MILLENNIUM CITIES INITIATIVE (MCI)
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

University of Ghana
Legon

Report to the Accra Metropolitan Assembly on Solid Waste Composition in Aryee Diki electoral area, Ayawaso Central Submetro, Accra New Town

Millennium Cities Initiative

Report on Findings of the Waste Composition Study for the Aryee Diki electoral area of Accra New Town, Accra

Prepared by The Millennium Cities Initiative (MCI),
a project of the Earth Institute, Columbia University
and
The University of Ghana, Legon

For submission to the Accra Metropolitan Assembly

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DISCLOSURE STATEMENT

This study was conducted in partnership with the University of Ghana Legon's Environmental Sciences Program and Zoomlion Ghana Limited, the latter providing logistical support. This support included the time of laborers, who assisted with waste separation; provision of protective gears; waste bins for participant houses; and a site for the systematic separation of the waste.

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LIST OF ABBREVIATIONS

AMA	Accra Metropolitan Assembly
ISWMS	Integrated Solid Waste Management Strategy
MCI	Millennium Cities Initiative
MSWM	Municipal Solid Waste Management
UGL	University of Ghana, Legon
UESP2	World Bank Second Urban Environmental Sanitation Project
WMD	Accra Metropolitan Assembly Waste Management Department
ZGL	Zoomlion Ghana Limited

EXECUTIVE SUMMARY

Solid waste management is one of the most challenging and contentious issues in Accra, Ghana's capital city. In a recent citywide survey conducted by the World Bank and the Accra Metropolitan Assembly (AMA), solid waste management was viewed by residents as the third-most important urban service, behind sanitation (including toilets) and drainage (World Bank, 2010). A well-functioning system for proper municipal solid waste management (MSWM) is key both to ensuring the public health of all citizens and to achieving Millennium Development Goal #7, environmental sustainability.

Refuse generation in Accra is estimated to have increased three-fold over the last two decades, due to factors including population growth, increased urbanization, and lifestyle changes (WaterAid & EU, 2008). . Furthermore, the population in urban areas is projected to double within the next decade (WaterAid & EU, 2008). At the current population, records indicate that approximately 2,000 metric tonnes of waste are generated daily, but only 1,200-1,300 tonnes are properly collected (AMA 2009a). Given anticipated population increases in the near future, and urbanization, determining solutions for solid waste management in Accra has become an extremely critical issue. The subject is especially critical in low-income areas, which are particularly susceptible to the negative effects of a poorly managed municipal solid waste system.

The Accra Metropolitan Assembly (AMA) has recently focused its efforts on a waste incineration/waste-to-energy project as a potential means to minimize the city waste stream. Centralized composting has also been viewed as a potential intervention. In order to assess the viability and appropriateness of these large-scale and high-technology projects, a number of considerations must first be evaluated, prior to planning and implementation. The selection of an appropriate waste management system must be determined based on the proposed system[s]' appropriateness within specific localities, with all location-specific social, political and economic factors thoughtfully assessed and factored into the decision-making process.

A fundamental step in determining appropriate MSWM is having detailed and accurate data on quantity and composition of waste to draw upon for planning. The AMA Waste Management Department is in need of further such data, especially up-to-date data from low-income communities. To assist the AMA in filling this information gap, the Millennium Cities Initiative (MCI), in conjunction with the University of Ghana and Zoomlion Ghana Limited, conducted a waste composition analysis in the low-income electoral area of Aryee Diki, in Accra Newtown. Twenty houses (approximately 143 households) were randomly selected for House pick-ups for three weeks and were given bins in which to dispose of their waste.[1] The MCI-UGL research team separated and categorized the sample waste stream according to organic, plastic, paper and

[1] The houses were allowed to keep the bins after the study.

cardboard, textile, metal, glass and miscellaneous content and weighed. The percentage of combustible and compostable material was also calculated.

The MCI-UGL researchers found organic material to be prevalent in the sample waste stream, at 67 percent of the total, with plastics comprising 20 percent, and textiles rounding out the top three categories. Seventy-six percent of the sample waste stream was compostable, and 95 percent was combustible.

A household survey was also conducted in order to obtain data on per capita and household numbers within each compound and family house, as well as to gauge willingness to participate in source separation initiatives, and to learn resident perspectives on how waste management can be improved in their community. Eighty-five percent of the households (N=20, one head of household from each house, typically the landlord) responded in favor of participating in a source separation initiative if no additional costs to them are incurred and if public education is provided. The two most cited ways to improve waste management in Aryee Diki was for service providers to allocate more bins and to have more frequent waste pick-ups.

On the basis of its research findings, the MCI-UGL study recommends the following four interventions: 1) a source separation initiative for plastics recycling and composting, which can only be achieved with a community educational component; 2) employment creation and integration of the "Kaya Bola"[2] into the formal collection service, in order to ensure smooth collection of separated waste; 3) disposal of Aryee Diki's compostable waste to the Medie Composting Plant, scheduled to open between August - December 2011; and 4) establishment of a waste stream research program between the AMA and Ghana's research institutions, so that full waste stream analyses – including dry weighing, moisture content analysis, and calorific valuation - can be conducted, generating robust and reliable data that can be drawn upon for key decision-making regarding appropriate waste management technologies at the submetro and community levels.

These policy recommendations provide action items that augment the findings and objectives of the World Bank and AMA's Second Urban Environmental Sanitation Project's Integrated Solid Waste Management Strategy. As such, this report presents a small but potentially significant way forward toward improving MSWM in the community of Aryee Diki, which may be scaled up to cover the Central and East Ayawaso submetros.

[2] The Kaya Bola are waste pickers providing house to house service outside the formal waste collection sector. Their services are in demand, especially in low-income areas where vehicular access for waste collection is not possible.

INTRODUCTION

Solid waste management presents a major challenge in Accra, Ghana's capital city, primarily among residents living within high-density, low-income communities. Mismanagement of solid waste has resulted in a large majority of domestic refuse being dumped into open areas and storm drains. The clogging of storm drains has further exacerbated sewage and sanitation problems, leading to subsequent flooding and pollution problems and introducing public health hazards into the Accra area. Issues in sanitation span the entire sector, from operations management and collection to the transport and disposal of waste.

Proper municipal solid waste management (MSWM) is essential both for the public health of Accra residents and the city's environmental protection and future.. This is especially critical among the urban poor, who are particularly vulnerable to the effects of a poorly managed municipal solid waste system. As a consequence of dumping refuse into open drainage and other residential areas, existing drains are often clogged with waste material, leading to a proliferation of vermin and disease vectors in these communities. Standing pools of water, as a result of drainage clogging, promotes breeding conditions for disease-carrying mosquitoes. The spread of malaria, currently the most common communicable disease in Accra, as well as of the other leading communicable diseases (e.g., dengue and yellow fever), are associated with poor environmental sanitation and other conditions often associated with extreme poverty. Malaria currently represents the number one communicable disease in the area. In 2005, an estimated 292,685 cases of malaria were reported in Accra, among a base population of approximately 1.7 million (AMA 2009a).

Rapid urbanization and population growth have exacerbated the problems facing MSWM. According to the 2000 Ghana National Population Census, the population of Accra is approximately 1.7 million people, with an annual growth rate of 4.3 percent (UN-HABITAT 2010). A 2009 estimate placed the population of Accra at 2.1 million, with projections that the population exceeds 3.5 million when migration flows are factored into the population count (World Bank 2010, pg. 11). Refuse generation in Accra is estimated to have increased three-fold over the last two decades, due to factors including population growth, intensified urbanization and life-style changes. Furthermore, the population in urban areas is projected to double within the next decade (WaterAid & EU, 2008). At the current population, records indicate that approximately 2,000 metric tons of waste are generated in Accra each day, but only 1,200-1,300 tons are properly collected (AMA 2009a). Given future population projections, determining solutions to solid waste management in Accra has become an extremely time-sensitive matter.

