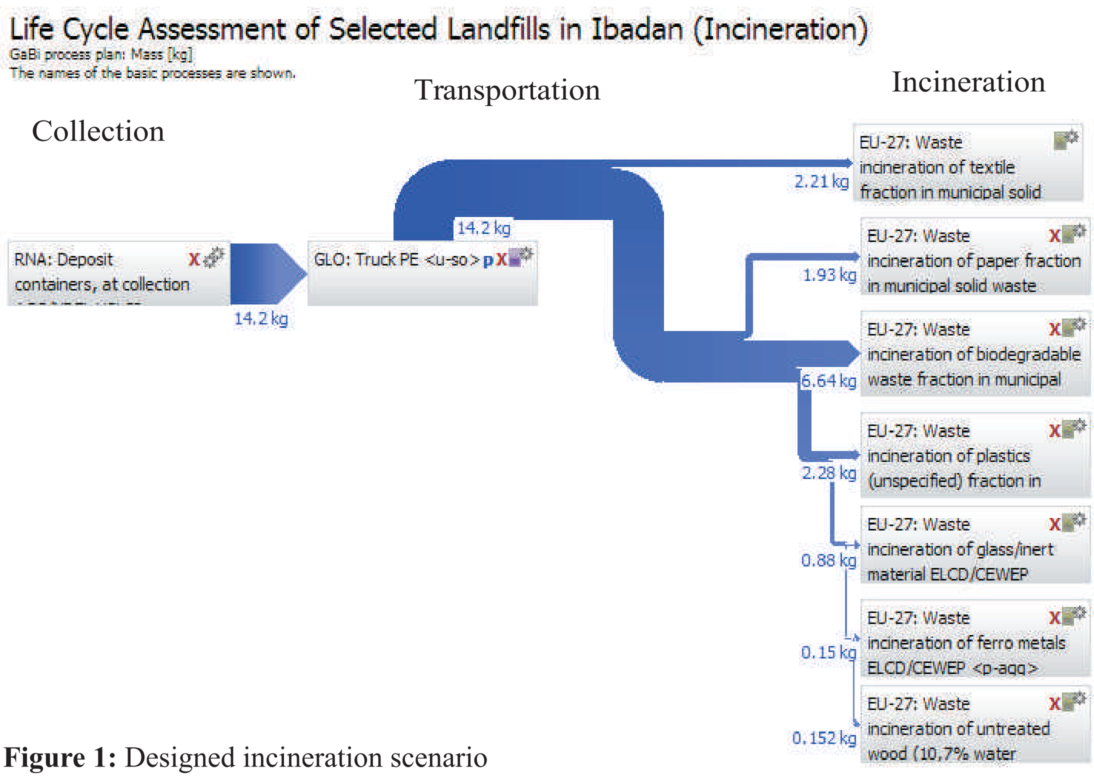

Figure 1: Designed incineration scenario

weight sample of 100 kg was obtained. The waste was sorted into individual components such as biodegradable, plastic, paper, textile, wood, glass and metal, and their weights determined. Analysis of the field data obtained was carried out using $GaBi_6$ LCIA software.

The $GaBi_6$ software is developed in accordance to ISO 14040 and ISO 14044 standards and allows for data management and analysis. Primary data were generated from the waste characterization carried out in the study area. The secondary data were derived from the database of the application.

Two scenarios: landfilling and incineration were designed for the study. The basic steps involved collection, transportation, landfilling or incineration as illustrated in figure 1 for the incineration scenario.

The Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) of the United States Environmental Protection Agency was employed to study the LCIA for the two scenarios.

