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ESTIMATION OF MUNICIPAL SOLID WASTE AVAILABLE FOR POWER GENERATION IN COCA-COLA, ILESA, OSUN STATE

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ABSTRACT
Municipal solid waste generation is a day-by-day activity by individuals, groups of people, and industries. The rate at which waste is generated varies due to some factors such as population growth and urbanization to mention a few. In knowing the amount of waste available for power generation in a day, waste collection and analysis were organized at the Coca-Cola community, Ilesa, Osun State, for eight consecutive weeks, in which the characteristics of the waste gathered in terms of contents were obtained by manual sorting through the use of hand picking with gloves, shovel, and garden hand fork. 15% of the initial total waste collected was partially good and considered for reuse and recycling. The remaining contents of the waste collected were sorted into twelve waste fractions, in which only eight under biomass and non-biomass combustible wastes were capable of generating energy by Biochemical and Thermochemical methods of waste conversion. It was recorded that 87.3% of the remaining waste streams after recycling, which is equivalent to 2.06 tons/day were available for energy (electricity and heat) generation in this area. This total waste in a ratio of 3.5:1 of biomass to non-biomass combustible wastes, was presumed to take care of 10% of power demanded in the community.
Keywords: Solid waste, Waste management, Combustible waste, Biomass, Electricity.

1. INTRODUCTION
Waste is no more a threat in the world today but a source of wealth and energy. This opportunity has not been harnessed by Nigerians. Nigeria as a country can benefit positively from the waste generated instead of receiving its adverse effects. Waste can be solid, liquid, or gas, but more emphasis is laid on solid waste, that is Municipal Solid Waste (MSW) because they appear to be more reusable than other forms of waste. Waste generated and dumped or buried in Nigeria at large, with a population approximately of 200 million and a land area of 923,768 km^2 (356,669 sq mi) which is in the 32nd position of landed property in the whole world, (*Index, (2018), World Population, (2019*)) is every day on the increase due to population growth, urbanization, economic development, low level of salvage and recycle, low public attitude towards conservation of natural resources, and lack of legislation to regulate the use of specific materials in production of some goods and materials to reduce the generation of certain type of wastes (World Bank, (2018); Ques10, (2022)).More than 32 million tons of solid waste was said to generate annually in Nigeria with less than 30% of it properly disposed of (Bakare, (2020)).
According to Olubanjo (2019), 70% of Nigeria's cities lack adequate capacity to manage waste, and because of this some plots and acres of land in all cities have become dumping sites that accommodating all wastes and have made our environment unhygienic due to environmental pollution, and also generate greenhouse gas which creates a greenhouse effect causing global warming and climate change. Poor solid waste disposal posed a great health risk to the lives of people, animals, and even plants, which resulted in disease outbreaks, and farmlands infertility that causes food scarcity which led to food price inflation. Nigeria needs Solid waste management characterized by efficient collection methods, sufficient coverage, and proper waste disposal which includes recycling, reusing, composting, burning, and land filled. This waste if properly handle can

be used to boost the economy of a country through one of the economic key areas which are power (electricity). Nigeria will become one of the greatest countries in the world, the day it gets its power problem solved. The quick and ultimate solution to power and all other problems in Nigeria is to positively change our way of life, our ideas, and our thinking to get new and better solutions. The power problem in Nigeria can be solved or reduced if the power generation can be diversified by investing in new and efficient power generation technology, which involves exploring alternative energy sources such as solar, wind, and (now) waste; and if waste management can be properly harnessed at all level of governments. Nigeria is among the lowest power generation counties in the world and far lower than most other African countries (PwC, (2016)).

