MUNICIPAL SOLID WASTE DUMPSITES TO SUSTAINABLE LANDFILLS

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Introduction

Rapid population growth and urbanization in developing countries have led to the generation of enormous quantities of solid wastes and consequential environmental degradation. An estimated 7.6 million tons of municipal solid waste is produced per day in developing countries. These wastes are disposed in open dumps creating considerable nuisance and environmental problems. Often lack of technical knowledge, financial and human resources coupled with existing lacunae in policies limit the extent to which landfills can be built, operated and maintained at minimum sanitary standards. The marked shift towards urbanization in the developing countries has become a pressure point on most of the urban centers for the management of municipal solid waste (MSW).

Most Asian countries have not viewed landfills scientifically as a means of effectively disposing waste discarded by the society. Open dumping of municipal solid wastes has been practiced as a default strategy in most of the developing countries with limited control measures, including those related to the environmental impacts (Figure 1). This approach is the primitive stage of landfill development and still remains the predominant waste disposal option in developing countries owing to their low initial costs and lack of expertise and equipments (Johannessen and Boyer, 1999). Liners are rarely used and little consideration is given to the groundwater pollution and/or gas migration. Problems of shortage of cover, lack of leachate collection and treatment, inadequate compaction, poor site design, and rag picker invasions are common in these sites. Waste pickers often set refuse on fire in order to recover valuable inorganic items thereby creating fire hazards and adding to air pollution (Figure 2). The workers are exposed to risks from human feces, slaughterhouse wastes, infectious biomedical wastes, vermin (snakes, rats, scorpions etc), broken glass, toxic dusts, landfill gases, spontaneous fires and explosions. In India and other developing countries, more than 90% of the solid waste is disposed in open dump. Identification and upgrading of such sites to sanitary landfills is one of the most important steps towards sustainable solid waste management (SWM) system.

Landfill is considered to be a reliable and cost effective method of solid waste disposal in the developing countries where adequate land is available. China alone has proposed to construct 1000 landfills in next 10 years. Operation of these landfills will be a major issue. The cost associated with landfilling practiced in the developed countries is construction and operation, post closure monitoring of gas and leachate and leachate treatment. The management of landfill requires substantial amount of money and technical expertise for post closure monitoring activities.

Figure 1: Open dumping amidst human habitation – a common sight in developing countries

Figure 2: A dumpsite in Chennai – a burning problem

Sustainable Landfills

Sustainability in the present context may be defined as "solving today's problems in a responsible and environment friendly approach without prejudicing the ability of future generations to exist or solve their own problems". Hence each generation should manage its wastes such that any emissions to the environment are acceptable without further treatment. In sustainable landfills, processes, control and use of products and residues will be optimal and negative impacts on the environment will be minimal. The goal of treating the waste within a lifetime can be achieved when the waste within a landfill is stabilized. Ideally, a sustainable landfill as depicted in Figure 3 combines the principles of bioreactor landfill to enhance the process of stabilization and landfill mining to recover the space for reuse while salvaging decomposed organic matter for agricultural use.

