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Characteristic and Composition of Household Solid Wastes from Lapai Town, Niger state, Nigeria

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ABSTRACT

This study was carried out to determine the quantity and composition of solid wastes generated by some households in Lapai. Point source daily collection of household wastes from selected homes that were initially identified and categorised as low income or high income households was carried out for five weeks. The collected wastes were weighed and sorted into vegetables, plastics, paper, metal, clothes, glass, wood and others. The average daily solid wastes per household and the estimated daily wastes generated in Lapai were calculated. From the results obtained, an estimated 93.88 tons of domestic solid wastes were generated daily in Lapai town. Of these, 44% were organic wastes, 26% were mixture of sand, ash and dust; while 30% were recyclable matter which can be sold to generate income for the community, if proper waste management policies are put in place. The results showed that the amount of wastes to be discarded in Lapai town can be reduced approximately to 26% of the total generated waste if at the point source segregation is encouraged.

Keywords: Daily waste generation, Lapai town, Solid waste composition, Waste characterization

INTRODUCTION

Solid waste has been defined as any unwanted or discarded materials with insufficient liquid content to be free flowing (USEPA, 1971). It was also defined as discarded material arising from man's activities which cannot be discarded through a sewer (Vanloon and Duffu, 2005). Waste in general is a consequence of human activities which is largely assumed to have started since the beginning of civilization resulting from the production of goods and services and the consumption of resources. In some developing societies, the increase in socio-economic development, industrialization and technological advancement has led to population increase with no commensurate increase in infrastructure leading to indiscriminate disposal of solid waste in such towns (Debnath *et al.*, 2015; Karishnamurti and Naidu, 2003).

Lapai is a town on the A124 highway in the west of Lapai Local Government Area of Niger State, Nigeria, at 9°03′00″N 6°34′00″E. It has an area of 3,051 km² and a population of 110,127 at the 2006 census (City population, 2020; Amadi *et al.*, 2017). This is before the coming of the state-owned university in 2006 and by 2016, the population is expected to doubled to 164,400 with the attending environmental problems (Tersoo *et al.*, 2011). The town is a transit with low commercial activities without the students' population. The presence of the university has led to increase in population since its establishment. With increased enrollment since 2013, Lapai town has witnessed explosion in population with open dumpsite visible in every street.

Municipal solid waste, (MSW) is basically waste generated from different sectors of the society which include educational, household, health, commercial institution, public places, etc (Williams, 2005). Over time, economic activities and consumption practices have been a major factor in the generation of municipal solid waste (MSW) (Romano and Molinos-Senante, 2020). In low and middle income countries, solid waste is often dispose on low-lying areas, as a result of poor regulation and this has enabled hazard related waste to be mixed with MSW which pose a harmful threat to both waste collectors, scavengers and to the environment (Ziaand Devadas, 2008). The selection of appropriate methods, management policies and technology and its proper application to achieve desired waste management objectives is predicated on an accurate data of waste characteristic and generation rate and quantity (Tchobanoglous *et al.*, 2002). The characterization of generated waste is very important for the design of proper collection, selecting appropriate transportation equipment, energy transformation and it plans for the application of 4Rs of waste management (that is reuse, reduce, recover and

recycle) (Ugwu *et al*., 2020). Furthermore, the design of optimal disposal routes and methods, all depends on accurate quantification and compositional characteristics of MSW. The composition and quantity of solid wastes differ from place to place and from household to household. These differences are attributed to factors such as income level, socio-economic distribution, consumption and disposal habits of the people (Ugwu *et al*., 2020).

Open dumping and open burning of waste is a predominant practice mostly in developing countries (Salami *et al*., 2011) and Lapai is no exception. Opening dumping has led to detrimental impact on the environment due to poor collection and improper disposal of waste (Yasin and Usman, 2017). Environmental threat associated with solid waste include contamination of surface and ground water by leachate from dumpsite, air pollution from incineration of the waste and release of greenhouse gas, particularly methane to the atmosphere, leading to global warming (Ilori *et al.,* 2019).