Table 1: Typical Waste Characteristization of Selected Landfills in Ibadan

Waste category		Average Mass(kg)	Percentage
1	Food waste	6.64	46.6
2	Paper	1.93	13.6
3	Plastic	2.28	16.0
4	Glass	0.88	6.1
5	Textile	2.21	15.5
6	Wood	0.15	1.1
7	Tin/metals	0.15	1.1
	Total	14.24	100

Results and Discussion

The typical composition of MSW in the two landfills is shown in Table 1. Over 45% of the waste is biodegradable,16% is plastics; textile and papers constituted 15.5%, paper 13.6% respectively, Other constituents such as wood and metals accounted for less than 5% of the waste. The waste composition is a reflection of the socio-economic and socio-cultural lifestyles ofthe people in the 1area of study: amixture of rural, semi-urban and urban dwellers, as

Table 2: Inputs/Outputs quantities (Landfilling)

Mass (kg)	Biodegradable	metal	glass	paper	plastic	textile	wood	truck
Flows (Total Inputs and Outputs)	543.00	1.41	17.90	160.00	183.00	181.00	12.80	0.08
Resources (inputs)	267.00	0.63	8.59	78.20	90.70	88.40	6.22	
Deposited goods (hazard and radioctive materials)	5.71	0.15	0.91	1.39	2.47	1.53	0.08	0.08
Emmission to air	14.20	0.02	0.19	5.91	1.68	6.82	0.65	0.00
Emissions to freshwater	255.00	0.61	8.18	74.30	87.60	84.00	5.86	
Emissions to seawater	0.05	0.00	0.01	0.14	0.16	0.16	0.01	
Emissions to agric. Soil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Emissions to industrial soil	0.03	0.00	0.00	0.01	0.01	0.01	0.00	

observed by Akintayo and Olonisakin (2014).

The input and output data for the landfilling scenario using the existing data base in $GaBi_6$ software are shown in Table 2. Figures 2 and 3 are for the different waste components. The input resources included the materials and energy used (renewable and non-renewable), measured in kilogram. The analysis showed that the energy used for biodegradable waste in landfilling (267 kg) is higher for incineration (49 kg). The result of incineration scenario shows that higher energy is required to incinerate plastics waste than any other waste components as shown in Figure 2.

The most significant emission to freshwater occurs during the process of landfilling biodegradable waste. The highest emission to air resulted from the incineration scenario and it occurred most at the incineration of plastic waste components, which has the highest value. Therefore, considering energy usage, incineration technique is preferred to landfilling.