In 2019, the power supply in Nigeria was an average of 4.0 GW, which was insufficient and estimated to be one-third of the country's minimum demand (USAID, (2020)) this Power shortage harms the overall economy, which both Nigerian consumers and businesses are suffering (PwC, (2016)). To improve the people's standard of living and also to make Nigeria an industrialized country like China, U.S.A, and Japan, the power generated must be raised to about 200,000MW to take care of 200 million population, following Thumb's Rule (PwC, (2016)). The power available from different sources in the country can be augmented by power generated from solid waste by conversion, and this will enable Nigerians to have access to adequate and regular power supply. It is quite unfortunate that Vision 2020 strategic objectives, in which Nigeria is to attain sustainable, adequate, qualitative, reliable, and affordable power supply are not achievable.

This vision can be achieved before 2025 if the Nigeria government and citizens can positively invest in waste energy as an alternative renewable source of energy. Many advanced countries such as the U.S.A, China, the UK, and Sweden are benefitting from waste to wealth and waste to energy (electricity) where millions of tons of waste burn every year to generate a billion Kilowatt-Hours of electricity and heat energy (EIA, (2016); *Amila (2017)*). Nigeria can generate electricity from waste to boost the already power generated from hydro and gas, by converting waste to electricity through Biochemical and Thermochemical methods of conversion (Salman, (2018)). Biochemical conversion converts waste to biogas to produce Methane used as fuel in a heat engine, while Thermochemical conversion converts waste into heat by burning, and gives pressurized steam or gas from water or air to operate a steam/gas engine or turbine to generate electricity (Energypedia (2016); Ovoenergy (2020); Bioenergy (2020)).This paper focused on how to determine the amount of solid waste that can be collected to generate electricity which can be used to improve the economic strength of our country Nigeria from each of its localities as in the case of Coca-Cola, Ilesa, and Osun State. It also shows means of collecting waste from every nook and cranny of the country, sorting out the waste unto different categories. For the reasons of a power failure and much more waste generated in this area, research was carried out to know how much waste disposed of in the community can lead to energy generation in terms of heat and electricity. This also will reduce waste deposited around the community that causes environmental deterioration and problems.

2. METHODOLOGY

2.1 Study Area

The research was carried out at Coca-Cola in Ilesa, Osun State. Ilesa is a city located in Osun State, southwest of Nigeria, and with many smaller surrounding cities. The town which is of geographic coordinates of Latitude 7.62°N, Longitude 4.73°E with Elevation of 462m comprises two local government areas: Ilesa West and Ilesa East Local Government areas. Coca-Cola is located at Ilesa West local government area along Ijebu-jesa road, and accommodated six hundred and twenty-seven houses including five guest houses, one hotel, three private Nurseries and primary schools, one private secondary school, and many religious houses.

2.2. Demographic Characteristics

The population of Ilesa municipality is 305,480 according to the 2007 census, (Osun, (2014)). Coca-cola community population density is three thousand eight hundred according to the house census carried out for the research. The sex distribution of males and females was 1,785 (47%) and 2,015 (53%) respectively. The community population comprises 25% children, 47% youths, and 28%

adults. Certain percentages of the adults and youths were into different job careers, such as civil services, contract, labor, farming, trading, entrepreneur, and artisan.

2.3 Field Research Approach

The research is a quantitative method which was approached through extensive literature search, personal observation, construction and positioning of seven large waste cabins in seven strategic places in the community, positioning of small trash containers for those houses with multi residents for easy collection of their waste, and provision of three trash bags/nylons of different colors for each building. Considering the time and resources available it was not possible to carry out the collection of waste in every house and also, not all houses deposited their waste to the general disposal sites available in the area, some houses have dumps in their back yard, where they buried or burnt their waste, why some discarded their waste at any available space in their vicinity. Therefore, an awareness crusade was made in the community to encourage residents in assisting in waste collection. All trash bags collected every two days were gathered together with waste in cabins for sorting, classification, and quantification of waste for energy conversion.

