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SOLID WASTE GENERATION AND COMPOSITION IN EGERTON UNIVERSITY COMMUNITY

Kariuki, J.M.[1]*, Moturi, W.N.[2], Shivoga, W.A.[3], Kilonzi, C.M.[2] and Kinyanjui, D.N.[1]
[1]Department of Environment and Resources Development, Chuka University, P. O. Box 109-60400, Chuka
[2]Department of Environmental Science, Egerton University, P. O. Box 20115, Egerton
[3]Department of Biological Sciences, Masinde Muliro University of Science and Technology, P. O. Box 150, Kakamega
**Correspondence: makqarix@yahoo.com; 0721-875-810*
jmaina@chuka.ac.ke; dkinyanjui@chuka.ac.ke

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ABSTRACT
Solid waste management is a requirement for any community with management strategies and impacts environmental and human health. For it to succeed, data on waste generation and composition should be availed. This research established the amount and composition of solid waste generated in Egerton University and the surrounding community. It was a cross-sectional survey of 40 households drawn from students, tenants and farmers. Generation and composition was determined using principles outlined by Pfammatter and Schertenleib. Waste generated was generally low for all respondents. Per capita waste generation of 142.31 g for tenants, 70 g for students and 102 g for farmers was lower than the average daily per capita waste generated in low income groups in the urban areas of developing countries. Food waste was the largest component for tenants and students, making up 69% and 73% of total waste generated by weight, respectively. Sweepings (mostly soil) made the largest fraction of waste (93%) of the total waste for farmers. Thus, waste generation was influenced by income with respondents earning highest generating the most. Also, waste composition was characteristic of developing counties with food waste having higher percentage (65%) of all total waste.

INTRODUCTION
Zurbrugg (2003) defines solid waste management as all activities that seek to minimise the environmental and aesthetic impacts of solid waste. It is defined by Pitchel (2005) as a process that comprise the collection, transportation, processing, recycling or disposal of waste materials, usually ones produced by human activity in an effort to reduce their effect on human health or local aesthetics or amenity. Fraser and Gelanis (2003) and Stokoe (1995) assert that waste management aims to reduce the negative impacts of waste on the environment and human health. Since generation of wastes is continuous, management of the waste need to take care of the quantities of wastes produced and their particular properties to ensure that wastes do not become a problem.

The impacts of the waste vary with its type. For example, biodegradable wastes decompose and therefore in the long run, pose no major threat to the environment although in the short term they may cause pollution. Whereas plastics wastes are persistent in nature and remain a problem long after their entry into environment, hazardous wastes require careful disposal measures in order to protect the environment from harm. Anaerobic decomposition of the organic fraction of waste generates methane gas which is a major greenhouse gas. This occurs whenever waste is piled in dumpsites or landfills that lack landfill gas control systems (Bogner, 2007; Fourie and Morris, 2004).

The state of development and income is a good indicator of the amount of waste generated. According to Cointreau-Levine (1997), countries with higher incomes produce more waste per capita with their wastes containing higher portions of packaging materials and recyclable wastes whereas in low income countries, there is less commercial and industrial activity, thus resulting in lower waste generation rates. Cointreau-Levine (1992) reported that the income elasticity of waste generation is 0.1 meaning that a 10% growth in incomes leads to a rise of 1% in the quantity of waste (as cited in Pearce and Turner, 1994: 1). Cointreau-Levine (2006) reported that larger the urban centre and the higher the income level, the high the per capita solid waste produced. For example, for a medium sized and a large sized city in a low income country the per capita waste per day in kilos is 0.35-0.65 and 0.5-0.75 respectively and 0.65-1.5 and 0.75-1.8 for a high income country. In a low income country waste generated in residential areas only was 0.25-0.45 kg waste per day. Troschinetz (2005, as cited in Finn, 2007) avers that cities in the developed world have higher waste generation rates than Third World cities. In the United States, the municipal waste generation rate was estimated at 2.04 Kg /person/day in 2003 while in Western Europe it was 1.51 kg. In some African cities it is less than 200 grams/person/day. In Addis Ababa people living in unplanned and poor housing conditions generate 0.15kg per capital per day of solid waste (Amiga, 2002). The general trend in per capita solid waste generation show an increase over time for instance, in the USA per capita generation was 2.7 pounds per person in 1960, 3.7 in 1980 and 4.7 pounds in 2006 (EPA, 2007b).

