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Managing Municipal Solid Waste for Energy Sustainability

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Abstract

The management of waste materials is a global problem. It affects both the urban and per urban areas on a much similar scale of importance. Increase in urbanization as well as economic development leads to larger quantities of waste materials. The rapid increase in municipal solid waste produces social, economic and environmental problems of significant proportion that needs effective and affordable technological solutions. Solid waste management programs are motivated by the desire to keep the environment clean, in the hope of promoting sound environmental quality and public health. As fossil fuels become less attractive due to its high prices and environmental impact, the need to look at municipal solid waste management for sustainable energy and environment became imperative. The paper will explore sustainable municipal waste management approaches with a view to providing options for improved waste management and for the adoption of waste-to-energy technologies for sustainability.

Key Words: *Municipal solid waste (MSW), Energy, Sustainability.*

1. Introduction

Waste is said to be any unwanted substance (s) emanating as a result of human activities. Municipal Solid Waste (MSW) more commonly known as Trash or garbage ,consists of everyday items we use and then throw away , such as product packaging ,grass clippings furniture, clothing, bottles, food scraps, newspaper, appliances, paint and batteries. This comes from our homes, schools, hospitals and businesses.

Table 1: Typical MSW Mixture (%)

	Lagos	**Kano**	**Ibadan**	**Maiduguri**	**Avg.**	**Std Dev.**
organics	56	43	76	26	49	17
Plastics	4	4	4	18	8	5
Paper	14	17	7	8	14	5
Textile	0	7	1	4	3	3
Metal	4	5	3	9	6	2
Glass	3	2	1	4	4	3
Others	19	22	9	39	17	8

	organics	Plastics, Textile, Paper	Metal	Glass	others
Average	49	25	6	4	17
Std. Dev.	17	8	2	3	8

Source: Egwueleka, 2009

Table 2: MSW Potential in Nigeria

Selected Major Cities	MSW Annual Generation Potential (tonnes)	Ethanol Production Potential (million litres)	Electricity Generation Potential (MWh)	Electricity Generation Potential (MWh)	People Supplied with Power
Kano	602250	33	129860	150563	494141
Ibadan	565750	31	121990	141438	464193
Kaduna	273750	15	59027	68438	224609
Niamey	237250	13	51157	59313	194661
Maiduguri	182500	10	39352	45625	149740
Zaria	164250	9	35416	41063	134766
Sokoto	91250	5	19676	22813	74870
Katsina	91250	5	19676	22813	74870

Source: Karidio, 2012

Rapid migration of rural populations to urban century, in search of better opportunities of livelihood, has resulted in an overwhelming demographic growth in many cities worldwide. This situation is made pronounced especially in Asia and Africa. The projected growth rate in North America is less because it has already recorded a growth rate of >70%. Also in Europe, the situation is similar. But in Africa and Asia around 35% of the population presently is urban . Asian countries are experiencing an urban growth of approximately 4%per year. This growth rate is expected to continue for several more years and by 2025, 52%of the Asian population is likely to be living in Urban (Reedy, 2011). As in Asia , Africa's population is mainly rural at present. However, Africa is also experiencing a high rate of urbanization at 4 to 5% per annum, and by 2025, urbanization is likely to be similar to Asia. This high rate of urbanization can lead to several environmental degradation in and around several cities.

Waste collection and disposal strategy differ from country to country. Landfill incineration and reigning are often used in developed countries to dispose MSW. In Nigeria for instance these categories of waste are often disposed in an unsustainable manner in open dumps streets, ravines and in other case into drainages which eventually flows into streams which serves as a source of water to the people residing in such locality. Regrettably, this unregulated waste disposal pattern continues to pose serious health and environmental hazard ,Dolk (2002) and lee et al (1991) noted that MSW are biologically diverse, dangerous, highly putrescible and may breed zoonotic pathogens. Gaudy et al (1981) revealed that most disease which infest humans are caused by protozoas including amoebic dysentery.Furthermore, they also noted that MSW hort a good number of fungi numbering up to 100,000 species out of which number, 100 are pathogenic to animals and humans. Most protozoa feed on bacteria, the free living protozoa can be found in any aerobic environment in which bacteria are present to support their growth. (Ye – Obang et al. 2013).

