



# ADAPTATION OF PLASTIC WASTE TO ENERGY DEVELOPMENT IN LAGOS: AN OVERVIEW ASSESSMENT

O. Adekomaya<sup>1,\*</sup> and K. Ojo<sup>2</sup>

<sup>1,2</sup> DEPARTMENT OF MECHANICAL ENGINEERING, OLABISI ONABANJO UNIVERSITY, AGO IWOYE, OGUN STATE, NIGERIA

*E-mail addresses:*<sup>1</sup> [oludaisiyetunde@gmail.com](mailto:oludaisiyetunde@gmail.com),<sup>2</sup> [ojooos@tut.ac.za](mailto:ojooos@tut.ac.za)

## ABSTRACT

*In view of the financial challenges experienced currently by government at all level in Nigeria occasioned by dwindling oil and gas revenue, this paper evaluates the possibility of adapting plastic waste to energy development for sustainable growth. Volume of wastes for the month of January, July and September, 2014 were reported to be 340,016.62m<sup>3</sup>, 302699.59m<sup>3</sup> and 298791.81m<sup>3</sup> respectively as contained in a report released by LAWMA. These specific months were primarily used as a case study to portray the fact that all measures put in place by government may not after all give required results. Although governments is making spirited efforts to reduce waste volume to considerable size, there appear to be unsurmountable obstacles ahead. These published waste volume results show clearly that wastes generated in Lagos is on the high side and concerted efforts need to be sustained in other to effectively contain these wastes. At a time, government is finding it difficult to generate adequate power supply to residence, the authors therefore recommend that alternative source of energy could be explored from these wastes which invariable may boost the economic fortunes of the people. The authors equally discussed some of the energy recovery process that may aid the reduction of waste volume in Lagos state.*

*Keywords:* Plastic wastes, Energy, Sustainable development, Environment, Government.

## 1. BACKGROUND STUDY

Nigeria is currently faced with the challenge of waste management couple with the dwindling oil revenue due to its overdependence on conventional energy. Energy generation is reported to be a global need and countries that have recorded improved power generation and distribution is now battling with increased energy demand which has made some countries to be rationalising energy supply to their people. Nigeria seems to have been in energy deficit for a long time and successive governments have not been able to tackle this crisis head-on. Sourcing for revenue to tackle this need may be a mirage in view of global energy market which has further worsen in recent times as evidenced in the price of crude oil. Nigeria solely depend on petroleum resources to source for income to tackle infrastructural gap and also natural gas has always remains most viable option of energy generation in the countries. Analysts [1, 15] have even predicted that fossil fuel may no longer be a reliable source of energy generation in some years to come in view of its volatility and most

importantly, it is not sustainable. It is therefore imperative for government to expedite action on how to develop a more sustainable blueprint on energy growth and expanding the existing source of energy in other to broaden power base of the country. Various researchers [8, 11] have exploited plastic wastes for potentials energy generation as seen in many publications, plastics wastes are now receiving attention for possibly full scale economic activity as various environmentalists[13, 14] have emphasized plastic waste as a source of energy considering its recyclability and affordability. According to Oyake-Ombiset al [23], Lagos is believed to be generating highest volume of plastic wastes in Nigeria and this volume may triple in the couple of year if efforts are not geared toward redirecting the waste to economic fortunes of the country. This literature review is aimed at adapting this estimated volume of wastes in Lagos with a view to recommend the most approximate method of converting the wastes for energy development.

