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POTENTIAL IMPACTS OF CLIMATE CHANGE ON SOLID WASTE MANAGEMENT IN NIGERIA

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ABSTRACT
Solid waste management processes and climate change operate at similar timescales, as such; there is a need to understand what the potential climate change impacts may be on waste management. The scope of this study was limited only to municipal and household waste. The study x- rayed the potential impacts of climate change on solid waste management through the assessment of the risk and impacts of climate change variables, to the sitting and operations of a wide range of waste management facilities in Nigeria. Definitions of solid waste, correlation between climate change and solid waste management, waste management policies, and regulations in Nigeria, as well as the status of waste management sector in Nigeria were discussed. Some strategies for reducing green house gases in municipal solid waste were product stewardship, paperless office, anaerobic digestion, use of bioreactors, co-firing, and biomass pyrolysis/gasification.

Keywords: Solid Waste Management; Climate Change; Green House Gases (GHGs); Potential Impacts

INTRODUCTION

Solid waste is any solid material which is discarded by its owner, user, or producer. Solid wastes are left-over arising from human, animal, or plant activities that are normally discarded as useless and not having any consumer value to the person abandoning them (Oyedele, 2009). In Timaru District (New Zealand), consolidated by-law 2007, solid waste was as “any material that is primarily not a liquid or gas that is unwanted and/or unvalued and is discarded or discharged by its owner”. Solid waste may include material that may potentially be reused, recycled, and composted.

Waste management processes and climate change operate at similar timescales. There is a need to understand what the potential climate change impacts may be on waste management in order to begin the process of identifying what changes may be needed in waste management operations, regulations, strategy, planning, and policy Climate change is a serious, international, environmental concern and the subject of much research. Moreover, in international scientific circles, a consensus is growing that the build up of $C0_2$ and other GHGs in the atmosphere will lead to major environmental changes, such as: rising sea levels that may flood coastal and river delta communities; shrinking mountain glaciers and reduced snow covers that may diminish fresh water resources; the spread of infectious diseases and increased heat-related mortality; possible loss in biological diversity and other impacts on ecosystems; and agricultural shifts, such as impacts on crop yields and productivity (McCarthy, 2001).

Although reliably detecting the trends in climate, due to natural variability, is difficult, the most accepted current projections suggest that the rate of climate change attributable to GHGs will far exceed any natural climate changes that have occurred during the last 1,000 years (Houghton, 2001). Many of these changes appear to be occurring already. Global mean surface temperatures already have increased by about 1 degree Fahrenheit over the past century. A reduction in the northern hemisphere's snow cover, a decrease in the Arctic Sea ice, a rise in the sea level, and an increase in the frequency of extreme rainfall events all have been documented (Houghton, 2001).

Climate change could have an impact on the future development and operation of waste management facilities and infrastructure as it could result in changes to a number of factors that affect waste management processes, including changes in temperatures, cloud cover, rainfall patterns, wind speeds, and storms. The time scales for climate change and waste management are similar. For instance, landfill sites can be operational for decades and still active for decades following their closure. There is, therefore, a need to consider potential changes over significant timescales and respond appropriately.

In most developed and developing countries with increasing population, prosperity, and urbanization, it remains a major challenge for municipalities to collect, recycle, treat, and dispose of increasing quantities of solid waste, especially in a changing climate. A cornerstone of sustainable development is the establishment of affordable, effective, and truly sustainable waste management practices in developing countries. It must be further emphasized that multiple public health, safety, and environmental co-benefits accrue from effective waste management practices, which concurrently reduce GHG emissions, improve the quality of life, promote public health, prevent water and soil contamination, conserve natural resources, and provide renewable energy benefits.

The scope of impact of climate change on waste management techniques and activities addressed within this paper is focused on the management of municipal and household waste. The management of other waste streams will also be impacted by climate change, but not specifically addressed here. The aim of this paper is to x-ray the potential impacts of climate change on solid waste management through the following objectives:

a. To make an assessment of the risk and impact of climate change variables to the sitting and operations of a wide range of waste management facilities in Nigeria, and
b. To make recommendations for further research and actions.