Researches have shown that the quality of surface waters and reservoirs are affected by all kinds of environmental threat including open dumping of MSW (Gu *et al*., 2016; Mutlu and Uncumsaoglu, 2017).

A report by Debnah *et al*. (2015) showed that there is going to be a significant rise in rate of solid waste generated per capita in decade to come. Nigeria annual MSW from its 195 million population was quoted to be 32 million tonnes with only 20-30 % of these collected (Adeniran *et al*., 2017). The problem have been linked to factors such as weak environmental laws, inadequate funding, uncontrolled and rapid urbanization and industrialization and finally the use of open dumping and land filling methods for waste disposal (Agunwamba, 1998). Therefore, it has become very important for researchers to help determine the waste generated in selected towns and cities and its compositions, in order to develop effective management strategies (Amijo *et al*., 2008). Waste management remains a major environmental and health challenge in today's world. The mode of managing solid waste in township differ from that of big cities, especially in developing countries like Nigeria and more importantly in poor states like Niger State.

The composition of generated waste around the world varies significantly due to seasonal and lifestyle variation, geographical, and local legislation impact (Alqader and Hamad, 2012). Waste management and characterization has been key factor to a green environment as it leads to an effective application of the 4Rs of solid waste management, that is reduce, reuse, recycle and recover. Waste segregation is possible only when the characteristics are well known. The recyclable component collected and recycled while organic components are collected and used as compost. The inconsistency in data collection on the composition and quantity of solid waste in Lapai as well as other townships in Nigeria has contributed to poor management of solid waste (Ejaro and Jiya, 2013). Therefore, the aim of this work is to quantitatively and qualitatively characterize the waste generated by households in Lapai town. This is the first study to look at the generation and compositional characteristics of domestic waste from source point and attempts to estimate the total waste generated in Lapai town.

MATERIALS AND METHODS

Materials

Waste Basket, hand gloves, heavy duty plastic bags were purchased from a shop. 20 kg Kwonnie balance (model: TN-17418745) was used for weighing.

Study area

Lapai town is the head quarter of Lapai local government area of Niger state. It is located at zone C of the state and it is approximately on latitudes 9°03'00" north and longitudes 6°34'00" east (Figure 1). Lapai town covers a total area of about 3,051 km^2 and have a population of 164,400 as at the 2016 (City Population, 2020). Fourteen streets were identified and selected, seven each from Lapai East (LE) and Lapai west (LW) regions as demarcated by the researchers and indicated on the map in Figure 1 with the red line. On each street selected, two households with contrasting economic status were identified and selected for their waste collection. Most households selected were approximately made up of 6 – 12 members of different age groups. The households were classified as high income (HI) and low income (LI) households. Criteria used to classify these household include living standard, access to basic amenities (such as borehole water source, standby power generating set and toilet facility), type of employment and salary scale/grade.

