Characterization of Household Waste in Kinondoni Municipality, Dar Es Salaam

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Abstract

This study was carried out in Kinondoni municipality to determine the per capita daily waste generation rate and waste composition, and correlate these variables with socioeconomic factors of the householders. Questionnaires, interviews, waste characterization, and observation were used in data collection. A sample of 75 respondents residing in middle and low-income settlements were selected for the study. The results showed that the generation rate of household wastes was 0.44 kg/persons/day. On average household solid waste consisted of kitchen/food waste, paper, plastics, glass, metals, aluminium and other wastes, the proportion of each waste was approximately 74.10%, 8.30%, 9%, 0.75%, 0.60%, 0% and 7.25%, respectively An evaluation of the relationship between daily per capita generation of household waste and socio-economic factors indicated a weak positive correlation with household size (r = 0.219, and r = 0.138 for middle and low-income households respectively). While, the obtained value of the Pearson coefficient (r) indicated very weak negative correlation (r = -0. 108 and r= -0.096 for middle and low-income households respectively) between the per capita daily waste generation and the household income. These findings suggest that there is a need to examine other factors that underlie the generation of household wastes.

Keywords: *household waste, solid waste management, waste characterization, socio-economic factors, Kinondoni*

1. Introduction

To plan a solid waste management strategy for a given city or municipality, it is essential to know the quantity of waste generated and its composition. Various authors in solid waste management have described the importance of waste characterization. Waste characterization studies provide useful data on the composition and quantities of solid waste streams (Newenhouse and Schmit, 2000). Bolaane and Ali, (2004) attributed that knowing the waste characteristics is important to waste management policy making and monitoring. Chung and Poon, (2001) stated that data from waste characterization are essential for waste disposal facilities planning and waste management policy formulation. Solomon (2011), reported that the waste characterization study on household level provides more detailed, accurate and crucial information on waste composition and the per capita daily waste generation.

According to Bandara et al. (2007), the per capita waste generation rate is needed to predict future waste generation rates and for evaluating the waste generation trends in given communities. Qu, Li et al. (2009), indicated that compositional studies are important for several reasons, such as the need to estimate material recovery potential, to identify sources for component generation, to facilitate the design of processing equipment, and to maintain compliance with national laws. For example, if solid waste generated at household level consists of large portions of kitchen or food waste, this indicates that frequent collection is needed due to its nature of decomposing rapidly

and bringing foul smell. It would be impossible to successfully understand and manage waste if management does not consider waste generation and composition. So as to maintain good waste management, we need not only accurate data on waste generation but also information on the factors that contribute to their generation. In several studies a relationship between waste characteristics (per capita daily waste generation and waste composition) and socio-economic factors is shown. Amongst other socioeconomic factors that have been said to influence per capita daily waste generation are household size and income of the households.

The recent studies of Parizeau et al. (2006), Bandara et al. (2007) and Ojeda-Benitez et al. (2008), concluded that as the number of household members increases, waste generation per capita has been found to decrease. Bandara et al. also concluded that as the number of people in a household increases, there is a reduction in the per capita waste generation rate, thereby establishing the fact that when waste generation parameters are considered, per household waste generation is as important as the per capita waste generation rate. Other studies with similar observations include that of Sujauddin et al. (2008), Jenkins (1993), Mosler et al. (2006), Qu et al. (2009). Abu Qdais et al. (1997), found a statistically significant but weak negative relationship between waste generation per capita and household size in Abu Dhabi. While Bolaane and Ali (2004), show that there is a poor relationship between the number of persons in a household and the waste generation rate. Studies of Hong et al. 1993; Jenkins 1993; Jenkins et al. 2003; Bandara et al. 2007; Afroz et al. (2010), correlated higher income with higher per capita daily waste generation.

