Unsafe Waste Disposal Practices in Nigerian Cities: Geoenvironmental Perspectives

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ABSTRACT:

Geoenvironmental contamination represents a real hazard to human health. There is no section of society that this issue fails to touch. This is why it ranks amongst the most important problems facing geoenvironmental engineers, earth scientists and policy makers in the industrialized countries where there is wider environmental consciousness. Governments of these countries have responded by promulgating stringent regulations on safe disposal of wastes.

This paper critically and objectively reviewed the issue of geoenvironmental pollution resulting from indiscriminate and unacceptable waste disposal practices in Nigerian cities. Effects of contaminants in leachate that drains from waste dumps into the soil such as organic and inorganic compounds, heavy metals and pesticides on human health were highlighted. It canvases for good disposal practices such as the use of engineered landfill which have been found to work in the industrialized countries.

INTRODUCTION

Scientists have long recognized that the quality of air and water can be degraded by human activities. Unfortunately, only few people have considered that the quality of geoenvironment (subsurface) can also be affected by different uses and management practices. Perhaps one of the most threatening environmental issues in recent times relates to subsurface contamination by unregulated land disposal of wastes arising from multiplicity of human activities. This has engaged the attention of policy makers, geoenvironmental engineers and other professionals in societies where environmental consciousness is high (Yong and Thomas, 2004; Yong *et al.*, 2003; Reddi *et al.*, 2000; Daniel, 1993a).

The annual production of domestic solid waste in Nigerian cities and towns exceeds 22 million tons, which is approximately 0.5 kg per person per day (Ogunbiyi, 2001). Such quantities are clear indications of the need for adequate and effective waste management strategies. Ironically these wastes are dumped indiscriminately without an overall plan for proper disposal. Other functional elements of a sound waste management system namely storage, collection and transportation systems of wastes from municipal, industrial and commercial sectors are grossly unsatisfactory and hardly coordinated (Ekenta, 2001; Ogunbiyi, 2001; Oyeshola, 1995; NEST, 1991). Most disposal sites are inappropriately located, without due consideration to the site modifications and precautionary measures required in a disposal site. Solid waste managers in our cities rely on indigenous subsoil filtration to reduce the concentration and migration of contaminants. But this cannot completely stop toxic leachates capable of causing pollution of underlying aquifer and other groundwater systems from migrating to groundwater environment (Lowe and Thompson, 1994). This is more worrisome now that solid waste composition is changing from vegetable based refuse to manufactured/synthetic materials as a result of new packaging techniques and consumption pattern. These sites receive a wide range of wastes possibly including toxic compounds. The most critical of these are heavy metals, synthetic materials with toxic properties e.g. chlorinated hydrocarbons and inorganic compounds such as nitrates (Yong and Thomas, 2004; Yong, 2000; Overcash and Pal, 1979). This is a serious hazard in our cities that rely heavily on groundwater for their water supply now and in the near future. In addition, such introduction of contaminants directly and indirectly affects the agricultural productivity of the soil by hindering the biological, chemical and physical processes of nutrient uptake in plants (Amhakhian *et al.*, 2003; Voutsa *et al.*, 1996).

Two important objectives of modern solid waste management are: (1) The disposal of the waste in a manner that is environmentally acceptable thus once it is disposed, we should not expect to suffer the consequences of its eventual return to our environment and (2) Avoiding the creation of some other form of pollution which may generate hazard than is present in the original waste. These are rarely considered in the disposal of waste in our cities which shows that there is little understanding by our waste managers of the long-term consequences of uncontrolled dumping of waste especially with respect to groundwater impact.

In the industrialized societies, governments have responded to this challenge by enacting stringent legislation to ensure the proper disposal of wastes and are strict on enforcement too (Benson, 1999; Rowe *et al.*, 1995).

Experience has shown that economic and industrial growth normally leads to increased societal expectations. With time, these expectations shift from the provision of plentiful and cheap food and potable water to things that give rise to higher quality life mostly environmental issues. In this regard and in line with the millennium development goals, it is timely for Nigerian government to act by promulgating regulations concerning waste disposal that will harmonize with those of the industrialized countries.