Low-income communities in Accra are particularly stricken by poor solid waste management. The lack of organized solid waste collection routes and passable road networks in slum areas has introduced additional difficulties in an already underserviced and ineffective system of waste collection and transport. Currently, the most common system of waste collection is the central container collection system, whereby households are responsible for transporting their waste to refuse containers located within the communities, managed by private waste collection companies. Both middle and low-income areas are serviced in this way, representing approximately 80 percent of the total collection system in Accra. Although the central containers are to be sited at a maximum of 150 meters from residences (AMA 2009a), MCI observed that containers are commonly located further distances than the maximum, up to 450 to 500 meters in some communities.

The challenges associated with MSWM necessitate the introduction of new waste management programs in Accra. The Accra Metropolitan Assembly (AMA) has recently focused its efforts on a waste incineration/waste-to-energy project as a potential means to reduce significantly the city waste stream. Centralized composting has also been viewed as a potential intervention.

In order to assess the viability and appropriateness of these large-scale and high-technology projects, a number of considerations must first be evaluated, prior to planning and implementation. Decisions regarding the selection of waste management systems need to be determined based on the proposed system[s]' appropriateness within specific localities, with all location-specific social, political and economic factors thoughtfully assessed and factored into the decision-making process. For instance, local capacity, potential stakeholders (i.e. local communities, private-sector enterprises, government agencies), the physical layout of the city, municipal budgets and access to capital, and local waste characterization must also be determined (Oteng-Ababio, 2009).

Waste characterization includes an assessment of current waste generation rates (city-wide as well as by community), its composition, major sources, etc. This is of particular relevance to the assessment of MSWM interventions, with regard to large-scale incineration and composting programs. The success of a waste-to-energy project relies on determining the amount of waste available for incineration, as well as the typical moisture content of the waste stream. Waste characterized by high moisture content may be less suitable for incineration, since more energy will be required to burn waste with high levels of moisture (Fobil, J.N. et al., 2007).

To help obtain such information, the MCI-UGL research team investigated the composition of waste in selected houses in one low-income Accra community, given that such communities, often victims of improper solid waste management, generally represent any city's most problematic areas. This study was designed to characterize the waste stream, to determine its composition by weight and to utilize this knowledge in assessing the suitability of those MSWM programs under consideration. Previous studies have demonstrated a correlation between waste generation trends and socio-economic characteristics (Oteng-Ababio, 2009). The MCI-UGL study focused on waste stream characteristics within the low-income electoral area of Aryee Diki in the Central Ayawaso submetro of Accra, in order to better inform the MSWM needs of this community.

A number of waste characterization studies have been conducted in Accra, mainly to determine the suitability of new MSWM programs. Fobil et al. (2005) explored the potential for a waste-to-energy project by calculating the calorific and moisture content of municipal waste. The authors divided the study area into three distinct waste zones based on income levels, under the assumption that a positive correlation exists between per capita waste generation and income. Waste was collected from 10 houses from each zone, and composite samples were analyzed from each zone. The authors found that the type of waste was similar in each zone; however, waste differed in its overall amount, and proportions of waste composition varied by zone.

Results demonstrated that organics constituted approximately 60 percent of total weight, averaged across all zones, and plastics/rubber and paper represented the second highest constituents of waste, both at eight percent of total weight. Wastes from all zones were found to have high moisture content (ranging from 39.8 percent in low-income zones to 62.2 percent in high-income zones) and low calorific values (ranging from 14MJ/kg in low-income zones to 20 MJ/kg in high-income zones). Average energy recovery efficiency was calculated at a rather low 40 percent. This study was valuable in that it included an analysis of waste characteristics from a range of income levels and different geographic areas. However, the analysis was limited by the inability to calculate caloric values for plastics/rubber, due to a lack of proper equipment. Therefore, plastics were not accounted for in energy recovery efficiency calculations (Carboo & Fobil, 2005).

This represents a significant study limitation, since plastics were tied with paper at eight percent of total composition by weight. Furthermore, the use of plastics in Accra is rapidly on the rise, due to an increase in plastic food containers and sachet water production

Carboo and Fobil (2005) conducted a follow-up study to better categorize the physical and chemical attributes of waste in Accra. As in the previous study, areas were divided into waste collection zones based on income levels. Similar moisture contents were derived, averaging approximately 60 percent. The authors observed solid waste from high-income areas to be greater in compounds containing high-energy bonds. It was concluded that high-income residents are less sparing in discarding goods, and therefore tend to discard more energy-rich materials than low-and-middle income residents. Ratios of carbon-to-nitrogen (C:N) were also calculated, to determine waste suitability for municipal composting. C:N ratios were extremely variable, ranging from 27:1 to 100:1 (ideal range is 25:1- 35:1). Based on their results, the authors concluded that a waste-to-energy project would not be economically feasible, but that composting programs may be a more viable citywide MSWM option (Carboo & Fobil, 2005).

Fobil et al. (2007) divided waste stream analysis data into "combustible" and "compostable" categories, in order to determine the ratio of waste material available for composting versus incineration. Calculations yielded a much larger percentage of non-combustibles in low-income areas, likely due to a high abundance of inert materials in the waste stream. In addition, the C:N ratio in low-income areas was approximately 34:1, with a moisture content of 39.8 percent, both ideal values for composting (Fobil et al. 2007, 11).

While waste characterization/composition studies have previously been conducted for the Accra metropolitan area, rapid population growth as well as life-style changes associated with economic development (i.e. increase in eating outside the home and rise in use of plastic/disposable packaging for take-out food items) requires periodic and up-to-date available waste composition data. In the absence of reliable data regarding waste stream characterization, there is potential for waste management facilities to incorrectly gauge the size and/or amount of waste stream materials. Such miscalculations can result in faulty and inefficient operations, improper management and technical problems in operational capacity, leading in turn to low satisfaction rates among urban residents regarding municipal service delivery.

The AMA recognizes the need to confront the problems of MSWM in low-income communities in particular. These areas contribute to the greatest burden of overall waste generation in Accra, since the largest share of the resident urban population resides in these areas (Fobil et al., 2007). As a representative example of these neighborhoods, and at the request of the AMA, the MCI-UGL research team chose to conduct its study within the low-income community of Aryee Diki.

