Characterization of Gosa Municipal Solid Wastes at Abuja, Nigeria

*Kamoru Seidu, 2Ibrahim D. Muhammad and 3Idris I. Ozigis
1National Space Research and Development Agency, Abuja, Nigeria
2Department of Mechanical Engineering, University of Abuja, Nigeria
kamorus@yahoo.com | (d.ibrahim.idris.ozigi)@uniabuja.edu.ng

Received: 29-JUL-2020; Reviewed: 22-AUG-2020; Accepted: 22-OCT-2020
http://dx.doi.org/10.46792/fuoyejet.v6i1.559

Abstract- The study examined municipal solid wastes characteristics of Gosa dumpsite at Abuja, Nigeria. Waste characterization has not yet been given adequate attention in management of waste in Nigeria and it is a major problem that affects waste materials handling and recovery processes. Wastes samples from Gosa waste dump site, Abuja, were randomly collected and subjected to moisture content, composition, density and size distribution determinations according to prescribed standards in literature. The moisture content of the Gosa waste solid was 19.3%. The results of the characterization of the Gosa municipal solid wastes show 34% organic, 10% paper, 28% plastic, 2% glass, 6% metal, 4% fabric, 2% rubber and 14% dust. The average density of glass, metal, plastic, fabric, rubber, paper, organic and dust materials were 0.044 kg/m$^3$, 0.045 kg/m$^3$, 0.176 kg/m$^3$, 0.043 kg/m$^3$, 0.042 kg/m$^3$, 0.074 kg/m$^3$, 0.143 kg/m$^3$ and 0.098 kg/m$^3$, respectively. The size distribution of the Gosa solid waste ranges from 10-28 cm for metals and plastics and 3-13 cm for paper and glass. The rubber had size ranges from 8-23 cm while size ranges of organic was from 3-6 cm. The large presence of organic, plastic, paper and metal wastes at Gosa waste dump site, is an indication that the municipal solid wastes can be sorted, recycled and processed to other useful products, using the characteristics as a guide.

Keywords: Characterization, Density, Municipal Solid Waste, Size Distribution, Waste Management

1 INTRODUCTION

Solid wastes are undesirable material generated from human activities within our municipality (Sharma et al. 2014). They are discarded solid materials, which are no longer needed and may be dangerous to human health if not managed properly (Ogunniran, 2019). Globally, there has been an increase in generation of municipal solid wastes as a result of population increase, changes in culture and attitude of people toward wastes generation (Ali et al. 2015). In addition, factors such as economic level of the people, and weather condition contribute to the changes in waste generation within the municipalities (Ali et al. 2015).

Otoniel et al. (2001) reported some sources of municipal wastes which were classified as residential wastes (food, packaging, cans, bottles, glass, plastics, newspapers and clothing); commercial establishments waste (Papers, glass, plastics, packaging, organic, and cotton); institution wastes (papers, glass, plastics, packaging, organic, yarn); industrial wastes (effluent, ashes, offcuts and broken materials) and agricultural sources wastes (rice husks, cornsobs, saw dusts and dungs). Solid wastes characterization is the means of identifying various components of wastes materials in wastes stream (Crowe & Carty, 1996). It involves percentage of paper, food, glass, metals, timbers and dusts, in waste stream obtained by sorting and weighing of the composition (Benjamin et al. 2014). Characterization includes moisture content, density, size distribution and magnetic properties.

Solid waste disposal has become major problem in Abuja metropolis. The city has been facing indiscriminate dumping, irregular collection of waste and inadequate resources to handle the solid waste safely according to Benjamin et al. (2014). Waste generated from the cities often resulted in litters and pollution (Ahsan et al. 2014).

Alabdraba & Al-Qaraghully (2013) reported composition, density and moisture content of Tikrit city domestic solid waste at Iraq. The study found out that the domestic waste had density of 229.08 kg/m$^3$ and the moisture content was 27.419%. However, solid waste material size analysis was not in their study but it is an important factor as oversize material in handling and processing can cause damage to the equipment and affects effectiveness of the material recovery and recycling mills.

