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RESEARCH ARTICLE

SOLID WASTE QUANTIFICATION AND CHARACTERISATION OF SELECTED LANDFILLS IN GHANA

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ABSTRACT

Population growth, urbanization and economic development are some factors contributing to an increase in waste quantities and diversification. Characterization and quantification of waste enhances efficient comparisons of different waste management systems .This study sought to investigate the quantity and characterization of land filled waste. Questionnaires, interviews, site visits and hand/manual sorting were done to obtain primary sources of information. This was substantiated with secondary data from books, journals and internet. Information for waste characterization study was obtained using recording sheet developed by Flint off. Three landfill sites (Kpone landfill, Abokobi dump and Nkanfoa dump sites) were selected. Twelve 240 L waste bins were filled with the waste from the landfill. A bin was weighed and its contents were sorted into organic, paper, metals, glass, textiles, plastics and rubber, residues and inert matter. The mass of the sorted fractions were measured with a mass balance and recorded. Average masses were calculated after the process was repeated for the other eleven bins. Organic component which was the highest waste stream in landfilled wastes accounted for about 51.90%, whiles residues had the lowest component (3.22%). Waste sorting and recycling would reduce the amount of waste that end up at the landfill sites.

INTRODUCTION

Solid Waste Management (SWM) is a major challenge across the world and this is mainly due to rapid population growth, urbanization and increasing standard of living. Solid waste streams refer to all wastes generated from municipal, industrial and agricultural activities. When the waste is not properly collected, stored and disposed, it leads to environmental and health problems. In Ghana, waste is disposed without considering its effects on the environment and the society. The methods of disposal limits the use of waste as a secondary resource. There are several methods applied for SWM in developing countries. The most common methods used include reuse, recycling and disposal. However, an estimated 90-95% of all solid waste in developing countries are disposed of in landfills (Schneider and Ragossnig, 2013). Kraft (2010) defined landfills as a waste disposal plant for the disposal of waste above ground. The term landfills is used to describe a unit operation for the final disposal of waste on land, designed and constructed with the minimum impact to the environment (Zhu *et al.,* 2008). Landfills in Ghana can be classified under four main types namely; open dump, improved dump, High Density Aerobic (HDA) and sanitary landfills. Land filling is the most common waste disposal method used in Ghana because it is cheap and convenient. However, landfills in Ghana are poorly designed, constructed and maintained such that they pose severe threats to the environment. Surface and ground water contamination, odours, off-site landfill gas migration and prevalence of disease vectors are some of the threats the landfills pose to the environment. There has been in existence landfill management guidelines designed to assist stakeholders in landfills construction and operation. Adaptation of sustainable solid waste management practices will avert adverse effects on economic efficiency, social equity and the environment (Kgathi and Bolaane, 2001).

Waste quantification and characterisation is essential in providing critical data required when designing sustainable management systems (Al-Khatib *et al.,* 2010). Moreover, when the waste streams are efficiently characterized and quantified, there will be enhancement in the comparisons of different collection systems and cause/effect discussions (Dahlen and Lagerkvist, 2008; Dahlen *et al.,* 2007). Finally, knowledge in waste characterization provides vital information on waste stream to divert for recycling and composting. The study is aimed at the quantification and characterization of Municipal Solid Waste (MSW) streams deposited on selected landfills in Ghana.

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MATERIALS AND METHODS

Research setting

The research was conducted in three Metropolis namely, Greater Accra Metropolitan Assembly (GAMA), Tema Metropolitan Assembly and Cape Coast Metropolitan Assembly. The selection was based on population density and proximity of the metropolis to waste disposal sites. GAMA inhabited 1.84 million people according to the population census conducted in 2010. It has a land size of 200 square km and it consist of six sub-metros. It is estimated that 2000 metric tonnes of waste is generated on the daily basis in the Metropolis. Nonetheless, only 1200-1300 of these waste streams are properly collected (Ministry of Local Goverment and Rural Development, 2010). Solid waste generated is mostly collected using the skip and rear loading compaction truck and disposed at Abokobi and Kpone landfill at a distance of 25km and 35km respectively from the city centre.

The Tema Metropolitan areas hosts most of the industrial companies in the country. As at 2012, it had a total population of 402,637 . A total of 376 tons of solid waste is generated daily in the metropolis. 70% of this waste is successfully generated and disposed at the Kpone landfill (Ministry of Local Goverment and Rural Development, 2010). The Cape Coast Metropolis covers an area of 122 square kilometres and it is the smallest metropolis in the country with a population of 169,894. Solid waste generated on a daily basis is 250 tons. 138.55 tons of the waste is collected and disposed of at the landfill.

Study sample selection and data collection

Landfills in the three study areas were divided into three strata; namely engineered, improved dump and open dump landfills. A systematic sampling method was used to select one landfill under each strata which receive only MSW. The sampling resulted in the selection of Kpone engineered landfill, Abokobi improved dump and Nkanfoa open dump for the study. Data on the daily waste landfilled, acreage of the landfill, annual waste intake were collected from Zoomlion Ghana Limited. Regional managers of the study areas granted the research team interviews after an electronic mail correspondence.

