



Research Article

Assessment of landfill sites for solid waste management in Delta state, Nigeria

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Landfills remains an important component in waste management as it deals with municipal solid waste directly and complements alternative waste management technologies, which in themselves give rise to residues that require disposal ultimately via landfill. As an assessment study, the work was carried out by visitation to existing dumpsites to obtain needed data and information through the instrumentation of a checklist, interviews, questionnaire and focus group discussions. Stratified random sampling was also used to provide appropriate representation of the societal classes in the population across the 25 Local Government Areas in the State. Results showed that most solid waste collected are deposited in open dumpsites/ landfills on the outskirts of urban areas thereby forming breeding sites for disease vectors and polluting the environment and plausible recommendations for improved waste and environmental management in the State.

Keywords: Solid waste, landfill, dumpsite, waste management, Delta state.

INTRODUCTION

The cities of third world countries are growing at very rapid rates compared to those in the developed nations (UN-Habitat, 2010). Such high rate of growth of cities has implications for the provision of urban infrastructural services to prevent the proliferation of urban slum. The increasing growth of cities, therefore, has implications for municipal waste management among other social services required in the urban communities (Ogunrinola and Adepegba, 2012). Waste management is the collection, transport, processing, recycling or disposal of waste materials; and can be regarded as one of the most challenging areas of modern environmental management (Egun, 2009).

Despite the intensive efforts in the other methods of disposal, and application of policies on waste reduction and reuse, landfills still remain as the essential part of the solid waste management plans in majority of the World (Ozeair and Mohsen, 2010). Landfills should not be viewed as being in competition with other waste

management technologies. Rather it complements alternative waste management technologies, as all alternative waste treatment systems deal only with some portion of the waste stream, and in themselves give rise to residues that require disposal ultimately via landfill. In many cases, a landfill is the only option available to the Local Government Area waste management units and Private Sector Participants (PSPs) after the collection of municipal solid waste.

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LANDFILL SITE OPERATION

A landfill site or dumpsite is a site for the disposal of waste materials by burial. It is the oldest form and most common method of waste treatment and disposal in so many places around the world. Three types of landfills are normally used for solid waste disposal and they are: secured or sanitary landfills, controlled landfills and open dumps.

Open Dumps

These are dumps where there are no standards for refuse dumping (Gouveia and Ruscittodo Prado, 2010). They are locations where illegally dumped, abandoned piles of garbage and debris are left in large quantities. They have the lowest initial capital investment and operating cost; and are generally sited in vacant plots of land and are typically developed in low-lying marshy lands, often as a means of reclaiming land for subsequent development. Open dumping of municipal solid waste which is practiced by about three-fourth of the countries and territories in the world are a primitive stage of landfill development (Kumar, et al; 2004); and represent an increased risk to groundwater quality and health risks to surrounding residents.

Controlled Landfills

These are non-engineered disposal sites at which wastes are deposited in accordance with minimum prescribed standards of site operation. Typically controlled landfills have minimal site infrastructure, with improved operational and management procedures. The site is generally identified on the basis of land availability and convenience and is already being used as an open dump; and not on the basis of technical, environmental or financial criteria. Also, there is typically little provision for the management of pollutants released during decomposition of municipal solid waste.

Secured or Sanitary Landfills

A secure landfill is a carefully engineered depression in the ground (or built on top of the ground, resembling a football stadium) consisting of a bottom liner, a leachate collection system, a cover, and the natural hydrogeologic setting. The aim is to avoid any hydraulic [water-related] connection between the wastes and the surrounding environment, particularly groundwater (Environmental Research Foundation, 2011). The use of sanitary landfills is not feasible for many waste management authorities of most countries due to cost constraints.

During landfill operations the waste collection vehicles are weighed at a scale or weighbridge on arrival and their load is inspected for wastes that do not meet up with the landfill's waste acceptance criteria. Afterward,

the waste collection vehicles use the existing road network on their way to the tipping face or working front where they unload their contents. After loads are deposited, compactors or bulldozers are used to spread and compact the waste on the working face. Before leaving the landfill boundaries, the waste collection vehicles pass through a wheel cleaning facility. If necessary, they return to the weighbridge in order to be weighed without their load. Through the weighing process, the daily incoming waste tonnage can be calculated and listed in databases for record keeping.

