

OPEN DUMPS TO SUSTAINBLE LANDFILLS

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1.0 INTRODUCTION

The management of solid waste is an area of universal concern for both the developed and developing world. It is imperative that efficient, technically sound, and cost effective solid waste management solutions are developed in the near term – for the benefit of the burgeoning populations in the world's cities and the natural environments that must sustain them. This paper focuses on the Land disposal of solid waste and how current practice of open dumping could be improved to sustainable landfills in a phased manner.

2.0 OPEN DUMPS

Historically, countries dealt with solid waste by burying it in the ground, covering it up, and forgetting about it. Another approach was the uncontrolled burning of waste to reduce volume. The subsequent ash was then buried in the same manner as waste. A recent study of World Bank over 50 landfills in Asia, Africa and Latin America has identified current practices, emerging features and necessary improvements in the land disposal of solid wastes (Johannessen and Boyer, 1999).The landfills visited in the Africa Region ranged from open dumps to sanitary landfills. While decision makers in the region were aware that their countries had to upgrade open dumps to sanitary landfills, this was not regarded as a priority. An **Open Dump site** is a land disposal site at which solid wastes are disposed of in a manner that does not protect the environment, is susceptible to open burning, and is exposed to the elements, disease vectors and scavengers. These unplanned heaps of uncovered wastes, often burning and surrounded by pools of stagnated polluted water, rat and fly infestations with domestic animals roaming freely and families of scavengers picking through the wastes is not only an eyesore but a great environmental hazard.

As a default strategy for municipal solid waste management, open dumps involve indiscriminate disposal of waste and limited measures to control operations, including those related to the environmental impacts of landfills. Very often, open dumping sites are swamp lands or low-lying areas with the wastes being used for reclamation. Liners are rarely used and little consideration is given to the water table and groundwater pollution and/or gas migration. Problems of shortage of cover, lack of leachate collection and treatment, inadequate compaction, poor site design, and many ragpickers working at the site are common. The high percentage of organics, combined with much plastic, which forms layers when compacted, contributes to the build-up of methane gases at dumps. Fires often break out and workers are made ill by the gases. In cities where plastic shopping bags are used to put out wastes for collection, waste pickers sometimes set refuse on fire in order to recover valuable inorganic items. Spontaneous fires also break out in dumps. This greatly adds to the air pollution from dumps. The roads leading to dumps and those on dumps themselves are often elementary, becoming impassable in the wet season. Since most large dumps have hundreds of extra workers in the form of waste pickers, and the municipal workers are not provided with protective gloves, the health risks at dumps are much higher than in sanitary landfills in industrialized countries. These workers are exposed to risks from human feces, slaughterhouse wastes, landfill gases, toxic dust, infectious biomedical wastes, snakes, scorpions, broken glass, and explosions. Thus, these dump sites are essentially uncontrolled, creating considerable health, safety, and environmental problems.

