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Provisional Evaluation of Composting as Priority Option for Sustainable Waste Management in South-West Nigeria

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ABSTRACT: The management of Municipal Solid Waste (MSW) in Nigeria and most developing countries has remained a major public health challenge, thus creating the need for reliable and environmentally-acceptable alternatives. This study focuses on composting assessment as a viable recovery alternative for MSW in six States of Southwest Nigeria, namely: Ekiti, Osun, Ondo, Ogun, Oyo, and Lagos. Extensive literature review has been carried out to understand the waste generation patterns in these states. Reported literature data has been assessed for sustainability of composting strategy in terms of organic waste streams, amenable of biotransformation as well as in terms of return through energy saving and material recovery. A life-cycle framework has been used to estimate GHG emissions, available nutrients, and potential compost production, instead of landfill in each region. Results show significant potential compost production of 895,659-, 255,267-, 153,423-, 117,468-, 113,094- and 112, 397-m^3/yr for Lagos, Oyo, Ogun, Osun, Ondo, and Ekiti, respectively. It has been deduced from the study that composting would be very beneficial to the economy as its product would boost agriculture production while reducing the budget spent on fertilizer annually.

Keywords: composting, life-cycle-framework, organic-waste, Southwest-Nigeria, sustainability.

INTRODUCTION

Appropriate management of Municipal Solid Waste (MSW) is a major environmental challenge, faced by many developing countries. A developing country, Nigeria is characterized by growing population and rapid urbanization. Waste management is a major concern due to the high rate of waste generation and disposal in uncontrolled dumpsites (Olukanni et al., 2013; Olukanni et al., 2014; Igbinomwanhia et al., 2014; Olukanni & Mnenga, 2015). According to Guangyu (2002) and Ogwueleka (2009), 25 million metric tons of MSW is annually generated in developing countries at a daily rate of 0.44 kg-0.66 kg/capital/day, as opposed to 0.7 kg-1.2 kg/capital/day in developed countries. The capacity to handle these wastes has not been able to

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meet up with the ever-increasing rate of MSW generation. In addition, there has been a major change in the composition, as greater population in low socioeconomic groups and most of the organic components in the wastes stream are ideal for making compost.

The organic fraction of MSW (OFMSW) is an important component of MSW, for it constitutes a sizeable fraction of solid waste stream and its proper management is important for the protection of public health and the environment (Abila & Kantola, 2013; Olukanni & Mnenga, 2015). In developing countries, MSW typically consists of over 70% organic material (Hoornweg et al., 1999), including yard trimmings, food scraps, and wood. Studies in developed countries such as the United States have shown that nearly 65% of the total generated MSW, is made of organic materials. Composting of these materials has the potential to reduce landfill emissions and conserve valuable nutrients (Taiwo, 2011; Levis & Barlaz, 2011; Levis et al., 2013; 2014; Hodge et al., 2016).

Recent developments in the area of environmental regulations, equipment costs, and energy and fuel shortage have increased the cost of solid waste disposal by landfilling and incineration (Morris et al., 2012; Laurent et al., 2014). While landfills and open dumps remain a significant component of waste management infrastructure in Nigeria, there is an increasing interest in efforts to reduce the generation of waste and manage waste by recycling and composting. Studies on major cities in Nigeria show that organic waste and compostable materials constituted the majority of MSW streams (Adewunmi et al., 2005; Ogwueleka, 2009; Cristina, 2013; Olukanni et al., 2013), though there is neither any government policy nor initiative to promote composting of solid waste (Harir, 2015).