STATUS OF WASTE MANAGEMENT SECTOR IN NIGERIA

The availability and quality of annual data are major problems for the waste sector. Solid waste data is lacking for many countries, data quality is variable, definitions are not uniform, and the inter-annual variability is often not well quantified. There are three major approaches that have been used to estimate global waste generation. They are: data from National waste statistics or surveys, including Intergovernmental panel on climate change (IPCC) methodologies (IPCC,2006); estimates based on population (National Bureau of statistics of China,2006) and the use of a proxy variable linked to demographic or economic indicators for which national data are annually collected (US Environmental Protection Agency, 2003). Global solid waste generation rates range from <0.1 tons per capita per year in low income countries to >0.8 t/cap/yr (Table 1). Overall, the waste sector contributes <5% of global GHG emissions (US Environmental Protection Agency, 2003).

Table 1: Municipal Solid Waste Generation Rates and Income Level

Annual Income	**Low Income**	**Middle Income**	**High Income**
US $/Cap/Yr	825 – 3255	3256 – 10065	> 10066
Municipal solid waste generation rate	0.1 – 0.6	0.2 – 0.5	0.3 to > 0.8

* Income levels as defined by World Bank (www.worldbank.org/data/wdi2005)

Source: Huang,Q.Q.Wang, L. Dong,B.Xi and Zhou. B(2006)

In Nigeria, accurate data on the quantities of municipal solid waste generated in Nigeria are not easy to come by. Nevertheless, Rushbrook and Pugh (1999) outlined the range of per capita waste generation as well as waste densities (on net weight basis) from the low and middle income neighborhood of Nigeria cities (Table 2).

Table 2: Range of MSW per Capita Generation and Density in Nigeria

	Middle Income	**Low Income**
Waste generation (kg/cap/day)	0.5 – 0.9	0.4 – 0.6
Waste densities (net weight basis – kg/m^3)	170 – 330	250 – 500

Source: Rushbrook and Pugh (1999)

In Nigeria, recycling activities are not popular. However, the recovery of materials from wastes (scavenging) is practiced on a large scale. This type of recovery takes place at both legal and illegal dumpsites where scavengers search continuously for valuable metals, plastics, and bottles to be reused or for sale to buyers of different types of scraps. In general, treatment of solid wastes is not often carried out in Nigeria. Incineration of wastes or use of approved sanitary landfill is non-existent. The most common obsession is open dumping and burning of waste within residential areas and at illegal and legal dumps. Other strategies employed in disposing waste in the country include: composting, collection and transfer, combusting.

Composting is a biological process that uses micro-organisms to degrade organic matter using atmospheric oxygen. The stabilized end product occupies a reduced volume, compared with the starting materials. The principal emissions are CO_2, water vapor, bio-aerosols, and odor. It is estimated that nearly a quarter of all household waste is organic and can be composted. In Nigeria, compositing is undertaken in the open. The end product is, then, used on the farms.

Collection and Transfer**:** Waste transfer points are used by waste management companies as a means of increasing the efficiency of their waste collection service through the bulking up of waste into larger consignments prior to transferring to dump and disposal sites. At the transfer points, wastes are loaded directly into large bulk container vehicles and transferred by road to the dump site. The environmental impacts commonly cited are: odor, dust, bio-aerosols, birds, noise, surface water pollution, and surface water runoff management. Waste transfer stations are often located along the streets; while the dumpsites are usually located away from the city centers.

Combustion of Municipal Solid Waste(MSW) results in emissions of CO_2 (because nearly all of the carbon in MSW is converted to CO_2 under optimal conditions) and N_2O. CO_2, from burning biomass sources (such as paper products and yard trimmings), is not courted as a GHG because it is biogenic.