Table 3: Major Living Organisms present in various solid waste.

Category	**Fungus**	**Protozoa**	**Bacteria**	**Insect**	**Rodents**
Bio-medical Waste	✓	✓	✓	✓	✓
Food Waste	✓	✓	✓	✓	✓
MSW	✓	✓	✓	✓	✓
WEEE				✓	✓

Source: (Chandrappa et al; 2012)

2. Significance of Waste Management

Waste is any garbage or refuse or other discarded material including solid, liquid, semi-solid, or contained gaseous material arising from domestic, community, industrial, commercial, agricultural or human operations. The sludge from a waste water treatment plant, water supply treatment plant, or air pollution control facility is also considered as waste.

Waste management is a global issue and requiring maximum attention. It is highly obligatory to reduce the pollution of air and water the dreadful effects on human health and to maintain a clean environment. Waste management sector can contribute to green house gasmitigatran in ways that are economically viable and next many social priorities. The adverse effects of global warming arelentnessed already around the globe to varying degree in different regions. A safe and sustained living. The civic society has therefore, exclusive responsibility of considering waste treatment as a priority issue.

The management of waste involves wastes collection, resource recovery and recycling, transportation and processing or disposal. Of theses the most important one is processing/disposal of waste.

Effective MSW management represent an opportunity to boost economic and can serve as a means to achieve energy security and save foreign exchange. It will also represent an important household in achieving energy save sufficiency and sustainable development.

According to Ezemonye (2012), sustainable development is a pattern of resource used that earns to meet human needs, while preserving the environment and so that this needs can be met not only in the present but also for generation to come. It maintains energy security, affordable, low carbon, renewable and environmentally friendly energy system. The current pattern of energy production and utilization shows a sharp gap in sustainable development and threaten biodiversity and other environmental concern. Therefore the use of energy for economic growth and improved of lives must be done in a manner that minimizes any deliberately effect on the environment.

Therefore, waste management is about all the options society has to manage the transition of the value of goods and materials from positive to negative ideally, waste management will ultimately turn waste into a zero-value good (e.g appropriately treated for residuce which can be left in a safe landhill for indefinite durations)or recycle it by transforming it physically and / or chemically so that it becomes valuable again as a raw material for new products (Ludungetal. 2003)

From the above, we can conclude the following:

1. Waste management is inextricably linked to economy, as waste is defined by as relative economic value.
2. Waste management is likewise linked to ecology as left on its own waste is likely to effect the environment.
3. Waste management is a social issue as waste is merely a social construct and it raises the question about the responsibilities of individual towards society. (Ludwigetal 2003)

It also seen that proper waste management has the potential benefit of greatly reducing incidence of mobility caused by indiscriminable waste disposal and can contribute to the

solving of energy need of the affected communities were the waste are disposed. On the whole, proper MSW management would not only improve the air quality and minimize the dissociated health hazards which people residing and working in such area are subjected to but would also reduce the rate at which green house gases and other poisonous gases which contributes to global warming are emitted into the atmosphere. The study indicates that from a daily delivery of 2, 714 tons of waste in just one city about 30 to 52 MSW of electricity can be generated (Ye- obang et al 2013).

3. Conversion of Municipal Solid Waters to Fuels

Global supply energy is facing several increasing challenges. Energy consumptions is a moderateincrease, especially in rapidly developing countries. The overall size of the world energy market nearly doubled between 1971 and 2003, driven by rapid expansion of energy usage in the developing world, where population and energy activity has grown. (Adrian & Loana 2011).