Dyankova et al. (2016) carried out research on particle size distribution of a natural food supplement on pectin base. Interesting aspect of the study was utilization of laser technology based on wavelength diffraction to determine granular sizes but municipal solid wastes are mainly coarse material, which will be amiable to combination of metrology tools and devices such as use of steel rule, sieves, 3D video and camera to determine solid waste size distribution. Kristanrito & Zikrina, (2017), worked on analysis of the effects of solid waste’s particle size variation on bio-drying method which is relevant in combustion process. The significant of the study was establishment of optimum size of 100-300 mm, which caused reduction of 37.3% for an output moisture content of 50.99% that resulted in volatile solid waste of 74.29%, however, heterogenous materials requires initial separation of the components which was not part of their study. Nakamura et al. (2006), reported particle size distribution and distribution of shape factors in a municipal solid waste collected in New York city. Their achievements include particle size and shape that enhance combustion processes of municipal solid waste.

The aim of this study is to determine the characteristics of Gosa municipal solid wastes for design of management facilities, processing and to determine proportion for waste to energy and materials recovery on the waste stream. The specific objectives include determination of

*Corresponding Author
moisture content, composition, density and size distribution of the Gosa waste dumpsite.

2 MATERIALS AND METHODS

2.1 MATERIALS

The Gosa dumpsite is located about 10 km off the Nnamdi Azikwe Airport road, Abuja, Nigeria, within coordinates N09° 01.270’ E007° 19.59’ and N09° 01 173’ E007° 20.510’ (Ige, 2010) as shown in Figure 1.

![Location of Gosa waste dump site](image)

The materials used include 15 x 24 cm shovel, 15 x 20 cm hand fork, 0.15 m³ box, 50 kg measuring scale, 50 m tape rule, 200 litres graduated bucket, constructed coarse sieves (10-300 mm) and medium sieves (10-1 mm) and sieve shaker, 900°C capacity oven and personal safety gears, available at Faculty of Engineering workshop, University of Abuja, where the tests were conducted.

2.2 SAMPLING AND SAMPLE PREPARATION OF GOSA SOLID WASTE

The samples were collected and analyzed for a period of 8 months using the method in ASTM D5231 and ASTM D3665 (2019). About 17 kg each of samples were collected at three identified locations (I, II and III) from February to August 2018 within the Gosa waste dumpsite using measuring scale that sum at 100 kg solid waste as recommended by Crowe & Carty, (1996) and Gawaiakar & Deshpande, (2006). Then coning and quartering technique was used to prepare the mixed samples into sub samples A, B, C and D at 20 kg each for moisture, composition, density and size distribution determinations, respectively.

2.3 DETERMINATION OF MOISTURE CONTENT, COMPOSITION, DENSITY AND SIZE DISTRIBUTION OF THE GOSA MUNICIPAL SOLID WASTE

The moisture content determination was conducted on samples A, B, C and D. Each of the samples; B, C and D were for composition, density and size distribution determinations (Aladrababa & Al-Qaraghuly, (2013)). Sample A for moisture content test was sub-divided into I, II, III and IV at 5 kg each. Each of the sub-samples was weighed to an accuracy of 0.1 kg and recorded as \( W \). The sample was evenly spread on a tray and placed in an oven at 90°C for 12 h. \( W_c \) is the weight of crucible. The sample was cooled to room temperature and reweighed which was recorded as \( W_c \). The moisture content was computed using equation (1) as follows:

\[
\text{Moisture Content} \% = \frac{W_i - W_f}{W_i - W_c} \times 100
\]

\( W_i \) is initial weight of waste sample
\( W_f \) is final weight of dried waste sample
\( W_c \) is weight of crucible

The sample B was subjected to sorting to determine the composition according to the procedures outline by Crowe & Carty, (1996). The dried samples were manually sorted out into various wastes components using hand fork. Larger materials were picked out first such as glass, paper, plastics, among others and the metals were separated using magnet while less than 10 mm were classified as others. The sorted samples were weighed, classified, measured and recorded. Also, the percentage composition of the component was calculated using procedures in ASTM D5231 (ASTM, 2019).