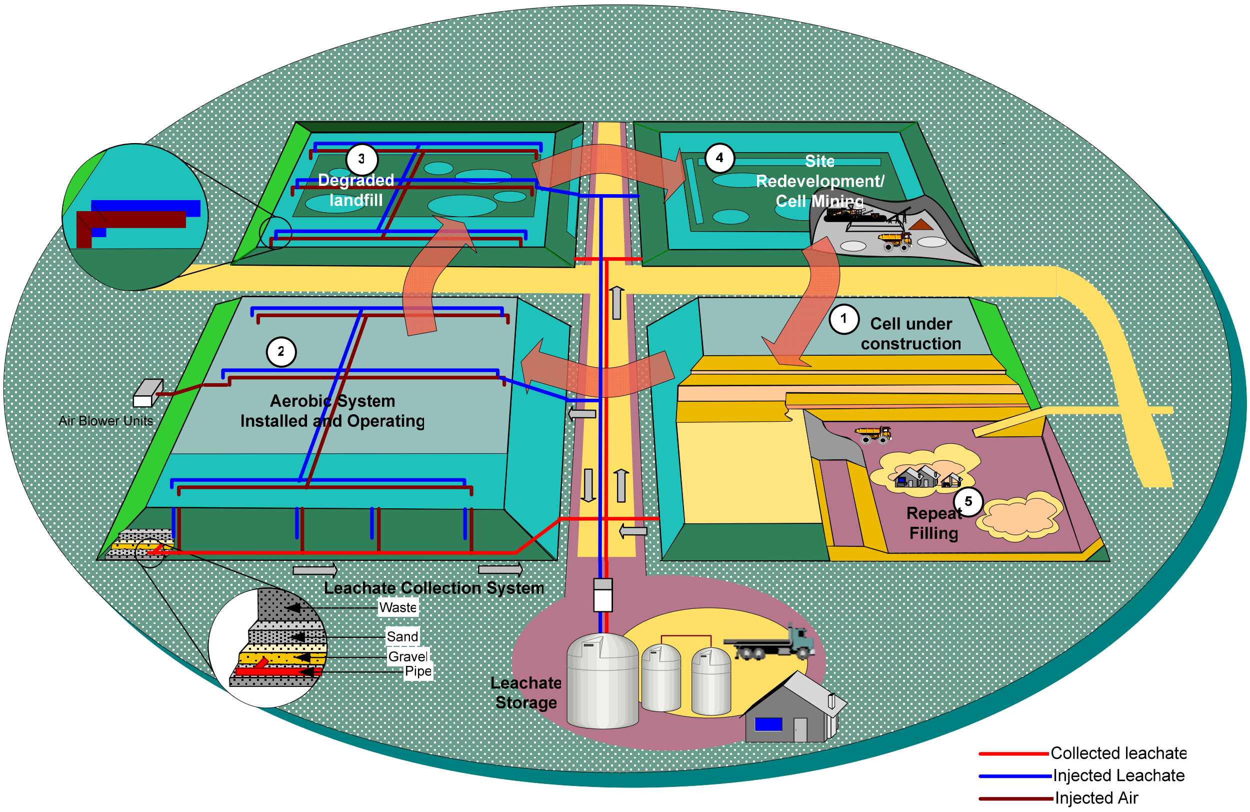

Figure 3: Schematic of a sustainable landfill

Dumpsites to Sustainable Landfills – the Indian experience

Closing the open dumps when an alternate upgraded landfill is available or upgrading them into sustainable landfills are the two viable options available for municipal authorities The latter option is feasible if the dumpsite is located in an area where ground water pollution is not a critical issue or if there is sufficient remaining void space to justify the cost and effort of conversion. The first step for rehabilitating an open dump is to study the condition of the site and its geographical setting. Detailed investigations are needed to make a choice between closing and converting the site.

Manfred Scheu and Bhattacharya (1997) have reported on the reuse of decomposed waste from the solid waste dumpsite in Deonar, near Mumbai, India. The site has been in use since the turn of the 20th century holding a very large amount of waste, much of it at an advanced state of decomposition. Decomposed waste from a portion of this dumpsite between 4 and 12 years old was excavated manually, sun dried and screened with about 8 mm sieves. The fine material was bagged and removed leaving behind the coarse material at the dumpsite. Two companies are involved in this work since 1989.

Studies are underway in Chennai where municipal solid wastes are being dumped in two locations, Kodungaiyur and Perungudi. The studies aimed at converting these dumping grounds into waste havens are focusing on:

1. Study of dumpsites for resource recovery through landfill mining
2. Biorehabilitation of MSW dumpsites
3. Determination of leachate and landfill gas at dumpsites
4. Solid phase anaerobic digestion

Some findings of the study in respect of dumpsite mining and biorehabilitation are presented here.

(a) Dumpsite Mining

The methodology and approach employed to carry out mining studies at the Kodungaiyur and Perungudi dump sites are presented in Figure 4.

