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An Assessment of Open Dumps and Landfill Management in the Federal Capital Territory, Nigeria- Using Scotland as a Case Study for Structural Development

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Abstract
Environmental pollution resulting from improper waste collection and disposal in the Federal Capital Territory (FCT) is becoming a cause for concern; and with an alarming population growth rate of 9.3% per annum, continued degradation of the environment is inevitable unless a well-structured sustainable waste management system is adopted. Being the capital of the most populous nation in Africa, it is of great importance that the FCT becomes a model city not just for the benefit of the population but also to create a sustainable conducive environment. This research was undertaken to assess and analyse the state of waste management in the FCT and propose engineered landfilling using the UK (Scotland) as a model/benchmark. The study reveals that in the FCT there are no organized well engineered landfill sites on ground that are equipped with liner systems and infrastructure to detect, extract and treat/refine leachate or landfill gas. The Abuja Environmental Protection Board (AEPB) which is the agency responsible for the control, removal and disposal of solid and liquid waste, lacks an established system for segregation and recycling of waste. Although Waste incineration is quite common in the FCT, it is unfortunately not done in a properly controlled environment like that of Scotland, the case study area. It is often done by scavengers and local residents, and when it is carried out by AEPB, it is done haphazardly. This poses a huge environmental, human health and safety risk. This paper therefore recommends that the government should explore the option of developing the current infrastructure to improve collection, segregation and disposal of waste, incorporate in its plans the construction of well-engineered landfill site(s) as well as recycling and utilizing waste as an alternative source of energy. This will enhance efficient waste management, reduce the adverse effects of the current inefficient disposal methods on the environment, strengthen economic development as well as reduce the amount of waste sent to landfill.
Keywords: Landfill management, waste, AEPB, SEPA and Environment,

Introduction

The efficient development of a country's waste management system to an extent depends on the perception that the country has about waste and where waste management lies on its scale of preference (Ayuba et al., 2013). The level of organizational management can be seen from the ability of the country to meet the health demands of the people. A large decider of health problems is cleanliness or the lack of it. There is a huge relationship between cleanliness and health (Singh et al., 2007).

In many parts of the African continent, environmental problems have emerged to pose a great challenge, especially in solid waste. With population growth and waste generation on the rise, there needs to be a quick and effective waste management response to combat the challenges of sustainable development if there's any chance of meeting current needs without jeopardizing the potentials and ability of future generations to meet theirs. (WCED, 1987). As the quantity of waste produced in cities continue to increase daily, the effectiveness of waste management in terms of collection and disposal remains undesirably low in most parts (Chaudhary and Rachana, 2006). Managing waste in urban areas is very important especially given the fact that waste generated from these urban areas most likely ends up being transported to rural and low-income areas for disposal (Ni-bin and Davila, 2008) with the full impacts of waste disposal activities to be felt years afterwards.

One of such waste management methods is landfilling. Normally landfilling should come after Reuse and Recycling (WRAP, 2012), but in most parts of Africa such as Nigeria, these stages are not as popular or deemed as essential as landfilling. Landfilling has been the most common method of solid waste disposal generated by different communities for many years (Komilis et al, 1999). Three types of landfills are important parts of most solid waste systems. These are the open dump, the semi-controlled landfill, and the sanitary landfill. Most of the urban centres in the developing world make use of open dumping as their topmost method of waste disposal (Rushbrook, 1999). According to Agunwamba (1998), in 1998 there were only two landfills in Nigeria. By 2007, the situation had not totally changed as Abuja, the capital city of Nigeria, did not have sanitary landfills for waste disposal, instead deposited their solid waste at the Mpape dumpsite (Imam et al., 2008).

As cities grow and produce waste, it is expected that their solid waste collection systems become more

efficient. Also, the environmental impacts from open dumps continue to become increasingly intolerable. The conversion of open or operated dumps to engineered landfills and sanitary landfills is an essential step to avoid future costs from present mismanagement. This is the plight facing Abuja currently and if nothing is done soon, bearing in mind the ever increasing population growth and expansion, it's only a matter of time before waste management becomes a critical challenge.

The main objective of this of research is to study the current state of landfill management in the FCT with a view of using Scotland as a benchmark study to proffer mitigating techniques that would improve efficiency of waste management and devise efficient ways of converting dump sites to proper landfill sites.

Specific objectives are:

- To assess the current state of waste management and dump sites in the FCT
- Identify landfill management practices adopted by the UK (Scotland)
- Identify and outline proper waste management methods and recommend ideal options on landfill management that will promise success through effective implementation
- Investigate problems affecting proper landfill management in the city.

Study Area

The study area Abuja is the capital of Nigeria. Abuja was created in 1976 and is located in the centre of the nation within the Federal Capital Territory (FCT). It was created as indicated by the Master Plan contrived in 1979. This distributed 2.0% of the FCT zone for government action/use, 49.0% for private advancement, and 32.5% as open/green/recreational ranges to add to the style of the city. The remaining land (16.5%) was utilized for auxiliary administrations, light businesses, other framework and business exercises (National Population Commission, 2012). The arrangement of the city was intended to stimulate development and avoid issues associated with unplanned development of urban communities in Nigeria.

Central Government stations moved to Abuja throughout the 1990s, and all government offices, the base camp of numerous national and multinational organizations and numerous national daily papers are currently in Abuja. This fast development far surpassed what had been expected in the Master Plan, and the number of inhabitants in Abuja now surpasses the first plan limit. In 1991, the number of inhabitants in the FCT was 378,671, and this had expanded to 1,724,205 by 2001. (National Population Commission, 2012)

Anticipated populace figures for the Abuja area foresaw huge development with 5.8 million individuals expected by 2026 (Olanrewaju and Ilemobade, 2009). Sadly, the chance to create a foundation (i.e. waste administration), on par with city development and in accordance with the pre-agreed Master Plan, was lost, and Abuja now imparts a hefty portion of the same issues as other Nigerian urban communities.

