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Characteristics and management of household solid waste in urban areas in Ghana: the case of WA.

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Abstract

This paper presents the characteristics (composition, bulk density and generation rate) of household solid waste and waste management practices in Wa; an urban community in Ghana. The study approach involved an assessment of the physical characteristics approximately 2.3tons of solid waste generated by 15 households in the study area over a 30-day period. Structured questionnaires were administered to residents, the Waste Management Department and the only private waste management company in Wa. The results indicate that the waste generation rate for the Wa is 0.68±0.24kg/cap/day with the average bulk density of 44.9±28 kg/m^3. Household solid waste is dominated by organic waste (48%) and inert materials (33%). Plastics/rubber and metals make up an average proportion of 5% each whiles textiles/fabric, paper/cardboard and miscellaneous constitute 4%, 3% and 2% respectively. The characteristics of the solid waste management system include disparities in waste collection services, lack of waste recovery mechanisms, disposal of comingled waste and lack of regulation and monitoring of the private waste collection company. The study identifies that, waste recovery can reduce to almost a third of the amount of household solid waste that end up at the landfill. The study recommends the pay-as-you-dump method as a cost recovery mechanism to offset waste collection costs.

Keywords: characteristics, household, solid waste, management, Wa

1. Introduction

Solid waste management has been one of the most crucial issues facing authorities in the fast-growing cities in developing countries. In Africa for instance, solid waste is regarded as the second most important environmental health concern apart from water quality as per the WHO (Zerbock 2003). The problems caused by solid waste in urban Africa is largely due to the explosive growth rates, particularly in sub-Saharan Africa, which eventually translates into generation of copious amounts of solid waste (UN-HABITAT 2010; Taiwo 2011). However, city authorities lack the financial and technical resources keep pace with the challenges associated with huge amounts of solid waste (Ogwueleka 2009). Consequently, heaps of solid waste are not uncommon sights in these areas.

In Ghana, available literature indicate that some proportion of solid waste generated are not collected and thus end up in open spaces and drains. The effects of this phenomenon are threatening to both human life and the environment. These repercussions range from flooding, water pollution, spread of diseases and ugly sights of stinking and pest-infested piles of solid waste in some parts of urban areas (Boadi & Kuitunen 2004; Puopiel 2010). Studies have shown that, in Accra and Kumasi, the two largest cities in Ghana, over 3,000tons of solid waste is generated daily out of which approximately 70% is collected (Anomanyo 2004; Ketibuah 2004; Mensah & Larbi 2005). In Tamale, Puopiel (2010) concluded that only 27% of the 810tons of waste generated daily is collected. This tends to portray that challenges still exist in solid waste collection in the country in spite of the fact that various private waste collection companies have been contracted to augment government's efforts in this regard.

According to Oduro-Kwarteng (2011), three different modes of solid waste collection are practised in Ghana; kerbside collection, house-to-house collection and communal collection. This is based on the income levels of the people, types of housing and the required level of service. As he noted, kerbside and house-to-house collection are rendered in middle and high income areas but communal collection is rendered in low income areas. In the kerbside collection system, waste is deposited at the kerbside on specific days within the week to be taken by collection crew whiles in house-to-house collection, the crew picks up the waste from each property to be emptied and the bin returned after being emptied into collection vehicles. In communal collection, waste is

deposited into containers placed at vantage points within the community and picked up by collection vehicles when it is full. Regardless of these strategies for waste collection in different income areas authors of various studies (Tsiboe 2004; Oduro-Kwarteng 2011) conclude that huge disparities exist in the level of service. Statistically significant difference exist between service quality in low-, middle- and high-income areas. Whiles service quality is very poor in low-income areas, that of middle- and high-income areas are comparatively better since the latter mostly pay for waste collection services whiles in most cases, the government bears the cost of solid waste collection on behalf of the former (Obirih-Opareh & Post 2002).

Anomanyo (2004) observed that, apart from lack of funds, insufficient information on quantities and characteristics of waste is the major contributing factor to Ghana's waste management problems. As he noted, the existing waste management systems in the country has not appropriately integrated other essential components of waste management such as reuse, recycling, reprocessing and treatment. However, as Tchobanoglous & Kreith (2002) puts it, an understanding of the characteristics of the waste stream is a must in any solid waste management system. This is helpful to municipalities in determining the best management methods for different materials, planning recycling and recovery programs, purchasing equipment, sizing facilities, among others Cheremisinhoff (2003). Various studies in Ghana in this regard has over the years been concentrated in the southern sector, where conditions (weather and income levels) widely vary from that of the northern sector.

Against this background, this study seeks to characterise household solid waste in Wa (composition, bulk density and generation rate) and to assess the waste management practices in the study area.