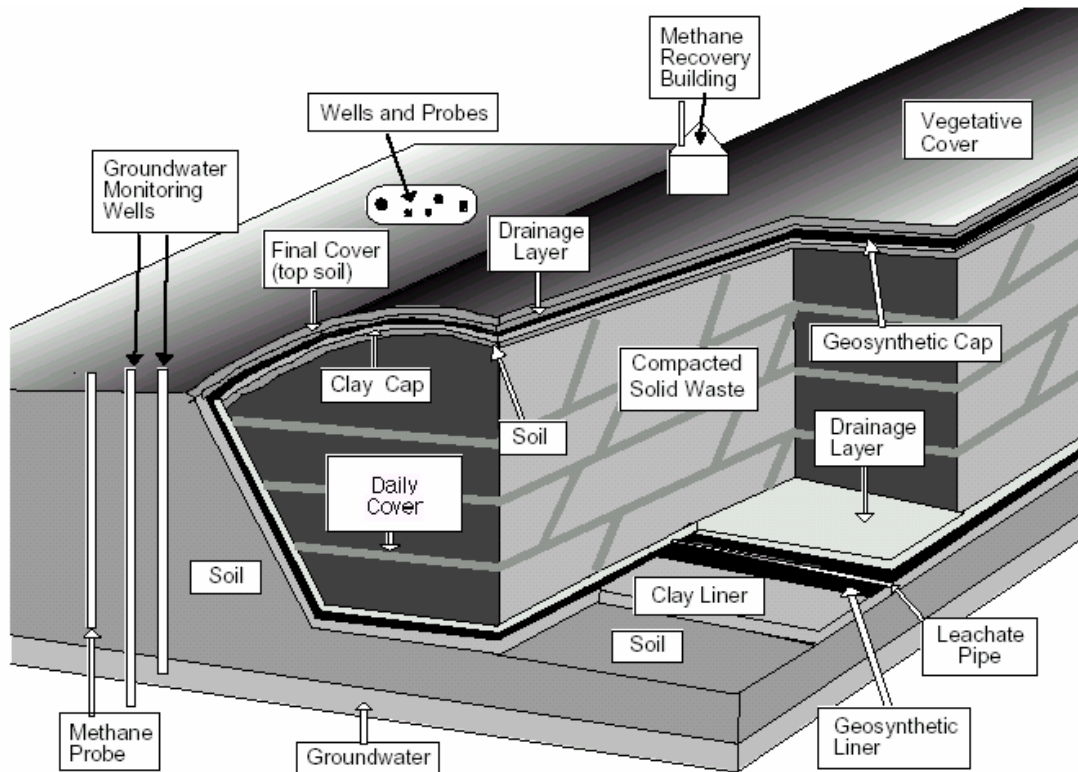
3.0 LANDFILLS

Landfills are a vital component of any well-designed Municipal Solid Waste Management (MSWM) system. They are the ultimate repository of a city's MSW after all other options have been exercised. The main differences among the landfills involve the degree of isolation, the means of accomplishing it and optimizing the landfill reactions. The rate and extent of decomposition of the land filled wastes are dependent on the design of isolation. Innovative planning and design can accelerate the decomposition and facilitate productive reuse of the landfill property after the landfill is closed. A number of general characteristics as listed in Table 1, distinguish a modern sanitary landfill from an open dump.

Table 1 Types of Landfills

Type	Engineering measures	Leachate management	Landfill Gas Management	Operation measures
Open Dumps	None	Unrestricted contaminant release	None	Few, scavenging
Controlled Dump	None	Unrestricted contaminant release	None	Registration and placement/ compaction of waste
Engineered Landfill	Infrastructure and liner in place	Containment and some level of leachate management	Passive ventilation or flaring	Registration and placement/ compaction of waste; uses daily soil cover
Sanitary Landfill	Proper siting, infrastructure; liner and leachate treatment in place	Containment and leachate treatment (often biological and physico-chemical treatment)	Flaring	Registration and placement/ compaction of waste; uses daily of soil cover, Measures for final top cover
Controlled Contaminant Release Landfill	Proper siting, infrastructure, with low-permeability liner in place. Potentially low-permeability final top cover	Controlled release of leachate into the environment, based on assessment and proper siting	Flaring or passive ventilation through top cover	Registration and placement/ compaction of waste, uses daily soil cover. Measures for final top cover
Landfill Bioreactor	Proper siting, infrastructure, liner and leachate recirculation / generation system	Controlled recirculation of leachates for enhanced degradation and stabilization of wastes and leachates	Landfill Gas recovery	Registration and placement/ compaction/ daily cover/ closure/ mining and material recovery

The modern implementation of a traditional landfill for municipal solid waste (MSW) has often been referred to as a "**dry tomb**," as depicted in Figure 1. This is a lined hole filled with waste and then capped to prevent the infiltration of water. Two new methods called the anaerobic bioreactor and the aerobic biocell are attempting to supplement this method of Dry Tomb Landfill. While almost minor at first glance, the concept comprises a substantial departure from old dumps, and modern landfills in that rather than being places where waste is placed in indefinite isolation from the environment, the bioreactor and biocell landfills transform the landfill into an active treatment process, which opens up a whole range of options.



Source: P. O'Leary and P. Walsh, University of Wisconsin-Madison Solid and Hazardous Waste Education Center, reprinted from *Waste Age* 1991-1992

Figure 1 Schematic of a modern "Dry Tomb" Landfill

The anaerobic bioreactor, or **landfill bioreactor**, is similar in design to a dry tomb landfill. It has a leachate collection and recirculation system, geomembrane liners, final cover, and gas collection system. (Reinhart 1998). In this type of system, the gas that is predominantly produced is methane, which can be collected and purified for sale and/or use. The level of methane production will be related to the level of organic waste present in the landfill. If the organic stream is diverted from the landfill, the resulting methane will be lower than in other anaerobic bioreactors. Another advantage of this design is that it has the capability of stabilizing the waste much faster than the dry tomb landfill. Waste may not stabilize for thirty years in dry tomb landfills while in an anaerobic bioreactor that may occur in less than ten.

The **aerobic biocell**, is set up just like the anaerobic except for the presence of an air circulation system. Unlike the anaerobic bioreactor, the ultimate objective is to maximize the speed of decomposition of the contents. Air is percolated through the landfill to encourage aerobic decomposition and the accompanying preferential production of carbon dioxide instead of methane (Stessel 1994). Since methane production is not the aim of this landfill, the level of organic waste will not affect its performance as much as the anaerobic system is affected. This design also allows for the rapid stabilization of the contained waste.

