**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 05, Issue 05 (May. 2015), ||V2|| PP 23-29

# Prospects of Material Flow Management in Waste Control and Energy Generation in Nigeria

A.O. Igbozulike[1*] and A.K. Aremu[2]
[1] Agricultural and Bioresources Engineering Department, Michael Okpara University of Agriculture, Umudike, Nigeria **Corresponding author; E-mail: austin.igbozulike@gmail.com*
[2]Agricultural and Environmental Engineering Department, University of Ibadan, Ibadan, Nigeria

***Abstract: -*** Human activities appear to end up in waste generation, either directly or indirectly. These waste generated should not be wasted. Nigeria faces serious environmental challenge as a result of increasing population. In many Nigerian cities, pungent odour emanating from piled up waste along the streets fills the atmosphere. Besides, substantial land for agriculture has been claimed by open waste dumps. This work studies the problems of waste management in Nigeria, and the role of Material Flow Management (MFM) in tackling them. Waste classification, generation, disposal methods were discussed. The Nigeria's waste problems were also highlighted. Nigeria generates an estimated 6.03million tons of solid waste and 83.04million tons of fresh animal waste per annum. Considering this amount of waste, this paper posits that MFM should be integrated in all aspects of waste in Nigeria for sustainable management in the present and future, and strongly recommends biogas technology as one of MFM's technique that will boost energy generation through waste.

***Keywords****: Waste, material flow management, biogas, energy, Nigeria*

## I. INTRODUCTION

Waste could be defined as those materials, used or unused, that have no usefulness in their present state or condition, and which in most cases are discarded. The United Kingdom's Environmental Protection Act 1990, re-enacting an earlier U.K statue, in section 75(2) defines waste, as contained in [1], to include any substance which constitutes a scrap material or an effluent or other unwanted surplus substance arising from the application of any process, and any substance or article, which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled. Waste can also be defined as any unwanted materials intentionally thrown away for disposal [2]. These definitions were affirmed by [3], [4] and [5] as they followed similar definition trend. It is evident, following the definitions, that waste could be easily identified by two striking attributes; namely material(s) that are thrown away and material(s) that are no longer needed.

Consumption of goods and utilization of raw materials are constantly increasing with increase in population and urbanization, and consequently increase in waste. Solid waste generation has been encouraged by rapid increase in population, changes or improvement in wages, massive expansion of the urban areas and the changing lifestyle or better standard of living as well as improvement in technology [6]. As a result of this progressive increase in waste generation, the effects on our environment continue to pose a great challenge to man. It is obvious that we cannot reduce the quantity of goods and raw materials we need, but, we can effectively manage our usage of these vital items and work on utilizing its attendant wastes.

Municipal solid waste and domestic waste remain a challenge to Nigeria cities, and [7] opined that the management of municipal solid waste is one key challenge to globalization and urbanization in developing world; hence, globalization is playing a negative role in waste management in African cities. However, it was found that waste disposal habit of the people, corruption, work attitude, inadequate plants and equipment among others militate against effective waste management in Nigeria [1]. Thus, improper waste management has led to serious environmental crises, health hazards, and worsened socio-economic development. Awareness on dangers posed by indiscriminate waste disposal, attitudinal change on the part of people, and responsiveness on the part of government and corporate entities, improvements on waste collection and proper disposal, and effort to turn waste into wealth remain crucial to improving proper waste handling culture and overcoming constrains posed by waste in Nigeria, and other developing nations.

## II. WASTE CLASSIFICATION, GENERATION AND DISPOSAL

The classification of waste helps in waste sorting, while information on waste generation and disposal help in handling and management of waste.

### 2.1 Waste classification

Waste could be broadly classified into the following [8];

i. *Garbage:* decomposable wastes from food
ii. *Rubbish:* non-decomposable wastes; either combustible (such as paper, wood, and cloth) or non-combustible (such as metal, glass, and ceramics)
iii. *Ashes:* residues of the combustion of solid fuels
iv. *Large wastes*: demolition and construction debris and trees
*v*. *Dead animals*
vi. *Sewage-treatment solids:* material retained on screens, settled solids, and biomass sludge
vii. *Industrial wastes*: such materials as chemicals, paints, and sand
viii. *Mining wastes:* slag heaps and coal refuse piles
ix. *Agricultural wastes:* farm animal manure and crop residues

### 1.2 Waste generation

Waste generation is the first point in waste management. Waste is generated wherever human beings live, work, operate and/or engage in other activities. The type of waste generated varies accordingly as can be seen in Figure 1 below.