The fraction of putrescible organic content in waste generated in developing countries tends to be very high as compared to waste generated in developed countries. According to Palczynski (2002) MSW from Accra, Ibadan, Dakar, Abidjan, and Lusaka shows putrescible organic content ranging from 35-80% (generally toward the higher end of this range); plastic, glass, and metals at less than 10%; and paper with a percentage in the low 10s. Furedy (2004) states that the organic fraction of waste streams typically comprises from 35-70% of total municipal waste generated in large cities of developing countries. Xiao *et al*, (2006) reported that in Beijing, China in 2003, the proportion of organic substances (food waste, paper, plastic, wood and fibre) accounted for 86% of total waste generated. In Kenya the composition of solid waste form low income areas of urban centers was reported as comprising food (57%), paper (16%), plastics (12%), textiles (2%), grass/wood (2%), leather (1%), rubber (2%), glass (2%), cans (1%), other metals (0) others (4%) (Rotich *et al*, 2005).

In developed countries the fraction of waste food is much lower. According to NIR and CRF (2003. as cited in Skovgaard *et al*, 2008) in 27 countries making up Europe, municipal waste in 2003 was composed of 38.9% food waste, 0.3% garden waste, 21.2% paper waste, 1.7% wood waste, 3.0% textile wastes, 10.6% plastics and 24.2% inert waste. In the USA, waste composition data in 2007 revealed paper and paperboard at 32.7%, glass 5.3%, metals 8.2%, plastic, rubber and leather, textiles, wood and other related waste were 27% whereas food wastes was 12.5, yard timings 12.8%, and other miscellaneous waste 1.5% (EPA, 2007). The Intergovernmental Panel on Climate Change (IPCC) (2006) reports that there is general lack of comprehensive data on waste generation in developing countries where most waste generation rate reported only account for the urban population. In the study area, where this study was carried out, there was inadequate data on waste generation and composition making the research necessary.

METHODOLOGY

The physical location, climate, population and economic activities of the study are described. The study was carried out in Njoro Division of Njoro District. It covered communities living in Njoro and Mukungugu sub-locations of Njoro Location. Njoro Division lies between longitudes 35^0 28′ E to 36^0 10′ E and latitudes 00 13′ S to 1^0 10′ S which is to the south-west of Nakuru town. It occupies an area of 313.6 km^2 (Nakuru District Development Plan, 2000). Egerton University (Njoro Campus) is located in Njoro sub-location in Njoro location. Whereas the University is wholly in Njoro sub-location most of the study population is in Mukungugu sub-location (Figure 1).