2.4 Method of Sorting, Quantity, and Characteristics of Municipal Solid Waste

The waste contents of the solid waste collected in this area were studied. The collections were done from February 9, 2020, to March 4, 2020. The collections were taken twice a week (Tuesday and Saturday) for eight consecutive weeks. All the waste, **i**n the large waste cabins, small trash containers, and trash bags, were gathered together and manually hand sorted into different components and into different containers, and weighed. In the entire period of characterization, the waste streams were sorted into twelve waste fractions, as shown in Table 1, and were classified into Biomass waste, Non-Biomass Combustible waste, and Non Combustible waste, Table 2 according to EIA, (2016) waste classifications.

For finding the rate of waste generated in this community, the amount of waste generated by individuals per day was carried out by close monitoring of six households with all levels of human stages including infants (babies) and old ages. The waste of these households was gathered every night after supper, and divided by the total number of occupants for three days.

2.5 Quantity and Percentage of MSW for Energy

Out of the twelve waste fractions obtained as shown in Table 1, eight were characterized for energy potential, due to their decomposability, combustibility, and heat capability properties. These are waste under biomass waste and non-biomass combustible waste, Tab. 3.

3. RESULT AND DISCUSSION

3.1 Classification and Quantity of Waste Contents Disposal at the Community

Analyzing of physical characterization of municipal solid waste gathered in this area every week for two months was shown in Tab. 1. All the waste every two days were first collected and later sorted out by hand-picking with gloves and shovels into twelve streams in which like waste were grouped. The paper products contain any paper materials such as newspapers, magazines, paper carton boxes, notebooks, textbooks, etc. Also, the plastic/polythene products involve nylon, plastic plates, spoons, bowls, buckets, pampers, etc. while the other under waste stream referred to wastes that cannot be categorized into any notable group, this waste such as sand and other smaller un-identified particles. These waste streams were classified into the group Biomass waste which includes food waste, vegetative materials, paper, rubber, etc., Non-Biomass Combustible waste which includes plastics, and other synthetic materials made from petroleum and Non Combustible waste which include glass, metal, and ceramics materials as shown in Table 2.

Table 1, Weight of waste collection in Weeks

Waste Components	Weeks with the weight of waste gathered in Kilogram (Kg)								Total wt (kg)	Wt %
	1st	2nd	3rd	4th	5th	6th	7th	8th		
Food waste	125	129	135	115	133	127	125	129	1018	17.28
Vegetative Materials	50	50	47	44	51	49	55	52	398	6.76
Plastic/Polythene Products	137	142	135	131	138	132	144	140	1099	18.66
Paper Products	93	95	89	92	89	86	90	92	726	12.33
Leather Materials	45	47	49	51	48	50	47	49	386	6.55
Rubber	67	64	62	64	66	57	58	62	500	8.49
Textile	51	52	55	49	50	48	51	50	406	6.89
Wood/Wood Products	79	83	74	68	75	70	81	79	609	10.34
Glass	23	21	18	16	19	13	17	19	146	2.48
Ceramics	23	25	20	16	20	16	24	25	169	2.87
Metal Materials	60	49	47	45	51	48	47	44	389	6.60
Other	06	05	06	04	06	03	07	07	44	0.75
Grand Total	759	762	737	695	746	697	746	748	5890	100.0

Table 2, Content of waste materials collected

Biomass waste (Black bag)	Non-Biomass Combustible waste (Blue bag)	Non-combustible waste (White bag)
Food waste	Plastics/polythene Products	Glass materials
Vegetative material		Metal Products
Paper products		Ceramics
Textile (Rag) Materials		Others
Wood/Wood products		
Leather		
Rubber		

Table 1 reflected the mass of each waste in kilogram (kg) collected each week and throughout the collection (2 months) with their weight percentage. It also shows the total mass of waste collected each week and throughout the collection. This help to determine the expected waste in this region from their population density. In the first week of waste collation, the total waste collected weighed 759 kg which plastic/polythene waste, food waste, and paper waste were of majority with 137 kg, 125 kg, and 93 kg in mass, while glass waste and ceramic waste were of the lower waste gathered with 23kg in mass. The total waste collected each week for the period of collection varied from week to week. This can be a result of changes in income and consumption. **15% of total waste gathered initially were good and useful and were considered for re-use and recycling** because of their high quality, and this goes for the waste-to-wealth concept which can create wealth in terms of money, job, raw material for other goods and lower or less level use of old products.