*Figure 1: Unsorted waste piled up along a major road in Nigeria.*

In Nigeria, most homes (both in cities and rural areas), farms and local markets generate biodegradable wastes while a mixture of both biodegradable and non-biodegradable wastes are generated in cities, offices and urban markets.

**Table 1:** Waste generation in some selected cities across Nigeria

| *City* | *Population* | *Tonnage /Month* | *Density (kg/m³)* | *Kg/Capita/Day* |
|---|---|---|---|---|
| Lagos | 15029200 | 315556 | 294 | 1.00 |
| Kano | 14248700 | 300676 | 290 | 0.98 |
| Ibadan | 8317840 | 212391 | 330 | 0.78 |
| Kaduna | 7457900 | 204433 | 320 | 0.69 |
| Port Harcourt | 5053900 | 117825 | 300 | 0.60 |
| Makurdi | 1249000 | 24242 | 340 | 0.48 |
| Onitsha | 2509500 | 84137 | 310 | 0.53 |
| Nsukka | 1100700 | 12000 | 370 | 0.44 |
| Abuja | 5159900 | 14785 | 280 | 0.66 |

Source: [9]

Nigeria has a population of about 150million and the average tonnage of monthly waste generation in some cities is shown in Table 1 above. This implies that the population of a city affects the quantity of waste generated and the linear relationship between monthly tonnage ($M_t$) of waste and population ($P$) can be expressed using regression equation thus;

$$M_t = 0.021P - 2865 \quad (1)$$

Worthy of mentioning here is the fact the majority of this waste could be utilized for biogas production; and others are recyclable. Nigeria also generates an estimated 227500 tons of fresh animal waste daily and this can produce about 6.8 million $m^3$ per day [10]. Besides, 37.6% of total waste generated is biodegradable as shown in Table 2. With these amounts of waste generation, Nigeria has a great potential of adding to her economic life through proper utilization of waste.

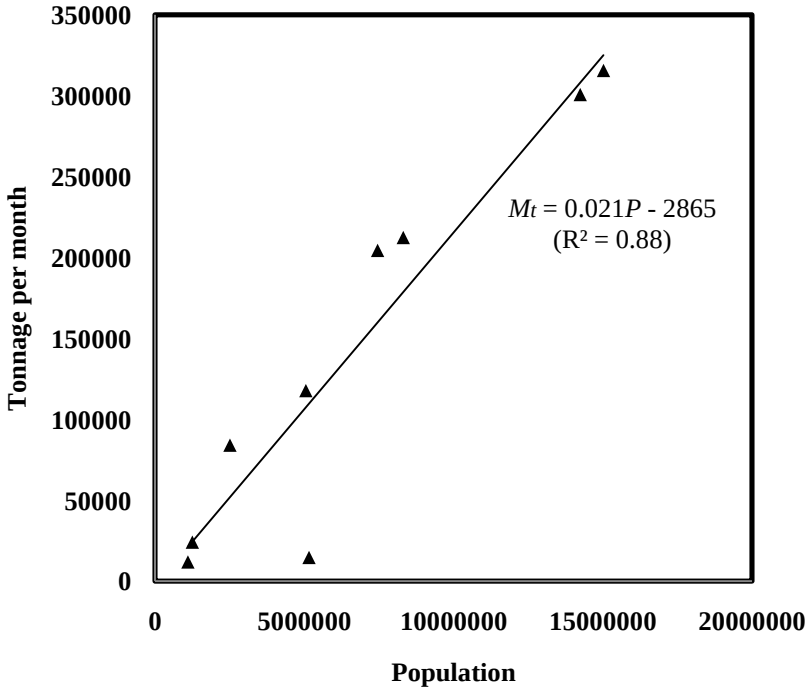


*Figure 2: Variation of tonnage of waste with city population*

### 2.3 Waste disposal and Composition

Three ways of disposing solid wastes have been in use for a very long time. These include incineration, composting and landfill. Wastes are collected first using bins, trailer, or other equipment meant for this purpose before they are disposed. Such equipments are usually positioned in strategic places. Also, it is a convention in waste management to sort wastes before disposal. Observation has shown that in most places in Nigeria wastes are not sorted, and equipments for disposal are inadequate or unavailable as shown in Figure 1. There is interconnectedness between waste collection and its management. If wastes are properly collected, it will enhance its management.