Abuja's topography is characterized by Aso Rock, a 400m high stone monument left by water disintegration (kadafa et al., 2013). The Presidential Complex, National Assembly, Supreme Court and a great part of the town stretch out to the south of the rock. Zuma Rock, a 792m high stone monument lies just north of the city towards Kaduna state (Olanrewaju and Ilemobade, 2009)

Huge sights incorporate the Nigerian National Mosque and the Nigerian National Christian Centre. The city's air services are served by the Nnamdi Azikiwe International Airport. Abuja is known for being one of the few urban capitals in Africa that was 'reason assembled' (reason being for security and protection, as Lagos is too close to the port) also, it's one of the wealthiest although plagued with management issues (CIA, 2012). There are also people living on the edges of the city in semi-created country ranges, e.g Mararaba and Karu.

Research Methodology

This research study will be carried out using data assessed from documented materials. This will involve reviewing reports from government agencies, presentations made in workshops, seminars and conferences; reviewing journals, books and research materials on the subject, analysing standards [British, European, etc.], and benchmarks on landfill development and developing scenarios. It will also consist of data obtained from interviewing the site managers of two case study landfill sites. The study areas include; Cathkin landfill facility located in East Kilbride South Lanarkshire Scotland, Greengairs landfill facility located in North Lanarkshire Scotland and data from the Abuja Environmental Protection Board (AEPB) on the major dump sites in the Federal Capital Territory (FCT); Mpape, Gosa, Ajata and Kubwa . Waste flow, waste composition, site operations will be assessed through review of literature and data collection in order to provide a detailed comparison of various landfill management operations (leachate detection, collection and treatment; landfill gas detection, collection and treatment, liner systems etc.) and determining the most viable and suitable landfill management system for FCT, Nigeria.

Results and Discussions

Successful result attained for the actualization of this research was carried out through the assessment on three

landfill site (Gosa, Mpape, Ajata and Kubwa landfill) in Abuja, analysis was made using result obtained from Abuja Environmental Protection Board (AEPB). Furthermore, comparison analysis were made between landfill practices in Scotland, using case studies approach through interviews with the respective site managers; Craig Steel of Greengairs Landfill site and Brian Duncan of South Cathkin landfill facility in Scotland

Waste management in Scotland

In recent years Scotland has successfully reduced her dependency on landfill disposal by increasing the availability of recycling services and more sustainable treatment technologies. Emphasis in terms of technology and improved effective modern methods geared towards regulation have been laid to reduce waste production but also to significantly increase the reuse, recycling and sustainable treatment of waste in Scotland (SEPA, 2013).

Investments in new technology and services have helped to create the conditions for success, coupled with new jobs and business opportunities emerging as a result. A key aspect of this is ensuring that the legislative system keeps pace and deals with the potential environmental hazards in a proportionate, targeted and customer-focused way.

Legislation has played a key role in Scotland's rise towards waste management prowess. Legislation on waste came at a time when Scotland's main method of dealing with waste was landfilling. New policies, practices and technologies have emerged in recent years which mean that the legislative controls have been improved to encourage innovation and ensure that the aims and requirements of the Waste Framework Directive are delivered in their modern context. The Scottish Government and the Scottish Environment Protection Agency (SEPA) have aimed to simplify the system while safeguarding the high levels of environmental and human health protection (SEPA, 2013).

The Scottish Government and SEPA remain committed to the principles of better regulation. Thereby some measures were put in place to ensure that:

- Outdated or unnecessary provisions in legislation are eliminated;
- Regulatory regimes are either consolidated, streamlined or merged where possible;
- Base-regulatory permitting, inspection and enforcement are centred on sound risk principles;
- Companies that break the law are swiftly and effectively apprehended or handled;
- Administrative burdens on companies and regulators are minimised wherever possible;
- Regulators are empowered to enforce regulations in a fair, consistent and proportionate manner;
- Best practice is encouraged and advice to regulated companies wherever possible. (SEPA, 2013)

Zero Waste Scotland

The Scottish Government launched Scotland's first Zero Waste plan on 9th June 2010. Scotland's Zero Waste Plan sets out the Scottish Government's vision for a zero waste society. This vision describes a Scotland where all waste is seen as a resource; Waste is minimised; valuable resources are not disposed of in landfills, and most waste is sorted, leaving only limited amounts to be treated (SEPA, 2013). To achieve this vision, the following measures were adopted:

- Development of a Waste Prevention Programme for all wastes, ensuring the prevention and reuse of waste.
- Landfill bans for specific waste types therefore reducing greenhouse gas emissions and capturing the value from these resources.
- Separate collections of specific waste types, including food, to avoid contaminating other materials, increasing reuse and recycling opportunities and contributing to the renewable energy targets.
- Two new targets applicable to all waste: 70 per cent target recycled, and maximum 5 per cent sent to landfill, both by 2025.
- Restrictions on the input to all energy from waste facilities, in the past only applicable to municipal waste, therefore encouraging greater waste prevention, reuse and recycling.
- Encouraging local authorities and the resource management sector to establish good practice commitments and work together to create consistent waste management services, benefitting businesses and the public.
- Improved information on different waste sources, types and management highlighting further economic and environmental opportunities.

Measure the carbon impacts of waste to prioritise the recycling of resources which offer the greatest environmental and climate change outcomes. This attitude towards waste management makes Scotland an ideal case study

SOUTH CATHKIN LANDFILL FACILITY, EAST KILBRIDE, SCOTLAND

Location and Description

The site is located in Cathkin near to Carmunnock Village in South Lanarkshire. Created with a well-established landfill site plan shown on figure 1 .It was opened to receive household municipal waste in May 2001 (SEPA, 2013) and was closed on the 14th August, 2013 after the time allotted had expired. Owned and maintained by the Glasgow City Council, the site now only accepts inert waste like soil, construction materials like gravel, stones, sand etc. The entire site is approximately 85 hectares in size, however, only 38 hectares (i.e. about 3.7 million m3) of it is designated for landfill purposes. At inception, the site was receiving approximately 400,000 tonnes of waste each year, however the figures reduced since recycling was implemented. It is expected to fully close down in August, 2015.