The Sample C was subjected to waste components density determination using the procedures in ASTM E1109-19 standard (ASTM, 2019). Sample C was sub-divided into eight groups according to the composition. The heavy and large material was placed in container and weighed, while its approximate dimensions needed to determine the volume were taken using tape rule. The materials in the sizes between 40 mm and less were filled into a container of volume 0.15 m³, which was constantly shaken during filling. The empty container weight and filled container with waste solid weight were taken. The density was computed by division of the net weight of the solid waste sample by the container’s volume. The net weight is the weight of filled container minus weight of empty container.

Size distribution was determined using the sample D. Sample D was sub-divided into eight groups according to the composition. The sample was visually inspected on a tray and a tape rule was used to measure the approximate dimensions for the components that were elongated, flat, irregular and were poured into coarse sieves of apertures 300 mm to 10 mm according to procedures described by Yang (2007) & Zhang et al. (2019). The set of sieves were manually shaken for about 10 mins period and classified according to procedures in ASTM E 11, (2019) and (ANSI/ASAE S424.1, (2003). The less than 10 mm materials were then subjected to classification in sieves, weighed and recorded as described by Yang (2007).

2.4 COMPUTING PROCEDURE TO ANALYZE DATA ON GOSA SOLID WASTE

The computation for evaluation of the solid waste analysis involves entering of collected data and equations into Microsoft Excel Spreadsheet (2007). The computation was repeated for each of the three tests and an average taken using the Excel software. The Excel software then automatically compute the moisture, composition, densities and size distribution, which were reported either as an MS Excel tables or graphs.
3 Results and Discussion

3.1 Moisture Content of Gosa Municipal Solid Waste

The moisture contents at different parts of the Gosa municipal solid waste ranges from 14%-26%. The moisture of the Gosa solid waste was higher at rain season than dry season due to low humidity and less evaporation out of the components of solid wastes. The result was similar to the moisture content of municipal solid waste in Kano area with an average of 26.75% - 28.77% as reported by Lawal et al. (2014). Low moisture of Gosa organic wastes, is similar to agro-waste that was briquetted with high value of calorific value as reported by Oni et al. (2020). The presence of high moisture content increases weight of the solid wastes and also, increase the cost of handling, transportation and processing (Mutala et al. 2017).

3.2 Composition of Gosa Municipal Solid Waste

The Gosa wastes stream contains eight components of materials as stated in Table 1. The percentage composition of the wastes stream of Gosa municipal solid waste was as in Figure 2. There were more plastic wastes generated than paper wastes in Abuja municipality due to increased number of water factories that use plastics and polythene leathers as packaging materials. Similarly, Benjoni et al. (2014) reported about 32.00% organic, 12.46% paper, 3.56% rubber, 2.85% plastic, 1.42% glass, 0.71% metal and 25.62% dusts for Abuja.

The design of sorting machine for a waste stream in percentages can be combined with differences in materials properties such as size, weight and density to select waste processing machines (moving beds, drums, screens and air separators) as reported in this study. Sensor technology, plastic physical properties and subsequent mechanical removal can be applied for handling waste plastic as reported by Crowe & Carty, (1996). The low-density, ferrous and high-density materials are useful in design of mechanical sorting as reported by Ojolo et al. (2011). From this study, there are potentials that the generated plastic wastes can support establishment of plastic recycling mills than metal recycling foundries in Abuja. Furthermore, the high percentage of organic wastes in Abuja, calls for more energy conversion technologies such as biogas digester and incineration plants as reported by Ozigis et al. (2019).

3.3 Densities of Components of Gosa Municipal Solid Waste

The densities and bulk density of the waste components are presented in Table 2. The density of organic waste was 0.143kg/m³, which might be attributed to incomplete drying of its constituents. These densities of the components of municipal solid waste obtained in the dumpsite were similar to Kano waste dumpsite as reported by Bichi, (2013). Density of wastes depend on solid wastes composition, for example, organic waste has higher density than for paper and cardboard. The density of solid waste change during the movement from source to disposal site, due to compression, treatment, moistening and aeration by weather, shaking in the gathering vehicle and breakages.

| S/N | Types of components | Description of the solid waste |
|-----|---------------------|-------------------------------|
| 1   | Organic             | Food waste, animal wastes part and plants waste, wood |
| 2   | Paper               | Wastes papers, packing board and carton boxes |
| 3   | Plastics            | All kind of plastics likes bags, and Polyethylene packaging crates |
| 4   | Glasses             | All glasses like bottles, wind screens, |
| 5   | Metal               | Metals like, aluminium, scrap metals, cast iron |
| 6   | Fabric              | Leather shoes and bags, clothing and textiles |
| 7   | Rubber              | All kind of rubber, synthetic rubber |
| 8   | Dust                | Inert soil, stone and miscellaneous materials |

Fig. 2: Percentage composition of the Gosa municipal solid waste.