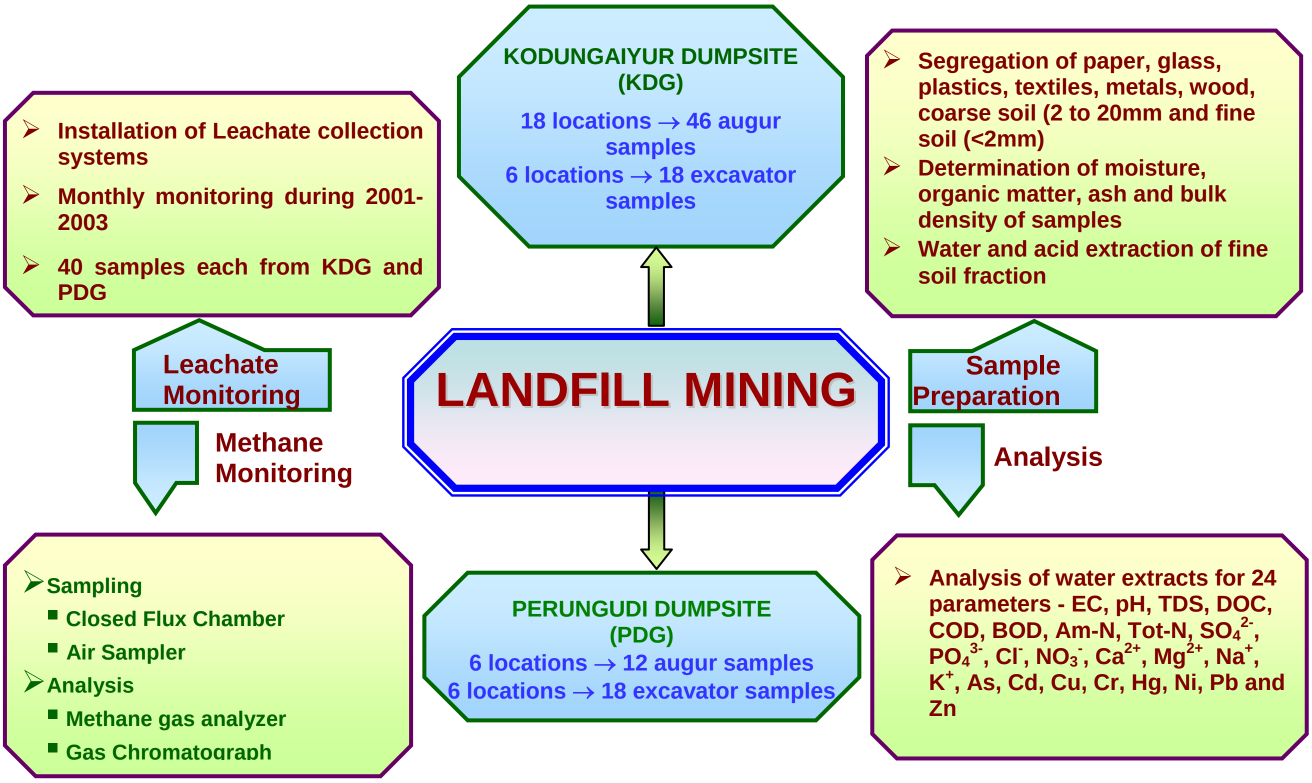

Figure 4: Methodology and approach to carry out mining studies at the Kodungaiyur and Perungudi dump sites at Chennai

Heavy metal speciation by sequential extraction was carried out for a sample collected from Kodungaiyur. About 30% of the total metal content was found available for biological functions. Zinc contributed the highest while chromium contributed the least.

From bulk sampling locations, 6 leachate collection systems were established in Perungudi and Kodungaiyur. Three boreholes (BH 2, BH 5, and BH 6) from the former site and one borehole from the latter are being monitored. Leachate samples were analyzed after filtration to determine pH, electrical conductivity (EC), total dissolved solids (TDS), chemical oxygen demand (COD) and biological oxygen demand (BOD) instantaneously. Monthly variations of these parameters are presented in Figures 5 and 6. In all the cases the pH is observed to be nearly neutral.