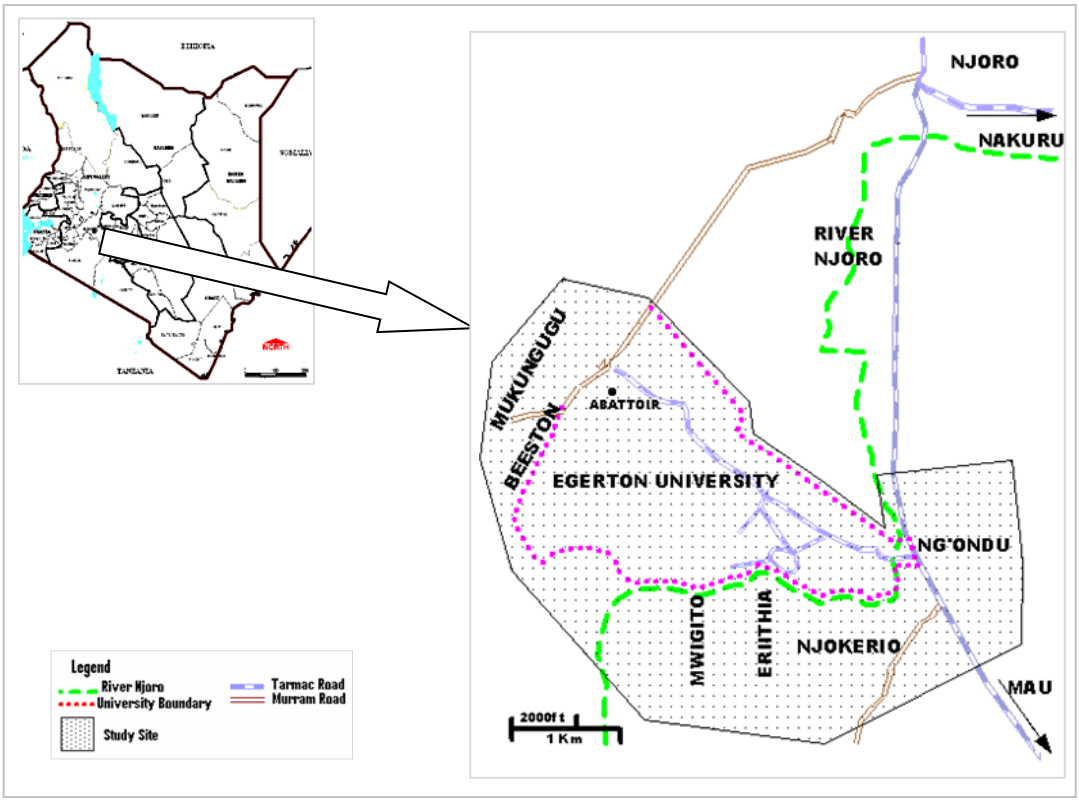

Figure 1: The study area (Source: modified from Google Maps, 2008)

The area is characterised by annual rainfall of between 760 – 1270mm and experiences a bimodal pattern with long rains in April – June and short rains from July – August. The average temperature is 16.5^{0}C and varies with altitude (Nakuru District Development Plan, 2000).

The study area has a high potential area for both cash crops and food crops. Coincidentally the principal economic activity for the land owners in this area is farming. However, due to the closeness to the University the area has diverse business activities. There is also a large pool of employees within the community. The employee provide labour to the University, companies and other institutions like Njoro Canning Factory, Kenya Highland Nurseries (a flower farm), schools and health facilities in the study area among others. This population of employed people necessitate the establishment of housing facilities for accommodation.

The study population occupy Egerton University and the following villages Mukungugu, Beeston, Mwigito, Eriithia, Njokerio and Ng'ondu. The population for Mukungugu sub-location was 12,415 persons as at 2007 (Kenya National Bureau of Statistics, 2007) which was equivalent to 2483 households given that on average a household had five persons. The inhabitants were land owners, employees and the business persons. Most of the land owners are small scale farmers with land sizes from two and a half acres to five and a half acres, for instance, in Mukungugu village the farm size is 2.5 acres whereas it is 2.75 in Mwigito, 5.5 in Eriithia and 0.5 in Njokerio. The farm size in Ng'ondu is a total of 17 acres, with 2 Acres close to the tarmac road (and the University) and 15 acres further away from the road. There are also informal settlements within the study area for instance, Beeston village is densely populated by squatters who originally lived in villages in the forest while taking care of plantation forests but were forced to move out. About 1000 families occupy an area of 82 acres (Area Chief, personal communication, 2007) in the village.

This study design adoptedwas a cross section survey and the sampling frame comprised the population within Egerton University and the neighbouring area in the villages Mukungugu, Beeston, Mwigito, Eriithia, Njokerio and Ng'ondu. The sample was made up of tenants, students and farmers who formed the strata. At the University the sample was included students and staff residing within the University. The sampling unit was for tenants and farmers was households. Systematic sampling was used to get to the next respondent from the starting point. The sampling interval

was obtained by dividing the population with the sample size. Only one tenant in every estate was the subject of the survey.