Nigeria embarked on an economy diversification agenda, aimed at re-invigorating the agriculture sector that contributed 31% in GDP in 2014 (NBS, 2016). The potential for finished compost to improve agricultural sector is important because compost is a resource, derived from organic matter that can be utilized to enhance the biological, chemical, and physical properties of soils (The US Composting Council, 2001). Babalola et al. (2016) stated that many areas of Nigeria are losing their capability to support efficient crop production. In addition, environmental conservation and climate change mitigation is a pressing concern for policy makers. Effective management of the organic fraction of solid waste has been identified as a way to significantly decrease greenhouse gas emissions (Giannopoulou et al., 2015). Shiralipour et al. (1992) and Antonious et al. (2011) stated that the incorporation of composted MSW on soil usually brings a positive effect on crop development as well as the ecologic restoration and economic functions of land.

Effective utilization of compost can help save money, increase healthy plant production, conserve natural resources, and reduce the use of chemical fertilisers (Saheri et al., 2009; Olanrewaju & Ilemobade, 2009; Harir et al., 2015). The composting process may now be economically feasible; embracing low technology, low cost with less pollution impact which is more environmentally acceptable method, compared to other waste disposal ones (Afon & Okewole, 2007; Kofoworola, 2007). Appropriate technology is more preferable in waste processing than extensive mechanization that is not affordable. Sridhar et al. (2013) in their study revealed that once communities are mobilized, they can be effective in launching composting projects. The purpose of this study is to explore the potential benefits of additional composting in southwest Nigeria. The next section describes the case study area, including current composting activities, followed by an analysis of the potential environmental

and economic implications of increased composting. Finally, the potential policy and agricultural implications of increased composting are discussed.

MATERIALS AND METHODS

The analysis considered six states in southwestern Nigeria: Lagos, Oyo, Ogun, Ondo, Osun, and Ekiti, as shown in Figure 1. The region lies between longitude 2.52 and 6.00 and latitude 6.35 and 8.62 with a total land area of 77,818 km^2 and an estimated population of over 40 million (NPC, 2006). No other official census record has been carried to date. Extensive literature review was carried out to understand the waste generation pattern in these states. Reported literature data was assessed for sustainability of the composting strategies in terms of organic waste streams amenable of biotransformation as well as in terms of return through energy saving and material recovery. A life-cycle framework was used to estimate GHG emissions, available nutrients and potential compost production instead of landfill in each region (go.ncsu.edu/swolf) (Levis et al., 2013; Levis et al., 2014).

RESULTS AND DISCUSSION

Table 1 shows waste generation and composition data for each state. Organic waste comprises 57% to 68% of generated MSW in each state. This is consistent with the fact that approximately 58% of household expenditure in southwester Nigeria belongs to food (Adewunmi et al., 2005). It is important to note that a fraction of organic wastes might be bad for the composting pile (e.g. most meat and dairy products). Composting of these materials should be avoided in order to prevent odours and avoid animals. Of the food category, 19.05% represent the commodities, not considered good for composting, leaving 80.95% as compostable (Adewunmi et al., 2005).

