Rate and Quantities of Household Solid Waste Generated in Kampala City, Uganda

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Abstract

The study concentrated on solid waste (SW) generation at households to establish rate of generation, quantities and overall composition. Kampala divisions were purposively stratified according to existing parishes. Areas of data collection were further stratified into three income-groups of low, middle and high using the quality of housing. Descriptive statistics of Statistical Package for Social Scientists (SPSS) was then used to analyze the data. Findings revealed that 846,155 kg/day of household SW was being generated in Kampala at the rate of 0.56 kg/person/day. However, rates of SW generation for the three income groups were respectively 0.29, 0.75 and 1.34 kg/person/day. Post-hoc tests of multiple comparisons revealed significant differences in the mean values of household SW generated between divisions. The average composition of household SW were 83.6% vegetable / organic matter; 10.9% waste paper; 1.2% waste plastics; 0.3% waste metals ; 0.1% glass / cullet materials and 3.9% other materials.

Keyword: Generation, household solid waste, rate, composition, quantities.

Introduction

The rapid increase in volumes and types of MSW as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste (UNEP, 2009). It was estimated that in 2006 the total amount of MSW generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (UNEP, 2009). It was further estimated that between 2007 and 2011, global generation of municipal waste will rise by 37.3%, equivalent to roughly 8% increase per year (UNEP, 2009).

Generation rates for Africa continent's major cities are estimated to range from 0.3-1.4 kg per capita per day (Achankeng, 1995). This gives an average of 0.78 compared to an average of 1.22 kg per capita for developed countries (Beukering et al., 1999). In Egypt, studies indicate that the amount of MSW generated in urban areas is in the order of 24,000 tons per day and in rural areas about 11,000 tons per day, adding up to 35,000 tons per day nationwide (Palczynski, 2002). The garbage generation rate in Cairo is 9000 tones per day (Palczynski, 2002). In Nairobi, Kenya, the total SW generated at present is estimated at 1530 tons per day (Palczynski, 2002) and the SW composition (percentage by volume) estimated by Nairobi City Council

(NCC) Environment Department in the year 2000 were: combustibles 51.5%, metals 2.6%, paper 17.3%, glass 2.3%, plastics 11.8% and others 14.5%.

Little documentation was done in the 1970's and 1980's regarding MSWM in Uganda. According to available data, it is evident that in the 1970's and 1980's garbage pile-ups were not such a big problem as in the 1990's. The National Environment Management Authority (NEMA) of Uganda reported that SW generation rates in Uganda today vary from one urban area to another due to factors such as economic status of the population, social habits, season of the year as well as the extent of salvage and recycling operations (NEMA, Uganda, 2001). Whereas much of the food consumed in the urban center comprised mainly of cereals with little residues in the 1970's and early 1980's, in recent periods the trend has changed. In Kampala, for example, it was estimated that banana peelings, leaves and other forms of organic matter accounted for 70-80% of SW generated (Ngategize et al., 2001).

The average SW generation rate for Kampala was estimated to be about 0.6 kg per capita per day, averaging about 900 tones of wastes per day (KCC, 2000). In another survey carried out in Kampala by Environmental Resources Limited, it was revealed that vegetable matter constituted 73.8% of the total SW generated while non-biodegradable materials accounted for 5.6% (Walyawula, 2004). Unfortunately, there is no data on the composition of household SW in rural areas - it probably consists of more organic matter than that of urban areas (Walyawula, 2004). This study particularly assesses the rates and quantities of household SW generation in Kampala city as an urban area.

Methodology

Study areas

The study was carried out in Kampala and concentrated on the five administrative divisions of the City, (Central, Kawempe, Makindye, Nakawa and Rubaga) shown in figure 1.