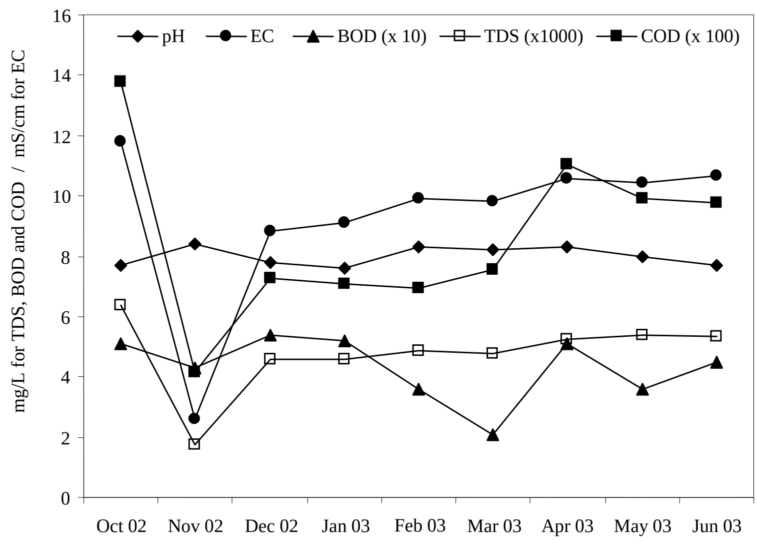

Figure 5: Monthly variation in pH, EC (mS/cm), BOD (mg/L), TDS (mg/L) and COD (mg/L)of leachate collected from borehole 6 of Perungudi.

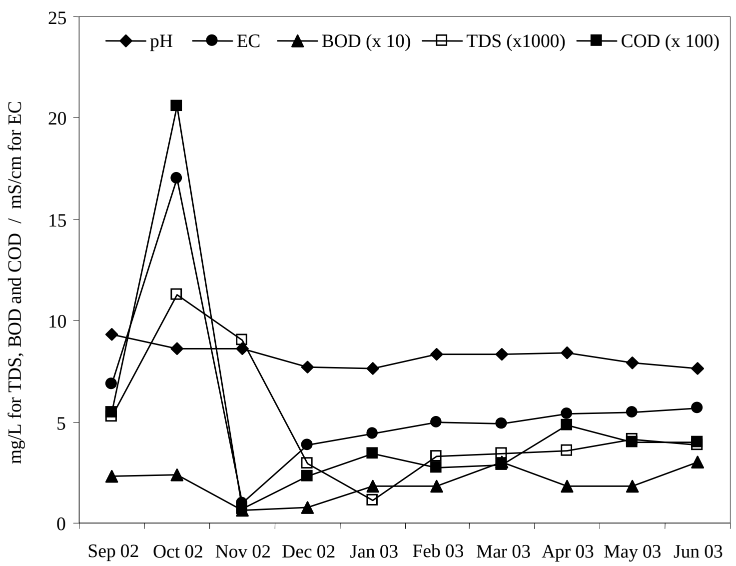

Figure 6: Monthly variation in pH, EC (mS/cm), BOD (mg/L), TDS (mg/L) and COD (mg/L) of leachate collected from borehole 6 of Kodungaiyur.

For other parameters, comparatively lesser values were observed during November 2002, possibly due to the dilution of the leachate by rain. Thereafter, a steady increase was observed in the values which could be attributed to the decrease in the water content of the leachate. Correlation between TDS and EC (TDS/EC) varied from 0.52 to 0.54 for PDG and 0.68 for KDG. BOD/COD ratio is around 0.05