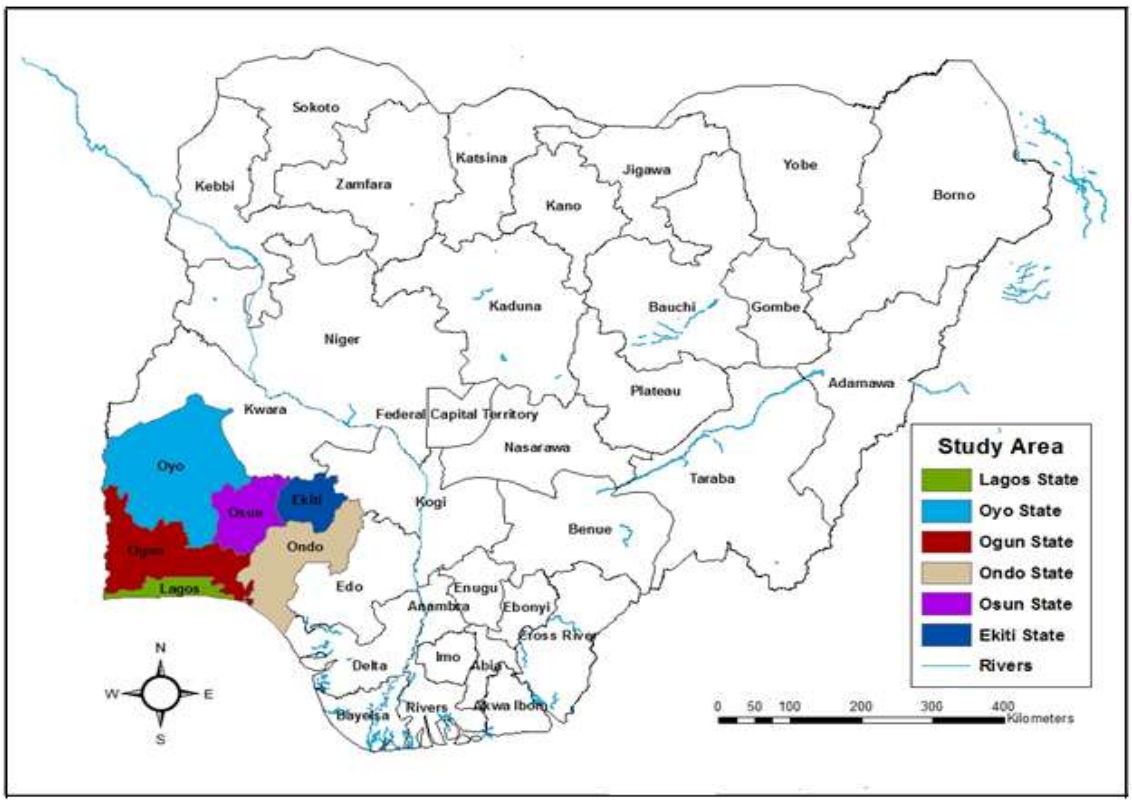

Fig. 1. Map of Nigeria showing the study areas

Lagos

Lagos is the second most populous state as well as the country's largest urban area (17.5 million to 21 million) after Kano, arguably the most economically-important state of Nigeria with an area of 3,577 km^2. The state has made the most efforts to integrate composting in its waste management system. It daily generates about 13,650 (tons/day) of waste with an estimated average of about 0.65 kg/capital/day, whereby only 0.175% (24 tons/day) of the total waste is currently composted (Oyelola & Babatunde, 2008; Adewunmi et al., 2005).

Oyo

Oyo had an area of 28,500 km^2 and a population of 5,591,589 in 2006. Its capital, Ibadan, is the largest city in West Africa, having a population of 3,565,108 (NPC, 2006). There is little data on waste generation in this state as a whole, but available data belongs to the city of Ibadan as well as the town of Oyo. The rate of waste generation in Ibadan sums up to 0.71 kg/ capital/ day, 0.55 kg/ capital/ day of which is biodegradable. On the other hand, the town of Oyo produces 0.63 kg/ capital/ day, 0.51 kg/ capital/ day of which is biodegradable (Adewunmi et al., 2005). Based on the report by (NBS, 2016) on the consumption pattern in Nigeria in 2010, of the total amount spent on food in Oyo, 47.12% is on vegetables, tubers, and plantains, which are good compost materials. The unsuitable part of the food represents 15.46% leaving and 84.54% as compostable materials.

Ogun

Ogun had an area of 16, 980.55 km^2 and a population of 3,751,140, according to the last census in 2006. Adewunmi et al. (2005) revealed that about 0.60 kg/ capita/ day of municipal waste is generated in this state, resulting in a figure of about 2, 250 metric tonnes of daily-generated waste. Similar to other states, organic waste is the largest fraction of solid waste, generated in Ogun (Table 1). Adewunmi et al. (2005) found that majority of solid waste, generated in the state comes from households (74%).