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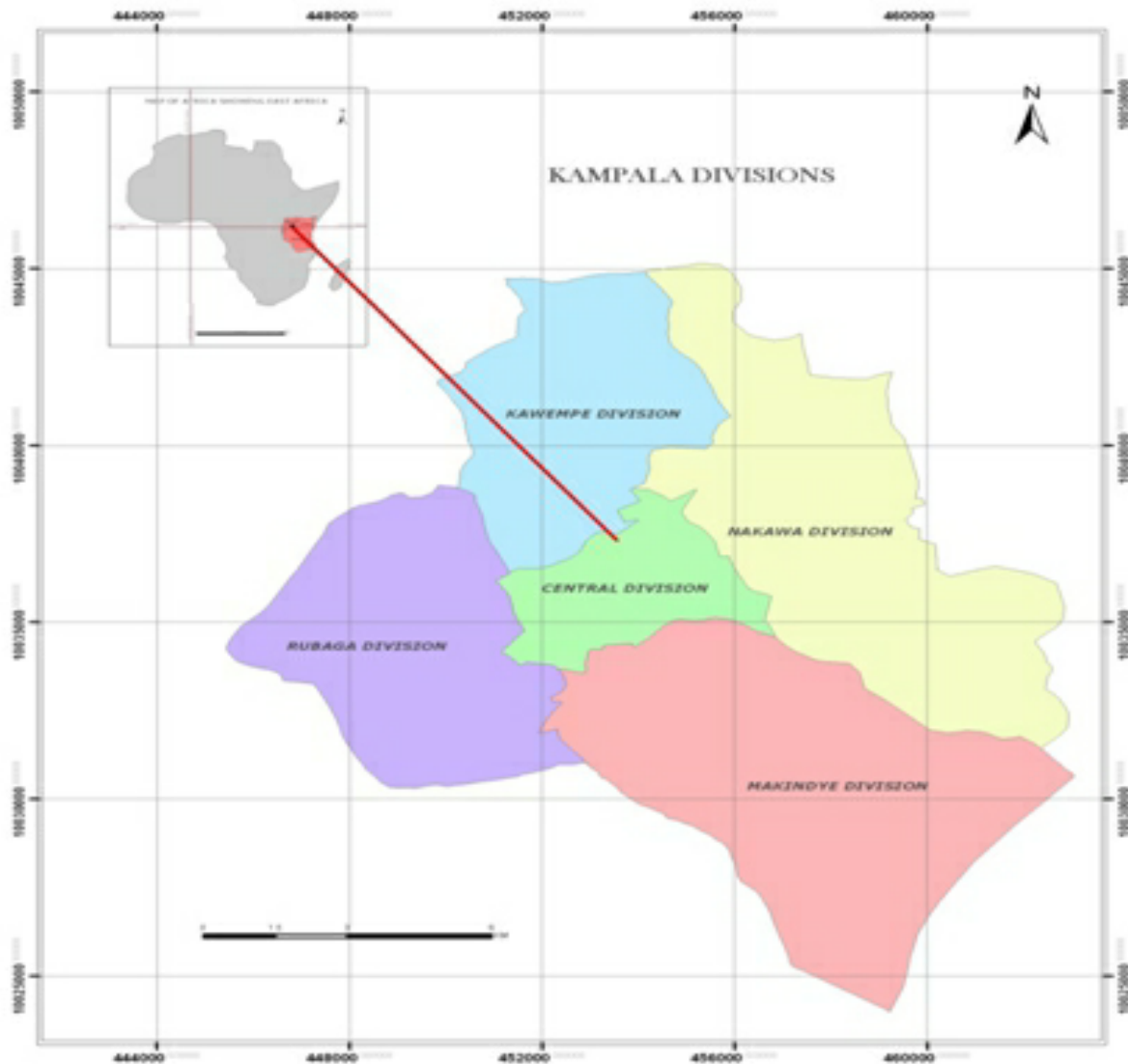Email:ojokjulius08@gmail.com

Figure 1: Map of Africa showing Uganda and Kampala district administrative divisions (Source: UBOS, 2007)

A two-stage sampling technique was employed. The first stage involved the use of purposive sampling techniques whereby the Divisions were stratified according to already existing parishes. The five divisions of Kampala had a total of ninety nine (99) parishes in 2008 when the study was carried out. To ensure maximum coverage, the parishes were numbered clockwise, starting from the top in each divisional map and odd number parishes were taken as sampling units. The second stage involved stratifying the areas of data collection in each of the five divisions of Kampala city into three income groups of low, middle and high using the quality of housing in the absence of any other formal way of stratification and acknowledging the problems of using proxies and unpublished information. This step was very important because WTP for improved SWM involves demand estimation, and its main determinant was expected to be income.