It has been reported by many authors [24, 30] that the economic and environmental advantages of plastic wastes may far exceed metallic wastes if it is properly integrated for human need. Plastic waste is recyclable and therefore could be used for agricultural manure as reported in some literatures [17, 20]. The invention of plastics has revolutionised the world as these plastic materials are evidently seen in homes in different forms due to its peculiarities. To properly situate the proportion of plastic in homes, a preliminary assessment of wastes volume was undertaken by [29, 31] to estimate percent content of plastic wastes in commonly used appliances. According to the authors, it was confirmed that plastic wastes account for larger wastes volume globally in homes due to its friendly nature (see Table 1 and 2). Table 1 depicts the percent of plastic in every volume of waste estimated and it is crystal clear that weight fraction of plastic appears high among all other wastes which is a clear signal that once plastic waste is contained, insignificant volume may henceforth be left as waste. In table 2, further analysis was done to estimate the proportion of plastic waste in home appliances and the report was presented in the table under study. This analysis further validated our earlier position that plastic waste constitute larger portion of waste in Nigeria.

*Table 1: Percent content of plastic wastes[32]*

Waste types	% weight
Plastic	57
Paper and cardboard	10
Wood	3
Textiles	3
Inerts and others(including metals)	27
Total	100

The concept of plastic engineering was first studied in early 1900s, and the world has never remain the same since then. Plastics has continuously replaced many types of materials such as wood, metals and ceramics

due to its inherent properties and the fact that it is a poor conductor of heat further enhances its usefulness. Its relative weight advantages have continued to draw market to plastic as they are light, durable, and resistant to corrosion [4]. Diverse literatures [11, 19] have reported that light weight material are currently being used in automobile to reduce payload which ultimately reduces fuel consumption. Higher payload mean higher fuel consumption. Plastic materials are generally lighter and always have lower thermal conductivity. These two advantages makes plastic find market in homes and automobile industries[8].

Nigeria solely depend on fossil fuel to boost its energy supply as seen in government policy to increase the supply of LNG to most of the power plants. This attempt has always been a short time measure since the menace of fossil fuel outweigh its immediate gains. In view of the prevailing threat to the ecosystem and the need to preserve the nature for the unborn generation, the world is faced with emerging and undaunted challenges to combat climate change head-on or face the looming and imminent disaster. Fossil fuel has been the major contribution to climate change and global warming. Depletion of ozone layer is worst affected by emission of carbon-monoxide which fossil fuel breed. It is therefore necessary to take proactive measure to develop a more pragmatic approach to covert this waste for sustainable development. Biron [12] had reported the need to diversity material usage which has both technical and economic consequences in view of the cost involved in waste management. Material wastes generated in Lagos continue to pose a challenge to and some of the wastes have defiled existing measures. Lagos being the economic hub of the nation needs special pilot strategy to reduce waste volume. Kofoworola [21] had reported some of the findings on Lagos wastes to be 4 million tonnes of municipal solid waste (MSW) as at 1995(see Table 3) and this is a far cry to what is presently generated in the year 2015[4].

*Table 2: Contents of plastic proportion in home appliances in percentage[29].*

Appliances	Plastic (%)	Aluminium (%)	Copper (%)	Steel (%)	Glass (%)	Others (%)
PC(CRT monitor)	23	14	7	21	30	5
Air conditioner	11	7	17	55	0	10
TV set	23	2	3	10	57	5
Refrigerator	40	40	3	4	50	<1
Washing machine	36	3	4	53	<1	4

Table 3: Waste generated in Lagos as at 1995[21].

Reference point	Estimated Population(millions)	Year	Municipal waste generated(tonnes)	Annual statistics (tonnes/cap/year)
Lagos	10	1995	4 million	0.40

Table 4:Waste volume for the month of January, 2014(Cubic meter)

S/n	Landfill sites	Truck trips	Total (cubic meters of refuse)	Remarks
1	Olusosun	10206	185529.10	55
2	Solous ii	2024	38020.79	11
3	Solous iii	3000	54966.74	16
4	Ewuelepe	1522	36704.78	11
5	Epe	1062	24795.21	7
	Total	17814	340,016.62	

Source: LAWMA

Table 5: Waste volume for the month of July, 2014(Cubic meter)

