Available online at www.sciencedirect.com
ScienceDirect
Waste Management 27 (2007) 1139–1143
wasteWmanagement
www.elsevier.com/locate/wasman

Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria

O.F. Kofoworola *

Environment Division, Joint Graduate School of Energy and Environment, King Mongkuts University of Technology Thonburi, 91 Prachauthit Road, Bangmod, Tungkru, Bangkok 10140, Thailand

Accepted 2 May 2006
Available online 10 August 2006

Abstract

The population of Lagos, the largest city in Nigeria, increased seven times from 1950 to 1980 with a current population of over 10 million inhabitants. The majority of the city's residents are poor. The residents make a heavy demand on resources and, at the same time, generate large quantities of solid waste. Approximately 4 million tonnes of municipal solid waste (MSW) is generated annually in the city, including approximately 0.5 million of untreated industrial waste. This is approximately 1.1 kg/cap/day. Efforts by the various waste management agencies set up by the state government to keep its streets and neighborhoods clean have achieved only minimal success. This is because more than half of these wastes are left uncollected from the streets and the various locations due to the inadequacy and inefficiency of the waste management system. Whilst the benefits of proper solid waste management (SWM), such as increased revenues for municipal bodies, higher productivity rate, improved sanitation standards and better health conditions, cannot be overemphasized, it is important that there is a reduction in the quantity of recoverable materials in residential and commercial waste streams to minimize the problem of MSW disposal. This paper examines the status of recovery and recycling in current waste management practice in Lagos, Nigeria. Existing recovery and recycling patterns, recovery and recycling technologies, approaches to materials recycling, and the types of materials recovered from MSW are reviewed. Based on these, strategies for improving recovery and recycling practices in the management of MSW in Lagos, Nigeria are suggested.

1. Introduction

Waste management is the organized and systematic channeling of waste through pathways to ensure that they are disposed of with attention to acceptable public health and environmental safeguards. However, proper management cannot be achieved without a well-designed waste management plan. According to Rossel and Jorge (1999), waste management planning strategies should advocate avoiding waste generation, using cleaner technology, promoting waste recycling and recovery, using suitable treatment for generated waste and adequate waste final disposal.

Globally, there is an increasing awareness of environmental planning and management. Nigeria also recognizes this need. Unfortunately, Nigeria has not developed and implemented environmental protection policies efficiently. Lagos is one of the largest and the most industrialized cities in Nigeria and, unfortunately, also one of the dirtiest with waste littering its landscape. There has been a tremendous increase in MSW generation in Lagos over the years, principally as a result of rapid population growth as well as economic and industrial development in the country.

This waste management problem can be directly linked to its ever-increasing population, but this problem is not different from that of India where MSW management has become a major environmental issue as shown in Singhal and Pandey (2001). The study of Kolawole (2000) shows that the Lagos metropolis with its high level of industrial and social activities has a high rate of solid waste generation, as presented in Table 1.

* Tel.: +66 2 470 8309 10; fax: +66 2 8726 736.
E-mail addresses: sholafemi28@yahoo.com, okofoworola@hotmail.com

0956-053X/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.wasman.2006.05.006

Table 1
Estimation of solid waste generated in Lagos, Nigeria

City	Estimated population (millions)	Year	Estimated MSW generated (tonnes)	Annual MSW generation (tonnes/cap/year)
Lagos	10	1995	4 million	0.40

The same study (Kolawole, 2000) also estimated that the more than 10 million inhabitants of the state produce a total of 4 million tonnes of MSW annually. How to control these wastes and hopefully recycle them has been a source of concern to the state government.

The management of urban MSW is a big problem in cities because of the lack of sufficient equipment to collect the waste. The situation is not different in Lagos, Nigeria. There are three major aspects of MSW management according to Ezeigwe (1995). These are storage, collection and transportation, and treatment and disposal.

Storage of waste deals with storing of the waste at its point of generation until collection by waste managers. Collection and transportation involves collection of the solid waste at the point of storage and its transportation to a treatment or final disposal site. Treatment and disposal refers to the practice of processing the material to recover resources or to render it innocuous, and to the final removal of the waste without harmful effect on human beings or the environment. Final disposal is achievable mostly by landfilling.

The statement by Matsuto (2002) that "every nation defines what its municipal solid waste (MSW) is" can be applied to the situation in Lagos, where such wastes are mostly generated by two categories of society: the household/residential sector and the business/commercial sector. The industrial sector generally disposes of the waste they generate. Therefore, such wastes do not constitute part of that encountered on a daily basis.