2.0 Materials and methods

Located in the Upper West Region of Ghana, Wa doubles as both the regional capital and the capital of the only Municipal Assembly in the region; Wa Municipal Assembly. Geographically, Wa is located on 10°4′N 2°30′W and lies within the savannah high plains in Ghana (Figure 1). It currently has an estimated population of over 100,000 people. Farming is the major source of livelihood for most rural folks in the Municipality with about 80% of them engaged in subsistence farming. However, in urban centres in the Municipality, including Wa, residents are mostly into commercial activities such as petty trading, shea butter extraction, local soap manufacturing, pito brewing, weaving, dressmaking, blacksmithing, masonry, carpentry, vehicle repairs.

The study approach involved an assessment of the physical characteristics (composition, generation rate and bulk density) of solid waste generated from 15 households in the study area over a 30-day period using the weight-volume analysis. Purposive random sampling method was used in the selection of the study households both for solid waste composition analysis and questionnaire administration. By this method, households and study respondents were selected from low, middle and high income communities within the study area to provide a holistic idea about the waste characteristics and management practices in Wa. The criteria used to classify the households were based on the residents' living standards, housing and access to basic essential services such as potable water, electricity and toilet facilities, among others, according to the Wa Municipal Assembly Valuation Unit. Three communities from Wa were therefore identified for study: Zongo/Sokpariyiri as low income community, Junior Staff Quarters as middle income community and Degu Government Residential Area as high income community. Five households from each of these communities were used for the study. Each of the participating households were provided with a 120L bin after thoroughly sensitizing residents on the study objectives for their full cooperation.

Figure 1: Location of Wa in the Upper West Region of Ghana (Courtesy: Zee maps)

Waste from each household was initially weighed and the weight divided by the household size (number of residents in the household) to determine the per capita waste generation rate. Over the 30-day study period the average per capita waste generation rate was computed from the equation below:

$$\text{Average waste generation rate} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\frac{W_{ij}}{s_j} \quad (1)$$

m = total number of days in the study period (30 days)

n = total number of houses involved in the study (15)

i = ith day on which waste was weighed

j = jth household

S_j = household size of jth household

W_{ij} = weight of waste on the ith day for jth household (kg)

The bulk density of the uncompacted waste was estimated by dividing the weight of the waste by its volume for a particular household for each day. For the entire study period, the average bulk density of the household waste was computed from the equation below:

$$\text{Average bulk density of waste} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{m}^{n}\frac{W_{ij}}{V_{ij}} \quad (2)$$

m = total number of days in the study period (30 days)

n = total number of houses involved in the study (15)

i = ith day on which waste was weighed

j = jth household used in the study

W_{ij} = weight of waste on the ith day for jth household (kg)

V_{ij} = Volume of waste on ith day for jth household (m^3)

The composition of household waste was obtained by the sort-and-weigh method. This involved sorting the waste into each of the categories considered under the study and weighing them individually. The components of

each category used for the study are shown in the Table 1.

Table 1: Classification of waste components

Category	Components
Organic	Food remains, green leaves, yam peels, dry leaves
Plastics/Rubber	Polythene bags, sachet water bags, plastic bottles, food wrappers, plastic bowls, sandals and pampers
Paper/Cardboard	Newspaper, used toilet rolls, cartons and scratch cards
Metal	Metal cans, scrap metal, spoons and used blades
Textiles	rejected used clothing, pieces of cut cloth and school bags
Inert materials	Charcoal remnants, ashes and sand
Miscellaneous	Bottles and ceramic

The proportions of each component was expressed as a percentage of the total weight of waste over the study period as illustrated in the equation below:

$$\text{Proportion of specific waste component (\%)} = \frac{100\%}{W_t}\sum_{i=1}^{n} w_{c,i} \quad (3)$$

Wt = Total weight of solid waste from all households over study period

i = ith day on which weight of waste was measured

n = number of days for study period (30 days)

wc,i = weight of a specific category of waste component for a particular house measured on the ith day

Structured questionnaires and extensive field observations were also used to determine the waste management practices at the household level vis-a-vis primary storage at the household level; final waste disposal and associated costs; waste recovery at the household level and the perception on the quality of service rendered by waste collection companies. 105 questionnaires, made up of 35 questionnaires for each of the three communities, were administered for the assessment of waste management practices in the study area. In addition, key stakeholder interviews were also conducted to ascertain the challenges to the solid waste management system in the study area.

