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A REVIEW OF SOLID WASTE MANAGEMENT IN NIGERIA

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ABSTRACT

Inappropriate disposal of these untreated trashes can be injurious to humans and the environment. Air pollution, underground water contamination, land degradation, soil contamination and habitat deterioration can be caused by inappropriate waste disposal. The poor state of the management of solid wastes is accompanied by poor implementation of policies and lack of proper sensitization of the public which worsens the situation, resulting in pollution of urban surface and ground water resources. The review shows that municipal solid waste is made up of residential or household waste; commercial wastes/ institutional trash and municipal services wastes. Values for solid waste generation in two States are found to vary from 0.13 kg/capita/day in Ogbomosho, Oyo State to 0.71 kg/capita/day in Ado-Ekiti, Ekiti State. Typical composition of municipal solid waste in Nigeria is found to consist of paper, metal, glass, textile, plastic, ash dust, organic content and other micro-elements. Waste reduction is presented to be the most efficient way to reduce the negative health impacts and environmental influence of a waste. It is imperative that inappropriate method of solid waste management should be addressed through effective implementation of policies and proper sensitization of the public.

Key words: solid-waste, municipal, waste-management, trash.

INTRODUCTION

The procedure of collecting, storing, treatment and disposal of solid waste in such a way that they are safe to humans, plants, animals, ecology and the environment in general is Municipal Solid Trash Administration (MSTA) (Ezerie *et al,* 2017). Waste management have progressed into material flow control which concerns cautious handling of raw materials, reduction of green gas emissions, environmental protection, job generation and revenue generation in developed nations. In disparity, waste management in developing nations is still at the formative and faces numerous confrontations. Municipal solid waste production can be affected by a number of determinants such as economic development, income level, industrialization, urbanization, human attitude and local climatic conditions (Agwu, 2012).

Inappropriate disposal of these untreated trashes can be injurious to humans and the environment. Air pollution, underground water contamination, land degradation, soil contamination and habitat deterioration can be caused by inappropriate waste disposal (Odoemene and Ofodu, 2016). Environment close to dumpsites are continually exposed to danger of infection, reduced agricultural yield, groundwater contamination, decrease in benthic communities due to toxicity and exposure to hazardous compounds (Ukpong, 2015 and Ayuba, 2013. Moreover, global warming, photochemical oxidant creation, acidification, ecotoxicity of water, eutrophication and abiotic resource depletion can be caused by random dumping of waste (Nkwachukwu *et al*, 2010)

The path of efficiently managing refuse production has necessitated the need for an effective way of waste management services. Realizing this has been an enigmatic task for most developing economies due to the incompatibility between rapid population growth, increased waste generation and management concluding in the inability of major stakeholders: city authorities and/or private sector to succeed (Oteng-Ababio, 2012). The complexity in providing the required level of service matching with the increasing demand for good sanitation service is characteristically connected to institutional, technical and financial constraints at the various levels of governance: national and local levels, along with the private sector (Oteng-Ababio, 2012 and UN-habitat, 2010).

The attempt being made in Nigeria has concentrated mainly on the collection and disposal of solid trash which does not involve the total functional elements of solid trash administration. The elements embrace; generation, onsite storage/sorting recyclable and non-recyclable materials, collection, transfer and transport, disposal, processing and recovery of solid waste (Tchobanoglous *et al*, 1993). However practicing the total functional elements of solid trash control is the ideal situation to guarantee good sanitation, it remains a wish for most developing economies across the globe.

The achievement on solid waste management has been little in this respect as a result the fact that in recent past, solid trash administration services in these developing countries have continually failed to keep pace with the amount of solid waste produced in towns and cities though this major step is taken.

Regardless of the great amount of research on solid waste management in different parts of the world, amazingly, little attention has been given to the spatial dimension with regards to the distribution of solid trash collection facilities especially in cities and towns in developing countries. That can explain why residents take up environmentally unfriendly exercises: dumping of wastes onto the streets, public areas, lowlands and into rivers or directly into the sea which can have disastrous public health consequences. This does not only bring about environmental problems but also cause economic burden and heads to loss of valuable materials (Fobil *et al*,

2010), (Fobil *et al*, 2010), (Songsore *et al*, 2005), (Alam *et al*, 2008). The problem is sometimes assigned to the absence of thorough collection of solid trash from roadsides and dustbins which cause severe contamination in the environment (Mayer, 1992).

Statement of the Problem

The poor state of the management of solid wastes is accompanied by poor implementation of policies and lack of proper sensitization of the public which worsens the situation, resulting in pollution of urban surface and ground water resources. Considerable percentage of this solid wastes produced are deposited on the road, in the gutters close to surface water and in unapproved dumpsites which adversely affects plants, animals, humans as well as the environment. It is imperative that this inappropriate method of solid waste management should be addressed through effective implementation of policies and proper sensitization of the public.

Municipal Solid Waste (MSW)

Any material that is unusable and does not stand for any economic value to its owner, the owner being the trash generator is defined as waste (Maria *et al,* 2011). According to the physical state of trash, trashes are classified into solid, liquid and gaseous. Solid trashes are categorized into municipal wastes, hazardous wastes, medical wastes and radioactive wastes. Administrating solid trash generally entails planning, financing, construction, operation, planning and financing of facilities for the collection, transportation, recycling and final disposition of the trash (Maria *et al*, 2011). Table-1 shows the different sources from which solid waste is generated.

Table-1. Types and Sources of Municipal Solid Waste (United Nations Environment Programme).