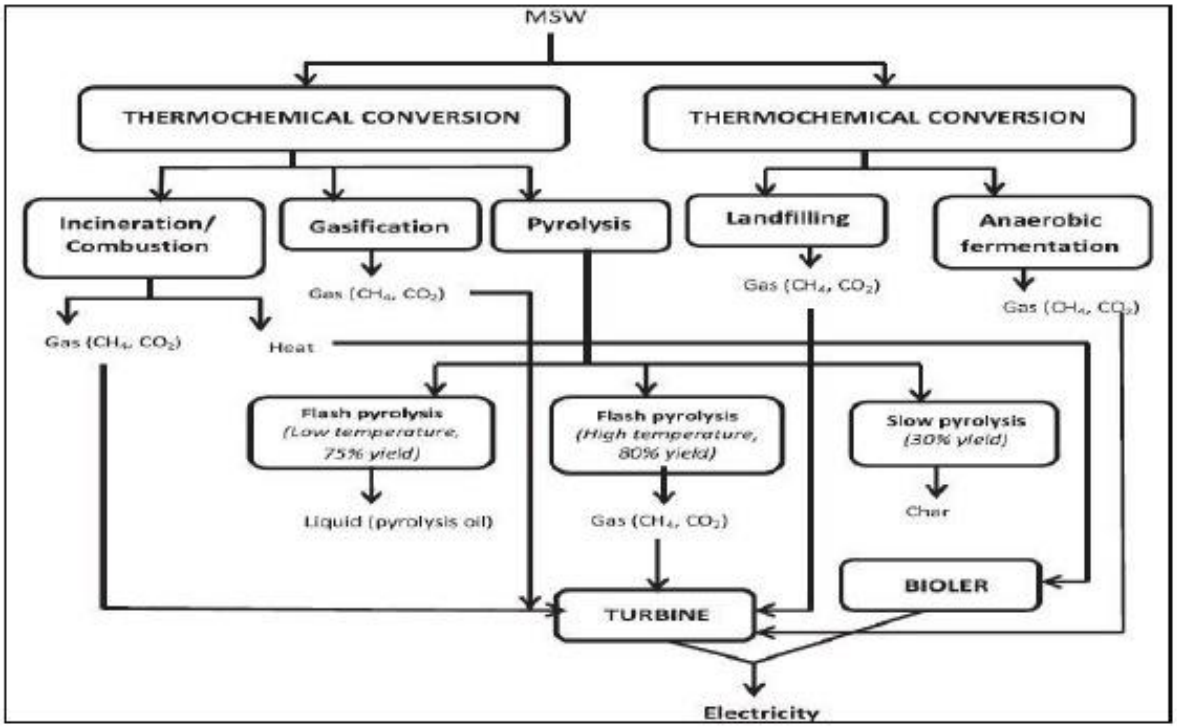
The International Energy Agency (IEA) has projected an increase in primary energy demand of 1.6 percent per year until 2030, when the cumulative increase will be equal to half of current demands. At present, fossil fuels – oil, coal, and natural gas – dominate the world energy economy, providing 80% of the world's primary energy supply of 449 EJ/year. (Heinimo, 2008).

MSW biomass can be processed into refuse derived fuel, a form of coase or fine powdered solid fuels that are briquetted with or without a suitable binder for easier handling. They may also be pyrolized into gasoline or fuel oil.

A (ii) Renewable energy sources such as biodiesel, bioethanol, biomass from wasted or hydrogen are subject of great interest in the current energy scene. These fuels contribute to the reduction of prices ad dependence on fossil fuels. In addition, energy source such as these could partially replace the use of what is considered as the major factor responsible for global warming and the main source of local environmental pollution. For these reasons they are known as alternative fuels. There is an urgent need find and optimize the use of alternative fuels to provide a net energy to be economically competitive and to be producible in large quantities without compromising food resources (Adrian and Loana, 2011).

B. MSW, hasa high potential for biogas generation, but the uncontrolled decomposition of waste results in large scale contamination of land, water and air. All of these cause potentially severe pollution problems and are subject to rigorous environmental regulations in most countries.