In order to produce both quantitative and qualitative data, a range of research methods covering questionnaires, interviews, observations and document reviews was used in the study (Layder, 1993). During sample data collection, which took place between August 2008 and July 2009, the Research Assistants would toss a coin in each parish to decide on the direction to take during the sampling exercise. A systematic sampling technique was then used whereby every 3rd building in the selected parishes was sampled. However, data collection was characterized by non responses to some questions from households, thus a total of 4015 households were sampled from all the five divisions as indicated in table 1. This fairly large number of samples was to cover up for the non responses.

The SPSS linear regression analyses using descriptive statistics were carried out in the data management.

Table 1: The total samples obtained from the parishes per division at 95% confidence level(CL)

Division	Total Number of Parishes	Number of Parishes Sampled	Samples at 95% CL	Households Sampled
Central	20	10	379	776
Kawempe	22	11	383	1019
Makindye	21	11	383	790
Nakawa	23	14	383	660
Rubaga	13	8	383	770
Total	99	54	1911	4015

Results and Discussions

Rate and quantity of Household SW generated

Table 2 shows the mean quantities of SW generated per person per day in the households of Kampala city as a whole and in each of the Divisions.

Table 2 revealed that Kampala currently has a mean household SW generation of 0.56 kg/person/day, with Rubaga division having the highest (0.74 kg/person/day), followed by Nakawa (0.58 kg/person/day) and Central (0.55 kg/person/day). The table further revealed that Kawempe and Makindye divisions had similar rates of household SW generation per person per day (0.50 kg/person/day, each). Rubaga division had the highest mean overall household SW generation rate of .74 kg/person/day due to high density solid waste generated in households and some commercial undertakings within the household premises. The Division had many cottage industries such as markets, restaurants, metal workshops, wood workshops, motor vehicle workshops and other small scale industrial undertakings, which produced high density SW. The average rate of SW generation for Kampala had earlier been estimated at 0.6 kg/person/day (KCC, 2000). Findings for Central and Nakawa divisions were in agreement with the earlier estimate, while those of Makindye and Kawempe divisions were below and that of Rubaga, above the estimate. However, despite the variations, there are similarities in the daily activities of the households in these divisions, the major occupation being business. Makindye division, having a population of 405,300, (refer to the table in Appendix I) is the most populated of the five divisions. The relatively low rate of household SW generation in the division was probably due to high household populations, resulting into fairly lower standards of living in the households.

When post-hoc tests were carried out, the results of Turkey HSD tests of multiple comparisons, shown in table 3, revealed significant differences in the mean values of SW generated per person per day in the divisions of Makindye and Rubaga ($p<0.001$), Makindye and Nakawa ($p=0.005$) and no significant difference in the mean values for Makindye and Kawempe ($p=1.000$) and Makindye and Central ($p=0.114$). The mean value for Central division was only significantly different from those of Rubaga ($p<0.001$) but not significantly different from those of the other three divisions. However the mean value for Rubaga was significantly different from the mean values of all the other four divisions ($p<0.001$ in each case). The mean value for Kawempe division was significantly different from that of Rubaga ($p<0.001$) and Nakawa ($p=0.003$) but not significantly different from those of Makindye ($p=1.000$) and Central ($p=0.085$. On the other hand the mean values for Nakawa division was significantly different from those of Makindye ($p=0.005$), Rubaga ($p<0.001$) and Kawempe ($p=0.003$) divisions but not significantly different from those of Central ($p=0.842$) division. The significant differences in the mean values of SW generation per person per day between divisions was probably due to the various average incomes of the households in the Divisions, resulting in varying lifestyles and consumption patterns.