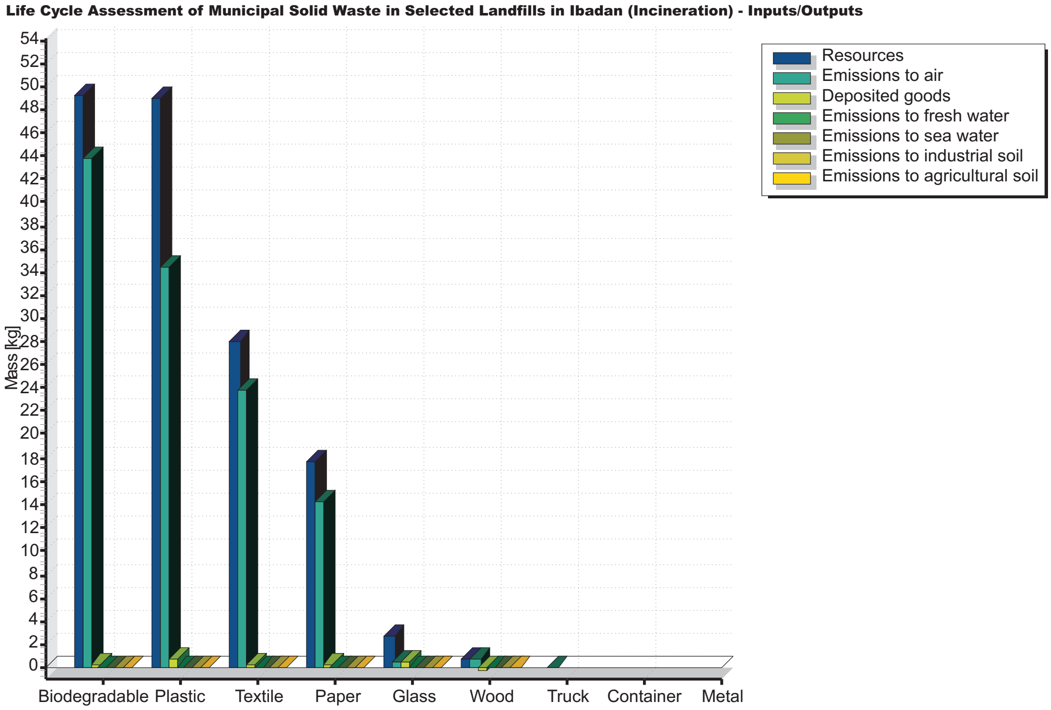

Figure 2: Input/output chart for incineration scenario

The GWP impact using the TRACI method for the two scenarios are shown in Figures3 and 4. The landfilling scenario had the highest impact (24.33 kg CO_2-equivalent) on global warming with the biodegradable waste contributing about 48% (11.56 kg) of this value. The plastic component contributed most to global warming (5.19 kg) for incineration scenario which has a total impact of 15.2 kg.It can be deduced from these results that incineration technique is preferred over landfilling for the study area given that it produced the least impact to global warming.