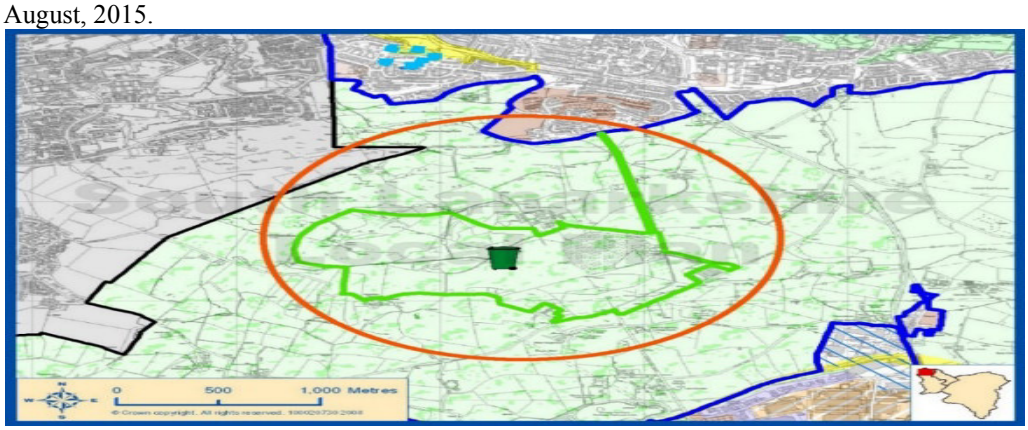

Figure 1: Cathkin Landfill site plan (Source: South Lanarkshire Council, 2001)

Site operations

Liner System and Leachate Treatment: The liner is firstly made of a natural clay based system about 3m rolled with a 'pig's foot' roller to flatten it out. Then a man-made clay GCL is placed next (3-4m rolls) and rolled out across the natural clay layer. This acts as another meter of clay. Installed on top of this is the leak detection system (to detect if the liner is punctured or breached), a maze of electric wires and probes placed all over the surface where the HDPE liner will be placed and welded together. On top of this plastic liner, a drainage carpet is installed. It's an underlay (about an inch in thickness) to cover the plastic layer. It aids the water to reach an attained level in order to drain towards collection point. Then on top this carpet, a 0.3m of 2cm gravel is placed across the base of the cell for protection of the liner and drainage.

The leachate treatment facility has a 1400m^3 total capacity (two treatment lagoons) lagoon 1 as shown in figure 2 is the leachate pumping lagoon while lagoon two shown in figure 3 is discharged leachate lagoon. It is allowed to discharge 300m^3 daily which cannot be higher than 70 mol/L (ammonia per litre) before it is then treated to a consent level and discharged to sewer. The pools can be lowered to about 40% capacity level before they can be filled back to a level of 95% so as to keep the treatment active

Figure 2: **Leachate pumping station (Source: field work 2014)**

Figure 3*: Leachate lagoon being discharged. (Source: field work 2014)*

Landfill Gas Management: The site had a gas extraction and power production plant installed in 2003 and has been drawing gas since then. This plant generates electricity from the methane-rich gas that is extracted. A carbon filter was installed in 2013. All the gas extracted on site goes through the filter, and it filters all the impurities in the gas before it reaches the engines. The plant has 8 engines shown in figure 4 (each being a V20 piston engine seen in figure 5, 1.1 megawatt [MW]) with a full capacity of 7.5MW of power generated. The engine converts the energy in the gas into mechanical torque at one end, and then the generator at the other end converts the torque into electrical energy and then it's fed into the national grid.

GREENGAIRS LANDFILL SITE, AIRDRIE GLASGOW, SCOTLAND

The Greengairs Landfill is a non-hazardous household, commercial and industrial waste site from the North

Figure 4: *The eight 7.5MW capacity engines installed on site (source: field work 2014)*

Figure 5*: Close view of the V20 piston engine (Source: field work 2014)*

Lanarkshire area. Greengairs was opened in 1990 and features leachate treatment and landfill gas collection systems which is used to generate electricity for export into the National Grid. The landfill is owned and operated by Foment de Construcciones y Contratas Environment (FCC, 2013).

As the largest landfill site in Scotland, the Greengairs Mechanical Biological Treatment (MBT) facility has a considerable impact on increasing recycling and composting rates. It is estimated that with MBT installed on site, only 25% of municipal waste arriving at Greengairs (that which cannot be recycled or composted) will be disposed of in landfill.

Location and description

The Greengairs recycling and waste treatment facility lies within the south western part of Greengairs Landfill, approximately 1 km south of Wattston, 1.2km south of Greengairs and 1.4km north of Plains. The landfill activities are currently undertaken as means of reclaiming and restoring a former open cast coal site and are consented until 2038. The site of the proposed facility covers an area of 9.8 hectares, south of the existing Landfill site offices. Ball park Greengairs accepts 1-2,000t of waste materials per week day to 28-45,000t per month.

Liner System: Engineering of cell is performed using an excavated ground which is stable and at least 2m above groundwater, with the procedure using a standard permit of 500mm requirement of engineering clay (5x10-10 m/sec permeability). This acts as a natural geological barrier if linear barrier fails due to unforeseen events. Next, a 2mm HDPE linear material (1x10-15m/sec permeability) is laid. Then a geotextile (carpet) barrier is also placed on top underlying layer. The next step requires the use of gravel filter bed (500mm thick) that acts as a protection blanket for the lining material to stop punctures. This can be reduced in the depth and is placed depending on material grade used on the geotextile barrier. Both are to serve the same purpose of protecting the linear, act as a collection area and wicking material for the leachate produced to ensure it is channelled to collection points via gravity where it is then extracted. The entire purpose of the engineering is to ensure there is a robust and physical barrier to prevent the release of leachate to land surrounding the landfill and most importantly the groundwater. On construction of a landfill cell shown in figure 6, the design parameters are strictly checked by an independent CQA (certificate of Quality Assurance) an auditor who is present throughout the construction process.

