Characterization of Municipal Solid Wastes from Lagos Metropolis, Nigeria

O. M. Ojowuro, B. Olowe and A. S. Aremu

Abstract This study examines the characteristics of solid waste from different parts of Lagos metropolis, southwestern Nigeria. Solid wastes from the four main disposal facilities in Lagos State were sampled and analyzed. Samples were taken from trucks mainly operated by Private Sector Participation contractors so as to stratify the wastes according to land use type, population density, and income. A total of 286 samples, each weighing 90 kg were stratified into ten material classes and weight recorded. The results of the study show slight disparity in all the solid wastes samples sorted by land use type, population density, and income level. In all solid wastes from residential land use types contain mainly organics (33.06–46.25%), plastics (12.73–20.7%), paper (4.61–10.3%), and textiles (1.66–12.33%). On the other hand, solid wastes from commercial land use types are composed majorly of 29% plastics, 22% organics, and 14% each of paper and textiles. Source separation of these wastes is recommended, and technologies for resource and energy recovery are required for sustainable solid waste management in Lagos State.

Keywords Municipal solid waste · Components · Lagos State Nigeria

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1 Introduction

Solid waste is a non-liquid, non-gaseous material which is no longer of use or unwanted by the owner. It consists of discards such as food wastes, plastics, paper, wood, glass, textiles, cans, and other miscellaneous unwanted items. Municipal solid waste (MSW) is an embodiment of all forms of solid waste dumped in municipal receptacles and the responsibility of collection and disposal falls on the government, city or local authorities, or an appointed organization/agency. MSW originates from households (apartments, estates, compounds, and multi-storey buildings), commercial areas (markets, business complexes, hotels, and motor parks), institutions (schools, jailhouses, recreational centers, hospitals and government offices, or establishments), industries and municipal services such as street sweepings, litter pickup, and drainage debris evacuation. Municipal solid wastes in developing countries are highly heterogeneous in terms of composition with 55–80% generated from households, 10–30% from commercial or market areas while the rest are from streets, industries, and institutions [1].

There is an apparent unevenness in the generation rates and composition of solid wastes across the globe, even within a given neighborhood. Solid waste composition is influenced by several factors such as area (i.e., residential, commercial), geographical location, standard of living (income level), culture, energy source, and season/weather [2, 3]. Land use (area) and income level tend to prevail over other factors. Residential land use types generate wastes as a result of household activities such as food preparation, unwrapping, sanitation, gardening, and food/beverage consumption. Commercial waste is heterogeneous in itself, and it is related to the kind of commercial activity such as trading in goods or products, small-scale manufacturing, and provision of professional services.

Income plays a significant role in solid waste composition as constituents of solid waste may even vary within the same country or city because of income disparity. The World Bank Atlas classification system classifies the economy of countries with low income, lower middle income, upper middle income, and higher income based on Gross National Income per capita. According to the World Bank [4], MSW from low-income countries is mainly organic in nature consisting of food scraps, yard waste, wood, and process residues while MSW from high-income countries consists mainly of paper, plastics, and other inorganic materials. This is also relevant within a classified country as wealthier individuals consume more packaged products resulting in a higher percentage of inorganic materials in the waste stream [5].

Information on the composition of solid wastes is important in management programs/plans and determining equipment needs [6]. The in-depth knowledge of MSW composition is an insight for policy change in most instances, i.e., moving from landfill-based to resource-based waste management systems [7]. An accurate knowledge of the quantity and composition of the waste input is equally essential to the success of a resource recovery project as quantity and quality of the input must be assured [8]. It is observed that higher volumes of waste and a changing

composition have a profound impact on solid waste management practices thereby necessitating policy changes in developing countries [5]. Also, solid wastes composed of high inorganic materials could have a significant impact on human health and the environment. Hence, the composition of solid waste at any particular time may influence several decisions in solid waste management. The aim of this study is therefore to determine the characteristics of solid waste from different parts of Lagos metropolis, southwestern Nigeria.