For instance, mechanically compacted cardboard had more density up to 13 times when compared to uncompacted cardboard as reported by Gawaikar & Deshpande, (2006). Similarly, compressed density has positive effects on production of briquettes from agricultural wastes as reported by Oni et al. (2020) and Agomuo et al. (2019). Bulk density of Gosa solid waste was estimated as 11.0 kg/m³, which reflect the amount of air and water within the solid waste.
3.4 SIZE DISTRIBUTION OF THE SOLID WASTE

The eight sorted components of Gosa municipal solid waste with their images underwent visual inspection, measurement and was analyzed, respectively, and their mean values were obtained. However, this study had challenge of split image analysis but obtained approximate size distribution of the components of Gosa municipal solid waste using sieves as presented in Figures 3 and 4. From the study, metals and plastics had size distribution from 10-28 cm, while size distribution of paper and glass ranges from 3-13 cm. The rubber had sizes from 8-23 cm while size ranges of organic was from 3-6 cm as shown in Figure 3. The dust had sizes that range from 1-10 mm as shown in Figure 4. The fabric was difficult to undergo sieve test but was measured to had an average of 43 cm and 18 cm for length and width, respectively. Size distribution of various components in solid waste is important to match feed to input opening of the handling, recovery and processing machines. Size distribution can be used to determine quality, to establish degree of shredding and grinding, as well as useful to determine size range to minimize losses via removal of oversize and undersize to sustain maximum efficiency (Zhang et al. 2019).

4 CONCLUSION

The characterization of Gosa municipal solid wastes at Abuja, Nigeria was carried out. The conclusion drawn from the study include average moisture content of the solid waste determined to be 19.3%. The average density of the group of glass was 0.044 kg/m³, metal had 0.045 kg/m³, plastic had 0.176 kg/m³, fabric had 0.043 kg/m³ and rubber had 0.042 kg/m³, among others. The percentage component of wastes produced were: 34% organic waste, 10% paper, 28% plastic, 2% glass, 6% metal, 4% fabric, 2% rubber, 14% dusts. The size distribution of the Gosa municipal solid waste ranges from 10-28 cm and 3-13 cm, for metal and plastics as well as paper and glass, respectively. The rubber had size ranges from 8-23 cm while size ranges of organic was from 3-6 cm. The large presence of organic, plastic, paper and metal wastes at Gosa waste dumpsite is an indication that the municipal solid waste can be sorted, recycled and processed to other useful products, using the determined characteristics as a guide.

REFERENCES

Agomuo, U. C., Evutu, A. M., Ozigis, I. I., & Abba, A. H. (2019). Optimization of calorific value of briquettes from mixture of rice husk and sawdust biomass using Taguchi approach, Nigeria Journal of Engineering Science and Technology Research, 5(2), 96-103.

Ahsan, A., Alamgir, M., El-Seryangy, M. M., Shams, S., Rowshon, M. K., & Daud, N. N. (2014). Assessment of municipal solid waste management system in a developing country. Chinese Journal of Engineering. Hindawi 2014(561935), 1-11.

Alabdraba, W. M., & Al-Qaraghully, H. A. K. (2013). Composition of domestic solid waste and the determination of its density and moisture content: A case study for Tikrit City, Iraq. International Review of Civil Engineering, 4 (2), 1-6.

Ali, K., Muhammed, N. C., & Syeda, A. B. (2015) Effect of socio-economic status and seasonal variation on municipal solid waste composition: a baseline study for future planning and development. Environmental science Europe,1(27), 1-8.

American National Standards Institute/ American Society of Agricultural engineers (ANSI/ASAE S424.1 (2003), 606-608.