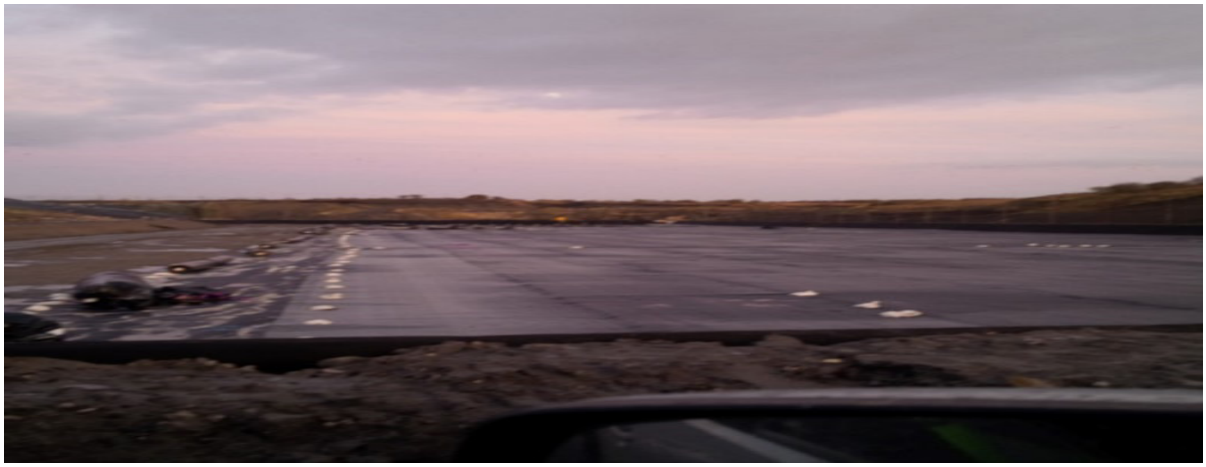

Figure 6*: A vacant landfill cell (Source: field work 2014)*

Landfill Gas management and Leachate Treatment: Currently the site produces 6MWh (Megawatt/hour). It is also connected to the grid with potential to produce 7.2MWh. Meanwhile the leachate system as shown in figure 7 discharges about 100-200m^3 of leachate per day in the leachate reservoir shown in figure 8, from the entire site which has over 10million tonnes of waste. Around about 20-70m^3 comes from the operational cell's large fluctuations due to rain/weather as this is the only open cell, all others have been capped. All is fully treated onsite and discharged at set points and flow rates and so this water naturally returns back into the groundwater system/ ecosystem as a whole so no negative impact on water decrease.

Figure 7: Leachate collection and monitoring system (Source: field work 2014)

Figure 8: *Leachate reservoir (Source: field work 2014)*

Analysis result for both landfill sites

South Cathkin landfill and Greengairs landfill both practice engineered landfilling system, further Information acquired from both site visited shows that they carry out treatment on leachate accumulated; the leachate is pumped from the sump into the treatment tanks. The leachate is then mixed with chemical reagents to modify the pH as well as to coagulate and settle solids which help reduce the concentration of hazardous matter. Further treatment results in a modified form of activated sludge to substantially reduce dissolved organic content.

ASSESSMENT OF ABUJA (FCT) DUMP SITES

The Abuja Environmental Protection Board (AEPB) is the capital's waste management agency consisting of about 8 departments; Public Relations, Accounts and Finance, Environmental Health, Administrations and supplies, Enforcement and monitoring, Environmental monitoring, Planning, Research and statistics, Environmental conservation, Waste management and Sanitation department (inclusive of units such as solid waste, clinical waste and liquid waste) (AEPB, 2012). Municipal waste characterization for the federal capital city and estimated quality of waste deposited by AEPB are shown in table 1 and 2. Solid waste, clinical waste and liquid waste management are the responsibility for the waste management and sanitation department. Although the AEPB contracts waste collection and transfer to contractors which carry out door-to-door collection for residential areas. Designated collection points as well as waste generated by commercial areas and institutions within the Federal Capital City (FCC) are managed by the AEPB. The FCT has three landfill dump sites, of which only two are currently operational under the management of AEPB; Mpape landfill, Gosa landfill

and Ajata landfill. Currently only Gosa and Ajata landfills are currently operational (AEPB, 2012).

Table 1: Municipal waste characterization for the federal capital city. (Source: AEPB, 2012).

Municipal waste characterization for the federal capital city		
Composition of municipal waste	Quantity (tons)	(%)
Paper	16112.944000	25.30
Textile	1930.309900	3.03
Plastics	5357.687800	3.40
Water sachets	9257.822800	14.50
Glass	2250.388300	3.00
Metals	2642.803500	3.14
E-waste	1786.329865	2.80
Organic materials; food and garden waste	28420.761600	42.60
Other organic materials	1948.060000	2.15
Total	63707.107465	100
AEPB (2012)		

Table 2: *Estimated Quantity of deposited waste at the AEPB dump sites. (Source: AEPB, 2012)*