An additional advantage of both of these landfill designs is that they allow for the possibility of **landfill mining**. It is the process of exhuming existing or closed solid waste landfills, and sorting the exhumed materials for recycle, processing, or other disposition (Lee and Jones, 1990; Hogland et al, 1997; Carius et al, 1999; Cosu et al, 1999) . The objectives of landfill mining could be one or more of the following:

- Conservation of landfill space
- Reduction in landfill area
- Elimination of potential contamination source
- Rehabilitation of dump sites
- Energy recovery from recovered wastes
- Reuse of recovered materials
- Reduction in waste management system costs
- Redevelopment of landfill sites

Landfill mining uses the method of mining and sorting the material from the existing landfill and taking it to a screening machine that separates material by size into fine and oversize materials. The process is based on the methods of traditional opencast mining. The waste is segregated into streams depending on the desired recovery elements. The main part of the process is the screening where the main separation is done for the oversize and the soil elements. The magnetic separator would separate all the ferrous metals and the non-ferrous element could be separated out using an air classifier leaving the residue that could be combusted. The extent of the separation depends on the finance and the desired end product. The success of materials recovery is dependent on the composition of the waste, the effectiveness of the mining technology and the efficiency of the technology.

4.0 SUSTAINABLE LANDFILLS

The term sustainability means different things to different people. In the present context we consider the definition to be: "solving today's problems in a responsible and environment-friendly manner thereby not prejudicing the ability of future generations to exist or solve their own problems". This means that each generation should manage its wastes to a status that any emissions to the environment to be acceptable without further treatment. In sustainable landfills, airspace, processes, control and/or use of products and residues are at an optimum and where minimal negative effects on the environment takes place. The goal should be one of treating waste within a lifetime. This can be achieved when the waste within a landfill becomes stabilized and the stabilized waste is recovered for reuse of the recovered material as well as the space. An appropriate combination of the Landfill Bioreactor and landfill Mining will provide this solution.

In order to abandon the practice of open dumping, the municipal authorities may either close the open dumps when an alternate upgraded landfill is available or alternatively it may convert its open dumps as upgraded landfills. The latter option may be feasible only if the dump is in an area where ground water pollution is not critical or if there is sufficient remaining void space to justify the cost and effort of conversion. The first step towards rehabilitating open dumps should be to analyse the condition of the site and its geographical setting. The investigations need to be undertaken before the choice can be made on whether to close or convert the site, since the findings can guide the decision. As a minimum the following steps may be initiated to slowly move from open dumps towards sustainable landfills.

- Fires should be eliminated on the dump site
- Waste tipping should be restricted into small areas and a disposal plan must be followed
- Wastes should be deposited in thin layers of about 50 cm and compacted appropriately
- The surface of the newly deposited waste should be covered at the end of each day with approximately 15 cm of soil or similar material.
- Install landfillgas collection and rainwater diversion systems
- Keep the site access roads in good condition to allow vehicles to deposit wastes at designated places as quickly as possible
- The disposal site should be protected from scavengers/ public by boundary walls and access gates
- Records of waste deliveries and tipping should be maintained
- Carry out Environmental (Simple visual inspection to complex chemical analysis) monitoring should be done
- Provide for essential staff to manage the operation such as a landfill manager, office clerk, security, traffic controller, landfill equipment drivers and mechanic

The principle of 'keep it simple' and 'make it sustainable' should be adopted rather than a 'high tech' solution. Improvements may be introduced incrementally in keeping with the ability or willingness to pay.

5.0 RESEARCH ON REHABILITATION OF MSW DUMPSITES

A Research Project is in progress to address some of the issues of Open so that guidelines along with action plan could be developed for up gradation of land dumps in the country and other developing countries. These guidelines would take into account the basically different physical and economic situation prevailing in developing countries. The studies would be carried out by the **Centre for Environmental Studies, Anna university, India** on the existing open dump sites at Kodungaiyur and Perungudy at Chennai. **Swedish International Development Co-operation Agency (SIDA)** is providing financial support for this technological research on Rehabilitation of the dump sites. This study of three years duration is undertaken as part of the Asian Regional Research Programme on "**Sustainable Solid Waste Landfill Management in Asia**" funded by SIDA and coordinated by **Asian Institute of Technology, Bangkok**. Universities from Thailand, China and Sri Lanka are also involved in this programme.