Typically, in non-hazardous waste landfills, in order to meet predefined specifications; techniques are applied by which the wastes are confined to as small an area as possible; compacted to reduce their volume and covered (usually daily) with layers of soil. The space that is occupied daily by the compacted waste and the cover material is called a daily cell. Waste compaction is critical to extending the life of the landfill. Factors such as waste compressibility, waste layer thickness and the number of passes of the compactor over the waste affect the waste densities.

The existence of uncontrolled municipal solid waste (MSW) landfills have resulted in adverse environmental impacts, public health problems, socio-economic challenges and increased public opposition. Literature exist of several studies on the correlation between environmental pollution arising from waste dumps and public health, and the social consequences of the present urban waste management issues in developed and developing countries (Aatamila et. al. 2010; Gouveia and Ruscittodo Prado, 2010; Nwanta et. al. 2010; Ogunrinola and Adepegba, 2012). This study is aimed at assessing the present status of dumpsites/landfills utilized for waste management activities in Delta State; its statutory compliance to environmental sustainability principles; indigenous/ public perception of its location and operational activities; and plausible recommendations for improved waste and environmental management in the State.

STUDY AREA

Delta State is located between longitude 5°00C and 6°45C East and latitude 5°00 and 6°00 North in the Niger-Delta region of Nigeria, with a total land area of 18,050 sq. km and an estimated population of 4,098,291 people (Federal Republic of Nigeria Official Gazette, 2007). The State is made up of twenty five (25) Local Government Areas (LGAs); twelve (12) major urban centres with Asaba as the capital city and Warri as her largest commercial city and the most populated in the state (Egun, 2009). It has a tropical climate marked by dry and rainy season distinctly; average annual rainfall of about 229 cm; average temperature of 30°C (81°F) and vegetation varying from the mangrove swamps along the coast to rainforests in the north. Delta State is a part of the Niger Delta

Structural Basin, with the surface rock in parts of the State consisting of the Ogwashi-Uku Formation, while the subsurface stratigraphy units of Benin, Agbada and Akata Formations occur throughout (Kogbe, 1976).

The geographical setting of the State has very serious ecological problems such as erosion and flooding which are widespread phenomena in the State. The critical environmental issues that need to be addressed cover not only waste management but also water supply, wastewater treatment, and environmental protection. Waste collection and disposal in particular is inadequate and does not meet the United Nations (UN) technical standards. Level of awareness about environmental issues is also poor, not only at the community level, but also at administrative level as well (Egun, 2010).

METHODOLOGY

As an assessment study, the scope of the work included visitation to existing dumpsites to obtain needed data and information through the instrumentation of a checklist, interviews, questionnaire, and focus group discussions. Stratified random sampling was also used to provide appropriate representation of the societal classes in the population. A total of 2,500 persons were interviewed, consisting of about 100 respondents in each of the 25 Local Government Areas in the State.

Focus group discussion – a form of qualitative research (Greenbaum, 2000); was used to collate public perceptions, opinions and attitudes towards waste disposal practices and landfill site location, with the researcher as the facilitator.

Interviews and administration of questionnaire to Private Sector Participants (PSPs) in waste management in the State; Environmental Health Officers and Environmental management experts to get an insight into the operability of landfills and their opinions. Also, some questions were asked exclusively to experts/ professionals in the field of soil science, chemistry and environmental management.

Checklist prepared by the researcher was applied through direct visitation. The main issues assessed included: distance of the housing units to the dump site, water source and methods of refuse disposal / sanitation, presence/ absence of 'buffer' zones, presence/ absence of safe limits for location of wells and boreholes, and compliance to regulatory criteria obtainable in the laws of the Federal and State Environmental Protection Agency of Nigeria, and other non-regulatory criteria.