S/n	Landfill sites	Truck trips	Total (cubic meters of refuse)	Remarks
1	Olusosun	8404	149048.86	49
2	Solous ii	1864	34029.11	11
3	Solous iii	2460	45326.40	15
4	Ewuelepe	1486	41594.59	14
5	Epe	1161	32700.63	11
	Total	15375	302699.59	100

Source: LAWMA

Table 6: Waste volume for the month of September, 2014(Cubic meter)

S/n	Landfill sites	Truck trips	Total (cubic meters of refuse)	Remarks
1	Olusosun	9044	160277.55	54
2	Solous ii	1747	32040.55	11
3	Solous iii	2476	45384.30	15
4	Ewuelepe	1188	30532.18	10
5	Epe	1091	30557.18	10
	Total	15546	298791.81	100

Source: LAWMA

## 2. PERFORMANCE INDEX OF MANAGING WASTE IN LAGOS

Lagos is entirely a marine island which is largely surrounded by water. The population of Lagos has

been reported to have reached 21,883,047 million people in 2014 and this is a huge challenge considering the volume of generated from Lagos. Adewole [2] has reported that Lagos lagoon is believed to have been absorbing 10000m<sup>3</sup> volume of industrial and associated wastes daily which has resulted in the pollution of water for human consumption. With a minimum number of 2000 people relocating to Lagos on daily basis from other part of the country, Lagos is likely to be the fastest populating cities in the Africa. Managing waste in Lagos is may be a herculean task in view of daily migration to Lagos without proper planning. Waste management in Lagos is principally the constitutional responsibility of Lagos waste management authority (LAWMA) and their giant strides in curtailing waste is widely acknowledged to be monumental[15]. In this study, waste volume for the month of January, July and September, 2014 were sourced from LAWMA to serve as a pilot test for this research.

LAWMA is currently faced with the challenge of waste management as reports show that waste volume recently rise from 10,000 to 12,000tonnes[17]. In Table 5 to 7, it is shown that waste is still a challenge as evident the proportion of data released. In January 2014 alone, waste volume stood at 340,016.62m<sup>3</sup>, which to a larger extent, has indicated that existing methods to contain these wastes may not be sustainable.

## 3. PROPORTION OF PLASTIC WASTES IN LAGOS

Scarlatet al [27] investigated African proportion of plastic wastes generated by income earner and gave a tabular representation as shown in Table 7. According to the authors, plastic waste is easily generated and efforts have to be taken in view of its energy potential.

Table 7: Proportion of constituent of Wastes. Adapted from Scarletet al [27].

Income earners	Organic range%	Paper range%	Plastic%	Glass%	Metals%
Low income	64(18-22)	6(2-21)	9(1-20)	3(1-12)	3(1-12)
Low medium income	59(20-76)	10(2-18)	13(2-18)	4(1-9)	2(1-20)
Upper medium	54(5-70)	15(7-37)	12(3-36)	4(1-13)	3(1-8)
High income	25(4-56)	30(4-68)	11(1-24)	7(1-13)	6(1-16)
Africa	57(18-88)	9(2-21)	13(1-20)	4(1-5)	4(1-5)

In fairness to Lagos state government, concerted efforts are being explored to manage waste volume but there appear to be enormous waste volume to contend with. Plastic waste appears to have been the most ravaging wastes in recent times as virtually daily materials and utilities in Lagos homes contains 70% plastics[18].According to Salamiet al [26], plastic wastes account for 15% of total waste volume and some of the organic materials may still be classified as plastic material as fraction of its production is from plastic materials. The authors characterised Lagos wastes in the category presented in Table 8.