Ondo

Ondo's area and population were 15,500 km^2 and 3,441,024 residents in 2006, respectively. Adewunmi et al. (2005) estimated that Ondo generates about 660,488 metric tonnes of waste per year. According to the report (NBS, 2014), 65.38% of Ondo State residents exspenditure is on food and of the total food, the commodities, not suitable for composting, represent 15.74%, meaning 84.26% is suitable. This shows that out of the 59% organic waste, generated in Ondo, about 50% can be composted, leaving 9% unsuitable (Oyelola & Babatunde, 2008; Adewunmi et al., 2005).

Table 1. Waste generation and composition data for each state and the total region

	Lagos[a]	Ogun[b]	Oyo[b]	Osun[b]	Ondo[b]	Ekiti[b]	Regional Total
Population (millions)	21.0	3.8	5.6	4.1	3.4	2.4	40.3
Per capita waste generation rate (kg/capital/day)	0.65	0.60	0.71	0.46	0.54	0.71	0.64
Waste generation rate (tons/day)	13,650	2,250	3,970	1,903	1,858	1,693	25,325
Materials (%)	**Lagos[a]**	**Ogun[b]**	**Oyo[b]**	**Osun[b]**	**Ondo[b]**	**Ekiti[b]**	**Regional Total**
Organic Waste	68.16	57.8	64.9	58.2	59.5	60.4	64.8
Paper	12.46	26.2	14.2	17.8	15.5	21.4	15.2
Glass	1.78	2.2	1.7	0.6	6.3	2.2	2.1
Plastic	11.32	8.7	9.9	12.1	1.7	4.3	9.7
Metals	2.08	1.6	2.9	1.4	7.2	0.2	2.4
Fines/others	4.2	3.4	6.5	9.9	9.8	11.5	5.8

[a] Oyelola & Babatunde (2008); [b] Adewunmi et al. (2005)

Osun

Osun had an area of approximately 9,251 km^2 with an estimated population of 4,137,627 in 2006. According to the reports (NBS, 2014), 60.53% of Osun's household spending is on food, of which 13.41% belongs to foods that are not suitable for composting, leaving a ratio of 86.59% as suitable. Therefore, it can be assumed that 86.59% of the 58% organic waste is suitable for composting which represents 50.22% of the total waste generated. According to Adewunmi et al. (2005), Osun generates 455,999 metric tonnes of biodegradable waste per year, meaning that about 394,850 metric tonnes is compostable.

Ekiti

Ekiti has an area of 6,353 km^2 and a population 2,384,212 people. Households in this state spend 52.42% of their total income on food (NBS, 2014). Of the 59% biodegradable waste generated in the state, about 50% is suitable for composting and the remaining 9% is supposed to be discarded.

Composting projects

Composting is still uncommon in the southwest region. Table 2 shows the summary of existing composting operations in the region. Some of the state's plan to start composting, though without commencing any program yet, while some have no facilities or plans for composting.

Table 2. Summary of existing composting operations in the region.

State	Waste Throughput (Mg/day)	Materials Composted
Lagos	15 to 21[a]	OFMSW, manure
Oyo	1[b]	OFMSW
Ogun	No facilities or plans for composting	N/A
Ondo	0.14	OFMSW, poultry litter
Osun	Plans to begin composting, but no programs have begun.	N/A
Ekiti	Plans to begin composting, but no programs have begun.	N/A

[a] Calculated by dividing 6250 kg of compost produced per day by 300 or 400 kg of compost produced per Mg of incoming waste.
[b] Out of maximum capacity of 5 Mg/day

Lagos

In 2007, the state, developed a composting facility at Ikorodu area, through a project proponent, EarthCare Nigeria Limited (ENL), in collaboration with its technology partner. It aimed at providing environment friendly waste disposal option and producing high quality compost for agriculture and horticulture use. About 300 to 400 kg of compost can be produced from 1 metric tonne of organic waste, which might vary as a result of the composition of the waste to be used. Earthcare Incorporated currently delivers 250 bags of organic compost daily (LAWMA, 2016). Earth Care Nigeria Limited (ENL, 2016) reported that the compost is free from the adverse effects, compared to chemical fertilizers, being is full of micronutrients that are absent in chemical fertilizers (ENL, 2016). The process is in three major stages:

1. reception and weighing of OFMSW;
2. windrow composting;
3. preparation of final composting, shown in the flow process of composting at the processing facility (Fig. 2).