Figure 1: Sustainable Waste Management



Source: Ofori – Boateng, 2013

Sustainable Waste Management (SWM) entails the treatment and subsequent disposal of waste in a manner that will not cause any health or environmental hazard but the present and future inhabitant of the locality where MSW are disposed. It involves the transformation of the energy inherent in MSW to a form that will be more beneficial to the society. Waste to energy (WTE) is one of the sustainable means of managing MSW (3)

While it is not possible to completely eliminate the possibility of waste disposal in dump site and landfills, the fact remains that through recycling and incineration of Municipal Solid Waters, the amount of waste that originally would have been reduced significantly, which by implication would not only reduce the harm due to the environment and the inhabitants but would also contribute to meeting her energy need in Nigeria, according to a report by (5) the annual generated municipal solid waste is about 25 million tones for some urban areas in Nigeria.

4. Waste to Energy

The conventional method of generating eclectic from the MSW is by direct combustion, with the heat recovered and used to propel turbines or by natural anaerobic digestion in the landfill. According to (7) the organic fraction of MSW can be anaerobically stabilized in a high-rate digester to obtain biogas for electricity or steam generation another method which is argued to be more efficient than energy generation incineration is steam generation. Another

method which is argued to be more efficient than energy generation from incineration is steam generation from gasification. The gasification of synthesis gas which is often abbreviated as (Syngas) which can be used to raise steam or can be further processed for direct application in gas turbines or engines which further enhances in efficiency. The potential to generate electricity from MSW through some of these processes would disclosed briefly.

4.1 WTE Generation through Incineration/Combustion

Basically, the incineration process often carried out in different stages namely; drying and degassing, Pyrolysis and gasification and oxidation involving the controlled oxidation of the combustible materials which is contained in waste at a temperature of 870 – 1200^0C(1600 to 2200^0f)

The very high temperature allows energy time for at least about 99% of the organic substances such as minerals, metals and water contained in the waste to be oxidized. The high pressure steam is then used for power generation. Also, flue gas (ClO_2, H_2O, O_2N_2) which are generated contains a good majority of fuel energy available as heat (8) (10), asserted that the volume of and weight of waste is reduced by 90% and 70% respectively through incineration.

4.2 WTE Generation through Gasification

Gasification can be considered to be a process between combustion and pyiolyses because of the partial oxidation of the substances involved. This partial combustion of organic sustainers (MSW) is done at high temperature at about (500 -1800°c)under controlled conditions to produce a synthesis gas which could be used as a feed stock or processed as fuel for the generation of electricity(14 13)it is observed by that a typical gasification system for WTTE generation would normally consist of the following units: gasifies, gas scrubber (for cleaning and removal of all harmful gas from the produce gas) and an energy recovery unit for the production of electricity e .t .c.

4.3 WTE Generation Through Pyroigsis

Pyroigsis is thermal disintegration of waste enter in the complete absence of oxygen, or with only a limited suppy in order to provide the thermal energy required for pyrolysis moderately low temperature (400 -900°c) are required. The products of pyroigsis is according to (15) include : bio – char, bio-oil and gases(methane, hydrogen, carbon monoxide.

5. Types of Solid Waste

According to Reddy (2011) municipal waste can Domestic waste:-be classified as follows.

These are generated by household anchovies such as cooking, cleaning, repairs, interior decoration and used products/materials such as empty glass/plastic/metal containers, packaging stuff, clothing, old books, newspapers, old furniture e. t. c

Commercial waste:-

These are generated in offices, wholesale store, shops, restaurant and hotels, vegetable, fish and meat markets, warehouse and other commercial establishments

Institutional waste:-

These are generated from institutions such as schools, colleges, hospitals and research institutions. The waste include mostly paper, cardboard, e. t. c. and hazardous waste.

Municipal waste:-

These are waste generated due to municipal service such as street sweeping and dead animals, market waste and abandoned vehicles or part: also include already mentioned domestic waste, institutional waste and commercial waste.