Estimated Quantity of Waste Deposited at AEPB Dumpsite														
Quantity of Waste(tons)														
MONTH								YEARS						
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
JANUARY	1820.9		3262	1373.2	3298.32	1140	3316.22	2379.57	3920.57	4706.23	6023	15117	4262	13500
FEBRUARY	1821		3261.2	1012.7	3071.38	970.93	4278.5	2289.16	3654.23	4781.92	6012	10697	3116	123426
MARCH	2283.4		4077.1	1428	2466.5	966.67	4473.87	2756.69	4159.97	5230.58	6991	10193	2967.8	142366
APRIL	2283.4		2261.7	1226.5	2873.09	1267.11	3549.02	3316.42	4844.42	5666.6	7150	13706	2968.5	102326
MAY	1820.4		4077	1651.4	2854.05	2117.11	4274.13	3597.76	3932.2	6084.26	7765	9885	3212.25	132404
JUNE	2283.4		3261.7	1699.4	2625.52	2099.37	4677.02	4292.79	5364.47	6723.81	7965	9734	4382.25	121883
JUNE	2283.4		3262	1565.9	0	2287.92	5585.11	4825.59	5936.81	6549.6	7981	17116	5546	133362
AUGUST	1820.9		4077.1	1750.8	0	2193.65	6847.86	5718.57	6333.36	6535.97	7965	9601	10348.5	126676
SEPTEMBER	2283.4		3261.7	2105.4	0	3239.37	5211.02	5265.86	5883.18	6948.34	7412	6445	24986.25	128982
OCTOBER	2283.4		3261.7	2330.1	0	3128.95	5825.2	5109.42	6333.16	6349.04	6860	6106	24614	135300
NOVEMBER	1821		4077.1	1332.6	0	2958.02	3907.44	3938.5	6276.74	5865.87	6063	5366	20009.75	137897
DECEMBER	2283.4		3261.7	4868.5	0	2016.11	3662.98	4164.73	5811	5606.62	6218	5285	6461.75	134781
TOTAL(M3)	25088		41402	22344.5	17188.86	24385.21	55608.37	47655.06	62450.11	71048.84	84405	9937.59	112875.1	1432903
TOTAL(tons)	25.088		41.402	22.345	17.189	24.385	55.608	47.655	62.45	71.049	84.405	99.376	112.875	143.29
YEARLY AVERAGE	2.091		3.45	1.862	2.865	2.032	4.634	3.971	5.204	5.921	7.034	8.281	9.406	11.941

MPAPE LANDFILL

The Mpape landfill approximately 15-20m in depth, covers about 16 ha (hectares) of land. This dumpsite was operational from 1989-2005 by the AEPB and was formerly a quarry but was converted to and used as a dumpsite (open dump) after its closure. The landfill is up slope with residential housing 200 m down slope and one of the major issues of concern is the contamination of the ground water within the residential areas near to the landfill. Since boreholes are the major domestic water source within that specific area and generally within the FCT Abuja. The boreholes as of 2013 hadn't been tested to confirm contamination. The leachate was sent to a laboratory in Germany by AEPB to test which major contaminants are in the leachate (AEPB, 2012). AEPB however had tried to operate a controlled dumpsite in Mpape; using intermediate laterite cover (construction waste) and machinery (AEPB, 2012). The landfill has been closed due to exhaustion of space, fire outbreaks and complaints from the surrounding residents who live in close by. Cases of a 'fowl and awful liquid' (leachate) emanating from the buried waste flowing to the surface have been observed and reported, especially during the raining season, which in turn produces more leachate due to infiltration (figure 9). As shown in figure 10, the

residential housing is in close proximity to the landfill with leachate flowing down the slope. During the dry season there are instances of fires from the buried waste causing air pollution and destruction of vegetation within the area.

Figure 9: *Leachate seeping from the covered ground (Source: Kadafa et al., 2013)*

Figure 10: *Residential housing near Mpape landfill showing leachate flowing downslope (Source: Kadafa et al., 2013)*

One of the major issues the AEPB have in managing municipal waste in Mpape landfill is the high volumes of non-degradable aggregates such as polyethylene as shown in Figure 11, which hardly decompose after it has been buried for several years. The cost of recycling polyethylene is higher than the cost of producing new polyethylene which makes it non-profitable to consider recycling (Tunesi, 2010). Polyethylene is still quite popular amongst manufacturers in Nigeria because of its low cost and durability, and as such is used majorly for the packaging of high demand products such as drinks, water and other food products (Ahiamadu, 2007).

Figure 11: *Polyethylene buried years ago in Mpape landfill (Source: Kadafa et al., 2013)*

GOSA LANDFILL

The Gosa site as marked out in the Abuja master plan, is designated for construction of a standard engineered landfill with 505ha provided for a solid waste treatment plant (which includes the engineered landfill, a treatment facility; composting, recycling and waste to energy plant intended to generate 120 megawatts from 3 plants; each generating 40 megawatts) (AEPB, 2012). Geological and hydrological studies contracted out by AEPB show that the site consists of clay-sandy soil which with the incorporation of bentonite, would be an ideal location for an engineered landfill (Kadafa et al., 2013). Operations however started in the 1980s; the initial operation consisting of boring a pit, placing waste within and closure. The site was fenced, had an administrative building and access road (Kadafa et al., 2013). Figure 12, however shows a different picture with the current access road to the landfill in a dilapidated state due to lack of maintenance. This was what initiated the usage of Mpape site as a dumpsite in 1992, till after the exhaustion of Mpape site before operations were relocated back to Gosa site (AEPB, 2012). Sadly, the Gosa landfill site is closed down every year during the raining season due to the inaccessibility of the access road into the dumpsite which is largely because of the clay soil surrounding and underlying the area.

Figure 12: *Access road into main landfill dumpsite (Source: Kadafa et al., 2013)*

A major challenge the AEPB faces regarding management of Gosa landfill is indiscriminate fly-tipping of waste during the raining season due to the inaccessibility of the main tipping point entrance (shown in Figure 13). The indiscriminate tipping increases management costs for AEPB as they have to clear the waste properly and place it at the designated tipping point to ensure the landfill remains operational. Currently engineered waste segregation and recycling is no practiced in FCT Abuja (AEPB 2012). Segregation and recycling is carried out mainly by independent scavengers within the landfill as shown in the figure 14. The scavengers sort out the waste after it is dumped and sells the collected items in bulk to companies located in different parts of the city and the nation at large. AEPB needs to utilize this avenue as a means of generating revenue toward facilitating waste management operations.

AJATA AND KUBWA DUMP SITES

The Ajata dump site began operations in 1999 and no official closure information was available. The Kubwa dump site only operated for about one year after it opened in July, 2004 before problems with odour and random

Figure 13*: Indiscriminate tipping along landfill road (Source: Kadafa et al., 2013)*

Figure 14: *Scavengers collecting recyclable items from tipped waste at Gosa landfill (Source: Tribune Nigeria, 2014)*

fires forced its closure (AEPB, 2012).