Table 8: Characterization of waste proportion

Category	Volume(tonnes)	Percent proportion
Organic	5580	62
Plastic	1350	15
Paper	900	10
Glass	360	4
Silts	630	7
Ashes	180	2
Total	9000	100

Rigamontiet al [25] had equally given precise fraction of plastic in municipal solid waste. According to their study, plastic has definite proportion in municipal solid wastes which make plastic waste a major waste in need of solution (see Table 10). For example, it was reported further that plastic in municipal solid wastes is made of polyethylene terephthalate (PET) or high density polyethylene (HDPE), of soft plastic or plastic films made of low density polyethylene (LDPE) and of hard plastic made of HDPE. The remaining plastic material fraction is regarded as non-recyclable mixed plastic in which high proportion is non plastic. This assertion was further supported by the authors [22, 28]. In the same vein, Al-Salemet al [3] investigated recovery process of plastic wastes having considered all methods in the developing countries and concluded that recycling and energy recovery appeared to be more pragmatic and sustainable if developing countries desired to catch-up with the millennium development goals (MDG).

Table 9: Weight fraction of Plastics according to Rigamontiet al [25]

Proportion of plastic fraction	% weight average
Bottles	27
Soft	36
Hard	11
Non-recyclable	26

#### 4. CONCEPT OF ENERGY RECOVERY FROM PLASTIC WASTES.

Energy has always been a debating issue in Nigeria especially in Lagos where there is large deficit in power generation and transmission. The concept of source reduction of wastes has been widely published by many authors [5, 16] and is currently receiving attention from government. Energy from wastes may be conceptualised in two perceptions. The first concept has the idea of power generation from wastes which is critical to emerging cities like Lagos while the second agenda evolves from fuel energy in which sizeable authors [20, 27, 30] have reported. This idea if properly harmonised can serve as a role in minimizing wastes and also give more room for power development and growth. This study was aimed at x-raying the possibility of energy generation from wastes as widely championed by United Nation to save the environment from imminent collapse. Nature is in dire need of attention as reported by Bajićet al [7] which is one of the goal of MDG in terms of sustainable development and it is high time Lagos looked into energy development from waste in view of its critical location in Nigeria economic setting. According to Wonget al [33] plastics wastes could be converted into energy using thermal and catalytic pyrolysis, microwave-assisted pyrolysis and fluid catalytic cracking.

Igoniet al [19] had reported a comparative volume of energy derivable from Port Harcourt waste and this study was critical to estimate the volume of waste convertible to energy generation in Lagos environment, the entire area has to be delineated, a procedure widely reported by[6]. The procedural process involves core use of Simpson's rule for the estimation of volumes, also called the Prismoidal formula.

The rule may be illustrated mathematically as follows:

$$X = \frac{a}{3} [A_1 + 4A_2 + 2A_3 + \dots + A_{n-1} + A_n] \quad (1)$$

With this equation the entire volume of waste in Lagos can be estimated while  $A_1$  is considered first area or local government council or development area of Lagos state.

According to Beathet al [9]energy content in waste volume may be estimated by using the relation

$$E = 0.051 [F + 33.6(CP)] + 0.352 (PLR) \quad (2)$$

The content of total solid (TS) and volatile solids (VS) will be determined as recommended in the standard method.

