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ScienceDirect

Procedia Manufacturing 35 (2019) 613–622

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

2nd International Conference on Sustainable Materials Processing and Manufacturing (SMPM 2019)

Municipality solid waste management system for Mukono District, Uganda

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Abstract

Solid waste management (SWM) poses a great concern to researchers and academia globally. The result of inadequate waste disposal scheme threatens human settlement both in the urban and rural dwelling, and the environmental and social impact worsens as world population increases. There is no doubt that every person is an essential contributor to this problem. Regardless, to generate waste is one thing, the type of waste generated is another, and yet also the way it is generated, managed or disposed-off, entirely a different issue. The present study uses a quantitative research approach and collects data from Mukono town which is located within east of the central business district of Kampala. In this community, there are challenges of lean assets to administer their solid wastes, leading to unrestrained dumping, also poor management of wastes, thereby contributing to environmental pollution, and the spread of diseases, land degradation, and unhealthy living. The research evaluates, analyzed and characterizes the composition of the existing SWM practices in Mukono municipality. The results show that up to 50000 m^3 of composting landfill space is required to handle the solid waste disposal of not less than 25023.6 tons generated in Mukono district. The research also recommends ways to alleviate some of the present solid waste management concerns.

Peer-review under responsibility of the organizing committee of SMPM 2019.

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2351-9789
Peer-review under responsibility of the organizing committee of SMPM 2019.
10.1016/j.promfg.2019.06.003

Keywords: Solid waste management; Environment; Mukono; Landfill

1. Introduction

Globally, SWM is among the significant environmental health problems and continues to affect local authorities and Governments of various nations as urban migration continue to rise [1–4]. A prediction which we now see unfolding. "Cities will generate up to 1.3 billion tons of solid waste per year, and the volume of these waste shall continue to rise up to 2.2 billion tons by 2025,'' of which will become twice the value for developed countries [5]. Uganda, like many other developing countries, are facing rapid urbanization of 4.5% per annum [6]. These have led to permissible and the growth of slums that are inadequate and lack necessary services and infrastructure, characterized by poor solid waste management. These led to various environmental risks including contamination of useful land areas and ecosystem degradation, groundwater, soil, and GHG emissions [7], especially during anaerobic decomposition of some specific waste. In these municipality, poor guidance have resulted to land erosion, air pollution, and spreading of diseases and unhealthy living conditions such as respiratory ailments and diarrhea, and leading to gross economic and social losses [8,9]. The practice of solid waste disposal in Mukono town, like in most urban areas in Uganda is such that, wastes are release in gardens, open dumps, and fields, along with the road side and channels. The district is therefore faced with a big challenge of SWM, and has come out as a governing environmental problem, which calls for investigation to ameliorate the causatives.

An economic and media debate over the years has developed into an independent discipline on the matter of waste management. The theoretical approach to the subject identifies seven major compostions of the solid waste management system [10]. The waste generated includes activities in which materials are pinpointed as no longer of any value and so are either thrown away or gathered together for disposal. In the late 1990s, it was estimated that each person in the world generated 200 kg of solid waste per year and this was forecasted to increase as population global population figure increase [11,12]. The Mukono community has lack of resources for efficient management of the waste generated, specifically with regards to the delays in waste collection and disposal. The current solid waste management practice is poor as it is characterized by indiscriminate dumping of waste and non-separation of waste at both source and final disposal unit. The purpose of this research is to evaluate and analyze the existing solid waste management in Mukono municipality and designed an adequate solid waste disposal system adoptable in Mukono, and scalable globally in developing cities.

2. Methodology

2.1. Study area

The resarch was conducted in Mukono town which is approximately 27 kilometers (17 mi) east of the central business district of Kampala. It has a population of about 50,000 people occupied in various business undertakings from the educational institutions, trading, hotel industry, open markets for fresh foods, carpentry, motor vehicle repairs, and wood works in addition to hospitals [13]. This research deals with comprehensive evaluation that is well organized to achieve the earlier mentioned research objectives. Various approaches were attempted such as questionnaires, interviews, document review, public consultation, site visits or observation, weighing and separation process of the solid waste.

2.2. Document review

Documents were readily available relating to Mukono Municipal Council (MMC), and information concerning the immediate neighborhoods were reviewed. The waste generation factors include: population,

economic activities, area, real land use and suggested plans among others. More documents which were reviewed and included the Mukono District State of Environment Report, documentation of waste management in other municipalities, and legislation applicable to waste management.

2.3. Site visits and observation

Transect walks were conducted through the proposed site and neighborhood, assessing site suitability and the likely socio-economic and environmental impacts due to the possible implementation of a waste management project. Hence the researcher was able to underscore some observation in light to the physical environment, and the likeliness to organize the waste collection, with inferences on possible pathways to do so.