The total waste collected in this environment for the project as shown in the Tab. 1 is far away from the actual waste generated, this is due to some houses' backyard spaces and proximity spaces around the nooks and crannies of the community in which people were so used to, and most of these wastes were dumped, buried and burnt in these available spaces.

In determining the waste generated per day, a population of fifty-six (56) people of six households in the community were under surveillance through observation and close monitoring to know the amount of waste likely generated by individuals. For days One, Two, and Three, 41,910g, 40,624g, and 40,112g of waste were gathered, making the average waste per individual per day to be 730g. It is presumed that each person in the community produced an average waste of 0.73kg per day.

This individual waste per day determined in the community was within the speculation of The United Nations, 'World Population Prospect' projection for Nigeria that, in 2025 waste generating rate capacity would have increased to 0.85kg/cap/day from 0.65kg/cap/day in 2012 with population of 182.2 million to 233.5 million (Arogundade, (2018)) and, also by Chinedu et al, (2018), which estimated Nigeria waste rate generation at 0.65- 0.95kg/capital/day with average of 42 million tonnes of waste generated annually. The individual waste generated multiplied by the population density gives the expected waste generated in the community and this is accountable to 2.37 tons of waste generated in the community in a day and 2.06 tons of waste generated for energy generation after Re-use, recycling, and non-combustible wastes had been removed, as shown in Tab.3.

3.2 Physical characterization of waste at Coca-cola

Table 3, Weight of waste collection in Weeks

Waste Components	Weeks with the weight of waste gathered in kilogram (kg)								Total wt (kg)	Wt %	Wt/ Day (Ton)
	1st	2nd	3rd	4th	5th	6th	7th	8th			
Food waste	125	129	135	115	133	127	125	129	1018	17.28	0.41
Vegetative Materials	50	50	47	44	51	49	55	52	398	6.76	0.16
Plastic/Polythene Products	137	142	135	131	138	132	144	140	1099	18.66	0.44
Paper Products	93	95	89	92	89	86	90	92	726	12.33	0.29
Leather Materials	45	47	49	51	48	50	47	49	386	6.55	0.15
Rubber	67	64	62	64	66	57	58	62	500	8.49	0.20
Textile	51	52	55	49	50	48	51	50	406	6.89	0.17
Wood/Wood Products	79	83	74	68	75	70	81	79	609	10.34	0.24
Grand Total	647	662	646	614	650	619	651	653	5142	87.3	2.06

From Table 3, the weight of waste generated in a day in tons was shown for all power generation waste streams. Plastic and polythene products were of the highest waste of 0.44ton each followed by food waste of 0.41ton. The highest wastes on this list were of the products of food and drinks, that is food waste and plastic/polythene waste, which were common and also of the basic needs of the people across all classes and genders. From the table about 87.3% of solid waste was available for energy production through Biochemical and Thermochemical conversions, this shows that there is enough and sufficient waste for energy production from waste generated in the community.