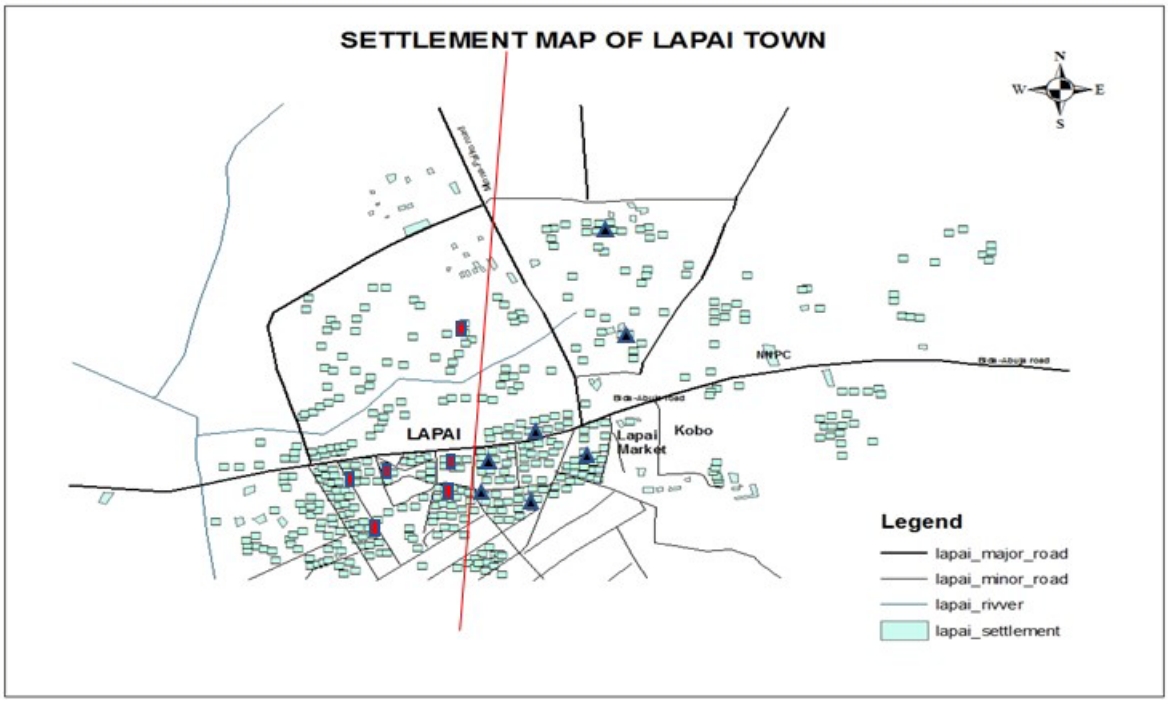

Figure 1: Satellite image of Lapai town obtained from Geography Department, Ibrahim Badamasi Babangida University Lapai. The shapes on the map indicate the sampling points

Methodology

The method published by Bernache-Perez (2001) was modified and used. Also, ASTM test method D5231 – 92 (Standard Test Method) for weighing and sorting of the wastes was adopted. It involves the direct sampling of solid waste from specific sources and as described here after. It is a labour intensive manual process of sorting, classifying and weighing all items in each sample unit and a detailed recording of the data.

Plastic bags and waste baskets were purchased and supplied to each selected household for the collection of their domestic wastes. The heavy duty plastic bags were pre-weighed before use. The wastes were collected per day to prevent been mixed with the new day's waste. The solid waste collected were weighed and recorded before it was sorted into eight components namely vegetables, plastics, paper, metal, clothes, glass, wood and others.

The total amount of generated wastes and the percentage of each component were computed. The waste components were further categorized as bio-degradable and non-degradable wastes. The remaining which consists of ash, charcoal, home dust and sand were classified as "others". These procedures were repeated each day for each of the twenty-eight (28) households (fourteen households from each region) for five (5) weeks and the average of daily solid waste collected from each household reported.

The results obtained were analyzed using one-way ANOVA ($p \geq 0.05$) to understand the relationship between the classes and between the two regions.

RESULTS AND DISCUSSIONS

The results of domestic waste generated from selected households in Lapai town are presented in Tables 1 - 2 and Figure 2.

Waste generation

Table 1 presents the daily wastes generated by the selected households sampled. From the results, it can be observed that the average waste generated by these households in Lapai town ranged from 1.00 ±0.64 to 9.21 ±0.85 kg. The high-income household wastes generation ranges between 1.52 ±0.62 kg and 7.99 ±1.68 kg, while the low-income household waste ranges between 1.16 ±0.65 kg to 9.21±0.85 kg.