The research team adopted a methodology recommended by F. Flintoff in 1984 to conduct the waste characterisation study. The characterisation study was limited to two sites-Kpone and Abokobi- because a study by K. N. G. Rockson *et al* in 2012 revealed that there is insignificant difference in waste stream generated across the country. Twelve 240 L waste bins were filled with the waste using a shovel after it has been deposited on the landfill. Whiles filling, the bins were shoved three times to allow for sedimentation. The bin was weighed and its contents poured onto a tarpaulin designed to withstand the waste characteristics. The contents were then manually sorted into organic, paper, metals, glass, textiles, plastics and rubber, residues and inert matter fractions. The mass of the sorted fractions were measured with a mass balance and recorded. The average masses were calculated after the process was repeated for the other eleven bins. The entire waste characterisation process was completed within two hours after deposition to avoid errors from moisture loss.

RESULTS AND DISCUSSION

Waste quantification

Figure 1 is a graphical presentation of the quantity of waste received daily for the three study areas. It showed that Kpone landfill received the highest amount of waste on daily basis (1,300 tons), followed by Abokobi (400 tons) and Nkanfoa dumpsites (138.66 tons) of solid waste. A recommendation by the EPA on the quantity of refuse a metropolitan city should landfill daily (>150 tons per day) justifies both Kpone landfill and Abokobi dumpsites to serve Accra and Tema Metropolitan cities. Although Nkanfoa dumpsite serves Cape Coast Metropolitan, the quantity of waste it landfilled daily puts it in the class of a municipality. It is estimated that Accra and Tema generate a total of 2248 tons of waste daily of which 75% are deposited at Kpone and Abokobi landfill sites. The amount of waste received yearly at the three sites is shown in Table 1. According to Blight in 1996, landfills can be classified based on their Maximum Deposition Rate (MDR), thus the maximum quantity of waste that will be disposed of in a year during the lifetime of the landfill. Landfill sites with MDR of more than 150,000 tons per year are considered as large landfills, whiles those with less than 150,000 tons and 5000 tons per year are considered to be medium and small landfills respectively. Kpone landfill can therefore be classified as large, whiles both Abokobi and Nkanfoa landfills can be classified as medium landfills. Kpone landfill serves the entire Tema Township and part of Accra making up 57% of the total, whiles Abokobi serves only a small part of Accra representing 18% of the total.

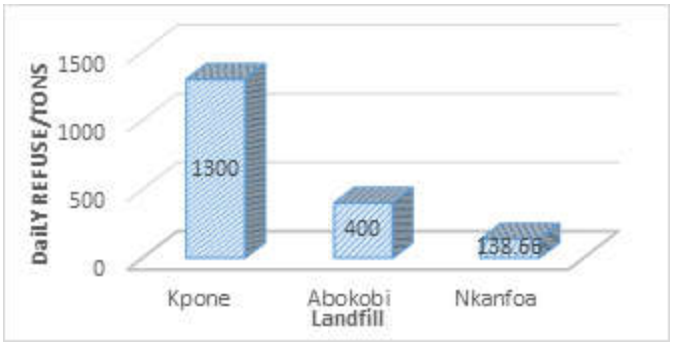

Figure 1. Daily refuse landfilled

A number of factors accounted for the disparity in the volumes of waste each site received. These may include population size relative to volume of waste generation per each household, number of communal containers in circulation relative to the distance users have to cover before reaching the containers. Kpone landfill serves the whole of Tema and part of Accra hence the highest amount of waste it receives daily. Abokobi landfill serves only a small part of Accra. The low collection rate in Cape Coast due to the use of the sea for waste disposal by the communities close to it contributed to the low quantity sent to the Nkanfoa Dumpsite. With regards to waste concentration, Abokobi final disposal site with a total landfill size of 8.1ha recorded the lowest waste concentration of 49.4 tons/ha, followed by Nkanfoa with the lowest land area of 1.6ha, which recorded 86.66 tons/ha. Kpone landfill with the landfill size of 14.6ha recorded the highest waste concentration of 89.0 tons/ha (Figure 2).