**Table 2:** Typical composition of solid waste in Nigeria

| *Waste component* | *m*/kg | *w*/% | $V_{\text{initially collected}}/\text{m}^3$ | $\rho_{\text{initially collected}}/(\text{kg.m}^{-3})$ | $V_{\text{compacted}}/\text{m}^3$ | $\rho_{\text{Compacted}}/(\text{kg.m}^{-3})$ |
|---|---|---|---|---|---|---|
| Food waste | 46.5 | 29.2 | 0.14 | 310.7 | 0.12 | 362.5 |
| Wood/leaves | 18.7 | 8.4 | 0.05 | 254.0 | 0.04 | 317.5 |
| Paper | 28.5 | 12.4 | 0.21 | 88.1 | 0.17 | 108.8 |
| Plastics | 24.7 | 9.9 | 0.24 | 61.3 | 0.23 | 63.9 |
| Textiles/rubber/leather | 21.4 | 7.6 | 0.08 | 142.5 | 0.06 | 190.0 |
| Miscellaneous | 5.7 | 1.8 | 0.02 | 135.0 | 0.01 | 270.0 |
| Glass | 30.1 | 13.5 | 0.11 | 182.7 | 0.08 | 251.3 |
| Metals | 35.6 | 17.2 | 0.13 | 196.9 | 0.12 | 213.3 |

Source: [11]

## III. PROBLEM OF WASTE IN NIGERIA

The Federal Ministry of Environment in Nigeria [12] attributed the problem of solid waste to the following:

i. Overgrowing urban population with its characteristic increase in the rate of solid waste generation;

ii. Inability of the local government councils to cope with the problem of solid waste management due to inadequate technical and financial resources;

iii. Peoples belief that solid waste management is a social service and hence their unwillingness to pay for disposal charges;

iv. The inability of people to discern what constitute wastes, reusable wastes, recyclable wastes, biodegradable and non-biodegradable wastes; and

v. Investment in functional waste treatment and enforcement of anti-pollution laws are given low priority in developing countries.

Apart from the above, unavailability of comprehensive data on the amount of waste generated in the country is a major problem in waste management. Again, waste disposal habit is a serious cause for concern in Nigeria. Such acts include throwing out banana peels and other fruits garbage from moving vehicles on the roads, pilling wastes inside the gutter meant for drainage, dumping refuse on our roads and in streams, discarding sachet water packet arbitrarily, burning of waste within residential areas, open dump sites, among others. These constitute serious environmental challenge. Mixing of all kinds of waste presents another bottleneck in waste management as could be seen in Figure 1. The failure of the government to implement laws meant to curb this menace is a major problem in handling waste. Waste management is yet to be given the urgent attention it requires.

## IV. THE CONCEPT OF MATERIAL FLOW MANAGEMENT (MFM)

The effort to tackle the danger posed by waste has led many researchers to proffer solution(s) to ensure sustainable environment. MFM is one of those solutions. The Figure 3 below shows a simple MFM technique, in a flow chart, for waste handling. MFM is a means of achieving a sustainable environment through efficient economic use of raw material and reuse of waste arising thereof in a given system. This technology evolved as a veritable means to achieving safe environment in many developed nations like Germany. The whole idea of MFM is to preserve our environment, minimize waste, utilize waste as raw material, conserve energy, protect humans, and other living things. MFM is defined as the goal oriented, efficient use of materials, material streams and energy [13]. The goals are given by ecological and economical areas and by observing social aspects. Though MFM is relatively an innovative technology, its many advantages make it a sure technology in tackling waste menace globally. Among the techniques of MFM is biogas.