This paper is a review of the current solid waste disposal practices in Nigerian cities, the associated health and environmental risks that may arise from geoenvironmental contamination and makes a case for the use of engineered landfills.

CURRENT WASTE DISPOSAL PRACTICE

Despite the existence of numerous disposal options, treatment and disposal of waste in Nigeria have been haphazard undertaking. In many of the urban and rural centres, waste collection and disposal facilities are grossly insufficient and generally ineffective, hence city dwellers and private collectors resort to indiscriminate dumping of their wastes on streets, bus stops, market places, and free uncultivated or undeveloped plots, in drains and waterways in the cities which often result in blockages (Ekenta, 2001; Ogunbiyi, 2001; NEST, 1991). Some public institutions like schools and hospitals in the municipalities make use of pits dug in their premises, which they occasionally set on fire (Ekenta, 2001). While most manufacturers discard their solid and liquid wastes freely as they chose unless challenged by authorities or neighbours.

The official or approved disposal sites for dumping are far from sanitary or engineered landfills as seen in the industrialized countries. There are no engineering inputs in the preparation, operation or closure of the sites. The authorities identified areas which may be simply flat, swampy, natural depressions or burrow pits abandoned by construction companies. In Jos town and its environs, disused quarries, which are results of mining activities in the area, are commonly used while erosion gullies in the eastern part of Nigeria serve as dumping sites.

In all these sites, wastes are just deposited in such places without compaction or soil cover (e.g Plate 1A, B, C and D). The only compaction provided in some cases is by people scavenging for recyclable items and the trucks traveling over previously deposited wastes. Cover material is applied only on very rare occasions and is done so casually to improve truck accessibility rather than as a sanitary condition.

LIMITATIONS OF NATURAL SUBSOIL FILTRATION

Geological materials such as soils and sediments naturally have intrinsic attenuative capacity thus movement of potential contaminants is prevented through complexation with organic and inorganic compounds, precipitation and adsorption mechanisms (Yong *et al.*, 2003; Hansen, 1997; Rouse and Pyrih, 1993). The extent to which this can work depends on a number of factors namely (Yong *et al.*, 2003; Shackelford and Jefferis, 2000; Water Resource Characterization DSS-Heavy metals, 1997; Headley, 1994):

- thickness and nature of the strata making up the unsaturated zone
- the physico – chemical attenuation capacity of these strata as a result of chemical reaction and biochemical degradation
- the pH and Eh conditions that are established during contact of the leachate with the geological material.

Such 'indigenous filters' cannot be relied upon for total contaminant removal because of the uncertainty associated with the integrity of the system.

Even when these conditions are locally or extensively favourable, there is likely to be considerable scope for short-circuiting by rapid preferential flow through hydraulic defects or imperfections such as fissures, cracks, joints, holes etc in the underlying strata.

The contaminant migration governed either by molecular diffusion, saturated or unsaturated flow will eventually reach the groundwater tables, which vary from hundreds of metres in stream water zone to just few metres in sheet water zone.

The heavy metals adsorbed in the solid phase of the soil may from time to time be desorbed as a result of changes in soil chemistry (change in pH and redox status, Eh) and get mobilized into soil solution. These metals may leach to the groundwater environment causing increase in concentration while some fractions are transferred to the food chain through bioassimilation (Water Resource Characterization DSS-Heavy metals, 1997). In either case, serious health hazard is building up.

The fiasco at love canal in New York is a well-known example where natural subsoil filtration and purification failed to work. This led to serious health impacts and eventual evacuation of residents in the area (Benson, 1999; Daniel, 1993a).

Assuming incidences of such magnitude have not taken place in this country, our waste managers have to learn from the many mistakes of the industrialized countries to avoid such fiasco and apply the technologies that have been found to work in these countries.

ASSOCIATED HEALTH AND ENVIRONMENTAL RISKS

It is widely believed that there is a strong link between the quality of soil environment in a community and the health and well being of the people who live there. If properly managed, the soil serves as an environmental buffer, producing abundant and nutritious food but if mismanaged, it works against us, polluting the air, groundwater and produces 'poisonous' instead of nutritious food (Doran and Parkin, 1994).