The components of the waste include food, paper, plastics, metals etc. and are either combustible or incombustible. The composition and properties of MSW in Lagos are given in Table 2.

2. Problems of MSW management in Lagos

2.1. Improper collection systems

Facilities for proper collection and management of waste are either absent or grossly inadequate in most of the local government areas in Lagos state. The effect of this is that most of the population, who do not pay fees to the unregistered refuse/waste collectors to collect their domestic wastes, dump their wastes on the streets; around streetlight poles and beside embankments along the expressways. Consequently defaced landscapes, air pollution and partially obstructed roads are observed.

2.2. Lack of adequate waste collection equipment and vehicles

Collection and transportation of solid waste requires adequate machinery and equipment. MSW is currently transported over long distances to the treatment area. The Lagos state waste management authority (LAWMA) and the highway managers have been commendable in their efforts to keep the streets clean, but the lack of adequate equipment and waste collection vehicles has made their job a herculean task.

2.3. Indiscriminant dumping of waste

The inhabitants of Lagos dump their wastes at any location that suits them because there are no defined waste collection points. This creates a collection problem, as most areas of the city are densely populated and improperly planned; therefore, neither the LAWMA nor the Lagos

Table 2
Composition and properties of Lagos MSW (Adebayo and Ojetayo, 2001)

Components	Mass (%)	Properties	Composition (%)	Mode of Disposal	Potential uses
Vegetables and putrescibles	68	Biodegradable and Maldorous. Compactable	29.77	Dumping	compost
Paper	10	Combustible, biodegradable, compactable and recyclable	10.24	Recycling	Paper products
Textiles	4.0	Compactable, combustible, biodegradable	3.75	Dumping/open burning	Compost
Metal	3.0	Mostly corrosive, recyclable	4.08	Informal fabrication	Metallic and non-metallic
Plastics	7.0	Combustible, less compactable, recyclable	7.59	Recycling	Plastic products
Glass	4.0	Rigid but recyclable	2.78	Dumping	Glass products
Miscellaneous inerts (others)	3.0	Non-combustible	18.79	Dumping	None
Bones	0.70	Non-combustible	1.80	Dumping	Feed mills
Ashes, dust	0.30	Non-combustible	21.20	Dumping	Compost and stones
Total	100	Total	100		

state environmental protection agency (LASEPA) officials/ workers can reach these wastes.

2.4. Lack of continuity and implementation of government policies

Other problems militating against the effective management of municipal solid waste in Lagos are the lack of continuity and implementation of government policies on MSW management.

2.5. Current MSW management practice in Lagos

In Lagos, the main governmental agencies that have been entrusted with the responsibility of keeping the environment clean are the LAWMA, LASEPA, the Local Government Councils, (LGCs) and the Ministry of Environment and Physical Planning (MEPP).

Treatment of urban waste is achieved by mass burn (open incineration, which pollutes the environment). The state has two incineration plants that have never been used. These are located along Oshodi-Apapa expressway and at Ebute-Meta, respectively.

The landfill sites in the state are at Oloshosun, Agege and Iyana-Iba (no longer used). The process is simple; the waste is collected by the various agencies, transported to the designated landfill sites, and occasionally openly burnt to reduce the volume. This creates pollution problems for the environment through the release of particulate matter and harmful gases into the atmosphere.

Lagos does not have an integrated waste management plan, and the limitations of the current waste disposal methods are obvious.

Open burning contributes to atmospheric pollution and leaves residues to be disposed of in landfills. Incineration produces ash, metal and non-combustibles while composting yields residue like glass, ferrous, material, and plastics (Ezeigwe, 1995). These eventually end up in a landfill (Landry and Bertola, 1999). Landfilling involves placing the waste on the land surface, and although it is regarded as one of the least costly options of MSW disposal, allocation of land for waste disposal would be practically impossible since areas with the largest generation and concentration of solid waste are also areas with a serious scarcity of land.

Consequently, as in Japan (Kazuhiro and Koizumi, 2001), Lagos must now address the solid waste problem by implementing programs that promote waste reduction, reuse and recycling of useful materials.

It is wasteful to throw away anything that could be made use of, particularly when there is a desperate need for it elsewhere (Mathew, 1999). The study of Adebayo and Ojetayo (2001) revealed that most of the secondary raw materials scavenged from wastes are not recycled by industries in the state. This is due partly to the fact that most of the industries, also, do not actively promote take-back recycling as practiced in Japan (Kazuhiro and Koizumi, 2001). If secondary raw materials scavenged from wastes are recycled, it is expected that there will be a reduction in the energy associated costs by industries during production because recycling provides easily obtainable manufacturing feedstock (Mumma, 1995; Gheewala and Nielsen, 2003).