3. Results and discussion

3.1 Household waste characteristics and options for recovery

A total of approximately 2.3tons of solid waste generated by 15 households over the 30-day study period was used for the assessment. Half of this total quantity of solid waste emanated from households in the low-income area whilst middle- and high-income households contributed 24% and 26% respectively. The greater proportion of waste emanating from low-income households is due to relatively larger household size as compared to middle- and high-income households. However, the average per capita waste generation rate in the low-income area (0.49kg/cap/day) was lower than that of middle and high income areas (0.72kg/cap/day and 0.82kg/cap/day respectively). The increasing trend in waste generation rate from the low to high income groups as shown by this study is similar to that reported in Kumasi by Mensah (2010) - 0.542 kg/cap/day, 0.608kg/cap/day and 0.728kg/cap/day for low, middle and high income areas respectively. Moreover, the difference in waste generation rates among the income groups conforms to available literature (Chandrappa and Das 2012; Hoornweg and Bhada-Tata 2012) which assert that the quantity of waste generated is a function of the residents' lifestyle and living standards. Residents in low-income communities are generally poorer and has low purchasing power resulting in low waste generation rates. In addition, the average per capita waste generation rate for Wa throughout the study period is estimated as 0.68±0.24kg/cap/day. This falls within the range of per capita waste generation rates reported by Hoornweg and Bhada-Tata (2012) for sub-Saharan countries (0.09 - 3.0kg/cap/day) but slightly higher than that reported in Accra by Anomanyo (2004) - 0.5kg/cap/day.

The bulk density of uncompacted household solid waste obtained for the low-, middle- and high-income households involved in the study are 84.1±25.7kg/m3, 30.8±9.1kg/m3 and 27.6±7.8kg/m3 respectively. Moreover, the average bulk density of solid waste for all households is 44.9±28 kg/m3. These values are far below those reported by Acquah (2010) from his study in Kumasi in which the bulk density of waste for low-, middle- and high-income households were reported as 381 kg/m3 237 kg/m3, 306 kg/m3 respectively. This

could be due to the relatively low proportion of wet waste in the domestic solid waste in Wa (average of 48%) as compared to Kumasi (average of 71%). Although the density of domestic waste is lower at the household level, Cointreau (1982) asserts that it can double upon storage in communal containers over a couple of days. Knowledge of the density of waste and the waste generation rates, expressed in weight, are essential in estimating the payload capacity of collection equipment as well as the number of vehicles needed for waste collection.

The two principal components that dominate solid waste from all income areas in Wa are organics and inert materials (Figure 2). Particularly for the low income area, the organic proportion forms approximately half (54%) of the household waste produced followed by inert materials (sand, ash and charcoal remnants). It was observed from the study that, sand from household sweepings forms a substantial amount of the inert materials found in the household waste. This results from sweepings from unpaved areas in the households, particularly for low income areas, subsequently increasing the proportion of inert materials ending up in the waste stream. According to Zurbrugg (2003), the abrasiveness of inert materials such as sand and stones in the solid waste stream may rapidly weaken waste collection equipment. Therefore, education of residents to desist from adding sand from sweepings to their household waste would significantly reduce the fraction of inert materials ending up in the waste stream as well as protecting collection equipment from rapid deterioration.

The proportion of organics and inert materials in the household waste reduces from low-income areas to high income areas - 54%, 47%, 37% (organics) and 39%, 35% 20% (inert materials). However, all other components show a reverse trend. This pattern in waste composition is attributed to factors such as high spending among rich folks on packaging materials and a relatively low level of recovery of components such as metals, plastics and papers for scrap dealers (Chandrappa and Das 2012). Moreover, compared with results from available studies by Ketibuah *et al*. (2004) conducted in Kumasi, the proportions of organics in the waste from all areas are relatively lower.

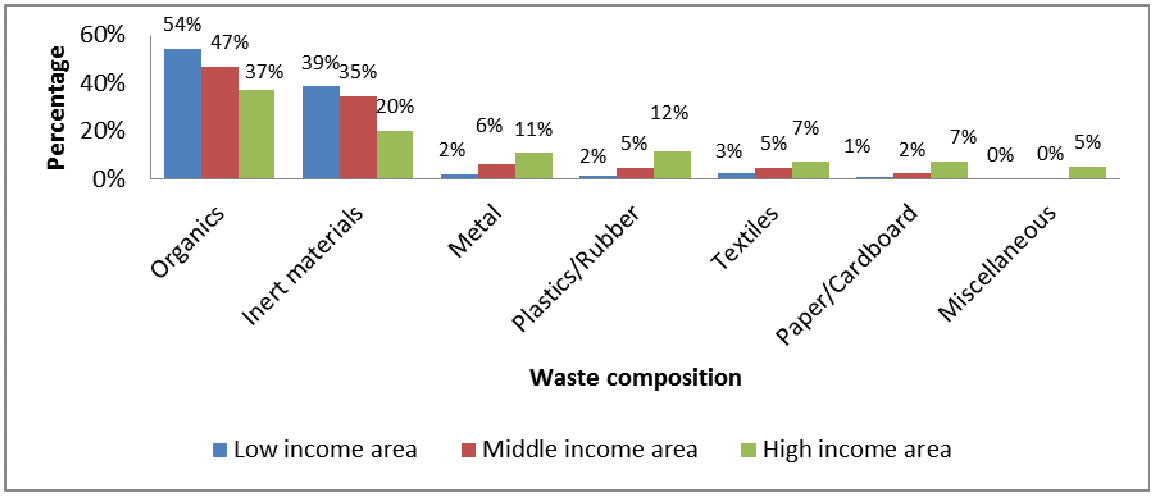

Figure 2: Variation of solid waste composition for low-, middle- and high-income areas

