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Solid Waste and Its Implications for Climate Change in Nigeria

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ABSTRACT This study presents Nigeria's solid waste generation, characteristics, current management practices, greenhouse gases (GHGs) emission particularly contribution by the solid waste sector, and the implication for climate change. The study reveals that based on the current solid waste generation, management practices and future potentials, the waste sector will be a significant contributor not only to Nigeria's GHGs emission, but to the world. As a mitigation option the study recommends formalization of recycling into the waste management system to reduce land filling.

1. INTRODUCTION

As the evidence for human induced climate change becomes clearer, so too does the realization that significant harm is already occurring on socio-economic systems and physical processes (United Nations Foundation-Sigma Xi 2007). Concerned with the implications, several governments came together in 1988 and formed the International Panel on Climate Change (IPCC). This led to the United Nations Framework Convention on Climate Change (UNFCCC) which was tabled in 1992 at the United Nations Conference on Environment and Development. The Nigerian Government ratified the UNFCCC in August 1997.

According to recent estimates, the waste sector contributes about one-fifth of global anthropogenic methane emissions (IEA 2005) and methane contribution to climate change is about one- third to a half of that of carbon dioxide (Hansen and Sato 2001).Waste sector emissions have grown steadily globally and are expected to increase in the forthcoming decades especially in developing countries such as Nigeria because of the increase in population and GDP (IPCC 2000) and in recognition of this, the Clean Development Mechanism (CDM) established by Kyoto Protocol in 1997, recognized waste and its disposal as one of the sectors identified for greenhouse gas reduction.

Since the beginning of the oil boom of the 1970s, Nigeria has become an increasingly urbanized and urban-oriented society. During the 1970s, Nigeria had possibly the fastest urbanization growth rate in the world (Ochuo 1986; ICMPD 2010). Because of the great influx of people into urban areas, the growth rate of urban population in Nigeria in 1986 was estimated to be close to 6 percent per year, more than twice that of the rural population (Afolayan et al. 2008). Between 1970 and 1980, the proportion of Nigerians living in urban areas was estimated to have grown from 16 to more than 20 percent, and by 2010, urban population was expected to be more than 40 percent of the nation's total (NPC 2004).

Cities are recognized as engines of social modernization and economic growth but are also areas where globalization impacts are manifested. For Nigeria this reflects in fueling the already unprecedented urban growth that outstrips available infrastructures many times over. Other impacts include the increased volume and variety of solid waste, resulting from increased flow of goods and services, and changed lifestyle and consumption pattern. A study by the European environment agency indicated that the amount of municipal waste is expected to grow by 25 % from 2005 to 2020 and that limiting or avoiding growth in waste volumes would reduce greenhouse gas emissions from the waste sector and deliver other benefits to society and the environment (European Environment Agency 2008).Also, according to EPA rising levels of gases in the Earth's atmosphere are causing changes in our climate, and some of these changes can be traced to solid waste. The manufacture, distribution, and use of products—as well as management of the resulting waste—all result in emissions of atmospheric gases that affect the Earth's climate. The study further shows that by cutting the amount of waste we generate back to 1990 levels, we could reduce greenhouse

gas emissions by 11.6 million metric tons of carbon equivalent (MTCE).

As a developing nation, Nigeria is particularly sensitive to the effects of climate change. A large part of its economy depends on natural resources which are vulnerable to climate change. The consequences of climate change could thus undermine economic development (Christopher 2001), increase poverty and the lack of effective adaptation and mitigation measures to the adverse effects of climate change can jeopardize the achievement of MDG goal 1 (eradicating extreme poverty and hunger) goal 6 (combating HIV/AIDS, malaria and other diseases) and goal 7 (ensuring environmental sustainability (Hulme et al.1995; Christopher 2001).

Current knowledge on waste generation and emissions in Nigeria is characterized by dearth of serious studies .This is partly due to the scientific constraints on African climate science which lacks reliable data (Nicholson 2001). Waste statistics are also lacking due to the low level coverage of waste collection. Yet, such information is necessary for understanding the likely impact of the sector on emissions of greenhouses gases (USEPA 1998; ADB 1998; IPCC 2006). The objective of this paper is to assess Nigeria's current solid waste generation, characteristics, management practice, greenhouses gases (GHGs) emissions scenario and likely implications for climate change with a view to drawing the attention of adaptation experts and policy makers on the possible role of waste management research in adaptation and mitigation to climate change in Nigeria and other developing countries in general.

2. MATERIALS AND METHODS

Solid waste generation, characteristics and management practice in fifteen cities in Nigeria were selected as representative of the current solid waste sector in Nigeria. The study was carried out in three stages between March and July 2009.