The quantity of incoming garbage as well as the emerging compost from ENL composting facility is recorded and the company ensures that quality control checks are carried out on each composting process and the final product is in accordance with national and USEPA standards. Once the quality is established, the products are loaded on dump trucks and transported for packaging. The fine compost is packed in bags, each 25 kg in volume, and sold for N2,000 (NGR) (6.8 USD) per bag, i.e. about N500,000 (NGR)

(1,695 USD) is made as revenue from the sale of 250 bags of compost per day. If the state is able to increase the amount of wastes to be composted per day to around 10% of the organic waste generated in the state, it means about N15 million (NGR) (51,000 USD) can be generated daily as state revenue from organic fertilizers. This clearly indicates how valuable waste is for mankind and how sure a tool it is for human sustainable development.

Oyo

The only known composting program in Oyo is in the Ayeye community in Ibadan, set up as part of the Sustainable Ibadan Project (SIP), established in 1994 by the United Nations Centre for Human Settlement, UNCHS (HABITAT), as part of the Sustainable Cities Programme. The composting facility accepts biodegradable wastes from homes and the markets. Majority of the funding came from United Nations Development Programme (UNDP) and UNICEF, while the Oyo State Government and other stakeholders (e.g., the local university) provide material and human resources. The plant was commissioned in 2002 with a 5 metric tonnes/day capacity and an expected production of 45-50 bags of 50 kg fertiliser per day. The facility has struggled due to unreliable electricity availability, lack of land area for expansion, and lack of an organised marketing framework. The plant only produces ten 50 kg bags of fertiliser per week since only four workers regularly staff the sorting centre, producing Grade "A" compost by fortifying it with additional nitrogen (3.0 to 3.5%) and phosphate (1.8 to 2.0%), greatly demand by farmers who grew maize and other crops, requiring high Nitrogen (Wahab et al., 2010). The total compostable waste, generated in the community was 9,913 metric tonnes per week, from a total population of 13,720 people in 2002. This represents only a fraction of the organic waste generated in Oyo State.