CLIMATE CHANGE AND SOLID WASTE MANAGEMENT

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “a change of climate which is attributable directly or indirectly to human activity that alters the composition of the global atmosphere, which is, in addition to, natural climate variability observed over comparable time periods” IPCC, 2001).

The earth’s atmosphere contains many types of gases, including those known as “greenhouse gases”, which hold in the sun’s warmth. Scientists call this naturally occurring phenomenon the “greenhouse effect”. Greenhouse gases help regulate global temperatures. Certain human activities, such as burning fossil fuels and dumping solid waste, however, produce additional greenhouse gases and upset the natural balance by raising global temperatures. The global temperature has risen by about 0.6^{0}C over the last 100 years. 1998 was the single warmest year in the 142 –year global instrumental record (Hulme 2002). Climate change could have an impact on the waste management industry and, given the operational time frame for many waste management sites, there is a need to examine whether the issues that arise are of such significance that policy or operational changes are required. This paper concentrates on the issues that are likely to arise from the management of municipal and household waste. However, many of the issues will also apply to the management, treatment, and disposal of industrial, commercial, agricultural, construction, and demolition wastes.

WASTE MANAGEMENT POLICIES AND REGULATIONS IN NIGERIA

The discovery of a major toxic waste dumped by a foreign company at Koko town near Warri in Delta State, Nigeria in 1987 led to the establishment of the Federal Environmental Protection Agency (FEPA) by Decree No. 58 of 1988. In June, 1999, the Federal Government of Nigeria created the Ministry of Environment and, as a result, FEPA’s function was absorbed by the new ministry.

The Federal Ministry of Environment has the following instruments of intervention in place to tackle the problem of environmental degradation, including waste management as outlined in these articles: 1) the revised policy on environment, 1999. (2) The National Agenda 21 (published in 1999).

These instruments complement what has existed in form of guidelines and standards for environmental pollution control in Nigeria and other regulation that deals with effluents, industrial pollution, waste management and environmental impact assessment (Federal Ministry of Environment,2003). Among FEPA’s instructions in combating environmental degradation are the waste management regulation S.1.9 of 1991 and the Environmental Impact Assessment (EIA) Decree No. 86 of 1992. FEPA policies regulate the collection, treatment, and disposal of solid and hazardous waste for municipal and industrial sources and makes EIA mandatory for any major development project likely to have an adverse impact on the environment.

There is also, in existence, an environmental sanitation edit of 1997 that declared the last Saturday of every month to be used for cleaning the environment for three (3) hours (7am – 10am). This edit is still being observed all over Nigeria. The post-1988 environmental laws and regulations continued to prevail without any change.

HOW SOLID WASTE IMPACTS ON CLIMATE CHANGE

Even before a material or product becomes a solid waste, it goes through a long cycle that involves removing and processing raw materials, manufacturing the product, transporting the materials and products to markets, and using the energy to operate the product. Each of these activities has the potential to generate greenhouse gas emissions through one or more of the following means: Energy Consumption**:** Extracting and processing raw materials, manufacturing products, and transporting materials and products to markets all generate greenhouse gas emissions by consuming energy from fossil fuels. Methane Emissions**:** When organic waste decomposes in landfills and dumps, it generates methane, a greenhouse gas. Carbon Storage**:** Trees absorb carbon dioxide, a greenhouse gas, from the air and store it in the wood through carbon sequestration. Waste prevention and recycling of wood and paper products allow more trees to remain standing in the forest, where they can continue to remove carbon dioxide from the air, which help minimize climate change impacts.

Different wastes and waste management activities have varying impacts on energy consumption, methane emissions, and carbon storage. For example, recycling reduces greenhouse gas emissions by preventing methane emissions from landfills or open dumps and by preventing the consumption of energy for extracting and processing raw materials.

CLIMATE CHANGE IMPACTS ON WASTE MANAGEMENT PROCESSES.

In order to give some indication of how climate change and waste management could interact, Table 3 Presents a general assessment of what climate change could mean for waste management.