Solid wastes, a heterogeneous mass of variable composition range from strongly acidic to strongly alkaline (Cheremisinoff, 2002; Rowe *et al.*, 1995; Daniel, 1993a). Some wastes in the spoil are rich in metals, some are rich in organic compounds and some are mixtures that contain both metals and organics. An important feature of solid wastes is that they degrade chemically and biologically to produce solid, liquid and gaseous products. Ferrous and other metals are oxidized. Liquid waste products (called leachate) can be produced from dumped wastes either by consolidation of fluid bearing wastes, by decomposition, chemical reaction or by the leaching action of water percolating through the waste. Leachate from dumpsites contain a wide range of organic compounds some of which are toxic at low concentrations in addition to inorganic compounds, heavy metals, pesticides etc. Once in soil environment, some of these compounds migrate and contaminate the surrounding environment and impair the use of groundwater as there were no control measures taken to limit the migration of the leachate at the dump sites (Rowe *et al.*, 1995; Edil, in press,).

Water taken from such sources for drinking is capable of causing acute poisoning or death if contaminants are in higher doses. Smaller doses of heavy metals and organic compounds bioaccumulates in the tissues of living organisms over a length of time and gradually reaches toxic level. This bioaccumulation, which occurs in individual organisms, is compounded through the food chain. Mutagenic, carcinogenic and teratogenic reactions are some of the dreaded medical problems associated with these contaminants in view of their fatal effects in some cases and more importantly the consequences to the future generation (Overcash and Pal, 1979; Bruce, 1977). These manifest in humans in the form of cancer (various types), cardiac abnormalities, hypertension, liver damage, neural damage, defects or abnormalities in fetal development etc (Water Resource Characterization DSS-Heavy metals, 1997; Roane *et al.*, 1996). Similarly, elevated contaminant levels in natural waters have effects in aquatic organisms such as;

- histological or morphological changes in tissues.
- changes in physiology such as suppression of growth and development.
- changes in biochemistry such as enzyme activity and blood chemistry.
- change in behaviour
- and change in reproduction.

Nitrates at higher doses in domestic/drinking water leads to nitrate poisoning popularly known as *methaemoglobinaemia* or 'Blue baby' disease in infants (Lowe and Thompson, 1994; Bohn *et al.*, 1985).

ENGINEERED LANDFILLS (WASTE CONTAINMENT FACILITIES)

We cannot just ignore wastes generated in our cities, neither is the old idea of dumping it anywhere and anyhow valid any longer. We must manage and dispose of these wastes properly. In the industrialized countries of Europe and America, the dominant and preferred route for disposal of solid wastes is the containment landfill (Williams, 1997; Edil, in press). It is an engineering project whose objective is to contain the waste in a manner that is protective of human health and the environment. It therefore requires highly sophisticated technology employing engineering methods in which the waste is deposited on excavated and prepared cells compacted to the smallest practical volume and covered with a layer of soil at the end of each day's operation (Daniel, 1993b).

Landfill technology has gone through significant development in the last decades from uncontrolled dumpsites to its present state, all geared towards protecting the environment. It is regarded as today's reality and the best practicable environmental option considering available technologies for other disposal options.

REGULATIONS

In response to the environmental problems that crude dumping has caused, many governments world over are now regulating the design of waste disposal facilities. For example, the proponent of a disposal site in some of these countries like Canada and USA is required to demonstrate that the proposed facility will not impact on the present or future 'reasonable use' of groundwater at the site boundary. In addition, minimum requirements such as barrier and cover systems, detailed design of leachate collection and removal system etc are specified (Benson, 1999; Daniel, 1993b).

In these industrialized societies, waste containment has been driven more by environmental regulations, that is to say that regulations dictate the minimum technology required to keep risks associated with waste containment to the lowest mark. In which case, the objectives of the owner and the engineer are to comply with regulatory requirements. In Nigeria, there are still no clearly specified regulations by the Ministry of Environment on landfill construction and operation. There is need for legislation on this important issue.