Sources	Typical trash generators	Constituent of solid waste
Domestic	Multifamily and single dwellings	Food trash, paper, cardboard, plastics, textiles, glass, metals, ashes, special trash (bulky items, consumer electronics, batteries, oil, tires) and domestic hazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government centre, hospitals, prisons	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Community services	Street cleaning, landscaping, parks, beaches, leisure areas	Street cleaning, landscaping, general wastes from parks, beaches and leisure areas

Any trash created by domestic, commercial and/or institutional activities and is not hazardous is defined as municipal solid waste (Maria *et al*, 2011). According to the source, Municipal solid trash is classified into three categories: Residential or household waste which results from domestic areas from individual homes; commercial wastes and/or institutional trash which results from individually bigger sources of Municipal solid trash like hotels, office buildings, schools, etc.; municipal services wastes which results from area sources like streets, parks, etc. MSW usually comprises food trash, paper, cardboard, plastics, textiles, glass, metals, wood, street sweepings, landscape and tree trimmings, general trash from parks, beaches, and other recreational areas (Maria et al,2011). Sometimes other domestic trash like batteries and consumer electronics also get mixed up with community solid waste.

Solid Waste Management (SWM)

The objectives of Community Solid Trash Management are:

- To support the proficiency and productivity of the economy
- To safeguard environmental health
- To produce employment and income
- To advance the quality of urban environment

Per Capita community Solid Trash (CST) Generation

Solid waste generation cover all the activities involved in the generation of unwanted solid materials following-on from human and animal activities. The per capita trash production rate is strongly compared to the gross domestic product (GDP) of a nation. Per capita trash generation is the amount of trash generated by one person in one day in a country. The waste production rate generally rises with rise in GDP. High income nations produce more trash per person compared to low income countries (Ranjith, 2012).

Waste Handling, Separation, Processing and Storage at the Source

This entails handling and separation until they are positioned in storage containers for collection. Storage of waste onsite is usually the duty of home owners, tenants or business owners. (Ogwueleka, 2009).

Collection

Collection operation entails removing wastes from production districts and transporting to processing facilities, transfer station and disposal sites.

Separation, Processing and Transformation of Solid Waste

Separation and processing embrace removal of bulky items, separation of waste constituents by size utilizing screens, manual separation of trash by shredding, separation of ferrous metals using magnet, volume reduction by compaction and combustion. The separation of waste is one of the best ways to attain the recovery/ reuse of materials.

Transfer and Transport

Transfer and transport entails the removal of wastes from the smaller collection vehicles to the larger vehicle. Thus it must be large enough to reduce the number of trips to the processing site and yet small enough to be enable ease of movement during collection and haul over long distances. Haul operation entails total normal trip time from generation sources to disposal.

Disposal of Solid Wastes

The techniques of solid trash disposal consist open dumping, open burning, composting, incineration and sanitary land filling. Table-2 shows MSW components: Compostables, recyclables, Inerts and their makeup.

Table-2. Components and Waste Materials in MSW; Source (Ranjith, 2012).

MSW components	Materials
Compostables	Food waste, landscape and tree trimmings
Recyclables	Paper, Cardboard, Plastics, Glass, Metals
Inerts	Stones and silt, bones, and other inorganic materials

Solid Waste Generation

Solid waste production rate was discovered to vary from 0.13 kg/capita/day in Ogbomosho to 0.71 kg/capita/day in Ado-Ekiti. Determinants affecting solid trash production rates were identified. Typically, food trash was discovered to make up close to 50 percent of total community solid waste in Nigerian towns. This investigation reveals that the pace of production of plastics, water proof materials and diapers has taken up an ascendant direction.

Due to the defective state of many municipal waste management authorities, many cities have been overwhelmed by open dumps. For example, more than 50 percent of inhabitants of Maiduguri in northern Nigeria and Ughelli in southern Nigeria dispose of their trash in open dumps. Careless disposal of trash has also brought about the prevalence of deadly heavy metals in agricultural soils and the resulting bioaccumulation in plants in addition to groundwater pollution. The main setback of this investigation is that municipal waste management authorities do not have relevant data.

Efficient waste management is expensive, often making up 20%-50% of municipal budgets. Operating this important municipal service requires integrated systems that are effective, workable, and socially supported.

(Ramachandra *et al*, 2018) Studied community solid waste: Production, constituents and GHG emissions in Bangalore, India. Municipal solid trash in developing nations mainly comprise of degradable materials (>70%), which plays a significant role in GHG (Greenhouse gas) emissions in urban localities. The growing municipal solid waste production among the high fraction of organic trash and its crude disposal is resulting in emission of GHG (methane, CO_2, etc.) in the atmosphere.

The investigation showed that the per capita trash produced is about 91.01± 45.5 g/day with the per capita organic trash production of 74±35 g/person/day. The domestic per capita trash production was negatively related with family (household) size while positively related with income and education levels. Integrated solid trash management plan is suggested to manage the organic fractions through technology and policy interventions, which helps in allaying GHG emissions with potential economic gains.

Victor and Dacio (2017) investigated the effect of socioeconomic factors on community solid trash production in São Paulo, Brazil. They stated Social factors have not been sufficiently researched in community solid waste management examination. Latin America has generated even fewer studies with this method; technical and economic inquiries have succeeded. They researched the effects of socioeconomic factors on community solid waste production in Greater Sao Paulo, which includes 39 municipalities.

They studied the link between municipal solid waste production and social factors by Pearson's correlation coefficient. The Student's *t*-test (at $p \leftarrow 0.01$) proved significance, and further regression analysis was carried out with important factors. We considered 10 socioeconomic determinants: income per capita, inequality and human development. Population, rural population, density, life expectancy, education (secondary, high and undergraduate level), A later multicollinearity analysis produced in the determination of inequality ($r_p = 0.625$) and income per capita ($r_p = 0.607$) as key drivers. The outcome illustrated the importance of considering social aspects in community solid waste management and isolated inequality as an important factor in planning.