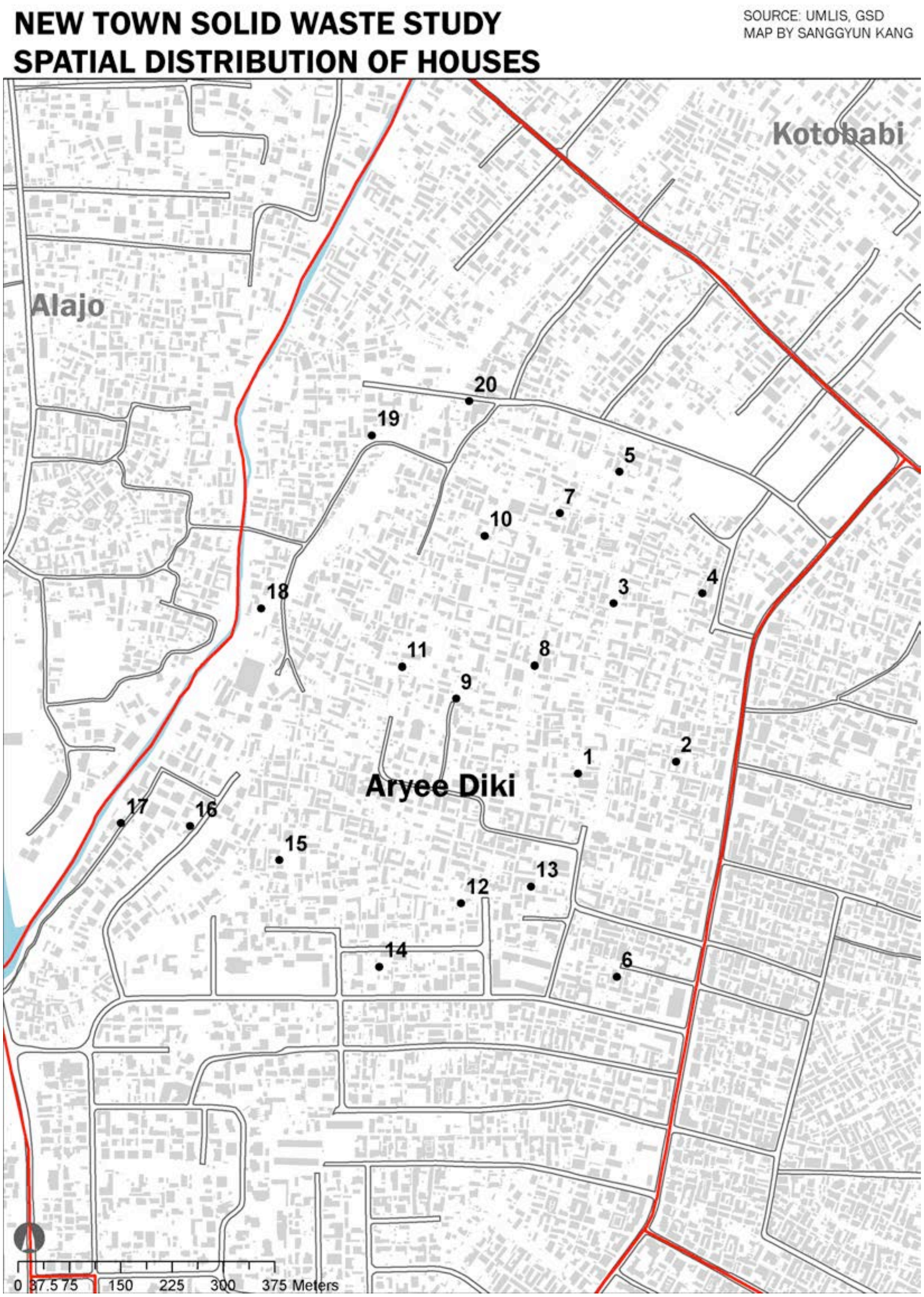
RESEARCH METHODOLOGY

STUDY AREA

The study was conducted in Accra, the seaside capital of Ghana, a country located on the Atlantic coast of West Africa. Ghana occupies a total land area of 238,537 square kilometers and has a total population of 18.9 million (GSS, 2000, 2003). The greater Accra region in which Accra is located is both the administrative and economic capital of the republic. Although it is the smallest of Ghana's 10 political regions, it has the largest population (Stephens, 1999) of Ghana's 10 leading urban centres, with an approximate population of 1.7 million in 1990 and 2.1 million in 2009 (World Bank 2010, pg. 11).

Aryee Diki is located in the Ayawaso Central Sub-Metro area, within the district of Kpehe (see map 1, pg. 12). The electoral area is bordered by the communities of Alajo to the north/northwest, Kpehe/Kokomlemle to the south, and New Town and Kokomlemle to the east. Based on a 2009 Sub-Metro District Council publication, the estimated population is 57,933 residents, with approximately 961 residential units (AMA 2009b). One public toilet facility exists to the north of the community, adjacent to one of two central refuse container locations. The other central container units are located along the southwestern border of the community, in proximity to the newly constructed Onyasia drain. Based upon observation from site visits, there are approximately two to three refuse container units located in each of the two locations. Aryee Diki waste is managed by ZGL. Like most of the city's low-income neighborhoods, Aryee Diki enjoys significant commercial activity within the residential area (GLSS 4, 2000).

Map 1: New Town (Aryee Diki) Solid Waste Study- Spatial Distribution of Houses



SELECTION OF HOUSES

The entire area was divided into three zones based on size. The houses were then selected in the ratio 7:8:5, depending on the size of the zone. In all 20 houses were selected (each house had a 1-6 chance of been chosen), and these selected houses were spaced far enough apart to ensure more of a representative sample.

WASTE COLLECTION

Each of the 20 houses was provided with a 240-liter plastic waste bin supplied by ZGL. Each bin was lined with a bag. Residents were then required to dump their waste into the bin. Refuse from each house was collected twice a week, on Mondays and Thursdays, to obtain a representative week's worth of household waste. The bags from each house were given special identification numbers and then transported to a designated site for sorting and segregation.

WASTE STREAM ANALYSIS

A large clean plastic sheet was spread on the floor at the sorting site, and the contents of the bag(s) of waste taken from each house were manually separated to determine the proportion of the various waste components in the waste stream. Each category of waste for each house was weighed on a manual spring scale and recorded on a spreadsheet. The type of materials present in the waste stream of each house was the same, except that they differed in weights and proportions. The component materials in the waste stream were classified as follows:

- Plastics and rubber
- Glass
- Metals and cans
- Textiles
- Paper and cardboard
- Organic and putrescible
- Miscellaneous and others.

The MCI-UGL research team used a classification methodology that has been deployed in earlier Accra studies (Fobil et al, 2005). Inerts were not analyzed, as they had been mixed with organic material at source.

HOUSEHOLD SURVEY

A representative household member was selected from each of the 20 houses for a survey intended to ascertain the following:

- the composition of each house, in terms of total number of persons living there;

- the number of households in the house;

- their waste generation and disposal patterns;
- their willingness to participate in source separation;
- their recommendations for improving waste collection and management in the area.

LIMITATIONS TO ANALYSIS

A number of material and time constraints narrowed what the researchers were able to accomplish in this initial study.

Time, Resources, Limited Logistical Support: Due to limited time, available resources and logistical support, a more thorough waste stream analysis - including a moisture content and calorific content analysis – could not be conducted. These analyses require the use of sophisticated scientific equipment (i.e. waste shredders, solar dryers, high temperature ovens, incubators, desiccators, bomb calorimeters, hygrometers, etc.), which the MCI-UGL research team did not have at their disposal. In addition, the drying process for each sample analysis can take up to nine days -- an impossibility, given the time restrictions that were an unfortunate but necessary condition of this first study. Given these constraints, the study was limited to an analysis of waste composition by weight. The research team's calculations are based on the wet weight of material.

Also, past waste composition studies have demonstrated seasonal differences. It is possible that Aryee Diki waste might differ in composition in the dry season; however, the researchers were unable to account for seasonal variability in their analyses due to time restrictions.

In addition, lack of proper technology limited the research team's ability to properly separate out inert materials from bulk waste. Therefore, no separate category for inert weight is included in this analysis. Inert material was mixed into organic weight at source. However, the calculated value for total "compostables" (including both organics and inert material) should be given greater credence, as this is more important for determining suitability for municipal composting programs. Conversely, this limitation has the potential to overestimate the value for "combustibles," since organics are combustible material, whereas inerts are not defined as "combustibles."