Table 1: Results of domestic solid waste from selected households in Lapai town

No. of home	Average weight of household waste from Lapai East (kg)		Average weight of household waste from Lapai West (kg)	
	HI	LI	HI	LI
1	3.06 ±1.44	1.72 ±0.97	5.56 ±1.35	2.33 ±1.04
2	7.86 ±0.91	9.21 ±0.85	1.51 ±0.62	2.45 ±0.51
3	4.18 ±0.69	4.99 ±0.27	1.98 ±0.32	4.11 ±0.57
4	6.84 ±1.01	4.33 ±0.53	3.29 ±1.96	7.85 ±1.29
5	7.04 ±2.63	7.10 ±0.46	4.11 ±0.86	8.11 ±0.96
6	7.99 ±1.68	1.00 ±0.64	2.53 ±0.62	1.16 ±0.65
7	3.32 ±0.58	4.43 ±0.78	3.25 ±1.30	4.36 ±0.53

Note: HI- high income household; LI – low income household

The average waste generated from the high-income household was observed to be a little lower than that from the low-income households. This can be attributed to the large number of individuals in most of the low-income households. These numbers range from 6-12 with an average of 9 ±2; while the high-income household ranges from 6-10 with an average of 7 ±1. Again, the fluctuation in the amount of daily waste generated in both high-income and low-income households can be attributed to the irregular or unplanned visits from friends and relations, which most time cannot be predicted. The fixed market days in the town also contribute to these variations in daily wastes generation among households in Lapai town, however the market day effect can be predicted (Al-Khatib *et al.*, 2010).

Wastes composition and characteristics

Table 2 presents the compositional analysis results of the wastes generated across Lapai town. Pie charts were also presented in Figure 2 showing the percentage composition of each component in each group.

Table 2: Composition of domestic solid wastes from Lapai town

Component	Lapai East average MSW weight (kg)		Lapai West average MSW weight (kg)		Total weight (kg)
	HI	LI	HI	LI	
Vegetables	15.92	18.57	11.78	10.97	57.24
Metals	1.05	6.00	1.18	0.76	8.99
Plastics	4.32	2.12	3.03	3.30	12.77
Paper	1.79	1.70	0.72	1.28	5.49
Glass	1.96	1.21	0.69	0.30	4.16
Clothes	0.45	0.60	0.21	0.18	1.44
Wood	0.66	1.03	0.92	1.04	3.65
Others	6.82	9.98	11.56	5.81	34.17
Total	32.97	41.21	30.09	23.64	127.91

Note: HI- high income household; LI – low income household

From the results, it can be observed that vegetable wastes which includes left over foods, waste from meal preparation and waste from spoilage in stores, accounts for 39-48 % of the waste stream. The component labelled “others”, which is made up of ash, charcoal sand and dust was observed to be second highest in waste stream, accounting for 20-38 %.The remaining part of the waste stream which can be classified as recyclable constituents of the waste accounts for 22-31 %. This shows that, on average, approximately 26.98 ±7.83 % of the total waste generated from Lapai town daily maybe required to be discarded at landfills. Others can be used from composting to produce organic manure and/or sold to recycling companies (Ozores-Hampton, 2021).

Waste estimates

From the sampled households, the average waste generation is estimated to be 0.57 kg per person per day. The total wastes collected per day from selected households in Lapai town on average were calculated to be 127.91 kg. Out of which 44 % were vegetable wastes, 27 % were ash, charcoal, sand and dust, while approximately 30 % were recyclable materials as shown in Figure 2. The projected total daily wastes from Lapai town was projected to be 93.88 tons by multiplying the average daily waste for an individual of the

sampled area by the total population estimate of Lapai town (that is 164,400). These average daily wastes are considered reasonable when compared with the results published by Yiougo *et al*. (2013), an indication that Lapai is still a growing town.

The one-way ANOVA analysis to compare the classes and effect of location where individuals lived on the waste generation showed that there is no significant difference (at $P \geq 0.05$) among high income households. Their waste generated showed similar characteristics. However, between the low-income households either in east or in west, there is a significant difference in the waste generation pattern and the composition of their waste. This can be attributed to the factors earlier mentioned which include the number of occupants in the household and the unrestricted access to friends and relatives. The number of individuals could go high sometimes than the initial regular members of the household reported. Market days and days after also showed increased waste generation, as every household restock the house till the next market day. Furthermore, seasonal factors such as religious celebration were observed to influence the amount of waste generated. This has been observed in similar investigations by Siti and Mohd (2010) and Azam *et al*., 2019. The potentials inherent in the proper management of the waste generated from Lapai are enormous. Further comparison between the high-income households and low-income households showed significant differences in the composition and quantity of wastes generated either in the LE or LW. Table 1 also showed that some low income households generated more waste than the high income households.