Table 3: Summary of Potential Climate Change and their Impacts

Climate Variable	Potential Climate Change	Examples of Impacts on Waste Management
Temperature	Annual warming by 2080s of between 1^0 and 5^0C	Increased water demand for both workers and site operations.
	More hot days, especially in the dry seasons	Decline in air quality and subsequent negative impacts on heat of vulnerable groups.
	Number of cold days decreases, especially during the rainy seasons	Impacts on biological processes for example composting, anaerobic digestion, etc.
	More frequent stagnant summer anti-cyclones.	Increased risk of fines changes in distribution of vermin and pests.
Precipitation	General wetter days for Nigeria, especially in the south.	Increased risk of flooding from groundwater, surface water, tidal, and sea surfaces.
	Precipitation intensity increases in rainy seasons	Disruption to infrastructure e.g. road and rail
		Increased precipitation intensity could affect slope stability on waste management sites (Jones, 1993)
		Impacts on biological processes, for example, composting, anaerobic digestion, etc.
Cloud Cover	Reduction in cloud cover	Risk to workers of skin conditions associated with increased exposure to sunshine during working outdoors.
Humidity	Specific humidity increases, especially during rainy seasons	Impacts on outdoor biological processes.
Sea level	Mean sea level will be up to 86 cm above its current level, due to thermal expansion and natural land movements by the 2080s.	Inundation of waste management facilities. Increased erosion of coastal areas.

Specific Impacts on Waste Management Processes

Table 4 Applies these potential impacts to various waste management processes in more details.

Table 4: Final Dump Sites (Open Dump)

Waste Management Option	Climate Variable
Dump Sites	<u>Higher Temperature Could:</u> • Alter waste decomposition rate • Lead to reduced water availability; alter site hydrology and leachate production. • Reduce outdoor workers productivity. • Enhance disease transmission. • Give rise to increased vermin e.g. flies. • Give rise to increased risk of odour nuisance. • Increased stress to vegetation and planting in landscaping and screening areas. <u>Precipitation Could:</u> • Alter the waste decomposition rate • Alter site hydrology • Increase leachate strength • Increase flooding occurrence on site due to saturated waste and rising groundwater. • Lead to disruption to transport infrastructure (road and rail) due to flooding and hence delivery of waste. • Increase slope stability risks. • Increase risk of erosion. <u>Rising Sea Level Could:</u> • Lead to inundation of sites. <u>Reduced Cloud Cover Could:</u> • Increase the risk to outdoor workers from sunburn and other skin conditions. • Have an adverse impact on the life of exposed materials.
Composting	<u>Higher Temperature Could:</u> • Alter waste decomposition rate. • Reduce outdoor and indoor worker productivity. • Give rise to increased vermin e.g. flies. • Increased combustion risk. • Increase the risk of odour nuisance and bioaerosols. • Increase dust potentials. <u>Precipitation Could:</u> • Reduced precipitation could reduce water availability for site management. • Increase flooding occurrences on site due to inundation of site facilities. • Alter waste decomposition rate. • Lead to disruption to transport infrastructure due to flooding and hence delivery of waste.

STRATEGIES FOR REDUCING GHGS IN MSW

Product Stewardship: More and more companies are moving toward redesigning their products to reduce their environmental foot print. By necessity, this trend involves rethinking how their products are managed at the end-of-life so that valuable materials can be recovered and reused. The electronics industry is reducing the energy usage of their products, as well as reducing reliance on toxic inputs in their products. They are also redesigning their products to make them easier to recycle. The packaging industry is moving towards package designs that use less material (reducing GHG emissions from transportation) and are more easily recyclable (reducing GHG emissions and energy investments in processing virgin materials). Many other industries, such as the carpet, office furniture, and textile industries, are in the process of developing sustainability standards for their products. Companies committed to this kind of change are very interested in the metrics that will help them measure the environmental benefits of the changes they are making to their products.