OBSERVATION AND DISCUSSION

In Delta State, all the municipal solid waste and garbage collected are deposited in the various open dumpsites/ landfills located on the outskirts of urban

areas where there are water bodies, arable farmlands, and rural settlements; which form breeding sites for disease-carrying vectors such as rodents and mosquitoes in the communities. A survey across the State shows that there are no properly sited landfill site, and most existing dumpsites/ landfills are developed as a result of the negligence of the Environment/ Public Health officers to check the indiscriminate dumping of waste (Figure 1); which has led to the utilization of unsuitable land areas such as canals, swamps, underneath bridges, laterite excavation sites, river banks etc. for landfill operations. This is a common feature in the urban centres, as the "Not in my backyard" (NIMBY) phenomenon of waste disposal exhibited by residents in the neighbourhood has resulted in the utilization of undeveloped lands within the residential areas as dumpsites; which are sometimes subsequently relocated in the course of urban renewal development projects.

Pollution

The inappropriate location of solid waste disposal sites has resulted in the contamination of surface and ground water, soil contamination, air pollution, spreading of diseases by various vectors, aesthetic problems and societal nuisance (Egun, 2011; Weli and Adekunle, 2014). Environmental pollution generated by the various dumpsites specifically in the forms of obnoxious odour oozing from the dumpsite; regular discharge of pollutants and effluents into the atmosphere and water bodies as a result of incineration activities on the dumpsite, very dirty and unkempt environments is clearly obvious to every observer and passer-by. The levels of Suspended Particulates Matter (SPM) in one of the studied dumpsites ranged between 773 and 801 $\mu\text{g}/\text{m}^3$ which is three (3) times more than the regulatory limit of 250 $\mu\text{g}/\text{m}^3$, which may be attributed to huge oily smoke billowing from the sites; presence of heavy metals, ammonia and phosphates in water sources (FEPA, 1995; Ohwohere–Asuma and Aweto, 2013; Rim-Rukeh, 2014). The extent of air and water pollution is worse in the raining season as a result of offensive and disease-carrying odour, as well as surface water pollution.

Dumpsite fires

A common observation was the presence of dumpsite fires which are used by the dump site operators to reduce the volume of waste, operating costs, and increase a dump site's operating life. Dump sites fires have been categorise into two, surface and underground fires (FEMA, 2002). Surface fires involve recently buried or uncompacted refuse, situated on or close to the dump site surface in the aerobic decomposition layer. Underground fires in dumpsite occur deep below the dump site surface and involve materials that are months or years old; and are generally more difficult to extinguish than surface fires.

Table 1. Which criterion do you think is the most important when locating a landfill/ dumpsite?

	Freq.	Percent (%)	Valid %	Cumulative %
Distance from residential area	353	47	47	47
Distance from water resource	105	14	14	61
Depth of Water table	75	10	10	71
Soil and Geology characteristics	60	08	08	79
All of the above	157	21	21	100
Total	750	100	100	

Table 2. Do you consider distance to landfills/ dumpsites when purchasing land for residential use or renting a home?

	Freq.	Percent (%)	Valid %	Cumulative %
Yes	1,375	55	55	55
No	625	25	25	80
Undecided	500	20	20	100
Total	2,500	100	100	

Table 3. What are your reasons for considering distance to landfills/ dumpsites?

	Freq.	Percent (%)	Valid %	Cumulative %
Odour	247	18	9.9	9.9
Aesthetic Nature of Neighbourhood	220	16	8.8	18.7
Environmental Health	275	20	11.0	29.7
All of the Above	633	46	25.3	55.0
Total	1,375	100	55.0	

Observed dumpsites show the presence of both surface and underground fires, evident by the emission of dense black smoke. Also observed was spontaneous combustion of materials in the dumpsites (Rim-Rukeh, 2014), and deliberate fires by scavengers/ waste pickers to aid their search.