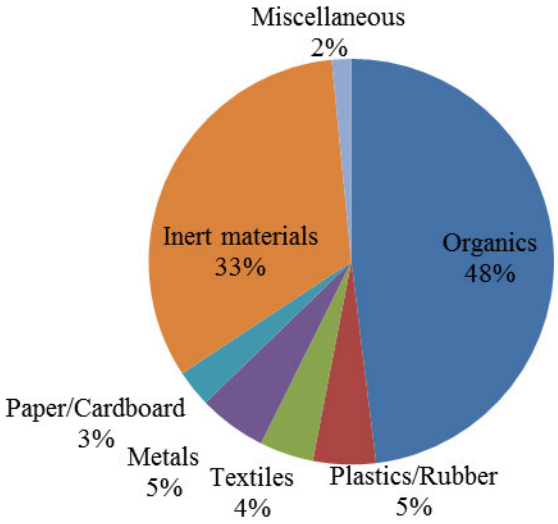

Figure 3: Average household waste composition for all areas

On the average, the bulk of solid waste from households in Wa was found to be dominated by organics (48%). This was followed by inert materials, with an overall average of 33% (Figure 3). The other components (plastics/rubber, textiles, metal, paper/cardboard and miscellaneous) generally have proportions between 2% and 5%. Compared with studies from other parts of Ghana, the proportion of organics in household waste from Wa is similar to that reported by Kotoka (2001) in Kumasi (44%) but considerably less than that reported by in literature (Tsiboe & Marbell. 2004; Anomanyo 2004; Mensah 2010) for Accra (Table 2). The proportion of metals is also appreciably higher than those reported in Accra and Kumasi by the same authors whiles other components were similar.

Table 2: Comparison with solid waste composition from other parts of Ghana

Waste composition	This study (Wa)	Accra Metropolitan Assembly (Accra)*	Kumasi Metropolitan Assembly (Kumasi)**
Organics	48	65	44
Plastics/Rubber	5	3.5	3.82
Textiles	4	-	3.2
Metal	5	1.8	0.64
Paper/Cardboard	3	4.2	3.1
Glass	-	1.9	0.64
Inert materials	33	22.5	-
Miscellaneous	2	1.1	44.6

All values represent percentage (%) by weight *Source: Mensah (2010)**Source: Kotoka (2001)

Generally, the composition of household waste in Wa presents a good opportunity for waste recycling. This however requires intensive education of residents to practice source separation of waste since approximately half of the waste could be considered for recycling through composting. Van Dijk & Oduro-Kwarteng (2007) underscores the importance of recycling organic component of solid waste to ensure sustainable solid waste management. According to them, recycling organic solid waste diverts a substantial part of waste, particularly in developing countries, which would otherwise end up in landfills thereby prolonging the lifespan landfills as well as replenishing soil nutrients.

The proportion of plastics/rubber and paper/cardboard, although constitute an insignificant part of the household waste by weight (5% and 3% respectively) can increase overall waste volumes occupying a significant volume of space during landfilling due to its bulky volume (Hoornweg and Bhada-Tata 2012). If not collected, open burning of plastic waste by residents could result in air pollution with associated health problems due to heavy metal additives (Ketibuah *et al.* 2004). Moreover, littering of the environment with plastics also cause environmental nuisance through choking of drains and reducing the aesthetic beauty of the environment. All

these problems can be averted if plastics are separated at source and sold to recycling companies in the country to make other products. Papers/cardboard can also be recycled to manufacture egg-crates and toilet roll.

The average proportion of metals in household waste in the study area (5%) is considerably higher than those reported in Kumasi (0.64%) and Accra (1.8%). This presents the prospect for selling this component of waste to metal scrap dealers if source separation is practiced. In spite of the numerous items which could be potentially recovered for recycling none of the residents interviewed during the survey recovered or sorted out any item from the waste. There is therefore the need to educate residents on source separation and a readily available market made available to purchase recovered items from residents who recover valuable items for recycling.

3.2 Household waste management options and quality of solid waste collection service

More than half of the respondents (64.8%) were between the age group of 36-60 with the least proportion being those above 60 years (Figure 4). With respect to sex distribution, females constituted a greater proportion (81%) of the respondents. This is due to the fact that household waste management is generally regarded as the duty of women, as part of their culture, and thus the men were usually reluctant to contribute whatsoever to the study. Almost half (44.8%) of respondents have no educational background with approximately a quarter (22.9%) attaining Tertiary level education (Figure 4). This confirms the low level of literacy rate (46.2%) in the Upper West Region of Ghana as reported by Ghana Statistical Services (Dapatem 2013). Majority (41.0%) of respondents are engaged in commercial activities like shea butter extraction, local soap manufacturing, pito brewing, weaving, dressmaking, blacksmithing, masonry, and carpentry offering a form of self employment whilst 36.2% are government employees.