Stage 1: Review of current greenhouses gases inventory in Nigeria particularly the role of waste sector.

Stage 2: Waste characteristics and management practices in fifteen Nigerian cities were analyzed with a view to assessing their current and likely future contributions to emission of GHGs in comparison with data for different waste management practices established by (USEPA 1998).

Stage 3: Identifying the best possible adaptation and mitigation options in relation to current state of the waste sector in Nigeria.

3. INVENTORY OF GHGS IN NIGERIA

Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC 2005) requires each Party to periodically report the emissions of greenhouse gases (GHGs) including CO2, CH4, N2O and non-methane volatile organic compounds (NMVOC) in their National Communication. In fulfillment of the article, Nigeria's national communication based on emission per unit human population (based on gross population of 96.7 million for the year 1994) indicates a gross per capita CO2 emission of 0.5 t C/cap. Per capita, non-CO2 GHG and precursor gases are between 2 to 4 orders of magnitude lower than CO2 per capita emissions.

An overview of gross carbon emissions by sources and removal by sinks indicates gas flaring, transportation, and electricity generation as the most significant energy consumption processes leading to GHG emissions. Energy and land use change sectors were the main contributors to CO2 emissions, while energy, agriculture and solid waste are the main contributors to CH4 emissions.

The total methane emission in Nigeria is 5.9 Tg CH4. The energy production and consumption sector with a total emission of 1.48 Tg-CH4 contributed 25% of gross national emissions with agriculture contributing the rest. Municipal solid wastes and waste water treatment contributed 0.21 and 1.88 Tg CH4. These respectively represent 4 and 32% of gross national emissions. The gross emission of nitrous oxide was 11.95 Gg N2O. The energy sector (principally petroleum refining, small combustion and transport sub-sectors generated 7.47 Gg N2O representing 63% of gross national emissions for the year. This was closely followed by emissions from savannah burning (28%), field burning of agricultural wastes (6%), burning of solid wastes (2%) and on-site biomass burning from forest conversion (1%).

The total CO2 emission was 17.05 Tg CO2. Out of these, the energy sector generated 13.1 Tg CO2 with the following major energy sub-group emissions: transport 4.73 Tg CO2 or 28% of the gross national emissions; small

combustion sources and gas flaring each representing about 25% of the gross national CO2 emissions. The agricultural sector emitted 3.59 Tg CO2 or 28% of the gross national emissions for 1994, while the other energy sub-sectors, solid waste and land use change emitted 33.2 Gg CO2, 171 Gg CO and 162 Gg CO2.

The total generation of GHGs based on the current data for Nigeria is low when compared to emissions from the United States and other developed economies. However, Nigeria's gross emissions may approach those of these countries if its population continues to grow at the current rate of 3.5% per annum since per capita emissions is also likely to increase. The current population of Nigeria is put at 140 million, representing 20% of the entire population of Africa. The United Nations projected a population of 289 million for the Nigeria by 2050. Apart from population growth, Nigeria has been experiencing increased urbanization over the last five decades. The proportion of the population living in the urban centers has risen from 15% in 1960 to 43.3% in 2000 and is projected to rise to 60% by 2015 (NPC 2004). Furthermore, current economic growth of 7% per anum since 2005 has been projected to continue and would invariably fuel increase in the generation of solid waste.

4. OVERVIEW OF SOLID IN NIGERIA

Nigeria shown in Figure 1 is the largest black nation in the world and generates 25 million tons of solid waste annually with a per capita waste generation of 0.49 kg/cap/day (FMHE).

Table 1 shows the waste generation for fifteen cities across Nigeria. However, several researchers have indicated that like other developing nations, statistics on waste generated in Nigeria's cities reflect only 50% of the actual generation as the remaining 50% are assumed to be partially decaying at dumpsites and partially burnt before collection (Contrieu 1982; Ogwekela 2003; Nabegu 2008) suggesting that actual generation is much higher than what is officially reported.

Table 2 shows the different categories of waste observed in the dump sites in the Nigerian cities. These included food scarp, ash, dirt, vegetable, paper, textile, plastic, glass and metals. Biodegradable portion accounts for 68.26% of the average weight of the entire waste samples, while the non-biodegradable accounted for 31.74% showing clearly the predominant waste in Nigeria is biodegradable. Studies in other developing nations show similar type of waste, for instance, a study in Bandung, Indonesia and Sri Lanka have found residential waste composed of 78% and 81% biodegradable material (Cointreau 1982; Hoornweg et al. 1999; Eric 2003). Nigeria's current solid waste management strategy focuses on bulk collection and disposal. It involves hauling the waste from the dump site and transporting it to the landfills. The predominant solid waste disposal method is open dumping.