2 Methodology

2.1 Study Area

The study area, Lagos is a megacity located in the southwestern part of Nigeria. Lagos is Nigeria's economic focal point with Gross Domestic Product of about $131 billion. It lies between latitude 6° 34′ 60″N and longitude 3° 19′ 59″E along the West African coast and covers a total area of 3,475.1 km^2. It was the administrative capital of Nigeria for a long time before the capital was moved to Abuja in 1991. Lagos State is subdivided into twenty administrative Local Government Areas, and its 2015 population is in excess of 23 million [9]. The city has also been distinguished as the nation's commercial nerve center with 65% of the nation's commercial activities, over 2,000 industries and having two of the nation's largest seaports for import and export activities [10].

It is estimated that about 13,000 metric tonnes of solid waste is generated daily in Lagos State from various human activities. The Lagos State Waste Management Agency (LAWMA) has been in existence since 1991, and the agency is responsible for solid waste storage, collection, disposal, and management of landfills in Lagos State. The agency is also responsible for sanitation of major highways and street sweeping activities, monitoring of contractors' (Private Sector Participants) activities, and establishment of performance standards on waste management activities in Lagos State. The inclusion of private waste collectors under the Private Sector Participant (PSP) scheme has tremendously improved solid waste collection within the megacity. Therefore, there is the need to characterize solid wastes coming from different parts of the city so as to obtain baseline information for its efficient management.

2.2 Method

In line with the aim of this research, identification of specific characteristics of waste generated in waste sector make it a different sample of the waste stream. Waste can be separated into two major land use types:

1. Residential—waste collected mainly by both private haulers called Private Sector Participants (PSP) and LAWMA from residences across the state. These wastes are primarily collected by skip trucks, double and single dino trucks, trailer trucks, open-back trucks, and mammoth compactors.
2. Commercial and Institutional—waste generated by businesses, government/education institutions, markets, and motor parks. These wastes are collected by a variety of vehicles including those described above.

Solid wastes with similar characteristics were identified by similarities in population density and economic characteristics. The metropolis was divided into six subsectors based on these two criteria. The sampling areas and the corresponding Local Government Area (LGA)/Local Council Development Area (LCDA) are listed in Table 1.

Industry standard formed the basis for our sampling method, while for the sampling size, D5231 was chosen as the standard.

Field officers were used in the selection of samples from trucks arriving at the dumpsite. Waste disposal trucks were randomly selected, and samples were gotten from the tipped waste at designated points.

A total of 286 samples were obtained from PSP collected solid wastes at the four existing solid waste disposal facilities in Lagos State. The samples consisted of approximately 90 kg of waste and were then sorted into ten material classes; Paper, plastics, glass, metals, organics, construction and demolition wastes, inorganic, and textiles. Materials within these ten fundamental classes were further split into 87 individual material groups:

(a) Paper—Newsprint, High-grade Office Paper, Magazines, Uncoated OCC/Kraft, Boxboard, Mixed Paper—Recyclable, Compostable Paper, Other Paper;
(b) Boxboard—Cardboard boxes, Package boxes;
(c) Plastics—Pet Containers and Packaging, HDPE Bottles and Packaging, Expanded Polystyrene Packaging (EPS), All Other Rigid Plastic Products, Trash Bags, Commercial and Industrial Film, Other Film, Remainder/Composite Plastic;
(d) Glass—Recyclable Glass Bottles And Jars, Flat Glass, Other Glass;

Table 1 Density income and locations within the study area

Category	LGA/LCDA	Specific location
High density, low income (HDLI)	Ajeromi, Ebute Metta	Ajegunle, Otto
Low density, high income (LDHI)	Ikoyi Obalende, Iru Victoria Island	Ikoyi, Lekki, VI
Medium density, high income (MDHI)	Ikeja, Kosofe, Oshodi Isolo	Ikeja GRA, Ogudu GRA, Ajao Estate
Medium density, low income (MDLI)	Alimosho, Lagos Mainland	Alimosho, Ebute Metta
Low density, low income	Imota, Ikorodu North, Epe	Imota, Isiu, Agbowa, Epe