2.4. Data collection and sampling

The research questionnaire was developed in English and translated to *Luganda*; the local language approach was adopted to ensure that sufficient interaction with more respondents and to bridge communication gaps. The questionnaires were administered to two categories of respondents; the technical people or professionals responsible for solid waste management in MMC and the generators of solid waste in the Municipality (residents, road commuters and market dealers). It allowed us to assess separations, waste storage, and disposal practices and their concerns regarding inadequate solid waste management such as environmental pollution, increase in diseases, and vector populations. Also, the general opinions and willingness to participate in solid waste composting, separation, and recycling should the need arise.

2.5. Public consultations

General consultations were made with the public and leadership of Municipal Divisions especially Mukono Central division to capture information on the acceptability and viability of the project, and on the effectiveness of the waste collection and management system in the municipality. This was done through a check-list assessment of the responses/information received from individuals interviewed privately.

3. Result and discussion

This section presents the research findings, data analysis and discussion of results. Result showed that the waste generated from the MMC and the immediate catchment constitute of over 33.3% plastics especially at low-density polyethylene with the rest (glass, clinical debris, waste paper, vegetable food, wood savings, ash, and clothes) comprises of about 66.7%. Currently, the MMC releases waste on an open gazetted ground, about 15 hechares of land at Katikolo village. The societies around the Municipality and its nearest neighborhood that does not have opportunity to handle waste infrastructure, these wastes were dispose along the road side verges and channels. The waste segregation is not practiced. This community has low support and facilities for efficient utilization of waste generated, hence the delays in waste collection and disposition. This study will serve a ways of reducing or eliminating waste management within the MMC. The current solid waste management practice is weak as it is characterized by indiscriminate dumping of waste and non-separation of the garbage constituent at both source and final disposal unit. The authors cite the primary source of solid waste in Mukono Municipality to include; households, shops, offices, institutions, religious places, schools, colleges and marketplaces and proffer strategies in the conclusion section on waste organizing and management.

3.1. Storage and collection

The MMC are responsible for collecting the waste and associated with three different departments such as engineering, health and environment. There are various collection centers around the municipality. Municipal garbage skips are customarily placed at strategic locations for convenient access, and used by the neighboring communities, complemented by individual containers provided by the council at strategic locations. An average of 6 to 8 trips of solid waste skip trucks weighing about 28 tons are officially collected per day. These represent only 30% of the total waste estimated to be produced per day in Mukono Municipality. The remaining 70% of the solid waste produced is used, partially collected, recovered and recycled casually or as wastes which accumulate at the provisional storage positions, and transfer stations from where it is washed into the drains. Most of the solid waste which is collected from Central Business District (CBD), covering the whole of Mukono Central Division, are recovered through personnel who sweep and transfer the wastes in using wheelbarrows to the Central solid waste transfer stations; the first, which is located in front of the central market in Mukono Central (Fig. 1b) and the second which is located near the taxi park in katikolo village Usually, between 4 to 6 skip loads of garbage are collected per day from in front of the central market alone.

Fig. 1. (a) Transportation of solid waste (b) Waste storage point at Mukono main market (c) Disposal of solid waste

3.2. Solid waste transportation

The Mukono Municipal Council Solid, Waste Transport System, is comprised of a skip lorry; a multi-compartment refuse truck and a small tractor donated by the Member of Parliament for Mukono Municipality and tippers that are occasionally hired during significant solid waste removing operations such as to Keep Mukono

Clean campaigns and contractors engaged by Divisions. The skip lorry is used for ferrying filled garbage skips to the open dumpsite situated in Katikolo village along Mukono-Jinja road. The tractor transports waste from hot spots where garbage is accumulated to the open dump site (Fig. 1a). Skips are filled during working hours and carried away using the self-skip loading truck every morning between 7 a.m. to 12 p.m. The skip lorry and tractor usually work from Monday to Saturday. In of a lorry failure, tractors are deployed for emptying filled garbage skips. The tractors are sometimes used for road works and water supply. Moreover, it is also used for emptying the removable metallic bins placed along the main street and fixed twin metallic garbage demonstration bins placed by Mukono Municipal Council in selected public offices, schools and open spaces. More so, the tractors are also sometimes used for transporting construction debris and other large-scale solid wastes such as kiosks among others.

3.3. Disposal

The disposal system used in Mukono municipality is non-energy recovery which includes free open dumping where disposal of solid waste is done without any control or treatment posing threats to the nearby low-lying areas as shown in Fig. 1(c). This system is discouraged because it facilitates breeding of vermin and pathogens, and generation of noxious gasses leading to unbalance to the ecosystem, treat to land security and socioeconomic loss.