In Dar es Salaam there is no recent waste characterization study which has been carried out to document the per capita daily waste generation and composition of household waste. According to the information given by Kinondoni Municipal health Officer[1], waste characterization studies are rarely carried out in Dar es Salaam city owing to the lack of funding to carry out appropriate field studies and the lack of awareness among policy makers and waste management officials of its importance. The earlier studies in Dar es Salaam which were performed to characterize domestic waste include: Kaseva and Mbuligwe (2005), who found the average per capita generation rate of domestic solid as calculated at 0.42 kg/cap/day, while 0.39 kg/capita/day was reported by Kaseva and Gupta (1996), for low income households. These studies did not deal with the socio-economical factors that influence per capita daily waste generation.

The purpose of this study was, therefore, to determine the per capita daily waste generation and the composition of household solid waste generated in Kinondoni municipality at the source of generation (households). Waste characterization studies have been carried out mainly at the disposal points or material recovery facilities, rather than at the source of waste before any scavenging or recycling activities occur. However, only a few studies have been conducted at the source of generation, namely individual households. In this study it was decided to conduct waste characterization study at the source, as, it allowed for the collection of personal data from each of the participating household. Since it represented a single source, therefore, produced more accurate data. Additionally, it was important to carry out waste characterization study at source in order to assess the effect of the socio-economic factors of householders on per capita daily waste generation and composition. The socio-economic factors considered included: household size and income. The reason for considering only these two factors is that they have widely been acknowledged as important factors influencing solid waste characteristics (Collins and Bryan 1977; Cointreau 1982; Zuilen 2006; Abel 2007). Understanding how these variables affect households' waste generation enables policy makers to take more informed decisions about where and when to implement a particular policy.

This paper starts with introduction followed by brief description of Kinondoni municipality. The

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[1] Discussion held in 2008

methodology is discussed in detail. The results and discussions include: the characteristics of the respondents, per capita daily waste generation, and composition of waste. The effects of socio-economic factors on per capita daily generation rates and composition are also discussed in detail. Lastly, the conclusion is provided.

2. About Kinondoni municipality

Kinondoni is the largest municipality of the three municipalities in Dar es Salaam City. Others being Ilala and Temeke (see figure 1). The whole of Kinondoni municipality effectively encompasses an area of 531 km^2, and a population of 1,083,913 according to national census of 2002 and estimates for 2007 was around 1,3337,875[2]. The population density is estimated at 2,825 persons per square kilometre. The municipality is administratively divided into twenty seven (27) wards, which in turn are sub-divided into villages for rural areas and sub-wards commonly known as Mtaa[3](singular) or Mitaa(plural) in the urban areas.

Figure.1. Dar es Salaam showing the city municipalities

Source: www.dcc.go.tz 2007

3. Study Methodology

3.1 Selection of the study area: Sampling procedure and sample size

Kinondoni being the largest municipality in Dar es Salaam city was purposively selected for the study. The survey samples were obtained from 2 sub-wards under the jurisdiction of the Kinondoni Municipal Council namely Midizini and Mkunguni. Accordingly, Midizini is categorized as very low-income sub-ward, while Mkunguni is categorized as middle-income sub-ward. However, the income category was not the basis of selection. These 2 neighbourhoods were purposively chosen as being together representative for the settlements with the most serious problems of solid waste management in Kinondoni municipality. In addition, they represent areas that are predominantly informal in nature and have relatively high residential density. They are among the oldest informal

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[2] Population projection from 2002 census by using a growth rate of 5.4% per year. The next Tanzanian National census is on 25th August 2012

[3]Mtaa is the lowest level of the local government system in the urban setting

settlements which have existed since1940's. Midizini sprang up in 1945, and has since experienced rapid urbanization (URT, 2004). These sub-wards were selected in consultation with Dar es Salaam city and Kinondoni municipal health officers. Within the two sub-wards 75 households were selected using a random sampling strategy following a list of households provided by the sub-ward leaders[4]. In Midizini 45 households were selected, and in Mkunguni 30 households were selected. Midizini had the largest number of households (3350) compared to Mkunguni (1309), and hence the disproportionality in the sample sizes[5].