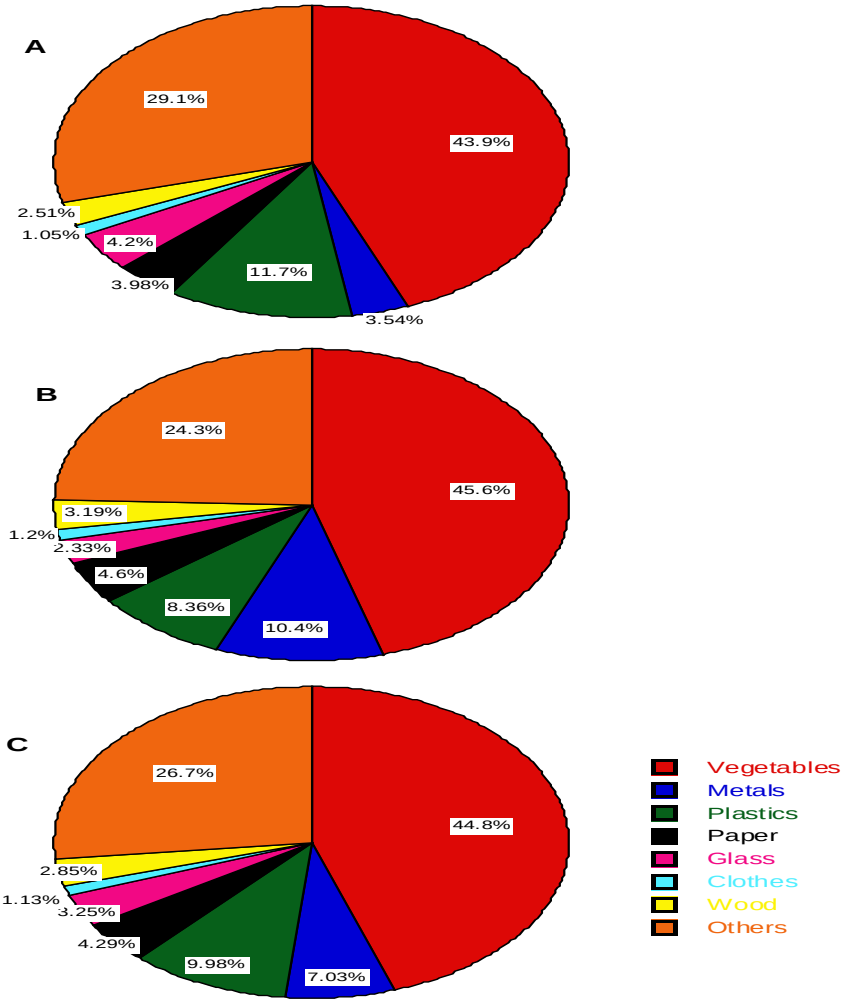

Figure 2: Percentage composition of cumulative waste generated per day in Lapai town. A- characteristics of waste from high-income households of Lapai, B- characteristics of waste from low-income households in Lapai and C- the average waste composition in Lapai town

Expected trends and projection

The presence of the state-owned University in Lapai is expected to attract attention in the nearest future. As stated earlier, the population of the town in 2006, before the creation of the University was 110,127. From 2006 to 2013, the University had four faculties with less than 22 programmes running. Also, the popularity of the university was not as high as it is today among prospective undergraduate and postgraduate students. The average wastes generation was reported to be 507.5 kg/day as at 2013 (Ejaro and Jiya, 2013). Although the result quoted may be questioned because of observed lapses, it remained the only published work before now. The estimated wastes generation based on our results is 93.88 ton/day. This is expected to rise even higher because of the expected expansion in the number of programmes offered by the university. Three new faculties were introduced at the end of 2020. Therefore, the population of the town, which was estimated to be 164,400 as at 2016, is expected to rise further. This means the economic activities around the town will increase if not doubled. This expected increase can be observed in the number of residential buildings, hotels and business centers springing up.