Sources of Solid Trash Production

Various Sources of Solid Trash

The homes, offices, industries and various other agricultural activities generate this waste. These wastes generated, when not properly treated and stored, causes foul smell to ooze out from these land fill sites. It can adulterate the surrounding air and can seriously influence

the health of humans, wildlife and our environment. The following are key sources of solid trash:

Residential

Some of the key sources of solid trash are the domestic and homes where people live. Refuse from these places comprises paper, glass, leather, cardboard, metals, yard wastes, food wastes, plastics, ashes and exceptional wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil. Garbage bins are located in most homes where they can throw away their solid trash and later the bin is emptied by a trash collecting firm or person for treatment.

Industrial

Industries are acknowledged to be one of the biggest producers of solid waste. They comprise fabrication plants, canning plants, power and chemical plants light heavy manufacturing industries and construction sites. Housekeeping trash, food trash, packaging wastes, ashes, construction and demolition materials, special trash, medical wastes as well as other hazardous trash are produced by these industries.

Commercial

Another source of solid trash today is commercial facilities and buildings. Commercial edifice and facilities in this case denote Hotels, markets, restaurants, go downs, stores and office buildings are the commercial building and facilities in these case. Some of the solid trash generated from these places includes Plastics, paper, glass; wood, cardboard materials, food wastes, metals, special wastes and other hazardous trash are some of the solid waste generated from these places.

Institutional

Colleges, prisons, Schools, military barracks and other government centres are some of the institutional centres that also produce solid trash. Some of the common solid trash gotten from these places include Glass, food wastes, wood, paper, metals, cardboard materials, rubber waste, plastics, electronics as well as various hazardous wastes are some of the common solid waste gotten from these places.

Construction and Demolition Areas

Solid waste problem are also contributed by construction and demolition sites. New construction sites for edifice and roads, road repair sites, edifice repair sites and building destruction sites are all construction sites. Steel materials, wood, plastics, rubber, copper wires, concrete; dirt and glass are some of the solid waste produced in these places.

Municipal services

Solid waste crisis are greatly contributed by urban centres. Trash from parks and beaches, wastewater treatment plants, street cleaning, landscaping trash and trash from recreational areas including sludge are some of the solid trash produced by municipal services.

Generation of solid waste by weight is presented in Table-3 for low, middle and high income areas:

Table-3. Typical distribution of components in residential MSW for low, Middle and Upper Income Areas excluding recycled materials (Ogwueleka, 2009).

Component	Low-income Areas(tons)	Middle-income Areas(tons)	Upper-income Area(tons)
Organic			
Food wastes	40-85	20-65	6-30
Paper	-	-	20-45
Cardboard	1-10	8-30	5-15
Plastics	1-5	2-6	2-8
Textiles	1-5	2-10	2-6
Rubber	-	-	0-2
Leather	1-5	1-4	0-2
Yard waste	-	-	10-20
Wood	1-5	1-10	1-4
Miscellaneous Organics	-	-	-
Inorganic	-	-	-
Glass	1-10	1-10	4-12
Tin cans	-	-	2-8
Aluminium	1-5	1-5	0-1
Other Metal	-	-	1-4
Dirt, ash etc	1-40	1-30	0-10

Table-4 shows the composition of municipal solid wastes of different kinds generated in selected States in Nigeria. (% by weight).

Table-4. Typical Composition of municipal solid waste in selected States in Nigeria (% by weight) [Ogwueleka, 2009).

City	Paper	Metal	Glass	Textile	Plastic*	Ash & dust	Organic	Others**
Kano	17	5	2	7	4	-	43	22
Nsukka	13.5	7.0	2.3	3.0	8.6	-	55.8	9.8
Ibadan	6.6	2.5	0.6	1.4	4.0	-	76	8.9
Maiduguri	7.5	9.1	4.3	3.9	18.1	21.5	25.8	9.8

The Table-5 depicts the composition information of domestic waste for different districts in Abuja. The table shows food and plastics as the type of domestic waste with the highest composition, with food having the highest value followed by plastics. The total values of the solid wastes added up shows that Apo district have the highest amount with a value of 105 (%) by weight and Garki having the lowest value with a value of 88 (%) by weight. The Table also shows high income districts of Maitama and Asokoro among the districts generating high amount of wastes.

Table-5. Domestic waste composition data for different districts in Abuja [Ogwueleka, 2009).

Waste Type (%)	District name and characteristics					
	Garki	Wuse	Maitama	Asokoro	Gwarinpa	Apo
Paper	1.3	12	13	13.6	6.9	10.1
Metal	5.6	3.3	5.3	6.7	5.4	4.9
Glass	5.5	4.4	5.32	4.1	4.1	
Plastic	16.2	17.3	20	15.1	21.3	18.7
Food	52	54.3	54.8	53	61.2	65.3
Textile	2.2	4.7	0.1	3.1		
Rubber	3.4	1.5	0.19	0.7		0.9
Other[a]	13.8	2.5	1.29	3.7	1.1	0.1
Total	100	100	100	100	100	100

Processing, Waste Handling and Storage at the Source

Processing is organized to improve disposal options, recover precious resources, and set up different processing choices for the system's effect on the local and universal environment, dependability, safety to workers and the local community, simplicity of operation, efficiency, economics and aesthetics (noise, odours, litter increased traffic) (Ogwueleka, 2009).

Solid waste processing is done to attain the following:

- Volume reduction (baling, shredding, incineration)
- Size reduction (shredding, grinding)
- Component separation (screening, magnetic separation, hand sorting, air classification for lighter materials such as paper and plastic)
- Resource recovery (composting, energy recovery, material recovery)

A number of processing technologies have been developed for solid trash management and one of the responsibilities of the engineer is to decide on and design the most maintainable and cost effective for a given community. At the point of production for storage of trash until they are collected it is necessary to provide facilities.