3.2 Data collection

A field work was conducted to identify the socioeconomic parameters, solid waste generation and composition. The main tools used in data collection were household questionnaire survey, waste characterization, interviews, and direct observation.

3.2.1 Structured household survey questionnaires

This tool was used in this study to gather information on demographic information which is concerned with location and size of household, characteristics and status of the respondents in terms of gender, household size and age. Socio-economic status variables include education, source of income, and monthly income. Another variable which is included in this part is business activity. These variables may affect solid waste management practices, amount of waste generated attitudes and perception of the household towards solid waste management.

The household survey questionnaires and the waste characterization study were combined and carried out at the same time in May to June 2008. The questionnaire contained a total of 27 questions related to the household waste management in selected areas, but only the data that were useful for the waste characterization study will be reported here.

3.2.2 Waste characterization study

This study was carried out by research team (a researcher and 4 research assistants) to determine the per capita daily waste generation and the percentage fractions of household waste constituents. The surveyed households were subsequently asked to participate in waste characterization exercise. Each selected household was provided with a plastic bag to keep all their waste generated for the particular day of study. One for each day of the study, and one extra bag in case this was necessary. In order to obtain a realistic estimate, measurement of the amount of waste produced by a particular household was performed for three different days, in a week and then the average value was recorded. The bagged waste from each household was sorted by research team into seven pre-determined fractions, namely food waste, glass, plastics, paper, metal/tins, aluminium, and residues (inerts, ashes, and sweepings)**.** Each waste fraction was weighed separately and its weight recorded. A portable weighing machine of 50 kg capacity was used to weigh the waste samples. Other materials were plastic bags with a volume of 12 litres for collecting and weighing the waste constituents. The amount of waste generated per capita per day for each household in the selected study area was determined.

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[4] Keep register for households in their respective sub-wards.
[5] Sub-ward leaders provided the number of households in the respective sub-wards

E-ISSN 2281-4612
ISSN 2281-3993

Academic Journal of Interdisciplinary Studies
MCSER Publishing, Rome-Italy

Vol 2 No 13
December 2013

3.2.3 Face to face interviews

Face to face interviews were held with key informants who included: Dar es Salaam City Health Officer, Kinondoni Municipal Health Officer, sub-ward leaders from sub-wards under study, and formal waste contractors[6] providing service in the selected sub-wards. These officials have overall responsibility in solid waste management; and waste contractors are solid waste management service providers. The rationale for conducting interviews with these people was to obtain expert information on solid waste management, given their knowledge, and experience.

3.2.4 Secondary information

Secondary information such as available documents, e.g. different reports from municipal solid waste departments served also as a source of information.

3.3 Analysis of data

Data analysis covers both descriptive as well as bivariate analysis. While the former was used to describe characteristics of the sample population by the use of the Statistical Package for Social Sciences (SPSS version 16) program, the latter assessed the relationships between the respondents' socio-economic characteristics and the amount of wastes generated using Pearson's coefficient(r). Attributes in the study include gender, employment, income, education, age, household, size, and daily waste weights. Hypothesis of the study stated that the per capita daily waste generation was directly linked to household size and income per household. The dependent variable used was the amount of waste generated by weight per capita per day.

4. Results and Discussions

4.1 Socio-economic characteristics of the respondents

According to the household survey, the average household size from sampled population was 4.48 and 7.71 in Mkunguni and Midizini, respectively. The mean household size was found to be 6.1 as calculated from average means of each sub-ward. The value of household's size obtained in this research was slightly larger than what was reported by National Bureau of Statistics, (2002)[7]. The major causes of rapid urban population growth in the whole of Tanzania are high natural births and rural-urban migration (UN-Habitat 2010).