Sample Size and Compliance Issues: Lack of compliance from participants during the study reduced the number of overall samples we were able to obtain. House ID #1 was not utilizing the provided waste bin and was reassigned for the final two remaining pick-ups. In addition, we were unable to determine if all houses were utilizing the bin for all of their accrued waste throughout the term of the study. There may therefore have been additional waste generated from the selected households during this time that was not accounted for in our study.

In addition, obtaining a larger sample size for our study would have been ideal. However, due to time restraints and limited logistical support as mentioned above, twenty houses was the maximum sample size the research team could realistically include in order to properly manage the study.

Initial Waste Collection: While the research team performed a total of five pick-ups during the study, final analysis of waste composition did not include data from the initial collection. Weight readings were recorded using a digital scale that was later deemed inaccurate. To maintain the integrity of our results, the data from the initial pick-up were therefore excluded from the dataset. However, the data from the initial pick-up is presented in the Appendix. Weight measurements from the remaining pick-ups were obtained using a spring scale.

FINDINGS

Results from the waste composition analysis conducted in the Aryee Diki study area show organic material (such as food, yard trimmings, etc.) to be most prevalent in the sample waste stream, comprising 67 percent of the waste generated among the participant houses. Plastic material (such as plastic bottles and sachet bags) accounted for 20 percent of the waste composition, and textiles rounded out the top three percentage fractions of waste generated in the study area at five percent (inerts would likely have been in the top three percentage fractions of waste generated in the study area, but mixing between inerts and organics made it too difficult to categorize). Figure 1 presents the percentage fractions of each category of the waste stream.

The percentage of compostable and combustible material in the study area waste stream was also measured. Compostable material may include organics, paper and textiles, although organics are typically the material most widely used for composting. Percentages of compostable material in the sample waste stream are provided for 3 iterations of composting: organics, organics and paper, and organics, paper and textiles; while combustible material is defined as the combination of organics, paper, plastics and textiles (Fobil 2005). Table 1 shows these results (see next page).

Figure 1. Percentages of Waste Composition Categories

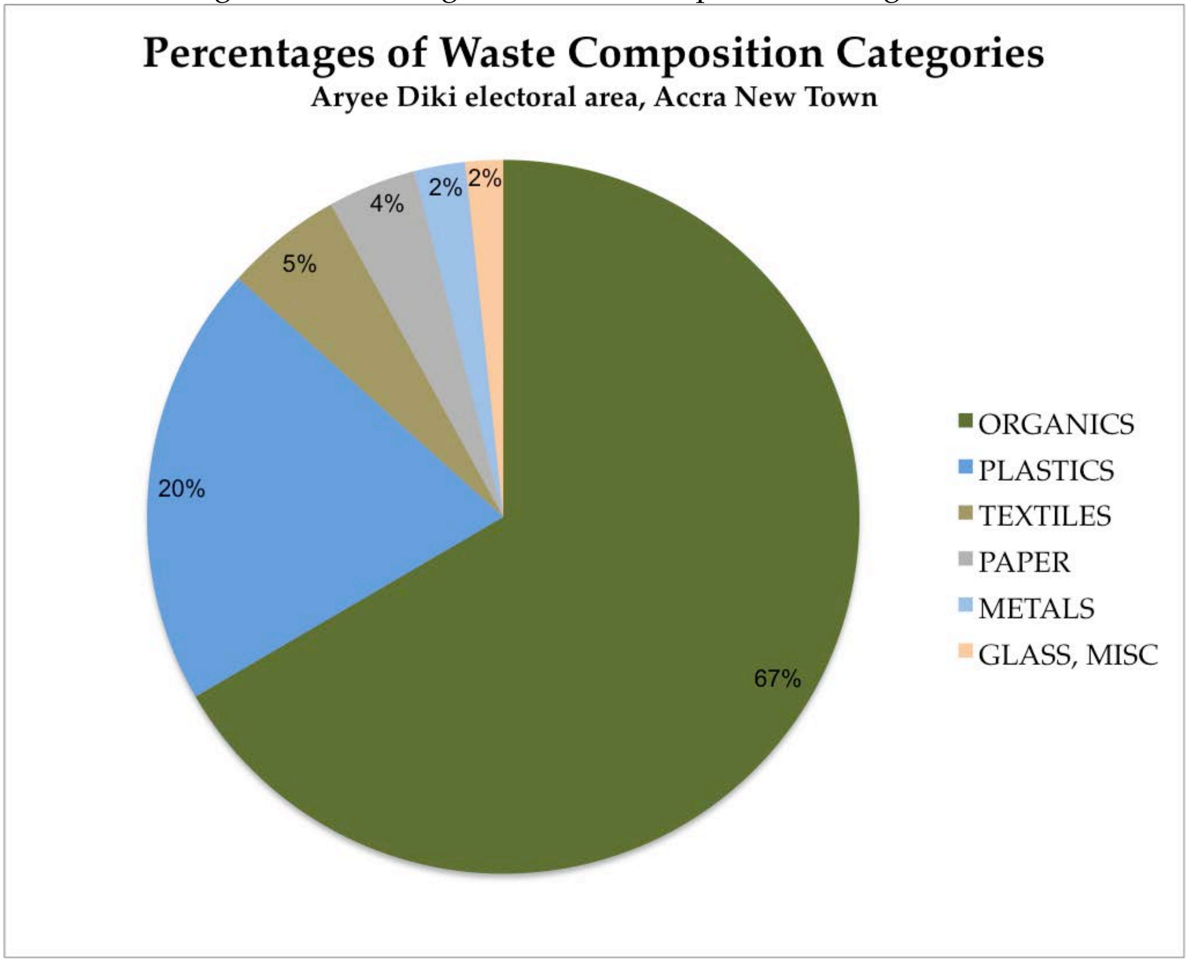


TABLE 1: Percentage of compostable & combustible material in sample waste stream

Compostable, combustible materials	**Percentage in waste stream**
Compostable: organics only	67
Compostable: organics and paper	70.6
Compostable: organics, paper, and textiles	76
Combustible: organics, plastics, paper, textiles	96

Given the above data, the following inferences can be provided with respect to potential composting, waste-to-energy technologies and recycling:

COMPOSTING

The data shows favorable conditions for waste conversion to composting in Aryee Diki, as compostable material comprises up to 76 percent of the sample waste stream. Additionally, in general there was willingness among residents surveyed in Aryee Diki to participate in source separation for composting, if no additional costs are incurred and if educational initiatives can be mobilized to support this activity (please refer to Figure 2, pg. 20).

WASTE-TO-ENERGY

Unfortunately, given the constraints of this study, it cannot be inferred that waste in Aryee Diki can be converted to energy. Data shows that 96 percent of the sample waste stream is potentially combustible, but clearly this does not amount to favorable conditions for waste-to-energy conversion – it only illustrates that most of the waste may be incinerated with relative ease. To determine the appropriateness of waste-to-energy technology for this study area and other communities in the sub-metro, a full waste stream analysis is needed, including calorific valuation and gauging of moisture content. Given seasonal variations and its impact on moisture content in the waste stream, such analysis would have to be conducted during dry, and rainy seasons.[3]

PLASTIC RECYCLING

Though this study focused on only one community (Aryee Diki electoral area) while other studies such as Fobil (2001) presented waste composition estimates for other low-income communities in Accra, it is worth referring to them (Fobil 2001, AMA-WMD 1993, AMA-WMD 2005), if only to make observations regarding the evolving presence of plastics in waste streams. In Fobil (2001), the percentage fraction of waste generated in "low-class residential" area(s) was estimated at nine percent. AMA 1993 reported a solid plastics percentage fraction of 1.3 percent, and 3.5 percent in 2005 (AMA-WMD 1993, AMA-WMD 2005). Citywide inferences cannot be made using the Aryee Diki waste stream data, as it cannot serve as an accurate representative sample for Accra Metropolitan Area, given the heterogeneous waste stream characteristics, socioeconomic and cultural features within AMA's communities. However, the Aryee Diki waste stream data provides some evidence that the presence of plastics in waste streams has increased significantly in the past decade in low-income communities in Accra, especially in light of previous estimates. This may be due to the increase in use of polythene bags for take-away food orders as well as water sachet bags.