Paperless Office: The rise of computer technology for research, communications, and other everyday workplace functions has presented a major opportunity for source reduction in the modern office. Today's offices are commonly equipped with all the necessary technologies to bypass paper entirely and, instead, rely on electronic communication. This form of "comprehensive" source reduction comes with significant GHG benefits.

Anaerobic Digestion**:** Several facilities are using this technique to produce CH_4 from mixed wastes, which are then used to fuel the energy recovery. The approach generates CH_4 more quickly and captures it more completely than in a landfill environment and, thus, from a GHG perspective offers a potentially attractive waste management option (Environment Canada, 2001)

Bioreactors**:** Bioreactors are a form of controlled land filling with the potential to provide reliable energy generation from solid wastes, as well as significant environmental and solid waste management benefit. The concept is to accelerate the decomposition process of landfill waste through controlled additions of liquid and leachate recirculation, which enhances the growth of the microbes responsible for solid waste decomposition. The result is to shorten the period of landfill gas generation, thereby rendering projections of landfill gas generation rates and yields that are much more reliable for landfill gas recovery.

Compost **as** Landfill Cover**:** Using compost as landfill cover on closed landfills provides an excellent environment for the bacteria that oxidize CH_4. Under optimal conditions, compost covers can practically eliminate CH_4 emissions. Furthermore, the covers offer the possibility of controlling these emissions in a cost-effective manner. This technology is particularly promising for small landfills, where landfill gas collection is not required and the economics of landfill gas-to-energy projects are not attractive. Ancillary benefits also might arise in the compost market from this technique if using compost as a landfill cover becomes a widespread practice. An increase in composting could reduce the quantity of organic waste disposed at Municipal Solid Waste (MSW) landfills, thereby reducing CH_4 emissions.

Biomass Pyrolysis/Gasification**:** Pyrolysis and gasification are similar technologies in which waste is thermally decomposed in an oxygen- poor environment. In pyrolysis, organic matter is vaporized and the vapor is condensed and collected as "bio-oil", which can then be burned for energy .The advantage of pyrolysis over normal waste-to energy incineration is that pyrolysis produces a liquid fuel that can be stored and used in a number of applications (similar to biodiesel), whereas waste-to-energy(WTE) produces only electricity for immediate consumption. Biomass gasification is similar except that a gas, rather than a liquid, is produced.

Co-firing Waste Biomass**:** For utilities and power generating companies with coal-fired capacity, co-firing involves replacing a portion of the coal with biomass at an existing power plant boiler. This replacement can be achieved by either mixing biomass with coal before fuel is introduced into the boiler or by using separate fuel feeds for coal and biomass. Specific biomass feedstocks include agricultural and wood waste, MSW, and industrial wastes.

CONCLUSION

There is, without any doubt, a systematic neglect and ultimate failure in solid waste management in Nigeria. The gloomy consequences are a source of anxiety to the Nigeria public, especially with the multiple effects of climate change. A refusal to adopt appropriate measures to address the issues of solid waste problem in our changing climate will incur severe penalty at a later time. This may be in form of resources unnecessarily lost and overwhelming adverse impact on the environment, such as increased adverse impacts on biological processes, risk to outdoor workers, disruption of infrastructure, increased risk of flooding, increased risk of changes in distribution of vermin and pests, decline in air quality, etc. Unfortunately, the effect of poor solid waste management is already taking its toll on us. For instance, Kajogbola (1998) revealed that prominence of malaria, dysentery, chicken pox, measles, and pneumonia was the greatest causes of morbidity within Ibadan metropolis in Nigeria. The study also revealed that the leading killer diseases in Ibadan are solid waste related; and this will be more with the increasing change in our climate.

This study has begun the process of understanding what climate change could mean for waste management in Nigeria. As it is a new area, it is recommended that more research is carried out into specific impacts. The selection of truly sustainable waste strategies is very important for both the mitigation of GHG emissions and for improved urban infrastructure.

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