Infrastructure and Management

There is poor sanitation practice within and around the dumpsite, inadequate manpower to supervise daily activities, lack of necessary equipment for clean-up activities within the refuse dumpsite. Visited dumpsites showed the absence of weighbridges for the weighing of waste collection vehicles entering and existing the dumpsites; thereby making it difficult to collate the tonnage of waste deposited daily at the various dumpsites for database/ record keeping. Also there are no vehicle wheel cleaning facility available; which has led to the pollution of local roads from wheels of vehicles when they leave the dumpsite, and infrastructure disruption such as damage to access roads by heavy vehicles have been observed.

Economic Activity

As in many developing countries; dumpsites in addition to being a place for depositing waste, are places of work for waste pickers, waste collectors using push-cart to dump refuse on waste sites, waste buyers who sell them to recyclers and re-users, among others

(Aderibigbe, 2010; Egun, 2012). Waste pickers/ scavengers are seen actively on major dumpsites across the State, with some setting up temporary accommodation for themselves within the perimeter of the dumpsite. The activities of the waste pickers have led to a high increase of waste diversion for recycling and reuse especially for metal scraps/ materials.

Considering the criterions for landfill site selection; the common criterion seen to be considered as a priority in landfill site selection across the State is the distance from urban/ residential settlement, which showed the highest response of forty-seven percent (47%) and twenty-one (21%) regarded every aforementioned criteria as important in the sitting process (Table 1).

A good majority of the respondents (55%) across the social strata sampled gave a positive response in the consideration of distance to landfills/ dumpsites when desiring a land for residential purposes; giving reasons of odour, aesthetic nature of neighbourhood and environmental health (Table 2 and Table 3). Several studies have also reported significant correlations between air quality and certain diseases such as, shortness of breath, cardiovascular problems, increased morbidity and mortality rates; as medical tests carried out on humans living around dumpsites shows evidence of infections from water, land and air pollution (Ayotamuno and Gobo, 2004; Laden et al., 2000; Nwanta et. al. 2010; Aatamila et. al. 2010). Also, research studies have shown that proximity to landfill

Table 4: Do you think improper waste disposal has effect on the properties of soil/ land?

	Freq.	Percent (%)	Valid %	Cumulative %
Yes	750	100	100	100
No	-	-	-	-
Total	750	100	100	

Table 5. Are dumpsites in the State properly managed?

	Freq.	Percent (%)	Valid %	Cumulative %
Yes	-	-	-	-
No	1,750	70	70	70
Undecided	750	30	30	100
Total	2,500	100	100	

Table 6. Are you satisfied with waste management activities in the State?

	Freq.	Percent (%)	Valid %	Cumulative %
Yes	250	10	10	10
No	1,750	70	70	80
Undecided	500	20	20	100
Total	2,500	100	100	

Table 7: Integrated Waste Management Scheme is capable of creating employment

	Freq.	Percent (%)	Valid %	Cumulative %
Yes	2,175	87	87	87
Undecided	325	13	13	100
Total	2,500	100	100	

sites depresses the value of residential properties. It is also seen that the perceived quality of life of the respondents, security and total outlook of the area is affected negatively; hence the value of residential properties around this site is more reliant on demand rather than suitability or choice (Nelson et al., 1992; Ijasan, et al., 2012). This is reflective on the personal monthly income; as earnings is positively related to owning a house as well as the distance of residential accommodation to the pollution source – the dumpsite, and lowering the rate of being affected by effluents and disease vectors (Ogunrinola and Adepegba, 2012).