3.4. Nature and composition of the solid waste

The residue comprises of food waste, paper, cow dung, plastics, metal, glass, syringe, street cleaning, wood and wood shavings, rubber, leather, and clothes among others. The nature and composition of solid waste generated within Mukono municipality is grouped into; Residential waste, commercial waste, municipal waste and institutional waste. Commercial residues contribute up to 62% of the waste collected, while domestic wastes measure up to 16%. Institutional wastes added 12%, and Municipal service waste contributes only 10% of the total waste collected. The details idealized from the questionnaires issued out to the respondents and these wastes were separated and measured using weighing balance and presented in percentage weight proportion, shown in Table 1.

Table 1. A dataset of Solid wastes collected in Mukono District in Uganda

Composition	Number of Respondents	Percentage Composition (%)
Polythene	40	33.3
Bottles	4	3.33
Clothes	3	2.5
Metals	4	3.33
Glass	2	1.67
Leather	3	2.5
Grass	7	5.83
Cow dung	2	1.67
Ash	4	3.33
Peelings	10	8.33
Syringe	5	4.17
Construction debris	3	2.5
Waste food	20	16.67
Papers	13	10.83
Total	**120**	**100 %**

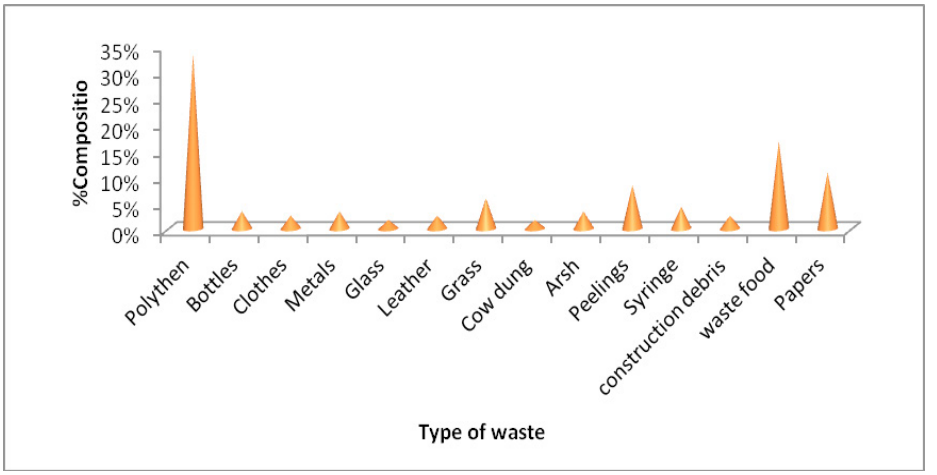

Fig. 2. Percentage weight composition of solid waste collected in Mukono District in Uganda

3.5. Determination of per capita contribution

3.5.1. Population data

The Sub-National Projections 2005 – 2015 report, Central Uganda; the population of Mukono municipality was estimated in two different years as follows: the total number of people in 2005 was 81,790 inclusive of 40,398 males and 41,392 females, while in 2016 the projected population was up to 114,263 people [14].

3.5.2. Amount of solid waste generated

In tropical African countries, the solid waste generated is 0.6 – 1.0 kg/person/day and the mean European production is 1.2 kg/person/day [14].

Given that the population currently in Mukono municipality is 114,263 people, and from the Equatorial African countries generation rate of 0.6 – 1.0 kg/person/day. Uganda being a low-income country, the waste generation rate is estimated at the range of 0.4 – 0.6 kg/person/day [15].

Taking the generation rate for Mukono municipality to be 0.6 kg/person/day,

Therefore, the amount of solid waste generated is

$$0.6 \times 114{,}263 = 68{,}557.8 \text{ kg/day}.$$

Amount generated per year is

$$(68{,}557.8 \text{ kg/day}) \times 365 = 25023597 \text{ kg or } 25023.6 \text{ tones}.$$

3.6. Design of solid waste management

3.6.1. Population

The total number of people in 2005 was 81,790 while in 2015 the projected population was up to 114,263 people (office of the district planner)

Using geometric progression relationship in equation 1;

$$P_n = P_i\left(1+\frac{r}{100}\right)^n \quad (1)$$

$$114263 = 81790\left(1+\frac{r}{100}\right)^{10}$$

$$\frac{114263}{81790} = \left(1+\frac{r}{100}\right)^{10}$$

$$1.3970 = \left(1+\frac{r}{100}\right)^{10}$$

$$r = 3.4\%$$

Where;
P_n = projected future population after n years
P_i = initial population in the base year
r = estimated annual population growth in percentage (%)
n = number of years (taking design of 20 years)