DESIGN CONSIDERATIONS

The design of landfills given what we know today often requires the balancing of a number of conflicting criteria. It involves planning or outlining of all site modifications and structures necessary for handling and disposing of the waste in a manner that will not endanger public health or the air and the water resources of the area. The design should be sufficiently comprehensive to provide for specific use of the site after land filling is completed (see figure 1 below). Important aspects in the implementation of landfills include:

Site selection

Site selection is perhaps the most difficult obstacle to overcome in the development of a landfill. Opposition by local citizens eliminates many potential sites. Factors to be considered in evaluating potential sites include proximity of the site to the source of waste generation, the impact of site operation on the local environment, convenient transportation access, site underlain by suitably strong material, favourable hydrogeological characteristics, and site that is not located in a flo plain or a low lying area.

Site preparation

The plan and specifications should require th certain steps be carried out before operation begin In most cases, construction logistics and operation practice favour many small cells rather than or massive landfill (Daniel, 1993a). As such it is wis to develop the site stage by stage rather than th whole site at a time. The steps include grading th site area, constructing access roads and fences an installing signs, utilities and operating facilities. A landfill site should also provide suitable faciliti for keeping and servicing the site equipment.

Barrier and cover systems

Barrier system is one of the most importan elements of a modern engineered landfill. Barrie technology has evolved significantly in the las decades in countries where landfill has been in use For instance barriers typically have bee constructed with compacted clay ranging from 0.9m thick in the late 70's to 1.5m in the 80's. Later new concepts such as geomembrane (a 1.5-mm shee made from high density polyethylene), composite barrier system consisting of a clay barrier overlain by a geomembrane and more recently geosynthetic clay liner GCL (thin factory manufactured clay liners 10-mm thick that are filled with bentonite clay) whose primary objective is to minimize release of leachate to the subsurface were introduced (Benson, 1999; Shackelford, 1997; Rowe *et al.*, 1995; Daniel, 1993c).

The final covers of an engineered landfill are used as horizontal surface barriers to minimize the infiltration of water into the facility and may consist of several layers. The potential materials for each layer are soil, compacted clay, geomembrane, geosynthetic clay liner (GCL), recycled or reused waste or select waste.

The choice of barrier/cover system should always be site specific and should take account of local hydrogeology, nature of the waste, size of the landfill, climatic condition, availability of suitable materials and local social and regulatory systems (Rowe *et al.*, 1995).

Leachate collection and removal system

Modern landfills are designed to have leachate collection system, which consist of gravel, perforated pipe collector system, sump/manhole, large diameter pipes and a protective filter layer (Koerner, 1993). Submersible pumps are commonly used to pump the collected leachate to trucks, storage tanks, reservoirs or directly to treatment facilities. Leachate production is influenced by the contents of the landfill and local hydrologic processes (water balance analysis) at the site. Thus, if well constructed, the quantity of leachate released into the subsoil for transport into the hydrogeologic system will be minute and hence the environmental impacts (long and short term) will be negligible.

Operational practice

A number of operational details have to be carefully planned. In a typical modern landfill, the sequence of operations for an incoming waste vehicle may include the weighing of the truck on a weighbridge, documents and waste inspection. Once cleared, the waste is tipped, the truck is weighed out of the site to determine the weight of the waste deposited and the driver collects any necessary documentation. The tipped waste is compacted using specially designed compacting vehicles and a daily cover of soil or alternative material is added at the end of each working day, which serves the critically important function of keeping insects and rodents out of the waste (Williams, 1997).

Final land use consideration

Due to envisaged structural and stability problems that may arise as a result of low bearing capacity and high settlement (immediate and long term) and gas emission, restrictions must be imposed on the future use of the site.

One problem that seems endemic with landfills is the propensity to forget where they are located after years of closure (especially smaller landfills) and then to utilize the land for other purposes. The resultant problems can be severe especially if used for heavy construction (Overcash and Pal, 1979). To overcome this, landmarks to serve as reminders and to delineate the boundaries of the landfill area should be established. The most appropriate uses of completed landfill sites are open space and recreational areas, ranching ground and other agricultural purposes. Parks, playgrounds, golf courses are ideal for installation on these sites. In some cases light construction can be carried out.

SUMMARY/CONCLUSION

Recent interest in evaluating the impact of waste in the geoenvironment has been provoked by the increasing awareness that soil is a critically important component of the earth's biosphere functioning not only in the production of food but also in maintenance of local, regional and worldwide environmental quality. It however works against us when mismanaged by polluting not only the soil and groundwater systems but also the air.