The average age for respondents were 40 with the lowest being 21 and highest 75 years old when considering the total sample of the study. The study found that 16% of the respondents were male and 84% of the respondents were female in Mkunguni. In Midizini 20% of respondents were male and 80% of respondents were female. There were more people employed in the formal sector in Mkunguni (67%) as compared to Midizini. Only 18% of the respondents in Midizini sub-ward were employed in formal sector. In all cases, there were a significant number of respondents working in informal sector with 70% in Midizini and 33% in Mkunguni. Over two third, (66.47%) of respondents in Midizini the most educated members of households had primary school level of education, 28% secondary school education and only 5% with members who had tertiary

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[6] Solid waste service providers with legal contracts of providing collection and disposal services to households
[7] According Tanzanian Bureau of Statistics (2002) the average value of household size was calculated at 4.8 and, 3.9 for Midizini and Mkunguni sub-wards respectively.

education. In Mkunguni, 45% most educated members had secondary school education and 45% reported to have completed primary school education. The remaining 10% of households had members who had university education. In this study two socio-economic factors were related to per capita waste generation: income and household size. As mentioned in the introduction the reason for considering only these two factors is that they have widely been acknowledged as important factors influencing solid waste characteristics.

The survey found that a significant number of interviewed households conduct business activities which take place from their households representing 65.67% in Midizini, and 37% in Mkunguni. Within these sub-wards food-related businesses are undertaken by households as their source of income. Income is measured in Tanzanian Shillings (TZS) per household per month. In Midizini 10.7 % earn between TZS 0 – 50,000/=, 61.3% earn between TZS 50,001 to 100,000/=, and 28% earn between 100,001 to 150,000/=. Whereas, in Mkunguni, 1.3% earn between TZS 50,000 to 100,000/=, and 5.3% earn between TZS 100,001 to 150,000/=, the majority 88% earn between 150,000 to 200,000/=, the remaining 5.3% earn more than TZS 200,000/=.

4.2 Solid waste generation rates

The mean waste generation rate values were established to be 0.39 and 0.49 kg/cap/day with a mean value of (calculated by first averaging the daily weight of waste for each household, then dividing this by the number of people in each household, as reported in the household survey, and then averaging the daily per capita waste generation figures across the studied households for Midizini and Mkunguni, respectively. From these findings, an average of 0.44 kilograms of solid waste generated per person per day was computed. The rate is quite in line with World Bank Standard for developing countries which is 0.3 to 0.6 kg/c/d. Another, study on waste generation reported average domestic waste generation rates of 0.34 kg/day per person in low-income areas and 0.42 kg/day per person in planned areas in Dar es Salaam (Kaseva and Mbuligwe 2005). In Nairobi a study carried out by Kasozi and von Blottnitz,(2010), in low to middle income level households per capita generation rates varied from 0.24 – 0.82 kg/person/day, with a mean of 0.43 kg/person/day. A study in Accra Ghana, by Boadi and Kuitunen,(2004), found the specific waste generation rate in low income areas, was at 0.40 kg per capita per day and in middle income areas showed a specific waste generation rate of 0.68 kg per capita per day.

4.3 Physical composition of waste

The results of household waste composition are shown in table 1. A comparison of the average composition of solid waste of the two areas with those reported for some other countries for the overall average of low and middle-income households is presented in Table 2 (Abu Qdais et al, 1997; Kasonzi and von Blottnitz, 2010; Nabegu, 2010)

From table 1 it can be noted that kitchen/food waste makes up the largest fraction of household waste at 74%, which might be expected for domestic/ household waste in developing countries. This is probably attributable to the fact that in the study sub-wards most of the food items were unprocessed with high moisture content, bulky and therefore denser. Also it can be noted that the percentages of plastics (9%) and paper (8.30%) was fairly high compared with glass, metals and aluminium, and the percentages of glass (0.75%) and metal (0.60%) are relatively low compared with other cities (table 1). This is due to the fact in recent times plastics materials have turned up as food containers, water bottles, medicine bottles etc. where previously metal or glass containers were commonly used. The absence of recycling programs in Kinondoni municipality also results in large quantities of plastics entering the waste stream. Being low and middle-income areas, few people consume imported canned food and drinks due mainly to social and economical factors. The high content of residual waste (ash, dust, silt, sand, sweepings) of waste was high due to high density of ash and earth contents. Investigation and observations

indicated that the overdependence on firewood and charcoal as a source of energy by the majority of households led to the excessive presence of ash in household waste. In addition to this, the proportion of ash, silt, and sand may be high also due to the presence of unsurfaced yards and streets within the settlements. Furthermore, it was common to see in Kinondoni some people using paper and thin plastics as an igniting agent for their charcoal stoves, which may also increase the presence of ash in the solid waste composition.