(b) Biorehabilitation studies

Biorehabilitation studies were conducted at the dumpsites using earthworms and two plant species, *Cynodon dactylon* and *Tagetes erecta.* Monthly monitoring indicated that the earthworms did not survive in the experimental plots even for a month. Data on growth and chlorophyll contents in *C. dactylon* and *T. erecta* plants are presented in Tables 1 and 2. In *C. dactylon,* the growth pattern indicated significant variation when raised under control and in the MSW soil inoculated with earthworms. Interestingly, the variations were noticeable only during the first month as data for subsequent months did not indicate the same. But an appreciable variation was noticed in *T. erecta* grown in plots containing earthworms. Since the earthworms did not survive in the experimental plots, the variation in growth responses may be attributed to some other factors. Variations in heavy metal contents of soil samples collected from in *C. dactylon* plots show a decrease in heavy metal content.

Laboratory experiments were conducted in polyethylene bags. Plants were grown in the soil fraction of MSW and in red soil (control) to evaluate their growth. Earthworms did not survive in the polythene bags. In general, *Cynodon dactylon* and *Gomphrena* sp. grew better in MSW soils than in control soil. In case of *Tagetes erecta* and *Chrysanthemum*, MSW soil exhibited a negative effect on growth and dry matter production.

Table 1: Growth and chlorophyll content of *Cynodon dactylon* raised in field experimental plots

S. No	Experimental conditions	Time (months after planting)	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)	Total Chlorophyll (mg/g live weight)
1	Control*	1	21	8	0.71	0.13	2.43
2	Earthworms**	1	19	7	1.06	0.19	2.71
3	Control	2	42	12	3.17	0.63	2.91
4	Earthworms	2	48	12	3.77	0.77	2.95
5	Control	3	83	17	18.6	2.71	3.13
6	Earthworms	3	91	18	20.0	3.24	3.07

* Control – Soil medium without earthworms
** Earthworms – Soil medium inoculated with earthworms

Table 2: Growth and chlorophyll content of *Tagetes erecta* raised in field experimental plots

S.No	Experimental conditions	Time (months after planting)	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)	Total Chlorophyll (mg/g live weight)
1	Control*	1	58	14	9.23	1.6	2.03
2	Earthworms**	1	66	16.3	14.83	2.6	1.75
3	Control	2	72	18	23.1	2.5	2.14
4	Earthworms	2	80	22.1	33.8	3.2	2.06

* Control – Soil medium without earthworms
** Earthworms – Soil medium inoculated with earthworms

The future

The principle of *'keep it simple and make it sustainable'* and not the '*high-tech*' solutions holds the key for the rehabilitation of dumpsites. Improvements to existing may be gradually introduced in keeping with the technical capability. Issues related this approach were discussed at a recently concluded international workshop on "Sustainable Landfill Management" at Chennai, India (3 - 5 December, 2003). This workshop organized by the Centre for Environmental Studies, Anna University in association with the Asian Institute of Technology, Thailand and supported by Swedish International Development Cooperation Agency (SIDA) is a part of the Asian Regional Research Programme on Environmental Technology (ARRPET). Twenty international experts from Thailand, China, Russia, Sri Lanka, U.S.A, and Germany and 150 Indian resource personnel and delegates participated in it. The following points emerged during the deliberations would play a major role in developing concrete and viable strategies to tackle the myriad issues and concerns related to rehabilitation of dumpsites in this region:

i. Policy makers should prioritize SWM schemes on the lines of drinking water supply systems.

ii. A comprehensive master plan should be developed and implemented by all municipal bodies for managing the MSW and monitoring of activities with periodic reviews.

iii. Specific provisions in the budget should be made for SWM in all municipal bodies that should specifically allocate funds for solid waste processing and disposal.

iv. Minimization of solid waste generation through source reduction, source separation, reuse, recycle and recovery should be given the highest priority in the hierarchy of waste management.

v. Rehabilitation of existing dumps should be given top priority with the upgradation and rehabilitation of dumpsites to sanitary landfills in a phased manner depending on the risk and financial aspects of each. Transformation from open dumping to standardized sanitary landfilling cannot be achieved overnight. The key to such a change is today's scientific knowledge and continuous improvements in the disposal standards while availability of financial resources generally dictates the course of transition. The intermediate stages between open dumping and sanitary landfilling would include:
   - designated dumping (within a designated site without operational control);
   - controlled tipping with supervision of organized waste disposal in layers and periodical covering; and
   - engineered landfilling after environmental impact assessment and mitigation by engineering measures that limit, but not necessarily eliminate the impacts.