### 4.1 Biogas technology

Biogas has been an area of interest for many researchers spanning over six decades. Biogas refers to the technology for creating methane from organic or biodegradable wastes. Such wastes as crop residue, animal wastes, wood, municipal solid wastes, and wastes from food and feed processing. Biogas is essentially made up of methane ($CH_4$) and carbon dioxide ($CO_2$); it is produced from wastes using anaerobic digesters. Biogas can be used for;

- boiler facilities producing heat or steam for use directly on site or in neighboring facilities, and/or
- generation of electricity, for use both on-site and to sell to the grid.
- the production of fertilizer to boost agriculture

Many researchers have outlined the benefits of biogas technology; among them are [10], [14], [15], [16], [17] and [18]. These benefits include; reduction of air pollution and deforestation, poverty reduction and better quality life through affordable energy, good sanitation, general health and environmental improvement, efficient municipal and agro-industrial wastes management, fertilizer generation for agricultural production, opportunity for job and wealth creation, and contribution to the national power grid. A simple chart of biogas technology using animal, municipal and domestic waste is shown in Figure 4. Considering the amount of waste generation in Nigeria, the nation stands to benefit a lot from biogas technology. Unfortunately, there are only few small / medium biogas digesters (below $100m^3$) and no large biogas digester ($>100m^3$) in Nigeria [11]. Waste from animal can be mixed up with municipal and domestic waste to increase the biogas production.

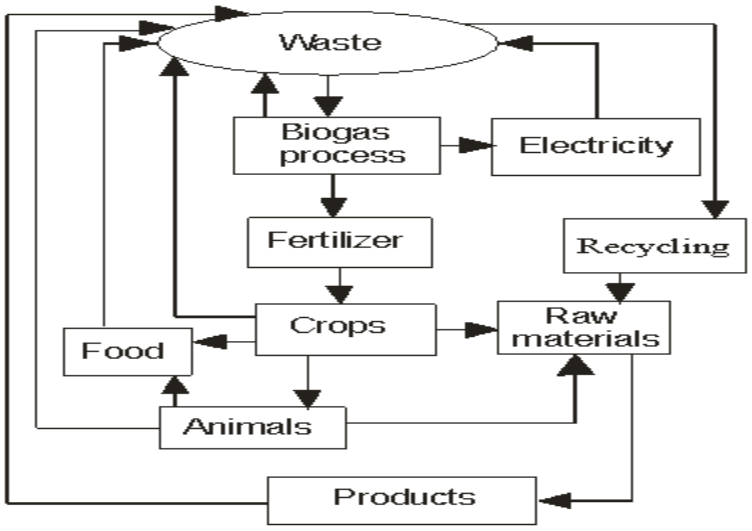


Figure 3: A simple MFM flow chart.

## V. CONCLUSION

Nigeria has the capacity of increasing her economic activities through proper waste management. With MFM, most problems posed by increasing waste generation could be tackled economically. Waste should not be wasted; rather, waste should be used to create wealth.

Considering the quantity of waste generated in Nigeria, utilizing biogas technology could add considerable amount of electricity to the national grid and ameliorate health hazards which those wastes could have caused.

The government should rise to the challenge of securing the future today by adopting stringent measures regarding waste control. If we do not manage our waste properly, it will definitely impact negatively on our environment, health, land for agriculture and infrastructure, and socio-economic activities. No nation is isolated from the globe, since the environmental activities of a nation may have a direct or indirect impact on other nations. Hence, international cooperation is much needed in solving environmental problems.