Table 1. Physical composition of household waste in areas under study

s/n	Waste component (%)	Midizini (n=45)	Mkunguni (n=30)	Average (%)
1.	Kitchen/food waste	68.70	79.50	74.10
2.	Paper	8.75	7.85	8.30
3.	Plastics	11.00	7.00	9.00
4.	Glass	1.00	0.50	0.75
5.	Metal	1.20	0.00	0.60
6.	Aluminium	0.00	0.00	0.00
7.	Residual waste	9.35	5.15	7.25
	Total	100.00%	100.00%	100.00%

Table 2. Comparison of major solid waste components for studied areas in Kinondoni with some other cities

| Waste component		Average component weight (%)		
	Kinondoni	Nairobi-Kenya	Kano-Nigeria	Abu Dhabi-UAE
Food/kitchen waste	74.10	58.6%	47	50.5
Paper	8.30	11.9	6	7
Plastics	9.00	15.9	10	11
Glass	0.75	1.9	7	10
Metal	0.60	2.0	5	8.5
Other	7.25	9.7	18	13
References	This study	Kasozi and von Blottnitz,(2010)	Nabegu, (2010)	Abu Qdais, et al.(1997)

4.4   Influence of socio-economic factors on per capita daily waste generation

As earlier mentioned, household size and income of the household are the two variables which are generally considered to be most important socio-economic factors affecting per capita waste generation and the composition of waste. The relationships between per capita and household size as well as income are shown in figure 2. Also a statistical method of bivariate analysis using Pearson's coefficient (r) was employed to see whether there is any correlation between these variables.

4.4.1   Relationship of per capita daily waste generation to household size

Figure 2 shows the bar chart with error bars of the mean per capita daily waste generation per different category of household size. As can be noted from the chart the results indicate that the relationship between per capita waste generation and household size is not clear-cut. However, the bivariate analysis showed weak positive correlation. Pearson's coefficient (r) of 0.219, and 0.138

were found for Mkunguni and Midizini households respectively. Several previous studies (Jenkings, 1993; Abu Qdais et al, 1997; Bolaane and Ali, 2004; Ojeda-Benitez et al, 2008; Qu, Li et al, 2009) have shown that as the number of household members increases, waste generation per capita has been found to decrease. This means that the larger the household size, the smaller the daily per capita waste generation. However, this is not confirmed in the findings of this study. This study's findings agree with those reported by Abu Qdais et al. (1997) and Bolaane and Ali,(2004) who found a poor relationship between the number of persons in a household and the waste generation rate in Abu Dhabi and Gaborone respectively.

Per capita daily waste generation rate household size in Mkunguni

Per capita daily waste generation rate vs. vs. household size in Midizini
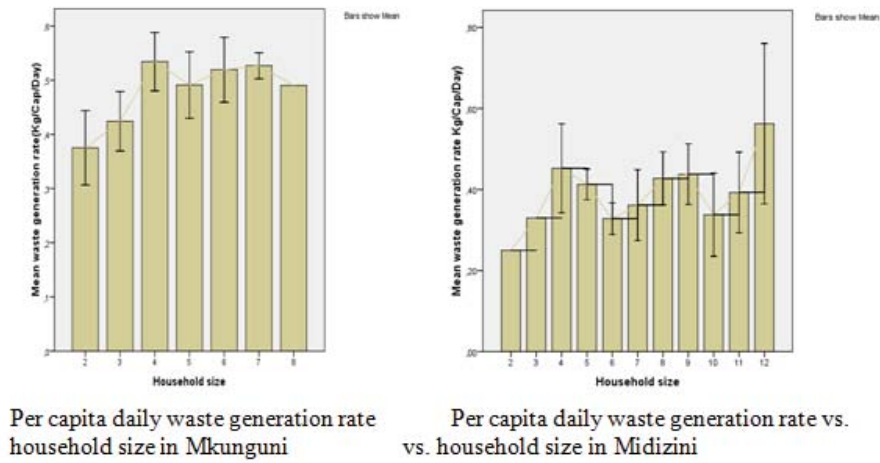
Figure 2. Per capita daily waste generation rate vs. household size in Mkunguni and Midizini sub-wards