This is why discussions in this paper focused on the very low standard of waste disposal in Nigerian cities, which is still by dumping. The paper addressed the far-reaching health consequences of continued ignorance of subsurface contamination caused by such disposal practices. It suggested that efforts should be made to adopt methods that have environmental control measures such as engineered landfills.

A brief description of the constructional details and operational practice of an engineered landfill was given.

Finally, Nigerian government should through the appropriate regulatory agency enact tight environmental regulations similar to those of the industrialized countries in order to arrest the situation. This is necessary because from the experience of the industrialized countries, many contaminated sites have resulted from activities in the distant past that were not perceived to be potential threat to the environment and therefore were not regulated.

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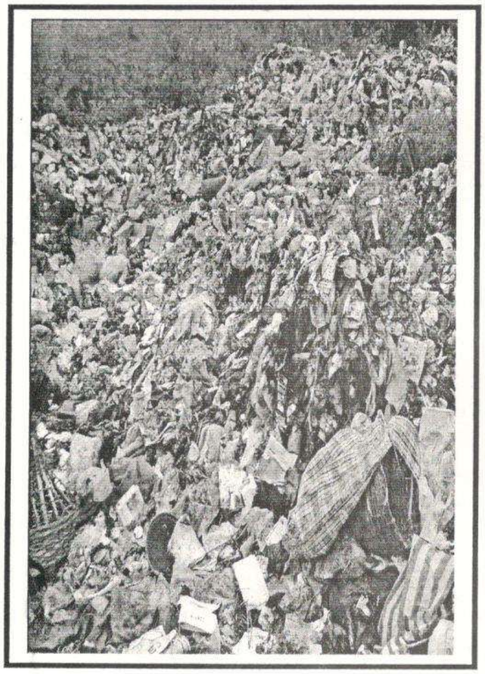
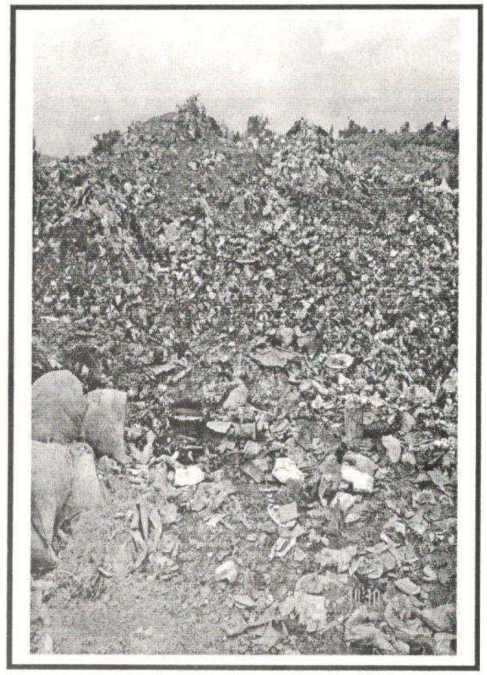


A



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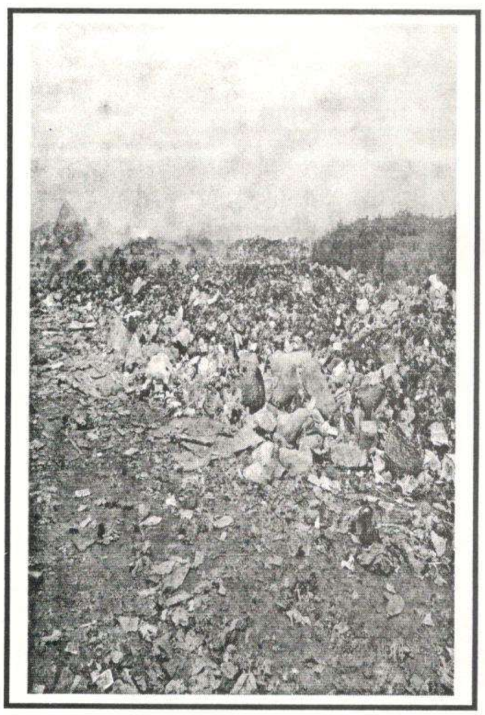