Separation and Processing and Transformation of Solid Waste

Recycle, Reduce and Reuse

The primary aim of all community solid trash management programs is to lessening the quantity of wastes that must be hauled and disposed. In situations where a product has usefulness in more than one purpose this is what brings about reuse of waste materials. For example, waste tyres for cars can be utilized to mount the foundation where metallic housing containers are placed. Paper and cardboard, glass, metals, and aluminium cans are recovered as much as possible by material recovery facilities (Ogwueleka, 2009).

Recycling is a chain of activities where in discarded materials are collected, sorted, processed and changed into basic products, which can be used to generated new materials. Resource recovery from the

waste stream is important because it cuts down on the cost of hauling and disposing waste. Informal private sector workers (scavengers) in developing countries usually carry out recovery of materials, while the recovery and reuse of materials is generally for individual use. Street hawkers, scavengers, middle dealers, main dealers, recyclers, selling agents, brokers, shop keepers etc are among the many directly or indirectly engaged in the recycling of solid trash. They are badly threatened by diseases organisms, sharp objects. Recycling in developed and many undeveloped countries is generating substantial economic gains for the communities. The 3Rs approach- Recycle, Reduce and Reuse of wastes- is gaining acceptance.

Material Recovery

Recycling

Reducing and reusing are the most effective ways to avoid production of wastes. Once the wastes are generated and collected, the best choice to control them would be recycling where the materials usually undergo a chemical modification. After collection sometimes reusing can also happen, in situation where informal traders collect products of no longer needed from residents, reshape or renovate them and sell in second-hand markets. Unlike reutilizing a used material, recycling demands using the trash as natural resource to make new items unlike reusing a utilized material (The Open University UK, 2017).

Recycling thus make up for the use of virgin raw materials. It is known that as much as 95% of a product's environmental impact occurs before its discarded, most of it during its manufacturing and mining of virgin raw materials. Thus, recycling is decisive in lessening the complete life cycle effect of a material on environment and public health. Recycling however needs a single stream of waste, whether source separated or separated later on (after collection). It becomes hard to separate them once the wastes are mingled.

Recyclables can still be set apart manually to some extent. Such separation and sale of recyclables from mixed wastes generates livelihood to the less privileged urban populations in low and middle-income countries. Machines are used in the high income countries to do the same but they would need the recyclables to be collected as a single dry stream without mingling with organic food wastes.

The segregated stocks of paper, plastic, metal and glass can then be recycled. A complete separation of these materials from MSW is highly energy and time intensive and is usually not carried out. Therefore, mixing of trash will always end in a division of residues, which can cannot be recycled and which cannot be composted, and needs to be combusted in RDF (Refuse Derived Fuel) plants to avoid land filling, and generate energy.

Recycling waste means that the material is reprocessed before being utilized to make new products. The reprocessing activities can have an influence on people's health and the environment, but these influences are usually lower than those from making the product from new, raw materials. Waste Recycling means treating the materials as precious resources rather than as waste. It has many gains but it is important to have a market for the end product, otherwise the process will not be economically sustainable (Moral *et al*, 2009).

The alternatives for recycling depend on the type of waste. For instance, waste paper can be broken down to its fibres in a process called pulping. The pulp is cleaned and then shaped into new paper to be used for printing or packaging. Waste metals and glass can also be recycled by melting them down into new raw materials. Sheet metals can be beaten and reformed into new products. Plastic bottles can be ground down and utilized to make plastic rope or plastic coating for electric wires.

For some wastes, recycling entails complex technical processes and needs specialised machinery, but others can be recycled more simply and on a small scale. All types of organic waste can be recycled by composting, which can be carried out at home or on a larger scale.

Waste Reduction

The Open University UK, (2017) at the top of the pecking order is waste reduction. The most efficient way to reduce the health impacts and environmental influence of a waste is not to create trash in the first place and so trash reduction is the best option. Making any new product materials and energy is needed in making any new product. Raw materials have to be mined from the Earth and processed, and the product must be produced, packaged and hauled to wherever it will be sold. Each of these phases may generate solid waste as well as liquid wastes and air contaminants.

If we can discover approaches of making a particular item whilst producing less trash in the process, this is one of the most efficient ways to reduce contamination, save natural resources, protect the environment and save money. Industry has a major part to play in waste reduction. If more effective manufacturing processes were taken up, greater measure of products could be made without increasing the use of raw materials. Industry can also work to merge less material into its products - so for instance, an item could be packaged using less cardboard than before (The Open University UK, 2017).

There are many viable methods of lessening the quantity of waste created at home that could be suggested to householders. These include teaching and inspiring them to:

- Purchasing products that use less packaging. Purchasing in bulk, for instance, can lessen packaging and save money. Where households cannot come up with large sums of money up front, it may be possible for neighbours to club together and purchase a large quantity of a basic foodstuff between them.

- Rather than disposable items make use of reusable. For instance, utilize refillable containers where possible; washable instead of disposable nappies;

cotton handkerchiefs instead of paper tissues; rechargeable batteries and refillable ink pens.

- Utilize their own shopping bags, preferably produced from cloth or other recycled material instead of plastic bags.
- Lessen food scraps or feed these scraps to animals, if it is okay.
- Items such as clothing for them to last longer, they must be repaired and maintained.

Benefits of reducing and reusing solid waste

Waste is becoming a greater difficulty in municipal areas every year. Residents are creating more trash, so disposal locations are filling up and new spots are further away from household areas. This is becoming more costly where trash is collected and transported to a disposal site. Where householders have to discard of waste themselves, they have to spend more time doing this. Anything that lessens the quantity of waste that has to be discarded of helps to lessen these problems. Some other merits of trash reduction and reutilization are summarised below (The Open University UK, 20170.

Municipal benefits

Reutilization can be very beneficial for less privileged people who cannot meet up with money to purchase new goods. These could entail clothing, building materials, and business equipment. Reuse centres that collect and distribute reusable goods can also provide community gains by engaging in job-training programmes and general training for the long-term unemployed, disabled people and young people.