Data from the study area shows a significant amount of plastics in the sample waste stream at 20 percent. Observations from the field illustrate indiscriminate disposal of plastics in drains (both legally and illegal constructed, and fissures in

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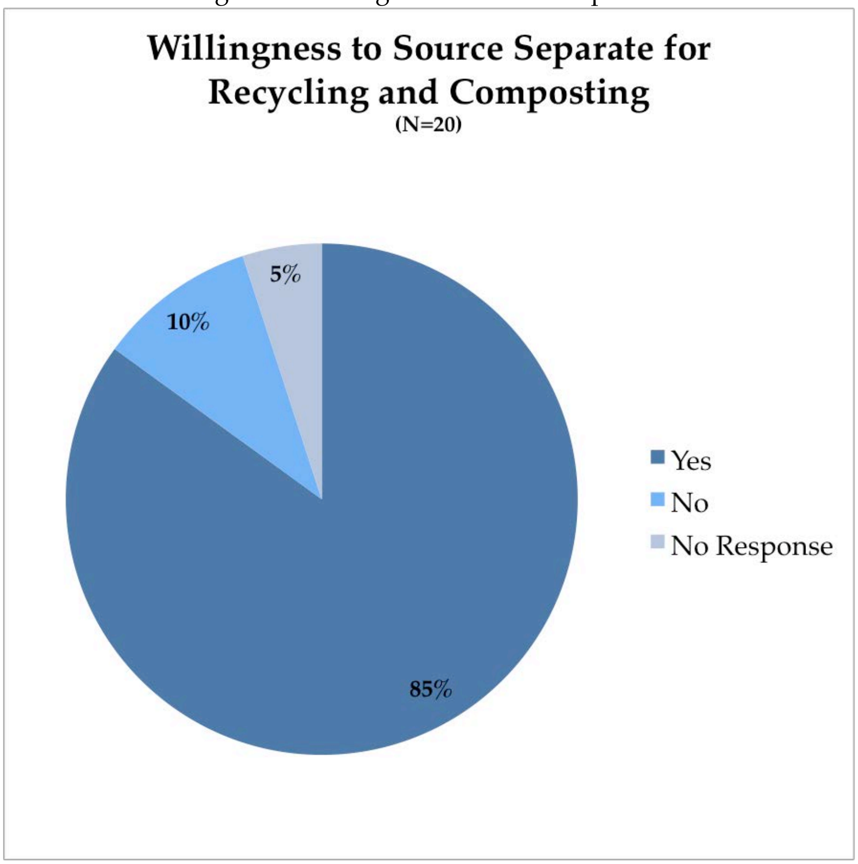
[3] Personal communication, Anderson Blay, Director, Waste Management Department

roads serving as de-facto drains), a common sight in the Ayawaso East and Central submetros and across Accra as a whole. As such, data and field observations demonstrate a need for plastic recycling programs, including, perhaps most importantly, the separation of plastics at the household level – which would require willingness of households to participate in such a program. The majority of participants in the study expressed willingness to separate plastics from their waste (see Figure 2).

Figure 2: Willingness to Source Separate



IMPROVING SERVICE DELIVERY

Household survey data reveal mild to moderate frustration among residents with respect to current waste collection service provision. While few residents expressed serious problems with their waste service – whether provided by a formal or Kaya Bola service – 85 percent of survey respondents provided feedback on how to improve existing waste collection service conditions in Aryee Diki. Figure 3 illustrates the respondents' suggestions for improving waste collection. The majority of respondents requested more bins and more frequent collection schedules.

Figure 3: Survey responses regarding how to improve waste collection service

RECOMMENDATIONS

This section provides a series of recommendations addressed to the AMA regarding possible solid waste management interventions in the Aryee Diki electoral area, and on a potentially greater scale, the Central Ayawaso Submetro. Specifically, these recommendations can be considered as proposed "action items" augmenting findings and observations as indicated in the World Bank/AMA Second Urban Environmental Sanitation Project's Integrated Solid Waste Management Strategy (UESP2 ISWMS).

I). Begin a composting and plastics recycling initiative in the Aryee Diki electoral area as a pilot program, with the intent of scaling up the initiative to the entire Central Ayawaso submetro if the pilot program proves successful. This recommendation falls within the scope of the following UESP2 ISWMS objectives:

- Section i.5, conduct public education on recyclable waste
- Section i.7, implement pilot projects for waste separation
- Section i.10, implementing pilot projects for composting

The proposed action items are as follows:

A) Begin source separation project

Source separation at the household level is an instrumental step in providing more efficient MSWM. With 85 percent of survey respondents willing to participate in source separation for plastics recycling and composting (if no additional costs are incurred), this is an opportune time to begin a source separation project in Aryee Diki. Such a project would require:

- Community sensitization on proper source separation, including public education meetings, neighborhood print advertisements, and selected door-to-door visits;
- Provision of an adequate number of bins at each house so that plastics, organics, paper and textiles can be separated, each labeled clearly.

A note on recycling: it is not certain what capabilities and facilities are at the disposal of AMA (as well as the private sector) to begin a stable plastics recycling program. A feasibility study on current recycling logistics would be beneficial for informing policy. The lack of incentives for private-sector engagement may be behind the dearth of recycling facilities in Accra. Public-private partnerships in recycling should also be considered, as well as buyback schemes that might further incentivize households to participate in recycling programs.

B) Waste collection, employment generation

For this initiative to be successful, a smooth institutional and logistical transition from the current waste collection method to a collection service for source-separated waste is essential. This would fall under the responsibility of the current service provider for Central Ayawaso submetro. The obstacle for the service provider, however, would likely be accessibility. Roads and alleyways in Aryee Diki are currently either in too poor condition for a Bola taxi to navigate in, or too narrow for a truck or taxi to reach houses in order to collect unsorted waste. The continuous stoppage of trucks to pick up waste from every house may also be economically unattractive to the private sector, due to depreciating conditions of vehicles and related maintenance costs.

This obstacle, however, can open up an opportunity for employment generation. The AMA has acknowledged the importance of integrating the manual waste pickers known as "Kaya Bola," into the formal waste collection service. Furthermore, the UESP2 ISWMS states (pg. 43),

> Upgrading the existing informal activities of scavengers through integration into the formal sector needs to be looked at very seriously in view of the potential for job creation at the grassroots level.

The benefits of such integration are clear; taking advantage of an established service that is familiar and widely accepted by low-income communities. In Aryee Diki, for example, 80 percent of the study participants use the Kaya Bola service. Additionally, given that numerous housing clusters in Aryee Diki are only accessible by foot, it makes sense for the Kaya Bola workers to collect source-separated waste.