Fig.1. Location of the study area

Table 1: Volumes of solid waste generation in some Nigerian cities

Urban areas	*1982*	*1985*	*1990*	*2000 (Tonnes per year)*
Lagos	625,399	681,394	786,079	998,081
Ibadan	350,823	382,224	440,956	449.882
Kano	319.935	348,580	402,133	535,186
Kaduna	257,837	280,925	324,084	431,314
Onitsha	242,240	263,929	386,593	304,477
Port Harcourt	210,934	229,821	265,129	352,853
Oshogbo	131,903	143,712	173,720	253,841
Aba	131,903	143,712	169,719	236,703
Jos	99,871	111,905	135,272	197,660
Warri	67,477	75,607	91,396	133,531
Gusau	44,488	48,471	7,243	79,835
Potiskum	15,434	16,816	19,399	28,347
Uyo	12,508	13,628	15,721	20,336
Suleja	9,383	10,514	13,311	21,336
New Bussa	5,690	6,200	7,152	9,518

Source: Federal Ministry of Housing and Environment, The State of the Environment in Nigeria, Monograph Series, Lagos, (no date)

The collection from dump sites is the function of state and local government agencies. Informal solid waste collection operations exist in parallel with official agencies in some major cities like Kano, Onitsha and Lagos. There is inadequate service coverage as only limited areas of the cities are covered (Ogwueleka 2003; Zurbrugg 2003; Nabegu 2009).

Table 3 shows the nature of typical waste disposal by households in Nigerian cities as typified in Kano metropolis. In cities across Nigeria, solid waste is disposed by transporting and discharging in open dumps, which are environmentally unsafe. Most households 66.25% throw their refuse in any available open space. Only about 3.7% of the sampled households dispose their refuse in proper depots for which there are containers either of metal, plastic, concrete blocks, or mud walls provided by the state agencies esponsible for waste management. However, there exists great variability between cities, and even within a single city. For instance, in Kano metropolis, 76.25% of the residents in the old city and 79.25% in suburban do not use authorized dumping site for their waste and residents that were interviewed blamed the lack of collection point close to them for disposal of waste in paths, riversides and road walkways (Nabegu 2009).

1. Implication of Nigerias Waste Management to Climate Change

Current management of waste in Nigeria is predominantly in unmanaged landfills where anaerobic degradation of organic material occurs causing CH4 emissions. When organic waste is sent to open dumps as is the case in all Nigerian cities, it is buried under layers of dirt. Eventually, all oxygen is consumed and organic matter decomposes in anaerobic conditions. Anaerobic decomposition generates methane, a greenhouse gas that is 20 times more potent than CO2 in trapping the sun's heat. Garbage dumps and landfills generate about 11 per cent of anthropogenic emissions of greenhouse gases (Cointreau 2008). Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Cointreau 1996). Also, Hoornweg et al. (1999) have shown that for every metric ton of unsorted municipal solid waste (containing 0.3 Mt carbon), 0.2 Mt are converted to landfill gases. Of this gas, carbon dioxide and methane each comprise .09 Mt. Both methane and carbon dioxide are major constituents of the world's problem GHGs. However, while carbon dioxide is readily absorbed for use in photosynthesis; methane is less easily broken down, and is considered 20 times more potent as a GHG (Johanesen 1999). Since it is believed that

Table 2: Percentage waste bulks collected in the three zones

	Nsukka	*Lagos*	*Markudi*	*Kano*	*Onitsha*	*Ibadan*	*Maiduguri*
Putrescribe	56	56	52.2	43.0	30.7	76	25.8
Plastic	8.4	4	8.2	4.0	9.2	4.0	18.1
Paper	13.8	14.0	12.3	17.0	23.1	6.6	7.5
Textile	3.1	-	2.5	7.0	6.2	1.4	3.9
Metal	6.8	4.0	7.1	5.0	6.2	2.5	9.1
Glass	2.5	3.0	3.6	2.0	9.2	0.6	4.3
others	9.4	19.0	14.0	22.0	15.4	8.9	31.3

Source: All Sites Engineering Ltd.

Table 3: Nature of solid waste disposal in atypical Nigerian city

Types of deposit/dumps	*Frequency (%)*
REMASAB bin	3.7
Authorized dump site	16.25
Unauthorized empty plot	66.25
Burning	3.75
Personal bin	13.25

Source: Nabegu 2007

landfill gases supply 50% of human-caused methane emissions and 2-4% of all worldwide greenhouse gases (Johanesen 1999) this is clearly an area of concern as more than 70% of waste in Nigerian cities are allowed to decompose. In Nigeria, there is also a general failure to segregate waste especially - industrial, municipal and sewage. This results in synergistic effects and intensified decomposition which are especially severe in sub-tropical and tropical climatic conditions (Cointreau 1992).