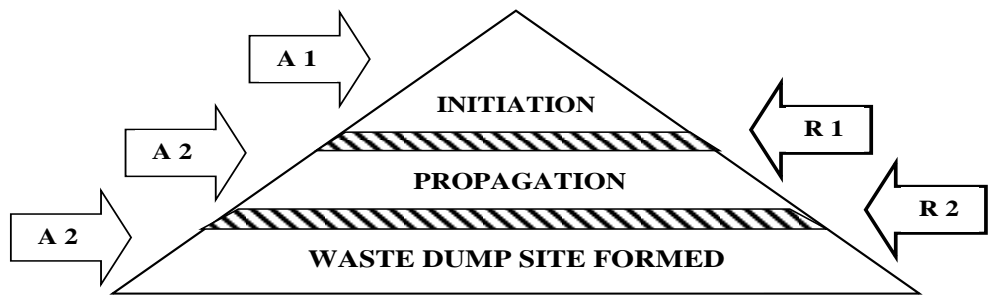
There was an observed high response (100%) to the direct correlation of improper waste disposal and the properties land and ecology (Table 4). Uncontrolled dumpsite and waste dumpsites threaten the groundwater supply as movement of leachates from dumpsites through the soil and the aquifers pose a risk to the environment. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designed waste disposal facilities (Amadi et al., 2012). As the release of pollutants through leachates from both functional and abandoned dumpsites pose a high risk to nearby soil and

groundwater if not adequately managed (Ikem et al., 2002).

There was a high disaffection among respondents (70%) to the management of landfills/ dumpsites (Table 5); and the waste management activities/ operations (Table 6) in the State.

Respondents showed a positive response (87%) to the capacity of an integrated waste management scheme in generating employment to both skilled and unskilled persons (Table 7).

Though open dumpsite is the easiest form of disposal of municipal solid waste that is available and affordable to Private Sector Participants (PSPs) and also utilized by the Waste Management Board; this basis on financial terms neglects the direct and indirect costs associated with the continuing and increasing environmental degradation along with its concomitant effect on public health and environmental sustainability. Taking into cognisance the potential and actual impacts of associated direct and indirect costs; there is a fundamental need for upgrading the overall standards of final disposal of Municipal Solid Waste in the State.



ACTIONS:

- A 1:** Disposal of waste on undeveloped/ virgin lands by residents within the neighborhood (NIMBY)
- A 2:** More waste deposited on the site, as residents of the locality now utilize site for permanent waste disposal.
- A 3:** Further deposit of waste on the site; waste transferred to the site from collection points by waste pickers. Also Scavenging activities carried out on the site.

REACTIONS:

- R 1:** Stoppage of waste disposal on the site by the property owner (private). Thereby terminating growth
- NO ACTION:** Negligence of duty of Environment/ Community Health Officers, lead to the dumpsite growth
- R 2:** Environmental/ Health officers are notified and instead of a total clear out of waste; they incinerate the waste on the site with the objective of reducing waste volume before clearance.
- NO ACTION:** Further negligence by appropriate authorities especially when the site is situated in areas habited by low income earners, lead to the improper siting of dumpsites/ landfills.

FIGURE 1: Schematic diagram of the Progressive Development of Improper Waste Dumpsites/ Landfills in Delta State.

RECOMMENDATIONS

Landfill is a necessary component of the waste management system that will be developed. The open dumping system that is been practiced in the urban centres and across the State over the years is not environmentally sound and socially acceptable; and needs to be highly discouraged. As this has also seen the rural areas and poor communities having to bear the waste burden as their reserved farmlands and environment are been selected and sacrificed for dumpsite operation. (Duru and Njoku, 2012). Therefore, the following recommendations are made:

Controlled Dumps: The open dumpsites across the State should as a matter of necessity be closed and rehabilitated to protect the public and the environment. For open dumps found to be located in hydro-geologically suitable locations; if carried out sensitively and with due attention to the protection of the environment including groundwater and surface waters; conversion of the open dumps to controlled dumps may be feasible with little capital outlay and few increased costs. Controlled dumps are relatively simple and relies upon operational and management practices. New sites should be properly selected for controlled dumps.

Landfill Site Selection: The suitable siting of landfills, taking into cognisance significant amount of spatial

information, including environmental, social, economic and engineering data is a necessity and major challenge to effective solid waste management in Nigeria. Other criteria such as geology (lithology), groundwater depth, water supply well points, hydraulic conductivity/ soil structure, land-use/ land-cover, slope, drainage pattern (water bodies), etc. should henceforth be given high priority consideration when selecting sites for landfill operations. Geographic Information System (GIS) along with appropriate models and spatial analysis methods have been shown as useful tool in the study and determination of suitable sites for landfill operations; location of treatment facilities; and the optimization of waste collection and transport (Ersoy and Bulut, 2009; Govindaraju, et al, 2011; Surendra, 2013; Egun, et al, 2015), and should be utilized for landfill sitting in the State.