Given these benefits, the MCI reiterates the UESP2 ISWMS' finding that it would be extremely worthwhile to begin a genuine, concerted process of transitioning the Kaya Bola workers into a formal work arrangement agreeable both to them and to the service provider. The AMA can play a key role in this by identifying the stakeholders in this arrangement, including the workers, service provider and local community-based organizations.

C) Disposal to compost plant

The source separation project would serve as a necessary precursor for disposal to a composting plant. Given that ZGL is the service provider for the Central Ayawaso submetro, it is recommended that all compostable material be disposed of at the pending Medie Composting Plant, which is scheduled to be operational between August - December of 2011[4].

The estimated opening of the Medie Composting Plant in mid-to-late 2011 provides a potential "action timeline" for readying compostable waste to be disposed there. The action timeline framed below is only for conceptual reference and can be configured by AMA as deemed appropriate.

Logistical planning, preparation	January to March 2011
Facilitate integrating Kaya Bola workers into formal work	January to March 2011
Community sensitization: Streamside area	March to June 2011
Community sensitization: Catholic school area	April to June 2011
Community sensitization: Bank area	May to June 2011
Source separation bin distribution	June 2011
Pilot pick-up run to Medie	August 2011
Commencement of regularly scheduled disposal:	Mid-August 2011

II. Establishment of waste stream research program

The following recommendations are made in light of the limitations of this study. This waste composition analysis, while presenting important information on the characteristics of waste in a predominantly low-income community in Accra, represents only the beginning of what should be a full waste stream analysis that can inform key decisions determining the appropriate technologies to be used in the city's waste management. Such an analysis would include:

- Drying out waste samples to determine dry weight;
- Determining seasonal variation in waste stream characteristics;
- Measuring moisture content;
- Measuring calorific values.

The latter two measures are clearly important for determining the viability of waste-to-energy as an appropriate waste treatment technology. It is important to note, however, that full waste stream analyses are needed, not simply to justify investment in waste-to-energy, but simply *to identify the appropriate technology – whether it be composting, waste to energy, recycling of plastics, etc*.

[4] Personal communication, Zoomlion Ghana Ltd.

Local "ownership" and documentation of data is especially important, as this data can be drawn upon as justification for investments (both domestic and foreign) in composting, waste-to-energy and recycling plants, as well as for community and household source separation initiatives.
As such, the MCI-UGL study recommends that the AMA creates a *waste stream research program* to facilitate further waste stream studies. This recommended initiative falls under the scope of the following UESP ISWMS objectives (see pp. 68,69 of ISWMS):

- Section i.22, Undertake the relevant studies to determine type(s) of appropriate technology;

- Section j.1, Review current waste composition and generation parameters, indicating physical and chemical properties and establish thermal values;

- Section j. 2, Establish and maintain research relationships with institutions of higher learning.

As a first step, the AMA may identify the lead agency – in this case, the WMD – and identify capacity needs for the WMD to coordinate this initiative efficiently, including staff and logistical support. Implementation, however, can and should be conducted in partnership with Ghana's academic research institutions, such as UGL and Kwame Nkrumah University of Science and Technology (KNUST) as well as private sector service providers, to take advantage of embedded expertise and capacities to conduct such research. Donor and/or private sector financing should be identified to scale up waste stream research, which would invariably require investment in essential research technologies. This technology can be allocated to research institutions, which are in the best position to carry forth such research.

The involvement of Ghanaian academic research institutions in waste stream research serves a two-fold purpose: to facilitate needed data in a cost-efficient manner, and to tap into an increasingly growing pool of young researchers with keen interests in pragmatically addressing Accra's solid waste management challenges. This endeavor is of great importance, as the City of Accra will need all the dedication and diligence it can muster from its emerging crop of talent to make headway in MSWM.[5]

The coordinated integration of the AMA's waste management activities with the expertise of Ghana's own research institutions, while long overdue, would present a novel if not paradigm-shifting approach to MSWM in Accra. Key facilitators for this new partnership would include:

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[5] A parallel might be the case study of the Phnom Penh Water Supply Authority, whose success hinged in part on hiring driven young professionals eager to overhaul Phnom Penh's fledgling water supply sector. (See Asian Development Bank: Phnom Penh Water Supply Authority – an exemplary water utility in Asia, www.adb.org/water/actions/CAM/PPWSA.asp .)

- AMA Waste Management Department
- UGL Chemistry Department (with a laboratory enabling calorific valuation)
- UGL Geography and Resource Development Department
- UGL Environmental Sciences Program
- KNUST engineering department
- Other academic institutions as identified
- World Bank water and sanitation/UESP office
- Private-sector service providers

It is recommended that engagement with potential partners begin in September 2010, with the objective of identifying specific research projects to commence in January 2011.

CONCLUSION

The findings and recommendations provided in this report in effect amount to a proposed re-structuring of solid waste management in one community that needs improved waste management services, yet is not plagued with problems to the point where interventions would encounter an array of cumbersome roadblocks. In other words, conditions in Aryee Diki are favorable for the commencement of a pilot project that, if executed effectively, can be scaled up to other electoral areas in the Central Ayawaso submetro. A successful submetro-wide initiative could justify further investment in duplicating such efforts in the Ayawaso East submetro, for instance, in Kwao Tsuru, Maamobi and Nima, where waste collection and disposal conditions are dire.

Given the confirmation here of observations made by the city's waste management authorities that the use of plastics has risen dramatically,[6] it is clear that citywide recycling activities have become increasing necessary. It is no secret that such efforts have been stifled in the past, perhaps due to lack of incentives for the private sector. An important follow-on point will be to determine those capacities and technologies currently available to the AMA area. Finally, given that it is unlikely that the AMA will have the facilities in place for waste-to-energy conversion within the coming year, it is important in the interim to support waste stream research that can inform planning and decision-making in terms of where such technology is appropriate. The paramount objective of such research should be to identify the best waste management technology or technologies, given geographic, socioeconomic, and cultural characteristics in submetro communities. This research can and should be facilitated in partnership with Ghana's capable academic research institutions, as well as with donor agencies and the private sector.

The recommendations made here complement the objectives delineated in the World Bank/AMA UESP2 ISWMS, regarding the importance of taking small but significant steps towards the implementation of strategies to improve the MSWM in Accra. Plans and strategies are not in short supply in this case; rather, what is in short supply are tangible signs of progress. With careful planning, determination and capable partners, the AMA can begin to carry out the action items delineated in this report in the community of Aryee Diki and learn from this example how best to scale the intervention to benefit also the residents of Ayawaso Central and Ayawaso East submetros.

REFERENCES

Accra Metropolitan Assembly (2009)a. "Integrated Solid Waste Management Strategy." Hifab-SIPU-Colan Consultants. Urban Environmental Sanitation Project; Accra, Ghana.

Accra Metropolitan Assembly (2009)b. Ayawaso Central Sub-Metro District Council "District Environmental Sanitation Strategy and Action Plan." *Accra Metropolitan Assembly (AMA).* Accra, Ghana.

Accra Metropolitan Assembly (2010). "Accra, the Millennium City: A New Accra for a Better Ghana." Urban Planning Department Lecture, Spring 2010. Columbia University, New York, NY.

Carboo, D. and Fobil, J.N. (2005). "Physico-chemical Analysis of Municipal Solid Waste (MSW) in the Accra Metropolis." *West African Journal of Applied Ecology*. 7; 31-39.

Fobil, Julius N. et al (2005). "Evaluation of Municipal Solid Waste for Utilization for Energy Production in Developing Countries." *International Journal of Environmental Technology and Management*. 5:1, 76-86.