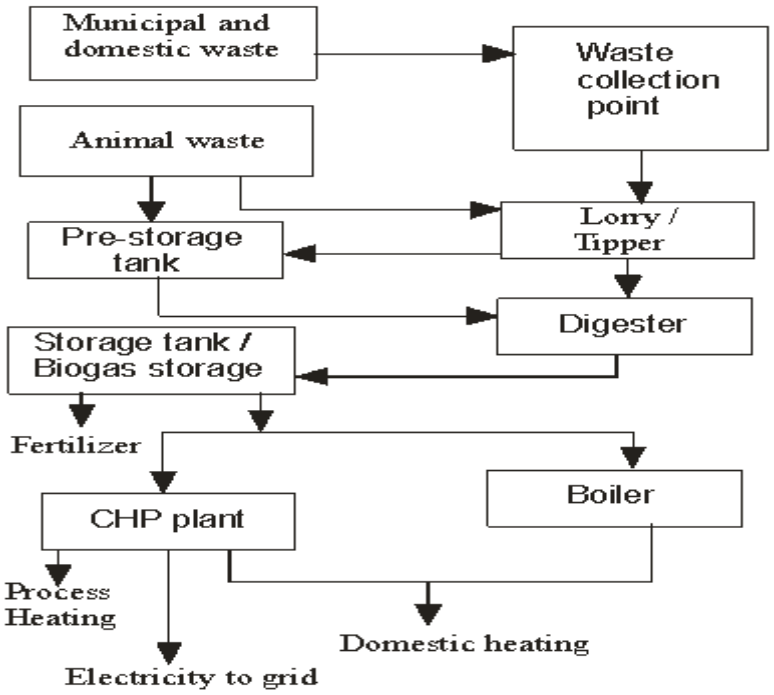


Figure 4: Flow sheet of biogas using animal, municipal and domestic wastes

## REFERENCES

[1] Adewole, A. T., *Waste Management towards Sustainable Development in Nigeria: A case Study of Lagos State,* International NGO Journal Vol. 4 (4), 2009, 173-179.

[2] Ogedengbe P. S., and Oyedele J. B., *Effect of Waste Management on Property Values in Ibadan Nigeria,* Journal of Land Use and Development Studies Vol. 2, No. 1, 2006.

[3] Ajadi B. S., and Tunde A. M., *Spatial Variation in Solid Waste Composition and Management in Ilorin Metropolis,* Nigeria J Hum Ecol, 32(2), 2010, 101-108..

[4] Babayemi, J. O., and Dauda, K. T., *Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria,* J. Appl. Sci. Environ. Manage, Vol. 13(3), 2009, 83 – 88.

[5] Ita M., *Waste- Is the Developing World Ready?* Science in Africa, Africa's First On-line Science Magazine, Science Magazine for Africa, MERCK. 2003.

[6] Akpen G. D., and Aondoakaa S. C., *Assessment of Solid Waste Management in Gboko Town,* Global Journal Of Environmental Sciences, 8(2), 2009, 71 – 77.

[7] Achankeng E., *Globalization, Urbanization and Municipal Solid Waste Management in Africa,* African Studies Association of Australasia and the Pacific 2003 Conference Proceedings – Africa on a Global Stage, 2003.

[8] Huang, Jerry Y. C., *Solid Waste Disposal.* Microsoft Student 2008 [DVD]. Redmond, WA: Microsoft Corporation, 2007.

[9] Ogwueleka T. C., *Survey of Household Waste Composition and Quantities in Abuja, Nigeria,* J. Resources, Conservation and Recycling, 2003, 77:52-60.

[10] Mshandete, A. M., Parawira W., *Biogas Technology Research in Selected Sub Saharan African Countries – A review,* African Journal of Biotechnology, 8(2), 2009, 116-125.

[11] Dauda S. A., Cao J. and Yu X., *Waste Treatment and Recycle in Nigeria,* Journal of Shenyang University of Chemical Technology, 28(1), 2014, 90-96.

[12] Federal Ministry of Environment, Federal Republic of Nigeria, *Study for Construction of Integrated Solid Waste Management Facility (IWMF) in Yola, Adamawa State.* First Progress Report: Site Selection and Waste Generation Survey, 2002.

[13] Enquete Commission of the German Bundestag, *Protection of Human Beings and Environment,* Pg. 259, 1994.

[14] Chuntao Y., *Using Integrated Biogas Technology to Help Poor Communities – China,* ENERGIA News vol. 5(2), 2002.

[15] Pokharel R. K., and Yadav R. P., *Application of Biogas Technology in Nepal: Problems and Prospects*. ICIMOD. MIT Series No. 11, 1991, 27p. BSP Lib Temp No. 103.

[16] Wang M., *Biogas Technology and Ecological Environment Development in Rural Areas of China,* Chinese Academy of Agriculture Engineering Research, 2002 EcoSanRes.

[17] Rajabapaiah P., Ramanayya K. V., Mohan S. R., Amulya K. N. R., *Studies in biogas technology. Part I. Performance of a conventional biogas plant,* Proc. Indian Acad. Sci., Vol. C2, Part 3, 1979, 357-363.

[18] Mateescu C., Băran G., and Băbuţanu C. A., *Opportunities and Barriers for Development of Biogas Technologies in Romania,* Environmental Engineering and Management Journal, 7(5), 2008, 603-607.