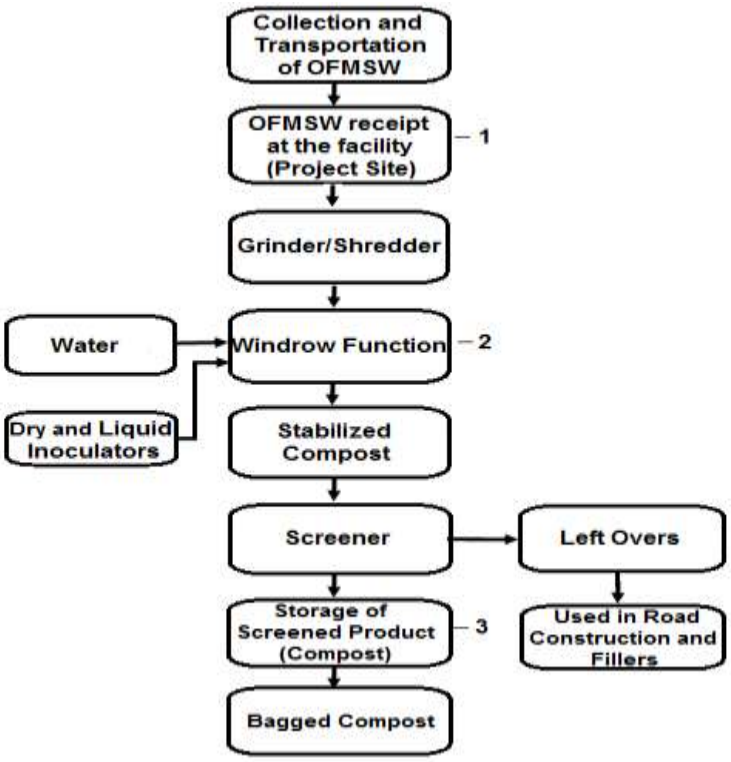

Fig. 2. Flow diagram of compost process by ENL

Ogun

Composting is not explored in Ogun currently, though it is one of the traditional agricultural states in the country; therefore, demand for compost is huge. In the 2015 budget, over N6.4 billion (NGR) (21,713,344 USD) (1.84% of the capital expenditure budget) was appropriated to the state's Ministry of Agriculture for capital projects, though none went to construction of any composting facility in the state.

Ondo

The Ondo State government in 2006 commissioned a waste recovery and treatment project in Akure with the aim of converting generated MSW into useful products. The project is called Ondo State Integrated Waste Recycling and Treatment Project (OSIWRTP). A small composting facility opened in 2006 as part of the project. Unfortunately, the plant is performing below expectation due to financial, maintenance, and collection challenges (Afun & Omowole, 2010). It recovered and processed about 241 metric tonnes of organic waste into compost fertiliser in 2007 but by 2009 this dropped to 50 metric tonnes (Afun & Omowole, 2010). The composting facility currently composts poultry litter and OFMSW from markets. Despite its small size, the compost plant generates more revenue than any other OSIWRTP unit.

Osun

The general manager of Osun State Waste Management Agency (OSWMA) announced in 2014 that the state would separately collect degradable and non-degradable waste for recycling for commercial purposes; however, to date there has not been any evidence of composting effort.

Ekiti

There is little information on composting projects in Ekiti State. However, the National Environmental Standards and Regulations Enforcement Agencies (NESREA) proposed a waste control composting plants to begin operation in Ilokun and Emirin in Ado-Ekiti in 2012, but there has been no information with regards to the progress of these plants since then.

Use of compost in agriculture

The use of compost in agriculture has the potential to significantly improve soils and increase crop yields (Adewunmi et al., 2005). Despite increased oil production in Nigeria, agriculture is still considered the main source of living for most Nigerians. The agricultural sector is the largest sector of the economy, responsible for two-thirds of the entire work force; however, significant challenges of crop production have lowered this sector's performance. The Food and Agricultural Organization of the United Nations (FAO, 2016), presented that the value added per capita has risen only by less than 1% in the last two decades, and it was estimated that equivalent of 10 billion USD has been annually lost due to incessant decline in producing crops like groundnut, palm oil, cocoa, and cotton. In addition, increase in crop production has not kept pace with population growth, consequently giving rise to the imports of food while declining national food self-sufficiency. Crop production is hindered by too much reliance on rain-fed agriculture, inefficient distribution of fertilizer, and its application and inadequate storage facility, among others.

A survey of 40 ornamental plant cultivators found that there had been a significant demand for compost due to the lack of available chemical fertilizers (Adeoye et al., 2013). This lack of available fertilizer led Nigeria to use a meagre average of 10 kg per hectare, compared to Egypt, South Africa, Zimbabwe, and Swaziland that use more than 50kg/hectare (Wallace & Knausenberger, 1997). In developed countries, it is quite common to use an average rate of 100 kg/ hectare and there is a high correlation between fertilizer use and

crop yield at that level (IFDC, 1996; Wallace & Knausenberger, 1997). In Europe and Asia, where composting is now widely practiced, both fertilizer and organic material are in short supply. The cost of fertilizer is rapidly escalating and many areas are experiencing a shortage of organic materials due to crop utilization, erosion, and natural oxidation. Given the increasing global demand of fertilizer it may be difficult for Nigeria to cost-effectively meet its nutrient demands with chemical fertilizers (Bumb & Baanante, 1996). The use of compost as a substitute for chemical fertilizer will save the costs of agriculture, potential to reduce poverty in developing countries, since 70% of the global poor earn their primary income from agriculture and the majority of this population (69%) are from the least developed countries (Khan, 2000; World Bank, 2008). In addition, composting can largely reduce the quantity of disposed waste in dumpsites (Harir et al., 2015).