Economic benefits

Rather than creating new products from raw materials by reusing materials, there is less liability on the economy as a whole - especially if reuse ends in a reduction in raw material and product imports. Reuse is an economical path for many people to get the items they need. It is almost always less expensive to buy a used item than a new one.

Environmental benefits

Reutilizing something utilizes little or no water, energy or other resources and is undoubtedly to result in contamination. As well as these profits, reuse eradicates the environmental destruction that would have been caused if the item had been disposed of, instead of been reused. In comparison, manufacturing an item from raw materials (and, to a lesser degree, recycling) consumes resources, causes pollution and generates wastes.

Methods of Solid Waste Disposal

Incineration

Ezerie *et al*, (2017) showed that incineration is a largely utilized trash management technology. The working of incineration relies on the combustion of trash at high temperatures. Incineration has the ability to (Uwadiegu and Iyi, 2014):

a) Lessen total organic matter content

b) Terminate organic pathogens or pollutants

c) Significantly lessen trash volume

d) Sustain raw materials and resources

Nevertheless, Incineration does not eradicate trash but lessen and transform it into new forms which also require disposal in landfills (Nwachukwu *et al,* 2010). There are huge worry about incinerators toxicity, disposal of produced ash due to aesthetic concerns such as foul odors, noxious gases and gritty smoke. Additionally air quality deterioration and potential leaching of heavy metals from fly ash are serious issues about incineration (Narayana, 2009). In developing countries where trash composition is mostly organic, incinerators need the supply of excess fuel for trash combustion due to high moisture content of solid trash (Ogwueleka, 2009, Zhang *et al*, 2004). According to Foo Tuan Seik, (Seik, 1997), trash administration by incineration is forecasted to cost about 7 times more than land filling. Recycling of community solid waste is largely practiced in developed countries. Thus, it is largely appropriate that incineration may not be suitable for developing countries.

Composting

Composting is a microbial technology infrequently utilized to stabilize different kinds of trash. Composting has the ability reduce trash volume by 40-50%, metabolically eradicate pathogens in the thermophilic phase and generate an end product appropriate for soil improvement (Singh *et al,* 2010). As a natural aerobic biochemical procedure in which thermophilic microorganisms break down organic materials into a stable soil like product, composting eradicates payment of tipping expense at landfills and pathogens present in the trash do not survive the thermophilic temperature (40-70°C) while composting (Schaub and Leonard, 1996). Composting can be done utilizing several methods such as open aerated systems and contained systems. The gains of composting biogenic trash include (Kato *et al*, 2005):

a) Substitute of synthetic fertilizers

b) Lessen greenhouse gas emissions

The most important confrontation to composting of community solid trash is sorting/separation of trash. Cities must build an approach to separate the organic trash in order to generate good compost. Utilization of unstable and immature compost to agricultural soil can bring about nitrogen starvation to plants (Kato *et al*, 2005), phytotoxic impacts as a result of the release of ammonia and other substances like phenolic compounds and low molecular weight organic acids (Bernal *et al*, 2009), and the existence of pathogens (Fang *et al,* 1999). To make sure the safety of compost in agricultural utilization, the maturity and stability have been utilized to define compost quality (Moral *et al*, 2009). Therefore, composting of MSW may be feasible for developing countries.

Solid Waste Disposal by Sanitary Landfill

The term "sanitary landfill" is too regularly used to denote a solid waste operation that is little better than an open dump. Truly, sanitary landfill means a system where an acceptable, trouble-free solid waste disposal operation is being operated out in compliance with acknowledged standard procedures. The working of a sanitary landfill needs skill and knowledge. It is a systematic method and should be treated as such (John, 1973).

Engineering and organization is needed to handle a satisfactory sanitary landfill. Sanitary Landfill: A technique of disposing of solid trash on land without causing nuisances or dangers to public health or safety, by employing the principles of engineering to restrict the solid trash to the least practical area, to lessen it to the least practical volume, and to conceal it with a layer of earth at the termination of each day's operation or at more regular intervals as may be required. The following sections present the important considerations in acquiring and operating a sanitary landfill (John, 1973).

Site Selection for Sanitary Landfill

Choosing of a sanitary landfill site depends upon examination of the site itself and upon community assent of the site for solid waste disposal aim. Ordinarily, choosing of a site starts with an investigation for conveniently find waste land or low-value land. Solid waste disposal locations in the state now comprises ravines, borrow pits, areas adjacent to water courses, and low-lying swampy land. Merits are relative simplicity of acquirement and isolation from built-up locations. Truly, it is achievable to utilize practically any site for a sanitary landfill, notwithstanding sub marginal, rather than possibly valuable land, would ordinarily be chosen (John, 1973).

Land costs, in addition, are not necessarily the controlling factor. The low first costs of waste land may be compensated by developmental costs in making the disposal site appropriate for landfill operation and in purchasing necessary cover material from another location. Long haul to a sanitary landfill may, upon analysis, prove cheaper than short transport to a costly disposal facility. More than one location may be required for the cost effective operation for large cities. Countries may operate sanitary landfills at sites that can be utilized by several communities.

Open Dumping

There is no precise description for unsanitary land filling. However, it is generally depicted by open dumping of wastes, shortage of monitoring of the site, stray animals and birds feeding on the wastes, deficiency of leachate or methane collection systems and trash exposed to natural elements (Ogwueleka, 2009). The direct consequence of unsanitary land filling include burying materials which were dug out by energy and infrastructure intensive and in most situations environmentally damaging technique and in turn depleting earth's natural resources.

From an energy recovery perspective, unsanitary land filling is comparable to burying barrels of oil. Aside from these moral consequences, land filling brings about extensive public health and environmental deterioration. Landfills generate unsanitary situations in the surroundings, attract pests and directly affect human health. Unsanitary landfills also deteriorate ground and surface water supply when the leachate created percolates to the water table or is eroded as runoff during rains.