The subject of the study was the household head of every third house in each plot. It had been assumed the minimum number of rental houses in an estate was not less than three. When sampling University students, the halls of residence were sampled first and then the rooms which were treated as households. The sample size for determining the amount of waste generated was 40 and was determined using the principles outlined by Pfammatter and Schertenleib (1996). According to Pfammatter and Schertenleib (1996), waste quantity and composition of a representative number of households could be determined in a period of one week. A reliable estimate could be made by assessing a minimum of 20 households or 1% of the households in the selected area.

Measurement was used to get information on per capita waste generated and on waste composition. Forty randomly selected respondents were provided with waste containers that collected all the waste generated for a period of seven days and each type was weighed and recorded. For those not using waste bins, 20 litre buckets were provided. Plastic bags liners were also provided which were placed inside the containers. The plastic bag liners with the waste were collected every two to three days. In most households, all the waste was placed in one container. In households that normally separated their waste, the waste was placed in different containers depending on category. The waste was weighed and composition determined after a period of one week.

This process was carried out at the middle of the semester to avoid extreme condition of waste generation at the beginning of the semester and towards the end of the semester with high and low generation rates respectively. This is because at the beginning of the semester the student were bound to produce a lot of waste because of more money. At the end of the semester the amount of money with the students would have dwindled hence less waste generation. At the middle of the semester, the average conditions of the students in regard to waste generation would be captured. This was done in the month of March during the January-May semester, 2009. Ashes were not included in the determination of waste generation rate. The reason for this was that most of the farmers used fuel-wood fireplaces where ashes were removed very occasionally, so it was likely that inclusion of the ashes might not have given the actual rates in a seven day period.

Data Analysis

Waste generated was determined by physical measurement of the waste generated for a period of seven days. This was done for students, farmers and tenants. The analysis was done using Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to present of waste amounts and composition results as means, percentages, measures of central tendency and frequencies.

RESULTS AND DISCUSSIONS

The results of waste generation amounts and composition of waste are presented in this section. Waste generation for the study population was generally low for all respondents. Per capita waste generation of 142.31g for tenants, 70g for students and 102g for farmers was lower than the daily per capita generation in low income groups in the urban areas of developing countries. The amount is lower than that given for low income areas of urban centres, 0.25-0.45kg waste per day by Cointreau-Levine (1996), the general waste per day per capita for developing countries of 0.5kg (UNEP 1995). The amount is comparable to what was reported by Amiga (2002) of 0.15kg per day per person in low income areas and figures given for generation in Nigeria ranging from 0.11kg to 0.78kg in urban centers (Federal Ministry of Housing and Environment, 1982 as cited in Sha'Ato *et al*, 2006: 354).

The per capita waste generated by tenants within the University was greater than for tenants outside the University (Table 1). One of the reasons that could account for this observation was income differences. Tenants within the University earned substantially more than those outside the University earning a mean of KSh 50,375 and KSh 5,055 respectively (Kariuki, 2010). It has been established that the higher the income the greater the amount of waste generated. This applies to countries as well as households. According to Cointreau-Levine (2006) a rise in income by 10% leads to a rise in amount of waste generated 1%.

Table 1: Waste generated by tenants within the University and outside

Strata	Waste per capita per day (g)
Within University	149.17

Outside University	136.62
Mean (weighted)	142.31

Intergovernmental Panel on Climate Change (IPCC, 2006) reported that generation rates reported in most literature in developing countries only account for urban areas. In the study area some waste streams were hardly disposed for instance, waste food, a fact that could be attributed to the mix between rural and urban characteristics of the area. The study site was in a rapidly developing rural area with the communities around the University made up of farmers, businesses, and workers who lived in housing estates. Immediately around the University was the highest concentration of businesses and housing estates interspersed by farmers. Away from the University into the neighbouring community, more farming activities were encountered. This close proximity with farmers led to high reuse of organic wastes in feeding domestic animals. In other places solid waste is primarily valued by farmers in the production of manure. In areas around Ouagadougou, farmers were reported to make informal and illicit arrangements with drivers of the municipal waste lorries to have solid waste dumped near their fields which would then sort out the larger particles and spread out the other waste on the farm before planting (Eaton and Hilhorst, 2003). In Nairobi several community based organisations engage in composting for sale to farmers (Kim, 1998).