Environmental implications of composting

Several studies have found that composting OFMSW can significantly reduce environmental impacts compared to landfilling or open dumping (Bruun et al., 2006; Boldrin et al., 2009; Levis & Barlaz, 2011; Olukanni & Mnenga, 2015). To quantify the potential benefits of composting in southwestern Nigeria, a life-cycle model was used to estimate the potential production of compost for each state as well as the associated nutrient recovery and greenhouse gas (GHG) emissions. The waste generation and composition for each state, presented in Table 1, was used as the analysis' basis. The organic fraction was split into food waste and wood, based on IPCC default data for West Africa (i.e. 90% food and 10% wood). The food fraction was then split into compostable (80%) and non-compostable (20%) divisions, based on operating experience in the region (Oyelola & Babatunde, 2008; Adewunmi et al., 2005).

The analysis calculated the potential compost production, nutrient recovery, and GHG emissions if all of the compostable food, wood, and paper in each region were composted instead of landfilled. As such, this analysis represents the maximum current potential for OFMSW composting in the region, and not necessarily a practically-achievable goal (Farrell & Jones, 2009; Taiwo, 2011).

Components of Solid Waste Optimization Life-Cycle Framework (SWOLF) was used to estimate GHG emissions, available nutrients, and potential compost production instead of landfill in each region (go.ncsu.edu/swolf) (Levis et al., 2013; Levis et al., 2014). The composting process model was described by Hodge et al. (2016). Soil carbon storage for the finished compost material and the one due to increased humus formation was estimated. Beneficial use of the available nitrogen, phosphorus, and potassium in the compost were counted as credits to offset mineral fertilizer production. The avoided landfill gas emissions were estimated using the first-order decay model presented by Levis & Barlaz (2011) with default data from Hodge et al. (2016). To simulate a typical landfill in Nigeria, it was assumed that the landfill did not collect or treat the generated gas, and 10% oxidation of the generated methane (CH_4) was utilized based on IPCC-recommended defaults (IPCC, 2007). The system boundaries are from the gate of the facility to final disposal/ land application.

Table 3 demonstrates the life-cycle inventory data for each compostable material, including the associated GHG emissions. Table 4 shows the total volume of generated compost, recovered nutrients, and GHG emissions for each state and the region as a whole.

Table 3. Life-cycle inventory data and greenhouse gas emissions for each material and sub-process

LCI Data	Compostable Food Waste	Wood	Compostable Paper
Diesel Use (L/Mg)	2.2	4.3	1.7
Electricity Use (kWh/Mg)	1.1	1.0	1.0
Composting CH_4 Emissions (kg/Mg)	0.45	0.062	0.63
Composting N_2O Emissions (kg/Mg)	0.024	0.0034	0.017
Soil C Storage (kg CO_2/Mg)	15	72	55
N fertilizer equivalent[a] (kg N/Mg)	0.34	0.071	0.34
Avoided Landfill CH_4 Emissions (kg/Mg)	19	7.7	70
Lost Landfill Carbon Storage (kg CO_2/Mg)	24	1290	896
Compost Volume (m^3/Mg)	0.27	0.29	0.22
GHG Emissions (kg CO_2e/Mg)	**Compostable Food Waste**	**Wood**	**Paper**
Diesel Use (L/Mg)	9	18	7
Electricity Use (kWh/Mg)	1	1	1
Composting CH_4 Emissions (kg/Mg)	11	2	16
Composting N_2O Emissions (kg/Mg)	7	1	5
Soil C Storage (kg CO_2/Mg)	-15	-72	-55
Avoided Landfill CH_4 Emissions (kg/Mg)	-475	-194	-1758
Lost Landfill Carbon Storage (kg O_2/Mg)	24	1290	896
Total GHG Emissions	-438	1046	-888

[a] The potential GHG benefits of the avoided fertilizer use were excluded because the additional nitrogen would not reduce mineral fertilizer use, it would also be more of total nitrogen applied to the crops and thus improve yields.