Table 2: Mean quantities of household SW generated per person per day in the individual Divisions and Kampala as a whole.

Division	N	Mean SW generated at the different income levels (kg/person/day)			
		Low Income	Middle Income	High Income	Overall Mean
Makindye	766	·3262	·7288	1·2866	·4957
Central	536	·3058	·7655	1·3650	·5526
Rubaga	770	·2701	·7926	1·4176	·7366
Kawempe	957	·2554	·7505	1·2337	·4967
Nakawa	489	·2986	·7291	1·3292	·5790
Total	3518	·2905	·7548	1·3366	·5624

Table 3: Turkey HSD multiple comparisons of mean values of solid waste generated per person per day. Letters a and b denote no significant difference while c denotes significant difference. Same letters denote similarity in the results.

Division	Significance at 0.5 level (p values)				
	Makindye	**Central**	**Rubaga**	**Kawempe**	**Nakawa**
Makindye	–	0.114b	0.000c	1.000a	·0.005c
Central	0.114b	–	0.000c	0.085b	0.842a
Rubaga	0.000c	0.000c	–	0.000c	0.000c
Kawempe	1.000a	0.085b	0.000c	–	0.003c
Nakawa	0.005c	0.842a	0.000c	0.003c	–

From the population data for each division of Kampala presented in Appendix I and mean quantities of SW generated per person per day data in table 2, a summary of the total quantity of SW generated in each division and Kampala city as a whole for the year 2008 was presented in table 4.

Table 4: Quantities (kg) and rate of household SW generated in Kampala in 2008

Division	Pop. in 2008	Rate of SW generation at the different income levels and the Overall Mean (kg/person/day)				Quantity of SW generated	
		Low Income	**Middle Income**	**High Income**	**Overall Mean**	**kg/day**	**kg/month**
Central	109500	·3262	·7288	1·2866	0·5526	60510	1815300
Kawempe	326400	·3058	·7655	1·3650	0·4967	162123	4863690
Makindye	405300	·2701	·7926	1·4176	0·4957	200907	6027210
Nakawa	299500	·2554	·7505	1·2337	0·5790	173411	5202330
Rubaga	367400	·2986	·7291	1·3292	0·7366	270627	8118810
Total	1508100	·2905	·7548	1·3366	0·5624	848155	25444650

A total of 848,155 kg/day of household SW were generated in Kampala in 2008 when the research was conducted. Of this total, Rubaga, the second highest populated division in Kampala, generated the highest quantity of 270,627 kg/day, followed by Makindye, the highest populated division, with 200,907 kg/day. Nakawa, fourth highest populated division ranked third with 173,411 kg/day while Kawempe, the third highest populated division was fourth with 162,123 kg/day and Central, the least populated division, was last with 60,510 kg/day of SW. The corresponding monthly quantities of SW generated per division is indicated in the last column of table 4. A total of 25,445 tons/month of SW were being generated in Kampala in 2008. Rubaga division generated the highest quantity of household SW amounting to 8,119 tons/month as a result of the high population and per capita SW generation capacity. Makindye division was second with 6,027 tons/month mainly due to its high population. The quantities of SW generated by Nakawa and Kawempe divisions were similar (5,202 tons/month and 4,864 tons/month respectively) as their populations and per capita SW generation capacities were also similar. Central division generated the least amount (1,815 tons/month) as it had the smallest population.