2.6. Current recovery and recycling practices of municipal solid waste in Lagos

Waste recycling is an interesting approach to achieve an efficient, integrated manner of managing municipal solid waste. However, MSW recycling is restricted to well segregated and clean high value materials. According to Adebayo and Ojetayo (2001), municipal solid waste recycling in Lagos is at an early phase, just like in Thailand (Danteravanich and Siriwong, 1997). Although it exists, recycling and resource recovery as forms of waste management have not received the attention of the government and the waste management authorities, neither in the past nor in the present. Also, there is no officially known material recovery facility (MRF) in the state.

Presently, only paper, plastics, glass and metals, have high market values in Lagos. These are separated from wastes either at the source or at landfill sites by scavengers and then sold to the market.

There are usually 1–30 scavengers sorting recyclable materials at each waste disposal site in the state. However, the number of scavengers at each disposal site also depends on how large the solid waste dumpsite is. These people sort domestic recyclable wastes at disposal sites and refuse bins. The materials collected are then subjected to some level of intermediate processing, such as washing and drying. The reclaimed materials are then sold to refuse dealers, either at the disposal site or at the junk shop. The items that are generally recycled are given in Table 3.

Table 3
Recycled wastes in Lagos State, Nigeria

Items	Purchased at landfill site	Purchased at the used materials shops
(A) Metals		
(1) Copper	Yes	Yes
(2) Aluminium	Yes	Yes
(3) Lead	Yes	Yes
(4) Blast	Yes	Yes
(5) Iron	Yes	Yes
(B) Paper		
(1) Cardboard	Hardly	Yes
(2) White paper	Hardly	Yes
(3) Color paper and old paper	Hardly	Yes
(C) Plastic		
(1) PVC	Yes	Yes
(2) Plastic bottles	Yes	Yes
(3) Plastic wares and other plastics	Yes	Yes
(D) Glass	Yes	Yes

It was observed that metals sold have the highest selling price in the market. However, the price of metals varies depending on type, quality and fluctuation of supply and demand in the market.

The refuse dealers separate the materials further and sell them to consumers, as well as supply them to appropriate processing/remolding mills and factories. Thereafter, the processed material continues to proceed through the cycle. It is estimated that approximately 5–8% of MSW are recycled through this type of processing (Danteravanich and Siriwong, 1997).

2.7. Addressing the Lagos MSW management problem

In order to have a sustainable and efficient MSW management system, the following aspects need consideration: targeting waste reductions at source, technological intervention efforts, and institutional and regulatory reforms.

The effective management of MSW in Lagos, Nigeria necessitates the development and implementation of laws and strategies to reduce waste generation at source through education and by setting mandatory standards. Setting mandatory standards makes business responsible for the waste they generate.

As in Japan and Germany, a regulation on recycling of packaging waste needs to be enacted. In Japan, municipal governments are obliged to begin collecting plastic and paper packaging waste separately from other household wastes. This law mandates that producers and retailers recycle the packaging wastes they produce; this practice is implemented by a designated privately owned recycling agent and paid for by producers and retailers. This is similar to the practice in Germany, where following an administrative directive, enterprises assumed the responsibility of collecting and recycling packaging making up one part of the dual system. The second part consists of the non-recyclable waste disposed of by the local government in the landfill (Kazuhiro and Koizumi, 2001).

The identification of collection points is very important to the effective and successful implementation of any waste management programs and policies. Public education must be pursued vigorously. The government must harness all of the media resources at its disposal and employ them to sensitize its citizens about the need to keep their environment clean by disposing their wastes at designated drop-off spots. Indiscriminant dumping of waste in places other than the designated collection points should be penalized.

A product or material is recycled when it is reintroduced into the original production process and used to form a new product. However, the availability of markets and favorable price structures for recyclable materials may encourage the continued production of waste items, while ignoring options that could eliminate wastes in the first place. Basic steps in recycling activities can be considered as involving the following interrelated steps: (1) source separation, collection and transport of wastes; (2) sorting and cleanup of wastes; (3) processing of marketable materials; and (4) marketing and sale of the product. The interrelation of these activities exerts a strong influence on the economics of the recyclable waste scheme. Therefore, these basic steps should be considered and practiced more efficiently.