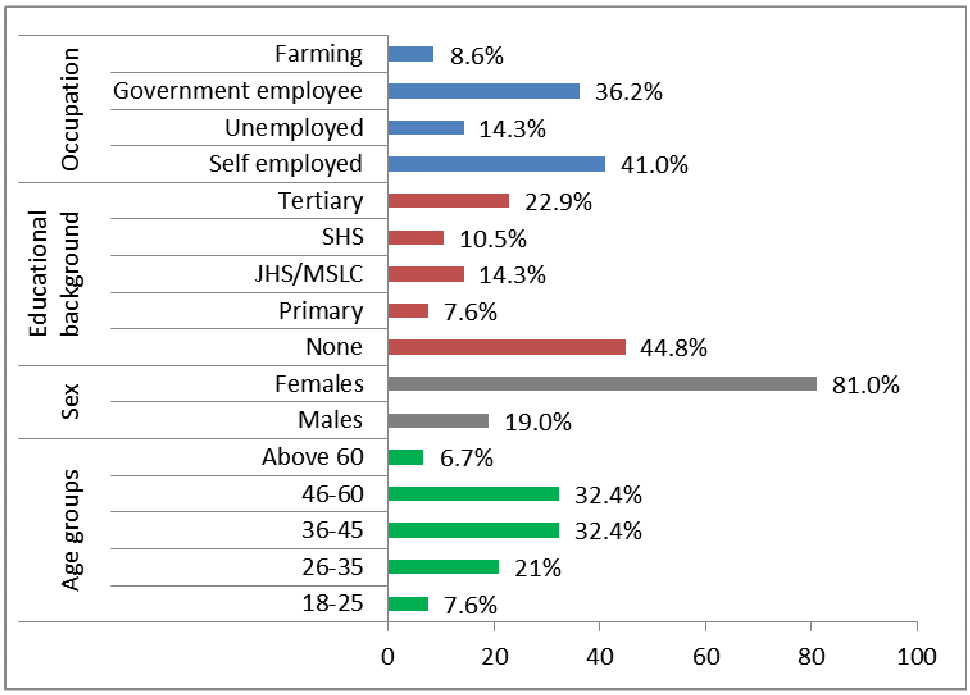

Figure 4: Socio-demographic characteristics of respondents

Table 3: Primary storage and disposal of household solid waste

Primary storage and disposal of waste		**Frequency (n = 105)**	**Percentage (%)**
Primary storage of waste	Gallon	1	1.0
	Basket	4	3.8
	Basin	22	21.0
	Sanitary bin	24	22.9
	Bucket	54	51.4
Fitting cover for storage bin	Present	46	43.8
	Absent	59	56.2
Waste disposal	Buried by household	2	1.9
	Bush	6	5.7
	House-to-House	23	21.9
	Communal container	74	70.5

Primary storage of solid waste refers to the storage of waste at the household level prior to disposal. Results from the study indicate that primary storage is generally very poor among low- and middle- income households. Approximately, a quarter of all respondents (23%) store their waste in a sanitary bin whereas the remaining fraction store their waste in either old gallons, buckets, basins or baskets (Table 3). Generally, the sanitary bins are used predominantly by households in the high-income bracket and have fitting covers whilst more than half (59%) of residents leave their waste uncovered. The waste is therefore exposed to flies, pests and domestic animals resulting in unsightly conditions and odour generation due to the high proportion of organic waste. According to available literature (USAID, 1982; Keiding, 1986), uncovered wastes provide suitable breeding grounds for flies which can transmit diseases to humans. This therefore calls for intensive hygiene education to forestall the spread of diseases among residents due to improper waste storage.

Deposition of waste into communal containers is the most predominant form of waste disposal in Wa as per the results from the study. Among residents interviewed, approximately 71% of disposed their waste into communal containers provided at vantage points within their communities for waste disposal whiles close to a quarter (22%) patronised house-to-house waste collection services (Table 3). House-to-house waste collection method is where a household stores the waste in a container and puts it at the roadside at designated times for collection. This method of waste collection is usually patronised by households in the high-income category. 83% of all households patronising this service are in the high income bracket whiles approximately half (46%) of the residents using communal containers were in the low-income bracket. This confirms findings from studies in other parts of the country (Oduro-Kwarteng 2011) which assert that house-to-house collection and communal collection in urban areas are carried out in the high class and low class residential areas respectively. Less than a tenth of respondents (8%) either buried their waste or dumped them in bushes indicating the practice of other crude forms of waste disposal in the community. The method of waste collection does not promote recycling of waste since waste is conveyed from households or secondary storage sites directly to final disposal sites. Source separation of waste should be given much attention in this regard to promote recycling of vital waste components. Since the Municipal intends to construct a plastic waste recycling plant in Wa very soon (Ghana News Agency 2010), source separation of waste would be very essential to evade the cost of waste separation at the plant and thus reduce its cost of operation.