Waste Composition

Composition of all the waste generated by farmers, tenants and students was as shown in Figure 2. For farmers, the largest fraction of waste was sweepings (mainly made up of soil particles) that made up 93% of the total waste. Among the tenants, food waste was the largest component, making up 69% of total waste generated. For students, food wastes made up 73% of the total waste generated by weight.

Waste from developing countries has food waste as the largest fraction . reported the fraction as ranging between 35-80% (generally toward the higher end of this range). (Palczynski, 2002; Furedy, 2004) On the other hand, Rotich *et al* (2005) observed that food waste make up 57% of waste generated in low income areas in Kenya. While this information from literature was mainly derived for urban areas, it shows similarity with waste generated from the study location, where food wastes made up over 70% of wastes.

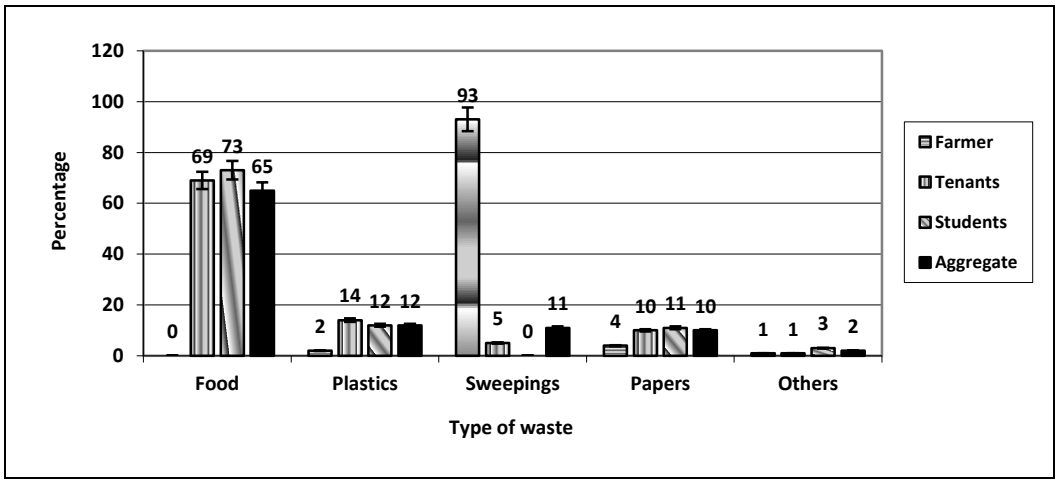

Figure 2: Waste Composition for farmers, tenants and students

Where "Others" include: Clothes, Ceramics, Rubber, Metals, dry cells and Leaves.

As for waste paper, Palczynski (2002) reported that its percentage was in the lower tens in a study in several African cities while plastic were less than 10%. On the other hand, according to Rotich *et al* (2005), paper made up 16% of waste generated while plastics were 12%. The proportion of waste paper and plastics generated by tenants and students was comparable. Plastic waste was 14% and 12% of waste generated by all tenants and students respectively while papers waste was 10% and 11%. The percentage of plastics and papers produced by farmers' households were 2% and 4%, respectively. This is on the lower end of what is reported in literature. In India's urban centres, the percentage of papers was reported as 2% which was the same case for Jakarta (Diaz and Golueke 1985; Yhdego, 1991 as cited in Pierce and Turner, 1994). For tenants within the University, food wastes made up 75% of the total waste, followed by

plastics and papers at 13% and 11%, respectively. Waste produced by the tenants outside the University comprised 64% food wastes, 16% plastics, 8% papers and 10% sweepings (Figure 3).