(Ogwueleka, 2009) showed that unplanned landfills catch fires as a result of methane production and heat and result in uncontrolled burning of trash, emitting harmful gases like carbon monoxide, hydrocarbons and particulate matter into low level atmosphere. In addition to these harmful effects, unsanitary landfills aids to Climate Change by releasing methane, a greenhouse gas (GHG) with 21times more global warming potential than carbon dioxide (in the first year of release, methane is 71 times more strongerthan carbon dioxide as a GHG).

Impact of Improper Solid Waste Management

Inappropriate solid waste management debilitate public health, damage quality of life, and pollutes local air, water and land resources. It also brings about climate and global and impacts the entire planet. Inappropriate waste management is also seen as the source of 22 human diseases and results in numerous premature deaths every year (Ranjith, 2012).

a) Improper solid waste management caused as a result of:

a. Air Pollution,
b. Water Pollution and
c. Soil Pollution

b) MSW blocks drains, creating

a. standing water for insect reproduction and
b. Inundation during rainy seasons

c) Greenhouse gases are created from the breakdown of organic wastes in landfills.

d) Insects and rodents spread diseases such as cholera and dengue fever and they are attracted waste.

e) Some Health Problems related to inappropriate solid waste management are:

a. Nose & throat infections Lung infection,
b. Breathing problems,
c. Infection, Inflammation,
d. High PM10 exposure,
e. High pollution load,
f. Bacterial infections,
g. Barrier in airways,
h. Elevated mucus production and
i. Covert lung hemorrhage,
j. Chromosome break,
k. Anemia,
l. Cardiovascular risk,
m. Altered immunity,
n. Allergy, asthma and

Inappropriate dumping of trash and leachate from landfills pollutes surface and groundwater reserve and the surrounding land resources. It also blocks sewers and drains and leads to floods.

Water Pollution (Leachate)

Leachate is created when unsanitary landfills pollute surface and ground water resources, permeates through the soil strata into the groundwater underneath or is eroded as runoff during rains. Leachate is usually a strong powerful liquid created under methanogenic (anaerobic) conditions. The attributes of leachate depend on the content of different components in the dumped waste (Ranjith, 2012).

"Biswas A.K researches on Environmental Quality in and around Municipal Solid Waste Dumpsite "in Kolkata, discovered that moderately high concentrations of heavy metal in groundwater surround the dumpsite. The research discovered that the groundwater quality has been substantially impacted by leachate permeation. Leachate usually contains organic chemicals created by anaerobic breakdown of organic wastes and heavy metals seeped from inorganic trash. The heavy metals usually observed in leach are Lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni). During permeate through soil strata due to the reducing attribute of leachate, it reacts with Iron (Fe) and Manganese (Mn) species underground and lessens them into more soluble species, thus enlarging their concentrations in groundwater (Ranjith, 2012).

Such reactions when they occur, causes a severe drinking water toxic risk. These forecasts are confirmed by researches which discovered high concentrations of Cr, Cd and Mn in groundwater due to leachate percolation. Nitrates present in the environment can also be lessened to nitrites due to leachate. Nitrites taken through drinking water can oxidize haemoglobin (Hb) in the blood to methaemoglobin (met Hb), thereby restricting the transportation of oxygen about the body (Oloruntande *et al,* 2013). The research clearly ascertained that unsanitary landfills in India and elsewhere are viable sources of heavy metals pollution in groundwater sources adjoining the landfills. It also states that there is an earnest need to take up credible solutions to control water contamination due to inappropriate dumping of wastes.

Institutions for Waste Management in Nigeria

- National Environmental Standards and Regulations Enforcement Agency
- Federal Ministry of Environment (FMOE)
- States Ministries of Environment
- Ministry of Water Resources
- National Oil Spill Detection and Response Agency (NOSDRA)
- State Environmental Protection Agencies (SEPAs)
- Waste Management Society of Nigeria (Beatrice and Jussi, 2013)

The Roles of Regulatory Bodies in Solid Waste Management in Nigeria Abuja Environmental Protection Board (AEPB):

This is liable for solid trash control in Abuja. It has duty to (Abuja Environmental Board):

- Remove, haul and discard of domestic, commercial and industrial waste.
- Clear and sustain public drainage facilities, street cleaning and clearing of abandoned vehicles.
- Enlist private waste collection companies.
- Prepare and periodically revise the master plan of waste collection and discarding in the city.
- Endorse and observe all disposal systems in the city.
- Evaluate recycling as a waste management alternative for industries and government agencies

Institute and propose the essential standard necessities for solid, liquid, gaseous or toxic waste management provided they do not disagree, but balance, the standards of the FEPA.

- Institute and suggest acceptable safe techniques of collection and discarding of hazardous and toxic waste products in the FCT.

- Coordinate and rally the public to partake keenly in habitual clean-up exercises and beautification of their environment

National Environmental Standards Regulatory and Enforcement Agency (NESREA)

NESREA is entrusted with the liability of implementing all guidelines, policies, standards environmental laws, and regulations in Nigeria. It also has the liability to implementing observance with provisions of protocols, conventions, international agreements and treaties on the environment (National Environmental Standards and Regulation Enforcement Agency).

The dream of the Agency is to make certain a healthier environment and cleaner for all Nigerians, while the assignment is to motivate personal and collective responsibility in building an environmentally aware society for the realization of sustainable development in Nigeria.