The Ajata and Kubwa dump sites sit on a small footprint (approximately 6.5 and 5 hectares respectively) and from field observations, the waste piles observed have been significantly diminished in volume from continuous incineration. Information from AEPB states that these sites are officially closed with future conversion plans to create allocation stations for waste transfer to Gosa site which is larger and spacious. However, indiscriminate waste dumping was still observed during this visit. As noted earlier, these sites were not evaluated for, nor do they have, any beneficial methane gas utilization potential.

Analysis Assessment on Mpape, Gosa, Ajata and Kubwa dumpsites.

Presently, there is no organized well engineered landfill site on ground equipped with liner systems and infrastructure to detect, extract and treat/refine leachate or landfill gas. With population size on the rise yearly, measures have to be taken to ensure efficiency of waste collection, recycling and disposal. The minimum standard in terms of waste management is at least the operation of a controlled dumpsite (Adekunle et. al, 2011). Table 1 and 2 shows that organic and paper waste is of high percentage and need to deviate from dumping to the landfill. Another big challenge observed was the jurisdiction in terms of waste management.

AEPB was set up to manage all waste management and environmental challenges within the Federal Capital Territory, however under the Nigerian constitution, municipal solid waste management is the sole

responsibility of the area councils. This creates a lot of problems for AEPB and inhibits the board from properly carrying out their responsibilities. This also leads to uncoordinated open dumps within some areas.

Waste incineration is quite common in the FCT, however it is not done in a proper controlled environment like that of a well-engineered site. It is often done by scavengers and local residents, and when it is carried out by AEPB, it is done haphazardly. This poses a huge environmental, human health and safety risk.

During the course of this research, other reoccurring issues identified as challenging towards proper and efficient municipal waste management within FCT Abuja where;

- Lack of proper funding,
- Inadequate trained staff,
- Jurisdictional bureaucracies,
- Inadequate basic waste collection and removal equipment (garbage trucks, tractors etc.) and Personal Protective Equipment (PPE),
- Insufficient land,
- Attitude and unwillingness of the residents in terms of waste reduction and recycling.

Comparative analysis of landfills management practice in Scotland and Abuja (FCT) Nigeria

Comparatively landfill management practice of Scotland is far different from that of Abuja. Basically from the landfill site visited, it was clearly shown that Scotland practice a well-engineered landfilling system unlike that of Abuja where dump sites lack infrastructural technology as well as low maintenance techniques. To achieve infrastructural development for dumpsites and future landfill sites in Abuja, the following steps discussed below should be immensely considered.

Legislation: This formed the foundation to which all the supporting pillars were built. Waste legislation for Scotland controls the generation, transportation and disposal of waste within the European Union and the shipment of waste in and out of the EU. It covers controlled waste, duty of care, registration of carriers and brokers, waste management licensing, waste electrical and electronic equipment (WEEE) and the trans-frontier shipment of waste. The Waste (Scotland) Regulations 2012 were passed by the Scottish Parliament on 9 May 2012, in a bid to help make Scotland become one of the most resource efficient nations in Europe (SEPA, 2013). The legislations made provision for businesses and their waste disposal methods (i.e. ensure that waste is properly separated and/or segregated before disposal), elaborated the role local authorities are to play in terms of recycling, waste contractors and their roles as well as banning items like metal, plastic, glass, paper, card and food which have been collected for recycling from going to incineration or landfilling. Nigeria can learn from this as such regulations help give structure and clearly define what the country has set out to accomplish. Also with policies like Landfill Directive and Landfill Tax, legislation is further empowered towards achieving set goals.

Enforcement: This is essential, because it further equips the local authorities to tackle cases or issues with compliance. Nigeria can learn from the structure and power SEPA have in terms of dealing with environmental cases.

Funding: Funding is another integral part in the fight for resourcefulness. Projects in this regard require appropriate funding and consistent attention/interest from both the government and the public community to ensure transparency and commitment.

Landfill sites in the Scotland are well engineered to have liner systems, mechanism for leachate detection, collection and treatment, as well as on-site plants for landfill gas extraction and electricity generation. The latter would greatly augment the city's inconstant power supply.

Standards: Also there are standards that govern any construction done in the UK e.g. BSI or BS 10175, BS EN13125, etc.) These standards cover important aspects of engineering like soil investigation and civil engineering etc. These standards can be looked at closely with a view to improving upon the existing standards.

Two major factors are essentially required to enable the mitigation of waste to landfill sites in Abuja and it includes:

INTEGRATED SYSTEM OF WASTE MANAGEMENT (ISWM)

An ISWM has 5 components. They are waste reduction, reuse, recycling/composting, incineration and landfill disposal. It also involves waste separation at point of creation into categories and identifying the best form of disposal with minimal environmental and health impacts. The rationale for this new system is that, no single system of waste management can deal with all waste in an environmentally sustainable way (Tunesi, 2010). Therefore, it is better to have many closely related processes integrated together. There is a greater level of awareness regarding waste amongst all stake holders here in the UK than when compared to Nigeria. This is helped by an ISWM. Government spends time and money towards educating everyone about the effects of waste on the environment, the individuals, climate change, etc. Different waste management options can be ranked in a waste hierarchy, a framework within which the most desirable waste management options are set out with the

most desirable at the top and the least sustainable at the bottom.
Waste Reduction ► Reuse ► Recycling and Composting ► Energy Recovery with Heat and Power (incineration) ► Landfill

About 400 million tonnes of waste are produced in the UK each year (DEFRA, 2013), less than 10% of which is municipal waste. The remainder is made up of commercial and industrial waste, principally construction and demolition wastes, mining and agricultural wastes, sewage sludge and dredged spoils. Most waste traditionally ends up in landfill sites but the proportion of waste ending up in landfill sites is steadily reducing, and an increasing proportion of industrial, commercial and household waste is being recycled or composted.

ENERGY FROM WASTE (EfW)

Apart from reusing, recycling waste or the largely popular landfill, the use of waste for energy conversion is also of great importance and there are number of different EfW technologies available. They include combustion (incineration), anaerobic digestion (AD), gasification and pyrolysis, which are options for recovering energy from waste which cannot be re-used, recycled, composted or digested (Franchetti, 2013). Although it could be argued that most of these projects take time and research (inclusive of funding) to develop to certain capacity, they are still viable options especially when concerns are made in utilizing every bit of waste possible.