(e) Metals—Can, Other Aluminum, HVAC Ducting, Ferrous Containers (Tin Cans), Other Ferrous, Other Non-Ferrous, Other Metal;
(f) Organics—Yard Waste (Compostable), Food Scraps, Bottom Fines And Dirt, Diapers, Other Organic;
(g) Construction and Demolition (C&D)—Clean Dimensional Lumber, Clean Engineered Wood, Wood Pallets, Painted Wood, Treated Wood, Concrete, Reinforced Concrete, Asphalt Paving, Rock and Other Aggregates, Bricks, Gypsum Board, Composition Shingles, Other Roofing, Plastic C&D Materials, Ceramics/Porcelain, Other C&D;
(h) Inorganic—Televisions, Computer Monitors, Computer Equipment/Peripherals, Electronic Equipment, All types of batteries, Fluorescent Lights/Ballasts;
(i) Household Hazardous Waste (HHW)—Latex Paint, Oil Paint, Plant/Organism/Pest Control/Growth, Used Oil/Filters, Other Automotive Fluids, Mercury-Containing Items, Sharps and Infectious Waste, Ash, Sludge, and Other Industrial Processed Wastes, Sewage Solids; and
(j) Textiles—Carpet, Carpet Padding, Clothing, Other Textiles.

The weighing of each material category was carried out after sorting of samples had been made. Details of each sample were documented. Plate 1 shows weighing of a sample at one of the landfills.

Plate 1 Weighing of sorted organic fraction of the waste at a landfill

3 Results and Discussion

Figure 1a–e shows the top ten constituents of the separated wastes from residential land use types based on density and income. The constituents tend to follow the same trend; having the greatest proportion of organics followed by paper and textiles. Organics account for 33.06–46.25% of the waste stream, plastics 12.73–20.7%, paper 4.61–10.3%, and textiles 1.66–12.33%. As shown in the