The reasons for this surprising pattern may be contributed to households' social and economic activities. In household survey study it was observed that, waste from business activities taking place at households were mixed with the waste produced from domestic activities. Also residual waste such as sweepings and ash contents were mixed with domestic waste. These fractions of waste are independent of household size. In addition, per capita daily waste generation may be independent to household's size as there were variations of household size during the study period as relatives and friends move in and out. Another possible explanation could be that from a statistical point of view the accuracy of determining these parameters increases with an increase in the number of samples that are analyzed.
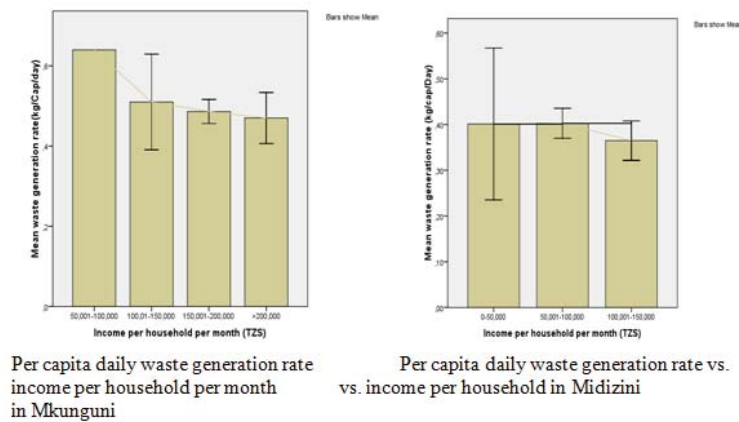
4.4.2 Relationship of per capita daily waste generation to household's income

Figure 3 shows that households with an income of TZS 50,000/= to 100,000/= per month in Mkunguni sub-ward had the highest per capita daily waste generation. The empirical analysis revealed that households earning this category represents very small percentage (1.53% - refer table 1) in this sub-ward. As can be noted from figure 3 there is sharp decrease of per capita waste generation. We can also observe that the per capita daily waste generated by households earning between TZS 100,001 to 150,000/= per month is similar to households with an income of TZS 150,001 to 200,000/= and there is a very slight decrease of per capita daily waste generation of households earning more than TZS 200,000/= per month.

For Midizini sub-ward, figure 3 shows that the per capita daily waste generated by households earning TZS 0 to 50,000/= per month is similar to households with an income of TZS 50,001 to

100,000/= per month. There is a small decrease of per capita daily waste generation of households earning between TZS 100,001 to 150,000/= per month. Overall, the two figures show that there is a minor decrease of per capita daily waste generation as the household's income increases. This may be caused by almost similar lifestyle between these income groups. It implies that there is no social and physical alienation among the residents in these settlements. Another important observation was that, although these sub-wards are categorized differently by NBS(2002), in terms of income status, this study found that there is co-existence of different socio-economic status of households within the same neighbourhood. The same observation was noted by a study of Ooko Midheme,(2007), on state-vs. Community- led land tenure regularization in Dar es Salaam city, that unlike many developing countries the informal settlements of Dar es Salaam accommodates a wide range of social and economical groups. In most of the informal settlements the affluent and the poor co-exist side by side.

Per capita daily waste generation rate income per household per month in Mkunguni

Per capita daily waste generation rate vs. vs. income per household in Midizini

Figure 3. Per capita daily waste generation rate vs. income per household per month in Midizini (low-income level).