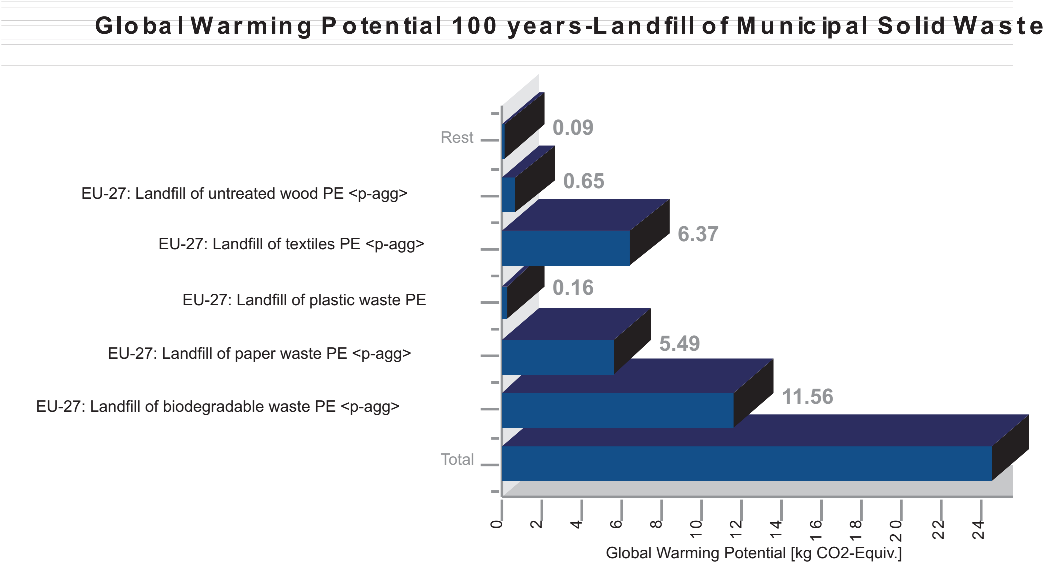

Figure 3: Global warming potential for landfilling

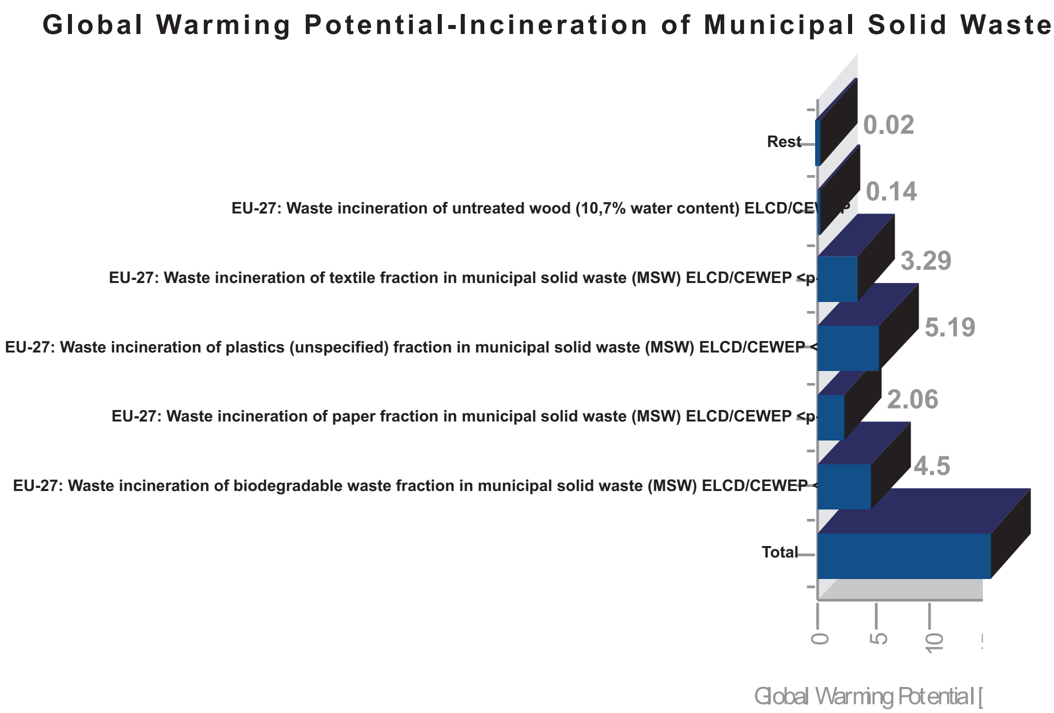

Figure 4: Global warming potential for Incineration

Conclusion

The overall results show that incineration technique is preferred to landfilling in the study area since it contributed less to global warming. However, if landfilling is to be considered for the study area, energy from the biodegradable component of the waste can be tapped for valuable uses. The result of this study is in agreement with Finnveden *et al.* (2005) that incineration is in general preferred to landfilling with regard to overall energy use, emissions of gases contributing to global warming and the total weighted results.

References

Abeliotis K (2011) Life Cycle Assessment in Municipal Solid Waste Management, Integrated Waste Management - Volume I, Mr. Sunil Kumar (Ed.), ISBN: 978-953-307-469-6, InTech, DOI: 10.5772/20421. http://www.intechopen.com/books/integrated-waste-management-volume-i/life-cycle-assessment-in-municipal-solid-waste-management.

Akintayo FO and Olonisakin OA (2014) Methane Generation Potential of Municipal Solid Waste in Ibadan. Nigerian Journal of Technology (NIJOTECH) 33(1): 49-53

Al- Salem SM and Lettieri P (2009) Life Cycle Assessment (LCA) of Municipal Solid Waste Management in the State of Kuwait. European Journal of Scientific Research 34(3): 395-405

ASTMD 5231-92. Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste, American Society Group, www.ipcc.ch/publications_and_data/ar4/wg1/encontents.html. Retrieved on December 5, 2012.

Banar, M et al. (2008) Life Cycle Assessment of Solid Waste Management Options. Waste Management,doi:10.1016/jwasman.2007.12.006.

Cleary J (2009) Life cycle assessments of municipal solid waste management systems: A comparative analysis of selected peer-reviewed literature Environment International 35:1256–1266.

Finnveden G, Johansson K, Lind P, Moberg A (2005) Life Cycle Assessment of Energy from Solid Waste-Part 1. General Methodology and Results. *Journal of Cleaner Production* 13(3):213-229.

International Organization for Standardization. ISO 14040 (2006a) Environmental management-Life Cycle Assessment- Principles and framework, second ed. http://www.iso.org/home.htm.ISO 14040.

Ogwueleka TC (2009) Municipal solid waste characteristics and management in Nigeria. *Eng* 6(3): 173- 180.

Ojoawo SO, Abayomi A (2013) Life Cycle Impact Assessment (LCIA) of Modeled Solid Wastes, Landfilling and Incineration in Oriire Local Government Area, Nigeria. A Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 4(2): 359-367.

PE-International (2013) Introduction to LCA and Modelling Using GaBi Part 1. Retrieved June 15, 2014, from http://pe-international.com.

Simelane T, Mohee R (2012) Future Direction of Municipal Solid Waste Management in Africa: Policy Brief. Africa Institute of South Africa (AISA). Briefing No. 81.

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