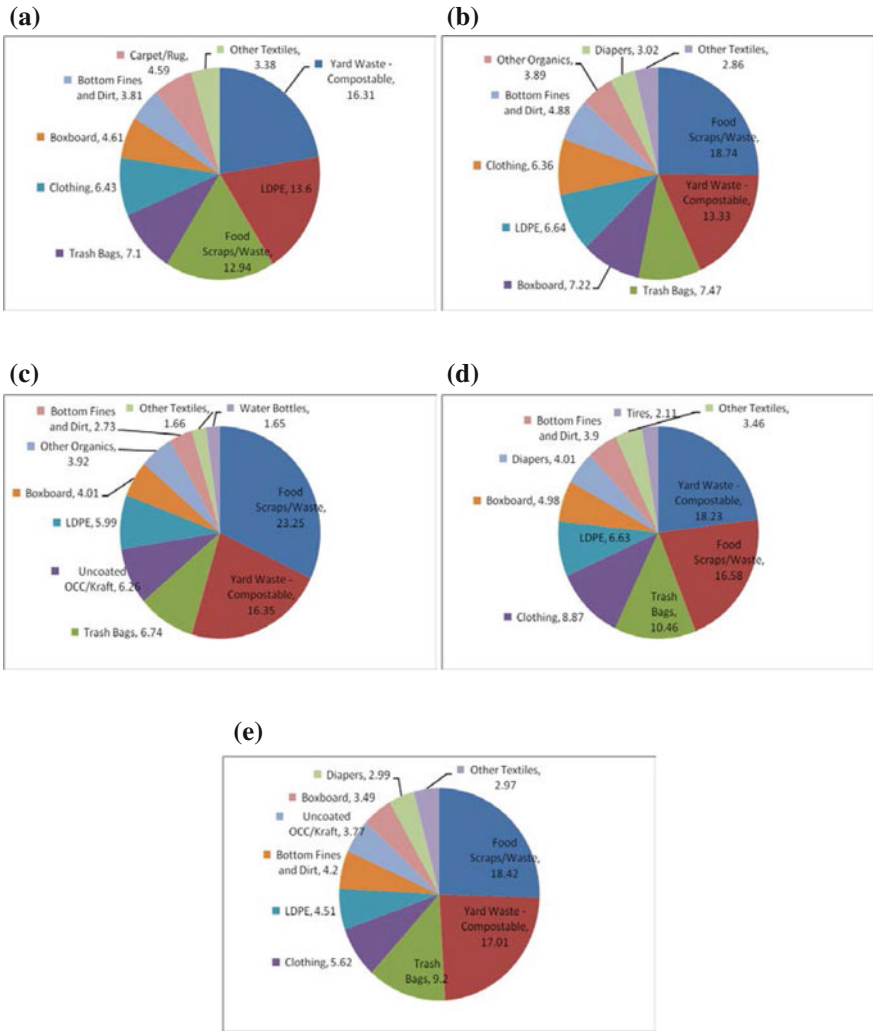

Fig. 1 **a** Composition of residential wastes from HDLI areas. **b** Composition of residential wastes from HDMI areas. **c** Composition of residential wastes from MDHI areas. **d** Composition of residential wastes from MDLI areas. **e** Composition of residential wastes from LDHI areas

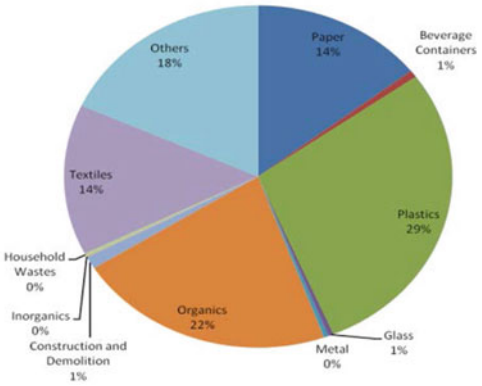

Fig. 2 Composition of wastes from commercial areas

Figures, there is a slight variation in the constituents with respect to population density and income level. However, there is no general trend in this variation more so they are insignificant according to population density or income level.

The percentage by weight of each of the various ten different material classes for commercial wastes arriving at the dump sites is shown in Fig. 2. The wastes coming from commercial areas consists of plastics (29%), organics (22%), others (comprising mainly factory dust) (18%), paper (14%), and textiles account (14%).

In comparison with residential wastes (Fig. 1a–e), commercial wastes contain more of plastics than organics. Perhaps this may be attributable to the reduction in household wastes as a result of food preparation, gardening, sanitation, and some other household activities. It may also be due to increased unpackaging activities, use of pet containers, and by-products of small-scale manufacturing process.

4 Conclusion

Solid wastes from different parts of Lagos metropolis, southwestern Nigeria, consist of identical components as solid wastes from other parts of world. Samples taken from trucks mainly operated by Private Sector Participation contractors and stratified according to land use type, population density, and income show slight disparity in composition. Irrespective of the population density and income level, solid wastes from residential land use types are composed mainly of organics (33.06–46.25%), plastics (12.73–20.7%), paper (4.61–10.3%), and textiles (1.66–12.33%). On average, solid wastes from commercial land use types are composed mainly of 29% plastics, 22% organics, and 14% each of paper and textiles. The increase in plastics and reduction in organics may be attributable to decrease in household wastes and commercial activity-based wastes resulting from small-scale manufacturing and unwrapping of products. Source separation of these wastes is recommended, and technologies for resource and energy recovery are required for sustainable solid waste management in Lagos State.

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