In Nigeria, current waste management trends suggest that increases in controlled land filling resulting in anaerobic decomposition of organic waste will continue parallel with increased urbanization. Incineration and open burning of waste containing fossil carbon are also important sources of CO2 emissions in the waste sector. These emissions are, however, a very small fraction of the total global CO2 emissions. In addition, N2O is produced as an intermediate gaseous product of microbial nitrogen cycling. N2O emissions depend on the type of waste treatment as well as conditions during the transport, storage and treatment. These emissions are small compared to total global emissions (UNFCCC 2005; IPCC 2006).

Composting has been recommended as an affordable, sustainable alternative to controlled land filling in Nigeria and similar developing countries especially where more labour-intensive lower technology strategies are applied to selected biodegradable wastes (Hoornweg et al. 1999). However, several studies have shown the environmental, economic, social and other benefits of waste recycling (Medina 1997). In Nigeria studies on benefits of recycling have been undertaken in Kano (Nabegu 2008, 2009), Onitsha (Nzeadibe 2008) and Aba (Agunwamba 2003), the reduction of waste through promotion of recycling has steadily worked its way to the environmental policy agenda and was endorsed at the 1992 UN Rio Conference. The Agenda 21 declaration called for the promotion of sufficient financial and technological capacities at the regional, national and local levels to implement waste and recycling policies, and actions. Yet the process of recycling is not just a reaction to environmental crisis but a reflection of the reality.

Recycling involves the collection of use waste materials, their reprocessing and their subsequent reutilization in place of new materials (Britannica Corporate Site 2001). This has proved to be one of the most promising methods for conservation of mineral resources. If carried out in an organized manner, re-cycling can greatly reduce the drain on supplies and utilization of new mineral resources. Recycling can help reduce the quantities of solid waste deposited in landfills, which have become increasingly expensive. Recycling reduces the pollution of air, water and soil resulting from waste disposal. It has a cleansing and refreshing effect on the surrounding environment.

Although essential informally organized in Nigeria, government can make the needed plans policies for the introduction and production of the necessary equipment and technology to improve and facilitate recycling in their waste management. Proper allocation of funds and appropriate resources will contribute adequately to such waste management schemes.

The USEPA (1998) has experimented on the emission potential of all waste management relative to land filling. Table 4 shows the change in emissions, relative to land filing, for each material and each waste management option.

Table 4: Waste Management options and impacts n GHGs emission

Material	*Sources reduction*	*Recycling*	*Combustion*
Newspaper	-2.7	-2.5	0.0
Office paper	-6.3	-5.4	-2.9
Cardboard	-3.3	-3.0	-0.9
Aluminum cans	-12.0	-15.7	+0.1
Steels cans	-3.4	-2.3	-2.0
Glass	-0.6	-0.4	0.0
HDPE containers	-2.5	-1.5	+0.8
LDPE containers	-3.6	-2.0	+0.8
PET containers	-4.0	-2.5	+0.8

Source: USEPA 1998

Almost all the options are negative, indicating that almost everything is an improvement over land filling from a climate change pers-

pective. However, recycling of all nine materials leads to a reduction in greenhouse gas emissions, relative to land filling.

5. CONCLUSION

Although developing countries are generally assumed to be responsible for insignificant generation of GHGs, current increase in population, economic development, urbanization, solid waste generation and the rather crude management of its management could result in enormous increase in GHGs generation. This is particular the case with respect to solid waste which is expected to grow as the urban population is projected to increase by as much as 20 percent in the next 30 years coupled with the adoption of western life style of consumerisms that characterize most urban centers in Nigeria and indeed the developing world . The issue is made more significant by the poor management of solid waste and dearth of data especially on actual solid waste generation.

Current approaches at mitigation and adaptation to climate change in Nigeria have focused on restricting emissions of greenhouse gases. Due to lack of awareness at the local levels, they have little impact. Sustainable mitigation and adaptation measures can be more successful if they are well understood and also if they enable people to engage in economic activities that provide for livelihood. Consequently adapting recycling as both mitigation and adaptation option will greatly succeed since, besides the creation of wealth and providing a means of livelihood to thousands, recycling activities can significantly reduce the amount of solid waste that generates harmful GHGs. The real challenge is to incorporate it into the formal waste management structure and to provide safer, healthier working conditions than currently experienced by scavengers on uncontrolled dumpsites.

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