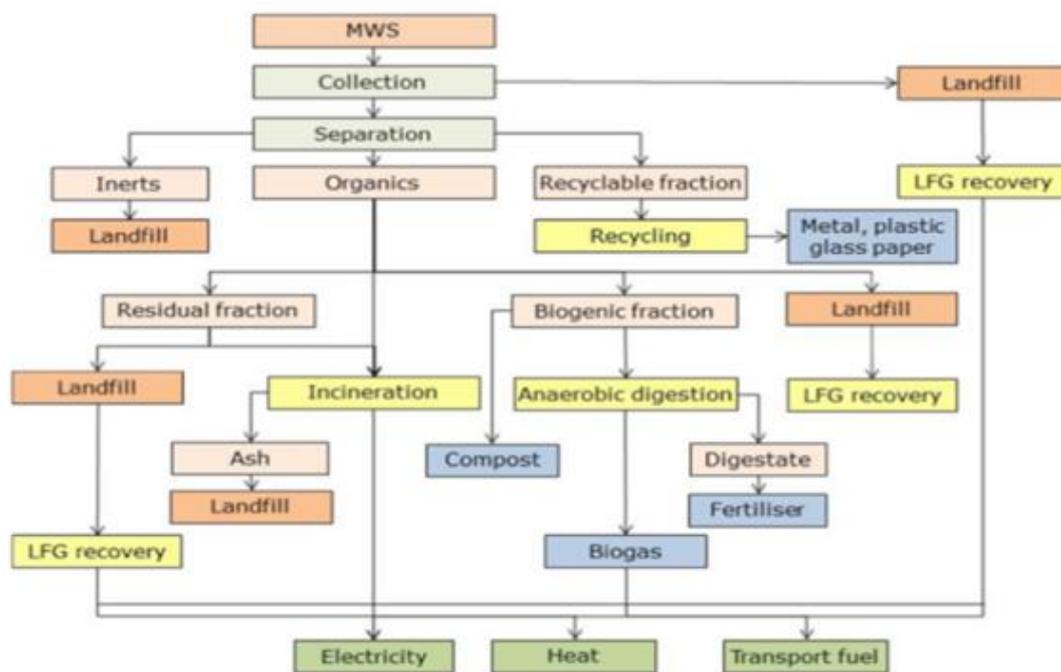


Figure 2: Framework mechanism of energy generation from wastes. Adapted from [27]

This will further enhance the determination of biodegradable content of the waste using the equation prescribed by Kiely, in which

$$BF = 0.83 - 0.028LC \quad (3)$$

In (3), BF is the biodegradable content of the waste and LC is the lignin content in the waste

Many authors [10, 13] have developed means of energy recoverable from waste. Several technologies are currently being used such as incineration, biochemical conversion which has been reported to have produced good result in developed countries. Schematic representation of this process is shown in Figure 2. Other recovery process are discussed in section 4.1 and 4.2

#### 4.1 Conversion of Plastic Waste to Biogas.

Biogas production from waste is currently being explored in the literatures as most friendly alternative waste management system. The United Nations Development Programme (UNDP) energy report further gave credence to this concept and reported that Africa need to take a cue from developed countries by developing installation of small biogas plants to contain the growing waste in the continent. Production of biogas from anaerobic digestion of organic materials particularly from the municipal waste may likely be the solution Lagos government need to explore in her bid to solve the epileptic power supply in the state. Sufficient biogas generated from

small to large scale biogas plant can be used for running gas turbines and generating electricity for remote and disconnected communities. Several researchers have described biogas production from municipal waste as a reliable technology and a sustainable innovation in electricity and power growth in developing countries. Now that the decentralization of electricity distribution and generation is already taking root in Nigeria, Lagos could independently use this platform as a pilot test for energy generation from waste.

#### 4.2 Combustion of Municipal Waste for Energy Utilization

A lot of studies have equally confirmed that biodegradable and combustible components of municipal waste could be processed for electricity generation. Many combustible organic materials from municipal and other sources of wastes that cannot be regenerated can be a source of fuel for incineration in major poultry industries. Plastic waste is reported to have high calorific value in view of its energy content. Some of these combustible materials from the plastic waste which are currently being burnt in the open can be channelled into electricity generation.

#### 5. CONCLUSION

In light of the volume of waste generated in Lagos and its associated management challenges, it is therefore

necessary for government to explore energy generation in future plans. The challenge is enormous and it behoves on regulatory agency to partner with expert on how to combat the challenge. Another possible way to inject sanity into waste management plans in Lagos is for government to privatise waste in its entirety. Waste appears to be a business in developed countries and unnecessary political interference has been a draw back in some of the developing countries. Laws need to be enforced where necessary so that it can serve as a deterrence to others. Waste minimisation seemed a mirage in Lagos as noticed in the data supplied for July and September, 2014. For any country to achieve millennium development goal, further attention need to be paid to the concept of waste to energy development.

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