In general, SW generation rates in developing or 'low-income' countries average only 0.4 to 0.6 kg/person/day, as opposed to 0.7 to 1.8 kg/person/day in fully industrialized countries (Cointreau-Levin, 1982). It was noted that SW generation rates vary between countries, cities and parts of cities in Africa, depending on the rate of economic developments (Achankeng, 1995). Generation rates for the Africa continent' s major cities were estimated to range from 0.3-1.4 kg per capita per day with an average of 0.78 compared to an average of 1.22 kg per capita for developed countries (Achankeng, 1995). Extreme cases may exist in both situations. According to the World Resource data of 1998 - 1999, the per capita SW generation (kg/day) in some selected African cities were estimated as follows: Porto Novo, Benin - 0.5; Ouagadougou, Bukina Faso -0.7; Bujumbura, Burundi - 1.4; Younde, Cameroon - 0.8; Ibadan, Nigeria - 1.1; Kinshasha, Democratic Republic of Congo - 1.2; Brazzaville, Congo Republic - 0.6; Abidjan, Cote d'Ivoire - 1.0; Cairo, Egypt - 0.5; Banjul, Gambia - 0.3; Accra, Ghana - 0.4; Conakry, Guinea - 0.7; Nouakchott, Mauritania - 0.9; Rabat, Morocco - 0.6; Windhoek, Namibia - 0.7; Niamey, Niger - 1.0; Dakar, Senegal - 0.7; Dar es Salaam, Tanzania - 1.0; Lome, Togo - 1.9; Tunis, Tunisia - 0.5 and Harare, Zimbabwe - 0.7 (Achankeng, 1995). Although extreme cases exist for the Africa continent's major cities, the figures compare well with the case of Kampala where the per capita per day is 0.56.

Composition of SW generated

The average composition of household SW generated in Kampala are summarized in the pie chart in figure 2.
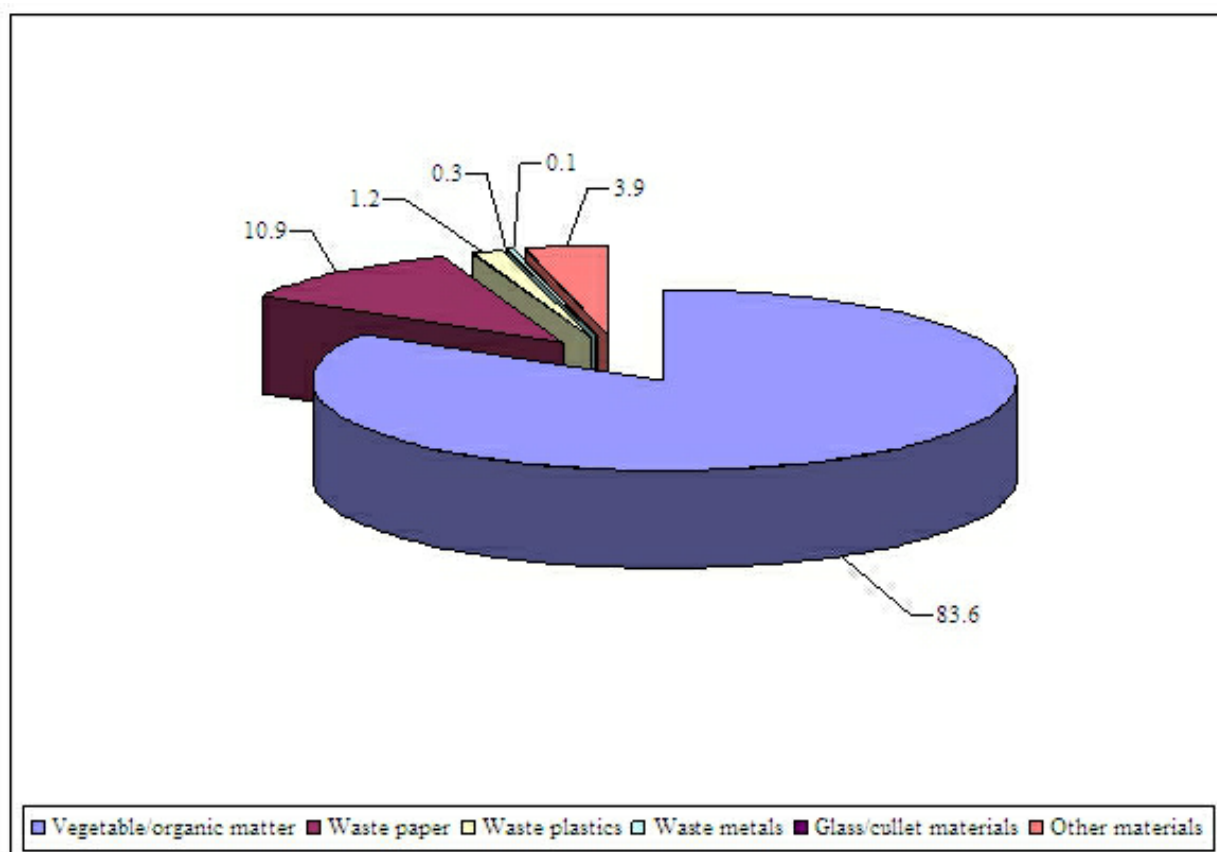
Figure 2: The composition (%) of household SW generated in Kampala.