Fobil, Julius N. et al (2007). "Assessing Municipal Solid Waste (MSWs) for Composting Programmes in Rapidly Urbanizing Areas: a case study from Accra, Ghana." *International Journal of Environment and Waste Management*. 6:1/2, 25-40.

Oteng-Ababio, Martin (2009). "Private Sector Involvement in Solid Waste Management in the Greater Accra Metropolitan Area in Ghana." *Waste Management & Research*. 00; 1-8.

Schubeier, Peter (1996). "Conceptual Framework for Municipal Solid Waste Management in Low Income Countries." *Urban Management Programme*. United Nations Development Programme/World Bank/SDC Collaborative Programme on Municipal Waste in Low-Income Countries. Working Paper No. 9; Washington, DC.

United Nations Human Settlement Program (UN Habitat) (2010). *Ghana: Accra Urban Profile.* Regional and Technical Cooperation Division; Nairobi, Kenya.

WaterAid and European Union (2008). *Urban Sector Assessment Report.* Accra, Ghana.

World Bank (2010). *City of Accra, Ghana, Consultative citizens' report card*. World Bank: Washington, D.C.

APPENDIX

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	**Type**	**Weight (kg)**	**(kg)**	**(kg)**	**Weight (kg)**		
1	Plastics						
	Organics						
	Textiles						
	Metals						
	Paper						
	Glass, misc.						
	TOTAL (kg)		**0.0**	**0.0**		**0.0**	**0.0**
2	Plastics	9.1			7.3		
	Organics	16.5			12.6		
	Textiles	1.8			0.5		
	Metals	0.2			2.2		
	Paper	0.2			3.1		
	Glass, misc.	0.3			0.7		
	TOTAL (kg)	**28.1**	**16.7**	**27.6**	**26.4**	**15.7**	**23.5**
3	Plastics	9.5			2.9		
	Organics	34.5			16.4		
	Textiles	0.7			0.5		
	Metals	0.6			0.4		
	Paper	1.4			0.5		
	Glass, misc.	0.8			1.1		
	TOTAL (kg)	**47.5**	**35.9**	**46.1**	**21.8**	**16.9**	**20.3**
4	Plastics	1.5			2.6		
	Organics	2.0			5.5		
	Textiles	0.3			0.0		
	Metals	0.2			0.4		
	Paper	0.5			0.6		
	Glass, misc.	0.4			0.3		

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	Type	Weight (kg)	(kg)	(kg)	Weight (kg)		
	TOTAL (kg)	**4.9**	**2.5**	**4.3**	**9.4**	**6.1**	**8.7**
5	Plastics	4.8			12.2		
	Organics	9.6			23.5		
	Textiles	0.0			6.4		
	Metals	0.7			0.6		
	Paper	0.5			0.7		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**15.6**	**10.1**	**14.9**	**43.4**	**24.2**	**42.8**
6	Plastics	2.4			1.3		
	Organics	0.4			0.9		
	Textiles	0.0			0.1		
	Metals	0.4			0.3		
	Paper	0.2			0.2		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**3.4**	**0.6**	**3.0**	**2.8**	**1.1**	**2.5**
7	Plastics	1.3			0.9		
	Organics	2.6			2.6		
	Textiles	0.0			0.0		
	Metals	0.6			0.4		
	Paper	0.6			0.2		
	Glass, misc.	0.5			0.0		
	TOTAL (kg)	**5.6**	**3.2**	**4.5**	**4.1**	**2.8**	**3.7**
8	Plastics	12.2			13.8		
	Organics	37.7			37.6		
	Textiles	7.0			2.6		
	Metals	0.8			1.3		
	Paper	2.4			2.8		

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	Type	Weight (kg)	(kg)	(kg)	Weight (kg)		
	Glass, misc.	0.8			1.0		
	TOTAL (kg)	**60.9**	**40.1**	**59.3**	**59.1**	**40.4**	**56.8**
9	Plastics	1.1			0.9		
	Organics	4.1			4.1		
	Textiles	1.6			1.9		
	Metals	0.4			0.1		
	Paper	0.5			0.3		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**7.7**	**4.6**	**7.3**	**7.3**	**4.4**	**7.2**
10	Plastics	10.5			3.3		
	Organics	17.6			11.0		
	Textiles	2.6			0.3		
	Metals	1.4			0.2		
	Paper	0.7			1.3		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**32.8**	**18.3**	**31.4**	**16.1**	**12.3**	**15.9**

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	**Type**	**Weight (kg)**	**(kg)**	**(kg)**	**Weight (kg)**		
11	Plastics	1.6			1.7		
	Organics	6.6			21.1		
	Textiles	0.5			0.3		
	Metals	0.2			0.4		
	Paper	0.8			0.2		
	Glass, misc.	6.1			0.0		
	TOTAL (kg)	**15.8**	**7.4**	**9.5**	**23.7**	**21.3**	**23.3**
12	Plastics	5.9			8.9		
	Organics	14.1			18.8		
	Textiles	0.0			0.4		
	Metals	0.5			0.1		
	Paper	1.4			1.0		
	Glass, misc.	0.0			0.9		
	TOTAL (kg)	**21.9**	**15.5**	**21.4**	**30.1**	**19.8**	**29.1**
13	Plastics	4.2			4.1		
	Organics	10.8			6.6		
	Textiles	7.6			3.7		
	Metals	5.4			0.3		
	Paper	1.5			1.1		
	Glass, misc.	0.0			0.7		
	TOTAL (kg)	**29.5**	**12.3**	**24.1**	**16.5**	**7.7**	**15.5**
14	Plastics	7.9			3.7		
	Organics	11.0			19.5		
	Textiles	1.0			0.5		
	Metals	0.5			0.6		
	Paper	1.0			1.0		
	Glass, misc.	0.0			0.2		

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	**Type**	**Weight (kg)**	**(kg)**	**(kg)**	**Weight (kg)**		
	TOTAL (kg)	**21.4**	**12.0**	**20.9**	**25.5**	**20.5**	**24.7**
15	Plastics	9.3			7.9		
	Organics	16.0			20.5		
	Textiles	1.0			0.8		
	Metals	0.8			0.1		
	Paper	0.7			1.0		
	Glass, misc.	0.0			2.2		
	TOTAL (kg)	**27.8**	**16.7**	**27.0**	**32.5**	**21.5**	**30.2**
16	Plastics	4.7			7.0		
	Organics	21.5			18.5		
	Textiles	4.2			0.5		
	Metals	0.9			0.5		
	Paper	1.0			0.4		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**32.3**	**22.5**	**31.4**	**26.9**	**18.9**	**26.4**
17	Plastics	18.6			11.2		
	Organics	26.7			48.5		
	Textiles	2.2			4.6		
	Metals	0.9			1.0		
	Paper	1.9			2.0		
	Glass, misc.	0.6			1.0		
	TOTAL (kg)	**50.9**	**28.6**	**49.4**	**68.3**	**50.5**	**66.3**
18	Plastics	3.5			3.7		
	Organics	8.9			11.1		
	Textiles	0.0			0.7		
	Metals	0.4			0.4		
	Paper	0.8			0.7		