The Agency shall

- Implement observance with laws, guidelines, policies and standards on environmental matters;
- Organize and act as a go-between with stakeholders, within and outside Nigeria, on issues of environmental standards, regulations and enforcement; impose observance with the provisions of protocols, conventions international agreements, and treaties on the environment, including conservation, desertification, forestry, oil and gas, chemicals, hazardous wastes, climate change, biodiversity, ozone depletion, marine and wild life, pollution, sanitation and such other environmental agreements as may from time to time come into force;
- Implement observance with policies, standards, legislation and guidelines on water quality, environmental health and sanitation, including pollution abatement;
- put into effect observance with guidelines and legislations on viable managing of the ecosystem, biodiversity conservation and the building of Nigeria's natural resources;
- Put into effect observance with any legislation on healthy chemical management, safe utilization of pesticides and discarding of spent packages thereof;

REGULATIONS ON SOLID WASTE

National Laws and Regulations

Public Health Law of Nigeria 1963

The public health law provides regulations that direct human activities together with civil works to make certain that the health of individuals and public in common are protected and the environment is secured (Nestoil PLC, Environmental Impact Assessment (EIA) operation base draft).

Harmful Waste Act No. 42, 1988

Activities linking to the purchase, sale, importation, transit, transportation, deposit and storage of harmful wastes are forbidden and affirmed unlawful under this act. From the origination of this Act, any person who without lawful authorization (Nestoil PLC, Environmental Impact Assessment (EIA) operation base draft):

- Is in ownership for the intention of carrying, Carries, deposits, dumps or makes it possible to be carried, deposited or dumped, or discarding in regional waters or adjoining zone or solely Economic zone of Nigeria or its inland waterways, or
- Causes to be hauled or dumping any harmful trash on any land, hauls or is in possession for the intention of hauling any harmful waste, or
- Bargain for the intention of importing any harmful waste, shall be guilty of a crime under this act.

National Environmental Protection (Management of Solid and Hazardous Wastes Regulations) (S1.15), 1991

This regulation provides that the purpose of solid and hazardous waste management shall be to:

- Recognize solid, toxic and tremendously hazardous wastes unsafe to environment and public health
- Provide for observation and monitoring of unsafe and exceptionally hazardous wastes and substances until they are detoxified and carefully disposed.
- Institute and provide appropriate essential requirements to help the disposal of hazardous wastes

Water Resources Act, 1993

The Water Resources Act confers in the Federal Government of Nigeria the right to control the utilization of groundwater and surface water in the nation. Pursuant to this Act, the Minister of Water Resources may forbid or control the partaking in any activity on land or water that may get in the way with the quantity or quality of any water in any water course or groundwater (Nestoil PLC, Environmental Impact Assessment (EIA) operation base draft).

The Act permits anyone to obtain the right that is a license from the Minister, to use or take water from any watercourse or any groundwater for any intention in agreement with the Act and any regulations pursuant thereto.

National Environmental Standards and Regulations Enforcement Agency (NESREA) Act 2007

(Nestoil PLC, Environmental Impact Assessment (EIA) operation base draft) After repeating of the Federal Environmental Protection Act of 1988, the NESREA Acct, 2007 became the main statutory regulation or instrument protecting environmental matters in Nigeria. It specifically makes condition for solid trash control and its management and prescribes approve for offences or acts which run opposing to appropriate and adequate waste disposal measures and practices.

CONCLUSIONS

a) The review shows that waste is any material that is unusable and does not have any economic value to its owner, where the owner is the one that generates the waste.
b) Municipal solid trash is classified into three categories: Residential or household waste; commercial wastes/ institutional trash and municipal services wastes.
c) Values for solid waste generation in two States are found to vary from 0.13 kg/capita/day in Ogbomosho, Oyo State to 0.71 kg/capita/day in Ado-Ekiti, Ekiti State.
d) Typical composition of municipal solid waste in Nigeria is found to consist of paper, metal, glass, textile, plastic, ash dust, organic content and other micro-elements.
e) Composition of domestic waste for different districts in Abuja shows that waste from food and plastics are the most common domestic waste found in the composition of the solids waste, with waste from food having the highest value followed by plastics.
f) Waste reduction is found to be the most efficient way to reduce the negative health impacts and environmental influence of a waste.
g) Reutilization of waste is beneficial for people that cannot afford to purchase new goods which include clothing, building materials, and business equipment.
h) Nigeria has regulatory bodies that work on actualizing effect solid waste management governed by national laws and regulations.

REFERENCES

Abila Beatrice and Kantola Jussi. 2013. Municipal Solid Waste Management Problems in Nigeria: Evolving Knowledge Management Solution. World Academy of Science, Engineering and Technology. International Journal of Environmental and Ecological Engineering. 7(6): 1-6.

Abuja Environmental Protection Board (AEPB), retrieved from www.aepb.gov.ng

Agwu M. O. 2012. Issues and challenges of solid waste management practices in Port-Harcourt City, Nigeria - A behavioural perspective. American journal of social and management sciences. 3: 83-92.

Alam R., Chowdhury M.A.I., Hasan G.M.J., Karanjit B. and Shrestha L.R. 2008. Generation, Storage, Collection and Transportation of Municipal Solid Waste - A case study in the city of Kathmandu, Capital of Nepal. Waste Management Science Direct Elsevier Journal. 28: 1088-1097.

Ayuba K.A, Manaf, L.A., Sabrina A.H., Azmin S.W.N. 2013. Current status of municipal solid waste management practise in FCT Abuja. Resource Journal of Environmental Earth Science. 5: 295-304.

Bernal M.P., Alburquerque J., Moral R. 2009. Composting of animal manures and chemical criteria for compost maturity assessment, A review. Bioresour Technol. 100: 5444-5453.

Division of Technology, Industry and Economics. State of Wase Management in South East Asia, Types of Wastes - Sources and Composition. United Nations Environment Programme. [Online]. p. 183.

Ezerie H. E., Chima G. N., Ogbonna C.E, Chibunna C. E. 2017. Municipal solid in Aba, Nigeria: Challenges and prospects. Environmental Engineering Research Journal. 22(3): 231-236.