Table 4:Cost and quality of household waste management services

Household waste management services	Variables	Frequency	Percentage (%)
Payment for household waste collection (n = 105)	Yes	23	21.9
	No	82	78.10
Cost of waste collection per month (n = 23)	GH¢7/120L (US$3.6/120L)*	3	13.0
	GH¢10/240L (US$5/240L)*	20	87.0
Opinion on cost of waste collection (n = 23)	Economical	20	87.0
	Expensive	3	13.0
Opinion on quality of service	Satisfactory	33	31.4
	Unsatisfactory	72	68.6

*Based on US$1 = GH¢1.97

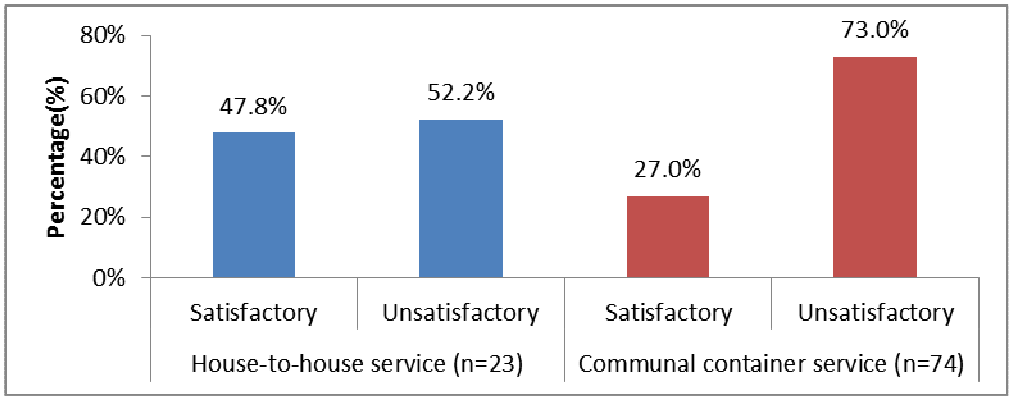

Figure 5: Residents' satisfaction with waste collection services

Payment for waste collection is only done by residents patronising the house-to-house waste collection service (22%) whiles others do not pay for waste collection (Table 4). The house-to-house method is given out on franchise basis to private waste management companies in urban centres in Ghana and subscribers are made to pay a fee for weekly collection (Puopiel 2010). Results from the study indicate that this service costs subscribers US$3.6 and US$5 per month for 120L and 240L bins respectively (Table 4). Majority of residents (87%) patronising this service paid US$5 per month. Moreover, most residents opined that the waste collection cost is economical.

However, according to the residents, the general quality of service regarding waste collection service is unsatisfactory. More than half (69%) of residents interviewed expressed their dissatisfaction about the quality of service rendered by the service provider. The major reason given for their assertion include delays in waste collection leading to overflow of bins or communal containers creating unsightly conditions and generation of offensive odour. Particularly among residents who deposited their waste into communal containers, close to 4 out of every 5 people (73%) regarded the waste collection service unsatisfactory (Figure 5). This confirms findings by Puopiel (2010) in the capital of the Northern Region of Ghana, Tamale regarding the quality of service by private waste management companies. Although more than half (52%) of residents patronising house-to-house collection (mostly high-income households) also considered their quality of service as unsatisfactory it can be deduced that it is comparatively better than the communal container service in low-income areas (Figure 5). This is in consonance with findings by various authors (Zurbrugg 2003; Anomanyo 2004; Tsiboe 2004; Oduro-Kwarteng 2011) which pointed out that the quality of service of solid waste collection in low-income areas is poor as compared to middle and high income areas.

Therefore, the urban poor usually suffer most from the repercussions from the poor solid waste management system. Nonetheless, residents have no medium to channel their concerns and attributed the poor quality of service to monopolization of waste collection services in the township by the private waste management

company. This poor quality of service could coerce some residents to revert to other crude dumping methods if drastic measures are not put in place to improve current conditions in the study area.