Vegetable / organic matter was high in average composition (83.6%). This mainly consisted of domestic peelings, cuttings and other vegetable remains of food items such as bananas, cassava, potatoes, cereals, waste food, leaf and grass remains. In most cases, these vegetable / organic matter were found to be mixed up with other assortments of household SW. Waste paper ranked second in average composition (10.9%). These mainly originated from household business premises and offices. Wastes plastics (1.2%), waste metals (0.3%) and glass / cullet materials (0.1%) were in relatively smaller quantities. Other materials (3.9%) were broken pots, enamels, containers other than plastics and metals. Findings from this study were consistent with the situation in the rest of Africa and other developing countries. In Sri Lanka, for example, MSW has a high content of organic matter, moderate content of plastics and paper and low content of metal and glass (Vidanaarachchi et al., 2005). A typical SW composition in Sri Lanka is 66% organic matter, 13% paper, 8% plastics, 3% metal, 2% glass and 8% others (DCS, Sri Lanka, 1998). It is comparable with typical developing country values (Rushbrook and Pugh, 1999). UNEP noted that the organic content of MSW in typical African cities exceeded 70% on a wet basis and that such an output offers opportunities for centralized composting, anaerobic digestion, and gas recovery (UNEP, 2000).

Conclusions

The composition of household SW generated in Kampala city were mainly vegetable / organic matter (83.6)%, consisting of domestic peelings, cuttings and other vegetable remains of food items such as bananas, cassava, potatoes, cereals, waste food, leaf and grass remains.

Kampala city had a mean solid waste generation of 0.56 kg/person/day, with Rubaga division having the highest (0.7366 kg/person/day), followed by Nakawa (0.5790 kg/person/day), Central (0.5526 kg/person/day), Kawempe (0.4967 kg/person/day) and Makindye (0.4957 kg/person/day).

A total of 848,155 kg/day (about 25,445 tons/month) of SW are currently being generated in Kampala city. Of this total, Rubaga division generates 270,627 kg/day (8,119 tons/month), followed by Makindye with 200,907 kg/day (6,027 tons/month), Nakawa with 173,411 kg/day (5,202 tons/month), Kawempe with 162,123 kg/day (4,864 tons/month) and Central with 60,510 kg/day (1,815 tons/month) of SW.

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APPENDIX I

The total projected population and housing in Kampala in 2008, the required number of samples at 95% confidence level(CL) and number of samples obtained per division

Division	2008 Population and Housing Projections		Total Land Area (km^2)	Total Number of Parishes	Number of Parishes Sampled	Required Samples at 95% CL	Number Sampled per division
	Population	Housing					
Central	109500	28313	14.6	20	10	379	776
Kawempe	326400	85651	31.5	22	11	383	1019
Makindye	405300	106494	40.6	21	11	383	790
Nakawa	299500	73795	42.5	23	14	383	660
Rubaga	367400	95756	33.8	13	8	383	770
Total	1508100	390009	163	99	54	1911	4015