Ashes:-

Residues from the burning of wood, charcoal and coal for cooking and heating in houses, institutions and small industries. Ashes consist of fine powders, cinders and clinker after mixed with small pieces of metals and glass.

Rubbish:-

Apart from garbage and others, other solid waste produced in household, commercial establishments and institutions.

Bulky Waste:-

Bulky waste are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, tyre, wood, trees and branches. The bulk metallic wastes are sold as scrap metal but some portion is deposited as sanitary land hills.

Street Wastes:-

Street waste include paper, cardboard, plastic dirt, dust, leaves and other vegetate matter collected from street, walkways, alleys, parks and vacant plots. Municipal waste include street waste also.

5.1 The way forward

Set a clear vision and specific targets

Develop a Waste management infrastructure

Collection, transportation, sorting

Communication, education, sensibilisation

Policy, regulation and incentives

6. Recommendation

Effective MSW management represent an opportunity to boost economic and can serve as a means to achieve energy security and save foreign exchange and could represent an important milestone in achieving energy self-sufficiency and sustainable development.

1. Government should facilitate partnerships b/w the local energy institutions and international lonar Agencies, international finance institutions, development partners etc.
2. Governments should endeavor to fashion at appropriate policies that targets renewable energy technologies as fulcrum for rural energy supply.
3. Governments need to declare energy state of emergency to harnessing and utilization of energy resources with particular emphasis on renewable energy.

References

Adrian Eugencioabla and LoanaLonel (2011).Biomass waste as a renewable source of Biogas production – experiments,.Alternative fuel, Dr. MaximioMagarura(ED), ISBN:978-953.

Arena, U. (2012). Process and technological aspects of Municipa; Solid waste gasification. A review, Waste Management, Vol.32, P, 625 – 639, 2012.

Chandrappa, R. and Das, D. B.(2012) Solid waste management. **"Environmental Science and Engineering**. Berlin: Springer- verlag.

Dolk, H.(2002)" methodological issues related to Epidemiological Assessment of health Risks and health impact of solid waste management Activities, PP.195 -209.

Eyemanye, L. I (2013)Environmental consideration in Renewable Energy development in Nigeria. Unpublished paper present at the 1stUmyu international conference on environmental protection agency (2014).

http://www.epa.goo/epawaste/nonhaz/municipal/index.htm.retrieved22nd/9/2014.

Gaudy ,A.F. na d Gaudy, E.T.(1981)**"Microbiology for Environmental Scientist and Engineers,** New York. MCGraw-Hill.

Heinimo J. (2008). Views on the international market for energy biomass in 2020, result from a scenario study. International Market for energy biomass, 547, ISSN 1750 – 7220.

Lee G.F. and James R.A. (1991). Municipal Solid Waste Management: Long Term Public Health and Environmental Protection in NWWA National outdoor Action Conference on Landfills and Ground water Quality. Las Vegas, Nevada.

Ludwig, C. et al (2003) Municipal Solid Waste Management. Springer – Verlay – Berlin Heidelberg.

Milbrant A. (2009). Assessment of Biomass Resources in Liberia

Mohan, D., Pittman J. and Steele, P. (2006). "Pyrolysis of wood/biomass for bio-iol; a critical Review" Energy & Fuels, Vol. 20, P.848 – 889, i

Morris, M. (1998). Electricity Production from Solid Waste fuels using advanced gasification technology. In Swana's waste com. ISW World Congress, North Carolina.

Murphy, J. and Mckeogh, E. (2006) "The benefits of integrated treatment of waste for the production of energy" Energy, Vol. 31. PP 294 – 310

Ofori – Boatery, C.K.T. Lee and M.Meusil (2013) "The prospects of electricity generation from Municipal Solid Waste (MSW) in Ghana: A better waste management option," Journal of Fuel Processing Technology, Vol. 110, PP 94 – 102.

Ogwueleke, T (2009) "Municipal Solid Waste Characteristics and Management in Nigeria." Iran Journal of Environmental Health Sci. Erg., Vol.6, no+.3, P. 173 – 180.