It could be deduced that the private waste company devote their resources to areas where they would readily recover cost viz. subscribers to house-to-house collection whiles neglecting those who do not readily pay for waste collection services. This is confirmed by findings by Quartey (2011) after conducting a performance audit on the solid waste management system in Accra Metropolitan Assembly. According to him, the delays in payment for services rendered by private waste management companies is the major factor that contribute to the poor waste collection services in communities relying on communal containers for waste disposal. The private companies are consequently unable to buy fuel, maintain their equipment and pay staff salaries, leading to low morale and low performance. The Assembly therefore lacks the thrust to undertake performance evaluation of the service providers and apply the necessary sanctions for the poor services rendered. Therefore, to reverse the poor level of service in low- and middle-income areas in the Wa municipality, other cost recovery strategies such as the pay-as-you-throw (PAYT) method, currently being practised in some parts of the country, can be employed. This where residents are made to pay a fee for waste disposal at communal container sites before depositing waste into communal containers based on the amount of waste to be disposed of.

3.3 Forces behind poor waste management services in Wa

The Waste Management Department (WMD) is the public outfit tasked with the day-to-day collection, transportation and disposal of waste (solid and liquid), public education on waste management, public cleansing and supervision of private contractors engaged by Metropolitan, Municipal and District Assemblies (Oduro-Kwarteng 2011). However, due to lack of funds, limited logistics and personnel, this task has been mostly contracted to private waste management companies in the country. Currently, the WMD plays the role of facilitation, regulation and monitoring of solid waste management services by private waste management companies. Although there are several private waste management companies in the country, ZoomLion Company Limited has the greatest proportion of the waste management services across the country, including the Wa Municipal Assembly. An assessment of the institutional arrangement for solid waste management in the Assembly indicated that, solid waste collection services is being monopolized by ZoomLion Company Limited possibly resulting in the poor services rendered by the company. There are also no punitive measures instituted to coerce the company deliver competitive services to residents.

Interviews with the Waste Management Department (WMD) and ZoomLion Company Limited revealed that the solid waste management system in place in Wa is plagued with many challenges resulting in the poor quality of service. Apart from the poor layout of the township which hinders collection and transportation of solid waste, respondents from the WMD indicated that inadequate communal containers, frequent breakdown of waste collection vehicles and the poor attitude of the public towards sanitation are among the factors that militate against solid waste management in Wa. The Department also lacks a strategic plan to monitor the quality of service and apply the necessary sanctions on the private solid waste management company. Moreover, representatives of the ZoomLion Company Limited also expressed similar challenges and also pointed out that bye-laws on sanitation is ill-enforced thereby encouraging insanitary practices among the public. According to them, practices such as indiscriminate dumping of waste, open defecation at communal container sites and disposal of waste containing embers sometimes resulting in burning of communal containers also adversely affect their operations in the township.

4.0 Conclusions

The study showed that household solid waste in Wa is dominated by organic waste (48%) and inert materials (33%). Plastics/rubber and metals together make up an average proportion of 10% of domestic waste (5% each) whiles textiles/fabric, paper/cardboard and miscellaneous constitute 4%, 3% and 2% respectively. Since almost half of the household waste is organic, composting could be considered as the best management option. This would reduce the household waste by half thereby prolonging the lifespan of landfills whiles at the same time serve as manure for farmers in the Municipality. It should however, be preceded by intensive education of residents on source separation of waste in order to evade the cost of waste separation at composting sites. The study points out that, the inert materials in household solid waste is mostly made up sand resulting from household sweepings of unpaved surfaces particularly in low income areas. As a result, education of residents to desist from adding sand from sweepings to their household waste would further significantly reduce the fraction of inert materials ending up in the waste stream. This will also protect collection equipment from rapid deterioration due to abrasion from inert materials. Moreover, since the Municipal has the intention of constructing a plastic waste recycling plant, efforts should be directed at recovering all the plastic materials in

domestic waste for recycling. This, apart from generating employment opportunities, will also curb the current practice of indiscriminate littering of the environment with plastics and at the same time recover valuable materials.

The average domestic waste generation rate (0.68±0.24kg/cap/day) coupled with the average bulk density (44.9±28 kg/m^3) would be helpful in sizing communal storage facilities, determining waste collection frequencies and the optimum number of trucks to be used for waste collection from households. However, the quantity of domestic waste that end up at the landfill site can be reduce to almost a third if waste recovery efforts are implemented. Considering the low density of waste in the study area, compactor trucks would be suitable for waste collection from households since it requires compaction.

Much effort is needed to ensure that waste is stored in a hygienic matter prior to disposal. From the study, about half of residents exposed their waste to flies and other insects before final disposal. Although insignificant, the study also found that a fraction of residents dump their waste into nearby bushes. This practice could lead to the spread of diseases in the community and thus require health education to be intensified among residents. Generally, more than half of residents are not satisfied with the level of service rendered by the service providers, particularly in low income areas. This could stimulate open dumping of waste among the residents due to overflow communal containers in the community which could trigger an epidemic. To improve the service level in low income areas, the study recommends a cost recovery mechanism for private waste collection companies viz. the pay-as-you-throw method to enable them offset the cost of solid waste collection. It is only by doing so that the Municipal can have the impetus to monitor and sanction non-performing service providers.