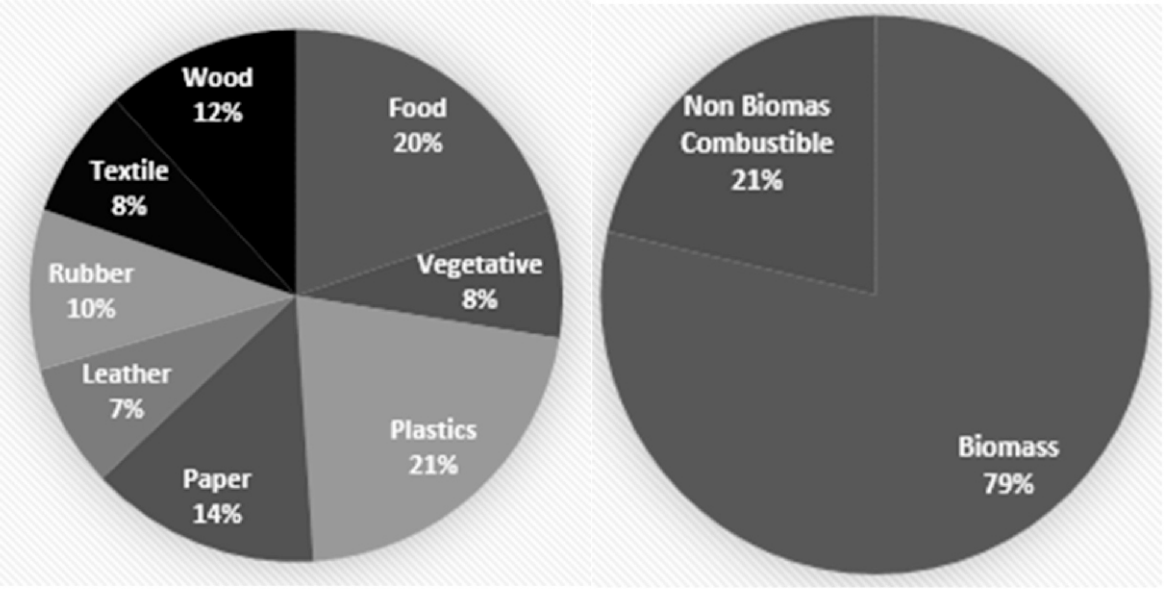


Chart 1, Percentages of Municipal solid waste contents for power generation

Chart 2, Percentages of Biomass and Non Biomass Combustible Waste for power generation

Chart 1, shows the percentage of each waste content from waste available for power generation while chart 2, shows the percentages of Biomass and Non-Biomass Combustible waste in a ratio of 3.5:1 in availability for power generation. According to Kumar et al., (2010); Gupta, (2013); Daura, (2016), and Ibikunle et al., (2019); through equations and by calculation, if this energy potential waste (2.06 tons) was subjected to burning experimentation by being processed and analyzed, it should be able to give a low heating value of 21 MJ/Kg, Energy Potential of 12MWh (which is equivalent to 2.3 tons of wood, 1.5 tons of coal, 1,330 liters of petrol and 1,211 liters of diesel oil, (DeepResource, (2012)), and Electrical Power Potential of 151Kw. If this power is compared with the power supply to the Coca-Cola area for 24 hours stable electricitysupply by Ibadan Electricity Distribution Company (IBEDC), which is 1.5MW (agent, Isokun Unit, Ilesa). This implies, that a waste-to-energy program using Coca-Cola municipal solid waste would provide approximately 10% of the power demand in the community.

2. CONCLUSION AND RECOMMENDATION

4.1 **Conclusion**

Waste is produced and could be gotten rid of by human activities, and one such activity is by conversion of waste to heat and electricity, which is construed as waste-to-power. The waste reviewed at the Coca-cola community in Ilesa, Osun State showed that the community was assumed to generate a waste quantity of 1012.51 tons/year and about 2.77 tons/day with a waste rate generation of 0.73kg/cap/day. Due to waste management processes and the good quality of some waste, 15% of the waste was good for Re-used and recycling, which left 2.36 tons of waste per day from which 2.06 tons was available for power generation by biochemical and thermo- chemical conversions. It can be concluded that about 87% of the remaining waste after reuse and recycling will be available for power generation while 13% remains will end up in landfills.

4.2 **Recommendations**

There should be efficient and effective means of waste collection established between waste generation and disposal for easy waste management processes; corporate waste management has to be developed at all levels of government. The government in each locality should provide sanitary dumping site(s) in their areas for easy disposal and easy quantification of waste generated. The government, NGOs, Waste Industry, and all others involved in waste management should organize public campaigns to enlighten the general public about the advantages and opportunities in waste business and recycling.

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