Incineration: This thermal process is one of the more popular EfW options. There are a variety of EfW incineration technologies available such as fluidised bed or moving grate. During incineration, the waste is burnt in the presence of oxygen at a high temperature – normally above 850 °C. The process produces steam which can be used to generate electricity and heat; wastes that are not incinerated remain as a solid residue (WRAP, 2012).

Gasification: Gasification is the thermal process of converting the carbonaceous content of waste into combustible gas and ash in the presence of a reactive atmosphere, air or steam (Samolada and Zabaniotou, 2014). The process occurs at high temperatures, normally above 750 °C, producing syngas ('synthetic gas', which typically contains Carbon Monoxide, Hydrogen and Methane) and a solid residue or char. The syngas can be burnt to produce steam or converted via a prime mover such as a gas engine or turbine which can be used to produce electricity and heat (WRAP, 2012)

Pyrolysis: During pyrolysis no oxygen is used; the waste undergoes thermal degradation at temperatures between 300 °C to 850 °C. The process typically produces a hydrogen rich syngas (which typically contains Carbon Monoxide, Hydrogen and Methane), a liquid oil and a solid char. The syngas can be burnt to produce steam or converted via gas engines to produce electricity and heat or condensed to produce more oils (WRAP, 2012).

Anaerobic Digestion: Anaerobic Digestion (AD) is the process by which microorganisms naturally decompose organic matter present in waste, in the absence of oxygen to produce biogas (a mixture carbon dioxide and methane) and digestate (a nitrogen-rich fertiliser) (DEFRA, 2011). Anaerobic digesters activate the process of AD in enclosed heated tanks, rid of all oxygen to aid micro-organism growth and breakdown of materials.

CONCLUSION AND RECOMMENDATION

CONCLUSION

Municipal solid waste management remains a serious challenge; due to its human health and environmental sustainability implications that has yet to be properly addressed within the FCT Abuja. Waste management encompasses a complete system of handling waste from point of generation, to its disposal. Waste has the potential to cause environmental degradation as well as health hazards to any community and therefore, needs to be properly disposed of. Developed countries such as Scotland have sought numerous ways to manage the growing increase of waste generated. Some common techniques employed today are the engineered landfills and incineration. These techniques cater for generated waste but pose environmental challenges such as production of leachate (which could contaminate the underlying aquifer) and air pollution (landfill gas). As a solution to these challenges, developed cities have resulted to a 5-tier Integrated System of Waste Management (ISWM). This system manages waste in an environmentally sustainable way by adopting strategies to reduce waste generated to the barest minimum.

Improving the Abuja waste management practice involves adopting a simple but reliable system which is responsive to demographic and industrial growth. The suggested waste management system for Abuja could be incorporated into the city's socio-economic development plans. The new system proposes further investment by the government in procuring waste management machinery. AEPB should invest in educating the city's residents of their responsibility in the management of their own waste.

Exploring recycling and the utilization of waste as an alternative source of energy will not only enhance waste management but also strengthen economic development. The reuse of items before they are eventually discarded as waste should be considered as this will limit waste sent to landfill. Hiring services of experts to

evaluate and develop an ISWM is a key factor to increase the effectiveness of Abuja's waste management system. Thereafter, AEPB should consider handing over the administration of Abuja city waste management authority to the hands of private investors. They are more likely to improve waste management strategies especially when mandated by law**.**

RECOMMENDATIONS

To effectively implement any waste management strategy, more efforts must be made to accurately improve the waste audit (which identifies the trend in the nature and quantities of wastes generated in the city). Stock taking is very vital in terms of tracking progress or failure. Most records are out-dated and not easily available.

Also, emphasis should be placed on reviewing appropriate legislation, developing and implementing it via acts or directives to ensure a reliable system which would help decision makers, enforcement authorities and other stakeholders better define duties and responsibilities. Other ways to improve waste management in Abuja include but not limited to:

Increased Government Investment: The government could invest more resources in personnel, vehicles, sanitary landfills and advanced technologies, as well as provide improved funding for AEPB. Waste specific bins would be provided around the districts clearly marked with the kind of waste that should be deposited in it. Thus some bins could be marked biodegradable and others non-biodegradable. It could go further to list some bins as paper, some as plastic, glass, batteries, computer hardware, green waste, old clothes and textiles. Residents and commercial outlets would be obliged to pay for waste clearing services provided to them as a means of generating revenue and recovering cost. Improved cost recovery ensures a financially sustainable waste management system. Customer charges can gradually be introduced and set at reasonably affordable prices to ensure a fully socialized system of waste management. This system would encourage further private sector involvement and allow further improvements to be carried out. This way, waste reduction could be encouraged.

User Attitudinal Responsibility: There is the need for increased awareness via citywide campaigns, TV ads, radio broadcasts and effective use of social media to educate people on their roles in waste management. It should involve instructions on how, where and when to dispose of waste as well as separation of their waste before disposal. Also, an obligation to call AEPB wherever a violation occurs and appropriate sanctions for violators could be emphasized. Public involvement is key in developing such a system, especially in terms of policy making. This helps establish institutional credibility, develop citizen empowerment, foster social responsibility and enhance information dissemination.

Recycling/Reuse: Recycling reduces cost of disposal, decreases the volume of waste disposed and preserve natural resources by preventing waste from contaminating the air, soil and underground water. With improved technologies, about 50 per cent of the world's energy requirements could come from renewable sources such as recycling waste. If the government looks into alternative uses for waste, such as power generation, a significant proportion of Abuja's energy requirement could be supplied from its own waste. Additionally, the culture of reusing waste from households needs to be encouraged. Reusing items in their existing form or alternate form does not require industrial processing. This reduces the amount of waste generated and keeps cost of waste management low.

Fostering Private and Social Partnership: After an elaborate plan has been put in place, the government can consider handing over the administration of the city's waste management to private enterprises or increase their involvement. These enterprises will oversee the daily operation of waste management services provided within the city. They usually operate on a profit basis and are more likely to improve and enhance services for collection, treatment including the disposal of waste as they are mandated by legislation. Thus, there would be government control at the highest level, but the private bodies will have sufficient autonomy to make their operational and financial decisions.