ASTM-American Society for Testing and Materials. (2019) The Composition of Unprocessed Municipal Solid Waste; ASTM D5231 and Standard test method for determining the bulk density of solid waste fraction, ASTM E1109: West, PA, USA, 11(04),1-6

Benjamin, T. A., Emmanuel, E. O., & Gideon, A. D. (2014) Characterization of municipal solid waste in the Federal Capital Abuja, Nigeria. Global Journal of Science Frontier Researchs: H Environment & Earth Science 14(2) Version 1.0 ISSN 2249-4626 Massachusetts USA.

Bichi, M. H., & Amatobi, D. A. (2013) Characterization of household solid wastes generated in Sabon-gari area of Kano in Northern
Nigeria. *American Journal of Research Communication*, 1 (4), 165-171 [www.usajournals.com](http://www.usajournals.com), ISSN: 2325-4076.

Crowe, M., & Carty, G. (1996). Municipal Waste Characterization Procedures, Environmental Protection Agency, Ardcavan, Wexford, Ireland, 11–14.

Dyankova, S., Doneva, M., Todorov, Y., & Terziyska, M. (2016). Determination of particle size distribution and analysis of a natural food supplement on pectin base, *Journal of Pharmacy* 6(5), 1-8.

Gawaikar, V., & Deshpande, V. P. (2006) Source specific quantification and characterization of municipal solid waste. *Journal of the institution of Engineers, India*. 86, 33-38.

Ige, O. O. (2010) Landfill Site Selection for Municipal Solid Waste and Assessment of Soils as Mineral Seals Around Ilorin, Nigeria. Unpublished Ph.D. Thesis, University of Ilorin, 256.

Kristanto, G. A., & Zikrina, M. N. (2017). Analysis of the effect of waste’s particle size variations on bio-drying method. *Proceedings of the 3rd International Conference on Construction and Building Engineering*, Indonesia, 040009-1 to 040009-5.

Lawal, A. D., Joseph, E., & Rufai, A. I (2014) Characterization and composition analysis of municipal solid waste in kano. *International Journal of Scientific and Engineering Research*, 5(9), 972-975

Mutala, M., Ismail, O., Aykan, K., & Mehmert, I. (2017) Pre-treatment and utilization of food waste as source by bio-drying process. *International Scientific Conference “Environmental and Climate Technologies” Riga Latvia*. 128, 100-107

Nakamura, M., Castaldi, M. J., & Themelis, N. J. (2006). Measurement of Particle Size and Shape of New York City Municipal Solid Waste and Combustion Residues Using Image Analysis, Earth Engineering Center, Columbia University, New York, USA, 1-4.

Ogunniran, B. I. (2019) Harmful effects and management of indiscriminate solid waste disposal on human and its environment in Nigeria: A Review. *Global Journal of Research and Review*. 6(1), 1-4

Ojolo, S. J., Orisaleye, J. I., Adelaja, A. O., & Kilanko, O. (2011). Design and development of waste sorting machine. *Journal of Emerging Trends in Engineering and Applied Sciences*, 2 (4), 576-580.

Oni, K., Adeleke, A. E., Ogundana, T. O., & Satimehin, A. A. (2020). Fuel characterization of agro-wastes and briquettes produced from rice husk, groundnut shell and corncob blends, *FUOYE Journal of Engineering and Technology*, 5(1), 17-21.

Otoniel, B. D., Gerardo, B. & Silke, C. (2001) Classification of source of municipal solid wastes in developing countries. *Resources conservation and recycling Journal*. 32(1), 29-41.

Ozigis, I. I., Oodo, O. S., & Lawal, N. M. (2019). Design of an anaerobic digester for generation of biogas fired in a burner and lamp, *FUOYE Journal of Engineering and Technology*, 4 (1), 52-57.

Sharma, P., Dhanwantri, K., & Mehta, S. (2014) Solid waste management. *International Journal of Environmental Research and Development*. 4(1), 49-54, Haryana, India.

Yang, Y. (2007). Image and Sieve Analysis of Biomass Particles and Separation after Size Reduction, Master’s Thesis University of Tennessee, Knoxville, 1-77.

Zhang, Y., Kusch-Brandt, S., Gu, S., & Sonia Heaven, S. (2019). Particle size distribution in municipal solid waste pre-treated for bioprocessing, *Resources*, 8, 166, 3-4.