	Date:	Thursday, July 15	Compostable	Combustible	Monday, July 19	Compostable	Combustible
House ID#	**Type**	**Weight (kg)**	**(kg)**	**(kg)**	**Weight (kg)**		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**13.6**	**9.7**	**13.2**	**16.6**	**11.8**	**16.2**
19	Plastics	0.6			5.5		
	Organics	29.2			35.1		
	Textiles	0.0			0.0		
	Metals	0.0			0.5		
	Paper	0.4			2.5		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**30.2**	**29.6**	**30.2**	**43.6**	**37.6**	**43.1**
20	Plastics	2.9			4.0		
	Organics	31.5			41.0		
	Textiles	0.2			0.0		
	Metals	0.0			0.4		
	Paper	0.4			0.6		
	Glass, misc.	0.0			0.4		
	TOTAL (kg)	**35.0**	**31.9**	**35.0**	**46.4**	**41.6**	**45.6**

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
1	Plastics	6.5			22.1		
	Organics	21.3			50.8		
	Textiles	2.2			4.7		
	Metals	0.6			1.2		
	Paper	1.2			3.9		
	Glass, misc.	0.6			0.7		
	TOTAL (kg)	**32.4**	**22.5**	**31.2**	**83.4**	**54.7**	**81.5**
2	Plastics	3.4			5.2		
	Organics	6.8			8.9		
	Textiles	0.0			0.2		
	Metals	0.2			0.2		
	Paper	0.4			0.3		
	Glass, misc.	0.3			0.0		
	TOTAL (kg)	**11.1**	**7.2**	**10.6**	**14.8**	**9.2**	**14.6**
3	Plastics	6.3			6.3		
	Organics	20.0			22.3		
	Textiles	1.0			0.2		
	Metals	0.3			0.1		
	Paper	0.8			2.0		
	Glass, misc.	1.8			0.0		
	TOTAL (kg)	**30.2**	**20.8**	**28.1**	**30.9**	**24.3**	**30.8**
4	Plastics	1.2			5.4		
	Organics	5.6			12.0		
	Textiles	0.6			1.1		
	Metals	0.2			0.6		
	Paper	0.8			1.0		
	Glass, misc.	1.5			0.6		

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
	TOTAL (kg)	**9.9**	**6.4**	**8.2**	**20.7**	**13.0**	**19.5**
5	Plastics	4.0			7.2		
	Organics	14.1			23.0		
	Textiles	2.0			2.1		
	Metals	1.2			1.3		
	Paper	1.0			0.6		
	Glass, misc.	0.2			0.2		
	TOTAL (kg)	**22.5**	**15.1**	**21.1**	**34.4**	**23.6**	**32.9**
6	Plastics	0.8			5.8		
	Organics	0.6			12.4		
	Textiles	0.0			1.1		
	Metals	0.1			1.1		
	Paper	0.1			1.3		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**1.6**	**0.7**	**1.5**	**21.7**	**13.7**	**20.6**
7	Plastics	2.2			0.8		
	Organics	2.1			2.0		
	Textiles	0.1			0.0		
	Metals	0.2			0.1		
	Paper	0.1			0.0		
	Glass, misc.	0.0			0.7		
	TOTAL (kg)	**4.7**	**2.2**	**4.5**	**3.6**	**2.0**	**2.8**
8	Plastics	9.1			20.7		
	Organics	33.8			46.8		
	Textiles	3.1			7.3		
	Metals	1.3			1.9		
	Paper	1.3			1.6		

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
	Glass, misc.	1.3			2.5		
	TOTAL (kg)	**49.9**	**35.1**	**47.3**	**80.8**	48.4	76.4
9	Plastics	1.3			1.3		
	Organics	1.6			2.8		
	Textiles	0.1			7.0		
	Metals	0.2			0.2		
	Paper	0.1			2.5		
	Glass, misc.	0.1			0.0		
	TOTAL (kg)	**3.4**	**1.7**	**3.1**	**13.8**	**5.3**	**13.6**
10	Plastics	4.2			1.2		
	Organics	13.6			6.5		
	Textiles	0.2			0.4		
	Metals	0.5			0.6		
	Paper	0.3			0.5		
	Glass, misc.	0.3			0.0		
	TOTAL (kg)	**19.1**	**13.9**	**18.3**	**9.2**	**7.0**	**8.6**

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
11	Plastics	1.2			1.8		
	Organics	13.0			18.6		
	Textiles	0.1			1.0		
	Metals	0.1			0.2		
	Paper	0.1			0.5		
	Glass, misc.	0.5			0.0		
	TOTAL (kg)	**15.0**	**13.1**	**14.4**	**22.1**	**19.1**	**21.9**
12	Plastics	4.6			7.5		
	Organics	10.3			18.5		
	Textiles	0.5			0.7		
	Metals	0.1			0.8		
	Paper	0.9			1.1		
	Glass, misc.	0.9			0.3		
	TOTAL (kg)	**17.3**	**11.2**	**16.3**	**28.9**	**19.6**	**27.8**
13	Plastics	2.6			6.6		
	Organics	18.0			15.5		
	Textiles	0.1			1.7		
	Metals	1.2			0.8		
	Paper	0.8			7.2		
	Glass, misc.	0.0			1.1		
	TOTAL (kg)	**22.7**	**18.8**	**21.5**	**32.9**	**22.7**	**31.0**
14	Plastics	1.8			1.5		
	Organics	13.6			16.2		
	Textiles	0.7			0.2		
	Metals	1.7			1.1		
	Paper	1.6			1.0		
	Glass, misc.	0.2			0.2		

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
	TOTAL (kg)	**19.6**	**15.2**	**17.7**	**20.2**	**17.2**	**18.9**
15	Plastics	5.7			6.5		
	Organics	17.4			14.5		
	Textiles	0.9			1.0		
	Metals	0.5			0.0		
	Paper	0.4			0.4		
	Glass, misc.	0.3			0.0		
	TOTAL (kg)	**25.2**	**17.8**	**24.4**	**22.4**	14.9	22.4
16	Plastics	2.9			6.4		
	Organics	16.5			21.9		
	Textiles	2.0			0.4		
	Metals	0.3			0.6		
	Paper	0.5			1.0		
	Glass, misc.	0.0			0.6		
	TOTAL (kg)	**22.2**	**17.0**	**21.9**	**30.9**	**22.9**	**29.7**
17	Plastics	9.3			12.8		
	Organics	37.3			49.7		
	Textiles	1.7			3.9		
	Metals	0.6			0.8		
	Paper	2.2			4.2		
	Glass, misc.	1.0			1.1		
	TOTAL (kg)	**52.1**	**39.5**	**50.5**	**72.5**	**53.9**	**70.6**
18	Plastics	2.7			5.4		
	Organics	10.0			22.5		
	Textiles	0.9			5.9		
	Metals	0.3			0.6		
	Paper	2.3			0.6		

	Date:	Thursday, July 22	Compostable	Combustible	Monday, July 26	Compostable	Combustible
House ID#	Type	Weight (kg)			Weight (kg)		
	Glass, misc.	0.0			0.4		
	TOTAL (kg)	**16.2**	**12.3**	**15.9**	**35.4**	**23.1**	**34.4**
19	Plastics	1.0			2.3		
	Organics	25.0			31.4		
	Textiles	0.0			0.4		
	Metals	0.7			0.1		
	Paper	0.2			0.9		
	Glass, misc.	0.0			0.4		
	TOTAL (kg)	**26.9**	**25.2**	**26.2**	**35.5**	**32.3**	**35.0**
20	Plastics	2.2			4.1		
	Organics	27.0			30.5		
	Textiles	0.1			1.0		
	Metals	0.1			0.5		
	Paper	0.2			0.7		
	Glass, misc.	0.0			0.0		
	TOTAL (kg)	**29.6**	**27.2**	**29.5**	**36.8**	**31.2**	**36.3**