Also the statistical method of bivariate analysis was used to determine the Pearson correlation to measure the strength of a linear relationship between the per capita waste generated and the income of the households. Despite many previous studies (Hong, et al, 1993; Jenkins, 1993; Jenkins, et al, 2003; Bandara et al, 2007; Afroz et al, 2010), correlating higher income with higher per capita daily waste generation, these findings certainly do not apply in this particular study. The obtained value of the Pearson coefficient (r) indicate very weak negative correlation ($r = -0.108$ and $r = -0.096$ for middle and low-income households respectively) between the per capita daily waste generation and the household income. As these values are very close to zero, it implies that household's income has very little effect or no correlation on per capital daily waste generation in this study sample. These findings agree with Bruvoll, (2001), and Yusof et al. (2002) and Congress of the United States,(1989) concerning the ambiguity in associating waste volume with income and social status on its generation. These studies showed that such as attributes as income, education, and other socioeconomic factors barely affect the amount of waste generated partly due to the difficulty in assessing the actual income of the residents.

   As observed in this particular study, large percentage of studied households was getting involved in informal businesses to generate income and be able to sustain its members. Therefore, most of their domestic waste originated from the informal activities they undertake, and no doubt affected waste per capita values. The study found that, significant amount of residual waste (sand, sweepings) which is generally dense and heavy also contributed to the generation of household waste. From our data of bivariate analysis we conclude that there was no relationship between

E-ISSN 2281-4612
ISSN 2281-3993

Academic Journal of Interdisciplinary Studies
MCSER Publishing, Rome-Italy

Vol 2 No 13
December 2013

these two variables and thus the null hypothesis should be rejected.

5. Conclusion

The characterization of household waste in the studied areas has provided detailed information on household waste composition and the per capita daily waste generation. This study found that the average per capita waste generation of the whole studied selected sample was 0.44 kg/cap/day, when socio-economic category was considered in the analysis per capita daily waste generation varied, in Midizini (low-income sub-ward) was 0.39 kg/cap/day and in Mkunguni (medium-income sub-ward) was 0.49 kg/day/day. These findings seem to be comparable with previous studies, although no recent waste characterization studies have been carried out in Dar es Salaam on this topic. The study by Kaseva and Mbuligwe, (2005), calculated the average per capita generation rate of domestic solid wastes to be 0.42 kg/cap/day, whereas, Kaseva and Gupta, (1996), reported a mean of 0.39 kg/capita/day. The composition of household waste contains more kitchen waste than other waste materials, which is a typical households waste characteristic in developing countries. The kitchen/food waste accounted for the highest proportion at 74.50%. These results suggest the feasibility of composting to ensure environmental protection by greatly reducing the volume of waste that would have to be disposed of. Perhaps the next step needed is for Kinondoni municipality to examine the potential for composting. Also paper (8.30%) and plastics (9%) are recyclable materials and their presence in domestic wastes suggests again taking a closer look at the possibilities for re-use and recycling. Glass (0.75%) and metal (0.60%) are also recyclable materials but their presence is almost negligible. The average amounts of waste generated per person can be used to predict the total amount of waste generated within a municipality. Household size had a weak positive relationship with the per capita daily waste generation rate. However, this relationship needs further investigation. Contrary to some previous studies, the waste generation rate was not directly related to household income. It appears that the relationship between income and waste generation rate depends on other factors. In this case, the higher waste generation rate as measured for low-income households could be attributed to consumption of unprocessed food, social and economic activities taking place within household's premises. The findings of this study can be helpful in developing policies concerning household waste. A more detailed and comprehensive research is necessary to establish reliable information on household waste generation and composition as well as the relationship between socio-economics factors and household waste generation rate in the entire Dar es Salaam City, including waste characterization at different times of the year, in a wider range of areas to suggest a more conclusive result in the future.

6. Acknowledgments

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E-ISSN 2281-4612
ISSN 2281-3993

Academic Journal of Interdisciplinary Studies
MCSER Publishing, Rome-Italy

Vol 2 No 13
December 2013

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