Ezerie H.E, Chima G.N, Ogbonna C.E, Chibunna C.E. 2017. Municipal solid waste management in Aba, Nigeria: Challenges and prospects. Environmental Engineering Research Journal. 22(3): 231-236.

Fang M., Wong J., Ma K., Wong M. 1999. Composting of sewage sludge and coal fly ash: Nutrient transformations. Bioresour Technol. 67: 19-24.

Fobil J., O. Kolawole O. and Hogarh J. 2010. Waste Management Financing in Ghana and Nigeria - How can the concept of polluter-pay-principles work in both countries. International Journal of Academic Research. 2: 3.

John Bell M. 1973. Sanitary Landfill Method of Solid Waste Disposal. Purdue Road School Associate Professor School of Civil Engineering Purdue University, Purdue University Indiana United States. pp. 1-20.

Kato K., Miura N., Tabuchi H., I. Nioh I. 2005. Evaluation of maturity of poultry manure compost by phospholipid fatty acids analysis. Biol. Fertil. Soils. 41: 399-410.

Maria G., Velasco P.A, Nickolas T. 2011. Generation and Disposition of Municipal Solid Waste in Mexico and Potential for Improving Waste Management in Toluca

Municipality. Waste-to-Energy Research and Technology Council (WTERT). [Online].

Mayer M. 1992. Synergetic Effects of Municipal Solid Waste Collection, Recycling and Disposal. International Reference Center for Waste Disposal (IRCWD), Duebendorf, Switzerland.

Moral R., Paredes C., Bustamante M., Marhuenda-Egea F., M. Bernal M. 2009. Utilisation of manure composts by high-value crops: Safety and environmental challenges. Bioresour Technol. 100: 5454-5460.

Narayana T. 2009. Municipal solid waste management in India: From waste disposal to recovery of resources? Waste Management Journal. 29: 1163-1166.

National Environmental Standards and Regulations Enforcement Agency (NESREA), retrieved from https://www.nesrea.gov.ng

Nestoil PLC, Environmental Impact Assessment (EIA) of Nestoil operation base Draft

Nkwachukwu O.I, Chidi N.I, Charles K.O. 2010. Issues of roadside disposal habit of municipal solid waste, environmental impacts and implementation of sound management practices in developing country Nigeria. International Journal of Environmental Science Development. 5: 409-418.

Nkwachukwu O.I, Chidi N.I., Charles K.O. 2010. Issues of roadside disposal habit of municipal solid waste, environmental impacts and implementation of sound management practices in developing country Nigeria. International Journal of Environmental Science Development. 5: 409-418.

Odoemene U. D. and Ofodu J. 2016. Solid wastes management in Aba Metropolis. International Journal Advanced Academic Research. 2: 1-7.

Ogwueleka T.C. 2009. Municipal solid waste characteristics and management in Nigeria. Journal of Environmental Health Science and Engineering. 6: 173-180.

Olorutande A.J., Adeoye P.A and Alao F. 2013. Municipal solid wastes collection and management strategies in Akure, South-Western Nigeria. Capsian Journal of Environmental Sciences. 11(1): 1.

Oteng-Ababio M. 2012. Solid waste management in African cities: Sorting the facts from the fads in Accra, Ghana. Research Gate Habitat International. 39: 96-104.

Ramachandra T.V, Bharath B.A, Gouri K., Sun S. 2018. Municipal Solid Waste: Generation, Composition and GHG emissions in Bangalore, India. 82: 1122-1136.

Ranjith K. A. 2012. Sustainable Solid Waste Management Submitted in Partial Fulfilment of the requirement for the degree of Masters of Science in Earth and Environmental Engineering Foundation School of Engineering and Applied Science Columbia University in the City of New York.

Schaub S. and Leonard J. 1996. Composting: An alternative waste management option for food processing industries. Trends Food Sci Technol. 7: 263-268.

Seik F.T. 1997. Recycling of domestic waste: Early experiences in Singapore. Habitat Int. 21: 277-289.

Singh R., Ibrahim M.H., Esa N., Iliyana M. 2010. Composting of waste from palm oil mill: A sustainable waste management practice. Rev Environ Sci Bio/Technol. 9: 331-344.

Songsore J., Nabila J.S, Yangyuoru Y., E. Amuah E., Bosque H.E.K, Etsibah K.K., Jan E.G. and Jacks G. 2005. State of the Environmental Health Report of the Greater Accra Metropolitan Area (GAMA). Ghana University Press, Accra.

Tchobanoglous G., Theisen H. and Vigil S. 1993. Integrated Solid Waste Management. McGraw-Hill, Inc., NewYork, open access Journal.

The Open University, UK/ World Vision Ethiopia, UNICEF Open, Learn and Create. 2017. Urban sanitation and solid waste management, Summary of study session 8, the Waste hierarchy and the 3Rs, Waste Reduction, Waste Reuse Solid waste reduce, reuse and recycling, Benefit of Reducing and Reusing.

Ukpong E.C.U, Udo E.A. and Umoh I.C. 2015 Characterization of materials from Aba waste dumpsites. International Journal Eng Applied Science. 6: 1-10.

UN-habitat. 2010. Solid waste management in the world's cities. Nairobi: Un-habitat. pp. 1-228.

Uwadiegu B.O and E.A. Iyi E.A. 2014. An Evaluation of the Operational Efficiency of a Public Agency: A Case Study of Enugu State Waste Management Authority (Eswama) In Enugu City, Nigeria. British Journal of Environmental Sciences. 2(2): 27-34.

Victor and Dacio. 2017. The impact of socioeconomic factors on municipal solid waste generation in São Paulo, Brazil. Waste management and research journal. 36(1): 79-85.

Zhang S., Herbell J.D., and Gaye-Haake B. 2004. Biodegradable organic matter in municipal solid waste incineration bottom ash. Waste Management Journal. 24: 673-679.