The research is focusing on the potential of **Landfill Mining** for recovery of resources such as Compost, Recyclables and Landfill cover soil from the dump sites. This will also assess the feasibility of **Vermicomposting** and **Phytorehabilitation** in Dump sites. The objectives are to:

- assess the physico chemical and biological characteristics of the waste from different locations of the dumps.
- conduct leachability studies on wastes at different stage/state of degradation.
- Monitor and assess the current status of the leachate quality around the existing dumpsite.
- study the feasibility of stabilizing the partly degraded organic wastes by vermicomposting.
- Study the feasibility of using the stabilized wastes from the dumps as compost as well as daily cover material
- rehabilitate the dump sites through macrophytes.

The results from the studies shows that samples from Perungudi dumpsite contained about 30-50% combustible materials such as textile, wood, plastics etc., with an average of 40%. The moisture content varied from 20-50% with an average value of 40% and the samples were slightly alkaline with pH varying between 7.6 and 8.6. The non-combustible fraction was about 10-30% with an average of 20%. The soil fraction varied from 30-65% with an average of 40%; 22% being fine size (<2mm). In solid samples from Kodungaiyur dumpsite, the combustibles constituted about 2-12%, non-combustibles 10-50% and the soil fraction 30-80%. The pH values were near neutral and ranged from 6.7 - 8.2 and the moisture content 20-30%. Physical characteristics of the fine fraction showed that the Bulk density varied from 700-1100 kg/m³ with an average of 965 kg/m³ and the organic matter varied from 90-160 g/kg, while the ash content constituted 840-910 g/kg indicating that the soil fraction was mostly stabilized and inorganic in nature. Chemical analyses of the water and acid extracts of the samples indicate that the trace metals and other constituents are within the limits prescribed by the CPCB for compost.

Comparison of constituents of solid wastes of Perungudi and Kodungaiyur indicates that the combustibles were low and the soil fraction was very high in samples from Kodungaiyur. This is attributable to the unorganized dumping and leveling of fresh waste at Perungudi especially during the monsoon. The results of the study support the feasibility of mining compost/ daily cover soil from the solid waste dump sites where the dumping has been done in a controlled manner. The high moisture content of the samples that require drying prior to component separation appears to be a limitation.

6.0 CONCLUSION

Municipal Solid waste Management services in most of the Countries comes a poor third in municipal priorities, after water supply and sanitation. However they are under pressure from their own legislation to move away from the current disposal practices of open dumping to sanitary landfilling. Such a change is unlikely to occur in the nearest future due to limitations on finance, shortage of technical resources and lack of institutional arrangements (Michel Pugh, 1999). It is advisable to have small incremental improvements in landfill design and operation rather than an attempt to make a single large technological leap. This approach should also match the affordability and sustainability considerations.

7.0 REFERENCES

- The Population Institute (1999). "The Four Horsemen of the 21st Century Apocalypse: overpopulation, deforestation, water scarcity, famine." Accessed July 30, 1999. Available at <http://www.populationinstitute.org/issue.html>.
- Mark H. Brady, M. Sasha Mackler, Richard Ian Stessel (2000), Waste Management in Developing Countries Earth Engineering Center Henry Krumb School of Mines Columbia University, New York, NY 10027 USA
- Jefferis S.A. (1995) "Old Landfills: Perception and Remediation of problem sites." Waste disposal by Landfill- Green '93, Sarsby(ed.) Balkema, Rotterdam.
- Johannessen L.M and Boyer G., (1999), "Observations of Solid Waste landfills in Developing Countries" Urban development division, Waste Management Anchor Team, The World Bank, Washington, USA.
- Michael Pugh (1999) "Landfill Technology in Developing Countries, Waste Management, October 1999, pp 58-59.
- Richard Beaven and Knox Associates (1999)," DESIGN OF A DEMONSTRATION HIGH RATE FLUSHING BIOREACTOR LANDFILL", University of Southampton, Highfield.
- Carius S, Hogland W., Jilken I, Klapp M, Mathiason and Anderson P.A (1999) " A hidden waste material resource – Displaced thermoplastics' Seventh int. Waste Management and landfill Symposium – SARDINIA'99.
- Christian Zurbrugg (1999) " The Challenge of Solid waste disposal in developing countries", SANDEC News, EAWAG, No.4, January 1999, pp 10 - 14
- Cossu R, Hogland W and Salerni E (1999), "Landfill Mining in Europe and USA".
- Hogland W, Marcia marques Gomes and Lars Thorney (1997) " landfill Mining- Space saving, material recovery and energy use" Seminar on waste Management and Environment, Kalmar, Sweeden.
- Hogland K.H.W, Jagodzinski K. and Meijer J.E. (1995) " Landfill Mining tests in Sweden", Procs. Sardinia 95, Fifth International Symposium, Calgiari, Italy