Environmental Monitoring: The overwhelming environmental significance and impact of leachates on soil and nearby groundwater and surface water has become a great concern because of its serious threat to the quality of life of human beings and the ecosystem. There is a present need for environmental compliance audit of all dumpsites in the State to develop an audit database and guidelines for proper monitoring, implementation and management of dumpsites. Regular monitoring of the baseline quality of the groundwater to determine the operational status of

dumpsites. Periodic assessment of air quality in the surrounding land use areas in relation to distance to landfill sites; and the presence of potential vectors for the spread of diseases in dumpsites. For improved health status of the populace and for better labour market productivity, a resettlement programme for persons living within 250 metres radius programme is a must for the government (Ogunrinola and Adepegba, 2012).

Infrastructures: Upgrading of standards is a continuous process. Infrastructural upgrades needed include: Primary access road constructed to high standard to minimize wear and tear on delivery vehicles and maintain traffic ability of haulage routes to waste discharge areas in wet weather conditions. Constructing surface water interception ditches to isolate surface water and storm water flows from deposited waste/ dumpsites in order to avoid potential wash-out. Site support facilities and services such as small site offices, electricity, water etc.

Management: Poorly run landfills may become nuisances because of vectors such as rats and flies which can cause infectious diseases; wildlife disruption, dust, odour, noise pollution, and reduced local property values. Therefore there is need for the regulation of access and activities on dumpsites. Such as regulation of waste pickers activities and prevention of dumpsite fires; control of pests and vermin; reduction in persistent odours; and reducing impacts of site activities upon developments adjacent to the site to minimum levels. Recording of waste quantity and types brought to the various dumps by a site clerk for efficient planning and operation. Recruitment of experienced Operations Manager and appropriate training of staff, and enforcement of site operational practices.

Waste Legislation/ Policy Formulation: Waste diversion or landfill diversion is the process of diverting waste from landfills through recycling, composting and waste-to-energy. The success of landfill diversion policies can be measured by comparison of the size of the landfill from one year to the next. The cost issue has prompted some municipal government authorities in some developing nations to adopt cost-reduction programme as well as conservation tenets of "reduce, reuse, and recycle". This is being achieved through aggressive community education of consumers and producers on waste reduction methods, while institutions and businesses that could buy up discarded materials are facilitated to enhance recycling and reuse. These activities not only have positive environmental impact on the communities involved, but also have an important economic dimension (Goldman and Ogishi, 2001).

Industrialization/ Integrated Solid Waste Management: An integrated approach to waste management should be exploited by the State

Government as it has the capacity of creating employment to both skilled and unskilled persons; and maintaining a healthy environment. Government should make financing mechanisms/ instruments available for the setting up of cottage industries involved in recycling and utilization of waste thereby increasing the volume of waste diverted from landfill sites. Also, waste as a resource potentials of the State should be showcased to attract Foreign Direct Investments (FDI) in the establishment of integrated waste management projects.

CONCLUSION

For any alternative waste management technologies/ methods to succeed; they must be sustainable, having taken into cognisance environmental, commercial and economic considerations. This requirement is invariably associated with increased costs. Financially, the use of landfills remains the least cost solution for final disposal of municipal solid waste in developing economies. Therefore, in the short to medium term (next 5 to 25 years), controlled dumps and secured landfills remain the options for replacing open dump sites system in Delta State and across Nigeria.

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Accepted 15 August, 2015.

Citation: Egun NK, Iniaghe OP, Evbayiro OJ (2016). Assessment of landfill sites for solid waste management in Delta state, Nigeria. *Journal of Environment and Waste Management* 3(1): 116-122.



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