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References

Anomanyo, D.E. (2004), "Integration of Municipal Solid Waste Management in Accra (Ghana): Bioreactor Treatment Technology as an Integral Part of the Management Process", *MSc. thesis*. Lund University, Sweden.

Boadi, K. O. & Kuitunen, M. (2004), "Municipal Solid Waste Management in the Accra Metropolitan Area, Ghana", *The Environmentalist* **23**, Kluwer Academic Publishers, The Netherlands.

Chandrappa, R. & Das, D. B. (2012), "Solid Waste Management: Principles and Practice", *Environmental Science and Engineering*, Springer, 48-50.

Cheremisinoff, P. N. (2002), "Handbook of Water and Wastewater Treatment Technologies", *Butterworth-Heinemann Publications*, Woburn, USA.

Cointreau S. J. (1982), "Environmental Management of Urban Solid Wastes in Developing Countries: A Project Guide", The World Bank, *Urban Development Paper* **5**, 10.

Dapatem, D. A. (2013), "Report on 2010 Population Census Out", Retrieved from: http://graphic.com.gh/General-News/report-on-2010-population-census-out.html Accessed: 7/6/2013

Ghana News Agency (2010), " Recycling Plant for Wa Soon",

Retrieved from : http://wa.ghanadistricts.gov.gh/?arrow=nws&read=33458 Accessed: 9/6/2013

Hoornweg, D. & Bhada-Tata, P. (2012), "What a Waste: A Global Review of Solid Waste Management", The World Bank, *Urban Development Series* **15**, 8-10.

Keiding, J. (1986), "The Housefly - Biology and Control", Training and information guide WHO/VBC/86.937, World Health Organization, Geneva.

Ketibuah, E., Asase M., Yusif S., Mensah, M.Y. & Fischer, K. (2004), "Comparative Analysis of Household Waste in the Cities of Stuttgart and Kumasi-Option for Waste Recycling and Treatment in Kumasi", *Proceedings of the 19th international CODATA Conference*, 1-8.

Kotoka, P. (2001), "Physical Analysis of Solid Waste in Selected High-Income Communities in Kumasi", *MSc Thesis*, Kwame Nkrumah University of Science and Technology, Kumasi.

Mensah, A. A. (2010), "Physico-Chemical Characteristics of Solid Waste and Treatment Options: A Case Study of Kumasi, Ghana", *MSc Thesis*, Kwame Nkrumah University of Science Technology, Kumasi, Ghana.

Oduro-Kwarteng, S. (2011), "Private Sector Involvement in Urban Solid Waste Collection: Performance, Capacity, and Regulation in Five Cities in Ghana", CRC Press, *Taylor and Francis Group*, 13-26.

Ogwueleka, T. C. (2009), "Municipal Solid Waste Characteristics and Management in Nigeria", *Iran. J. Environ. Health. Sci. Eng.* **6** (3), 173-180.

Obirih-Opareh, N. and Post, J. (2002), "Quality Assessment of Public and Private Modes of Solid Waste Collection in Accra", *Habitat International* **26**, 95 - 112.

Puopiel, F. (2010), "Solid Waste Management in Ghana: The Case of Tamale Metropolitan Area", *MSc Thesis*, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Quartey, Q. R. (2011), " Performance Audit Report of the Auditor-General on Solid Waste Management by Accra Metropolitan Assembly", Retrieved from:

http://www.ghaudit.org/reports/WASTE_MANAGEMENT.pdf Accessed: 14/6/2013

Taiwo, A. M. (2011), "Composting as a Sustainable Waste Management Technique in Developing Countries", *Journal of Environmental Science and Technology* **4**(2), 93 -102

Tchobanoglous, G. & Kreith, F. (2002), "Handbook of Solid Waste Management", *The McGraw-Hill Companies*, USA.

Tsiboe, I. A. & Marbell, E. (2004), "A Look at Urban Waste Disposal Problems in Accra, Ghana", *MSc Thesis*, Roskilde University, Roskilde, Denmark.

UN-HABITAT (2010). Housing as a Strategy for Poverty Reduction in Ghana. United Nations Human Settlements Programme. UNON, Publishing Services Section, Nairobi. Kenya, 11.

USAID (1982), "Water for the World: Planning Solid Waste Management Systems", Technical Note No. San. 3.P., *US Agency for International Development*, Washington DC, USA.

van Dijk, P.M. & Oduro-Kwarteng, S. (2007), "Urban Management and Solid Waste Issues in Africa", *ISWA World Congress,* Amsterdam.

Zerbock, O. (2003), "Urban Solid Waste Management: Waste Reduction in Developing Nations", Michigan Technological University, Houghton, MI.

Zurbrugg, C. (2003), "Urban Solid Waste Management in Low-Income Countries of Asia: How to Cope with the Garbage Crisis", *Urban Solid Waste Management Review Session,* Durban, South Africa, 1-10.