vi. While developing sanitary landfills, priority should be given to adopt emerging principles of landfill bioreactor and landfill mining.

vii. Segregation of wastes at household levels should be popularized by local bodies together with awareness programs on SWM developed and offered by the concerned to encourage public participation.

viii. Confidence building strategies should be evolved by the concerned to involve multi stakeholders during the setting up waste handling, processing and disposal facilities.

ix. Attempts should be made to collect and dispose inerts separately as they might not require any further processing.

x. Government-Private entrepreneurship or joint venture for SWM should be encouraged.

xi. Reliable scientific database on SWM should be generated with the help of academic institutions.

xii. Authorities should take measures to create linkage and cooperation among the SWM stakeholders.

xiii. A comprehensive policy should be formulated regarding the creation and use of co-disposal facilities for MSW and non hazardous industrial wastes.

xiv. Provisions of national legislations and policy framework should be reviewed in line with the principles of sustainable waste management.

Conclusion

Municipal SWM services in most of the developing countries receive low priority in municipal activities after water supply and sanitation. The civic authorities are under pressure from their own national legislations to divert from the current practice of open dumping to sanitary landfilling. Such a change is unlikely to occur in the near future due to limitations on finance, shortage of technical resources and lack of institutional arrangements (Pugh, 1999). It is advisable to have gradual incremental improvements in landfill design and operation rather than attempting a single large technological leap. This approach should also match affordability and sustainability considerations.

Generally, the following steps may be initiated for the metamorphosis of open dumps to sustainable landfills:

- Elimination of fires on the dumpsite.
- Restriction of waste tipping into small areas following a disposal plan.
- Deposition of wastes in thin layers of about 50 cm with appropriate compaction.
- Covering the newly deposited waste with approximately 15 cm of soil or similar material on a daily basis.
- Installation of systems for the collection of landfill gas and diversion of rainwater.
- Keeping the site access roads in good condition to enable vehicles to deposit wastes at designated places as quickly as possible.
- Protection of the disposal site from scavengers/ public by building boundary walls and access gates.
- Maintaining records of waste deliveries and tipping.
- Environmental monitoring - simple visual inspection to complex chemical analysis.
- Providing essential manpower - a landfill manager, office clerk, security, traffic controller, landfill equipment drivers and mechanic.

These steps would enable a gradual transformation and rehabilitation of the existing MSW dumpsites and sanitize the efforts of the municipal authorities to bring about sustainable solid waste management practices. The benefits that can be reaped from landfill mining could be incorporated in an effort for optimum utilization of land availability as well as obtain value from the once-considered valueless waste. Side by side, the new ventures into landfilling would be have to emerge in within the standards of sanitary landfills practiced in the developed countries thus paving way towards sustainable management of the environment.

REFERENCES

Johannessen, L. M. and Boyer, G. (1999). Observations of Solid Waste Landfills in Developing Countries: Africa, Asia and Latin America. Urban and Local Government Working Paper Series #3, World Bank, Washington DC..

Manfred Scheu and Bhattacharyya (1997). Reuse of Decomposed Waste in Lessons from India in Solid Waste Management. Ed. Adrian Coad, Department of International Development, UK Government.

Michael Pugh (1999) Landfill Technology in Developing Countries, Waste Management, October 1999, pp.58-59.

Kurian Joseph, Nagendran. R and Palanivelu K (2002), "Open Dumps to Sustainable Landfills", CES ENVISION, monthly news letter of the ENVIS node under EMCBTA project at CES (AU/CES/NL-02) supported by Ministry of Environment and Forests, Government of India, Vol.1, No.2 (http://envis.nic.in/news/newsletter_rana7.pdf)