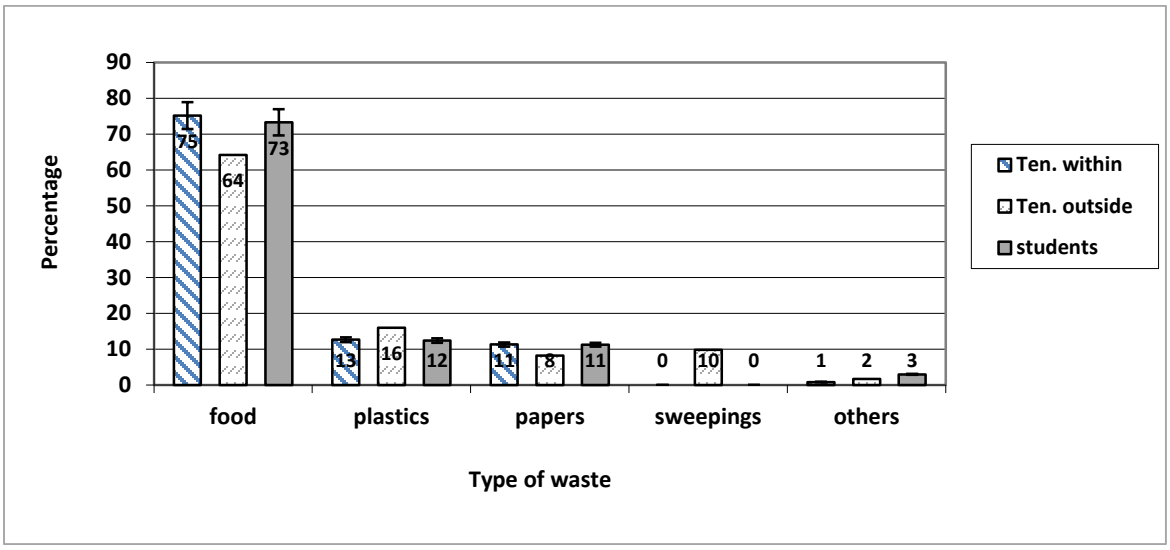

Figure 3: Waste composition for students and tenants within and outside the University
("Others" include: Clothes, Ceramics, Rubber, Metals, Dry cells and leaves)

A closer look at the composition of different waste generators, some observations can be made. Food waste was the major waste stream except for farmers. The reason for this observation was that farmers were able to reuse all the waste food and none was disposed mostly by feeding domestic animals. Tenants living outside the University generated the highest amount of plastic waste. The reason for this could be because of buying products in small quantities that are placed in or packaged in plastics due to relatively less incomes. On the other hand, tenants within the University, because of their average income was high would buy products in a comparatively larger quantity thus less plastic waste per product. The students on the other hand, could have generated a smaller fraction of plastic waste due to economies of scale. This is because a number of students lived in the same room so could have bought products in bulk therefore reducing the plastic waste generated.

As for waste papers it was observed that students and tenants within the University had the highest generation with each group's fraction of papers at 11% while for tenants outside the University the papers were only 8% and that for farmers was 4%. The most likely reason for this could be because of the fact that since these two groups are involved in learning within the University, use of paper was higher than for respondents outside the University
Some waste streams were unique stream to some generators e.g. sweepings. It was generated by farmers and tenants outside the University only. The reason for this observation was because some of the tenants outside the University and most of the farmers lived in semi-permanent houses with earthen floors. Daily sweeping of the floors produced this kind of waste. This waste stream was 10% of the waste generated by tenants outside the University and 93% of that generated by farmers.

CONCLUSION

Waste generation in the study area was comparable to rates reported for developing countries though at the lower end of the given ranges. The generation rates in the study were lower than for urban areas. The composition rates were similarly comparable to data for other developing countries where the largest fraction was food-related wastes.

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