Population projection for 20 years taking 2015 to be the base year will be;

$$P_n = 114{,}263\left(1+\frac{3.4}{100}\right)^{20}$$

$$P_n = 114{,}263\left(1+\frac{3.4}{100}\right)^{20} = 223{,}006 peoples$$

3.6.2. Waste generation

Waste generation rate is 0.6kg/person/day

Using current population of 114,263people

Amount of waste generated in a year will be, (0.6 kg/day × 114,263) × 365 days

25,023,567 kg

25023.6 tons

The volume of landfill space required = [(waste generated) / (density of waste)]
For waste densities (wet weight basis) of a low-income countries range of between 250-500 kg/m.
Hence, considering 500 kg/m

The volume of landfill space required:

$$= \frac{25023.6}{500} \times 1000 = 50 \times 10^3 m^3$$

3.6.3. Required land area

A planning restriction limits the height of the landfill to 10m
If the height is 10m,

Therefore, required land area = volume of landfill space required/height of the landfill

$$= \frac{50 \times 10^3 m^3}{10m}$$

$$= 5000\text{m}^2$$

$$= 0.5\text{ha}$$

This value will need to be increased by about 50% to allow for daily cover, road, receiving areas and fencing

$$\text{Required area for 20 years} = 0.5 \times 25 \times 1.5$$

$$= 15\text{ha}$$

3.6.4. Sizing the landfill

$$15\text{ha} = 150000\text{m}^2$$

Hence, the landfill dimensions are 500m × 300m × 10m

Take the length to be 500m

$$\frac{150000}{500} = 300\text{m}$$

3.6.5. Sanitary landfill

A trench of size $l \times w \times h$ (by length, width, and height respectively) is cut in the ground. The bottom of landfill is aligned with a network of plumbing that functions as a collection system of any liquid. When the landfill is done, wastes are placed into the landfill and then the wastes compacted. The landfill is organized in layers; the layers are always alternating between the wastes and the soil. This alteration reduces odors and also allows rapid decomposition of the waste. When the landfill becomes full, it is then sealed and covered using a thick layer of clay, the landfill is then be evaluated and if considered safe, then the space is used for other purpose like a parking for vehicles, sports arena or open space for horticultural practices.

4. Recommendation

Appropriate technologies in line with the nature of garbage generated needs to be explored. These could be used in conjunction with the present existing approaches but the possible options may rely majorly on composting. Since a large percentage of waste is polyethylene, efforts should be made to enlighten households about organizing their wastes. In the case of non-biodegradable waste, since polyethylene are generated in such significant and growing quantities, and yet without any immediately foreseeable solution, one option could be to convert them to energy, through the use of combustors or incinerators. These would serve in the meantime as other solutions are sought off. The other option would be to recycle the polyethylene. Regardless, the limitation with this option is that recycling firms may prefer them neat, yet those dumped are often dirty and difficult to clean. Landfills are necessary component of any municipal solid waste management system. Despite the capacity and environmental concerns associated with landfill operation, every waste management system must still have access to a dump. Source reduction and recycling, including composting is essential to divert significant portions of the solid waste stream

from final disposal, but not all materials are recyclable. Combustion of solid waste significantly reduces waste volumes, but even the most advanced facilities must dispose of residues (i.e., bottom ash and fly ash), and wastes may have to be removed during plant shut-down. Decision-makers must, however, work out sustainable strategies and legal policies to conserve existing landfill space or develop and site new ones, both of which could force a redefinition of the local waste management system**.**

The concept and practice of composting may undergo hindrance due to poor operations, indiscriminate dumping and non-separation of the waste after collection. However, the initiative, when considered for implementation holds vast potential. Hence, a great deal of input concerning time and resources is required to educate and sensitize the community. The Mukono municipality and community's substantial waste management challenge is a growing need that requires immediate solution hence a landfill will be the most viable solid waste management option. Mukono district must, improve on how documents are stored in different departments to facilitate future research in this area.

5. Conclusion

In summary, Mukono Municipal Council has not achieved the optimal level of performance as far as solid waste management is concerned. Though modest improvement has been registered in the middle of the city center, a lot has to be done to keep the entire waste of the city equally clean to prevent serious diseases that accrue as a result of uncollected refuse. The research results and inferences presented analyses on solid waste composition for Mukono municipality; 33.3% polythene, 16.67% waste food, 10.83% paper, 8.33% peelings, 1.67% glass and 1.67% cow dung. The glass and cow dung indicated the minimum constituents, and polyethylene showed the maximum. Solid waste management operation in Mukono is inadequate and lags behind due to insufficient enforcement officers, low composting and recycling. The proper management scenario should incorporate best waste management options in improving environmental quality as well as resource recovery. However, other situations which may reduce the negative impact but not sustainable for the basis implementation include the co-composting of organic solids with human excreta at household or community levels. This is advised for future exploitation as it will lead to a decentralized approach of urban waste management and bioenergy production.

Acknowledgments: The author gratefully acknowledges the financial support provided by German Academic Exchange Service (DAAD) in-country / in-region (**grant no.: 91712001**).

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