Table 4. Compost generation, nutrient recovery, and GHG savings for each state and the total region

	Lagos	Ogun	Oyo	Osun	Ondo	Ekiti	Regional Total
Potential compost production (m^3/yr)	895,659	153,423	255,267	117,468	113,094	112,397	1,648,690
Potential N to Soil (Mg-N/yr)	1,069	193	307	144	137	139	1,991
Potential C to Soil (Mg-C/yr)	90,025	19,236	26,667	13,273	12,283	13,183	174,900
Potential GHG Savings ($MTCO_2e$/yr)	-1,277,518	-292,191	-382,749	-196,187	-179,645	-197,277	-2,523,654

Results in Table 4 show there is significant potential benefit to increased composting in south western Nigeria with Lagos state having the highest capacity for compost production, followed by Oyo, Ogun, Osun, Ondo, and Ekiti, respectively. Wallace and Knausenberger (1997) stated that 64% of the fertilizers, consumed by developing countries, is nitrogen-enriched while phosphate and potassium takes 25% and 11% respectively. The emphasis on nitrogen has contributed to nutrient imbalances in many developing countries such as Nigeria. In addition, projected demand for fertilizers in developing countries is expected to be in short supply of the amount that would be required by 2020 to meet food security goals and sustain agriculture. Therefore, additional effort must be made to promote higher levels of fertilizer, as expressed in Bumb and Baanante (1996). The results may underestimate the environmental benefits since they do not include waterborne impacts from uncontrolled disposal, nor do they include the airborne emissions associated with burning at residential or centralized dump sites. Results also show that there is a GHG penalty for composting wood, due to its low methane yield and high carbon storage potential in landfills. However, woody materials are still necessary to compost food waste, and the benefits, associated with composting food

waste and paper, significantly exceed the penalty from composting wood.

CONCLUSION

In accordance with the recommendations of the World Bank concerning waste to wealth initiative (Hoornweg & Bhada-Tata, 2012), compost production for agriculture is the single most beneficial way for Nigeria to accumulate wealth from MSW. Currently, there is limited composting in the region, with significant opportunities to maximise the composting potential. Only three states (namely Lagos, Oyo, and Ondo) possess existing composting projects, and less than 1% of the generated compostable waste was composted in each state, despite the fact that the majority of MSW in each state is compostable. The progress, made so far in the three states, is as a result of initiatives from relevant ministries and parastatals, a high degree of governments' political will to support food production in favour of environmental condition for composting technology, and a strong financial commitment.

Composting is a cost-effective option, addressing two significant problems in the region: the rising cost of fertiliser and the increasing need of organic material to nourish the soil. It is no longer a surprise that the nation's reliance on crude oil as its source of income is very dangerous, citing the example of the sharp decline in the price of oil internationally. To actualize the potentials of composting, it is important that various stakeholders such as federal and state governments, local communities, waste generators, and the private sector, participate in these projects. It will also require appropriate policies and public education from the government to express the need to mitigate poor waste management. Integration with agricultural activities is crucial for the Nigerian government to survive with its diversification of the economy.

As harvests improve and stabilize, national food security will be strengthened and region's sustainable development will be increased. Composting, if successfully implemented, has the potential to increase the productivity of the agricultural sector, conserve resources, save money, and create jobs, thus improving the nation's economy.

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