Waste recycling can help eliminate and thus minimize wastes. It is possible to minimize waste through the practice of incineration. The limited data available shows that the MSW stream of Lagos at the point of disposal is high in putrescible organic matter. However, it is low in the concentration of commercially recyclable components and too low in heating value for energy recovery by incineration. This, combined with its higher cost relative to other MSW management options and limited infrastructure of human, mechanical and institutional resources, does not make waste minimization by incineration a very feasible technology for Lagos. Putrescible wastes, which constitute a large proportion of the municipal solid waste in Lagos, can be converted to organic fertilizer or soil conditioners by composting. This is an option which should be promoted in any municipal solid waste management program of the Government.

The use of landfills as a method of waste management is widely practiced all over the world; as such, landfill sites must be carefully selected, as it is a critical step in waste disposal. If improperly conducted, the overall efficiency of the waste management system is affected negatively as a result of the generated leachate as well as landfill gas (LFG), which is a powerful greenhouse gas and thus results in a transfer of pollution. Uncontrolled landfill gas migration from the site can not only damage the global environment but can also negatively impact human health and pollute the local environment.

However, if properly designed and operated, landfill gas provides a source of energy that can be used for several energy producing purposes and thereby generate revenue for the landfill. The theoretical total quantity of LFG generated from 1 tonnes of biodegradable carbon is 1868 m^3. For commercial recovery of generated LFG, a landfill should receive about 200 tonnes per day of waste, be designed for a minimum capacity of 500,000 tonnes, and have a minimum filling height of 10 m. Also, the waste should not have been deposited for more than 5–10 years before LFG recovery is attempted (Pacey et al., 1996). These requirements can easily be met by Lagos. The benefits of utilizing landfill gas recovery, especially for electricity production which would supplement the existing inadequate supply from the national grid, cannot be over emphasized.

In the near future, the combustion of MSW in open landfill site in Lagos will be abandoned. The government of Lagos state must develop environmental policies that promote recovery and recycling of MSW, and enforce compliance to those practices. Lagos is not yet ready for the practice of energy recovery from incineration and continues to landfill its MSW. Lagos can, however, maximize the benefits from the MSWs by recovering LFG and generating energy from the gas.

References

Adebayo, O.O., Ojetayo, T.A., 2001. Beneficial uses of Lagos state municipal solid waste. Mechanical Engineering Department, University of Lagos, Nigeria, pp. 22–27 (unpublished B.Sc Thesis).

Danteravanich, S., Siriwong, C., 1997. Solid waste management in Southern Thailand. In: Proceeding of the Thirteenth International Conference of Solid Waste Technology & Management, Philadelphia, USA.

Ezeigwe, C., 1995. Appropriate solid waste disposal methods for developing countries. NSE Technical Transactions 32 (2), 33–34.

Gheewala, S.H., Nielsen, P.H., 2003. Beyond energy efficiency – application of LCA and integrated environmental assessment. In: Proceedings of the Second Regional Conference on Energy Technology towards a Clean Environment, Phuket, Thailand.

Kazuhiro, U., Koizumi, H., 2001. Reducing household waste: Japan learns from Germany, Environment.

Kolawole, A., 2000. Waste Management in Lagos State with Oshodi-Isolo as case study. Mechanical Engineering Department, University of Lagos, Nigeria, pp. 1–19 (Unpublished B.Sc Thesis).

Landry, J., Bertola, D., 1999. The global plan for the management of waste in the Canton of Geneva. In: Barrage, A., Edelmann, X. (Eds.), Recovery, Recycling, Re-integration (R '99) Congress Proceedings, vol. 1. EMPA, Switzerland, pp. 39–90.

Mathew, D., 1999. Recycling putrescible/household waste. In: Barrage, A., Edelmann, X. (Eds.), Recovery, Recycling, Re-integration (R '99) Congress Proceedings, vol. 1. EMPA, Switzerland, pp. 363–366.

Matsuto, T., 2002. Residential solid waste generation and recycling. In: Proceedings of the International Symposium and Workshop on Environmental Pollution Control and Waste Management, Tunisia, pp. 187–192.

Mumma, T., 1995. Construction: reducing the embodied energy of buildings. Home Energy Magazine Online.

Pacey, J., Augenstein, D., Reinhart, D., Morck, R., R. Yazdani, 1996. The bioreactor landfill – an innovation in solid waste management. Available from: <http://www.yolocounty.org/recycle/docs/Bioreactor_issues.pdf>.

Rossel, S.A., Jorge, M.F., 1999. Cuban strategy for management and control of waste. In: Barrage, A., Edelmann, X. (Eds.), Recovery, Recycling, Re-integration (R '99) Congress Proceedings, vol. 1. EMPA, Switzerland, pp. 287–290.

Singhal, S., Pandey, S., 2001. Solid waste management in India: status and future directions. TIMES 6 (1), 1–4.