The reckless trend of dumping wastes on open fields may not be sustainable in the nearest future. Presently, there are four large unprotected open dump sites around the town, with several others scattered around. The increase in wastes generated will soon start having effect on other environmental components such as ground water and surrounding air. The aesthetics of the environment is affected already and if nothing is done urgently, the situation may overwhelm the concerned authority very soon. From available data, the population grew by approximately 49.28 % from 2006 to 2016. Therefore, it can be estimated that by 2026, the population of Lapai may reach 245,419 and with the current daily waste generation per individual (0.057 kg/day), the total wastes generation of Lapai town is estimated to be 139.89 tons/day. Hence the time to start strategy planning is now.

These estimates are limited for now because they were based on solely on household waste generation. Also, the daily influx of visitors to and from Lapai was not considered. Furthermore, the social activities that will accompany the increasing number of students and staff of the University and as a transit town, travelers are important factors to consider. Therefore, if the waste generation is to be projected with these factors in place, it is expected that the expected daily wastes generation will be much higher than what has been quoted here.

As observed, a huge amount of these wastes were vegetable wastes that can be used for farming purposes. This could potentially reduce the dependence on synthetic fertilizers. The campaign around organic fertilizer includes health benefits and environmental sustainability. The utilization of these components of the waste stream could go a long way in managing the waste stream. This can also lead to reduction in cost of their farming activities. Furthermore, the metal, plastics, wood, fabric and paper materials are all recyclable. If the wastes are properly sorted, they can be sold to generate income for the community. The sorting, collection and transportation could become sources of employment for some community members, thereby reducing the unemployment in the community. In addition, waste segregation will lead to reduction in the final quantity of waste that will be discarded. Reducing pressure on the environment, created by indiscriminate disposal of waste on any open or free site known as open dumpsite. The waste characteristics from Lapai town showed that the town is an average town; the people still depend largely on the agrarian culture. However, this present characteristics of the waste stream can change with time. As reported by Ejaro and Jiya (2013), the vegetable waste was just 35 % of the total waste, but as at today, because of increase in the student population and commercial activities that have scaled up, the vegetable wastes is now 44 %. This means that the purchasing power of the people have gone up. Hence the change in the characteristics of the waste generated.

Hence, the need to develop and manage a well-planned solid waste management system is now. Waste segregation at source will be another good strategy to consider. Since the students are enlightened and can adjust quickly to new trend. The quantification and characterization of waste from households in Lapai has shown that the observed open dumping of refuse along every street in Lapai can be curtailed if the authorities do the needful. If proper waste management system is put in place, the environment may accommodate the eventually discarded waste. Also there, is the untapped wealth in the waste generated daily from households in Lapai town.

CONCLUSION

Lapai is a residential town with low commercial activities. The presence of the state-owned university has led to the increased population, social and economic activities around the town and so also is the problem of waste generation which has also increased. To help manage the waste generated, a good understanding of the waste generation in Lapai with a very accurate data was required. This research work was able to quantify the amount of waste generated, by thoroughly and elaborately taking account of waste generation from selected household, while taking into consideration their economic and household sizes. From the result obtained a total of 93.88 tons of solid waste was estimated to be generated on daily basis out of which 44 % were vegetable waste, 26 % were ash, sand and dust, and 30 %

were recyclable material such as wood, metals, plastics, papers and fabrics. If proper waste management is put in place, it is assumed that about 74 % of the waste generated in Lapai town can be put to useful applications and generate small scale employment in the community. To protect and preserve the immediate environment from incessant dumping of waste, which is the case at present, government at the local level is advised to carryout sensitization of the people for the need to practice waste segregation at home and if possible provide some sort of support for them as incentive.

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