Table 1. Quantity of waste landfilled for different landfill strategies

S/N	Name of Landfill	Type of landfill strategy	Size of Landfill (ha)	Average Daily Refuse Received (tons)	Waste Concentration (Tons/ha)	Annual Capacity of Waste Landfilled (Tons)
1	Kpone	Engineered	14.6	1,300.00	89	468,000
2	Abokobi	Improved Dumping	8.1	400	49.4	144,000
3	Nkanfoa	Open dumping	1.6	138.66	86.66	49,920

Table 2. Characterisation of Municipal Solid Waste Landfilled

	% characterization		% Average characterization
	Kpone Landfill	Abokobi Landfill	
Organic	51.4	52.5	51.9
Paper	5	6.5	5.8
Metals	4.1	4.3	4.2
Glass	5.4	5.2	5.3
Textiles	4.2	5.4	4.8
Plastics and Rubber	6.8	6.9	6.85
Residues	3.51	2.9	3.22
Inert Matter	19.59	16.3	17.95

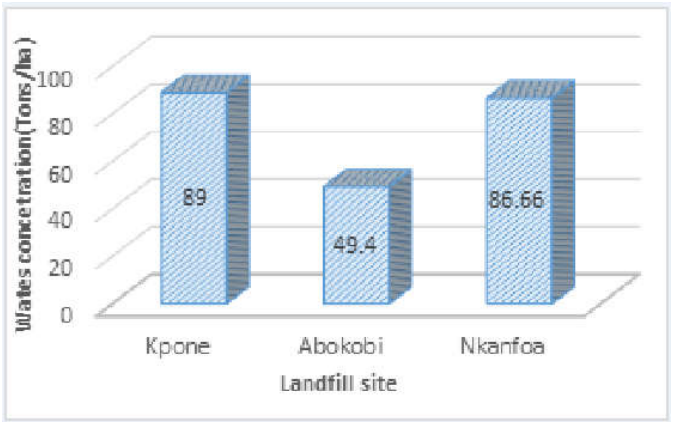

Figure 2. Waste concentration of the three landfill sites

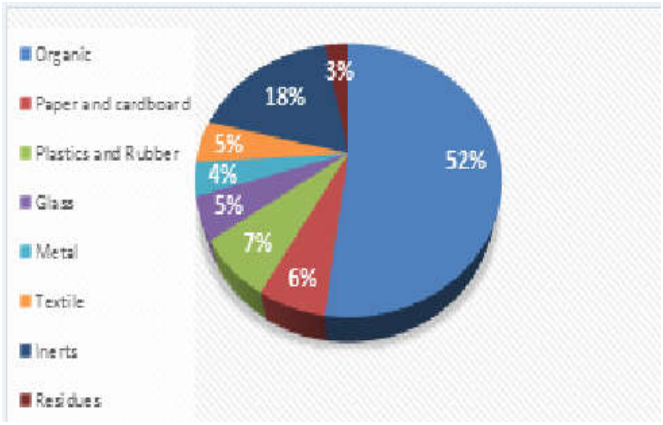

Figure 3. Average percentage characterisation of Solid Waste at the two landfill sites

Better waste placement and compaction methods adopted at Kpone landfill contributed to its high waste concentration.

Characterisation of landfilled waste

Table 2 shows the characterisation of solid waste landfilled for the different landfill types under study. The organic component was the highest waste stream with an average of 51.90%. This figure is within the range put forward by Cointreau, 2010 i.e. 20 – 65% for middle income countries. However, it was moderately lower than the 60% found by Ministry of Local Goverment and Rural Development (2010). This means that decomposition of the waste would be high and the need for landfill operators to compact waste effectively and provide a facility to manage the landfill gas with the aim of reducing odour at the landfill site and the surrounding communities. Leachate from organic seepage water could also be high due to high degradation of the organic constituent in the waste stream. Thus Abokobi with the highest organic content of 52.5% when compared with Kpone (51.4%) could have a higher leachate levels than Kpone landfill. Inert materials recorded an average of 17.95% which is significantly higher than that of MLGRD (2010) which was 11%. The high percentage could be attributed to sweeping dust and dirt together with other waste which enters the collection system. Paper and metals recorded an average of 5.80% and 4.20% The reduction of paper in the waste stream compared to that of 8% found by Ministry of Local Goverment and Rural Development (2010) can be attributed to its low usage as packaging materials. Glass and textiles recorded 5.3% and 4.85% respectively. These percentages were slightly higher than that of Ministry of Local Goverment and Rural Development (2010) as 2% for glass and 4% for textiles. A study conducted by R. Annepu and N. J. Themelis in 2013 in Accra showed that organic waste has the highest percentage. Inerts has the second highest percentage which is in line with our findings, placing inert as the second highest with a percentage of 18. However, glass recorded the lowest percentage (2%) in the study conducted by Annepu and Themelis, whiles residues recorded the lowest percentage (3%) for our study.

Conclusion

Landfilling remain the largest disposal option for municipal solid waste in Ghana due to the higher quantity of generated refuse which is sent to landfills. Engineered landfill (Kpone) received the highest quantity of waste with open dumps receiving the least. Landfill space is better utilised in engineered landfills compared to controlled and open dumps. The high quantity of organics in the landfilled waste present a major challenge to landfill operators to control the high amount of leachate and generated gas. The quality of waste

sent to the landfill should be considered by EPA as important criteria in the development of landfill guidelines if the effect of landfills on the environment is to be curtailed. Waste sent to the landfill contains valuable matter or recyclables such as plastic, paper, metals and glass which could be diverted for reuse or recycling in order to increase its life span.

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