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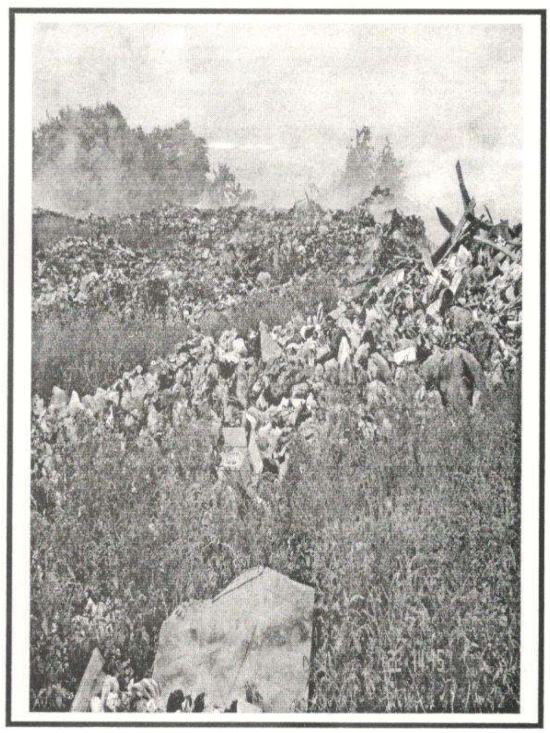

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Plates 1A, B, C and D. Official refuse disposal sites in Ibadan, Abeokuta, Lagos and Aba respectively.

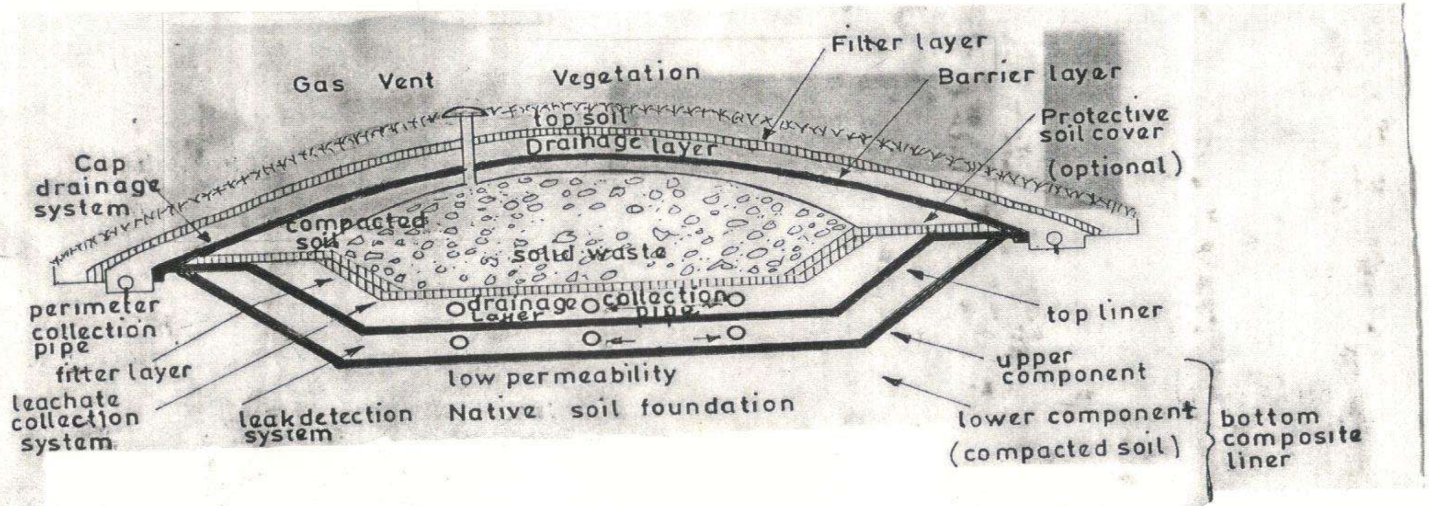

Fig. 1: **Cross Section of controlled solid waste landfill showing the basic liner and cover components (not to scale).**