The Nigerian Government in collaboration with AEPB should upgrade the open dump landfills to engineered landfills, or at least focus on one or two of them, then overtime move the open dumps to these sites. This would ensure structure and efficiency, as well as help clean up the city.

Develop and implement an ISWM and a proper remediation of Mpape landfill to reduce risks and also current environmental impacts.

Construction of a proper access road into Gosa landfill and ensure proper regular maintenance of existing waste disposal machines. It is quite common for people to wait till a machine breaks down before they think of repairing or replacing it as against regular maintenance. Regular maintenance helps lower long run costs and also ensures durability of machines.

REFERENCES

Abuja Environmental Protection Board (AEPB), 2012. Federal Capital Territory, Nigeria

Adekunle, I.M., A.A. Adebola, K.A. Aderonke, O.A. Pius and A.A. Toyin, 2011. Recycling of organic wastes through composting for land applications: A Nigerian experience. Waste Management. Res., 29(6):

582-93.

Agunwamba, J. C. (1998). Solid waste management in Nigeria: Problems and issues. Environmental Management, 25(2), 849-856

Ahiamadu, N.M., 2007. The Challenges of Municipal Solid Waste Management in Nigeria. Proceeding of 8th International Conference "Waste Management, Environmental Geotechnology and Global Sustainable Development, Ljubljana, SLOVENIA. August 28-30. pp 47-52

Ayuba K.A., Abd Mnaf L., Sabrina, A.H. and S.W. Nur Azim, 2013. Current Status of Municipal Solid waste management in F.C.T Abuja. Research Journal of Environmental and Earth Sciences 5 (6): pp 295 – 304.

Central Intelligence Agency, 2012. World Factbook: Nigeria. [online], Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html [Accessed 13th march, 2016]

Chaudhary R., Rachana M., 2006. Factors affecting hazardous waste solidification/stabilization: A Review. In: Journal of Hazardous Materials B137 pp.267–276

Department for Environment, Food and Rural Affairs (DEFRA). 2011, Anaerobic Digestion Strategy and Action Plan: A commitment to increasing energy from waste through Anaerobic Digestion, [Online]. Available from: https://www.gov.uk/government/uploads/system/ uploads/attachment_data/file/69400/anaerobic-digestion-strat-action-plan.pdf.[Accessed 18th July, 2016]

Department for Environment, Food and Rural Affairs (DEFRA). 2013, Energy from Waste: A Guide to the Debate, [Online]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221042/pb13892-energy-from-waste.pdf.[Accessed 6th February, 2016].

Foment de Construcciones y Contratas (FCC) Environment, 2013. Waste Management and disposal: A best practice business guideline. [Online], Available from: http://www.fccenvironment .co.uk/assets/files/pdf/content/20664-fcc-ebook-aw-v3-lr-0608-13.pdf
[Accessed 10th July, 2016]

Franchetti, M. 2013, "Economic and Environmental Analysis of Four Different Configurations of Anaerobic Digestion for Food Waste to Energy Conversion using LCA: A Food Service Provider Case Study", Journal of Environmental Management, Vol. 123, no. 0, pp. 42-48

Imam, A., B. Mohammed, D.C. Wilson and R. Cheeseman, 2008. Solid waste management in Abuja, Nigeria. Waste Management. 28: 468-472. International Journal of Politics and Good Governance 2(2.2):1-18.

Kadafa A.Y.,latifa A., Abdullahi,H.S., and Sulaman W.A 2013 comparative Assessment of the municipal solid waste management service.Nature and Science11(6):154-164

Komilis D. P., Ham R. K. and Stegmann R, 2009. The Effect of Municipal Waste pretreatment on landfill behaviour: a literature review. Waste Management and Research Volume 17, February, Issue 1, pp 10–19

National Population Commission Nigeria (NPC), 2012. National Demographic and Health Survey. [online], Available from: http://www.populationgov.ng/index.php/2013-nigeria-demographic-and-health-survey.
[Accessed 4th January, 2016]

Ni-Bin, C. and E. Davila, 2008. Municipal solid waste characterizations and management strategies for the lower Rio Grande valley, Texas. Waste Management. 28: 776-794.

Rushbrook P., 1999. Safe management of wastes from health-care activities. World Health Organization, Geneva. ISBN 92 4 154525 9. pp 58-59

Samolada, M.C. and Zabaniotou, A.A. 2014, "Comparative Assessment of Municipal Sewage Sludge Incineration, Gasification and Pyrolysis for a Sustainable Sludge-To-Energy Management in Greece", Waste Management, vol. 34, no. 3, pp. 411-420.

Scottish Environmental Protection Agency (SEPA), 2013. Landfill. [online], Available from: http://www.sepa.org.uk/waste/waste_regulation/landfill.aspx
[Accessed 20th May, 2014]

Singh A, Chandra S, Kumar Gupta S, Chauhan LK, Kumar Rath S., 2007. Mutagenicity of leachates from industrial solid wastes using Salmonella reverse mutation assay. Ecotoxicol Environmental Safety. February. pp 210-216

Tribune Nigeria Newspaper, 2014. 'Scavenging: More wastes, more wealth'. [online]. Available from: http://tribune.com.ng/life-and-living/item/7955-scavenging-more-wastes-more-wealth/7955-scavenging-more-wastes-more-wealth
[Accessed 4th April 2016]

Tunesi, S., 2010. LCA of local strategies for energy recovery from waste in England: Applied to a large municipal flow. Waste Management. pp 561-571

Waste and Resources Action Programme (WRAP), 2012. Energy from waste fW Development Guidance, [online]. Available from: http://www.wrap.org.uk/sites/files/wrap/O_And_EFW_Guidance_FULL.pdf

[Accessed 1st June, 2016]

World Commission on Environment and Development (WCED), 1987. Our Common Future. United Nations Report. [online] Available from: http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf

[Accessed 11th March, 2016]